Preliminary Assessment
Section 9 Lease Abandoned Uranium Mine
Coconino County, Arizona

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Region 9

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List of Acronyms

ABGMT	Arizona Bureau of Geology and Mineral Technology
ADEQ	Arizona Department of Environmental Quality
ADWR	Arizona Department of Water Resources
AEC	United States Atomic Energy Commission
AGS	Arizona Geological Survey
APN	Assessors Parcel Number
AUM	Abandoned Uranium Mine
BIA	Bureau of Indian Affairs
Babbitt	Babbitt Ranches, LLC
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
CO Bar	C.O. Bar Livestock Company
cpm	Counts Per Minute
DOE	United States Department of Energy
EPA	United States Environmental Protection Agency
GIS	Geographic Information Systems
HRS	Hazard Ranking System
MCL	Federal Maximum Contaminant Level
NAMLRP	Navajo Abandoned Mine Lands Reclamation Program
NDWR	Navajo Department of Water Resources
NMGS	New Mexico Geological Survey
NNEPA	Navajo Nation Environmental Protection Agency

NPL	National Priorities List
NSP	Navajo Nation Environmental Protection Agency – Superfund Program
PA	Preliminary Assessment
pCi/L	Picocuries Per Liter
Rare Metals	Rare Metals Corporation of America
RCRIS	Resource Conservation and Recovery Information System
SARA	Superfund Amendments and Reauthorization Act of 1986
Site	Section 9 Lease Site
μr/hr	Micro Roentgens Per Hour
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
WESTON	Weston Solutions, Inc.

1.0 INTRODUCTION

Under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and the Superfund Amendments and Reauthorization Act of 1986 (SARA), Weston Solutions, Inc. (WESTON) has been tasked to conduct a Preliminary Assessment (PA) of the Section 9 Lease Abandoned Uranium Mine (AUM) site (Site) near Cameron, Coconino County, Arizona.

The purpose of the PA is to review existing information on the Site and its environs to assess the threat(s), if any, posed to public health, welfare, or the environment, and to determine if further investigation under CERCLA/SARA is warranted. The scope of the PA includes the review of information available from federal, state, and local agencies and performance of an on-site reconnaissance.

Using these sources of existing information, the Site is evaluated using the U.S. Environmental Protection Agency's (EPA) Hazard Ranking System (HRS) criteria to assess the relative threat associated with actual or potential releases of hazardous substances at the Site. The HRS has been adopted by the EPA to help set priorities for further evaluation and eventual remedial action at hazardous waste sites. The HRS is the primary method of determining a site's eligibility for placement on the National Priorities List (NPL). The NPL identifies sites at which the EPA may conduct remedial response actions. This report summarizes the findings of these preliminary investigative activities.

The Site was identified as a potential hazardous waste site and entered into the Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) on October 10, 2011 (NNN000909110) (EPA 2012c).

More information about the Superfund program is available on the EPA website at http://www.epa.gov/superfund. The attached fact sheet describes EPA's site assessment process (Appendix E).

1.1 Apparent Problem

The apparent problems at the Site, which contributed to the EPA's determination that a PA was necessary, are presented below:

- The Site was mined for uranium at several intervals from 1957 until 1962. Low-grade uranium waste rock is present at the Site (WESTON 2011).
- Uranium ore was processed at the Site. Waste generated during the processing activities is present at the Site (WESTON 2011).
- The Site is located along the banks of the Little Colorado River, and Palustrine wetlands alongside the river are found within the site boundary (TGS, 1997; WESTON 2011).

- Gamma radiation has been found at the Site at levels significantly above the background (WESTON 2011).

2.0 SITE DESCRIPTION

2.1 Site Location

The Site is an abandoned uranium mine consisting of three separate mining areas within a single leased property, located approximately 10 miles southeast of Cameron, Coconino County, Arizona. The three mining areas constitute a total combined area of approximately 39 acres. The majority of the Site is located within Township 27 North, Range 10 East, Section 9, on land currently owned by Babbitt Ranches LLC, a livestock company based out of Flagstaff, Arizona. The Coconino County assessor's parcel number (APN) is 30215013. A portion of the southernmost mining area is located on land owned by the State of Arizona, located within Township 27 North, Range 10, Section 16. The Site is immediately south of the Navajo Nation boundary, and immediately west of the Little Colorado River and Navajo Nation boundary (TGS 2007; Appendix C-1; Appendix C-4).

The geographic coordinates for the Site are 35° 44' 21" North latitude and 111° 19' 25" West longitude (TGS 2007; Appendix D).

The Site Location is shown in Figure 1.

2.2 Site Description

The Site consists of three AUM areas (AUM Numbers 457, 458, and 459) within a single leased section, and is located in a largely uninhabited area. The boundaries of the AUMs were defined based on historical documents and remnants left from the mining operations. The three Section 9 Lease AUMs operated as a single mine claim. Dirt roads lead to all three mining areas. No current mining related activities take place at the Site (TGS 2007).

A Site Layout is shown in Figure 2.

As shown in Figures 3, 4, and 5, the following features are present individual mining areas at the Site:

AUM 457:

- A concrete foundation and two walls from a former "upgrader" processing plant were found in the center of AUM 457, the foundation was spread out between two levels, covering an estimated area of 100 feet by 50 feet. Two of the walls were still partially intact. The lower wall was a height of approximately 30 feet. Two chutes were still visible leading between the levels (WESTON 2011).

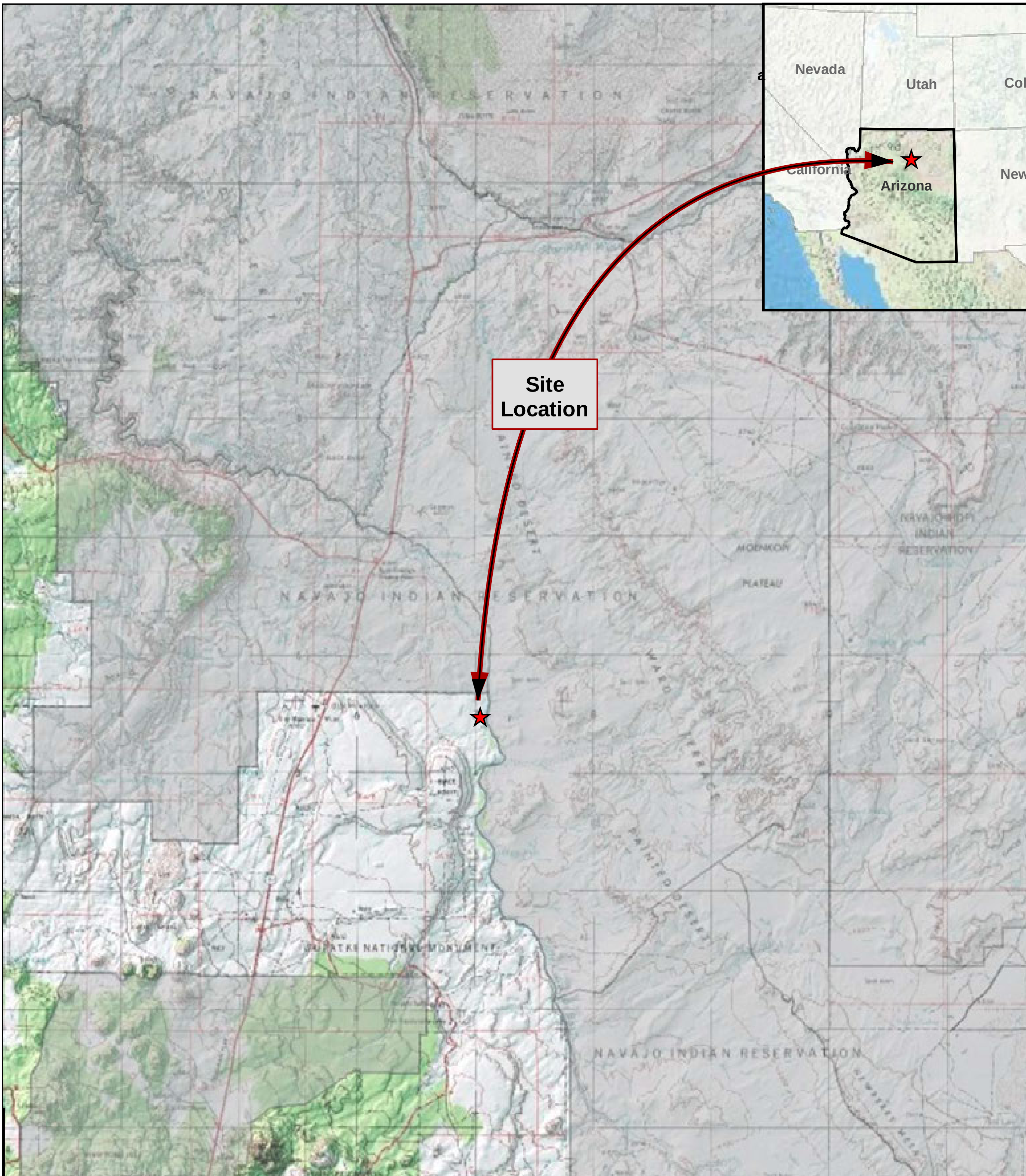
- A smaller 20 foot by 20 foot concrete foundation was found approximately 300 feet south of plant foundation (WESTON 2011).
- Various pieces of metal and wood debris were found throughout AUM 457 (WESTON 2011).
- Unreclaimed mining-related uranium waste rock was piled throughout AUM 457 (WESTON 2011).
- A recessed former pond area was found north of the plant foundation (WESTON 2011).
- Piles of a light colored, fine, sandy material were found surrounding the plant foundation (WESTON 2011).
- Gamma radiation measurements collected in 2010 were found at levels up to 999,960 counts per minute (cpm), more than 50 times the background level of 15,649 cpm (WESTON 2011).
- The mining area is bordered to the north, south, and west by uninhabited land owned by Babbitt Ranches, LLC. The mining area is bordered to the east by the Little Colorado River (WESTON 2011; Appendix C-1).

AUM 458:

- Unreclaimed mining-related uranium waste rock covered a majority of the mining area (WESTON 2011).
- Drilling parts and other mining related debris were spread throughout the mining area (WESTON 2011).
- A recessed pit/depression was found in the center of the waste rock area (WESTON 2011).
- Gamma radiation measurements collected in 2010 were found at levels up to 968,863 cpm, more than 50 times the background level of 15,455 cpm (WESTON 2011).
- The mining area is bordered in all directions by uninhabited land owned by Babbitt Ranches, LLC (WESTON 2011; Appendix C-1).

AUM 459:

- Seven piles of unreclaimed mining- related uranium waste rock were found in the mining area (WESTON 2011).
- An open pit area, approximately 60 feet by 80 feet wide by 15 feet deep, with a vegetated sandy bottom was found in the mining area (WESTON 2011).
- Gamma radiation measurements collected in 2010 were found at levels up to 879,863 cpm, more than 50 times the background level of 15,775 cpm (WESTON 2011).
- The mining area is bordered to the north by uninhabited land owned by Babbitt Ranches, LLC, and to the east, south, and west by uninhabited land owned by the State of Arizona. (WESTON 2011; Appendix C-1).
- The southern portion of mining area crosses into uninhabited land owned by the State of Arizona.



Legend

★ Site Location

Navajo Nation Boundary

0 3 6 Miles

Figure 1 - Site Location
Section 9 Lease Abandoned Uranium Mine
Preliminary Assessment

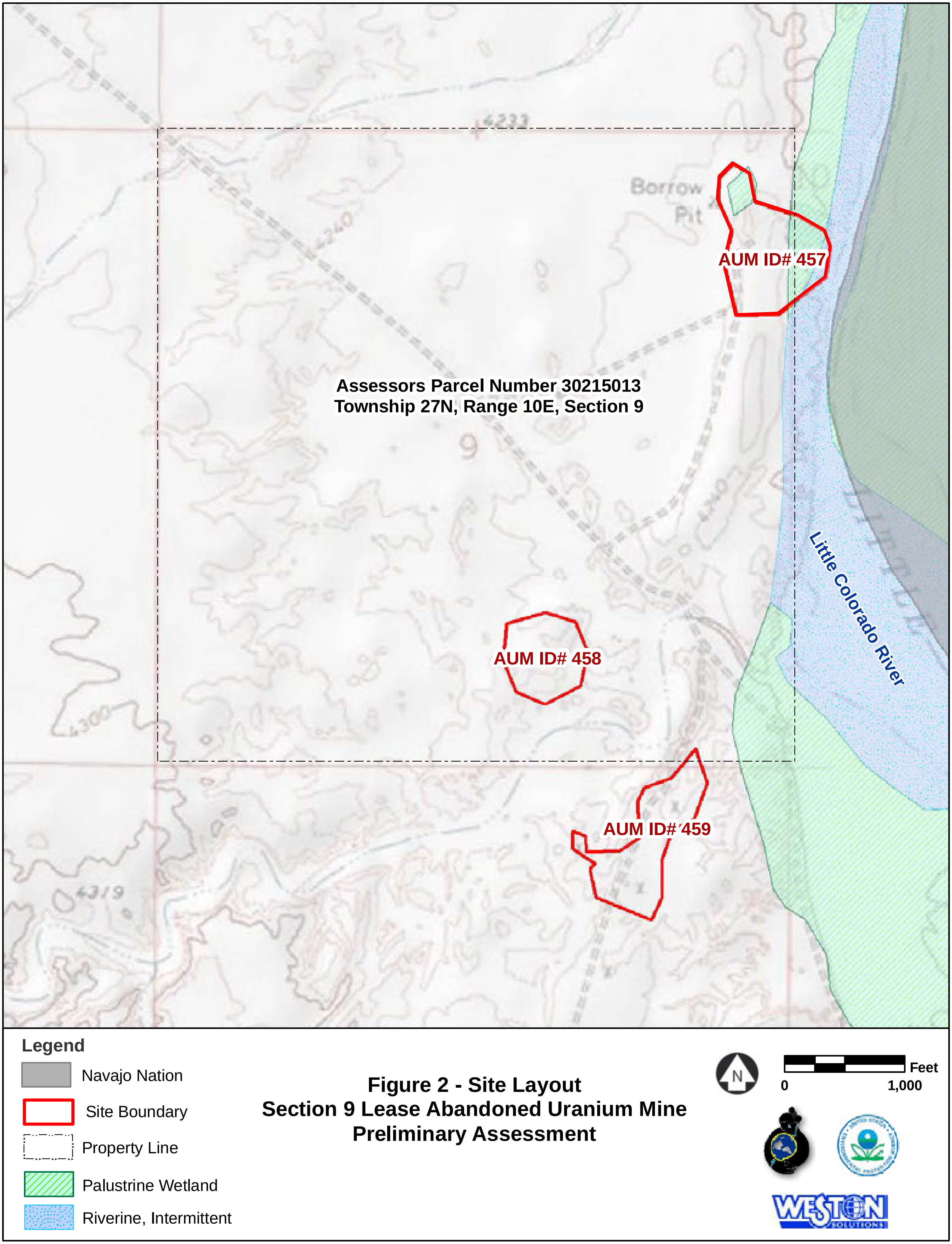
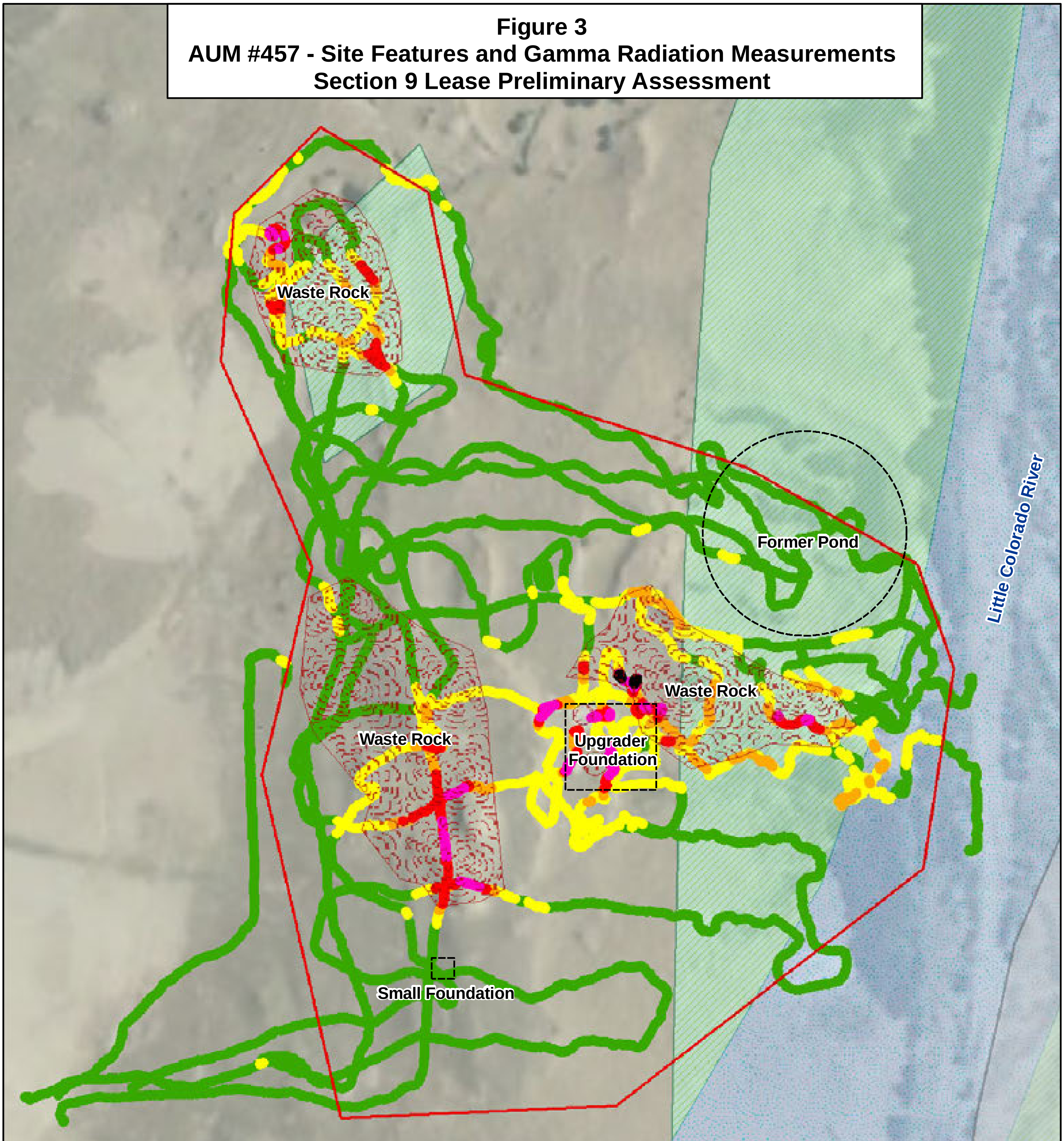


Figure 2 - Site Layout
Section 9 Lease Abandoned Uranium Mine
Preliminary Assessment

Figure 3
AUM #457 - Site Features and Gamma Radiation Measurements
Section 9 Lease Preliminary Assessment



Gamma Radiation Measurements

- < 2 x Background
- 2 to 5 x Background
- 5 to 10 x Background
- 10 to 20 x Background
- 20 to 50 x Background
- > 50 x Background

Background = 15,626 counts per minute

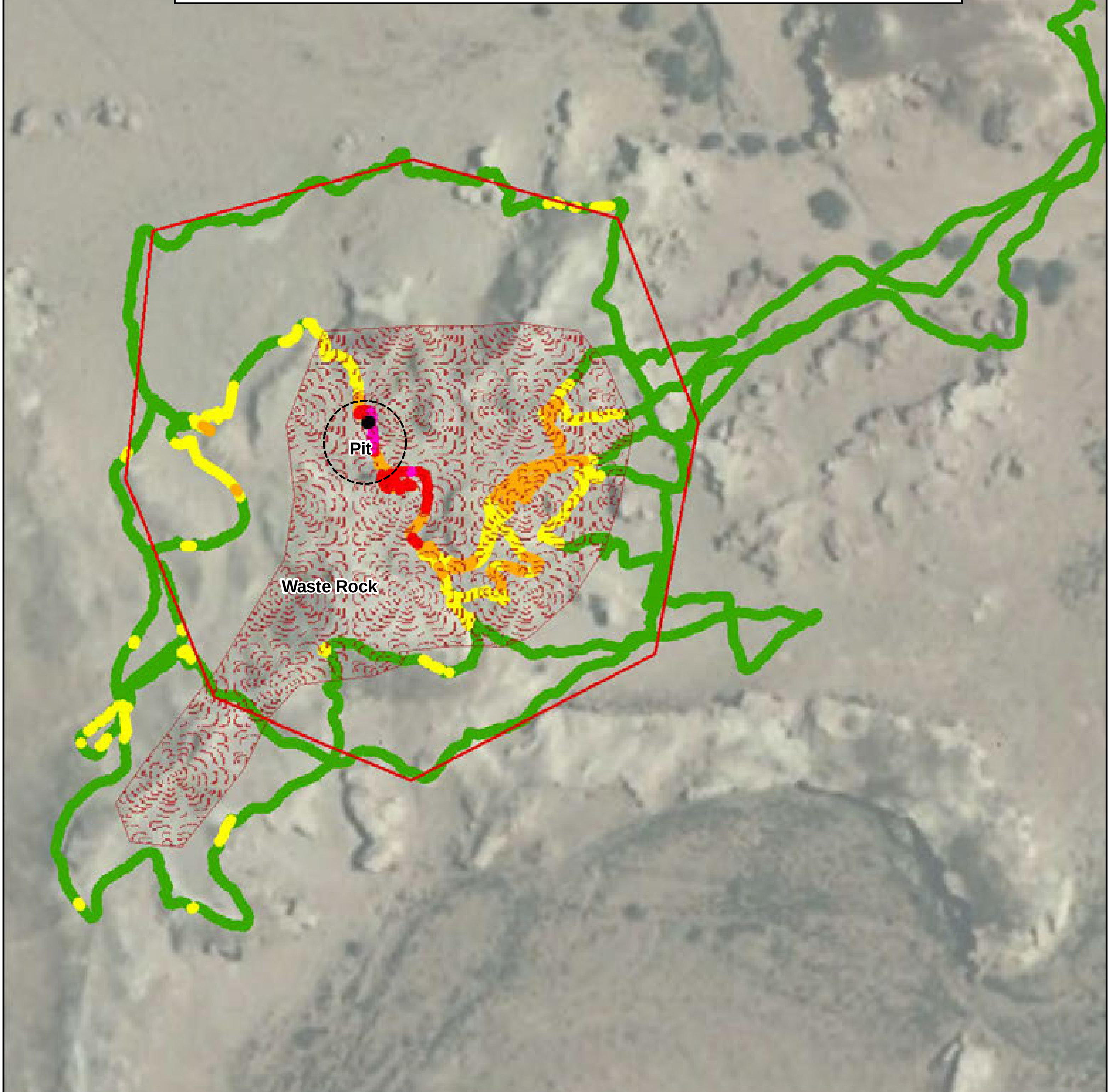
- Mine Site Boundary
- Navajo Nation
- Palustrine Wetland
- Riverine, Intermittent
- Observed Waste Rock

N

0 200 Feet

WESTON SOLUTIONS

Figure 4
AUM #458 - Site Features and Gamma Radiation Measurements
Section 9 Lease Preliminary Assessment



Gamma Radiation Measurements

- < 2 x Background
- 2 to 5 x Background
- 5 to 10 x Background
- 10 to 20 x Background
- 20 to 50 x Background
- > 50 x Background

Background = 15,626 counts per minute

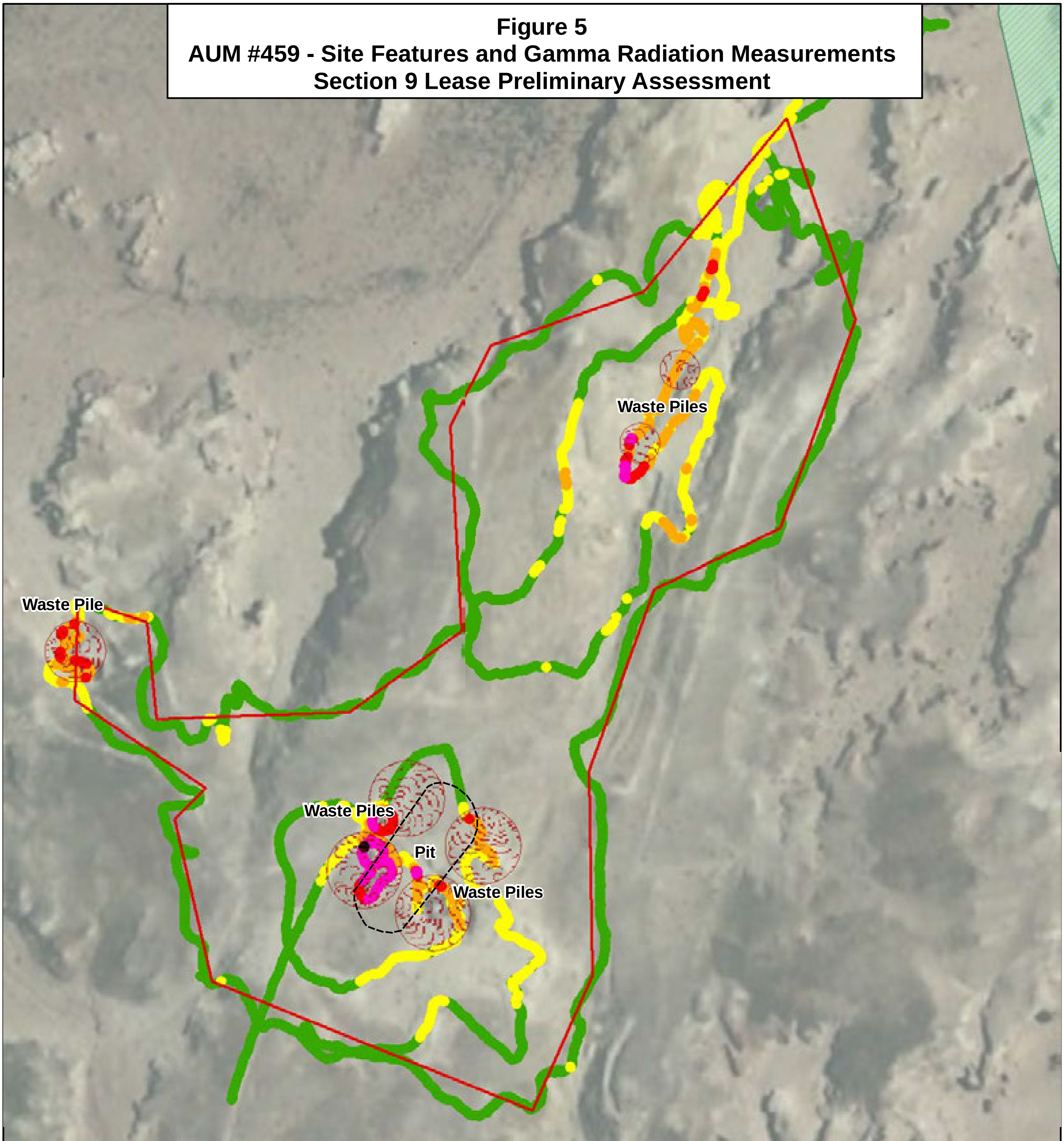
- Mine Site Boundary
- Navajo Nation
- Palustrine Wetland
- Riverine, Intermittent
- Observed Waste Rock

N

Feet

0 200

Figure 5
AUM #459 - Site Features and Gamma Radiation Measurements
Section 9 Lease Preliminary Assessment



Gamma Radiation Measurements

- < 2 x Background
- 2 to 5 x Background
- 5 to 10 x Background
- 10 to 20 x Background
- 20 to 50 x Background
- > 50 x Background

Background = 15,626 counts per minute

- Mine Site Boundary
- Navajo Nation
- Palustrine Wetland
- Riverine, Intermittent
- Observed Waste Rock

N

Feet
0 200

2.3 Operational History

Uranium was first reported in the Cameron area in 1950. Following the discovery, the United States Atomic Energy Commission (AEC) began to employ local Navajo residents to prospect the area for uranium ore, defined as material containing more than 0.10 percent triuranium octoxide (U_3O_8). Land rights within the Navajo Nation were handled by the Navajo Tribal Council, who assigned mining permits to the Navajo residents. The main mining production in the area began in 1951. In 1955, the Rare Metals Corporation of America (Rare Metals) was contracted by the AEC to build and operate a mill near Tuba City, in order to produce highly concentrated "yellowcake" from the mined uranium ore. By 1956, the production was reaching its peak, and in 1958 the AEC announced that after April 1, 1962 it would no long accept any new ore, and it would only buy concentrated ore that had been discovered before November 24, 1958. Uranium mining in the Cameron area ceased by 1963 (ABGMT 1981; AEC; AGS 1993; NMGS 1958, WLC 2012).

The Section 9 Lease site is an abandoned uranium mine claim consisting of three separate mined areas (AUMs 457, 458, and 459) within a single leased property, and was operational from 1957 to 1962. The Site is located immediately south and west of the Navajo Nation border. While the nearby land rights within the Navajo Nation were handled by the Navajo Tribal Council, the Site, along with many of the odd-numbered sections in the vicinity, was owned by the C. O. Bar Livestock Company (CO Bar) from Flagstaff, Arizona. The Site area has reportedly been used for livestock cattle production by CO Bar and its parent company, Babbitt Ranches LLC (Babbitt), since 1886. The Site has also been identified under the following names: Upgrader Property, C.O. Bar Livestock Company, and Milestone No. 1 (ABGMT 1981; AEC; AGS 1993; TGS 2007; Appendix C-4).

In 1957 Rare Metals leased the rights to Township 27 North, Range 10 East, Section 9 from CO Bar, and began an open pit mining operation at three separate locations within the section. In the first year, Rare Metals shipped 17.95 tons of low grade ore from the Site to the Tuba City mill (AGS 1993).

By 1958 Rare Metals ceased mining operations at the Site, and C.L. Rankin acquired the lease from CO Bar. C.L. Rankin shipped 87.21 tons of low grade ore in 1958, and 234.32 tons of low grade ore in 1959 (AGS 1993, WLC 2012).

In 1959 Murchison Ventures, Inc. from Denver, Colorado, acquired the lease of the Site. Murchison Ventures built a small processing plant known as a "Benson Upgrader" in the northeast part of the section (AUM 457), near one of the former pits. The upgrader plant reportedly separated the waste rock from previous mining activities into a "sellable" higher grade slime fraction and a lower grade sand fraction. The leftover sand tailings were left on the banks of the Little Colorado River, immediately east of the plant. Murchison Ventures sent a shipment of 10.76 tons of upgraded ore to the Tuba City Mill in 1959, under the name CO Bar Livestock Company Lease. In 1960, the plant was modified, and another shipment of 11.31 tons of ore was made. The company was reorganized in 1960 and renamed Milestone Hawaii, Inc. In 1961, the promoter of the operation, John Milton Addison, along with six associates, was convicted of fraud, conspiracy, and federal security violations as a result of the upgrading operation. In 1962, Milestone Hawaii made a shipment from the modified upgrader plant of 23.93 tons of previously discovered material, and labeled the shipment origin as Milestone 1. The majority of the material was mined from the southern portion of AUM 459, within Section 16 (ABGMT 1981; AEC; AGS 1993; SEC 1961, WLC 2012).

Mining operations ceased at the Site in 1961; no known mining activities have been performed at the Site since. While operational, the AEC estimated the uranium ore production volume at the Section 9 Lease Mine, which included all three AUMs, as 386 tons. The Site is currently used by Babbitt for livestock grazing (ABGMT 1981; AEC; AGS 1993).

2.4 Regulatory Involvement

2.4.1 The New Mexico Geological Society

In 1958, the New Mexico Geological Society (NMGS) published a report titled *Uranium Mineralization Near Cameron, Arizona*. The report does not specifically identify the Section 9 Lease Mine, but it summarizes the geology and uranium mining activities in the Cameron area (NMGS 1958).

2.4.2 Arizona Bureau of Geology and Mineral Technology

In 1981, the Arizona Bureau of Geology and Mineral Technology (ABGMT) published a report titled *The Radioactive Occurrence and Uranium Production in Arizona*. The Section 9 Lease site is not specifically identified in the report narrative, but is listed on a table at the end of the report. The table states that the Site was operational from 1957 to 1962, and had a total production of 386 tons of uranium ore. The report also identifies three additional aliases for the Site, including Milestone No. 1, Upgrader Property and C. O. Bar Livestock Company. The table notes that the Section 9 Lease Mine contained three pits, and was the location of the "upgrader machine scheme" from 1961 (ABGMT 1981).

2.4.3 United States Geological Survey

In 1991, the United States Geological Survey (USGS) investigated the potential impact of uranium mining in the Cameron area. The USGS collected water and leachate samples from 49 locations, for analysis of radionuclides and other potential contaminants. The water sampling locations included springs, an open mine pit, wells, mining drill holes, and auger bore holes. The leachate samples were collected from piles of unreclaimed mine waste. The only sample collected within four miles of the Site was a water sample collected from an open pit at the Ramco No. 20 mine, approximately 1.25 miles east of the Site, across the Little Colorado River from the Site. The sample collected at the Ramco No. 20 mine had a total uranium (234 and 238) concentration of 35 picocurries per liter (pCi/L). The federal maximum contaminant level (MCL) for total uranium is 30 pCi/L. The closest water sample collected downstream from the Site was collected from a mining drill hole at the Manuel Denetstone No. 2 mine, approximately six miles north of the Site. The sample collected at the Manuel Denetstone No. 2 mine had a total uranium concentration of 410 pCi/L. Additional water sample locations containing uranium concentrations greater than the MCL included a spring box at the Clay Well Spring, approximately 10 miles north of the Site; a well the Arizona Inspection Station, approximately 12 miles northwest of the Site; a shallow well at the Jack Daniels No. 1 mine, approximately 12 miles northwest of the Site; and an open pit at the Jeepster No. 1 mine, approximately 13 miles northwest of the Site (USGS 1994).

2.4.4 Navajo Superfund Program

In 1992, the Navajo Superfund Program completed four Preliminary Assessments of abandoned uranium mines near Cameron, Arizona. Two of the mines assessed are located approximately one mile from the Section 9 Lease site. The Charles Huskon No. 26 mine is located approximately one mile north of the Site, along the western edge of the Little Colorado River, and the Yazzie No. 1 mine is located approximately one mile southeast of the Site, along the eastern edge of the river. Although neither PA references the Section 9 Lease site, much of the background data is applicable to the Site (NNEPA 1992a; NNEPA 1992b).

2.4.5 Arizona Geological Survey

In 1993, the Arizona Geological Survey (AGS) published the report titled *The Geology and Production History of Uranium Ore Deposits in the Cameron Area.* The report expands on the 1981 ABGMT report, with further details specific to the Cameron area. The three Section 9 Lease mining areas are identified in the report narrative, tables, and maps, under the names Section 9 Lease and Milestone No. 1. Like the ABGMT report, the AGS report also notes the Site aliases of Upgrader Property and C. O. Bar Livestock Company. The report identifies the operators of the Site as Rare Metals in 1957, C.L. Ranking from 1958 to 1959, Murchison Ventures, Inc. from 1959 to 1960, and Milestone Hawaii, Inc. in 1962. The report stated the mine had a total production volume of 386 tons of uranium ore (362 tons at Section 9 Lease, 24 tons at Milestone No. 1). The report expands on the upgrader information from the ABGMT report (AGS 1993).

2.4.6 United States Department of Energy

From 1994 to 1999, the United States Department of Energy (DOE) conducted an aerial radiological survey of abandoned uranium mines throughout the Navajo Nation. The Cameron area, where the Section 9 Lease site is located, was surveyed in 1997. Although the Site it not specifically addressed in the survey, it shows the Cameron area to have an average background gamma radiation level of 8.26 micro roentgens per hour (μr/hr), and a maximum level of 66.66 μr/hr (DOE 2001).

2.4.7 Arizona Department of Environmental Quality

In 2007, Arizona Department of Environmental Quality (ADEQ) conducted a uranium site discovery project in order to identify uranium contamination throughout Arizona which may warrant further investigation. One of the 28 mines identified during the project was the Section 9 Lease site. The mine was described as containing three small pits and low grade ore dumps, and a total production of 386 tons of uranium production from 1957 to 1962. It is also noted that there were no known wells or residents within one mile of the Site (ADEQ 2007).

2.4.8 United States Army Corps of Engineers and Environmental Protection Agency

In 2007 the United States Army Corps of Engineers (USACE) and EPA, with the assistance of the Navajo Nation Environmental Protection Agency (NNEPA) and the Navajo Abandoned Mine Land Reclamation Program (NAMLRP) issued an AUM Geographic Information System (GIS) Report compiling the findings from earlier investigations of the uranium mining operations throughout the Navajo Nation. Using information from the GIS Report, EPA contractors visited and screened the three mines at the Section 9 Lease site in 2010, collected gamma radiation measurements, and characterized general site conditions. The Site was found to have gamma radiation levels significantly above background, with maximum levels more the 50 times background. The Site did not appear to be reclaimed, and waste rock from mining activities was found at each mine. The foundation and several concrete walls leftover from the upgrader plant were found at the Site, including piles of the sand fraction waste. The Site was also located within a wetland area, on the western bank of the Little Colorado River. The contractor completed a site screen report, detailing the Site visit findings and historical information from the GIS Report, including maps showing the gamma radiation measurements (TGS 2007; WESTON 2011).

3.0 HRS FACTORS

3.1 Sources of Contamination

For HRS purposes, a source is defined as an area where a hazardous substance has been deposited, stored, disposed, or placed, plus those soils that have become contaminated from migration of a hazardous substance.

Potential hazardous substance sources associated with the Site include, but may not be limited to:

- Low-grade uranium waste rock left onsite during previous mining and processing activities is still present at the Site. The three individual mining areas at the Section 9 Lease site have not been adequately characterized, but the estimated area of the waste rock observed at the Site is approximately 332,669 square feet. Gamma radiation readings were measured at levels significantly above the background, with maximum levels more than 50 times the background (WESTON 2011).

3.2 Groundwater Pathway

In determining a score for the groundwater migration pathway, the HRS evaluates the: 1) likelihood that sources at a site actually have released, or potentially could release, hazardous substances to groundwater; 2) characteristics of the hazardous substances that are available for a release (i.e., toxicity, mobility, and quantity); and 3) people (targets) who actually have been, or potentially could be, impacted by the release. For the targets component of the evaluation, the HRS focuses on the number of people who regularly obtain their drinking water from wells that are located within four miles of the Site. The HRS emphasizes drinking water usage over other uses of groundwater (e.g., food crop irrigation and livestock watering) because, as a screening tool, it is designed to give the greatest weight to the most direct and extensively studied exposure routes.

3.2.1 Hydrogeological Setting

The Site lies in the Arizona Department of Water Resources (ADWR) Eastern Plateau Planning Area. The Eastern Plateau Planning Area is composed of one groundwater basin, the Little Colorado River Plateau Basin. There are several local aquifers and three regional aquifers that lie in the Eastern Plateau Planning Area. The aquifers consist of sedimentary formations of sandstone and limestone that are stacked on top of one another and are generally separated by impermeable shales and siltsones. In descending order, the regional aquifers are the D-, N-, and C- aquifers. Each aquifer has a large areal extent within the basin and with the exception of the D- and N- aquifers; there is little vertical hydrologic connection between them. The water bearing formations gain thickness towards the center of the basin resulting in artesian conditions. Main recharge areas are along the southern and eastern periphery of the Eastern Plateau Planning Area. The Little Colorado River Plateau aquifers contain an estimated 508 million acre-feet of water (USGS 1994; ADWR 2006).

3.2.2 Groundwater Targets

There are no known active drinking water wells within four miles of the Site. There are potentially three livestock wells within the four mile radius, ADWR well A-27-1006 ABC, approximately 2.5 miles northwest of the Site; ADWR well A-27-0911DDD, approximately 3.5 miles southwest of the Site; and Navajo Department of Water Resources (NDWR) well 3T-554, approximately 3.5 miles northwest of the Site. It is unknown if the livestock wells are still active (EPA 2012b; TGS 2007; Appendix C-2; Appendix C-3).

3.2.3 Groundwater Pathway Conclusions

There are no known active drinking water wells within four miles of the Site. There are potentially three livestock wells within four miles of the Site.

3.3 Surface Water Pathway

In determining the score for the surface water pathway, the HRS evaluates: 1) the likelihood that sources at a site actually have released, or potentially could release, hazardous substances to surface water (e.g., streams, rivers, lakes, and oceans); 2) the characteristics of the hazardous substances that are available for a release (i.e., toxicity, persistence, bioaccumulation potential, and quantity); and 3) the people or sensitive environments (targets) who actually have been, or potentially could be, impacted by the release. For the targets component of the evaluation, the HRS focuses on drinking water intakes, fisheries, and sensitive environments associated with surface water bodies within 15 miles downstream of the Site.

3.3.1 Hydrological Setting

Surface water flows eastwardly into the Little Colorado River, immediately adjacent to the Section 9 Lease site. Annual precipitation at the Site is approximately six inches (TGS 2007; WESTON 2011).

3.3.2 Surface Water Targets

There are no known drinking water intakes and there are no fisheries within the 15-mile target distance limit of the Site. Surface water samples have not been collected along the 15-mile target distance. Approximately 2,000 feet of Palustrine wetlands frontage are found within the Site. The wetlands found onsite also include piles of unreclaimed uranium waste rock. Gamma radiation readings were measured within the onsite wetlands at levels significantly above the background, with maximum levels more than 50 times the background. While the wetlands continue downstream alongside the Little Colorado River for more than 15 miles, many additional former uranium mining sites are found along the pathway which may serve as contributing sources to any contamination (TGS 2007; WESTON 2011).

3.3.3 Surface Water Pathway Conclusions

Uranium waste rock generated during mining activities, with gamma radiation measurement significantly greater than background was found throughout the Site. The Site is immediately adjacent to the Little Colorado River, and includes an area of known wetlands. An observed release is documented by direct observation for the Surface Water Pathway.

3.4 Soil Exposure Pathway

In determining the score for the soil exposure pathway, the HRS evaluates: 1) the likelihood that there is surficial contamination associated with the Site (e.g., contaminated soil that is not covered by pavement or at least two feet of clean soil); 2) the characteristics of the hazardous substances in the surficial contamination (i.e., toxicity and quantity); and 3) the people or sensitive environments (targets) who actually have been, or potentially could be, exposed to the contamination. For the targets component of the evaluation, the HRS focuses on populations that are regularly and currently present on or within 200 feet of surficial contamination. The four populations that receive the most weight are residents, students, daycare attendees, and terrestrial sensitive environments.

The potential source at the Section 9 Lease site is low-grade uranium waste rock left onsite during previous mining and processing activities. The three individual mines at the Section 9 Lease site have not been adequately characterized, but the estimated area of the waste rock observed at the Site is approximately 332,669 square feet. Gamma radiation readings were measured at levels significantly above the background, with maximum levels more than 50 times the background. Although the Site is no longer an active mine, and there are no known residents within one mile of the Site, livestock herders are known to frequent the area, and evidence of livestock grazing was found at the Site. The Site is currently accessible via dirt roads leading directly to the Site. Given the location of the Little Colorado River and the mining debris left onsite, there is a possibility for recreational use (WESTON 2011).

An observed release is documented by direct observation for the Soil Migration Pathway.

3.5 Air Migration Pathway

In determining the score for the air migration pathway, the HRS evaluates: 1) the likelihood that sources at a site actually have released, or potentially could release, hazardous substances to ambient outdoor air; 2) the characteristics of the hazardous substances that are available for a release (i.e., toxicity, mobility, and quantity); and 3) the people or sensitive environments (targets) who actually have been, or potentially could be, impacted by the release. For the targets component of the evaluation, the HRS focuses on regularly occupied residences, schools, and workplaces within four miles of the Site. Transient populations, such as customers and travelers passing through the area, are not counted.

The potential source at the Section 9 Lease site is low-grade uranium waste rock left onsite during previous mining and processing activities. Much of the mining waste is a fine-grained, sandy material. Gamma radiation readings were measured at levels significantly above the background, with maximum levels more than 50 times the background. Although the Site is no longer an active mine, livestock herders are known to frequent the area, and evidence of livestock grazing was found at the Site. There are no residents within one mile of the Site, but there may be as many as 33 residents within four miles of the Site (EPA 2012b; WESTON 2011).

A potential for particulate release is documented for the Air Migration Pathway.

4.0 EMERGENCY RESPONSE CONSIDERATIONS

The National Contingency Plan [40 CFR 300.15 (b)(2)] authorizes the EPA to consider emergency response action at those sites which pose an imminent threat to human health or the environment. For the following reasons, a referral to EPA Region 9's Emergency Response Section does not appear to be necessary:

- There are no schools, daycare centers, or regularly occupied residences, on site and within 200 feet of potentially contaminated areas.

5.0 SUMMARY

The Site is an abandoned uranium mine consisting of three separate mining areas within a single leased property, located approximately 10 miles southeast of Cameron, Coconino County, Arizona. The three mining areas constitute a total combined area of approximately 39 acres. The Site is located within Township 27 North, Range 10 East, Section 9, on land currently owned by Babbitt Ranches LLC, a livestock company based out of Flagstaff, Arizona. A portion of the southernmost mining area is located on land owned by the State of Arizona. The Site is immediately south of the Navajo Nation boundary, and immediately west of the Little Colorado River and Navajo Nation boundary (TGS 2007; Appendix C-3).

The Site was operational from 1957 to 1962, during mining operations the property was owned by the C. O. Bar Livestock Company. The Site area has reportedly been used for livestock cattle production by CO Bar and its parent company, Babbitt Ranches LLC, since 1886. The Site has also been identified under the names Upgrader Property, C.O. Bar Livestock Company, and Milestone No. 1 (AGS 1993; Appendix C-4).

In 1957 Rare Metals Corporation of America leased the Site from CO Bar, and began an open pit mining operation at the three separate locations. By 1958 Rare Metals ceased mining operations at the Site, and C.L. Rankin acquired the lease from the CO Bar. In 1959 Murchison Ventures, Inc. acquired the lease of the Site, and built a small processing plant known as a Benson Upgrader. The upgrader plant separated the waste rock from previous mining activities into a higher grade slime fraction and a lower grade sand fraction. The leftover sand tailings were left on the banks of the Little Colorado River, immediately east of the plant. Murchison Ventures sent a shipment of upgraded ore to the Tuba City Mill in 1959, under the name CO Bar Livestock Company Lease. In 1960 the plant was modified, and another shipment of ore was made. The company was reorganized in 1960 and renamed Milestone Hawaii, Inc. In 1961 the "promoter" of the operation, John Milton Addison, along with six associates, was convicted of fraud, conspiracy, and federal security violations as a result of the upgrading operation. In 1962 Milestone Hawaii made a shipment of previously discovered ore from the modified upgrader plant, and labeled the shipment origin as Milestone 1 (ABGMT 1981; AEC;

AGS 1993; NMGS 1958; SEC 1961, WLC 2012).

Mining operations ceased at the Site in 1962, no known mining activities have been performed at the Site since. While operational, the AEC estimated the uranium production volume at the Section 9 Lease Mine, which includes totals from all three mining areas, as 386 tons. The Site is currently used by Babbitt for livestock grazing (AGS 1993).

Unreclaimed mining-related uranium waste rock and mining debris are present throughout the Site. Remnants of upgrader plant, along with waste generated from the plant, are also present at the Site. The Site has not been adequately characterized, but it is estimated area of the waste rock observed at the Site is approximately 332,669 square feet. Gamma radiation readings collected in 2010 were measured at levels significantly above the background, with maximum levels more than 50 times the background (WESTON 2011).

The following pertinent Hazard Ranking System factors are associated with the Site:

- Uranium waste rock generated during mining historical activities at the Site, with gamma radiation measurements significantly greater than background, was found throughout the Site. Gamma radiation readings were measured at maximum levels of more than 50 times the background.

- Surface water from the Site flows into the Little Colorado River, located immediately east of the Site.

- There are Palustrine wetlands within the Site boundary.

- There are no active drinking water wells within four miles of the Site.

- There are no schools, daycare centers, or regularly occupied residences, on site and within 200 feet of potentially contaminated areas.

6.0 REFERENCES

ABGMT 1981 — Arizona Bureau of Geology and Mineral Technology, Radioactive Occurrences and Uranium Production in Arizona, By Robert B. Scarborough, March, 1981.

ADEQ 2007 — Arizona Department of Environmental Quality, Uranium Site Discovery Project, Phoenix, Arizona, September 12, 2007

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AEC — United States Atomic Energy Commission, The Uranium Deposits of Northern Arizona, By Willaim L. Chenoweth and Roger C. Malan, Grand Junction, Colorado.

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DOE 2001 — Department of Energy, An Aerial Radiological Survey or Abandoned Uranium Mines in The Navajo Nation, Bechtel Remote Sensing Laboratory, October 1994 to October 1999.

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EPA 2012c — EPA, Superfund Site Information, http://cfpub.epa.gov/supercpad/cursites/srchrslt.cfm?start=1&CFID=87629763&CFTOKEN=97782841&jsessionid=4e30f51f84c26ec8d8b513b1b235d44592e6, data extracted June 1, 2012.

NMGS 1958 — New Mexico Geological Society, Uranium Mineralization Near Cameron, Arizona, By E. M. Bollin and Paul F. Kerr, Columbia University, 1958.

NNEPA 1992a — Navajo Superfund Program, Yazzie No. 1 Mine, Preliminary Assessment, February, 1992

NNEPA 1992b	Navajo Superfund Program, Charles Huskon No. 26 Mine, Preliminary Assessment, February, 1992
SEC 1961	Securities and Exchange Commission, News Digest, Washington D.C., June 6, 1961.
TGS 2007	TerraSpectra Geomatics, Abandoned Uranium Mines And The Navajo Nation - Navajo Nation AUM Screening Assessment Report And Atlas With Geospatial Data, August 2007.
USGS 1994	United States Geological Survey, Geohydrology and Water Chemistry of Abandoned Uranium Mines and Radiochemistry of Spoil-Material Leachate, Monument Valley and Cameron Areas, Arizona and Utah, Water Resources Investigation Report, Tucson, Arizona, 1994.
WESTON 2011	Weston Solutions, Inc., Navajo Abandoned Uranium Mines Site Screen Report, Section 9 Lease AUM Site, January, 2011.
WLC 2012	William L. Chenoweth, Section 9 Lease Analysis and Field Notes, September 1, 2012

APPENDIX A:

Transmittal List

Appendix A
Transmittal List

Date: November 29, 2012
Site Name: Section 9 Lease
EPA ID No.: NNN000909110

A copy of the Preliminary Assessment Report for the Section 9 Lease site should be sent to the following recipients:

Eugene Esplain
Navajo Nation Environmental Protection Agency
Superfund Program
P.O. Box 2946
Window Rock, AZ 86515

Babbitt Ranches, LLC
P.O. Box 520
Flagstaff, AZ 86002

APPENDIX B:

Site Reconnaissance Interview and Observation Report/Photo Documentation

Appendix B
Site Reconnaissance Interview and Observations Report / Photo Documentation

SITE: Section 9 Lease
EPA ID NO.: NNN000909110

DATE: October 2010

OBSERVATIONS MADE BY: Alex Grubb, Weston Solutions, Inc. (WESTON)

A site visit was conducted as part of the ongoing United States Environmental Protection Agency (EPA) Abandoned Uranium Mine (AUM) screening project. The purpose of the screening was to ascertain the status and location of the identified AUM sites, and record all immediate site information associated with the mining activities

The site screening was conducted by WESTON in October, 2010. The following WESTON personnel were present: Ian Bruce, Tara Fitzgerald, Alex Grubb, Steve LaMothe, and Robert Schoenfelder. During the visit, gamma radiation readings were collected throughout the site using a combination sodium-iodide scintillation detector and a GPS unit. A stand-alone scintillation detector was used as well.

The Section 9 Lease site was comprised of three separating mining areas, located within a single leased section (Township 27 N, Range 10E, Section 9). The following information was obtained and photographs were taken during the site visit:

Observations - AUM 457

AUM 457 was the northern most of three Section 9 Lease mining areas. It is located immediately west of the Little Colorado River. The banks of the river flow through the eastern portion of the site. An easily accessible dirt road led into the western edge of the site. There were no residential structures located in the immediate vicinity of the AUM. The site is surrounded by uninhabited land to the north, south, and west. The AUM did not appear to be reclaimed.

A concrete foundation and two walls from a former structure were found in the center of the site, the foundation was spread out between two levels, covering an estimated area of 100 feet by 50 feet. Two of the walls were still partially intact. The lower wall had a height of approximately 30 feet. Two chutes are still visible leading between the levels. A smaller 20 foot by 20 foot concrete foundation was found approximately 300 feet south of the large foundation. Piles of a light colored sandy material were found at many locations surrounding the foundation.

A low lying area, likely a former pond, was found immediately north of the former structure.

Unreclaimed mining-related uranium waste rock is piled throughout the entire central part of AUM, primarily surrounding the concrete structure foundation, with a total estimated size of 1,000 feet by 250 feet. Other various pieces of metal and wood debris were found throughout the AUM.

A total of 6,717 gamma radiation measurements were collected from AUM 457, ranging from 11,616 counts per minute (cpm) to 999,960 cpm. The measurements collected throughout the concrete structure foundation area were found at levels ranging from approximately 50,000 cpm (bare cement foundation) to 1,000,000 cpm (sandy piles atop foundation), at the waste piles throughout the site at levels ranging from approximately 40,000 cpm to 1,000,000 cpm, and at the former pond area and downstream drainage at maximum levels of approximately 100,000 cpm.

The average background gamma radiation level for the AUM was 15,649 cpm, the average background for all three Section 9 Lease AUMs was 15,626 cpm.

Observations - AUM 458

AUM 458 was the central-most of three Section 9 Lease mining areas. It is located approximately 0.5 miles southwest of AUM 457, 750 feet northwest of AUM 459, and 0.25 miles west of the Little Colorado River. An easily accessible dirt road passes 500 feet north of the site. There were no residential structures located in the immediate vicinity of the AUM. The site is surrounded by uninhabited land in all directions. The AUM did not appear to be reclaimed.

Unreclaimed mining-related uranium waste rock constituted a majority of the AUM. A recessed pit/depression was found in the center of the waste rock area. Drilling parts and other mining related debris were spread throughout the AUM.

A total of 7,037 gamma radiation measurements were collected from AUM 458, ranging from 10,725 cpm to 968,863 cpm. The measurements collected along the edge of the waste rock area were found at a maximum level of approximately 150,000 cpm, in the center of the waste rock area at a maximum level of approximately 1,000,000 cpm, and at the possible pit area at a maximum level of approximately 300,000 cpm.

The average background gamma radiation level for the AUM was 15,455 cpm, the average background for all three Section 9 Lease AUMs was 15,626 cpm.

Observations - AUM 459

AUM 459 was the southern most of three Section 9 Lease mining areas. It is located approximately 1,000 feet west of the Little Colorado River. An easily accessible dirt road bisects the site. There were no residential structures located in the immediate vicinity of the AUM. The site is surrounded by uninhabited land in all directions. The AUM did not appear to be reclaimed.

Seven piles of unreclaimed mining- related uranium waste rock were found at the AUM. Two of the piles had an estimated size of six feet by four feet x 4' x 2.5’, one pile had an estimated size of 10 feet by eight feet, and four piles had an estimated diameter of 20 feet.

An open pit area, approximately 60 feet by 80 feet wide by 15 feet deep, with a vegetated sandy bottom was found at the AUM.

A total of 4,040 gamma radiation measurements were collected from AUM 459, ranging from 10,775 cpm to 879,666 cpm. The measurements collected from the waste rock area were found at maximum levels ranging from approximately 60,000 cpm to 875,000 cpm, in the pit area ranging from approximately 30,000 cpm at the top to approximately 100,000 cpm at the bottom.

The average background gamma radiation level for the AUM was 15,775 cpm, the average background for all three Section 9 Lease AUMs was 15,626 cpm.

Photos – AUM 457

Photo 1	Section 9 Lease, AUM 457 – Western Boundary

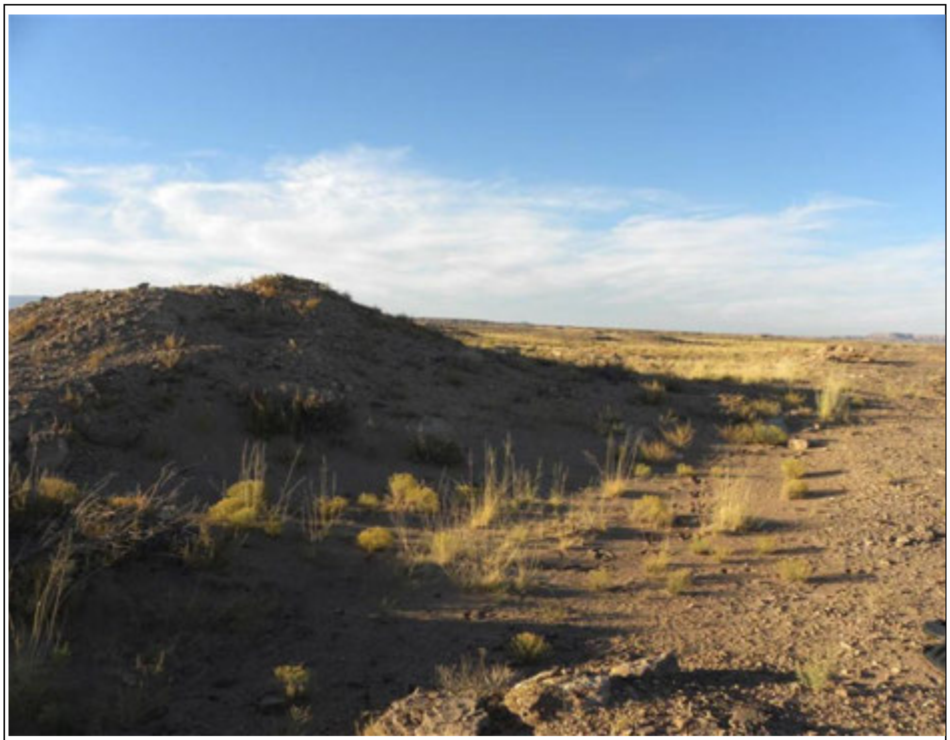

Photo 2	Section 9 Lease, AUM 457 – Waste Pile

Photo 3	Section 9 Lease, AUM 457 – Waste Piles

Photo 4	Section 9 Lease, AUM 457 – Concrete Foundation

Photo 5	Section 9 Lease, AUM 457 – Foundation Area

Photo 6	Section 9 Lease, AUM 457 - Foundation Area

Photo 7	Section 9 Lease, AUM 457 - Foundation Walls

Photo 8	Section 9 Lease, AUM 457 - Foundation Area Piles

Photo 9	Section 9 Lease, AUM 457 - Foundation Area

Photo 10	Section 9 Lease, AUM 457 - Foundation Area

Photo 11	Section 9 Lease, AUM 457 - Foundation Area

Photo 12	Section 9 Lease, AUM 457 - Foundation Area Pile

Photo 13	Section 9 Lease, AUM 457 - Foundation Area

Photo 14	Section 9 Lease, AUM 457 - Foundation Area

Photo 15	Section 9 Lease, AUM 457 - Chutes

Photo 16	Section 9 Lease, AUM 457 – Former Pond Area

Photo 17	Section 9 Lease, AUM 457 – Little Colorado River

Photo 18	Section 9 Lease, AUM 457 - Wetlands

Photo 19	Section 9 Lease, AUM 457 - Wetlands

Photo 20	Section 9 Lease, AUM 457 – Small Foundation

Photo 21	Section 9 Lease, AUM 457 - Debris

Photo 22	Section 9 Lease, AUM 457 - Debris

Photo 23	Section 9 Lease, AUM 457 - Debris

Photo 24	Section 9 Lease, AUM 457 – Western Access

Photos - AUM 458

Photo 25	Section 9 Lease, AUM 458

Photo 26	Section 9 Lease, AUM 458 - Waste Rock

Photo 27	Section 9 Lease, AUM 458 - Waste Rock

Photo 28	Section 9 Lease, AUM 458 - Waste Rock

Photo 29	Section 9 Lease, AUM 458 - Waste Rock

Photo 30	Section 9 Lease, AUM 458 - Waste Rock

Photo 31	Section 9 Lease, AUM 458 - Pit Area

Photo 32	Section 9 Lease, AUM 458 - Pit Area

Photo 33	Section 9 Lease, AUM 458 - Debris

Photos – AUM 457

Photo 34	Section 9 Lease, AUM 459 - Waste Piles

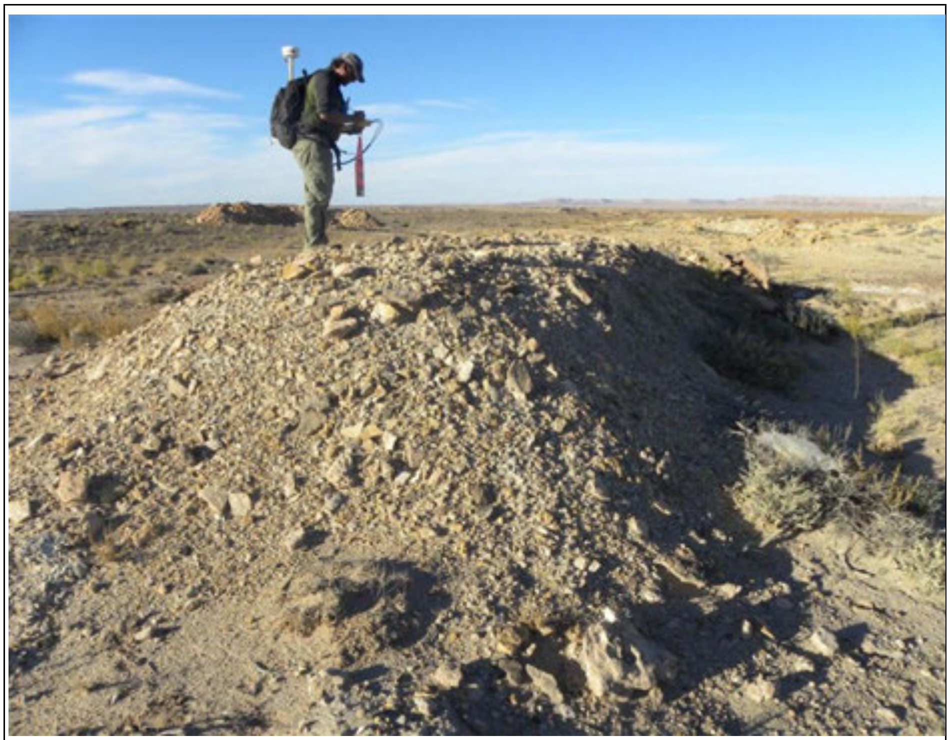

Photo 35	Section 9 Lease, AUM 459 - Waste Pile

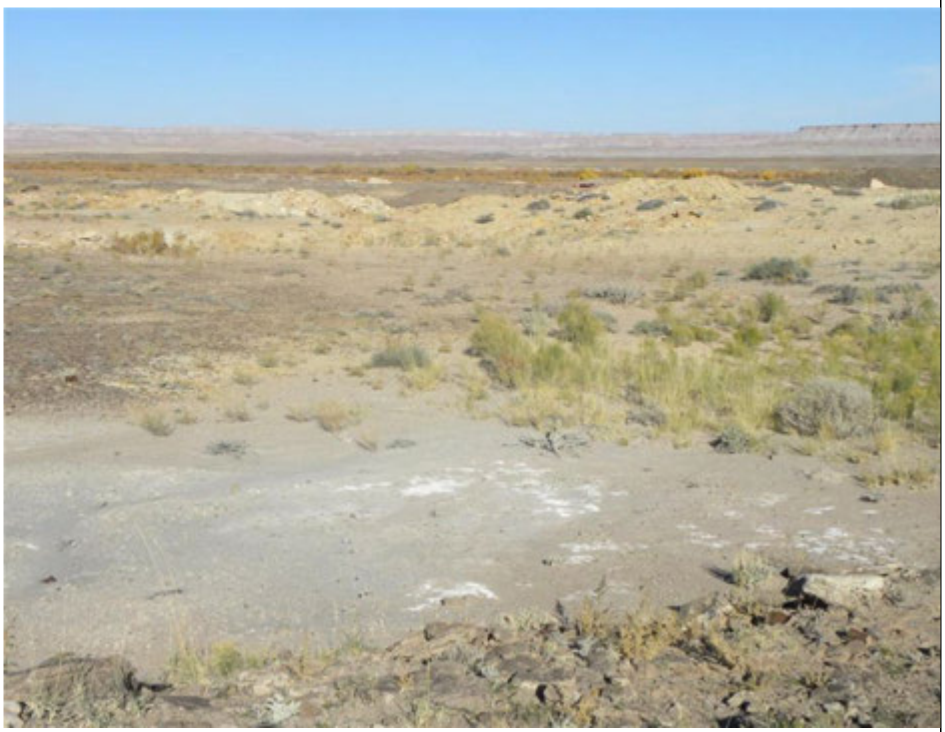

Photo 36	Section 9 Lease, AUM 459 - Pit Area

Photo 37	Section 9 Lease, AUM 459 - Waste Piles

Photo 38	Section 9 Lease, AUM 459

Photo 39	Section 9 Lease, AUM 459

APPENDIX C:

Contact Log and Contact Reports

Appendix C
Contact Log and Reports

SITE: Section 9 Lease
EPA ID NO.: NNN000909110

Name	Affiliation	Phone	Date	Information
Bruce Wilder	Arizona Department of Water Resources	(602) 771-8500	05/02/12	Contact Report 1
Bernie Williams	Navajo Department of Water Resources	(928) 729-4130	05/02/12	Contact Report 2
Christie Mazar	Coconino County Assessors Office	(928) 979-7962	05/09/12	Contact Report 3
Receptionist	Babbitt Ranches, LLC	(928) 774-6199	05/10/12	Contact Report 4

CONTACT REPORT 1

AGENCY/AFFILIATION: Arizona Department of Water Resources		
DEPARTMENT: Records		
ADDRESS/CITY: 3550 N. Central Avenue, Phoenix		
COUNTY/STATE/ZIP: Maricopa/Arizona/25012		
CONTACT(S)	TITLE	PHONE
Bruce Wilder	GIS Specialist	(602) 771-8500
WESTON EMPLOYEE: Alex Grubb		DATE: 05/02/2012
SUBJECT: Well Information		
SITE NAME: Section 9 Lease		CERCLIS ID NO.: NNN000909110

I contacted Arizona Department of Water Resources (ADWR) in order to determine if two livestock wells near the Site were still active, and if any additional information was available. The two wells were identified in both the Navajo Abandoned Uranium Mine Atlas (TGS, 1997) as well as the ADWR website. The well are identified as ADWR well A-27-1006 ABC, approximately 2.5 miles northwest of the Site; ADWR well A-27-0911DDD, approximately 3.5 miles southwest of the Site. Mr. Wilder was not able to provide any information further than what was found on the ADWR website.

The ADWR website identified the following information:

Well A-27-1006 ABC

- Drill Date: 8/1/1934
- Total Depth: 8 feet
- Water Level: 4 feet
- Diameter: 60 inches
- Water Level Date: 11/10/1966
- Use: Livestock

Well A-27-0911DDD

- Drill Date: 1/1/1966
- Total Depth: 12 feet
- Water Level: 4 feet
- Water Level Date: 5/10/1982
- Use: Livestock

CONTACT REPORT 2

AGENCY/AFFILIATION: Navajo Department of Water Resources		
DEPARTMENT: Water Code Administration		
ADDRESS/CITY: P.O. Box 678/Fort Defiance		
COUNTY/STATE/ZIP: Apache/Arizona/86504		
CONTACT(S)	TITLE	PHONE
Bernie Williams	Water Code Administrator	(928) 729-4130
WESTON EMPLOYEE: Alex Grubb		DATE: 05/02/2012
SUBJECT: Well Information		
SITE NAME: Section 9 Lease		CERCLIS ID NO.: NNN000909110

I contacted the Navajo Department of Water Resources (NDWR), Water Code Administration in order to determine if a livestock wells near the Site was still active, and if any additional information was available. The well was identified in the Navajo Abandoned Uranium Mine Atlas (TGS, 1997). The well was identified as NDWR well 3T-554. Mr. Williams was not able to provide any information further than what was found what was found in the Atlas.

CONTACT REPORT 3

AGENCY/AFFILIATION: Coconino County		
DEPARTMENT: Assessors Office		
ADDRESS/CITY: 110 Cherry Avenue/Flagstaff		
COUNTY/STATE/ZIP: Coconino/Arizona/86001		
CONTACT(S)	TITLE	PHONE
Christie Mazar	Assessor	(928) 979-7962
WESTON EMPLOYEE: Alex Grubb		DATE: 05/09/2012
SUBJECT: Ownership Information		
SITE NAME: Section 9 Lease		CERCLIS ID NO.: NNN000909110

I contacted the Coconino County Assessors Office in order to gather ownership information. Ms. Christie was able to access the ownership records given the township, range, and section. The owner of the site was identified as Babbitt Ranches, LLC, and the assessors parcel number was identified as 30215013.

CONTACT REPORT 4

AGENCY/AFFILIATION: Babbitt Ranches, LLC		
DEPARTMENT: N/A		
ADDRESS/CITY: P.O. Box 520/Flagstaff		
COUNTY/STATE/ZIP: Coconino/Arizona/86002		
CONTACT(S)	TITLE	PHONE
Receptionist	Receptionist	(928) 774-6199
WESTON EMPLOYEE: Alex Grubb		DATE: 05/10/2012
SUBJECT: Ownership Information		
SITE NAME: Section 9 Lease		CERCLIS ID NO.: NNN000909110

I contacted Babbitt Ranches, LLC, the current owner of the property in order gather more historical ownership information. During the time of mining, the owner was identified as C.O. Bar Livestock Company, and the Coconino County Assessors Offices identified the current owner as Babbitt Ranches, LLC, out of Flagstaff, Arizona. The receptionist at the Babbitt office noted that C.O. Bar Livestock Company is owned by Babbitt, and the Site property has been used by the company to for cattle grazing since approximately 1886. No other historical owners of the property were identified.

APPENDIX D:

Latitude and Longitude Calculations Worksheet

Latitude and Longitude Calculation Worksheet (7.5' quads)
Using an Engineer s Scale (1/50)

Site Name Section 9 Lease **CERCLIS #** N N N 0 0 0 9 0 9 1 1 0

AKA Milestone 1, CO Bar Livestock Company, Upgrader Property

Address N/A

City Cameron **State** A Z **ZIP**

Site Reference Point Site is approximately 10 miles southeast of Cameron, AZ, Township 27 North, Range 10 East, Section 9

USGS Quad Name **Scale**

Township **Range** **Section** 3 3 3

Map Datum ☐ **1927** ☐ **1983** **(Check one)** **Meridian**

Map coordinates at southeast corner of 7.5' quadrangle (attach photocopy)

Latitude ° ' N" **Longitude** ° ' W"

Map coordinates at southeast corner of 2.5' grid cell

Latitude ° ' N" **Longitude** ° ' W"

C a l c u l a t i o n s

LATITUDE(x)

A) Number of ruler graduations between 2.5' (150") grid lines **(a)**

B) Number of ruler graduations between south grid line and the site reference point **(b)**

C) Therefore, a/150 = b/x, where **x= Latitude in decimal seconds, north of the south grid line**

Expressed as minutes and seconds (1' = 60") = ° ' N"

Add to grid cell latitude = ° ' N" + ° ' N"

Site latitude = 3 5 ° 4 4 ' 2 1 N"

LONGITUDE(y)

A) Number of ruler graduations between 2.5' (150") grid lines **(a)**

B) Number of ruler graduations between south grid line and the site reference point **(b)**

C) Therefore, a/150 = b/x, where **x= Longitude in decimal seconds, west of the east grid line**

Expressed as minutes and seconds (1" = 60") = E > AW

Add to grid cell longitude = ° ' N" ° ' N"

Site longitude = 1 1 1 ° 1 9 ' 2 5 W"

APPENDIX E:

References

ABGMT 1981

Arizona Bureau of Geology and Mineral Technology, Radioactive Occurrences and Uranium Production in Arizona, By Robert B. Scarborough, March, 1981.

issued as DOE open-file
report GJBX-143(81)

RADIOACTIVE OCCURRENCES
AND
URANIUM PRODUCTION
IN
ARIZONA

FINAL REPORT

Robert B. Scarborough

Arizona Bureau of Geology
and
Mineral Technology
Geological Survey Branch
Tucson, Arizona

March 1981

STATE OF ARIZONA
BUREAU OF GEOLOGY
AND MINERAL TECHNOGY
OPEN-FILE REPORT

81-1

Yazzie 312
pg. 164

Prepared for the U.S. Department of Energy
Grand Junction Office, Colorado
Under Bendix Field Engineering Corporation
Subcontract No. 79-374E

This report is a result of work performed by the Arizona Bureau of Geology and Mineral Technology, through a Bendix Field Engineering Corporation Subcontract, as part of the National Uranium Resource Evaluation. NURE is a program of the U.S. Department of Energy's Grand Junction, Colorado, Office to acquire and compile geologic and other information with which to assess the magnitude and distribution of uranium resources and to determine areas favorable for the occurrence of uranium in the United States.

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CONTENTS (continued)

CONTENTS (continued)

ILLUSTRATIONS

CONTENTS (continued)

Tables

ABSTRACT

Nine hundred and sixty-five natural radioactive occurrences of uranium, some containing thorium, are known for Arizona. Of these, 328 localities were the source of 18.1 million pounds of U_3O_8 between 1948 and 1970. About 43 million pounds of V_2O_5 were present in the uranium ores. Ninety-nine percent of Arizona's total production is from the Triassic-Jurassic sedimentary rocks of the Colorado Plateau, approximately half of which came from the Salt Wash Member of the Morrison Formation in the Carrizo and Lukachukai Mountains. Historically, only a small amount of uranium has been produced from the Basin and Range Province. However, recent exploration has shown significant uranium potential in late Tertiary sediments in this region.

Arizona's largest single uranium deposit has been at the Monument No. 2 Mine of Apache County. There, about 5.2 million pounds of U_3O_8 and nearly eleven million pounds of V_2O_5 were produced from a single channel deposit in the Shinarump Member of the Triassic Chinle Formation.

Eighteen major groupings of uranium occurrences are recognized in Arizona for the purposes of classifications; eleven on the Colorado Plateau portion of the State, and seven more in the Basin and Range-Transition Zone portion. These are summarized as follows:

Colorado Plateau:

1. Pennsylvanian-Permian Naco and Supai Formations
2. Permian Kaibab Limestone
** 3. Jurassic Morrison Fm., Salt Wash Member
** 4. Triassic Chinle Fm.
5. Triassic Moenkopi Fm., basal portion
* 6. Jurassic Kayenta Fm.
* 7. Jurassic Navajo Ss.
* 8. Cretaceous Toreva Fm., of the Mesaverde Group
9. Cretaceous Dakota Fm.
** 10. Plateau breccia pipes
* 11. Pliocene Hopi Buttes, fine-grained clastics and tuffs

Southern Arizona:

** 12. Precambrian Dripping Spring Quartzite
* 13. Cretaceous sandstone
* 14. Oligocene, Miocene, Pliocene, fine-grained clastics
15. Mid-Tertiary volcanic rocks
* 16. Jurassic-Cretaceous volcanics, southernmost Arizona
** 17. Laramide porphyry copper deposits
* 18. Vein/pegmatite/granite occurrences, usually involving Precambrian crystalline terrain

**past or current major source in Arizona
*past or current minor source in Arizona

INTRODUCTION

Purpose and Scope

This report describes all known naturally anomalous radioactive occurrences in Arizona. Any locality where uranium mineralization was reported or radioactivity is two times or greater than background is considered anomalous. The major emphasis is placed on descriptions of geology, location, mineralogy, and radioactivity; less emphasis is placed on the history and detailed development of these occurrences.

Many uranium occurrences are concentrated in groups or districts, indicating a possible common genesis within the district. The first part of the report discusses sequentially each of these occurrence types, touching upon aspects of the relevant geology, and gives one or more examples of past uranium sources considered diagnostic of each type of occurrence.

The second part of the report lists in an abbreviated format the details of what is known about each of the 965 radioactive occurrences in the State.

All known data on pre-1971 uranium production is summarized and included. Post-1970 production data is not publicly available, but nevertheless is insignificant as compared to the pounds of U_3O_8 produced from Arizona before 1971. All production data to January 1, 1971, was compiled from official ore receipts (except for Monument Valley area) and supplemented by other Department of Energy (DOE) data.

Radioactive occurrences are listed alphabetically, county by county, and alphabetically within each county. The locations of occurrences, if known to within a section, are plotted on NTMS (1^ox 2^o) quadrangle maps. Four district maps for the Carrizo Mountains, Lukachukai Mountains, Cameron Area and Sierra Ancha Mountains, show the location of occurrences too numerous and concentrated to be plotted on the NTMS maps. Poorly located occurrences are not plotted but general description directions to these localities are provided.

The authors and/or the Arizona Bureau of Geology will appreciate receiving any additions or corrections to the data presented herein. Any information acquired after the publication of this report will be on file along with the data and reports from which this report is derived, at the Geological Survey Branch, Arizona Bureau of Geology, and available for public inspection. These files include details of past production and geology not found in this report.

Previous Work and Sources of Information

Most uranium mineral occurrences were prospected in the late 1940s and 1950s. During this time the Raw Materials Division of the U.S. Atomic Energy Commission identified many of the occurrences and monitored production from the active mines. Reconnaissance work by the A.E.C. and USGS geologists was documented in their brief preliminary reconnaissance reports (PRR). AEC and USGS geologists and others also compiled more detailed data on selected Arizona uranium occurrences and districts. These reports include those with the following prefixes: TM's, RME's, RMO's, TEI's, and TEM's listed with the references.

More recent information is being accumulated by the U.S. Department of Energy (DOE) National Uranium Resource Evaluation (NURE) program. These reports (GJBX prefix) on aerial gamma ray and magnetic reconnaissance, hydrogeochemical and stream sediment analyses, special study areas and NTMS quadrangle evaluations are becoming available to the public as they are open-filed. The DOE has also open-filed many of the old AEC reports and preliminary maps of the Carrizo Mountains, Lukachukai Mountains and Cameron uranium mining districts. Published and unpublished open-file reports and declassified data files at the Grand Junction Office (Colorado) of DOE were examined for this report. See Table 1 for new NURE Arizona reports.

In 1970, Stanton Keith reported on 408 Arizona uranium occurrences in Arizona Bureau of Mines Bulletin 182 by Peirce and others. The Arizona Bureau of Geology and Mineral Technology (formerly Arizona Bureau of Mines) in cooperation with DOE has undertaken this new evaluation of uranium occurrences because significant additional information is now publicly available from formerly classified data and through the NURE Program. Arizona uranium occurrences are also summarized in Arizona Bureau of Geology Reports by Peirce and others (1977), and Scarborough and Wilt (1979) a commercial report by Waechter (1979), plus USGS open-file report on the Hopi Buttes Uranium Occurrences, scheduled for publication in 1981.

For this report, we depended heavily on the PRR's, open-file reports and maps, DOE data files, pre-1971 production records, and Arizona Bureau of Geology data files. Information was also obtained from individual mining companies, and both USGS and NURE geologists. Reconnaissance field trips to the Sierra Ancha Mountains, Lukachukai Mountains, Carrizo Mountains, Fredonia region, Cameron area, Grand Canyon, Date Creek Basin, New River area, San Pedro Valley, Whetstone Mountains, Santa Catalina Mountains, Safford area, Ruby-Arivaca area and Santa Rita Mountains helped to up-date information on many occurrences.

Acknowledgments

The gracious help of many people is acknowledged for the preparation of this report. Primarily, the assistance of Mr. William L. Chenoweth, DOE, Grand Junction was of fundamental importance in gathering together of all DOE data. Mr. Chenoweth was the DOE monitor for this project. Peter Kresan assisted in field work and laborious data compilation.

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Key to Individual County Listings

Descriptions of all radioactive mineral occurrences in Arizona are listed alphabetically by geographic location and by county. A state-wide alphabetical listing is provided in the index. Aliases for the occurrence names are included in both county descriptions and index.

The descriptions of occurrences in this report are brief summaries of available pertinent data. Obviously, not all data could be included. For some occurrences the information is very limited or held confidential by companies. See also page 103 for instructions on use of the individual listings.

The descriptions contain the following information:

1) Name

Name of occurrence, associated claims, and aliases. A name in parenthesis indicates that is the name under which the information for that property is listed.

2) Location

Location as Section, Township and Range or as latitude and longitude for unsurveyed areas. If there was any question concerning the location of an occurrence within the section or if the occurrence location was defined by U.S. Bureau of Land Management protracted Township and Range, the word approximate (Approx.) precedes the given location. Geographic location, i.e. mountain range, is also provided. Descriptive directions are taken from the PRR's for poorly located occurrences. Locations were field checked when possible. PRR locations were not always correct. Every effort was made to provide accurate locations to within a section. The NTMS and district maps show the distribution of most occurrences. Poorly located occurrences are not plotted.

3) Quadrangle

The names of the appropriate 7½' and/or 15' USGS topographic and $1^{\circ} \times 2^{\circ}$ (NTMS) maps are provided.

4) Development

A short description of the type and extent of prospecting and mining at the site.

5) Production

Tons and grade of ore are from official ore receipts. Tons are calculated on moisture-free basis, and uranium-vanadium contents are based on assays before mill processing.

6) Radioactivity

The maximum radioactivity at the site is expressed as times background. All sites with radioactivity 2X or greater than background are listed.

7) Analyses

The sample analyses represent a summary of the radiometric and chemical assays provided in the various reports. When radiometric and chemical assays are given for the same sample, they are listed together on the same line, with the letter "e" preceding the U_3O_8, indicating that the value was determined radiometrically. No "e" indicates a chemical assay. Disequilibrium between uranium and its radioactive daughter products is indicated by a discrepancy between radiometric and chemical assays.

8) Geology

This is a brief summary of the host rock, mineralogy, stratigraphy, alteration, and structure. Not all information could be provided for some occurrences.

9) References

A short citation format is used for the sources of information in the individual listings. Full reference citations are provided in the listing of references. Two numbers may accompany referenced PRR's. The first is the file number recorded on the PRR when it was made. The second, in parenthesis, is a hand-posted number used by the Bendix library at Grand Junction, sequenced county by county.

10) Mine Maps and Geologic Cross Section

Mine maps and geologic cross sections are provided for some occurrences and are located in the general discussion sections occupying the first part of the report.

Table I

NURE REPORTS COVERING ARIZONA

2^o Quad	HSSR*	Early Air	Air*	Other*
Shiprock	143(80)		116(79)	
Marble Canyon	--		16(80)	
Grand Canyon	142(80)		35(80)	
Las Vegas	123(78)		59(79)	
Gallup	186(80)		116(79)	
Flagstaff	--		157(79)	
Williams	71(79)		59(79)	
Kingman	122(78)		59(79)	44(76)[1]
St. Johns	191(80)		126(79)	69(78)[2]
Holbrook	--		--	--
Prescott	122(79)		59(79)	72(79)[3]
Needles	--		114(79)	86(80)[4] 164(80)[5]
Clifton	69(78)	GJO-1643	23(79)	
Mesa	81(80)	GJO-1643	23(79)	
Phoenix	--		12(80)	
Salton Sea	113(80)		12(80)	
Silver City	69(78)	GJO-1643	23(79)	
Tucson	--	GJO-1643	23(79)	
Ajo	--		12(80)	
El Centro	--		12(80)	
Douglas	69(78)	GJO-1643	23(79)	
Nogales	--	GJO-1643	23(79)	102(79)[6]
Lukeville	--		12(80)	102(79)[6]

*GJBX prefix

[1]HSSR Roach Lake (in Nevada)

[2]HSSR portions of Douglas, Silver City, St. Johns, Clifton

[3]Artillery Peak HSSR; 164(80)

[4]Date Creek Drilling

[5]HSSR Date Creek Basin

[6]Papago Indian Reservation HSSR

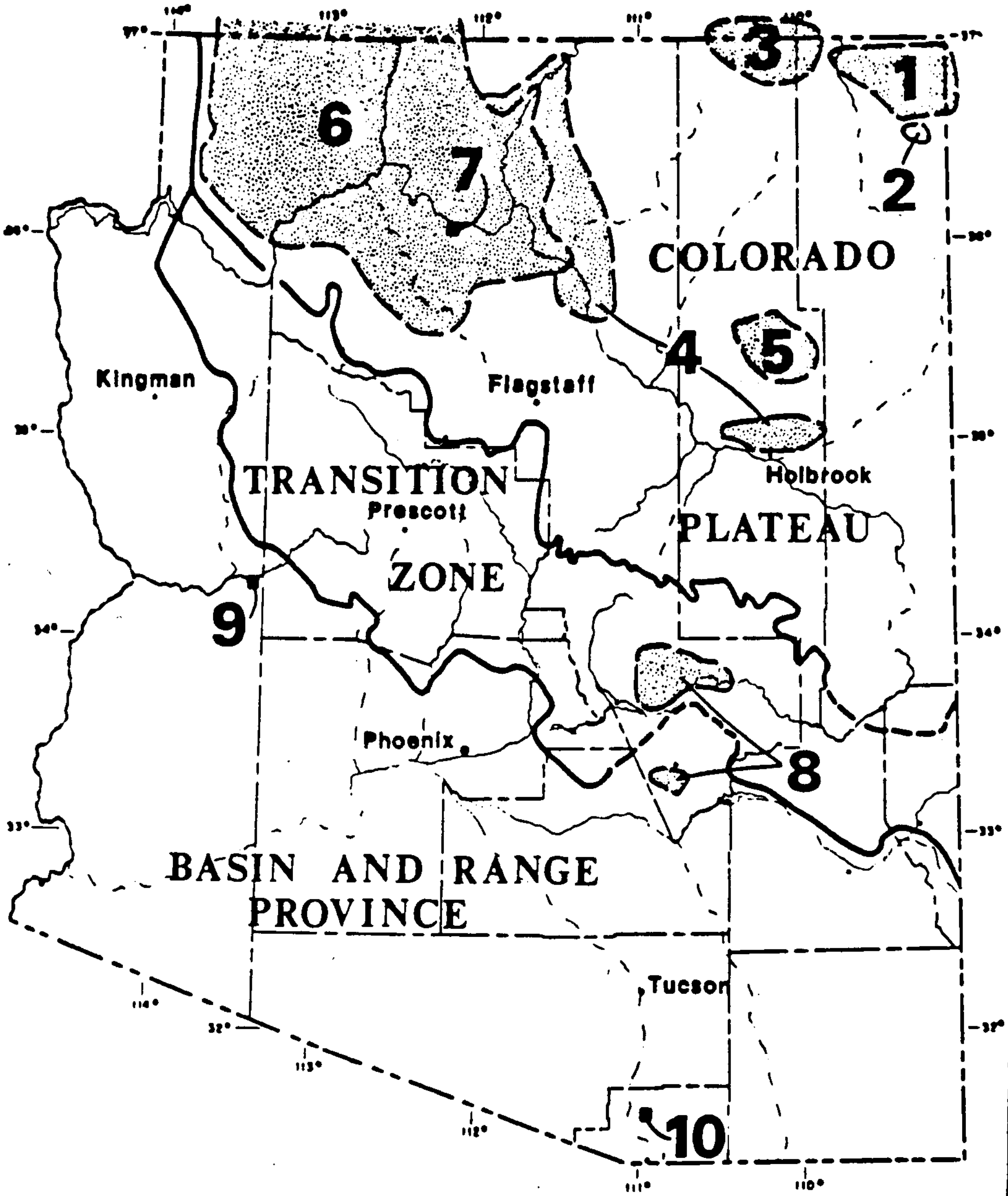
URANIUM OCCURRENCES IN ARIZONA

The first part of this report presents general discussions of the major uranium producing districts and environments in Arizona. For the sake of organization, the discussions are divided into two sequences, the Colorado Plateau, and Southern Arizona (in that order), based upon the physiographic division of the State adopted in Figure 1. Southern Arizona here is taken to be the totality of the Basin and Range Province and the Transition Zone Province. This two-part breakdown of uranium occurrences in the State follows logically from the very different geology and types of uranium host rocks found in the two regions. The Colorado Plateau occurrences are divided between Mesozoic-aged stratabound deposits and breccia pipe deposits. Southern Arizona occurrences also consist of some stratabound deposits in Cenozoic, Cretaceous, and Precambrian sedimentary host rocks, but in addition include vein-type and crystalline host rock types. Figure 1 also illustrates the districts with significant past uranium production. Notes concerning thorium occurrences in Arizona are given after the uranium discussions.

The Colorado Plateau portion of Arizona consists of a relatively complete and continuous flat-lying sequence of Paleozoic and Mesozoic cratonic sediments, rather gently deformed by a series of folds and monoclines. In contrast, the Basin and Range portion of the State consists of an extremely fragmented, faulted record of Proterozoic basement rocks overlain by locally preserved Paleozoic, Mesozoic, and Cenozoic sedimentary and volcanic rocks. This sequence is chopped up along a series of late Cenozoic-aged, quasi-parallel NW-SE trending faults which have in effect created discontinuous elongate mountain ranges and adjacent broad wide valleys that represent horst and graben blocks. Intense orogenies during Mesozoic and Cenozoic times, culminating with the Basin and Range disturbance described above, have served to fragment Basin and Range geology into a very incompletely understood record.

The physiographic province called the Transition Zone is a long narrow region that displays certain structural and stratigraphic properties of each of the two adjacent provinces.

Figure 1A illustrates a simplified State-wide stratigraphic correlation chart. It includes approximate stratigraphic positions for the most prominent uranium deposits and occurrences in the State.



Colorado Plateau Province

1. Carrizo Mountains
2. Lukachukai Mountains
3. Monument Valley
4. Cameron region
5. Hopi Buttes volcanic field
6. Plateau breccia pipes
7. Orphan Lode

Southern Arizona

8. Dripping Spring Quartzite
9. Anderson Mine
10. Duranium Mine

PHYSIOGRAPHIC PROVINCES AND MAJOR URANIUM DISTRICTS IN ARIZONA

Figure I

[The stratigraphic nomenclature and age designations used in this chart do not necessarily follow the usage of the U.S. Geological Survey, but follow the usage of authors who have described the several parts of the State. Terms in italics refer to informal rock stratigraphic units. Rock units known only in subsurface marked by asterisk (*). Arrows indicate known or possible wide range in age of named unit or that unit may be younger or older than indicated by position on chart.]

Geologic time units		Southeast (Includes Mexican Highland section)	Southwest (Includes Sonoran Desert section)	Central (Includes Tonto and Flagstaff sections)	Northwest (Includes Grand Canyon and Mohave sections)	Northeast (Includes Navajo section)
Cenozoic	Quaternary	*Alluvial deposits, basalt* *	*Alluvial deposits, basalt*	*Alluvial deposits, basalt* *	*Alluvial deposits, basalt*	*Alluvial deposits, basalt*
Cenozoic, Tertiary	Pliocene	Gila Conglomerate	*Basin fill deposits*	Verde Formation, Gila Group Hickey Formation	Muddy Creek Formation *	Bidahochi Formation *
Cenozoic, Tertiary	Miocene					
Cenozoic, Tertiary	Oligocene	*Volcanics* Whitetail Cgl.--Pantano Fm. *	*Volcanics* Helmet Fgl.--Locomotive Fgl. *	*Volcanics* * *	*Local volcanics and sediments* *	Chuska Sandstone
Cenozoic, Tertiary	Eocene					
Cenozoic, Tertiary	Paleocene	*Andesites and rhyolite*	*Andesites and rhyolite*	*Andesites*	*Andesites* *	
Mesozoic	Cretaceous	*Local sedimentary formations* * Pinkard Formation (north) Bisbee Group (south) * *Local volcanics (south)*	*Locally named sedimentary, volcanic, and metamorphic rocks of poorly understood or unknown age relations*	*Local sedimentary rocks*		Mesaverde Group * Mancos Shale Dakota Sandstone
Mesozoic	Jurassic	*Local volcanics* *			breccia pipes * Carmel Formation Navajo Sandstone	Morrison Fm. Bluff Sandstone } Cow Springs Ss. * Summerville Fm. Todilto Limestone Entrada Sandstone Carmel Formation Navajo Sandstone *
Mesozoic	Triassic	*Local red beds* *Local volcanics*			Kayenta Formation Moenave Formation Chinle Formation * Moenkopi Formation	Kayenta Formation * Moenave Formation Wingate Sandstone Chinle Formation * Moenkopi Formation
Paleozoic	Permian	Rainvalley Formation Concha Limestone Scherrer Formation Epitaph Dolomite Colina Limestone Earp Formation	Concha Limestone Scherrer Formation Epitaph Dolomite Colina Limestone Earp Formation	Kaibab Limestone Coconino Sandstone Supai Formation *	Kaibab Limestone * Toroweap Formation Coconino Sandstone Hermit Shale Supai Formation	De Chelly Ss. Supai Fm. Cutler Fm.
Paleozoic, Carboniferous	Pennsylvanian	Horquilla Limestone Black Prince Limestone (local)	Horquilla Limestone	Naco Formation	Callville Limestone	Rico Fm.* Hermosa Fm.* Molas Fm.*
Paleozoic, Carboniferous	Mississippian	Paradise Formation (east) Escabrosa Limestone	Escabrosa Limestone	Escabrosa Ls. or Redwall Ls.	Redwall Limestone	Redwall Ls.*
Paleozoic	Devonian	Martin Formation	Martin Formation	Martin Formation	Temple Butte Limestone or Martin Formation	Ouray Ls.* Elbert Fm.*
Paleozoic	Silurian					
Paleozoic	Ordovician	El Paso Limestone (east)			*Unnamed dolomite*	
Paleozoic	Cambrian	Abrigo Formation Bolsa Quartzite	Abrigo Formation Bolsa Quartzite	Tapeats Sandstone	Muav Limestone Bright Angel Shale Tapeats Sandstone	Tapeats(?) Ss.*
Precambrian	Late Precambrian	Troy Quartzite Apache Group *	Apache Group	Troy Quartzite Apache Group { Basalt, Mescal Limestone, Dripping Spring Qzt., Pioneer Shale } *	Chuar Group Unkar Group { Nankoweap Formation, Rama Formation, Dox Sandstone, Shinumo Quartzite, Hakatai Shale, Bass Limestone, Hotauta Cgl. }	
Precambrian	Early Precambrian	Pinal Schist *	*Metamorphic rocks*	Mazatzal Quartzite * Yavapai Series { Alder Group, Ash Creek Group }	Brahma Schist * Vishnu Schist	*Metamorphic rocks*

from Arizona Bureau of Mines Bulletin 180, (1969), p. 40-41.

* major producers for a region

* major occurrences, some with minor production

Figure 1A. Simplified stratigraphic correlation chart for Arizona. Included are approximate stratigraphic positions of important uranium deposits and occurrences.

COLORADO PLATEAU REGION

MORRISON FORMATION

In the Four Corners area the Morrison Formation of Upper Jurassic age is a regionally dominant source of uranium, with production from Utah, Colorado, and New Mexico far outweighing that of northeastern Arizona. The lowest member, the Salt Wash, is the sole source of Morrison ore in Arizona, while stratigraphically higher members, the Recapture, Westwater Canyon, and Brushy Basin, contain ores in the adjacent states. As well, these upper members contain volcanogenic beds which are hypothesized by some as uranium source beds.

For descriptions of Morrison Formation geology, see Mullens and Freeman (1957), Chenoweth and Malan (1975), and Galloway (1979). For uranium-related geology, refer to Masters (1955), Chenoweth (1955 and 1967), Stokes (1954), Wright (1955), and Dare (1961). For district maps, see DOE (ERDA) Preliminary Map No. 23.

Salt Wash Member ores in Apache County, Arizona supplied 815,100 tons of ore which contained 0.236% U_3O_8 (3,850,000 lbs) and 1.098% V_2O_5 (17,900,000 lbs) between 1948 and 1968. In addition, minor uranium was recovered from mill tailings from early Carrizo vanadium mine workings operated during 1942-1944. Total production from Salt Wash ores may be divided between the Lukachukai Mountains (724,800 tons of ore @ 0.24% U_3O_8 and 1.02% V_2O_5 in 1950-1968 from 53 properties) and the Carrizo Mountains to the north (90,300 tons of ore @ 0.20% U_3O_8 and 1.75% V_2O_5 in 1948-1966 from 71 properties.)

Radioactive ores in the Salt Wash Member of the eastern Carrizos were first mined in about 1920 and sent to Colorado for extraction of radium content. During 1942-1944 Salt Wash ores were mined in the Carrizos by the Vanadium Corporation of America and Wade, Curran and Company for vanadium and mining for uranium in these same deposits began in 1948. Mining continued in the Carrizos and Lukachukais until 1968. See Dare (1966) and Chenoweth (1980 a and b) for historical development of mining in the Carrizos and Lukachukais.

Studies of the Salt Wash Member by Craig and others (1951), Mullens and Freeman (1957), Masters (1955), and Peterson (1977) in Utah, Colorado, Arizona, and New Mexico indicate that these sediments were deposited by a proximal aggrading braided stream system on a massive alluvial fan and a more distal delta distributary system, the upstream apex of which was near what is today Lee's Ferry on the Colorado River. See Figure 2 for the fan geometry. Distributary channels in eastern Utah flowed generally northeasterly, while those in northeast Arizona and northwest New Mexico flowed easterly. In detail, the Salt Wash Member of northeast Arizona and northwest New Mexico is considered a separate eastern lobe of the main Salt Wash fan system of Utah and Colorado. The Lukachukais are near the thickest part of this lobe (Mullens and Freeman, 1957, Figure 4). Similarly, the Grants mineral belt is on the most southerly lobe of the Westwater Canyon fan system whose apex is somewhat south of Window Rock, Arizona (Galloway, 1979, Figure 2).

In northeast Arizona the Salt Wash beds, resting on a scoured surface cut on predominantly eolian Jurassic Bluff Sandstone (Figure 3), range in thickness from 100-180 feet. They are overlain by about 400 feet of Recapture Member fluviatile beds. All Mesozoic units in northeast Arizona as young as Cretaceous Dakota Sandstone are involved in folding (see the district maps of this report) and are beveled and overlain by the non-folded Eocene (?) Chuska Sandstone of the Chuska and Lukachukai Mountains. The Salt Wash Member in Northeast Arizona consists mainly of lenticular, gently cross-bedded sandstones, with minor pebbly sandstones, mudstones and claystones as discontinuous partings between the sandstone beds. The units weather to resistant ledges and cliffs, and cap broad benches and mesas. Most beds are between 6 and 30 feet thick. Fossil logs are common, and fragmental carbonized plant debris forms seams along bedding planes, and finer fragmental material is disseminated through the sandstones.

Only sparce uranium-vanadium occurrences are known in northeastern Arizona in units directly above or below Salt Wash outcrops. In the Lukachukai Mountains, several sub-ore grade uranium occurrences are known from the overlying Recapture Member fluvial beds (Chenoweth, 1967, p. 82). And in the underlying Bluff Sandstone, Chenoweth and Fergusson (PRR ED:R-263, 1954) describe an interesting vanadium occurrence which lacks appreciable uranium. In a reentrant near the crest of the Rattlesnake anticline, a short distance east of the Sweetwater T.P. road, vanadium staining is found 10 feet above the base of the Bluff Ss in a horizonal showing, with darkest coloration following individual cross-bed laminations. Uranium assays are negative. Clearly, vanadium has migrated without attendant uranium.

Lukachukai Mountains

In the Lukachukai Mountains, uranium ore is most common in trough cross-stratified sandstone that fills scours and channels in under-lying mudstones. The ore bodies are elongate and lenticular, consisting of one or more pods surrounded and separated by protore. Ore trends parallel paleostream directions, but often trend along a locally prominent joint set, suggesting some remobilization of uranium minerals (Stokes 1954; Nestler and Chenoweth, 1958; Chenoweth, 1967; Chenoweth and Malan, 1975).

Ore bodies occur some 30-80 feet above the base of the Salt Wash Member. All of the significant deposits (99.6% of total Lukachukai production) are located in a well-defined belt which trends nearly north-south across the southeast end of the mountains (Chenoweth and Malan, 1975). They lie on the shallow-dipping southwest limb of the Chuska syncline and are confined to a favorable interbedded sandstone-mudstone facies of the Salt Wash (see enclosed Lukachukai district map).

Tyuyamunite, the most common uranium-vanadium mineral, is irregularly disseminated through sandstone beds, and is concentrated in lenses, or distributed in bands. It fills sandstone voids, coats sand grains, and replaces calcite and carbon. Some uraninite replaces carbonaceous matter and fills sandstone voids in some incompletely oxidized ore bodies. Hence, a question arises as to the nature of the originally precipitated uranium species. Are the tyuyamunite deposits to be viewed as alteration products of pre-existing uraninite deposits? Calcite is found as a cement in the sandstone ore bodies, and probably moved in with the uranium (Chenoweth and Malan, 1975). Limonite staining, halos, and bands are common in ore-grade material.

Figures 4, 5 and 6 show outline maps of the Lukachukai Mesas I - VI mines. Figures 7 and 8 portray outline maps of the Frank No. 1 and Camp mines, respectively, which are typical of Lukachukai mines.

Carrizo Mountains

The general aspect of the Carrizo Mountains uranium deposits is very similar to the Lukachukai deposits, with some notable variations. The ore horizons in the Salt Wash tend to be in lower parts of the unit toward the northwest from the Lukachukais, such that in the northwest Carrizos they are in the basal 40 feet of the unit (Chenoweth and Malan, 1975, table 2). The ore bodies tend to be smaller than in the Lukachukais, and they have vanadium-uranium ratios near 9:1, as compared with 4:1 ratios in the Lukachukais. Also, ore rolls are more common in the Carrizos.

The main mass of the Carrizos consists of a series of Laramide-aged laccoliths (68 m.y. on one unit, Armstrong, 1969) which have intruded rocks as young as the Dakota Sandstone. No obvious large-scale redistribution of Carrizo Salt Wash uranium ores are known to have taken place as a result of this heating event. And at the Zona mine in the northeastern Carrizos, intrusion of the sills fractured, faulted, and silicified typical Salt Wash ore horizons, providing the only evidence in Arizona that the uranium mineralization event is pre-Laramide in age (Chenoweth and Malan, 1975, p. 147).

Figures 9-15 are in the Carrizo Mountains area. Figures 9 and 10 depict the Tsitah (Saytah) Wash area with the Martin, Saytah, and George Simpson mines. Figures 11 and 12 show mines of the Rattlesnake group and the Hoskie Henry mine of the northwest Carrizos. Figures 13 and 14 show the Oak Springs and RF&R-Hazell-Valley View mines of the eastern Carrizos. Figures 15a and 15b cover the productive Cove Mesa area of the southern Carrizos.

Black Mesa

Salt Wash sediments are well exposed on the northeast flank of Black Mesa. Fourteen miles north of the Black Mountain uranium mines in the Toreva Formation, two properties located north of the Rough Rock Trading Post in the Salt Wash Member (Tom Wilson and Tom Klee, Apache County) shipped 123 tons of ore averaging 0.75% U_3O_8 and 0.03% V_2O_5 between 1951 and 1958 (DOE (AEC) Map No. 31, 1973). The Salt Wash Member here consists of about 130 feet of interbedded fine-grained gray to gray-brown sandstone and gray, green and reddish-brown siltstone and mudstone. Secondary uranium minerals are associated with carbonaceous fossil logs and other disseminated carbonized plant debris, in sandstone lenses 10 to 40 feet above the base of the Salt Wash Member (DOE Map No. 31 data). Abundant calcite crystals associated with the logs produced an average of 31% $CaCO_3$ in the ore shipments.

Morrison Mineralization - Timing and Source

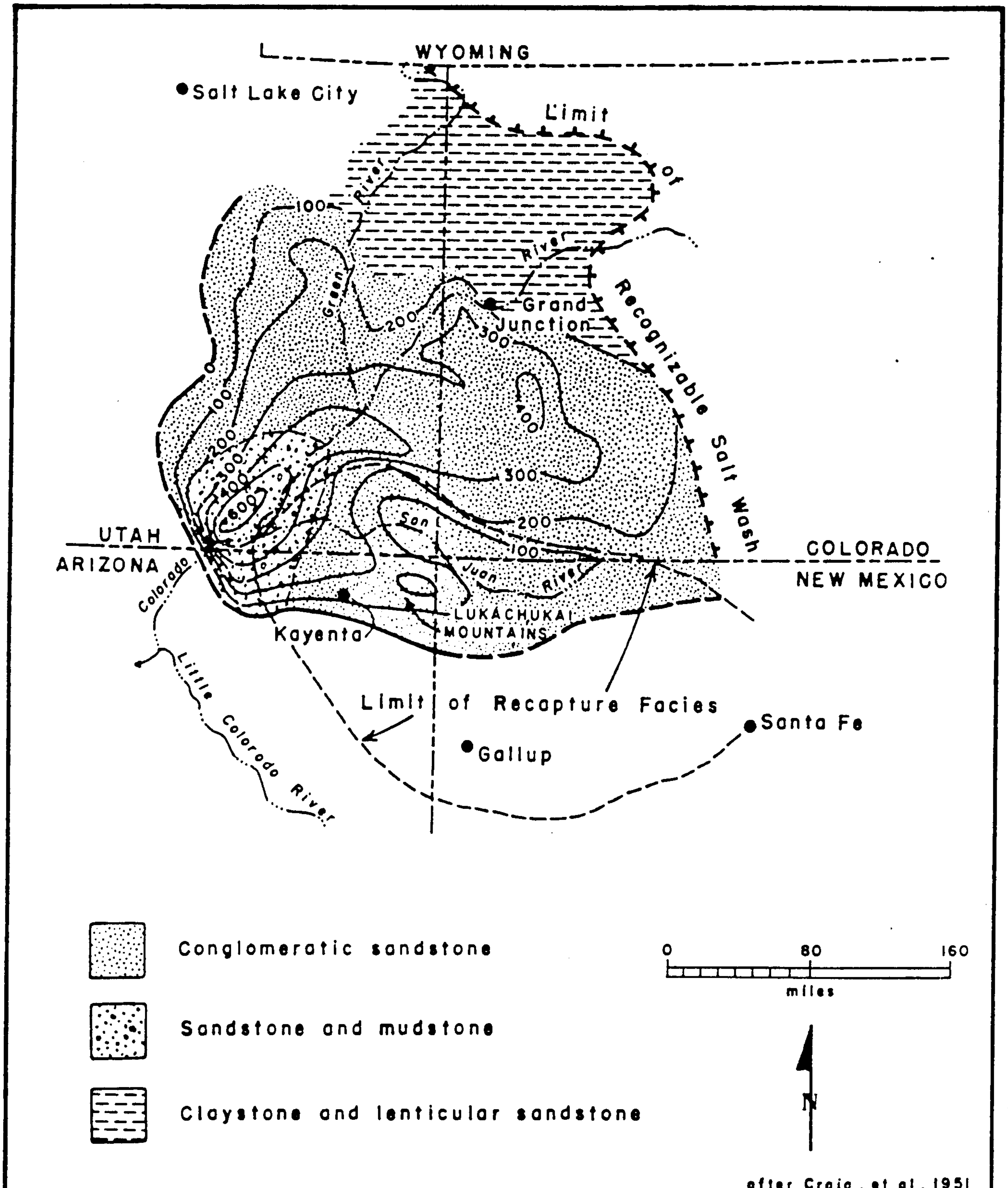
The prevailing opinion on the time of uranium mineralization in the Morrison Formation in Arizona is that it was shortly after deposition of Salt Wash beds, perhaps still in Morrison time (F. Peterson, pers. comm., 1980) or perhaps during Cretaceous or Early Tertiary weathering and erosion marked by a pre-Dakota Sandstone or pre-Chuska Sandstone erosional unconformity (W. Chenoweth, pers. comm., 1980), but, at any rate, was pre-Laramide in age. Uranium series age dating of uranium ores in the Grants mineral belt by Brookins (GJBX 16-76 and 141-79 reports issued by DOE) indicate ages of mineralization of about 138 ± 10 m.y. at Ambrosia Lake, and 110-115 m.y. in the Jackpile-Paguate area. Authigenic montmorillonite from both these areas was dated at 145 ± 10 m.y. (last half of upper Jurassic), and may represent either the time of initial diagenesis of Morrison beds or time of ore deposition at Grants.

Uranium in the Salt Wash could have been derived from sources such as volcanic detritus in the overlying Brushy Basin Member during the pre-Chuska erosion in the area (Nestler and Chenoweth, 1958, p. 53). However, a more regional picture, assembled with the help of plate tectonic theory, indicates the existence of a volcanic arc starting in late Permian time along the west coast of North and South America, temporally related to the formation of the modern Atlantic Ocean. This arc volcanism is the most probable source of volcanic debris and ash beds of the Mesozoic sediments of the Colorado Plateau, and is probably tied in with the tectonics which formed the "Mogollon highlands" of southwest Arizona and points west (Malan, 1968; Repenning and others 1969; Hamilton, 1978). Hence a model for Salt Wash mineralization is volcanogenic sources in the Mogollon highlands supplying uranium-vanadium-copper species for surface or underground aqueous transport downslope to areas of sedimentation where appropriate geochemical conditions caused precipitation. However, it is still not clear how the stratabound uranium-vanadium mineralization of the Salt Wash relates to mineralization of uranium-copper in the Plateau breccia pipes. Perhaps the pipes may be viewed as conduits or local sinks which trapped copper and some uranium while vanadium, most uranium, and many other elements continued to migrate eastward and northward onto today's Colorado Plateau where reduction and precipitation took place under appropriate conditions. The southern Utah uranium-copper association in some Shinarump paleochannels may be viewed as a hybrid case where ore-grade copper occurs in the sedimentary environment. Silver, et al. (1980) suggest the presence of a regional uranium anomaly in the Precambrian basement beneath the Colorado Plateau, based on uranium content of zircons extracted from igneous rocks. However, it is not clear how this basement anomaly may explain the numerous large-scale stratabound uranium deposits found at the top of the preserved Mesozoic units some distance above the basement.

Potential

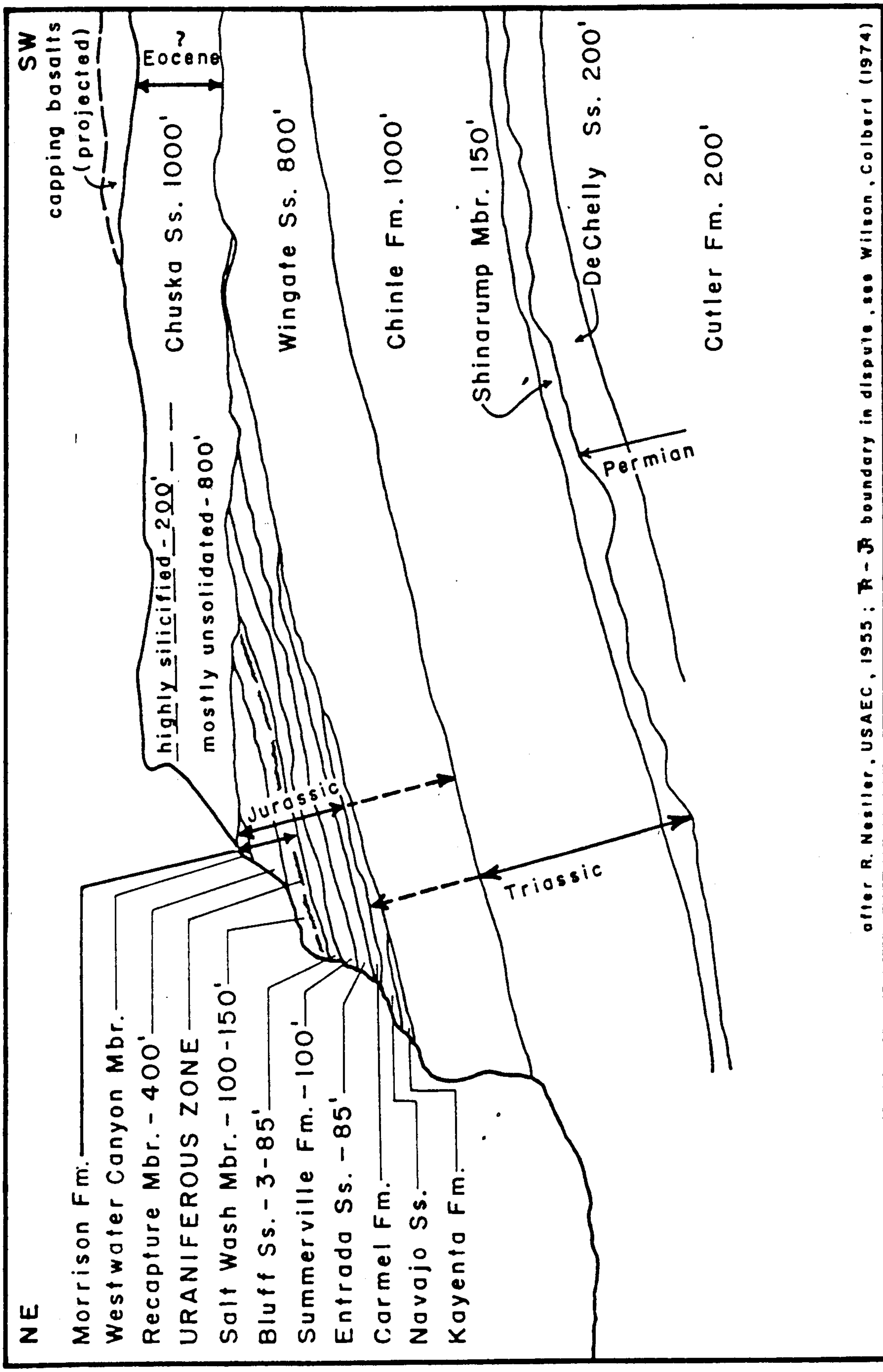
Some potential remains for uranium in the Salt Wash Member in northeast Arizona. Ore deposits were located in the 1950's by exploiting mineralized outcrops, first by "gophering", and later by drilling behind the outcrops. Hence, all major mines are located very near cliffs exposing Salt Wash strata. Many of these cliffs are along stream valleys that dissect middle limbs of monoclines or steeper limbs of anticlines.

Future exploration must probably take one of two forms. First, reevaluation of the old mines could be undertaken by careful mine mapping and drilling, being careful to take note of the known ore trends in the area (see individual mine maps). Secondly, exploratory drilling on an arbitrary grid around old mines could prove successful. The Block K and George Simpson "1B" Mines of the northwest Carrizos and some of the Cove Mesa Mines (southern Carrizos), among others, were discovered in this fashion. The Block K Mine was discovered by a single AEC drillhole placed through valley fill which buries the north limb of the Toh Atin anticline. Since most of the Salt Wash mines of the northwest Carrizos were near the crest of this structure, and since the productive Rattlesnake Mine group (Figure 11) was north of the fold crest near the edge of onlap of valley fill, the AEC decided to test the Salt Wash to the north where it was buried. Block K resulted. The George Simpson "1B" Mine was discovered by a drilling program on the Mesa top due west of the old Martin Mine. That area was chosen because an east-west Salt Wash ore trend was thought to exist in the Martin. Mineralized Salt Wash was encountered in the drilling and, during access tunneling driven from the Martin workings, an additional ore pod was discovered half way between the two areas. Similarly, George Simpson explored near the old Saytah Mine, just south of the Martin, and discovered additional ore nearby which was mined by the George Simpson "1A" and Incline Mines (Figure 10). Certainly, other situations similar to these still remain in the Carrizo and Lukachukai Mountains. The Salt Wash Member exposed around Black Mesa has been thoroughly explored with only three areas of mineralization noted, the Tom Wilson and Tom Klee shipments from north of Rough Rock Trading Post; the poorly located Blue Lake claim farther north; and one unrecorded occurrence somewhere around Kayenta (W. Chenoweth, pers.comm.,1981). The sparcity of Salt Wash mineralization in this southwest region may relate to a less favorable paleoenvironmental setting recorded as thinner individual sandstone beds and more dominant mudstone-siltstone lithologies as compared with the Carrizo-Lukachukai area. However, the mineralized logs in Salt Wash strata at Tom Wilson and Tom Klee indicate uranium moved through the strata, at least in the northeast Black Mesa region.



Isopach and Facies Map of Salt Wash Member, Morrison Formation, Utah, Colorado, Arizona, New Mexico

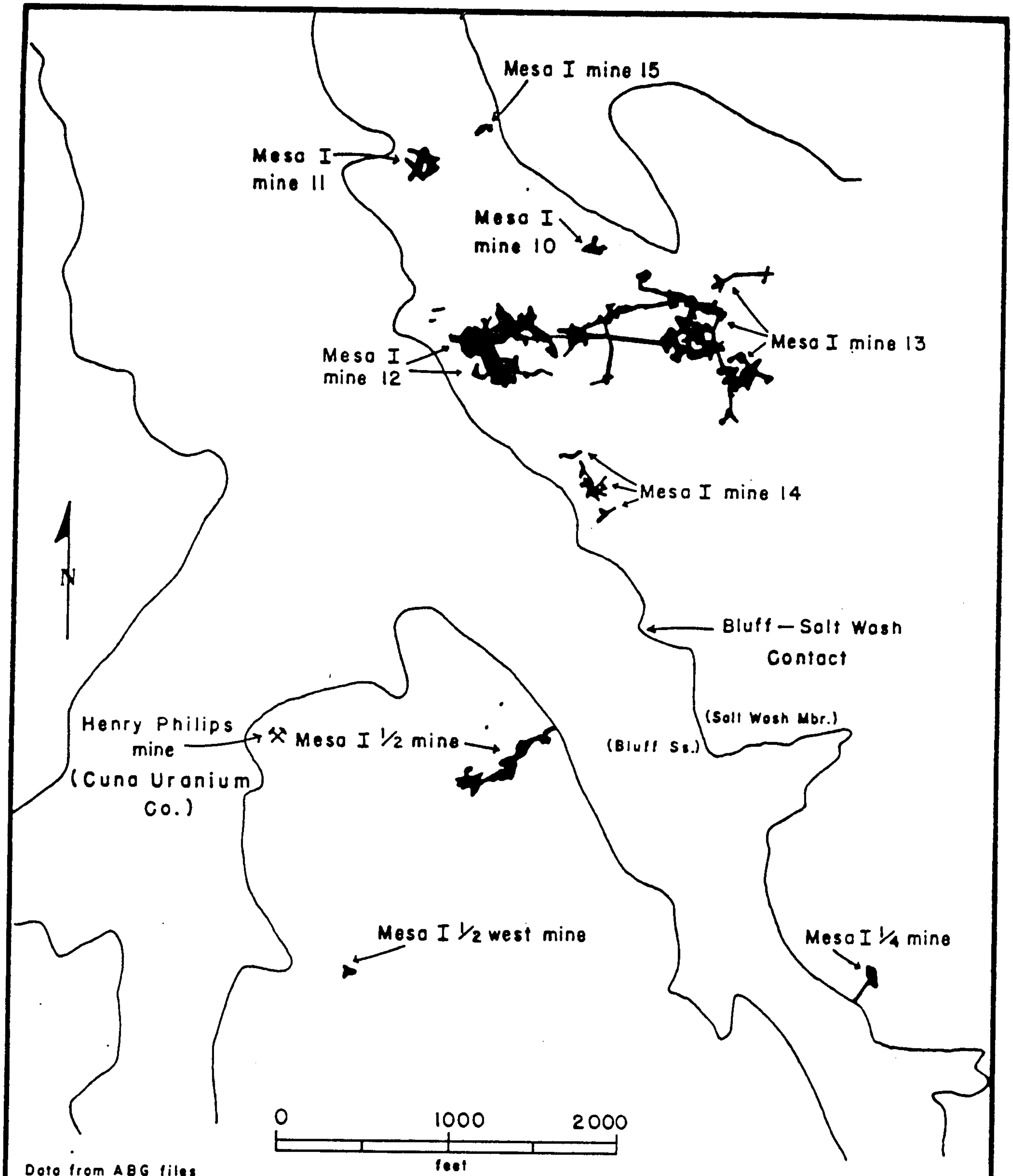
Figure 2



after R. Nestler, USAEC, 1955; ℞-J̶ boundary in dispute, see Wilson, Colbert (1974)

Generalized Geologic Cross Section across the Lukachukai Syncline, Lukachukai Mountains, Apache County

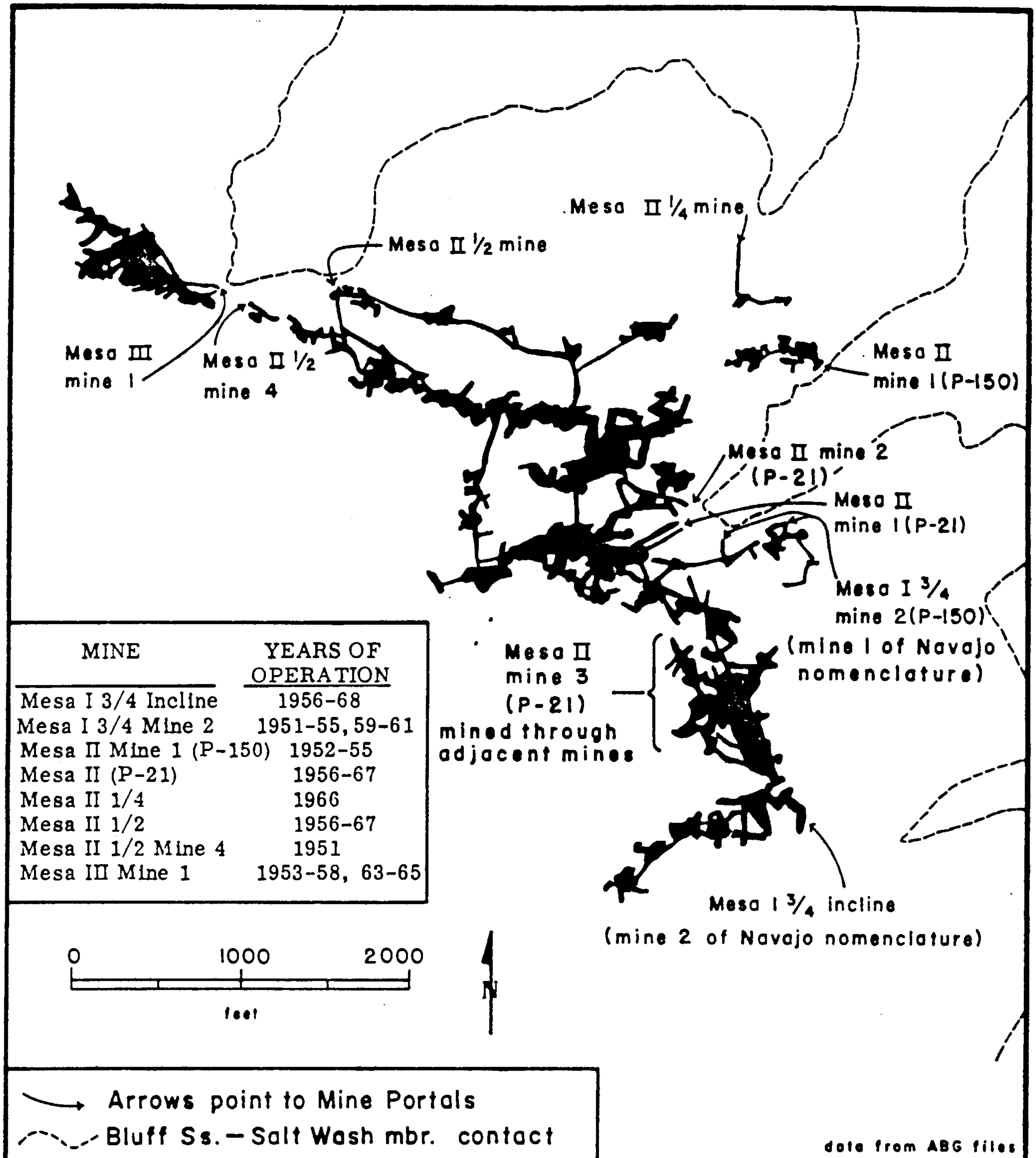
Figure 3



Kerr — McGee (Later VCA) Mesa I, I½, I¼ Mines

Lukachukai Mountains, Apache County

Figure 4

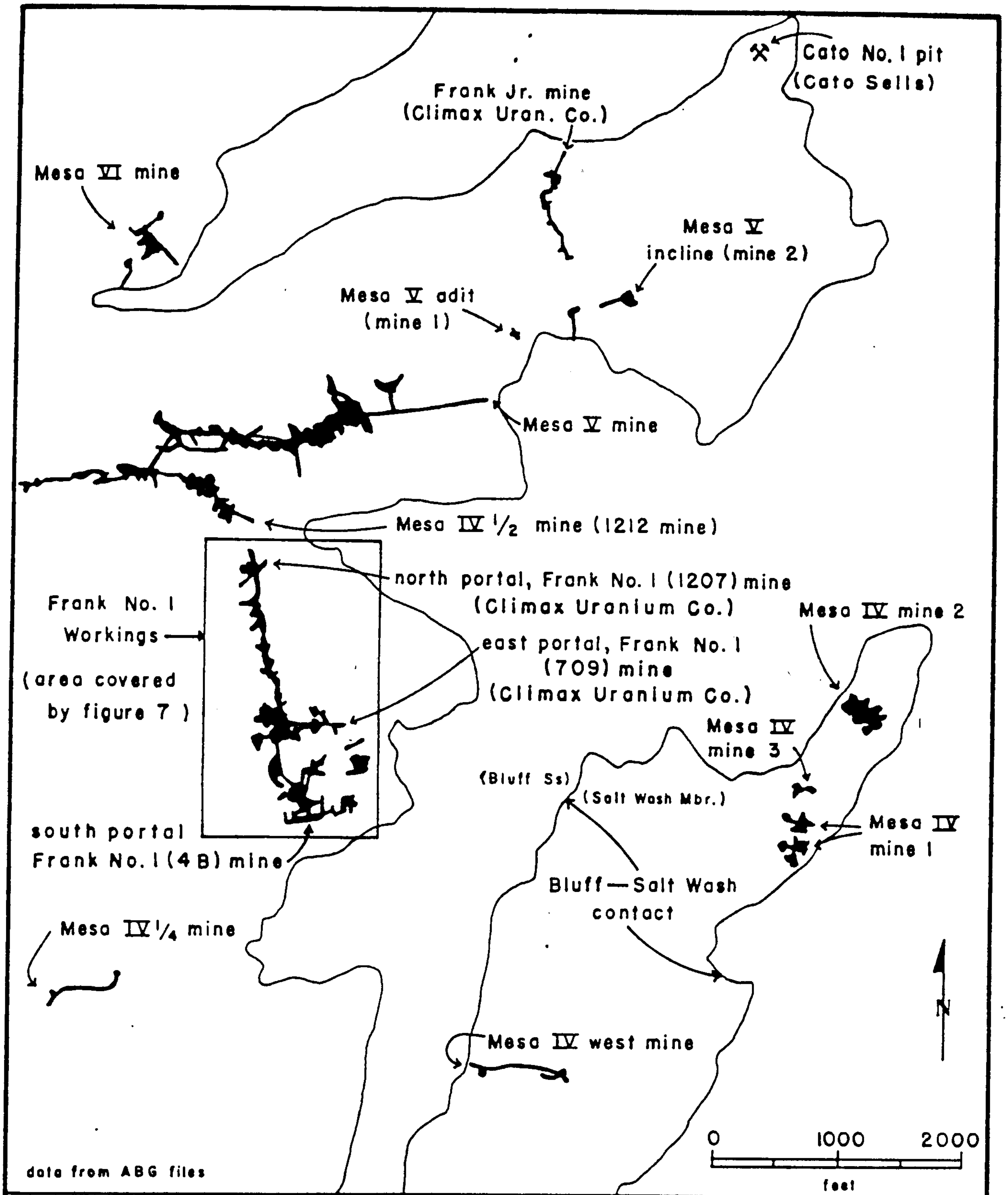


MINE	YEARS OF OPERATION
Mesa I 3/4 Incline	1956-68
Mesa I 3/4 Mine 2	1951-55, 59-61
Mesa II Mine 1 (P-150)	1952-55
Mesa II (P-21)	1956-67
Mesa II 1/4	1966
Mesa II 1/2	1956-67
Mesa II 1/2 Mine 4	1951
Mesa III Mine 1	1953-58, 63-65

Kerr-McGee (Later VCA) Mines, Mesa I 3/4, II, II 1/2, III

Lukachukai Mountains, Apache County

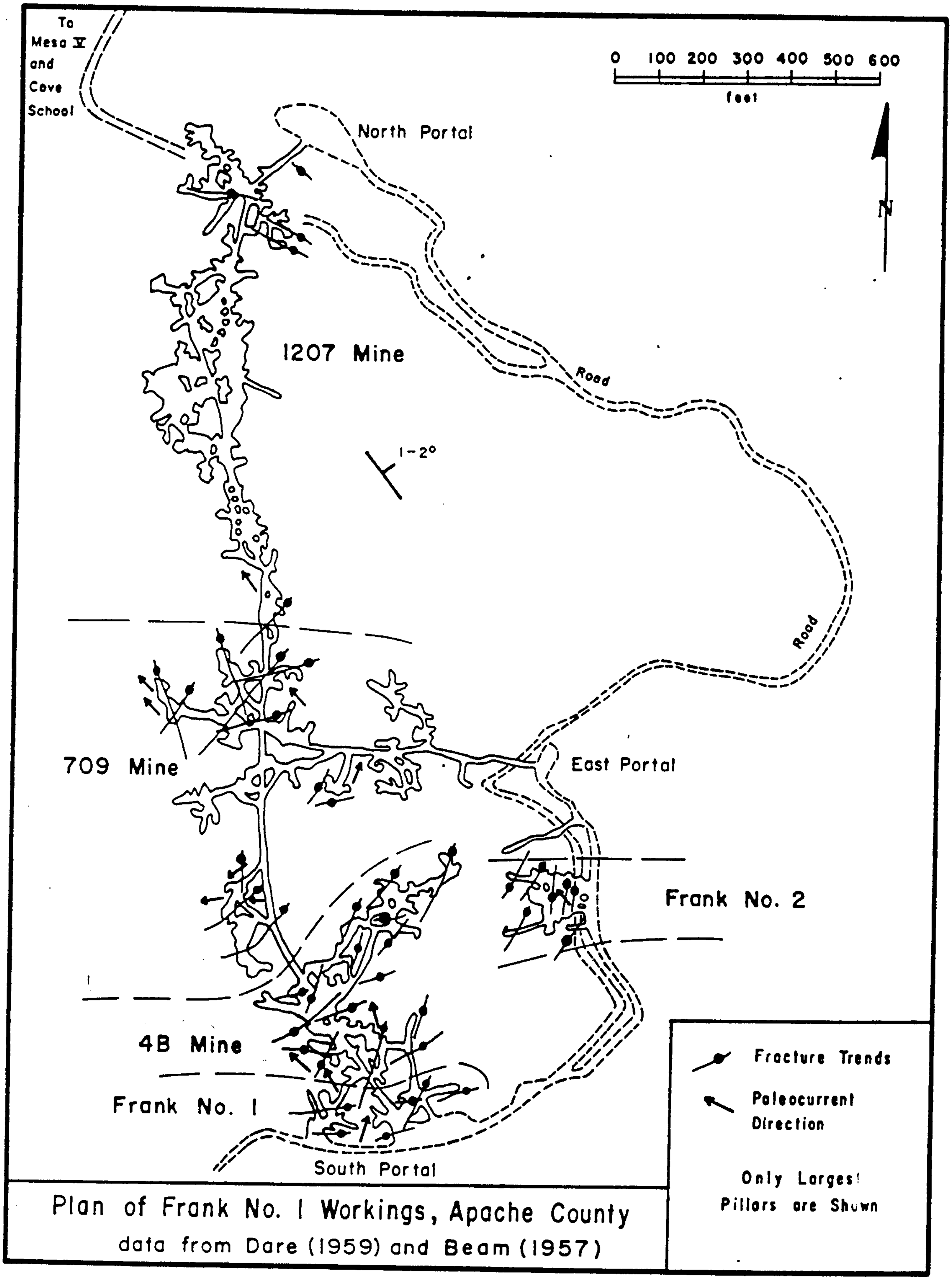
Figure 5



Kerr-McGee (Later VCA) Mesa IV, IV 1/4, IV 1/2, V and VI Mines

Lukachukai Mountains, Apache County

Figure 6



Plan of Frank No. 1 Workings, Apache County
data from Dare (1959) and Beam (1957)

Figure 7

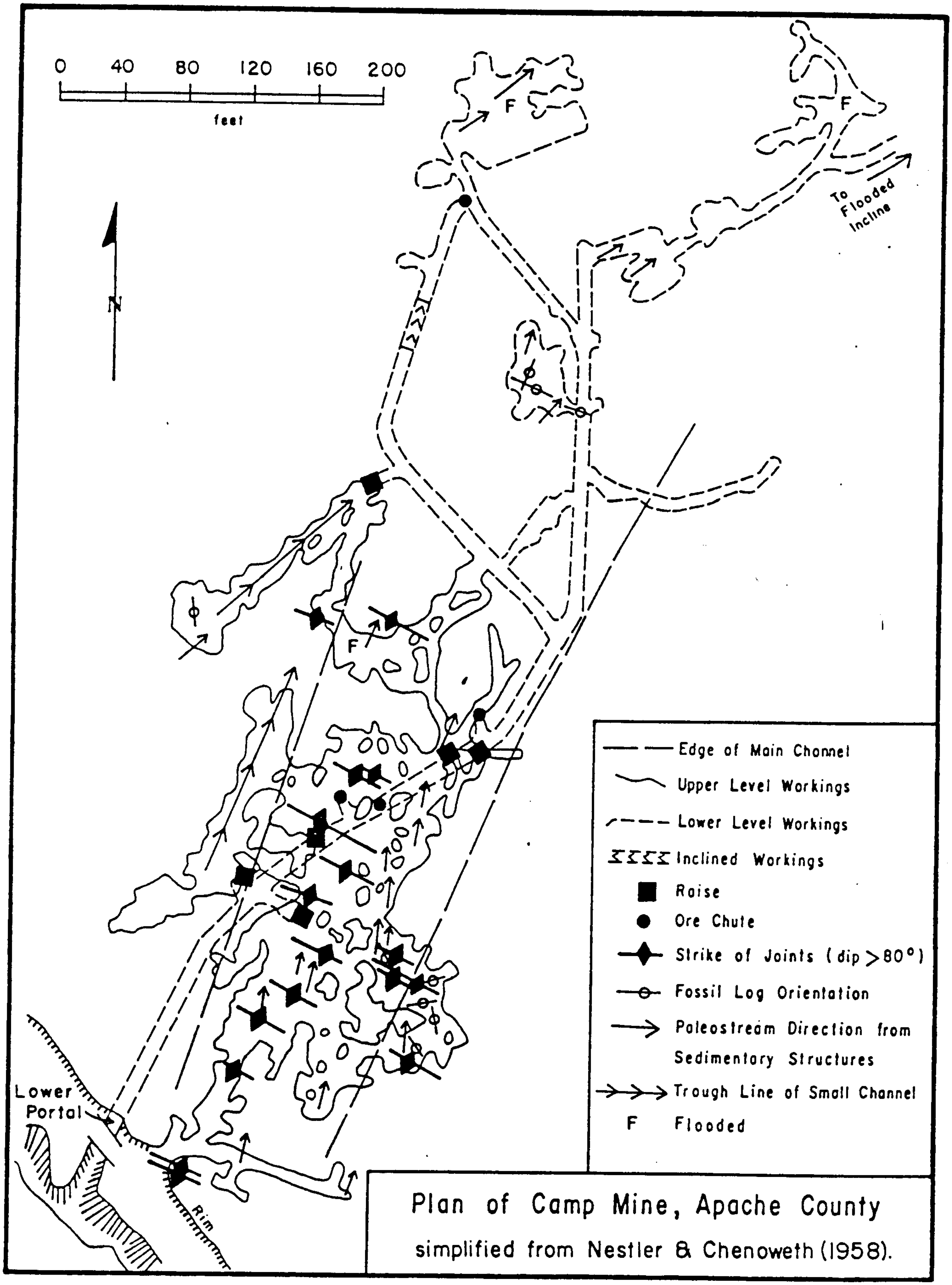

0 40 80 120 160 200
feet
N
F
F
To Flooded Incline
F
Lower Portal
Rim
Edge of Main Channel
Upper Level Workings
Lower Level Workings
Inclined Workings
Raise
Ore Chute
Strike of Joints (dip > 80°)
Fossil Log Orientation
Paleostream Direction from Sedimentary Structures
Trough Line of Small Channel
F Flooded
Plan of Camp Mine, Apache County
simplified from Nestler & Chenoweth (1958).

Figure 8

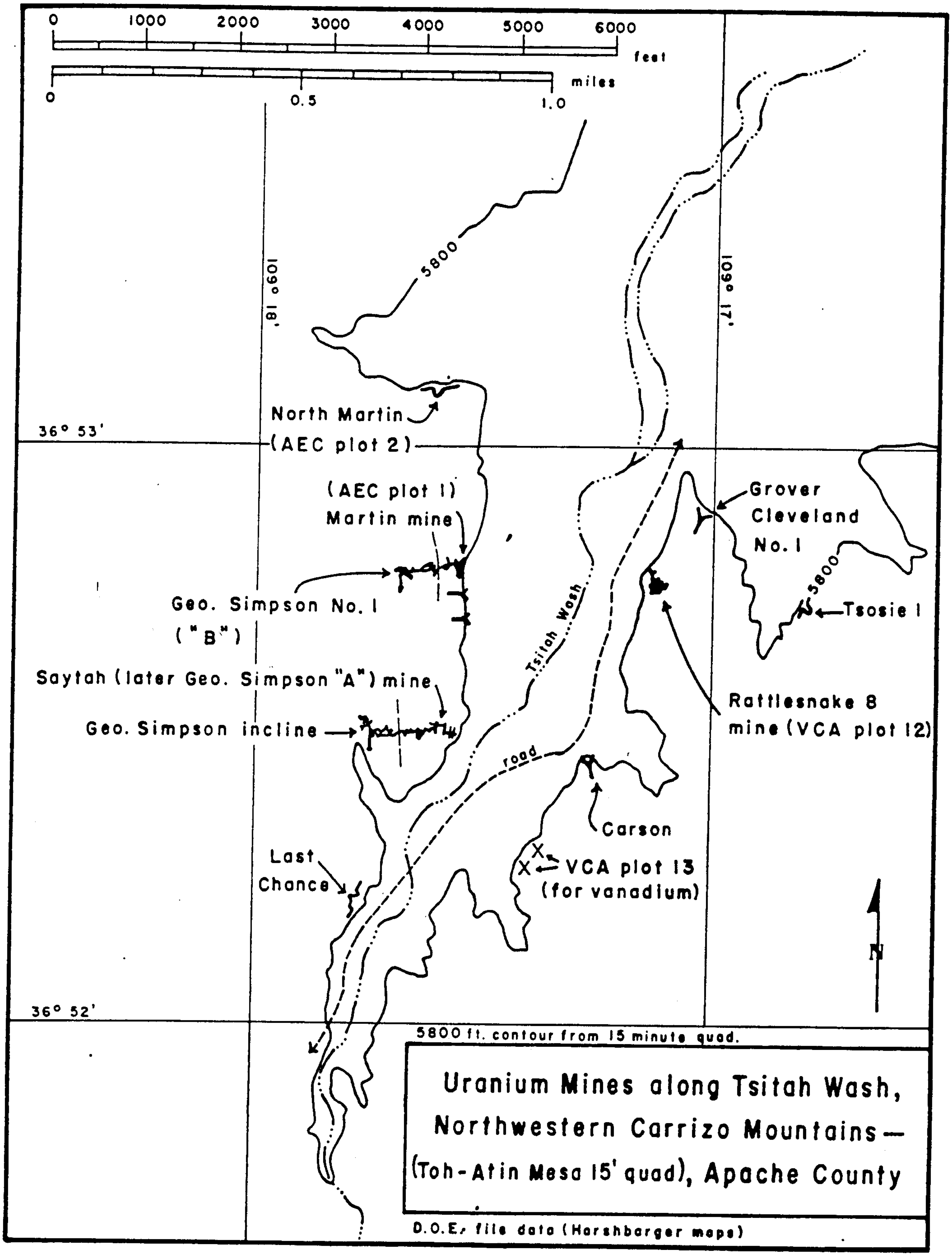
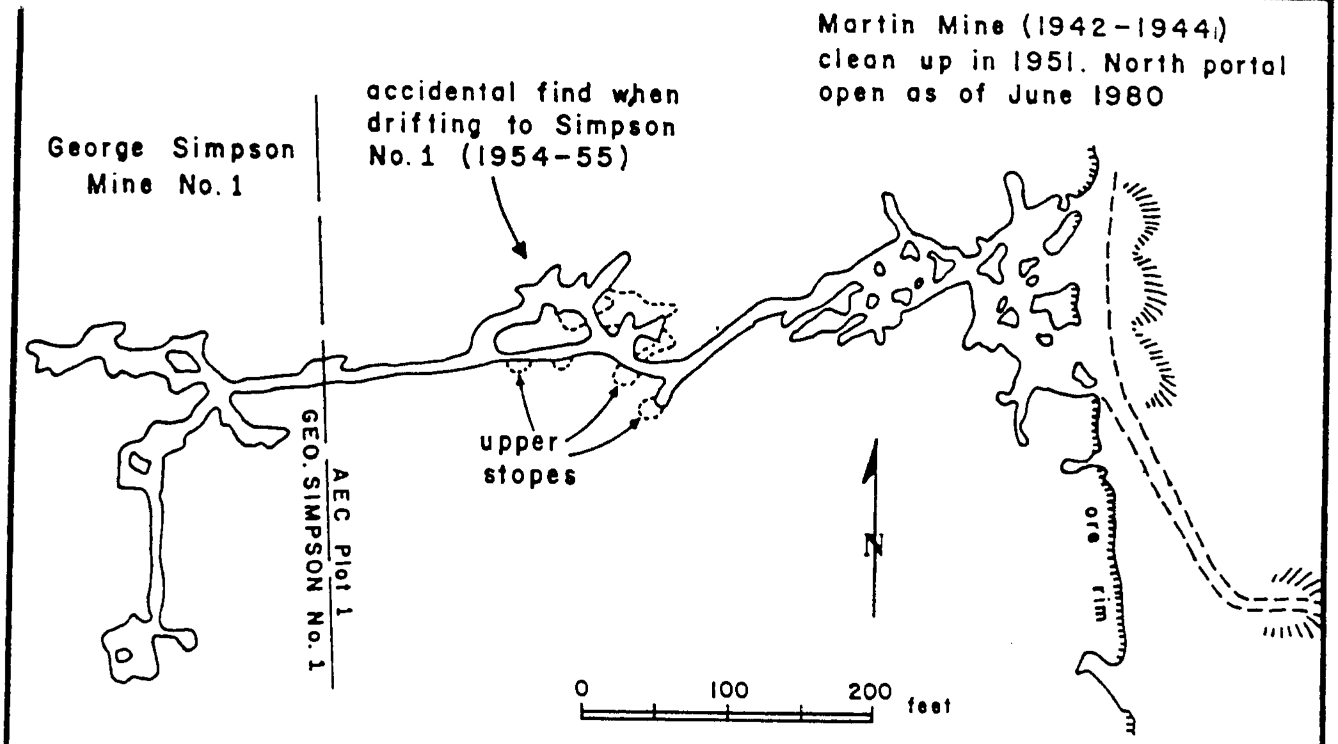
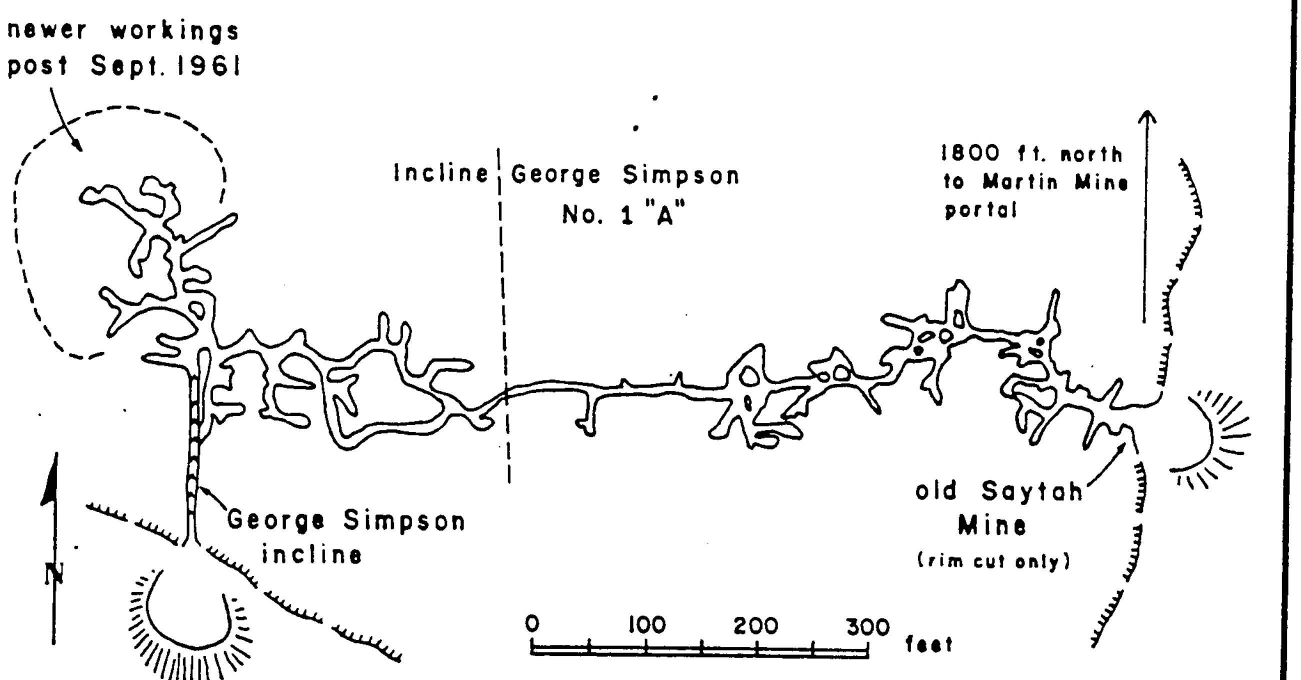

0
1000
2000
3000
4000
5000
6000
feet
miles
0
0.5
1.0
109° 18'
109° 17'
36° 53'
36° 52'
5800
North Martin
(AEC plot 2)
(AEC plot 1)
Martin mine
Geo. Simpson No. 1
("B")
Saytah (later Geo. Simpson "A") mine
Geo. Simpson incline
Tsitah Wash
road
Last Chance
Carson
VCA plot 13
(for vanadium)
Grover Cleveland No. 1
5800
Tsosie 1
Rattlesnake 8 mine (VCA plot 12)
N
5800 ft. contour from 15 minute quad.
Uranium Mines along Tsitah Wash, Northwestern Carrizo Mountains— (Toh-Atin Mesa 15' quad), Apache County
D.O.E. file data (Harshbarger maps)

Figure 9



Mine Map — Martin (AEC Plot No. 1) & George Simpson No. 1 "B"
as of 1961

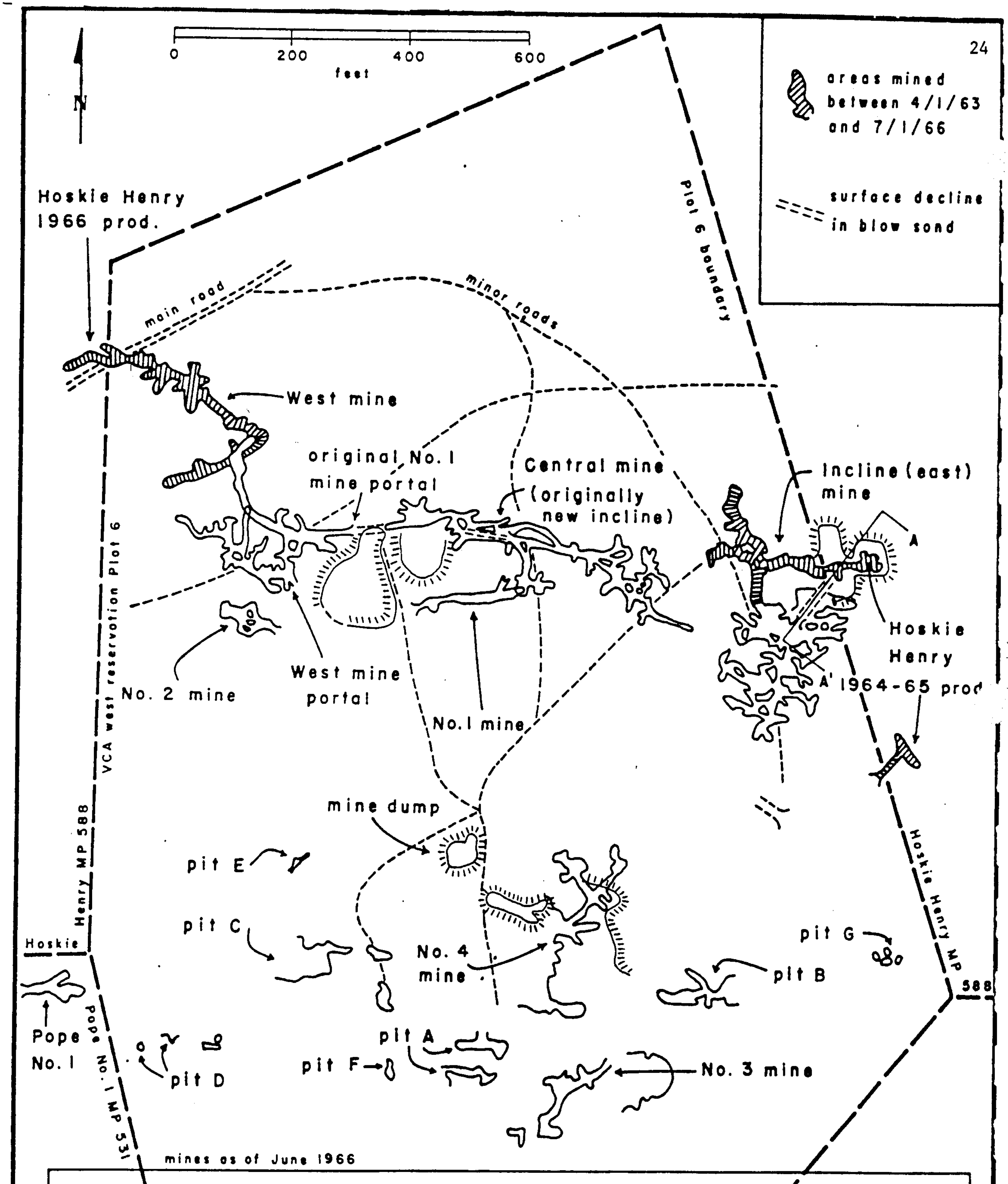
Data from DOE files



Mine Map — Saytah & George Simpson Incline and No. 1 "A"
as of Jan. 1962

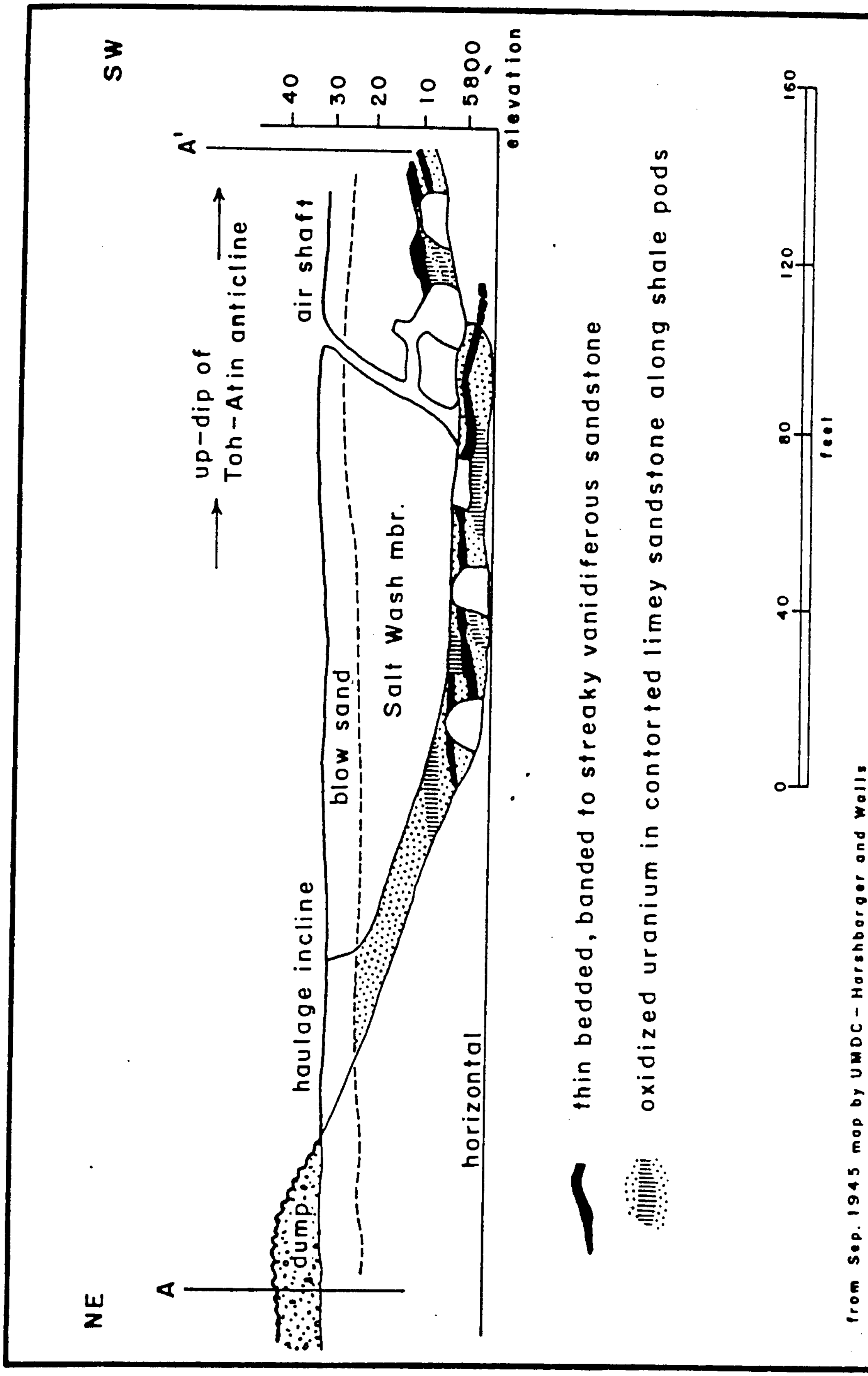
Data from DOE files

Figure 10



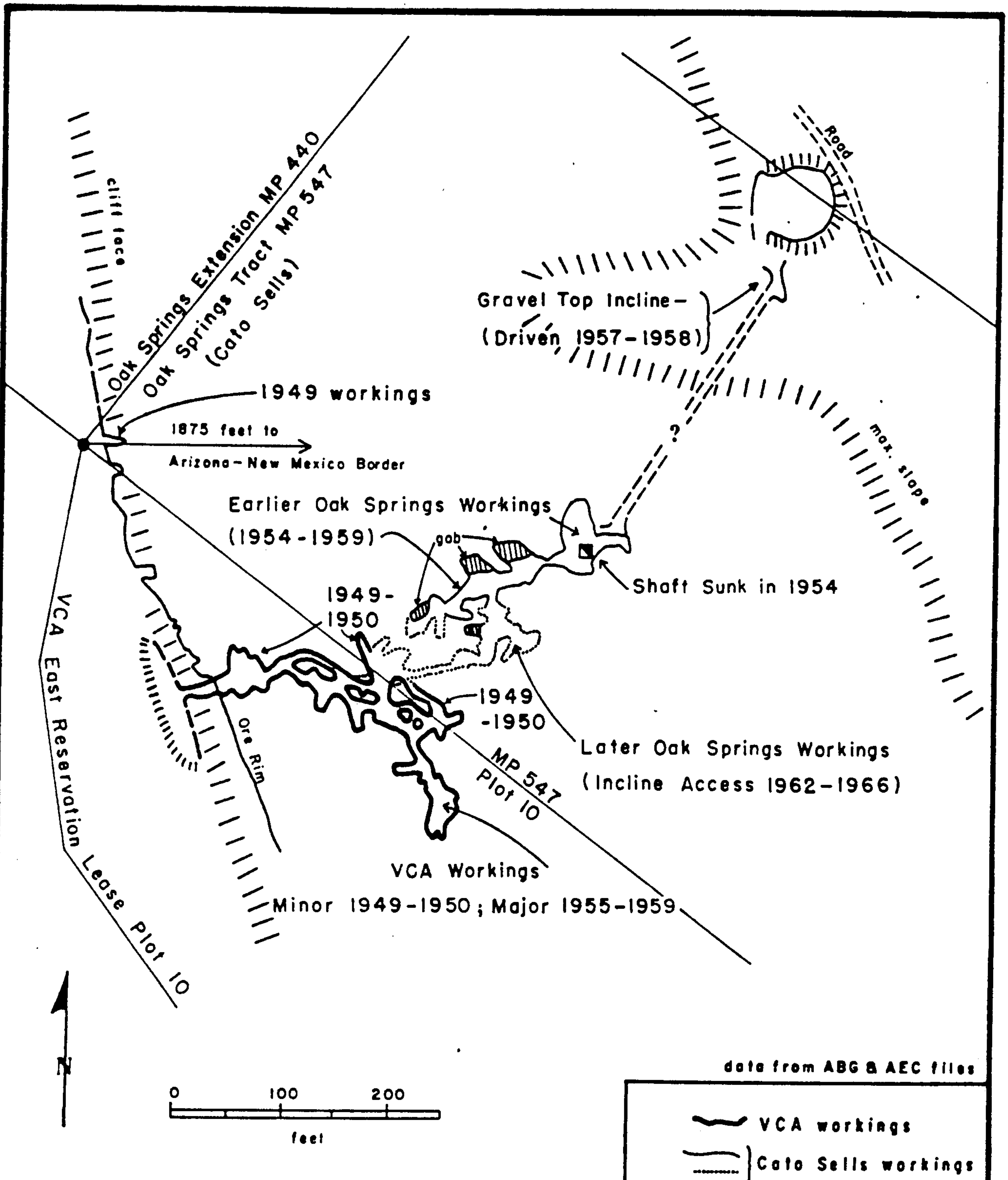
Mine Outline Map, VCA Plot 6 (Rattlesnake) group, northwest Carrizo Mountains, Apache County
(mines 3 & 4 are reversed on UMDC map dated 1945 by Harshbarger)

Figure 11



Cross section of Rattlesnake incline (east) Mine
(VCA west reservation plot), Carrizo Mountains, Apache County

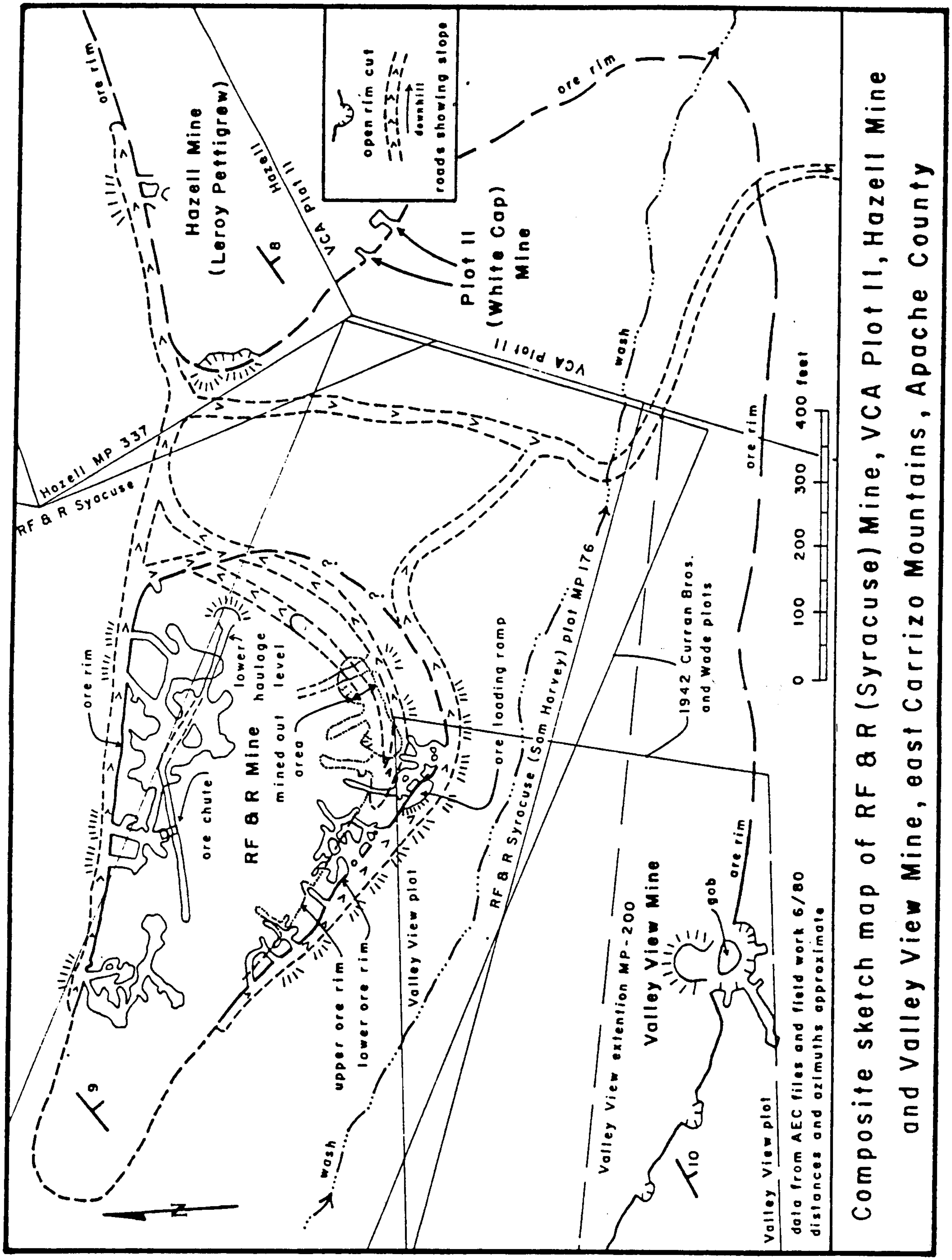
Figure 12



Oak Springs (Gravel Top)—VCA East Reservation Plot 10

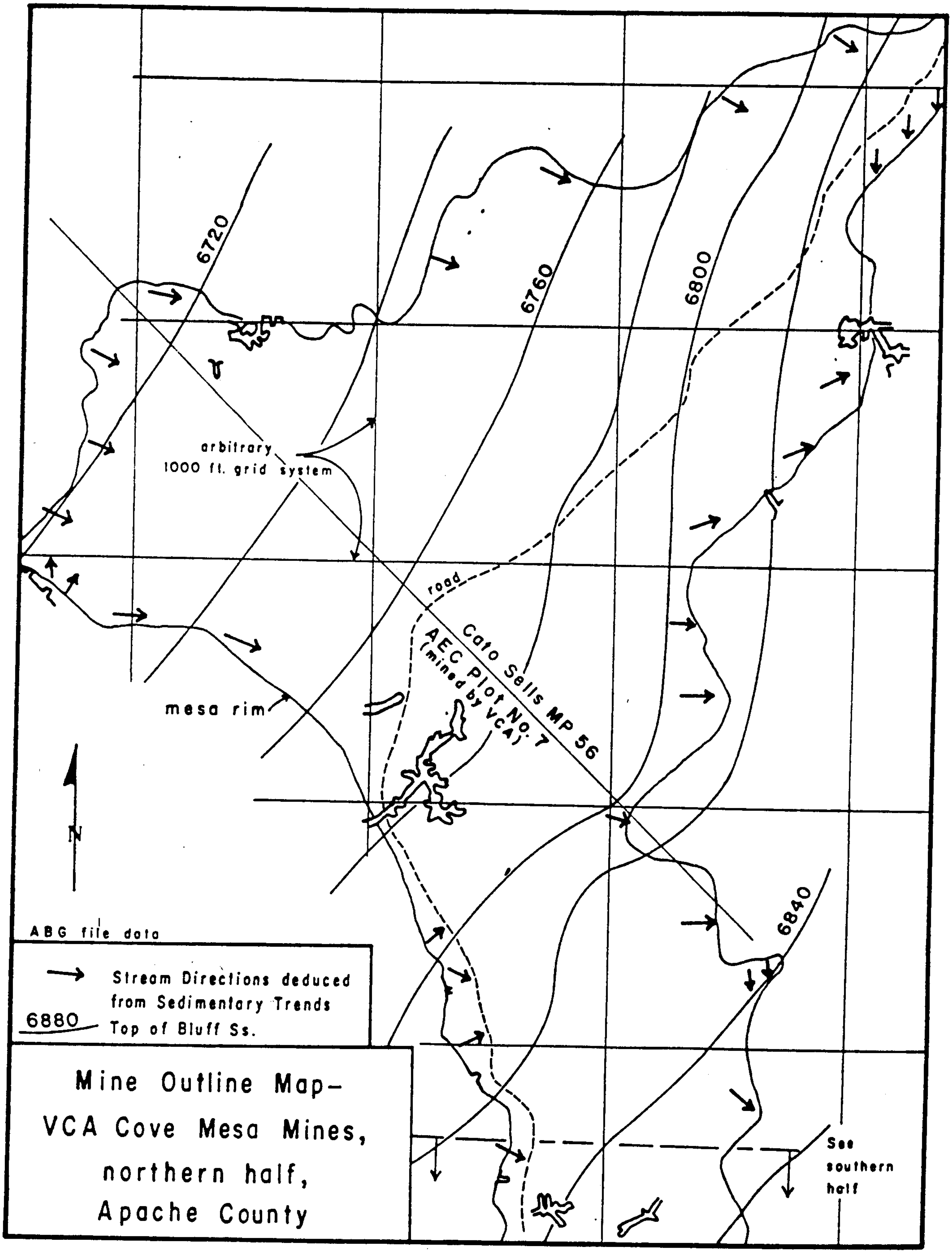
Composite Map, Carrizo Mountains, Apache County

Figure 13



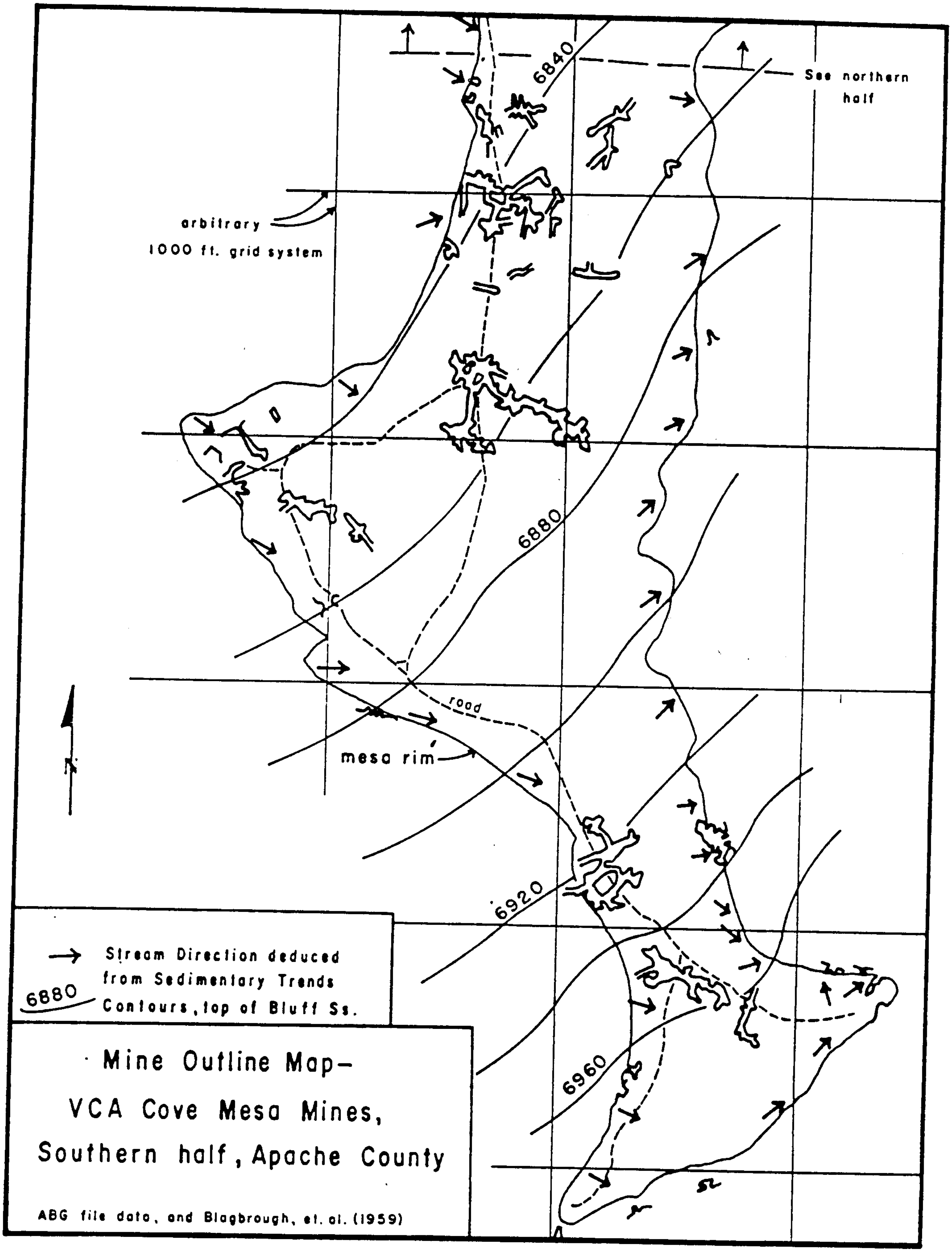
Composite sketch map of RF & R (Syracuse) Mine, VCA Plot II, Hazell Mine and Valley View Mine, east Carrizo Mountains, Apache County

Figure 14



Mine Outline Map–
VCA Cove Mesa Mines,
northern half,
Apache County

Figure 15a



See northern half
arbitrary 1000 ft. grid system
6840
6880
6920
6960
road
mesa rim
Stream Direction deduced from Sedimentary Trends
6880 Contours, top of Bluff Ss.
Mine Outline Map–
VCA Cove Mesa Mines,
Southern half, Apache County
ABG file data, and Blagbrough, et. al. (1959)

Figure 15b

CHINLE FORMATION

Monument Valley

Uranium was first noted in the Monument Valley region by Gregory (1917) in an area which was later to become Arizona's largest mined uranium deposit, the Monument No. 2 mine. Mining by the Vanadium Corporation of America during 1942-1944 for vanadium was superseded in 1948 by uranium recovery.

Monument Valley uranium ores are found predominantly in paleochannels of the Shinarump Member of the Upper Triassic Chinle Formation, and to a much lesser extent in the underlying Meoenkopi Formation. Shinarump channels were cut into the Triassic Moenkopi and Permian DeChelly Sandstone and filled with muds, sands, and gravels, now represented by 10-250 feet of resistant ledges which cap many of the prominant mesas and buttes of the region. About 800-950 feet of overlying soft Chinle shales have been removed by later erosion of the north-south elongate Monument Upwarp, of which Arizona's Monument Valley is the southernmost flank. (See Mitcham and Evensen, 1955, Figure 1.)

Total production figures from 73 Monument Valley properties indicate the mining of 1,322,000 tons of ore averaging 0.33% U_3O_8 (8,670,000 lbs) and 0.92% V_2O_5 (24,361,400 lbs) between 1948 and 1969. During 4 years, 1953, 1954, 1958, and 1959, the amount of U_3O_8 from the district exceeded 750,000 lbs/year. Much allied production came from equivalent Shinarump paleochannels (Figure 6) in adjacent Utah.

Monument Valley uranium occurrences are discussed by Mitcham and Evensen (1955), Finnell (1957), Evensen and Gray (1958), Witkind (1961), Witkind and Thaden (1963), Young (1964), Malan (1968), and Chenoweth and Malan (1973).

Uranium ores have been mined from the lower parts of the Shinarump channels, especially from scours where the channels are cut especially deep into underlying sediments. The Monument Valley Shinarump channels are filled mostly with pebble conglomerates and sands with abundant woody plant trash and fossil logs. They commonly contain only one ore-bearing scour. In a few mines ore extends beneath the scour bottoms as much as 15 feet into underlying beds. Ore bodies tend to be cigar-shaped and horizontal, parallel to the main channel trend. Length to width ratios vary from 5:1 to 50:1 (Chenoweth and Malan, 1973).

The deposits contain variable amounts of vanadium and copper. V_2O_5 grades range from 0.2 to 0.9% and copper ranges from 0.2 to 2.5%. There is a tendency for vanadium contents to decrease and copper contents to increase from east to west. Further, calcium carbonate is present in the ores as cementing material in sandstone host rock, ranging in content from 1.4 to 10.3%. There is an inverse relationship between calcium carbonate and vanadium contents, but no relationship is apparent between calcium carbonate and copper (Chenoweth and Malan, 1973).

Mitcham and Evensen (1955) list 27 guides to ore positions in Monument Valley Shinarump channels. They suggest that the best ores are confined to low scours, or are found at or downstream of meander bends in channels. Regional structures may influence ores in so far as the lower portions of limbs of regional anticlines and monoclines are more likely to contain ore deposits than higher portions.

Example - Monument No. 2 Mine

Production from this mine started as several different underground-open pit operations, several of which eventually merged, as seen in Figure 17, into a single open pit. Between 1948 and 1967, mines of this group are credited with 767,000 tons of ore averaging 0.34% U_3O_8 and 1.42% V_2O_5 with very low copper values. This makes the Monument No. 2 mine, with about 5.2 million lbs of U_3O_8, the largest uranium mine in Arizona to date. The overall V_2O_5:U_3O_8 ratio is slightly greater than 4:1.

The Monument No. 2 Shinarump paleochannel scour extends for at least 2 miles in a north-south direction within a wider depression or scour about 50 feet deep cut into underlying Moenkopi and DeChelly units. A narrow, inner scour is another 30 feet deep and 700 feet wide. Drilling along scour projections to the north and south indicates the paleochannel does not exist because of post-Shinarump erosion.

The best Monument No. 2 ores are in typical "cigars" or "rods" up to 8 feet in diameter and 100 feet long. Ore is both unoxidized (uraninite, coffinite, montrosite, corvisite, minor iron-copper sulfides, etc.) and oxidized (tyuyamunite, carnotite, hewettite, navajoite, etc.) types which impregnate sandstone voids, replace quartz grains, clay particles and abundant fossil plant debris, and fill vertical fractures which extend beneath the scour base. This latter observation led Finnell (1957) to suggest a hydrothermal source for the ores which rose from depths along en echelon fractures produced in Laramide time. Most other workers, however, subscribe to the groundwater-style ore emplacement hypothesis that envisions movement of ore solutions along Shinarump channelways during the Mesozoic, prior to erosional removal of much of the Shinarump.

Production from the mine was enchanced between 1955 and 1964 by a mechanical ore upgrader situated near the mine which separated a higher grade mud product (0.24% U_3O_8 and 2.6% V_2O_5) from lower grade sands (0.02% U_3O_8, 0.18% V_2O_5) that were discarded. Additional ore was recovered in 1964-67 by heap leaching of the sand residue and some low grade ores.

Cameron-Holbrook Region

Uranium production from 99 properties around Cameron, Coconino County, from the lower part of the Chinle Formation of Triassic age accounts for about 295,100 tons of ore averaging 0.21% U_3O_8 and 0.03% V_2O_5, mostly between 1954 and 1963. This total includes twenty properties in thin sandstone beds in the Chinle Fm. just north of Holbrook, which are credited with 2685 tons of ore (1% of the Cameron total) averaging 0.149% U_3O_8 and at least 0.14% V_2O_5 between 1953 and 1960. This total makes the Cameron region and 4th largest uranium production district in Arizona.

Most of the ores of the Cameron area have been produced from the Chinle Formation, although initial discovery and first production from the area (both in 1950) came from the Ward Terrace (Hosteen Nez) property in the stratigraphically higher Kayenta Formation. Two mines in lower Kayenta beds (Ward Terrace and Yellow Jeep) in the Cameron area produced 182 tons of ore averaging about

0.15% U_3O_8 and about 0.40% V_2O_5 between 1950 and 1957. In the Cameron area, sixty-seven mines in the lower part of the Petrified Forest Member yielded 1,177,500 lbs of U_3O_8, while 27 deposits in the underlying sandstone and siltstone member account for about 62,500 lbs. of U_3O_8 production (Chenoweth and Malan, 1975).

For general references on the Cameron area, see Wright (1955), Bollin and Kerr (1958), Austin (1964), Repenning, Cooley, and Akers (1969), Chenoweth and Malan (1975), Spirakis (1980), and AEC Preliminary Map No. 20.

Repenning, Cooley, and Akers (1969) divide the Chinle Formation around Cameron into (in ascending order) the Shinarump, sandstone and siltstone, Petrified Forest, and Owl Rock Members. The uraniferous units around Cameron are the lower part of the Petrified Forest Member and, to a minor extent, the sandstone and siltstone member (Chenoweth and Malan, 1973). The exact stratigraphic context of the Holbrook area uranium mines is not known, although the mines are in strata above the Shinarump, and beneath the Sonsela Sandstone.

The Petrified Forest ores are within elongate fluvial channelways filled with fine-to medium-grained sandstones containing reworked clay pellets, carbonaceous matter, and silicified-carbonized fossil logs occasionally reaching lengths of 50 feet or more. Ore consists chiefly of secondary uranium-vanadium minerals filling pore spaces in the sandstones and in fossil logs. Within the channelways, the ore tends to occur in abrupt depressions of the channel bottom or at meander bends, and tends to associate with carbonaceous layers. Most ore bodies are encased in an alteration halo composed of bleached sandstone and mudstone (Chenoweth and Malan, 1975). Jack Daniels, and Huskon 4 - Paul Huskie 3 are the largest Cameron deposits in the Petrified Forest Member.

The sandstone and siltstone member mines were developed in thin-bedded, cross-stratified fine-to medium-grained sandstone with abundant carbonaceous trash and fossil logs, in the upper 30 feet of the unit. The Huskon 11 mine is the largest source in the Cameron area from this member.

Figures 18 and 19 illustrate pit outlines of Jack Daniels and the Ramco pits, respectively. These represent the most productive open pits at Cameron. Mining methods at Cameron consisted of open pits to depths of about 150 feet, with small amounts of underground mining from the pit walls to recover additional ore (Chenoweth and Malan, 1975).

Concerning the mineralogy of the Cameron ore bodies, Austin's (1964) detailed mineralogical study states that most ore consists of oxidized uranium species, but fossil logs are found in various states of oxidation. As logs are exposed to oxidizing conditions, pyrite and marcasite alter to hematite, limonite, and iron sulfates, while uraninite and coffinite alter to uranophane, zippeite, boltwoodite, schroeckingerite, and uranocircite. Where primary pyrite and calcite have filled skrinkage cracks in carbonaceous material, they are found replaced by sulfates, especially gypsum and barite (Austin, 1964, p. 75). He accounts for mineralogical "double halos" around some oxidizing logs at certain deposits by a complex oxidation history involving ground water and possibly the downcutting history of the Little Colorado River (p. 76-84). However, with only local exceptions, the Cameron ores are in chemical-radioactive equilibrium.

Austin suggests that the main chemical elements related to the uranium ore zones are U, Ca, Mn, Cu, Mo, Co, Pb, Cd, Ni, and V (Zn notably absent). The best mineralogical guides to uranium ore are the presence of a) blue molybdenum oxide fracture films, b) calcite-gypsum-barite gangue minerals, and c) bleaching of country rock from gray to a yellow or buff color due probably to oxidation of sulfides in protore halos. The Huskon No. 10 and 11 mines contain notable trace amounts of molybdenum and cobalt-bearing minerals.

There are numerous collapse structures recognized around Cameron (Chenoweth and Blakemore, 1961; Barrington and Kerr, 1963), but only one, the Riverview mine, has recorded uranium production (508 tons of ore @ 0.38% U_3O_8). Curiously, the ore came from a peripheral shear zone and blocks of downfallen lower Chinle clastics within the pipe, a structural situation resembling the Orphan Lode. Also curious is the resemblance of the ores (high U, high Cu, very low V) to the Orphan ores much more than the other Cameron ores (intermediate U, intermediate V, some Mo, Cd). Barrington and Kerr (1963) describe in detail some silicified "plugs" intruding the Moenkopi Formation northwest of Cameron which contain bleached halos in Moenkopi beds and peripheral radioactive pyrite-copper anomalies, containing signs of argillic (kaolin to illite) alteration.

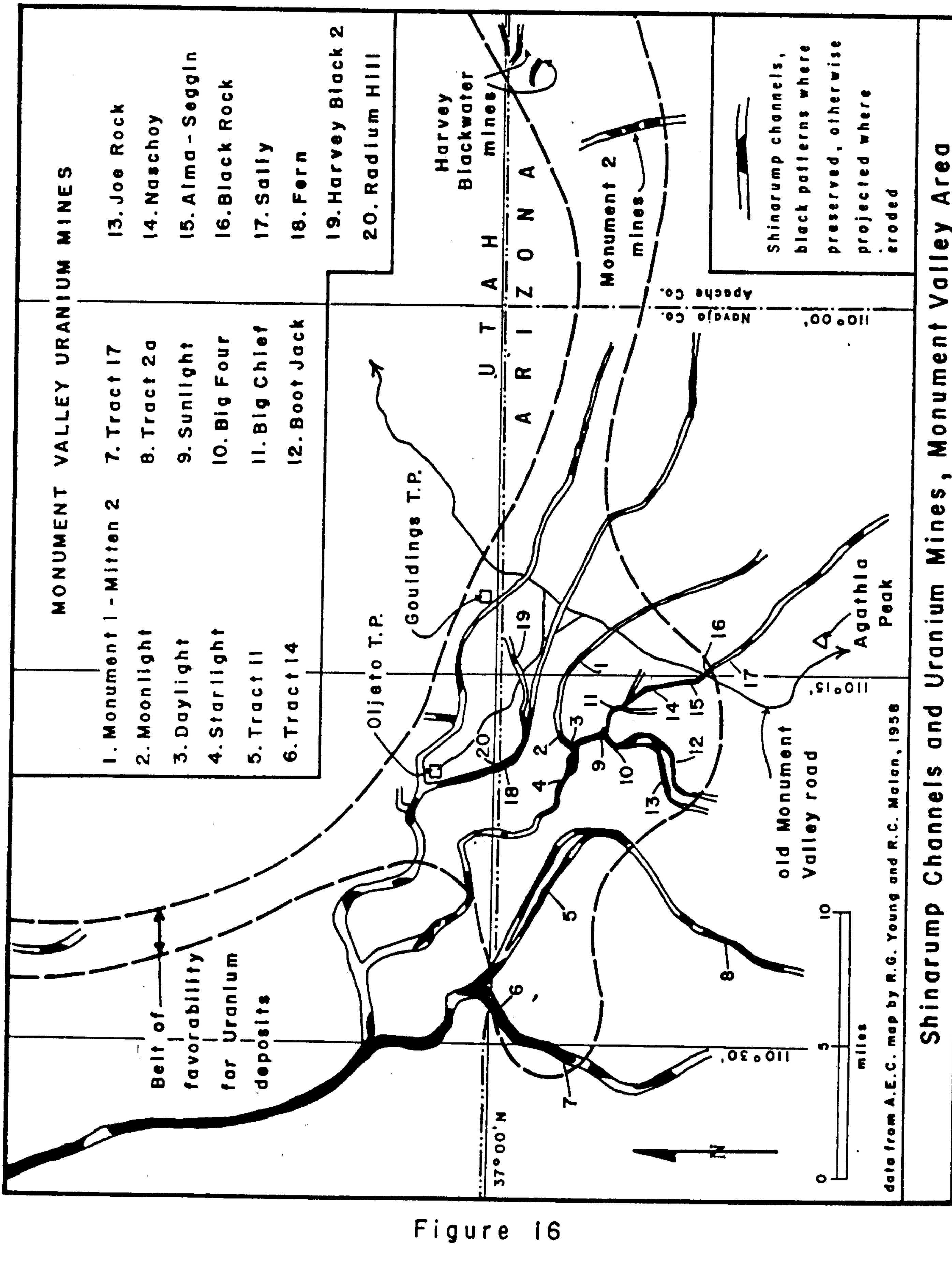
The Cameron district has potential for additional uranium deposits, especially east of the Little Colorado River where broad channels in lower Petrified Forest beds can be expected, and in lesser oxidized channelways at slightly greater depth in lower Chinle strata (Chenoweth, pers. comm., 1980). Drilling in 1977-1980 in the area has provided encouraging results for further exploration. Spirakis (1980) suggests that the Cameron district contains additional uranium potential based on a model of subsidence during Petrified Forest time and preservation of abundant organic matter in the sediments due to burial beneath ground water tables, prior to uranium emplacement.

Vermilion Cliffs - Lee's Ferry

Minor production is recorded from the Chinle Formation in the Vermilion Cliffs-House Rock Valley area astride the Colorado River near Lee's Ferry. Production is from both Shinarump paleochannels cut into the Moenkopi Formation, and from the Petrified Forest Member of the Chinle Formation.

Four mines in Shinarump paleochannels (El Pequito, Jimmy Boone, Sun Valley, and Vermilion No. 1) yielded 1212 tons of ore averaging 0.20% U_3O_8 (4759 lbs of U_3O_8), and six mines in lower Petrified Forest sand and mud channel fills (Big Blue, June, Red Wing, Sam, Thomas No. 1, and Tommy) produced 312 tons of ore at 0.22% U_3O_8 (1367 lbs of U_3O_8). Total production from the area is 1524 tons @ 0.201% U_3O_8 between 1954 and 1957. The geology of the ore deposits is very similar to the other Shinarump and Petrified Forest ores from Cameron and Monument Valley. Channel trends in the Shinarump and lower Petrified Forest indicate flow directions toward the NW - NNW (Phoenix, 1957, 1963). Uranium ores from the Sun Valley mine contain very unusual concentrations (to 0.07%) of a water soluble rhenium salt (Peterson and others, 1959).

Figure 20 shows outcrops of Chinle beds and some of the mines and occurrences in the Lee's Ferry area.



MONUMENT VALLEY URANIUM MINES
1. Monument 1 - Mitten 2
2. Moonlight
3. Daylight
4. Starlight
5. Tract 11
6. Tract 14
7. Tract 17
8. Tract 2a
9. Sunlight
10. Big Four
11. Big Chief
12. Boot Jack
13. Joe Rock
14. Naschoy
15. Alma - Seggin
16. Black Rock
17. Sally
18. Fern
19. Harvey Black 2
20. Radium Hill
Harvey Blackwater mines
Monument 2 mines
Shinarump channels, black patterns where preserved, otherwise projected where eroded
U T A H
A R I Z O N A
Apache Co.
Navajo Co.
110°00'
110°15'
110°30'
37°00'N
Gouldings T.P.
Oljeto T.P.
Agathla Peak
old Monument Valley road
Belt of favorability for Uranium deposits
N
0
5
10
miles
data from A.E.C. map by R.G. Young and R.C. Malan, 1958
to be released as DOE Preliminary Map No. 34 by Young and Malan
Shinarump Channels and Uranium Mines, Monument Valley Area

Figure 16

Explanation for Figure 17, Monument No. 2 mine

Qd	dune sand
Tcs	Shinarump Member, Chinle Fm.
Tm	Moenkopi Fm.
Tmh	*Hoskinnini tongue of Moenkopi Fm.
Pd	*DeChelly Sandstone

*For new nomenclature see Vaughn (1973), p. 99.

Structural contours drawn on base of Monument No. 2 channel.

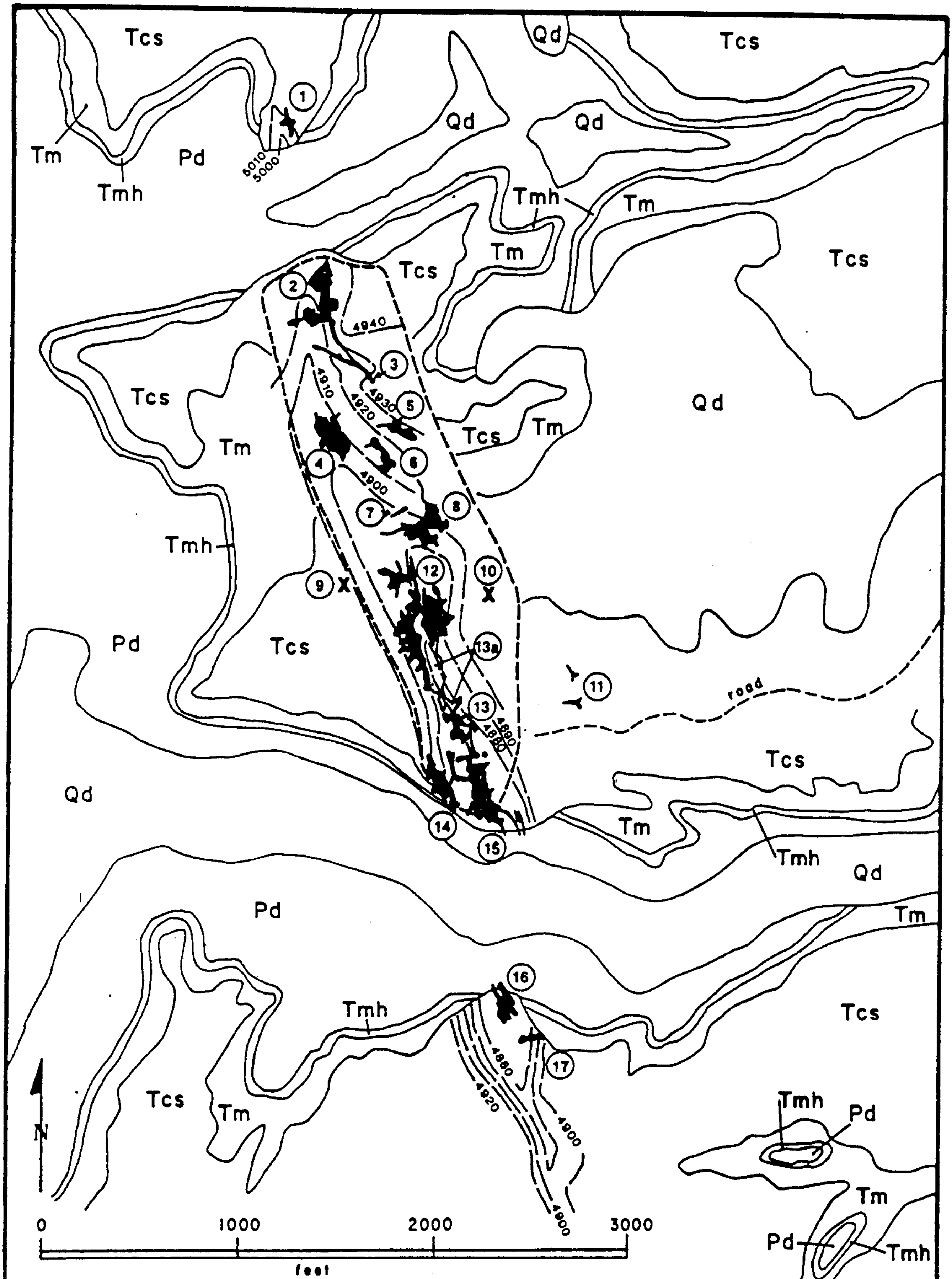
blackened areas are upper level workings
clear areas are lower level workings

open pit mine

Mine Names

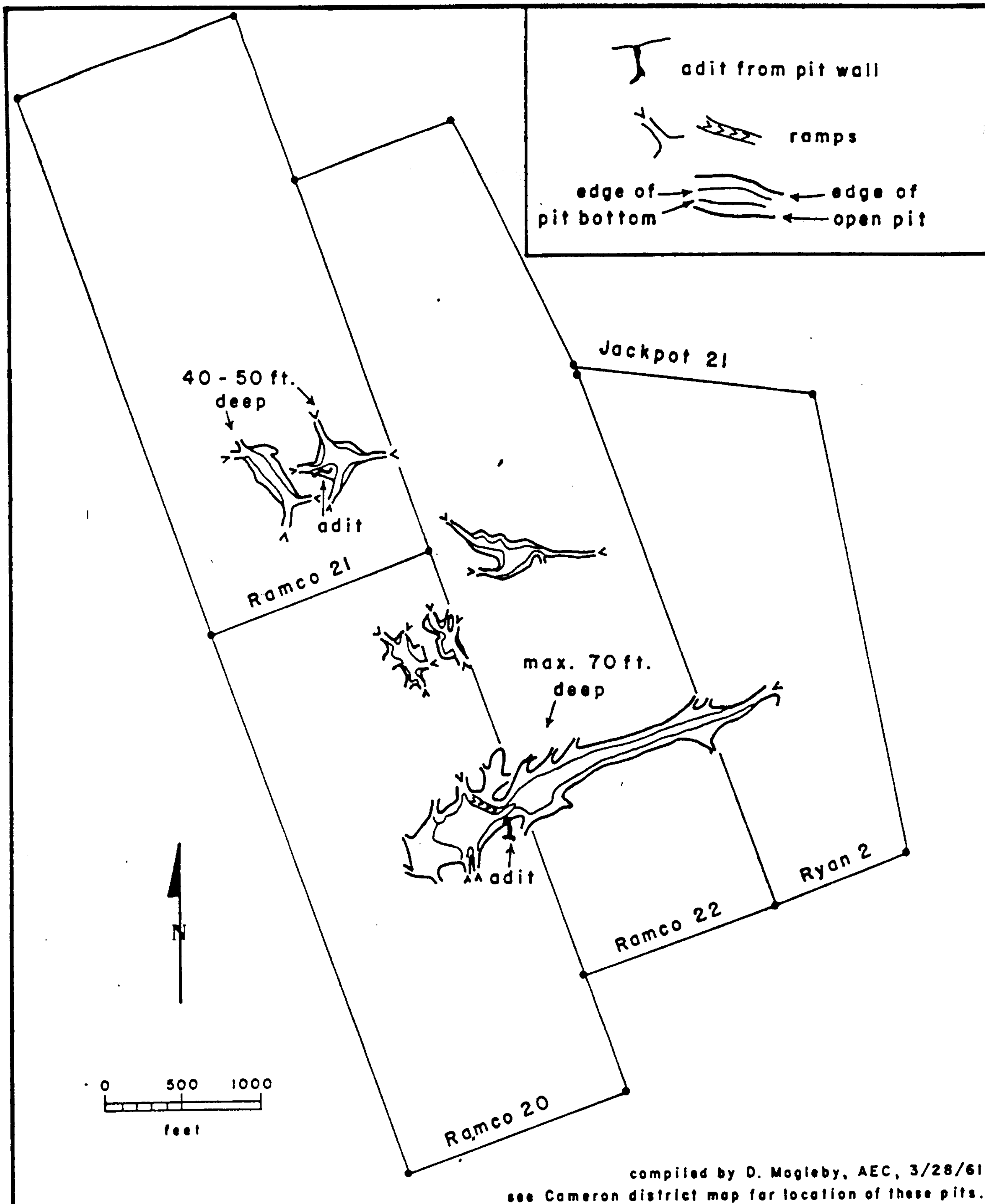
1	John M. Yazzie Mine
2	North workings, Monument No. 2
3	North drifts, Monument No. 2
4	West Red Oxide workings, Monument No. 2
5	East Red Oxide workings, Monument No. 2
6	South red oxide workings, Monument No. 2
7	Incline No. 3, Monument No. 2
8	Central workings, Monument No. 2
9	Cato Sells tract 2
10	Cato Sells tract 1
11	Black and Blackwater mine
12	Incline No. 1, Monument No. 2
13	Incline No. 2, Monument No. 2
13a	Incline No. 2, lower workings
14	Bobcat workings, Monument No. 2
15	South workings, Monument No. 2
16	South extension, Monument No. 2
17	Cato Sells tract No. 1 south

Geology and underground workings from Witkind and Thaden (1963).
Open pit outline from AEC guidebook RME-141, p. 2-63.



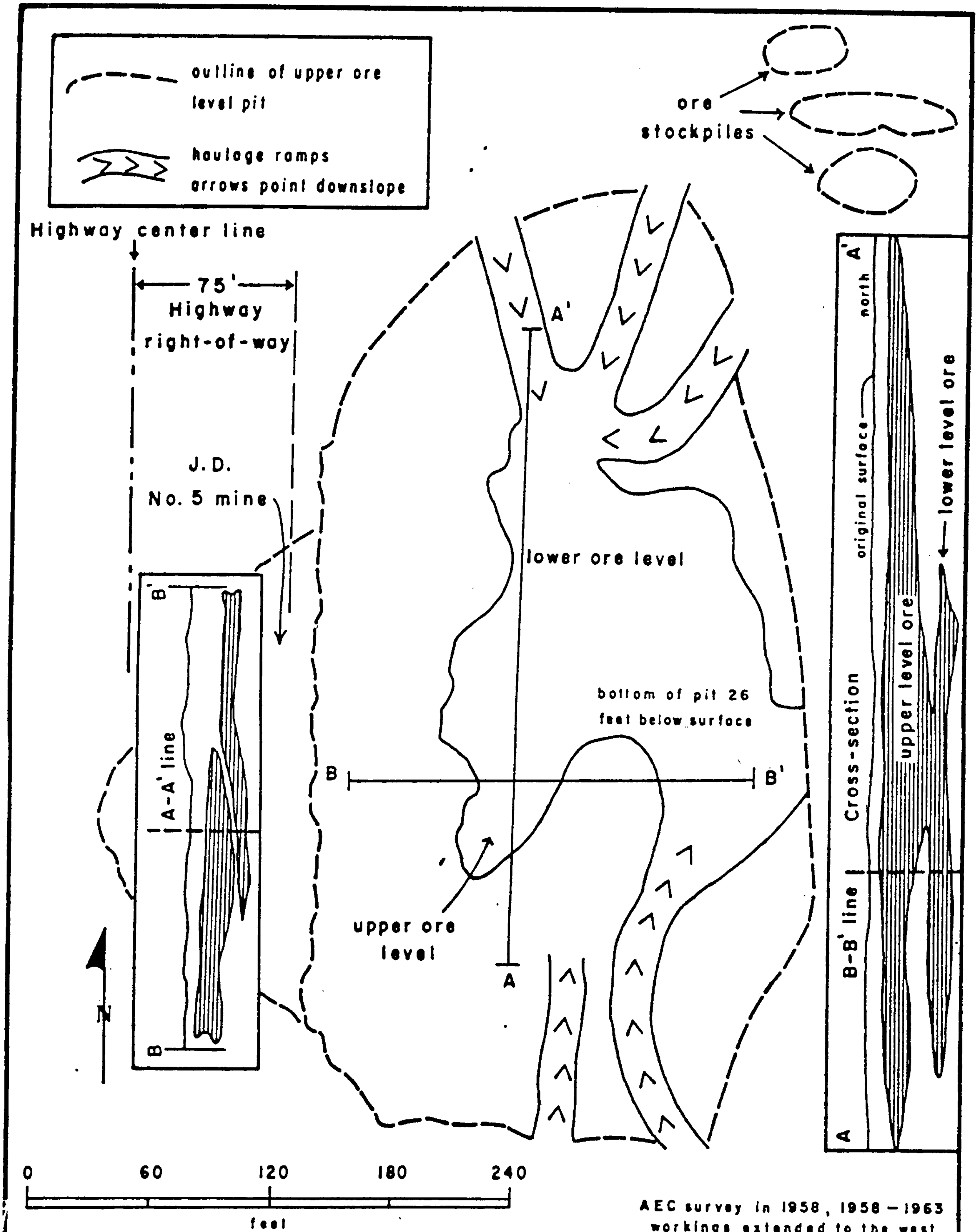
Geology and Mine Development at VCA s Monument No. 2 Mine, Apache County

Figure 17



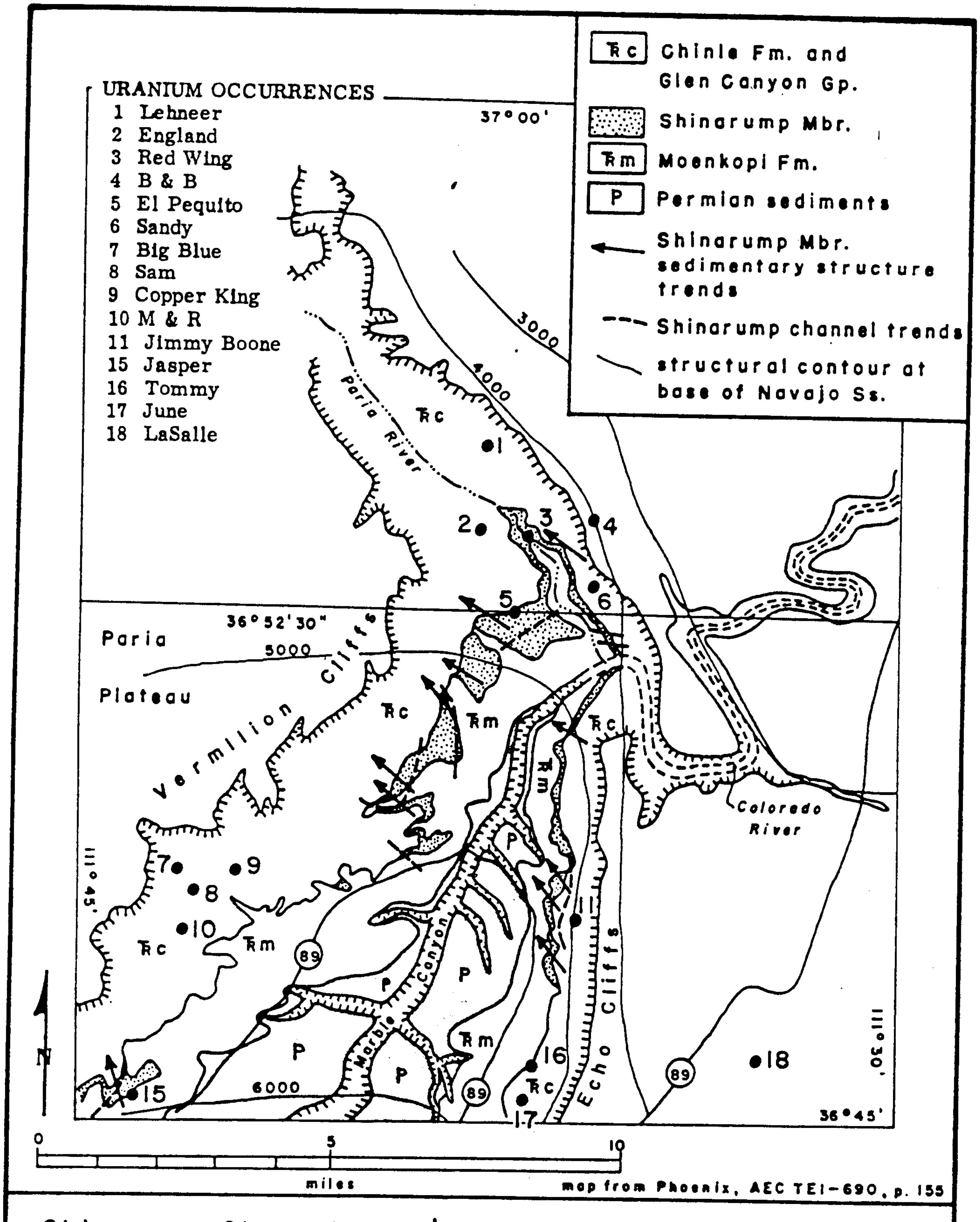
Pit Outlines, Ramco Pits, Cameron Area, Coconino County

Figure 19



Jack Daniels No. 1 Pit, Coconino County

Figure 18



Shinarump Channels, Lee's Ferry-Vermilion Cliffs area
Coconino County

Figure 20

TOREVA FORMATION

Thirteen mines in the upper Cretaceous Toreva Formation (Mesaverde Group) of eastern Black Mesa produced 16,781 tons of ore averaging 0.166% U_3O_8 between 1954-1958 and 1964-1968. An additional 123 tons was produced from two mines in the Salt Wash Member of the Morrison Formation a few miles north of Rough Rock trading post and were included in the Black Mountain-Rough Rock production figures on DOE Preliminary Map No. 31 of 16,903 tons @ 0.17% U_3O_8. Assays for vanadium on the Toreva ores were incomplete, but best indications are of a 1:1 U_3O_8:V_2O_5 ratio for the ores (Chenoweth and Malan, 1975).

General references on this area include DOE Preliminary Map No. 31, Clinton (1956), Repenning and Page (1956), Repenning and others (1969), O'Sullivan and others (1972), and Chenoweth and Malan (1973).

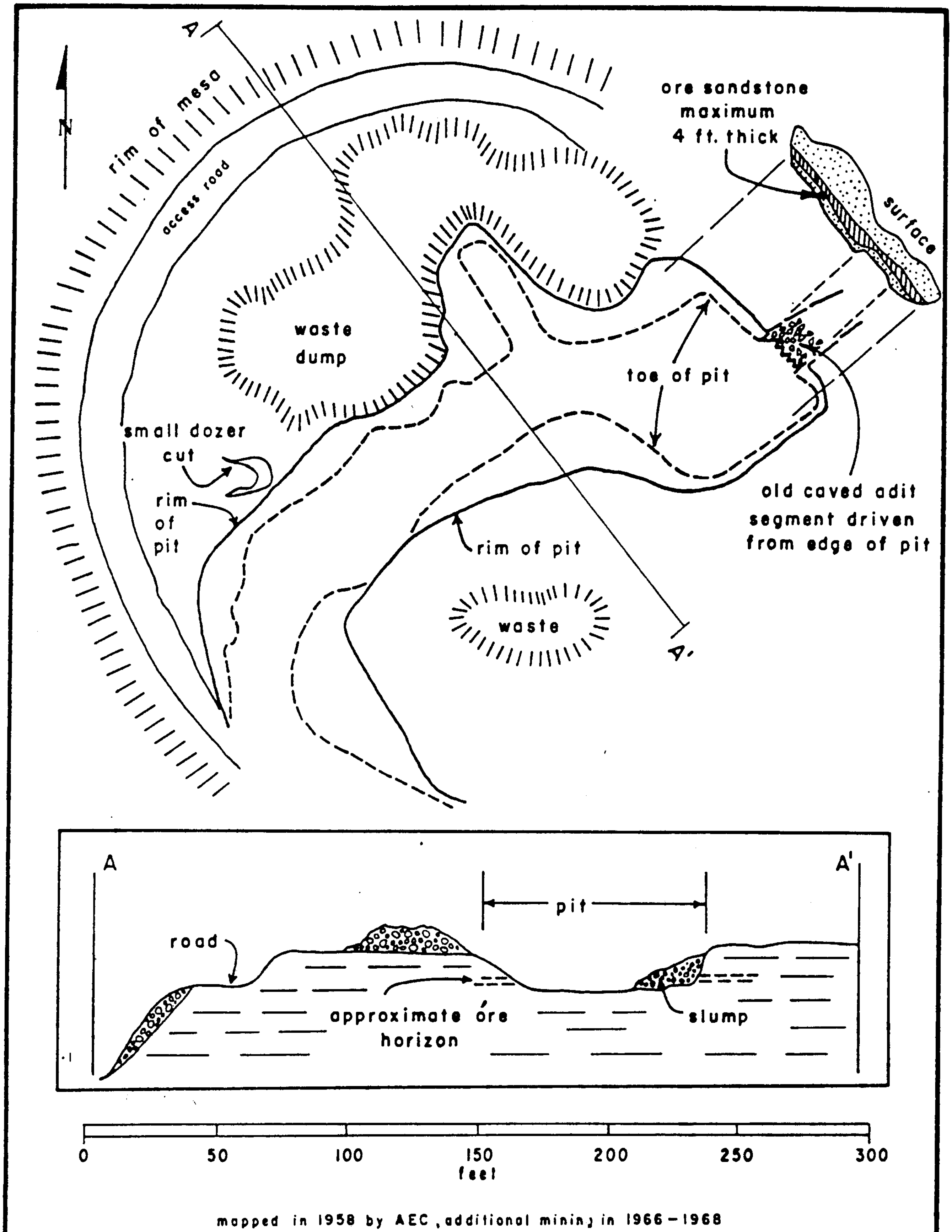
Uraniferous outcrops around Polacca Wash were brought to the attention of the AEC in January 1954. Subsequent ground and aerial surveys in 1954-1956 identified about 25 radioactive anomalies in the Lohali Point-Yale Point area, many of which were subsequently developed into mines. A few anomalies were caused by thorium-bearing heavy mineral placer accumulations in Upper Cretaceous intertidal sand deposits, discussed subsequently by Houston (1956), and Houston and Murphy (1977), who recognized these in association with the Cretaceous seaway throughout the Cordilleran region. See also Bingler (1963) for some northern New Mexico analogs.

Repenning and Page (1956) subdivided the Upper Cretaceous Mesaverde Group rocks of Black Mesa into three formations. They are, in ascending order, the Toreva Formation, Wepo Formation, and Yale Point Sandstone. These formations represent a complex intertonguing of marine and non-marine beds. See Cooley and others (1969, Figure 4) for a cross-section of Black Mesa stratigraphy and excellent geologic mapping. See also Beaumont and Dixon (1965) for additional geologic mapping in a part of the region.

The uraniferous horizons in the Toreva Formation occur in the "main ledge" sandstone, 140-170 feet of fine-to-medium grained noncalcareous sandstone, locally burrowed and micaceous, with lenses of coarse arkosic sandstone, coal, carbonaceous shale, and siltstone in the upper part. Most of the uranium occurs along bedding planes in low-relief channel sands in the upper 40 feet of the "main ledge," disseminated in the sandstone, quite often immediately below carbonaceous lenses. The host unit is described by Chenoweth and Malan (1973) as consisting of fining upward sequences interpreted as migrating point bar deposits with overlying abandoned channel-fill sediments. Facies relationships and channel cross-bedding measurements indicate a sediment source to the southwest, with a general NW-SE trend on paleo-shorelines in these beds. The NURE Gallup NTMS evaluation study concludes that these beds represent a delta-distributary system, one of the few of post-Dakota Sandstone age on the Colorado Plateau. The mined deposits consist of clusters of pods of ore-grade material surrounded by protore. Typical deposits measured 400 x 100 feet x less than 2 feet thick. Most ore was mined by shallow open pits, rim cuts, and in three places by underground methods (Rough Rock slope, Etsitty No. 1, and Claim 7). Uranium minerals include tyuyamunite and metatyuyamunite. Vanadium minerals include vanadium clays, metahewettite, and melanovanadite. Study of paragenesis at Etsitty No. 1 mine (Clinton, 1956) suggests first the introduction of vanadium clays and $CaCO_3$ (to 0.8% by weight of rock) as cementing agents followed by replacement in the interstitial voids by tyuyamunite.

The three largest uranium producers from the Toreva Formation are, in decreasing order of production, Claim 28 (17,300 lbs of U_3O_8 assaying 0.21%), Claim 10 (15,600 lbs. of U_3O_8 at 0.15%), and Claim 7 (12,500 lbs of U_3O_8 at 0.14%). Together these account for 81% of the U_3O_8 production from the Toreva Formation. The two other most significant deposits are Todecheenie No. 1 (6,100 lbs at 0.22%) and Claim No. 3 (2200 lbs at 0.15%), which make up an additional 15% of the total U_3O_8 produced. Figure 21 is a mine map of the Claim 28 mine.

Clinton (1956) suggests the most significant ore controls in the Toreva Formation to be: a) micaceous or arkosic quartz sandstones in close proximity to lignites or carbonaceous lenses, in shallow relief channel-fill deposits in the general stratigraphic context of interfingering marine Mancos Shale and fluvial (deltaic or shorline) Toreva sands and lagoonal deposits; b) localization of ore bodies at the sharpest bends in paleochannel directions, as indicated by cross-bed directions; and c) a NW-SE trending zone that lies on the steepest-dipping portion of the NE limb of the Black Mountain anticline-SW limb of the Rim syncline structure. This last point resembles that of W. L. Stokes on the ore controls of the northwest Carrizo Salt Wash mines (USAEC RME 3102, 1951), where he suggests response of stream directions and gradients in Salt Wash time to structural movements on nearby anticlines. However, the method by which the structures in these two cases act as ore controls is not confirmed. There is yet no direct evidence that there was structural movement contemporaneous with Toreva sedimentation whereby control of channel directions or placement of point-bar deposits was actually localized with respect to the fold structures seen today. However, Peirce and Wilt (1970, p. 18) note that stratigraphic thinning of overlying Wepo beds on Black Mesa may be related to structural bowing of the Maloney syncline during Wepo time. An equally probable hypothesis, at least in the Toreva (and Morrison) situation, is that postmineralization folding of the strata and subsequent erosion and stream cutting has merely exposed the mineralized areas and made discovery easier. Much of the folding may be Laramide in age; some of it could be Oligocene-Miocene in age, based solely upon intense tectonism in the Basin and Range country to the south during this time.



Claim 28 Mine, Black Mountain area, Apache County

Figure 21

BRECCIA PIPES

Breccia pipes are perhaps the most enigmatic of the Arizona uranium occurrence types. Those occurring on the Colorado Plateau are approximately vertically oriented chimney-like masses filled with brecciated, heterogeneous assemblages of sedimentary rocks derived from strata which have been displaced downward into the breccia pipe. Nearly one hundred pipes are known in northern Arizona, but uranium has been produced from only five. Of these, all but one have had less than 10,000 lbs of U_3O_8 production (Chapel, Ridenour, Hack Canyon, and Riverview), while the fifth (Orphan Lode) has been a major Arizona producer with production totaling nearly 4.4 million lbs of U_3O_8. Orphan production is exceeded in Arizona only by the Monument No. 2 Mine in Apache County. Because of the track record of the Orphan, exploration for more pipe uranium occurrences is continuing in the Grand Canyon-Arizona strip country. Certainly, many pipes contain radioactive anomalies, while perhaps the majority in this region are barren of mineralization at the surface. Methods such as detailed gravity surveying are being used to peer through superficial cover rocks in hopes of delineating buried pipes. Figure 22 indicates the geographic setting of the known pipes in the Grand Canyon region. Some of these are exposed in apparent WNW-trending groups or clusters where the Grand Canyon erosion event has stripped away cover rocks to expose the Coconino Sandstone-to-Redwall Limestone stratigraphic interval. Almost certainly, other pipes remain hidden in adjacent areas. The majority of the Grand Canyon pipes are found in the sedimentary units above the Mississippian Redwall Limestone. Frequently, their presence is indicated on aerial photographs by a bleaching to very light colors of red or red-brown clastic sediments. Barrington and Kerr (1963) describe analogous structures in the general Cameron area.

The only association of Plateau breccia pipes and attendant Cu-U minerals with any volcanic rocks known to this author is at the Copper House No. 2 claim of Mohave county, where a basalt dike underlies a gossen or iron-stained breccia zone which in turn is related to bleached radioactive Supai beds. The basalt is likely late Cenozoic in age, and may or may not postdate the Cu-U mineralization here.

Exploration continues for buried pipe structures, especially in the region north of the Grand Canyon. In December 1980, Energy Fuels Nuclear announced (Paydirt, No. 498, published at Bisbee, AZ) the discovery of a new breccia pipe about a half mile west of the Hack Canyon mine (Figure 23) in Mohave county. Drilling results indicate a possible 500,000 tons of uranium-copper ore in pipe fill. With a conservative grade of 0.3% U_3O_8, this represents 3 million pounds of U_3O_8. Ore shipments from the new Hack mine are going to Blanding, Utah starting in December 1980.

During 1979-1980, radioactivity associated with copper staining of surficial Kaibab Limestone in the Willaha-Anita area between the Grand Canyon and Williams (Coconino county) received some drilling attention, with the ultimate targets probably being buried breccia pipes such as the Orphan Lode. At least three companies have drilled an estimated two dozen holes. A strict Orphan Lode model would place major mineralization in Supai and Hermit beds, perhaps 1200 feet below the surface. This Kaibab surficial mineralization may also indicate that the breccia pipe phenomena of the region affected rocks at least as young as Kaibab limestone.

Example - Orphan Lode Mine

Many published reports have dealt with the complex origin and mineralization at the Orphan Lode, located near the tourist center along the south rim of the Grand Canyon. See Magleby (1961), Granger and Raup (1962), Kofford (1969), Gornitz and Kerr (1970), Bowles (1977) and Boyden (1978). Figuer 24 is a cross-section through the Orphan pipe, showing its approximate known vertical extent and overall mine development. Figure 25 shows plan views of the 245 and 400 foot levels in the mine. The following discussion is taken from the above sources.

The Orphan Lode claim was located in 1891 for surficial copper showings and was prospected intermittently for copper until about 1910. There may have been no actual production of copper from the mine. The claim was patented in 1906, with the papers being signed by President Theodore Roosevelt. The Grand Canyon was made a National Monument in 1909. In 1953, Golden Crown Mining Company acquired mining rights on the property, following the discovery of uraniferous minerals at the mine by H. Granger of the USGS in 1951. The company constructed an aerial tramway from the pipe outcrop to the canyon rim in 1955. Regular production began in 1956. Production was limited by the 1,000 ton/month capacity of the tramway. Late in 1959 first ore was removed by hoisting through a newly completed 1600 ft deep shaft and 1400 ft cross cut. A bill was passed by Congress in 1962 to allow the mining company (Western Equities since 1961) to mine newly found ore on National Park land, adjacent to the claim, in exchange for NPS ownership of the Orphan property 25 years hence, in 1987. Mining was continued from 1962 to 1967 by Western Equities, and 1967 through 1969 by the Cotter Corporation, which still controls mining rights. Most of the ore through 1969 was shipped to the Rare Metals mill in Tuba City.

The Orphan pipe surfaces in the lower Coconino Sandstone, 1000 feet below the rim of the canyon, and maintains a mean diameter of 230 feet down through the Hermit Shale. It then flares out symmetrically in the downward direction to a mean diameter of 400 to 500 feet in the upper Supai Formation. Vertical drilling suggests that the pipe bottoms near the middle of the Redwall Limestone, since lower units down to the Tapeats Sandstone beneath the mine appear undisturbed in a single deep drill hole.

Where mined, the materials filling the pipe were derived only from units above. Coconino Sandstone blocks have fallen as much as 275 feet below the Coconino base, and blocks of Hermit Shale beds have collapsed over 300 feet down to the 500 ft mine level. No volcanic material, Precambrian rocks, or lower Paleozoic rocks have been identified anywhere in the explored portions of the pipe, indicating only net downward transport of materials presumably due to some kind of collapse, perhaps provoked by solutioning of the underlying Redwall Limestone. Multiple collapse events appear to have occurred, since there are several "pipe within pipe" structures, separated by roughly concentric annular shear zones.

The pipe fill may be separated into breccia (containing blocks of recognizable Hermit, Coconino, and Supai lithologies), and massive sand fill, some of which has been partially calcified (calcite, with some dolomite and siderite filling intergranular spaces). Most of the loose sand fill was derived from the Coconino Sandstone.

The outer pipe wall is a sharp contact. Extensive color bleaching of the surrounding in situ rocks is noted for several feet beyond the pipe wall.

Briefly, there are two main types of ore occurrence in the mine, annular ring (includes "A" ore body of Figure 24) and interior pipe fill ("B" ore body). The "B" ore occurs in the highly fractured and brecciated central interior of the pipe. This ore extends from near the surface outcropping of the pipe to about the 450 ft level. Kofford believes the "B" body lies within an interior "pipe-within-pipe" which was displaced downward with respect to the "A" ore body. The annular ring ore is generally concentrated near the perimeter of the pipe, especially just below the level where the pipe constricts in the upward direction. It has been found downward to near the 550 ft level. In more detail, the annular ring occurs in (1) the shear zone marking the pipe boundary, especially above the Hermit-Supai contact, where it was mined as the high-grade "A" ore body, (2) the breccia just inside those shears, and (3) the disturbed and undisturbed rocks just outside the pipe in the Supai Formation. Outside the pipe, most of the annular ring ore is stratigraphically confined to certain sandy layers in a ring zone surrounding the pipe averaging 6-50 ft wide, and is controlled by placement of annular fractures surrounding the pipe. The annular ring ore appears to bottom out on top of a shale bed in the Supai Formation. In general, more ore occurs in areas having a greater intensity of shearing. High grade ore from the annular ring consists of uraninite intergrown with red earthy hematite, and fine-grained pyrite-chalcopyrite.

Uranium occurs chiefly as uraninite in interstitial intergranular fillings and veinlets following shear zones along with numerous other minerals of iron, copper, lead, zinc, nickel, and cobalt. Some molybdenum, arsenic, silver, maganesium, and barium minerals were also introduced. More than 60 minerals are reported for the mine.

Both sulfide and oxidized mineral assemblages are recognized. The detailed mineral investigations generally conclude that there was, in most part, a rapid, simultaneous precipitation of the sulfide components. The oxidized components may have been formed during the late Cenozoic Grand Canyon cutting event, and, more particularly, during the creation of the Esplanade surface inside the canyon (Bowles, 1977). This surface is a bench formed at the contact between the Hermit Shale above and the Supai Formation below.

Mineral zoning within the pipe is recognized, both in a lateral and vertical sense. The core of the pipe is mostly pyrite and uraninite, whereas the margins contain uraninite with a complex mixture of chalcocite, tennantite, various Ni-Co arsenides, and galena. The galena is of "common lead" composition (i.e., not recently separated from parent uranium) according to Miller and Kulp (1963). Although pyrite and marcasite are distributed throughout the vertical extent of the pipe, uranium content of ore generally increases upward in direct proportion to galena content. The sulfur in the sulfides has a highly fractionated isotopic composition which is much more similar to bacterially produced sedimentary sulfides than usual hypogene sulfide systems.

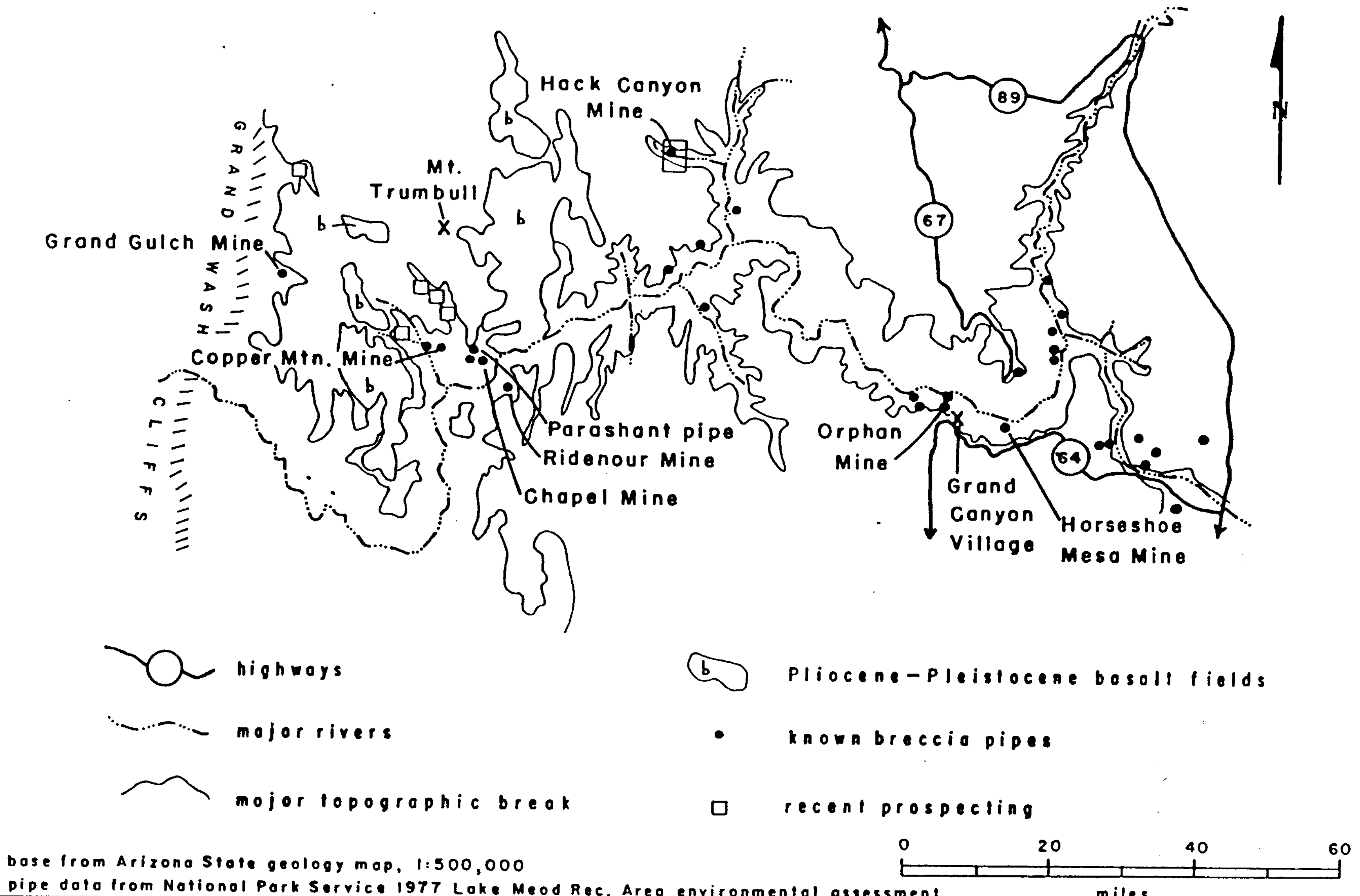
Kaolinite and illite (1 Md_1, minor 2 M_1) are the only clays associated with mineralization, and hence true arillic alteration may not be present

(Gornitz and Kerr, 1970). Fluid inclusion studies indicate temperature of formation of calcite in the pipe fill of 60-110°C. Miller and Kulp (1963) report sphalerite equilibration temperatures of not above 90°C.

Isotopic ages by various uranium-lead methodologies produce complex, discordant patterns for time of mineralization at the Orphan Mine. Gornitz and Kerr (1970) report age attempts of Miller and Kulp ranging from 87 to 402 m.y., with their best estimate for a minimum age of mineralization being 140 m.y. Miller and Kulp (1963) had originally reported "best" ages of 100-120 m.y. based upon their calculations of U-Pb systematics, including a hypothesized one or two-stage lead-loss model. Each lead loss episode hypothetically involves the dissolution and reprecipitation of "new" uraninite.

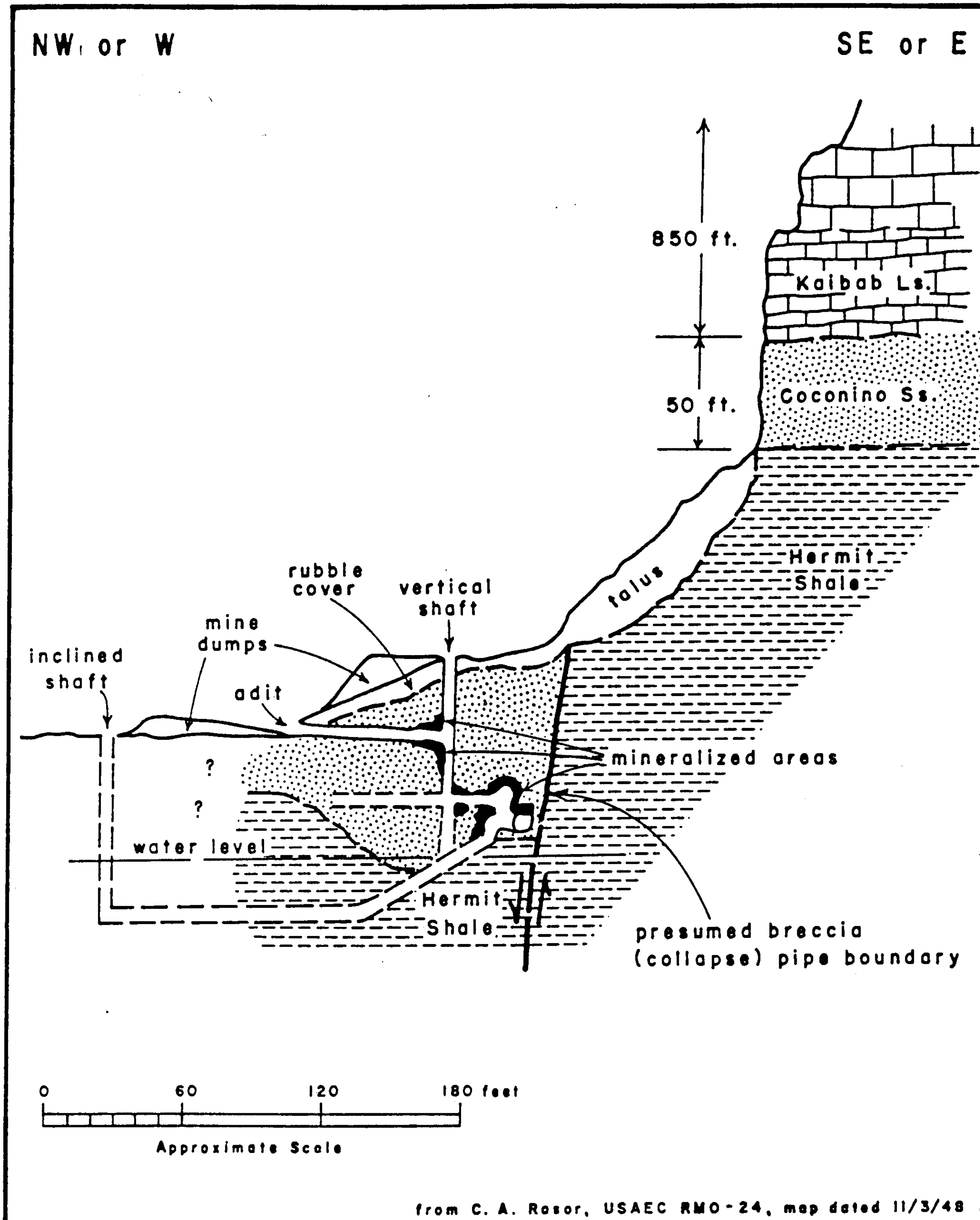
The origin of the Orphan ores remains enigmatic. We think that (1) the pipe formed by collapse into a solution cavity formed in upper Redwall Limestone, and (2) low-temperature copper-uranium mineralization was emplaced into permeable fissure systems and porous sandstone pipe fill, along with probably bacterially-derived sulfide sulfur, probably during the Jurassic-early Cretaceous time interval (120-140 m.y. ago). Major unanswered questions include the reason for the localization of the ores near the pipe constriction at the base of the Hermit Shale, the direction from which the mineralizing solutions came, the role in localizing uranium of carbonaceous materials found in the pipe (Kofford, 1969), and the thickness and lateral extent of Mesozoic cover rocks over the Grand Canyon at the time of mineralization.

Finally, one might consider a possible relationship between uranium mineralization during the late Jurassic - early Cretaceous at the Orphan Lode (as deduced by uranium dating) and the large amount of stratabound uranium-vanadium ore in the late Jurassic Morrison Formation of the Four Corners region, which is known to have sediment source areas to the west and south, in the general direction of the Grand Canyon region. It is possible that chemical components of both the Orphan and Morrison ores were transported northeastward in groundwaters or supergene solutions derived from Mogollon highlands volcanic sources in Morrison time or pre-Dakota time, and subsequently chemically fractionated into Cu-U and V-U-Cu components and precipitated in their respective environments. In this model, the stratigraphic lid that overlies both these deposit types is the regional truncation surface that underlies the Dakota Sandstone.



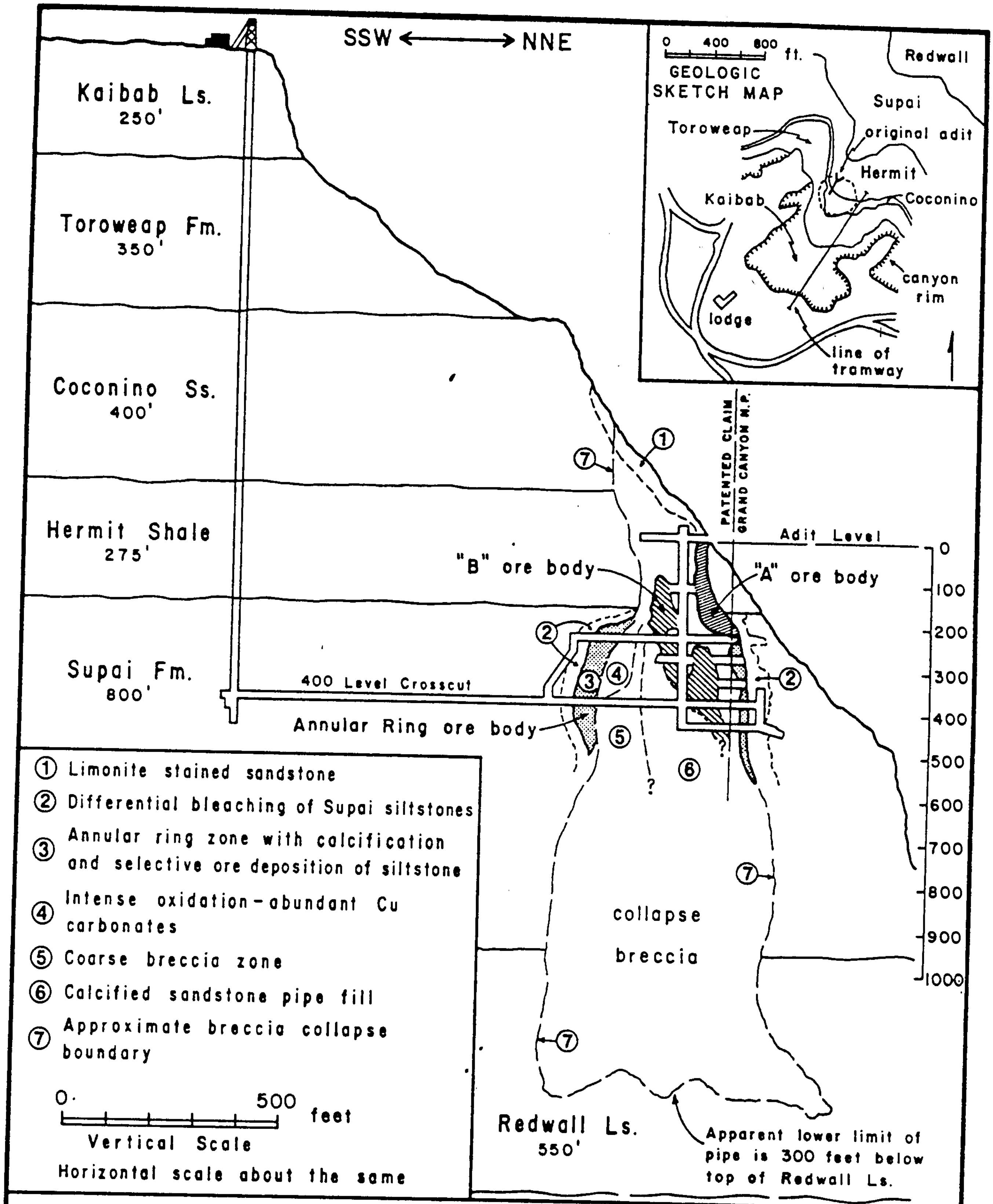
Location of breccia pipes in the Grand Canyon region, Coconino and Mohave Counties

Figure 22



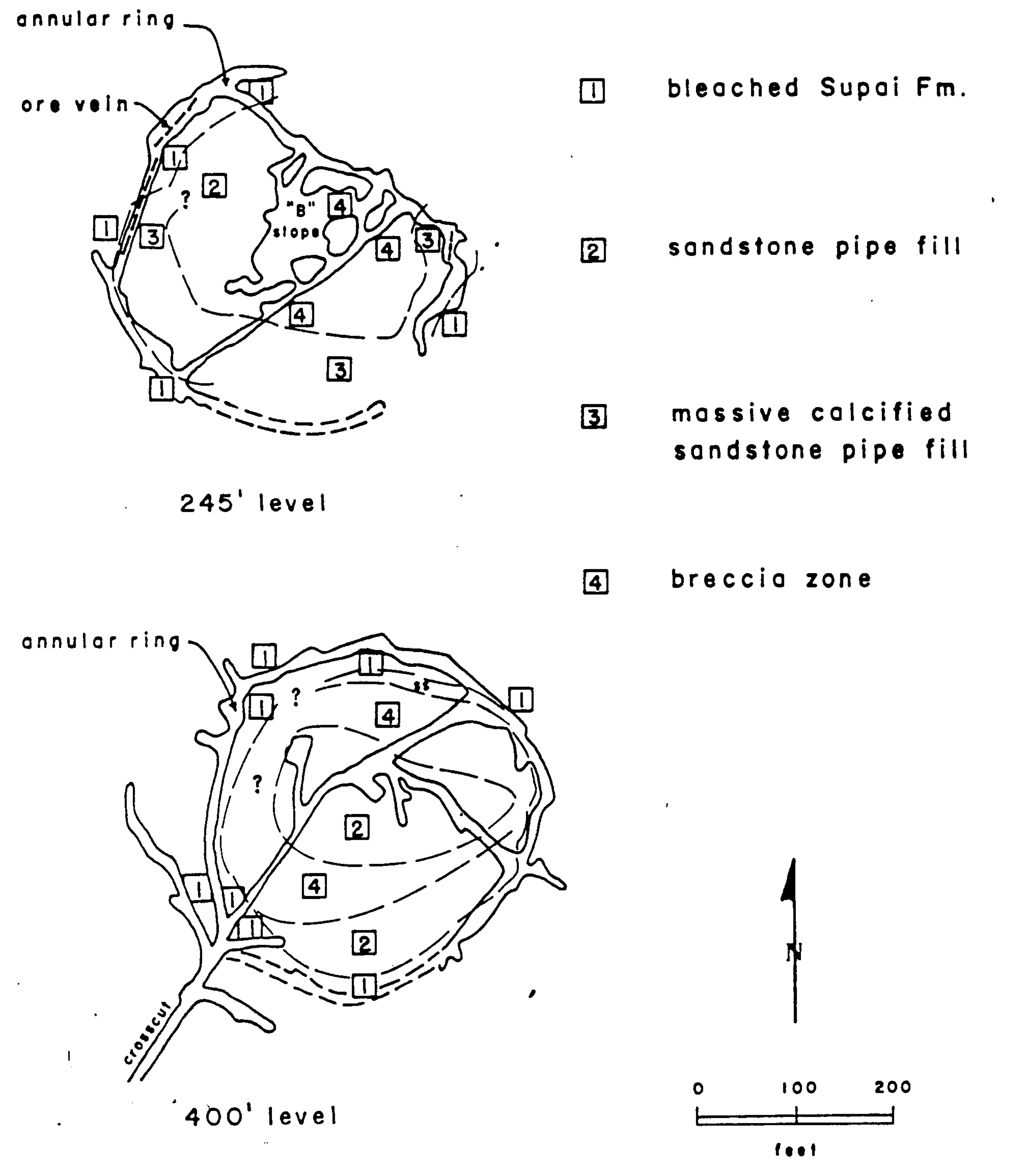
Generalized Cross Section through Hack Canyon Mine, Mohave County

Figure 23



Cross-Section of Orphan Lode, Grand Canyon National Park, Coconino County — composite of several published and unpublished maps, including Kofford (1969) and Gornitz and Kerr (1970).

Figure 24



Plan View of 245' and 400' levels, Orphan Lode from Gornitz and Kerr (1970)

Figure 25

HOPI BUTTES

Uranium was discovered in the Hopi Butte volcanic field of Navajo County in the early 1950s , with only one claim, the Morale, having yielded ore-grade material. Much uranium-related geologic work in the Hopi Buttes during the 1950s was discussed in open-filed USAEC TEI reports by Eugene Shoemaker, and summarized by Shoemaker, Roach, and Byers (1962). See also Lowell (1950). The USGS, in cooperation with the Bureau of Indian Affairs (BIA), did supplemental geology, petrology, and drilling studies during 1978-1980 which will appear in the NURE Flagstaff and Gallup NTMS folio evaluations (available for public inspection in Grand Junction as of January 1981). A summary of this work appears in Wenrich-Verbeek and Shoemaker (1980). The details below follow from these discussions.

The Hopi Buttes volcanic field consists of about 300 diatremes and associated flows and tuff beds contained in a circular field about 20 miles in diameter. The volcanic rocks of the field, where dated by K/Ar and paleontologic methods, range in age from 4 to 8 m.y. old. By all available evidence they erupted through a lacustrine environment which had already deposited varicolored lakebeds of the Bidahochi Formation in what is now called Hopi Lake. The diatremes and their associated tuffs and flows are seen to rest on top of these lakebeds. The uraniferous lakebeds are deposited inside the diatremes. The volcanics are depositionally overlain in the eastern part of the field by a fluvial (and aeolian?) sandstone (uppermost member of the Bidahochi Formation according to Shoemaker et al., 1962). The Bidahochi lakebeds rest upon Jurassic Wingate Sandstone in the southern part of the Hopi Buttes area, and upon younger Dakota Ss, Mancos Shale, and Mesaverde Group rocks of Upper Cretaceous age in the northern part.

Petrologically, the Hopi Buttes volcanic rocks are classified as limburgites and monchiquites, grading northwestward to minettes. These rocks have lower silica contents (<47%) and higher Na, K, Ti, and P contents as compared to "normal" continental alkali basalts of the southern Colorado Plateau. They also are notably high in Ag, Ba, Sr., Y, Zr, and U, with an average of 4 ppm U as compared with 1 ppm average for the continental basalts. They also generally contain primary $CaCO_3$, present as included masses and veinlets.

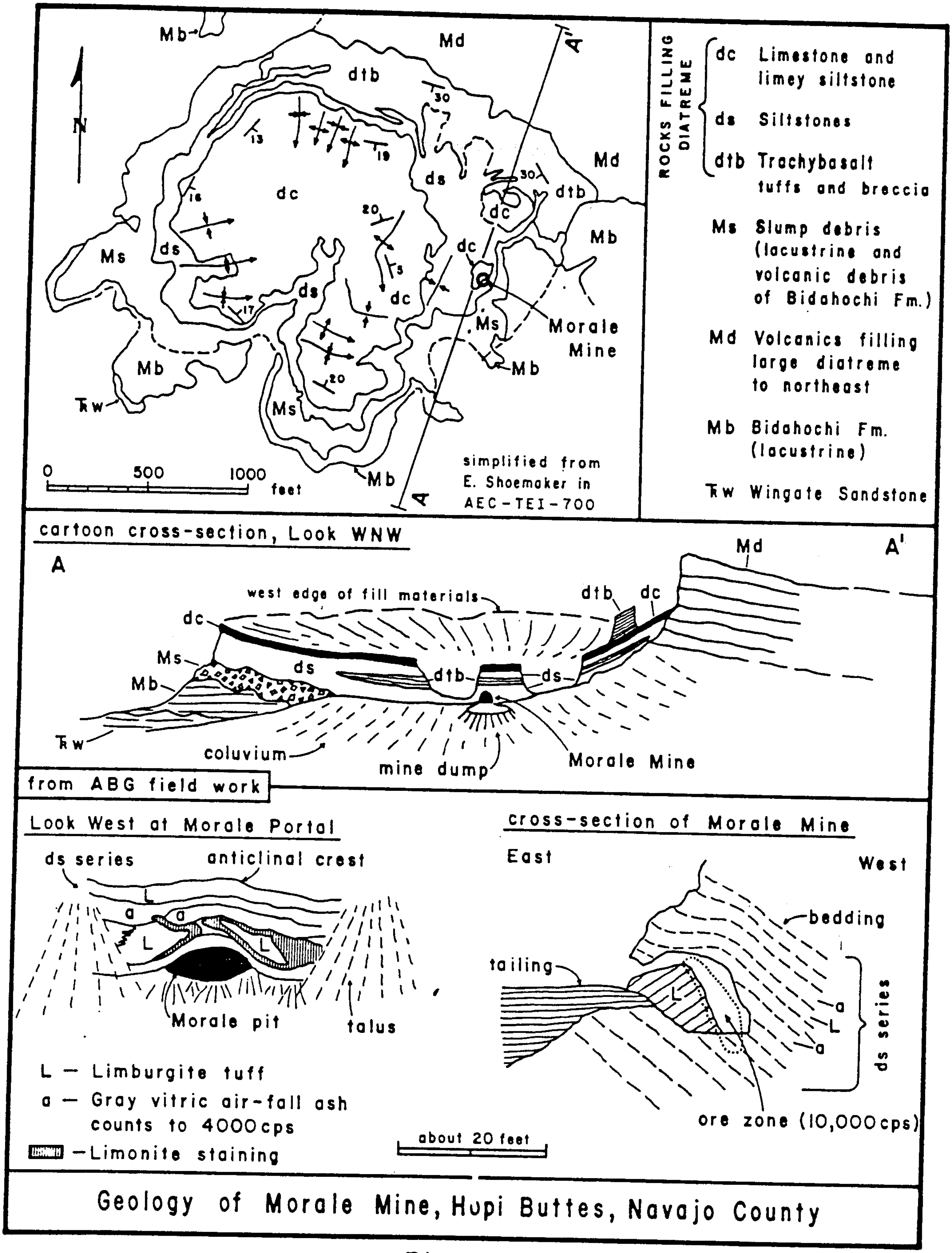
The diatremes are funnel shaped with sharp inward-dipping contacts with Bidahochi or older wallrocks. Spatter flows and coeval limburgite tuff distal facies compose the outer portion of the diatremes, with the diatreme interiors filled with brecciated debris produced from collapse and infilling following the phreatomagmatic diatreme-forming eruptions. This infill is composed of blocks of limburgite tuffs, flow rocks, and, Wingate Ss and other older wall rock material. Precambrian clasts are uncommon except in local circumstances.

After explosion and collapse of the central vent, the diatremes stood with bowl-shaped depressions which filled with up to 200 feet of mudstones and travertine-like carbonate layers, along with some rhyolitic air-fall ash beds which were being erupted from vents in the Hopi Buttes field. However, it is not clear if these later sediments were also deposited outside the diatremes, perhaps in a still-extant Hopi Lake, and were later removed in all areas except atop the diatremes by the erosion event that left the Hopi Butte diatremes standing as resistant "plugs". Alternately, the sediments could have been originally confined to individual ponds inside the diatremes, at a time when Hopi Lake was drying up. A question also arises concerning the origin of the bowl-style symmetrical inward dips of the sediments. They nonconformably overlie the volcanogenic collapsed infill and have flat dips near the center, and progressively steeper dips outward towards the diatreme margins. In places, 20-30° inward dips on shales (which at one place at Coliseum diatreme contain a fish fossil) suggest some post-sedimentation diatreme collapse may have occurred. If so, this post-sediment collapse could be a contributing reason for the preservation of these uraniferous sediments only inside the diatreme bowls, since only there were they protected from erosion because of resistant volcanic bowls surrounding them.

The "perched" diatreme infill sediments are the sole host for the 35 known uranium occurrences of the Hopi Buttes. Twenty of the occurrences in infill deposits contain radioactivity levels 5 times background. No anomalous radioactivity has been noticed at any Hopi Butte eruptive center that lacks these diatreme sediments. The most recent USGS work suggests that the limestone layers in the sediments resemble hot spring travertines and contain characteristic high concentrations of phosphate, sulfate, Ba, Sr, U, Se, Co, Ni, etc. These observations suggest a mineralization model involving thermal waters associated with the diatremes which supplied uranium to the diatreme sediments.

In detail, uranium is noted in two positions within the diatreme sediments. Both positions are noted at the Seth-la-kai diatreme, containing the Morale claim (see Figure 26). Uranium is stratigraphically confined to sandstone, mudstone, or limestone beds in the main mass of the sediments. And, at the Morale claim proper (Figure 26), uranium is concentrated (with assays to 0.50% U_3O_8) in lowermost permeable volcanic sandstone beds which are draped over blocks of limburgite tuff which protrude through the unconformity between the lower volcanic slump debris and the overlying diatreme sediments. Here, and elsewhere, there is a clear concentration of radioactivity near anticlinal crests in the younger sediments. Some radioactivity has been noted along fault boundaries at or near the diatreme margin, as well.

The recent USGS-BIA Hopi Buttes drilling program consisted of 24 holes through the diatreme sediment beds at Seth-la-kai diatreme and 6 holes drilled into Hoskie Tso diatreme. Based on this drilling, the USGS projects a content of nearly 400,000 lbs of U_3O_8 in an upper 50 foot interval at Seth-la-kai. Previous production from the Morale ore zone is listed as 576 lbs of U_3O_8 in grades of 0.15% U_3O_8 and 0.04% V_2O_5 between 1954 and 1959. Hoskie Tso diatreme drilling indicated very low uranium grades and thicknesses. Overall, however, assuming 30 diatremes to have similar uranium contents and ore volumes as Seth-la-kai, the USGS projects a content of 30,000,000 lbs of U_3O_8 in the Hopi Buttes, assuming average grades of 0.01% U_3O_8.



Mb
Md
dtb
dc
ds
Ms
Mb
Ŧ̄ₓw
N
A'
A
Morale Mine
0 500 1000 feet
simplified from E. Shoemaker in AEC-TEI-700
ROCKS FILLING DIATREME
dc Limestone and limey siltstone
ds Siltstones
dtb Trachybasalt tuffs and breccia
Ms Slump debris (lacustrine and volcanic debris of Bidahochi Fm.)
Md Volcanics filling large diatreme to northeast
Mb Bidahochi Fm. (lacustrine)
Ŧ̄ₓw Wingate Sandstone
cartoon cross-section, Look WNW
west edge of fill materials
coluvium
mine dump
Morale Mine
from ABG field work
Look West at Morale Portal
ds series
anticlinal crest
Morale pit
talus
L — Limburgite tuff
a — Gray vitric air-fall ash counts to 4000cps
—Limonite staining
about 20 feet
cross-section of Morale Mine
East
West
bedding
tailing
ds series
ore zone (10,000cps)
Geology of Morale Mine, Hupi Buttes, Navajo County

Figure 26

OTHER HOST ROCKS

Other Paleozoic and Mesozoic sedimentary rocks of the Colorado Plateau region are known to contain uranium anomalies. These strata include, in order of decreasing age, Naco-Supai Formations, basal Coconino Sandstone, the Kaibab Limestone, basal Moenkopi Formation, the Sonsela Sandstone of the Chinle Formation, the lower Kayenta Formation, and the Dakota Sandstone.

Radioactive clastic units near the contact of the Naco and Supai Formations, near the Pennsylvanian-Permian boundary, at Promontory Butte, Gila County have been explored by at least two drill programs in the 1970's. One shipment of less than 500 tons of low grade ore was made from the Neptune (Promontory Butte listing) in 1979. The host rocks consist of gray sandy shales associated with limestone pebble conglomerate lenses, both overlain and underlain by sandy redbeds (see Blazey, 1971; Peirce and others, 1977). The strata contain locally abundant carbonized plant remains. Uranium and copper carbonate mineralization are apparently loosely associated with the gray shales, contacts between various beds, and organic matter.

One occurrence of radioactive oxidized copper carbonates and iron-manganese staining is recorded at Saucer No. 1 claim, Coconino County, at the contact between the Hermit Shale and the Coconino Sandstone.

Radioactive oxidized copper occurrences in the Permian Kaibab Limestone are recorded at the following localities: In Coconino County at the Airport mine, Anita copper mine, Barranca de Cobre, Blue Bonnet, Copper No. 1, Packrat, National, Twin Tanks, and unnamed "B" occurrences, and at the School section claims of Mohave County. The Copper No. 1 claims shipped 29 tons of ore @ 0.10% U_3O_8 and 0.02% V_2O_5 in late 1956 under the name of the Doty Group.

The Kaibab occurrences are usually copper carbonates lining fractures, sometimes localized at crests of small tight folds. In the Willaha-Anita area north of Williams, some drilling was done in the early 1970s and again in 1979-1980 by at least three companies. The contemplation of a possible relationship between these surface copper-uranium shows and a possible buried pipe structure as represented by the nearby Orphan Lode, a major copper-uranium producer, is probably sparking this interest. Preliminary indications from the Willaha-Anita area are that pipe structures are present. If so, then this indicates that elements of pipe formation transgress upwards at least to the Kaibab Limestone, an observation not discernable at the Orphan Lode or at Hack Canyon because the pipes there top-out below the Kaibab.

Four radioactive occurrences with copper shows are recorded from the basal Moenkopi Formation: in Coconino County at the Clover Leaf mine No. 1 and at unnamed "C"; and in Mohave County at the Fredonia No. 1 and Little Three No. 1 claims.

Mineralization near the Sonsela Sandstone of the Petrified Forest Member of the Chinle Formation is found at the Mac No. 3 claims and the Ruth Mine of Navajo County. Stratigraphically, these grade downward into the numerous lower Petrified Forest Member ores around the Cameron-Holbrook district. The Ruth mine was the largest of the Holbrook area producers and is credited with small shipments in 1976 and 1978.

The lower Kayenta Formation yielded some uranium ore from the Cameron area (Coconino County) from two properties, Ward Terrace and Yellow Jeep during the 1950s.

The Navajo Sandstone (Jurassic? or Triassic?) contains three uranium-copper occurrences, in Coconino County at the Copper Mine Trading Post and at White Mesa copper claims, and in Apache County at the Bluestone No. 1 claims. Bluestone produced 53 tons of ore @ 0.22% U_3O_8 in 1956.

The Recapture Member of the Morrison Formation in the Lukachukai Mountains contains several anomalies which are noted in Chenoweth and Malan (1975). These are not plotted on the Lukachukai district map because of lack of location details.

Finally, the Cretaceous Dakota Sandstone contains one radioactive anomaly in Navajo County at the Fred Zahne Nos. 1-5 claims in a uraniferous lignitic coal bed.

COLORADO PLATEAU MINERALIZATION

SYNTHESIS

Many aspects of uranium mineralization in Colorado Plateau sedimentary rocks reccur in most host lithologies, irrespective of age. These have been noted by many previous workers including Finch, 1953; Stokes, 1954; Mullens and Freeman, 1957, Kerr, 1958; Peterson, 1977; and Galloway, 1979. The important themes are repeated here:

a) A primary lithologic characteristic of host rocks is interbedded sandstones and mudstones rather than sandstone-dominated units. The Lukachukai district map (Plate 19) shows this relationship very well. Auxiliary feldspar and mica grains are frequently mentioned.

b) Carbonized plant debris, present as mattes between sandstone-mudstone beds or disseminated in sandstones, or as fossil wood or log fragments, is ubiquitous in larger uranium deposits.

c) The recurring paleonenvironmental theme involves fluvial (stream) systems on alluvial fans, or delta distributary channel systems adjacent to lacustrine environments. No major Arizona Plateau sedimentary deposit is contained in any other paleonenvironmental setting.

d) Plateau uranium deposits are geochemically segregated - for unknown reasons - into either uranium-copper or uranium-vanadium associations (Finch,1953).

e) Plateau-type structural features are often noted to "accompany" uranium districts and mention is made of genetic relationships (Kerr, 1958; Stokes, 1954), the hypothesis being that the structures recognized today (monoclines, uplifts, etc.) had some movement history during sedimentation and hence somehow controlled favorable lithologies such as meander bend positions. At times, though, as in the Lukachukai Mountains, these effects may be very subtle, or even nonexistent. Overall, this aspect of the theme of Colorado Plateau uranium distribution may relate to the simple uncovering and erosion of the strata along flanks of uplifts or monocline middle limbs, making the mineralized strata discoverable.

f) The geochemically divergent mineral associations for the Plateau uranium deposits indicates complex, multiphase migration, chemical zonation, and fixing of uranium and related species (see Botinelly and Weeks, 1957). Paleothermometry measurements (Coleman, 1957) indicate low (55-115^{o}C) temperature of mineralization. Bleached zones, liesegang banding, fracture control of some veins, and mineral zoning all indicate post-sedimentation, diagenetic movement of ore-related solutions at somewhat elevated temperatures. Radiometric dating of uranium minerals and authigenic clays suggest a Jurassic-Cretaceous age for mineralization, a result that agrees with field data.

g) The ultimate source of uranium is most probably the Mesozoic arc volcanism and plutonism along the west coast of North America. Malan (1968) suggests that the pyroclastic components of this volcanism could be a primary source of Colorado Plateau uranium. Deep-seated hydrothermal emplacement of the ore-bearing solutions has sparce supportive evidence for the Plateau deposits (see Finnell, 1957 and Kerr, 1958). An alternate source of uranium

The lower Kayenta Formation yielded some uranium ore from the Cameron area (Coconino County) from two properties, Ward Terrace and Yellow Jeep during the 1950s.

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could be Precambrian crystalline rocks present either in the Mogollon highlands or beneath the Colorado Plateau. Silver (1976) and Silver and others (1980) suggest the presence of a regional uranium anomaly in Precambrian basement rocks centered beneath the part of the Colorado Plateau that contains all the major producing uranium districts. Their work is based on uranium concentrations in igneous zircons.

SOUTHERN ARIZONA REGION

STRATABOUND OCCURRENCES

Dripping Spring Quartzite

During 1953-1960, a total of over 122,000 lbs of U_3O_8 concentrate has been produced from 18 mines in the Precambrian Dripping Spring Quartzite in Gila County, with an overall average grade of nearly 0.20% U_3O_8. The vanadium content of the ores from two properties amounted to 6500 lbs of V_2O_5.

Uranium was discovered in the Dripping Spring Quartzite in 1950 at the Red Bluff property and in 1953 along Workman Creek. In the spring of 1954 the AEC conducted a three-month low-level airborne gamma ray survey of the Sierra Ancha area, resulting in more than twenty new discoveries which were subsequently prospected. In July, 1955, an AEC ore-buying station was established at a railhead at Cutter (near Globe) primarily to purchase Sierra Ancha Dripping Spring Quartzite ores. It closed June 30, 1957, when the AEC determined that remaining ore volumes were too small for further economic consideration. Because this buying station also received other ores from southern Arizona, its operation essentially controlled uranium mining in the region.

Overall, uranium production in Dripping Spring Quartzite ores has been disappointing. Cutoff width of ore grade veins has often been one to two feet. Past that width, dilution of ore by low grade wall rock was a serious problem, especially since ore sorting was difficult by using geiger counters. Ore veins were quite limited in extent, typically measuring 2 ft thick, 10 to 20 ft in height, and 100 to 200 feet in length.

Major discussions of Dripping Spring Quartzite uranium occurrences are found in Williams (1957), Schwartz (1957), Walker and Osterwald (1963), and Granger and Raup 1969(a) and 1969(b). In addition, the NURE Mesa quadrangle evaluation report prepared by Bendix, in review as of February 1981 contains an appraisal of Dripping Spring Quartzite occurrences. See Granger and Raup (1964) and Shride (1967) for discussions of central Arizona younger Precambrian stratigraphy.

The Dripping Spring Quartzite is a member of the late Proterozoic-aged Apache Group, which consists in ascending order of the Pioneer Shale, the Dripping Spring Quartzite, the Mescal Limestone, and a capping basalt (Figure 27). The Apache Group sediments were deposited on a surface cut on Precambrian granites and metamorphic rocks that have age dates as young as about 1,380 m.y. The Apache Group is overlain disconformably by the Troy Quartzie. All of these sediments are intruded by massive diabase-syenite sills that have age dates ranging from 1,050 to 1,250 m.y. (all age data from Livingston, 1969). Apache Group rocks are approximate lithologic equivalents of the Unkar Group sediments of the Arizona Grand Canyon region (described by Breed and Roat, 1974), and are rough age equivalents of the middle Belt Carbonate unit of the Belt Group sediments of Idaho, Montana, Alberta, and British Columbia, as described by Harrison (1972). Curiously, as Harrison points out, anomalously high copper values are found in many of the Belt terrain rocks, and are attributed to a syngenetic-diagenetic origin. Similarly, farther north in northern Saskatchewan, a moderate-size uranium deposit in quartzites of the Athabasca Formation (± 1,250 m.y. age) at McClean Lake is now being developed (anonymous, 1980). Here it is suggested that the uranium was hydrothermally derived from the underlying basement complex and precipitated in a reducing environment in the sandstones before their metamorphism to quartzites.

Carlisle and others (1980) describe uranium anomalies in the lower part of the Kingston Peak Formation of the late Proterozoic Pahrump Groups of southern California. These sediments, like the Apache Group, rest on 1400 m.y. crystalline rocks containing abundant uranium anomalies (World Beater complex). The Kingston Peak Formation is overlain unconformably by the Noonday Dolomite. Carlisle, et al, suggest derivation of uranium in the sediments from the eroding "islands" of older crystalline rocks during Pahrump time. Both quartz pebble conglomerates (Witwatersrand model) and pelitic schists containing unusual amounts of pyrite, chalcopyrite, and graphite are anomalously radioactive. It cannot be dismissed at this writing that the Pahrump and Apache Groups were part of the same sedimentary cycle, and as such may share information on origin of late Proterozoic stratabound uranium in the Western United States (see Carlisle and others, p.41-42 and 45). Studies reviewed in the Carlisle reference, based upon microfloras,and geologic relationships to diabase masses of presumed age indicate a possible pre 1.1 b.y. age for part, or all of the Pahrump Group.

Dickinson's (1977) Figure 1 shows the extent of known occurrences of sediments of this general age in North America. See also a general paper on the probable plate tectonic setting of the Apache Group rocks by Sears and Price (1978). Figure 28A from Shride (1967) is a north-south cross section through the Sierra Ancha, and suggests a pre-Troy warping and beveling event, and Figure 28B shows a post-Troy, pre-Devonian Martin block faulting event probably associated with the Antler Orogeny of Nevada. This is, in essence, the structural setting of the Apache Group rocks seen today in the Sierra Ancha, simplified as Figure 29. Figure 30, also from Shride (1967), shows all the known outcrops in Arizona of Apache Group rocks and the associated diabase. Outside of this region in Arizona the Apache Group rocks were apparently either not deposited or removed by erosional events ranging in age from late Precambrian to mid-Cenozoic. It is thought from drillhole information that the Apache Group rocks do not extend far to the north or east from the Sierra Ancha under the Colorado Plateau Paleozoic blanket. (H. Peirce, pers. comm., 1980). The Apache Group is not continuous with the Grand Canyon Unkar Group rocks under the Paleozoic cover of the Coconino Plateau because of either nondeposition on the Transcontinental Arch or extensive pre-Paleozoic erosion along this same feature, or both. Figure 29 suggests the southwest and northeast limits of the Apache Group rocks in the Sierra Ancha are, respectively, erosional removal in the Tonto Basin area and the burial of the section under Paleozoic cover east of the Canyon Creek fault.

Minor oxidized copper minerals occur at many of the deposits, though not in mineable quantities. See Granger and Raup (1969a, p,80) for a table listing ore and accessory mineral occurrences. Purple fluorite has been recognized only at the Hope 3, Sorrel Horse, Big Buck, and Tomato Juice deposits, and only in small amounts. The fluorite coexists with pyrite in thin veinlets in the central part of the radioactive vein zones.

Two theories exist to explain the origin of the uranium. Schwartz (1957) and Granger and Raup (1969a) favor the explusion of uranium-copper fluids from diabase differentiates and their subsequent incorporation into the favorable quartzite horizons along fracture channelways that formed adjacent to intrusive masses. They suggest that unidentified structural, mineralogical, or chemical properties of the gray unit made it very favorable as a receipient of the uranium mineralization (p.97). They note, however, that these sediments contain abnormally high carbon, and that iron sulfide contents could have contributed to a H_2S gas partial pressure that could have reduced mobile uranium species to UO_2. Granger and Raup (1969a, p.102) also note that at three deposits (Hope 1, Workman 1, and Red Bluff) uraniferous veins appear to end abruptly at contacts with diabase dikes and sills, as though the diabase had cut the mineralized veins.

Williams (1957) suggests, on the other hand, that the diabase, even with its alkalic differentiates, had less than one tenth the amount of uranium as the gray unit of the Dripping Spring Quartzite originally, and thus the latter is the more probable original source of the uranium. He subscribes, however, to the hydrothermal movement of the uranium into the fractures at the time of the diabase intrusions.

Granger and Raup (1969a, p. 76) list a series of uranium-lead age dates for five Dripping Spring uraninites. A series of single uranium-lead pair model ages range mostly from 900 to 1,300 m.y. with only four out of 15 determinations recording less than 900 m.y. In addition, one lead-lead determination on cognetic galena gave an age of 1,140 m.y. Concordia plots of the two isotopic systems produced two sets of curves which intersected at about 1,050 m.y. These numbers may minimally approximate the age of ore formation in view of the fact that on the whole, the dated Dripping Spring uranium minerals are in good radiometric equilibrium (Granger and Raup, (1969a, Figure 43). These ages are consistent with all known age relations of the Apache Group, and indicate that the mineralization is either syngenetic with Apache Group sedimentation or not appreciably younger than the diabase intrusion.

It is this author's opinion that Williams' (1957) suggestion is the more reasonable one, since a) other similar-appearing Dripping Spring Quartzite units are barren of mineralization, and b) the upper member nearly ubiquitously contains anomalous radioactivity in several mountain ranges, whether or not diabase intrusions are nearby. Shride's cross-section (Figure 28A) shows a gentle Apache Group-Troy Quartzite angular unconformity, a hiatus which could serve as a time during which mineralization could have occurred (H.W. Peirce, pers.comm.,1981).

Pyrometasomatic hematite-specularite mineralization bedded into the Mescal Limestone along Canyon Creek was earlier thought to relate genetically to the diabase intrusion. More recent suggestions by Moore (1968, p.27-29) discount this hypothesis.

Example - Red Bluff Mine

The Red Bluff claims, discovered in 1950, record the first uranium find in the Dripping Spring Quartzite. The deposit, seen in Figure 31, contains many characteristics of Dripping Spring occurrences. The mined deposits are in two main separate stratigraphic zones in a gently eastward dipping Dripping Spring Quartzite section on opposite sides of N20°E-trending Warm Creek Canyon, in the southern-most Sierra Ancha. Warm Creek follows a 150 foot-thick diabase dike that has intruded a fault zone with about 250 feet of apparent reverse, east side down movement. Mining has followed three separate stratigraphic zones, above and below the "barren quartzite" as seen in the cross section, and has also exploited a series of strong N70°W mineralized and limonite-filled fractures which strike at right angles to the large diabase dike. Within two miles to the southeast, as seen on the map, a series of large-scale shear zones with possible left-lateral offset also trend N70°W, but lack known mineralization.

Primary minerals at the deposit include uraninite, pyrite chalcopyrite, and galena, all disseminated in the quartzite host and often concentrated along bedding planes. Oxidation near the present land surface in recent times has produced metatorbernite, bassetite, uranocircite, and uraniferous hyalite as fracture coatings. These minerals also line bedding planes and are disseminated in leached, weathered host rock. Much of the Red Bluff uranium ore shows indications of recent uranium leaching, and has chemical uranium content that is 10-60% low when compared to radiometric uranium content (Kaiser, 1951, Table 1). As well, Granger and Raup (1969a, Table 5), indicate lower U-Pb age dates at Red Bluff than any of the other Dripping Spring localities. All these effects are probably related to the rapid modern weathering of the hilltops by the southward flowing streams in the area around the Red Bluff Mine.

Exploration at Red Bluff is continuing. Drilling and eastward extension of an adit in the eastern mine block by Wyoming Mineral Corporation (Exploration arm of Westinghouse Corporation) in the past several years has outlined 2.5 million pounds of low grade uranium ore that has undergone some metallurgical testing (Paydirt, Feb.1977 issue, p.64). Wyoming Minerals Corporation is also drilling as of late 1980 in the Workman Creek area.

Since 1977, Dripping Spring ores from the old Lucky Boy property of the Southern Pinal Mountains have been mined and heap leached by Pinal Minerals Corporation. Several shipments of a brine concentrate have been made from the mine.

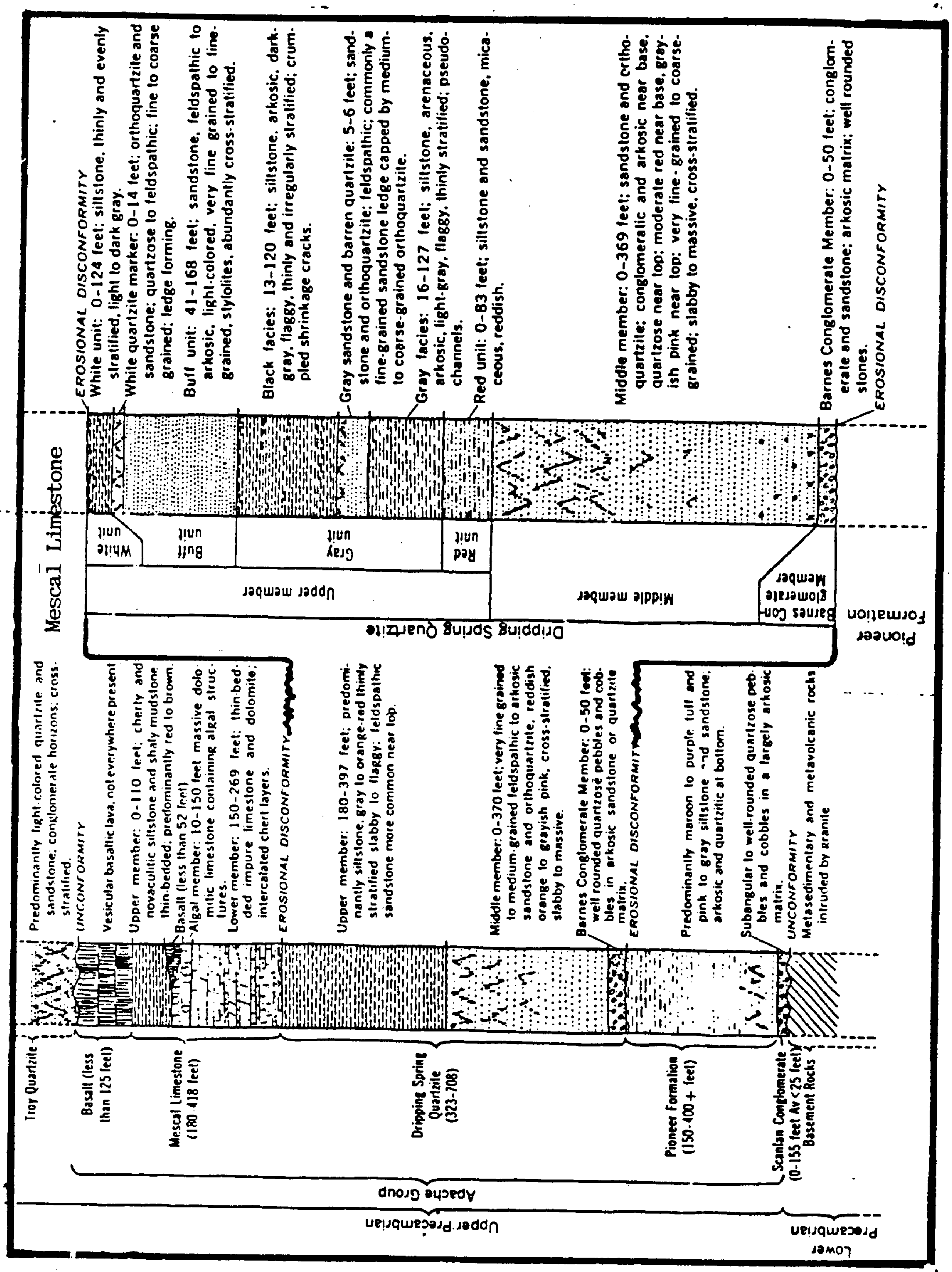
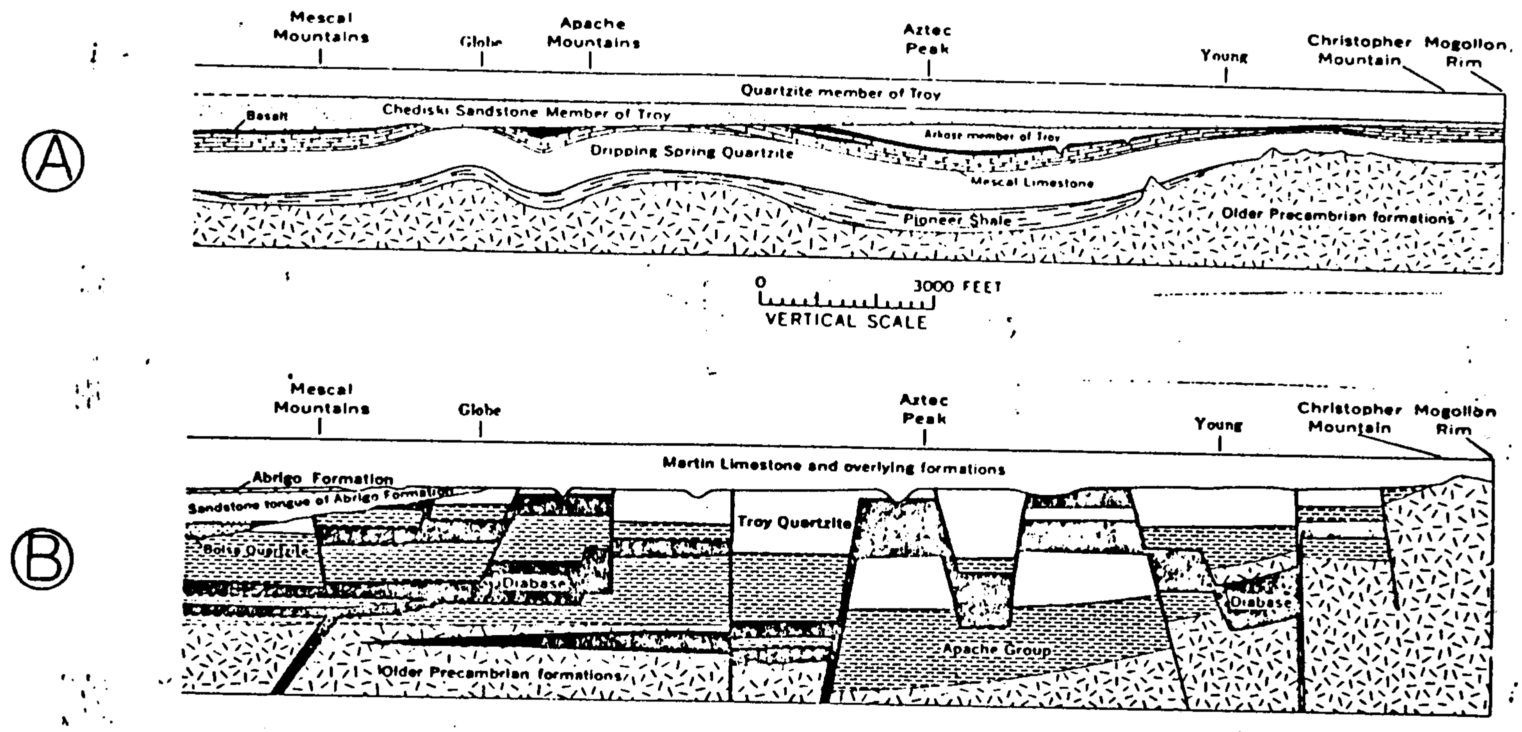


Figure 27 . Apache Group-Dripping Spring Quartzite stratigraphic column, from Granger and Raup (1964).

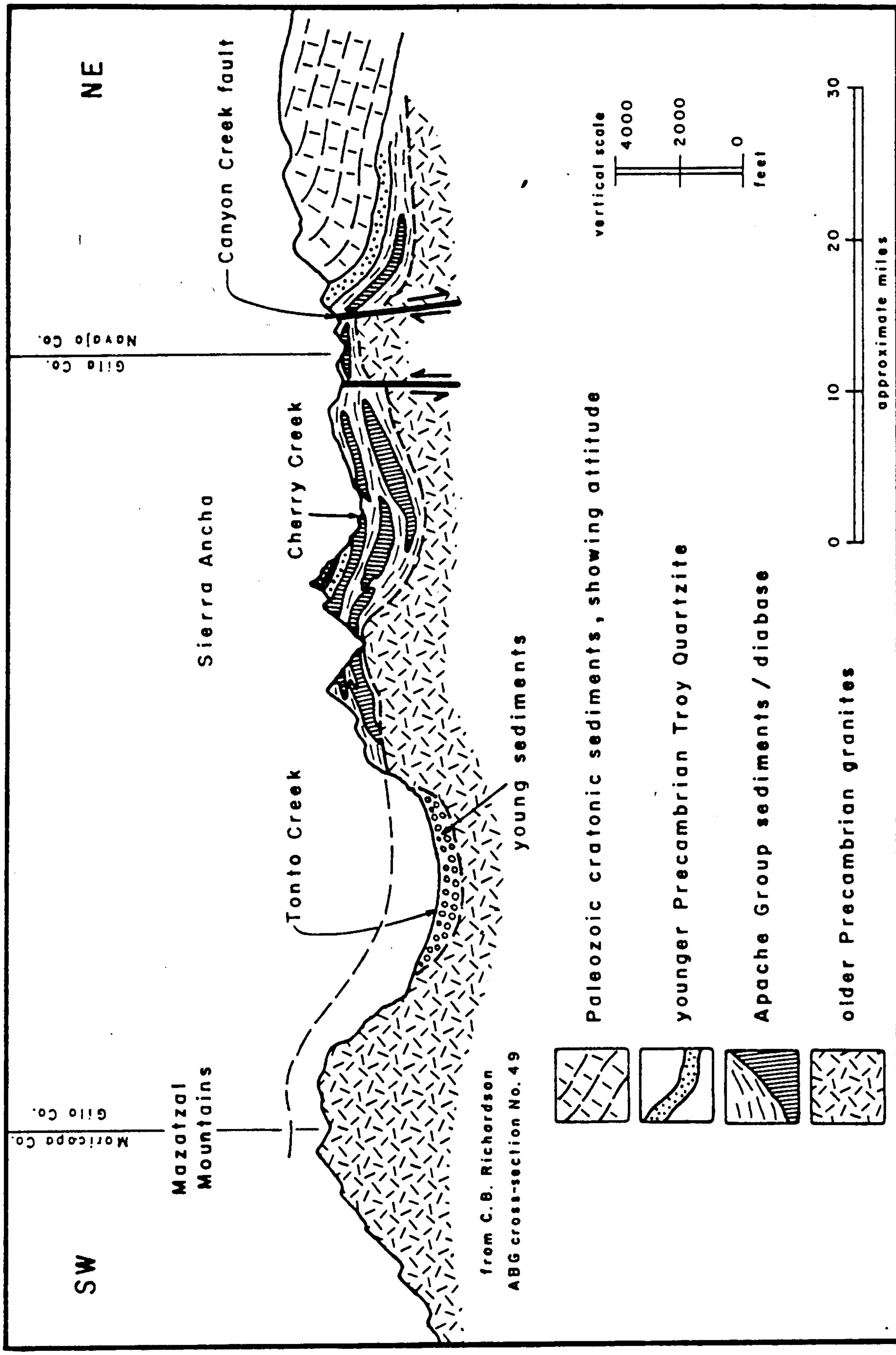


North-south cross sections through the Sierra Ancha, Gila county, from Shride (1967).

(A) at the end of Troy Quartzite time

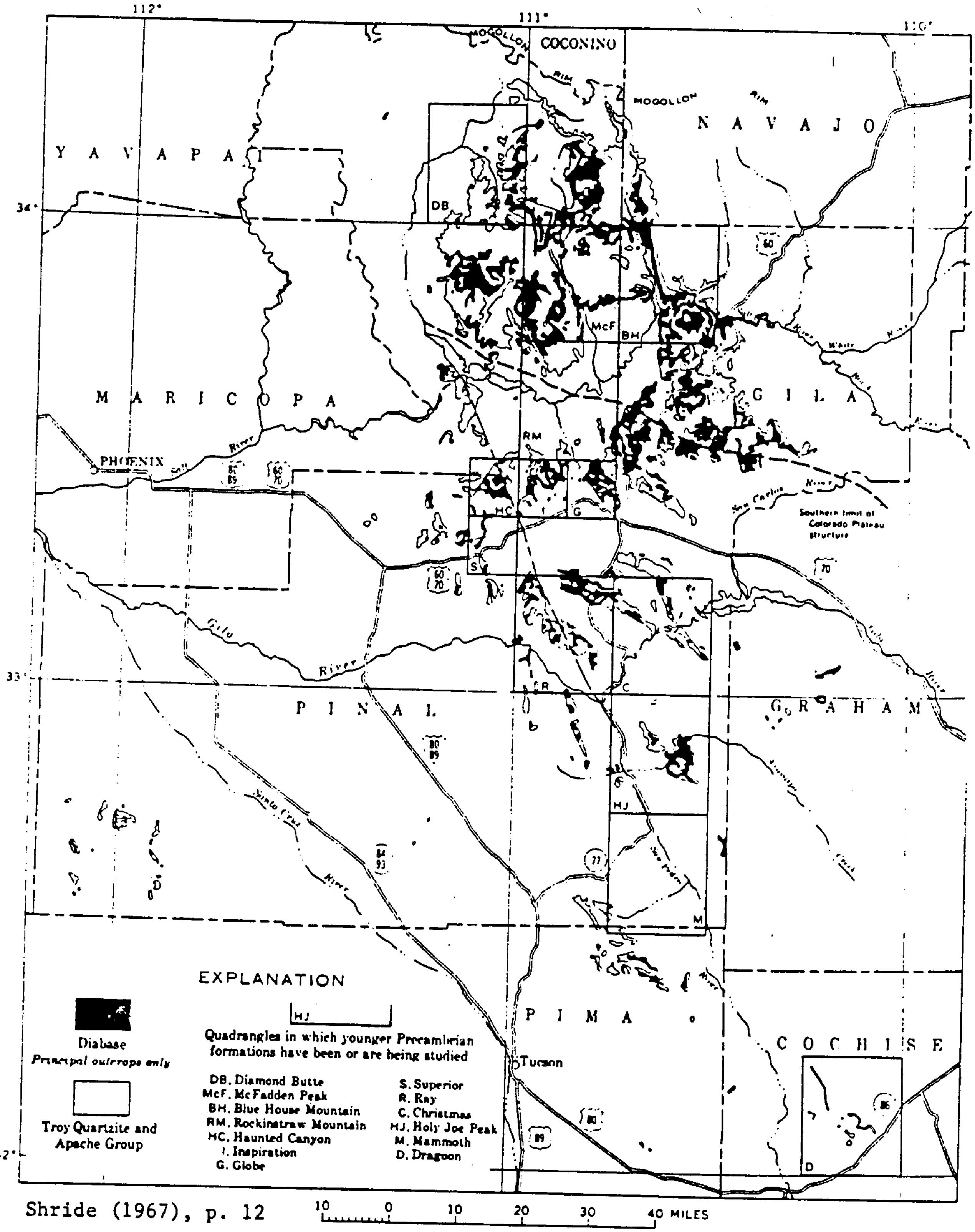
(B) at the end of Martin Fm. time

Figure 28



Generalized SW-NE Cross-Section showing extent of Apache Group Outcrops, Sierra Ancha, Gila County

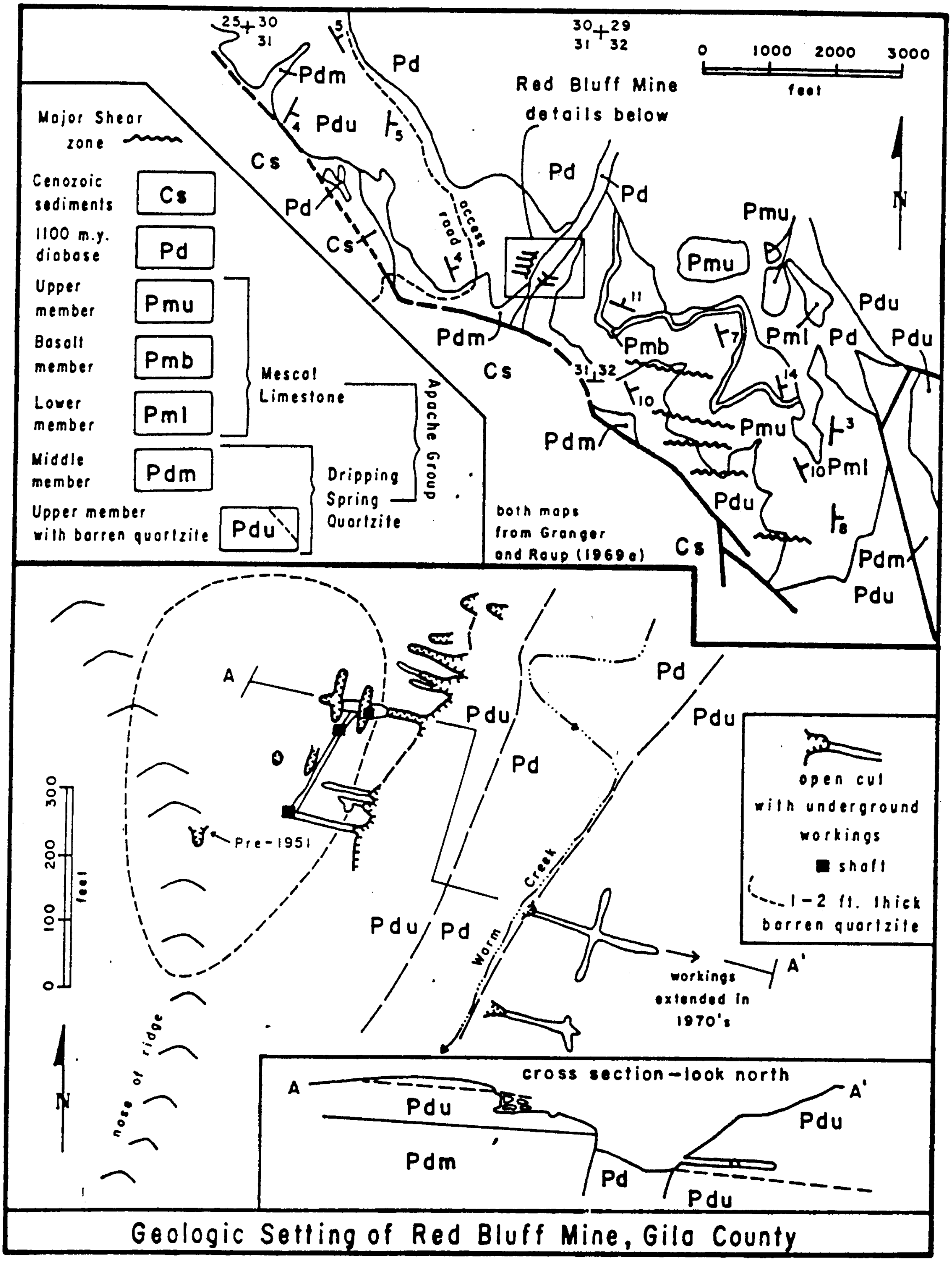
Figure 29



Shride (1967), p. 12

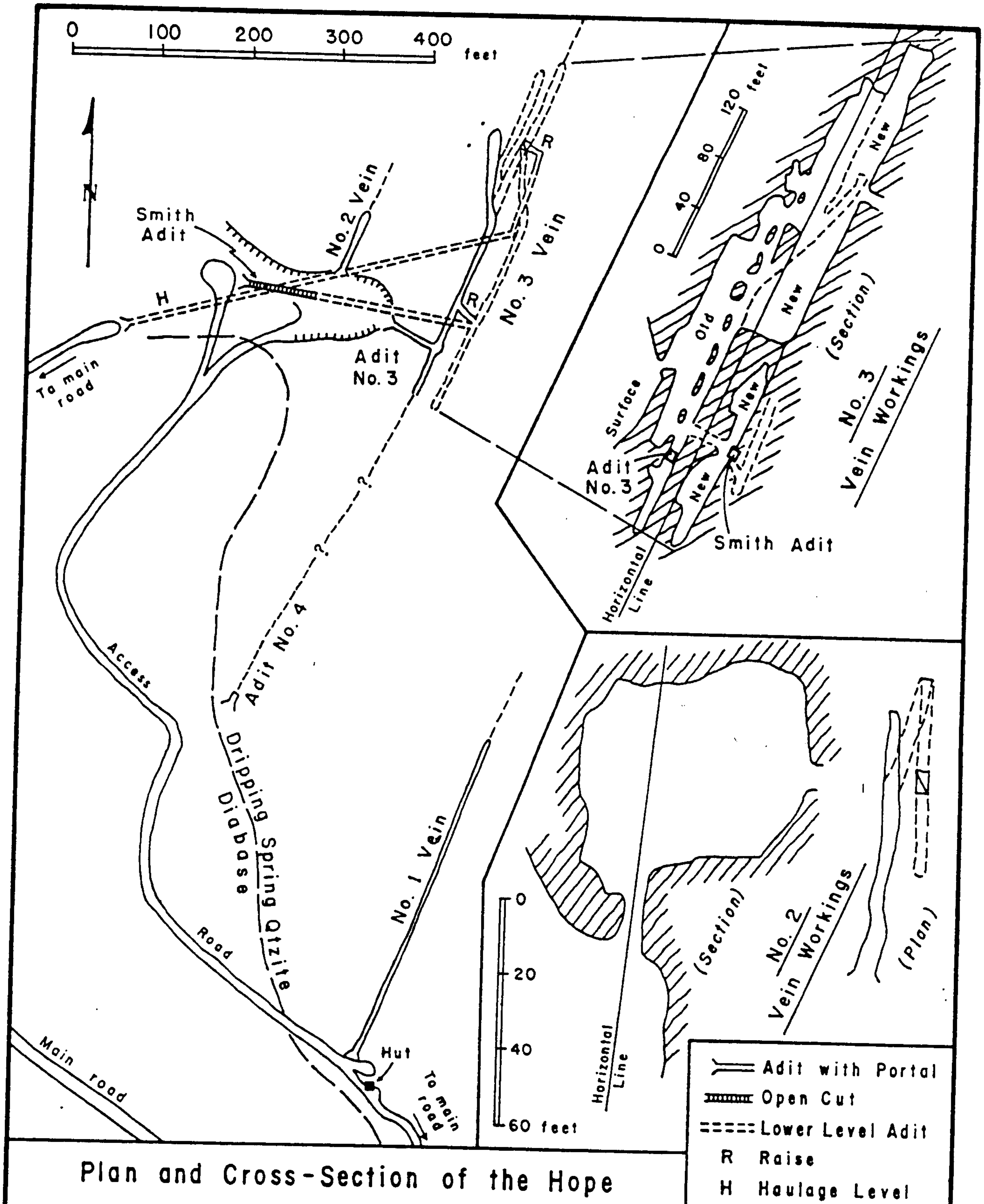
--Outcrops of younger Precambrian strata and coextensive diabase intrusions in southeastern Arizona. Modified from county geologic maps published by Arizona Bureau of Mines, 1958–60.

Figure 30



Geologic Setting of Red Bluff Mine, Gila County

Figure 31



Plan and Cross-Section of the Hope Workings, Sierra Ancha, Gila Co.
from AEC file data, dated 8/16/60

Figure 32

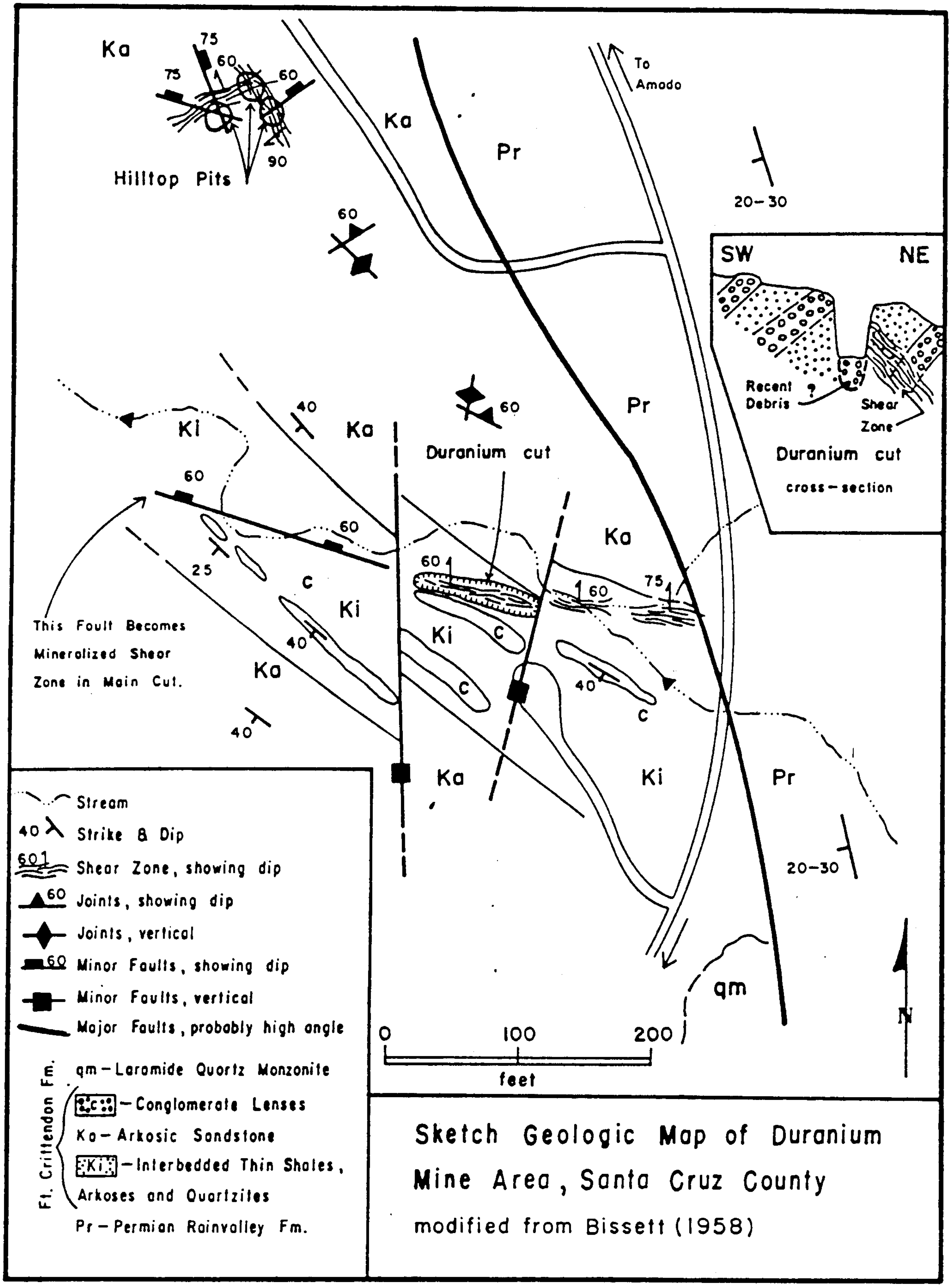
Cretaceous Sandstones

In contrast to the relatively abundant Mesozoic uraniferous sandstone deposits of the Colorado Plateau, southern Arizona has a paucity of such occurrences. Only three are noted: The Dipsy Doodle claims of Cochise County; the Duranium Mine of Santa Cruz County, and "unnamed D" occurrence of Pima County.

At the Dipsy Doodle claims east of Douglas in the Perilla Mountains, radioactivity is associated with limonite-hematite alteration zones in shales and sandstones of the Bisbee Group rocks of Lower Cretaceous age. At "unnamed D" occurrence on the southwest flank of the Whetstone Mountains, stratabound chrysocolla with very slight radioactivity fills intergranular voids in a 2-4 foot thick sandstone unit in a thick southward dipping clastic sequence mapped as Bisbee Group by Drewes (1980).

The only known uranium production from Mesozoic clastic rocks in southern Arizona comes from the Duranium Mine on the northwest flank of the Santa Rita Mountains. See Figure 33 for a sketch geologic map of the area. Drewes (1971, Mt. Wrightson quad geologic map I-614) maps the host rock as the upper red conglomerate and tuff member of the Upper Cretaceous Fort Crittenden Formation, and shows the Cretaceous clastics here as in high angle fault contact to the south and east with Paleozoic limestones. The entire Cretaceous section lies beneath a late Cenozoic pediment surface that terminates at the resistant Paleozoic outcrops. Uranium mineralization follows a N80°W shear zone that cuts across bedding in a conglomerate-arkosic sandstone-red shale bedded sequence which dips about 35°SW. Intense hematite and minor malachite follow the shear zone as well. Two miles to the southeast, a series of WNW-trending quartz latite dikes (dated at 67 m.y. by K/Ar) are mapped by Drewes (1971). These may relate to the Duranium shear zone insofar as their strike directions coincide.

The most radioactive rock at Duranium is a very hard, dense arkosic sandstone with void spaces filled with a shiny black mineral. 680 tons of ore @ 0.20% U_3O_8 was produced in 1956-57 from a long, narrow 15 ft deep dozer pit oriented along the shear zone. Mining stopped when the AEC ore buying station at Cutter (Globe) closed. Indications are that more ore-grade material remains in the area. Radioactivity and minor prospect pits are found on several knobs containing the same strata up to 0.5 miles northwest of the main pit, approximately along strike of the units exposed in the pit. Hence, there are indications of an underlying stratigraphic control of mineralization in the area, rather than an exclusive structural control.



Sketch Geologic Map of Duranium Mine Area, Santa Cruz County
modified from Bissett (1958)

Figure 33

Cenozoic Sediments

The Basin and Range portion of Arizona contains many stratigraphically confined uranium anomalies in fine-grained fluvial, paludal, and lacustrine rocks, of Cenozoic age, among them being the publicized Anderson Mine in the Date Creek Basin. This area contains estimated reserves of at least 30 million pounds of U_3O_8. In Arizona, some of these sedimentary occurrences are described in detail by Scarborough and Wilt (1979). Interesting analogs in California are discussed by Leedom and Kiloh (1978) and a report by Lucius Pitkin, Inc. (1980), and in Texas and Chihuahua, by Galloway and Kaiser (1980). Preliminary work on calcrete-gypcrete uranium deposits in the Southwest are compiled in Carlisle (1978).

Southern Arizona uranium occurrences of this category are found in sediments of Oligocene, Miocene, and Pliocene ages. Many of these rocks are coeval with a variety of volcanic rocks which commonly range in composition from high-potassic andesites through rhyolites, and occasional "ultra-potassic" trachytes (Shafiquallah, et al, 1976), yet, the fine-grained sediments contain many more radioactive anomalies than do the volcanics. In general, these deposits are assumed to have formed in paleo basins of restricted depth and lateral extent. Some of the larger basins were undoubtedly tectonically created, while many of the thinner sedimentary deposits found in volcanic terrains probably were created by volcanic damming effects as volcanism proceeded.

Lithologies in southern Arizona favorable for uranium mineralization include fetid, thin-bedded limestones that often contain chert pods or stringers; shale-mudstone lithologies with white, gray, or yellow-green colors; white marlstones (intimate mixtures of clays and finely divided calcium carbonate), thin-bedded aphanitic dolomites that sometimes contain plant root casts filled with chert; and dark gray-to-black carbonaceous mudstones or sublignites. In the absence of structural control, coarser-grained lithologies such as sandstones or conglomerates do not contain anomalies, nor do redbed lithologies. Examples of anomalies in redbeds with structural control are at the Cottonwood claim and Horseshoe Dam (Maricopa County), and the Rayvern and Ten Dee's claims (Yuma County).

Table 1, below, lists typical lithologies in southern Arizona which have radiometric or uranium shows, along with examples illustrating the lithologies:

TABLE 1. Examples of Uranium Occurrences in Cenozoic Sediments

Radioactive Lithology	Example(s)
Limestone, sometimes fetid, sometimes cherty	Masterson Claims, Mohave Co. Cave Creek Area, Maricopa Co. Dutchess Claim, Pima Co. Center Chance Claims, Pima Co. Catherine and Michael, Mohave Co.
Aphanitic dolomite, light colored	Los Cuatros Claim, Maricopa Co.
Light-colored mudstone	Teran Basin, Cochise Co. North Chance Claim, Pima Co. Muggins Mtns. Area, Yuma Co. Dab; Wharton; Sunset; Mohave Co.
White massive marlstones	Xmas; Half Moon Claims, Pima Co. Cottonwood Area, Verde Valley, Yavapai Co.
Dark carbonaceous mudstones to sublignites	Cigar Claims, Gila Co. Anderson Mine, Yavapai Co.

Stratigraphic sections containing Oligocene-Miocene layered rocks are often found tilted in a rather uniform direction and amount over large regions within the Basin and Range country of the Cordillera. Stewart (1980) suggests a certain elongate regionality to these "domains" of tilted rocks, though the ultimate reason for their existance is unknown at this time. Many of the Southern Arizona uranium occurrences in Oligocene-Miocene strata or fault zones are in terrains affected by this phenomenon. Examples include many of the occurrences in the Muggins Mountains, and the Rayvern claims, Plomosa Mountains of Yuma County, the Anderson Mine area of Yavapai County, the Horseshoe Dam sites of Maricopa County, Catherine and Michaels claim in Mohave County, and the Chance Group claims of Pima County with related Teran Basin deposits of Cochise County, to mention a few. Evidence is gathering that some of this tilting is due to NW-SE directed curviplanar fault systems ("listric" faults) which cause antithetic rotation of upper plate rocks (those above a master basal flat fault of unknown extent) to produce dips toward the listric fault, as faulting proceeds. The result, well displayed in the cross section near the Anderson Mine (Figure 36), is that the same stratigraphic section may be repeated time and time again at the surface, and hence, the observed tilted section appears much thicker than it really is.

The following examples are uranium occurrences in Cenozoic sedimentary rocks in Southern Arizona of three different ages. It is suggested in Scarborough and Wilt (1979) that there appears to be a certain regionality to the ages of Cenozoic sedimentary uranium occurrences in Southern Arizona, based upon the proposition that only at certain times were there fluvial-lacustrine environments of any extent that favored uranium deposition. These times, from which the examples were drawn, were during the late Miocene-Pliocene (6-2 million years B.P.), during the middle of the first half of the Miocene (20-15 m.y.), and during the middle part of the Oligocene (30-25 m.y.).

In all three periods there were regions where fluvial, deltaic and lacustrine facies were in close proximity, and where numerous uranium occurrences are now recorded. The examples are given in order of increasing age, in parallel with the age listings above. The Anderson Mine strata are rough age equivalents of the radioactive dolomites around New River and Cave Creek (Los Cuatros locality).

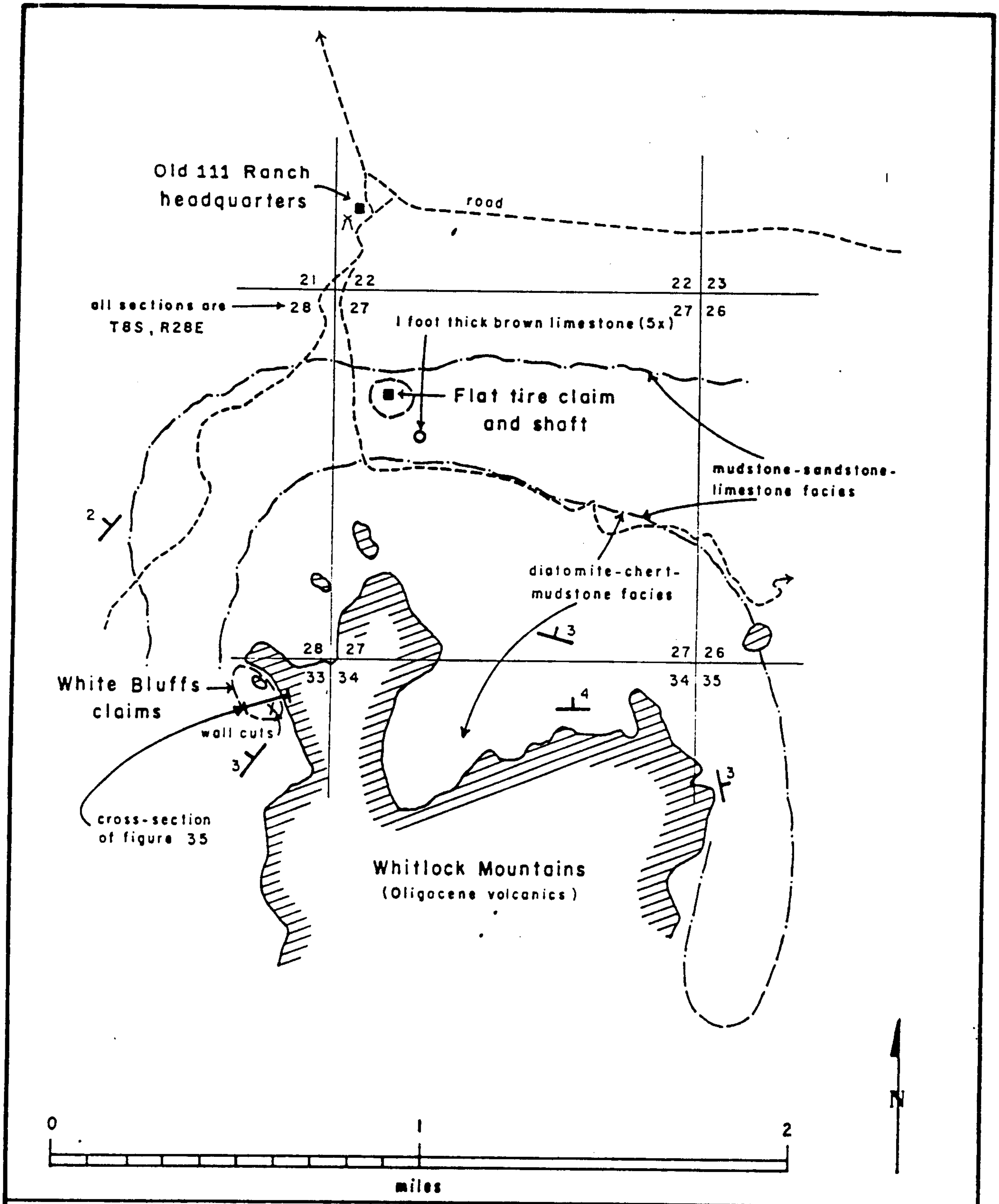
EXAMPLES:

Pliocene Rocks near Safford, Graham County

Figure 34 is a general map view of the northern Whitlock Hills, about 17 miles southeast of Safford, in Graham County. In this area a section of quiet water, lacustrine and paludal fine-grained sediments of Pliocene age has been deposited against a mass of Oligocene volcanics. Figure 35 (top) is a generalized south-looking cross section showing general lithologies and radioactive beds at the White Bluffs claims. The anomalous zones are in (a) the cherts of a mixed tabular green chert and gray-green mudstone zone, and (b) the basal 2 feet of an overlying 20 ft thick diatomite zone. Nearby masses of green chert incorporated into the diatomite are not anomalous. Figure 35 (bottom) is a nearby south-looking view of the same stratigraphy, folded nearly isoclinally, and displaying the highest radioactive readings at the crests of anticlines (see the Morale claim, Hopi Buttes, Navajo County for an interesting analog). Other claims in this area are staked on similar lithologies. At the Flat Tire claims (Figure 34) diatomaceous mudstones and a nearby thin, brown, fetid limestone containing bivalve fossil forms are anomalous. Most mudstones and cherts that have been analyzed for organic carbon in the White Bluffs-Flat Tire area contained 0.08-0.30% C (NURE data).

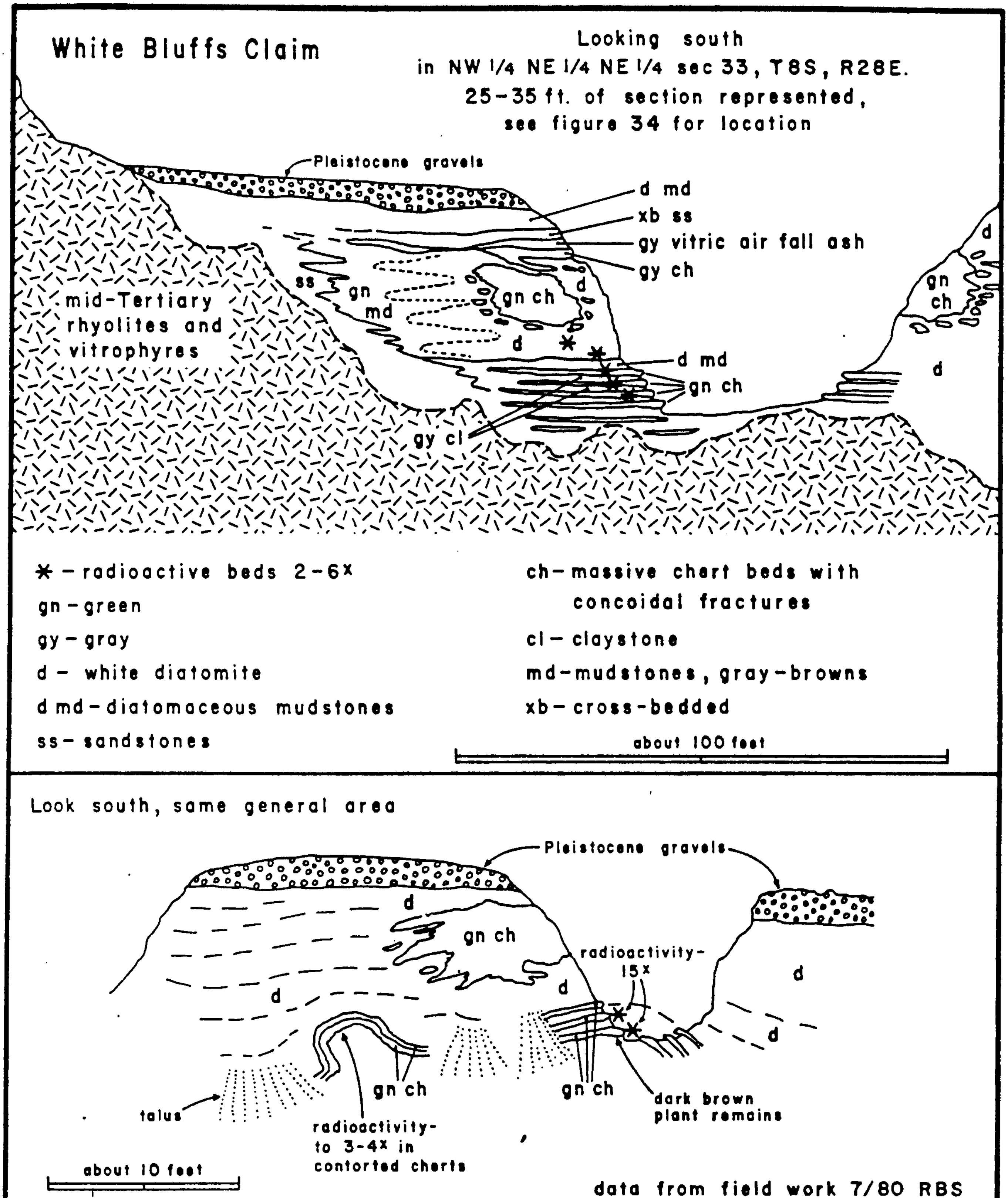
The exposed Pliocene section in the area measures about 100-150 ft thick and contains at least three thin vitric airfall ash beds of rhyolitic composition which have K/Ar age dates of about 3 m.y. and large mammal paleontologic ages of Blancan (5-2 m.y.) age. (Scarborough, 1974; E. Lindsay, pers.comm., Jan. 1981). The ash beds are undevitrified in places, but altered to clay-zeolite assemblages in others. They appear not voluminous enough or altered enough to account for the amount of uranium in the area.

Other radioactive occurrences in Pliocene-Pleistocene fine-grained sediments are noted in the San Pedro Valley east of Tucson at the Xmas and Half Moon claims (Pima County), in marly sediments around Cottonwood, Verde Valley, and in northern Mohave County at the Dreamer, Wharton, Dab, and Sunset claims. All of these appear to be local, low tonnage and grade concentrations of oxidized uranium minerals. Similar mudstone-diatomite-green chert assemblages near the Gila River around Duncan, Greenlee County, contain slight anomalies (A. O'Neill, pers. comm. Jan.1981), but are not plotted for this report.



Pliocene Paludal Uranium occurrences
111 Ranch area, Graham County

Figure 34



Radioactive Pliocene Paludal–Lacustrine Rocks, 111 Ranch Area, N. Whitlock Hills, Graham County

Figure 35

Miocene Rocks in the Date Creek Basin, Yavapai County

The largest known uranium reserves and resources in Arizona at this writing are in the Date Creek Basin of Western Yavapai County. Reserves of at least 30 million pounds of U_3O_8 and resources of probably at least twice that amount have been projected for that part of the basin in the general area of the Anderson Mine. Current resource estimates indicate minable uranium ore with cutoff grade of 0.02% U_3O_8 utilizing an average grade of 0.05% U_3O_8 and average thickness of ore zones of about 20 feet. Uranium distribution in these reserves is such that average grade increases to 0.12% if average mined-thickness decreases to 6 feet, but total tonnage drops to 48% of the above amount (Sherborne et al, 1979).

Our understanding of the Cenozoic geology of the basin has been much improved by recent ongoing studies by the NURE program and the USGS, but understanding of the real extent and style of Miocene regional tectonics which has served to complicate the distribution of rocks in the region has yet to be realized.

The geology and uranium deposits of the Date Creek Basin are discussed by Otton (1977a and b) and Sherborne and others (1979). An earlier account of manganese mineralization in Miocene sediments in the area was given by Lasky and Webber (1949). See also a summary article in Engineering and Mining Journal for January, 1978.

The uraniferous sediments at the Anderson Mine are contained in a section of tuffaceous, locally carbonaceous paludal-lacustrine mudstones, calcareous mudstones, sandstones, and siltstones with some silica (chert) as pods, stringers, and plant root replacements. Two zones of uraniferous sediments are known in the Anderson Mine area, the upper one being the focus of mining activity during 1955-59 when 10,700 tons of ore assaying 0.15% U_3O_8 and at least 0.05% V_2O_5 were removed. See Figure 37 for a cross section of the area.

The Cenozoic section in the Anderson Mine region was deposited on a surface cut into a gneissic and granitic terrain of mostly Precambrian age. The Cenozoic rocks consist, in ascending order (See Figure 36 and 37), of an older sedimentary section which contains Eocene plant remains (J. Otton, pers. comm., 1980); a volcanic section called the Arrastra volcanics, composed of silicic to intermediate rock types with ages of roughly 25-20 m.y.; the uraniferous quiet-water Anderson Mine rocks and some overlying sandy beds, both probable equivalents to the early to middle Miocene-aged Chapin Wash Formation exposed farther west; an overlying 13 m.y. old alkali olivene basalt flow; and two sedimentary units of late Miocene through Pliocene-Pleistocene age. Hence the uraniferous rocks are roughly 20-13 m.y. of age.

All the above rocks up through the uraniferous Chapin Wash equivalents are repeated a number of times along a series of dominant NW-trending faults, movement along which has served to impart moderate SW dips to these strata.

The units above the 13 m.y. old basalt flow are essentially undeformed (see Figure 36). The uraniferous horizons at the Anderson Mine contain these SW dips and are last seen at the surface dipping into the main mass of the present-day Date Creek Valley. As seen in Sherborne and others (1979), the present uranium reserves are known only by drill holes that intercept the ore horizons at increasing depths to the southwest. DOE-sponsored deep stratigraphic test drilling in the main part of the Date Creek Valley has encountered uranium shows at depth that are included within sedimentary packages believed to be equivalent in age to the Miocene Artillery Peak and Chapin Wash Formations of the Artillery Peak area (see DOE report GJBX-86(80) for drill hole locations and logs).

It is important to realize our lack of understanding of the original geographic extent of sedimentary facies conducive to uranium localization. We understand approximate limits of preserved potential uraniferous strata where they occur in outcrop. But to envision boundaries of original deposition for the favorable rocks of Anderson Mine type as being limited to the present confines of the Date Creek Basin does not seem justifiable. This is because the geologic event that produced the arches of gneissic rock now present in the Harcuvar-Buckskin Ranges (present southern boundary of Date Creek Valley) appears by new regional geochronologic information to have postdated the deposition of the Anderson Mine beds. Hence, subsurface exploration should not be confined to the present Date Creek Valley. For discussion of the complexities of these Arizona "metamorphic core complexes", see Rehrig and Reynolds (1977), Davis and Coney (1979), Reynolds (1980), and Crittenden and others (1980).

Otton (1977b) and Sherborne et al (1979) both recognize two kinds of ore, or near ore-grade uranium mineralization, in the Anderson Mine area. The first is in carbonaceous siltstones and mudstones with minor silicification, and the second is in highly silicified, oxidized tuffaceous (?) siltstones with abundant megascopic plant debris. Uranium in the carbonaceous ores occurs as a urano-silica complex, close to coffinite in composition, either in microveinlets or totally disseminated (with homogeneous audoradiographs) in organic-rich siltstone (Otton, 1977b). In the oxidized, near surface regime, uranium occurs as very fine-textured carnotite with hematite in jasper pods, or as uraniferous silica in massive jasper, or in small silica veins. In less silicified ore it occurs as carnotite cement. Hence, some uranium species were fixed contemporaneously with a silicification episode, which appears to be at least in part subsequent to the original presence of the uranium in the carbonaceous ores.

The uraniferous section at the Anderson Mine area is generally enriched in U, Li, B, Cu, F, V, Mo, and Ni. The carbonaceous ores generally are enriched in U, Ag, As, B, Cu, Ga, Ge, Ti, and Mo. Some of these enrichments are similar to examples on the Colorado Plateau, where Cu, U, or U-V mineralization occurs with Ag-Mo-Ni accessory minerals.

Several possibilities exist for the sources of Date Creek Basin uranium: (1) the anomalously uraniferous Precambrian granitic terrain adjacent to the Miocene depocenter in the Artillery Peak region (Otton, 1977a), and which was presumably exposed and eroding during the Miocene, (2) extensive leaching of the associated Miocene alkalic volcanic flows, tuffs, and ash beds - some of the coeval high-potassic volcanic rocks in the region contain 10-20 ppm by weight of uranium; and (3) a more remote possibility might be the leaching of alkalic Jurassic volcanic rocks that form a WNW-ESE swath through extreme south-central Arizona. Rocks of this affinity contain uranium occurrences in Santa Cruz County, and extend an unknown distance northwest towards the Blythe-Parker region. Possibility (2) appears most popular at this time, although the sparcity of anomalies in Cenozoic volcanic rocks is noted in the section on Cenozoic volcanics.

See discussion in the next section concerning possible temporal analogs of the Date Creek Basin uraniferous deposits.

Explanation for Anderson Mine general geology, Figure 36

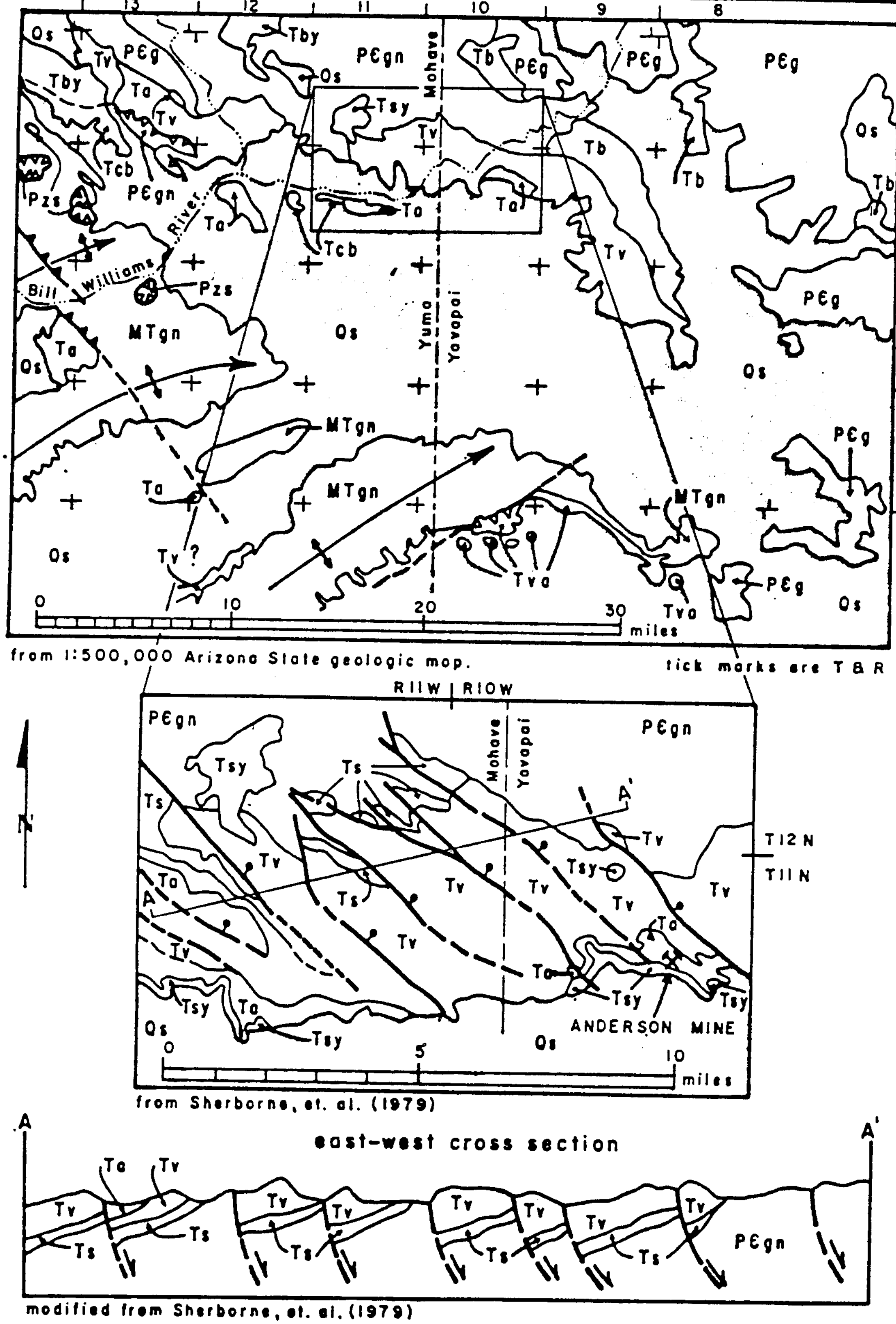
Qs	Quaternary sediments
Tb	Miocene basalts, exact age uncertain
Tby	9-10 m.y. old undeformed basalt flows
Tcb	13 m.y. old Cobweb basalt, faulted and gently folded
Tsy	Miocene sediments, containing 13 m.y. old Cobweb basalt
Ta	Miocene Anderson Mine Fm., and, to the west, Artillery and Chapin Wash Fms.
Tva	equivalent age volcanics
Tv	Oligocene Arrastra volcanics of Sherborne, et al, (1979)
Ts	basal Tertiary arkoses and tuffs
Pzs	metasediments involved in low-angle Miocene dislocation.
MTgn	Mylonitic gneisses
p€gn	Precambrian gneissic rocks
p€g	Precambrian granite


curviplanar, or listric Faults, dot on hanging wall


low-angle faults adjacent to MTgn masses, movement in mid-Miocene time, barbs on upper plate.

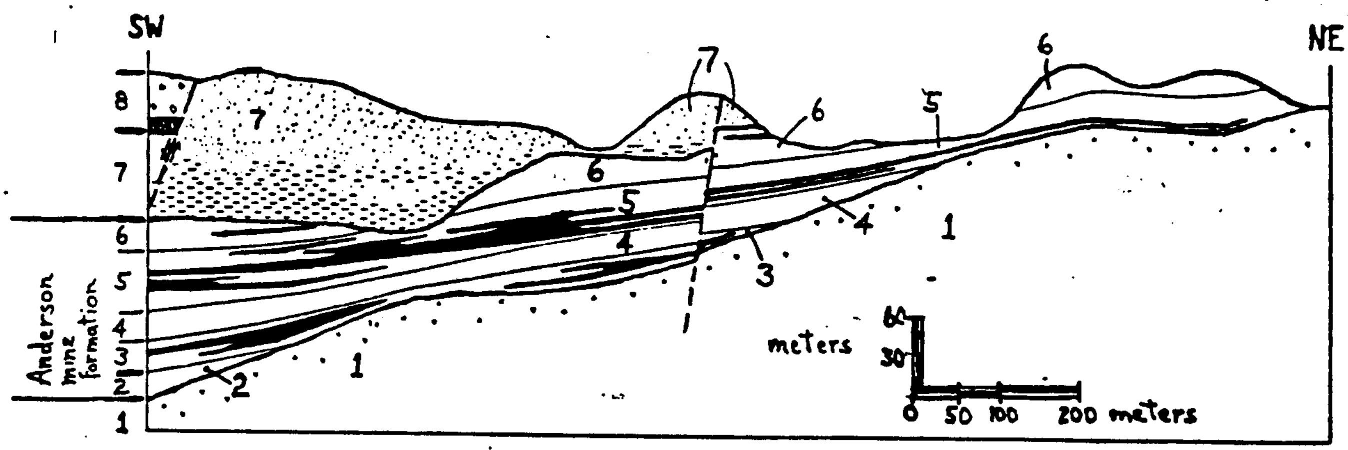

NW trending, SW vergent thrust faults, mid-Miocene age, barbs on hanging wall.


dome developed in MTgn in Miocene time, characteristic of the "metamorphic core complexes."



General Geology of the Anderson Mine area, Northern Date Creek Basin, Yavapai, Yuma and Mohave Counties

Figure 36



uranium-bearing strata

8 basalt and agglomerate (basalt is 13 m.y. old)
7 Flat Top formation

Anderson mine formation — upper mbr.:
6 upper tuff and carbonate unit
5 upper carbonaceous unit
4 intermediate clastic unit
3 lower carbonaceous unit

2 lower Anderson mine member

1 Oligocene Arrastra volcanics (about 22-26 m.y.)

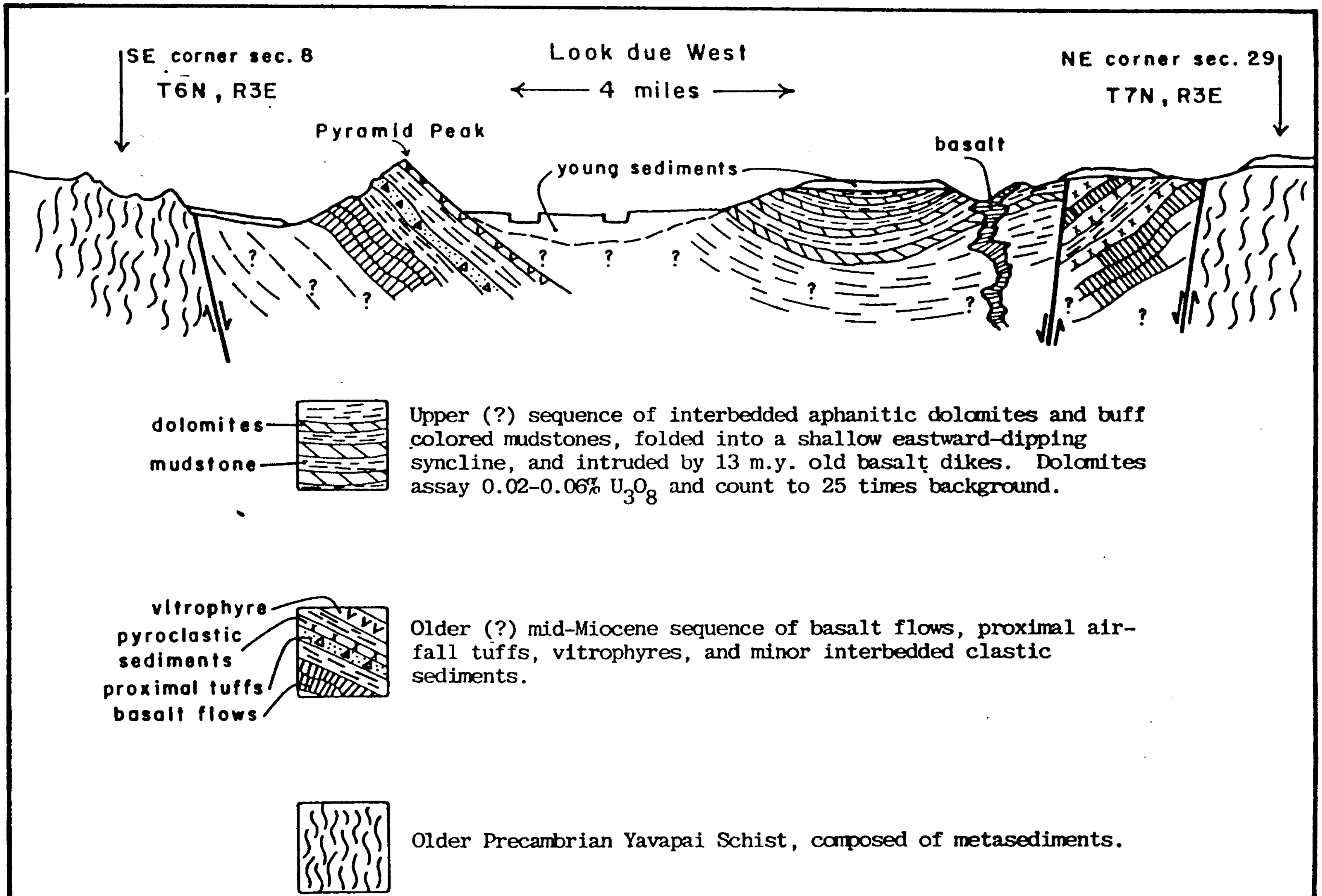
Figure 37. Southwest-northeast trending cross-section of uranium-bearing interval in the Anderson Mine area, from Sherborne and others, 1979.

Miocene Dolomite - New River Area, Maricopa County

A volcanic-sedimentary section of early-middle Miocene age in the New River Area of Maricopa County is depicted in Figure 38. It was prospected in the 1950's as the Los Cuatros claims, and has received renewed exploration interest with some drilling in the late 1970's. The section is exposed beneath late Cenozoic terrace deposits in a valley floor, and is in high angle fault contact with Precambrian granites and schist around the perimeter of the valley.

One part of the Cenozoic section consists of interlayered one-to-two foot thick light-colored aphanitic dolomite beds and buff-colored laminar bedded mudstones. Unconventionally, the dolomites are radioactive and assay 0.02 to 0.08% U_3O_8. The uranium, upon autoradiography and X-ray diffraction analysis, is randomly diffused throughout the massive dolomite, and is lacking any sign of concentration in the mudstones or sparce thin interbedded distal air-fall tuffs that are still vitric in places, altered in others. At the Los Cuatros locality, considerable tonnage of low-grade ore (about 0.03-0.06% U_3O_8) is suggested by the geology of Figure 38.

Interestingly, strata of similar age in other areas nearby (Cave Creek area and Rifle Range Section occurrences in Maricopa County listing; and in New River Mountains in cliffs on west side of Cave Creek), also contain very similar-appearing dolomitic rocks. The dolomites are known to be radioactive in the first two occurrences listed. Hence, an originally extensive areal distribution of these strata appears likely. Subsequent to Basin and Range faulting, they are now found both in range blocks and downdropped valley blocks in the region. Their subsurface distribution is not known. Age constraints on these rocks as reported by K/Ar dating results reported in Scarborough and Wilt (1979); are roughly 17-13 m.y. This time range corresponds to about the last half of the massive mid-Tertiary volcanic pulse (Cordilleran "igimbrite flare up" of Coney, referenced in Coney and Reynolds (1977), and described in Eberly and Stanley (1978). These middle Miocene ages are similar to the ages of the uraniferous units of the Date Creek Basin, which probably range roughly from 20 to 13 m.y. (Otton, 1977b; Scarborough and Wilt, 1979). Hence, from geochronologic information now available, it appears that this time during which the massive mid-Tertiary volcanic pulse of the southwestern United States was slowly shutting down, was also a time of mobility and fixation of uranium in sedimentary sumps in the central and west-central portions of Arizona. The fundamental question of the ultimate source of uranium and the role played by the massive mid-Cenozoic volcanic event in uranium mineralization remains unanswered. Positive evidence will come as more Cenozoic volcanic rocks in appropriate regions are checked for uranium depletion relative to thorium, to see if these rocks are indeed uranium depleted. Distal air-fall tuffs, when mixed into volcanoclastic sediments, may contribute appreciable uranium to the environment while losing much of their identifiable character, making them a "hidden source".



data from Scarborough and Wilt (1979)

Los Cuatros PRR locality, New River area, Maricopa County

Figure 38

Mineta Formation - Rincon Mountains

The Mineta Formation is an Oligocene-aged sequence of mixed clastics and thin bedded limestones, 1,000 to 2,000 feet thick, and is contained in a NW-SE elongate, fault-bounded block on the NE flank of the Rincon Mountains, Pima and Cochise Counties. The section is well exposed, and dips homoclinally 15-40° to the northeast. Figure 42 idealizes the general geology and shows the general Mineta Formation stratigraphy as envisioned by Clay (1970) and Thorman and others (1978). The tectonic event that tilted the Mineta section occurred largely before the extrusion of an andesite mass, dated at 27 m.y. (Shafiqullah and others, 1978), that unconformably overlies the tilted beds.

The Mineta Formation consists of lower conglomerates containing shale lenses, middle vari-colored laminar-bedded shales and thin-bedded fossiliferous fetid limestones, and upper gypsiferous mudstones. Numerous radioactive anomalies occur over a strike length of five miles, in the following lithologies: (1) in white-to-gray thin shale lenses within the basal gray and red colored conglomerates, at the North Chance claims; and (2) in various light-colored shales or in fetid limestone beds of the middle unit, at the Center and East Chance claims; especially very near boundaries of beds where permeability changes abruptly. See Figure 42 for stratigraphic data on these locations.

Several uranium occurrences arc known in complexly faulted rocks just upslope from the Mineta Formation outcrops. These include the Blue Rock claims (Pima County) and Robles Spring claims (Cochise County). These radioactive occurrences could have served as sources for uranium in the Mineta Formation, as could disseminated pods of radioactivity in Precambrian granites just upslope from the North Chance claims. However, there is no assurance that the structurally controlled occurrences in the older terrain formed before the Mineta Formation occurrences. They could all be part of a single mineralization episode.

Although some preliminary exploration work has been done in the Mineta Formation, the discontinuous nature of the radioactive outcrops and the steep dips of the formation discourage development. Potentially, however, similar rocks could underlie large areas of the adjacent San Pedro Valley at shallow depths, particularly since radioactive shales are noted in equivalent-aged sediments 10 miles east on the west flank of the Galiuro Mountains (Teran Basin occurrence of Cochise County).

Precambrian Sediments and Unconformities

As mentioned by Waechter (1979) several interesting radioactive occurrences in southern Arizona are found at or very near the contact between the base of the Pioneer Shale of the younger Precambrian Apache Group (with basal Scanlan Conglomerate missing) where it was deposited on Precambrian granite. The radioactivity appears associated with "silicified" red shales or "micropegmatites" or minor shear zones near the contact. Sometimes the red shales appear as small masses or pods within uppermost outcrops of granite. These occurrences are the Dutch Boy, Hammes, Hardrock, and Lonesome John claims of Gila County, and very possibly at the Red Hills claim in the southern Rincon Mountains near Tucson, Pima County. Other individual occurrences in Gila County (Bee Cave, Granite claims) have similar attributes, but with other modifications. None of the above occurrences except Bee Cave have any record of uranium production. Bee Cave shipped only one small shipment of "no pay" ore (i.e., assays less than 0.10% U_3O_8).

In a recently completed report by P. Anderson (GJBX-33(81), sediments of the Ader, Mazatzal, and Apache Groups of central Arizona were examined for uranium potential. Mild anomalies were located in the Mazatzal sediments associated with specularite and pyrite, and in sandstones and conglomerates of the Apache Group. Anderson attributes the lack of uranium in these sediments to their pervasively oxidized state and an absence of favorable and nearby Archean source terrain.

NON-STRATABOUND OCCURRENCES

Precambrian Granites

Radioactivity dispersed in granites of Precambrian age in southern Arizona has been recognized since the late 1940's when the first AEC reports covering the Basin and Range country were published. Anomalies disseminated in Precambrian granites, for example, are noted at the Diamond Head claims of Pima County and the Gypsy Queen, Malapai No. 1, and Valcarce claims of Maricopa County (among others).

With our increased understanding of ages of rock units as determined by isotopic dating techniques, new time-space patterns of uranium distribution in igneous rocks are emerging. Malan and Sterling (1969) summarized an AEC Project that sought "exploitable uranium resources" in the Precambrian of the United States. They concluded that of the four geochronologic subdivisions of the Precambrian of the Western United States in use at that time, the highest uranium and thorium contents (4.4 ppm and 32.4 ppm respectively) were found in the 1.35-1.50 b.y. old granite suite. They also noted an apparent geographic east-to-west increase of uranium and thorium content of granites from New Mexico to southern California, with virtually all of the 21 bulk samples with statistically anomalous U-Th values coming from west of the 112°meridian (near Phoenix). This spatial arrangement of anomalies led them to propose that these rocks, present in the Mogollon highlands in Mesozoic time, was a possible source of the uranium now found in the Colorado Plateau stratabound deposits. Their preferred model of mineralization is transfer of uranium in Precambrian basement into parent magmas of Triassic-Jurassic volcanic rocks whose pyroclastic components were mixed with the Mesozoic clastics and supplied leachable uranium to the sedimentary environment.

Carlisle and others (1980), in a study of uranium mineralization of the Proterozoic sediments of the Kingston Peak Formation of the Death Valley region of California, examined the possibility of derivation of the sedimentary uranium from the anomalous crystalline rocks of the underlying World Beater crystalline complex. These rocks consist of older augen gneisses (age of about 1.8 b.y.) that contain 2.9 ppm uranium and 49 ppm thorium, intruded by a 1.35 b.y. old porphyritic quartz monzonite that contains an average of 27 ppm uranium and 70 ppm thorium. In the region, older metamorphosed sedimentary and crystalline assemblages of 1.7 b.y. age contain only a very few mild radioactive anomalies. Clearly, the 1.4 b.y. old quartz monzonite is the most uraniferous of the Precambrians crystalline rocks of the area.

Silver and others (1980) suggest that the uranium content of primary zircons in igneous rocks is a measure of the overall uranium content of the host rocks. Using this assumption, they have defined a regional uranium anomaly in the Precambrian basement rocks directly beneath that part of the Colorado Plateau which contains all of the major sandstone uranium districts (see their Figure 4, p.31). They have also applied U-Th-Pb isotopic systematics to three granites in Southern Arizona that date at 1400-1450 m.y. and found evidence of significant uranium loss relative to thorium and lead in two of the three. These are the Ruin, Lawler Peak, and Dells Granites. Sampled parts of the Ruin Granite (Globe-Lake Roosevelt region, Gila County) have lost up to 60% (6 gm./ton) of their original uranium endowment probably within the last 75 m.y. Now, the Ruin Granite samples contain near-average crustal contents of uranium and thorium. The Lawler Peak Granite (Bagdad Mine area, Yavapai County) has lost 25% of its uranium during or since two geologic "events" at 230 ± 10 and 75 ± 25 m.y. This amount of loss, calculated for a reasonable volume of weathered granite, can account for the release of 100,000 metric tons of uranium into the environment. The Dells Granite (Prescott-Chino Valley, Yavapai County) is one of the most radioactive granites identified in the Southwest, as seen in the airborne radiometric surveys depicted in Figure 8 of Silver and others' paper. It is an equigranular two-mica granite, relatively massive and structureless, and contains about 39 ppm U and 31 ppm Th. Curiously, this very radioactive rock is in good isotopic equilbrium and has lost very little of its uranium or thorium after crystallization, based on a single sample site. The two times (230 and 75 m.y.) at which uranium loss appears to have occurred in two of the samples could be related to Permo-Triassic and Laramide orogenesis and volcanism.

In a detailed study of the Lawler Peak Granite, Silver and others (1980) concluded that most of the uranium is contained in rare high-uranium minerals such as brannerite, coffinite, and thorite. The remainder is distributed in the more common accessory minerals such as zircon, sphene, apatite, etc., and along intergranular positions and microfractures.

By all evidence, the 1400 m.y. old granite suite found throughout much of southern Arizona, does contain statistically anomalous amounts of uranium. However, no important uranium occurrences are known in these rocks where obvious shear or fault control of the occurrence is absent. However, several districts in southern Arizona with uranium prospecting or some production are situated where these granites constitute all or part of the Precambrian basement. These areas include the Bagdad region, Globe-Miami, Horseshoe Dam area (lower Verde River), northern Whetstone Mountains, Blue Rock claims of Rincon Mountains, and the western Sierrita Mountains. In the last four areas, uranium occurrences are situated along large faults that juxtapose 1400 m.y. granites with younger rocks. In each case, the granite is the most likely nearby rock to serve as a source of uranium.

Fluorite is a common accessory mineral in mineralized faults and shears involving Precambrian granites and schists in Arizona (Van Alstine and Moore, 1969). Many of the uranium occurrences in granites contain accessory fluorite, as noted in the individual listings. An example of a radioactive anomaly in Precambrian granite with fluorite is in a shallow pit just east of Highway 666 in NW¼ sec 23, T11S, R26E, (Graham County) where a thin purple fluorite veinlet cuts the granite (this locality not tabulated in individual listings). Arizona's largest fluorspar mine to date is the Lone Star Mine in the Whetstone Mountains of Cochise County. Here, greenish fluorite veins up to 2½ feet thick cut Pinal Schist. Nearby, drilling programs by Kerr-McGee and Rocky Mountain Energy have probed faults and shears involving Precambrian granite, for uranium anomalies concentrated near the present water table. Perhaps an association of Precambrian-aged fluorite mineralization with uranium is suggested in this granite-schist terrain. At the Blue Rock claims (noted above, and discussed under vein occurrences), purple fluorite veins cut the rocks near a uranium-mineralized 10-20 foot thick fault zone that has juxtaposed 1400 m.y. (?) porphyritic granite with younger sediments.

Jurassic-Cretaceous Volcanic Rocks

South-central Arizona is known to contain a complex mixture of volcanic and plutonic rocks produced during the existence of arc-style magmatic events maximized during Jurassic through Cretaceous time. For descriptions of rocks, see Cooper (1971), Drewes (1971, 1976, 1980), Simons (1972), and Haxel and others (1980). These rocks are abundant throughout Santa Cruz County, southwest Cochise County and southwestern Pima County. The bulk of the rocks are intermediate to silicic in composition. and some are alkalic in character (S. Keith, pers. comm.,1979).

In Santa Cruz County alone, there are at least 16 known uranium occurrences in volcanic rocks thought to be of this age, including the following: Alto Group, Annie Laurie, Blue Jay, Canary Yellow, Four Queens, Happy Day and Joe Parker No. 5, Grandview Group, Happy Jack, Little Doc, Lone Star, Purple Cow, Santa Clara, Skyline, Sunset, and White Oak. Of these, minor production is recorded from two: 9 tons @ 0.28% U_3O_8 and 0.4% Cu from Santa Clara, and 18 tons @ 0.34% $U_3O_8$from White Oak. This concentration of occurrences in Santa Cruz County was first noted by Wright (1950). Figures 39 and 40 depict the geology and extent of mining at White Oak.

However, the sequence or timing of various mineralization events in this terrain is not established. The exploited mineralization in western Santa Cruz County is predominantly a Pb-Zn-(Cu)-Ag-Au vein-type with occasional uranium. However, some of the above uranium occurrences appear devoid of Pb-Zn-Ag minerals, yet appear in NE trending shears. Production from the Oro Blanco mining district (Ruby area) includes 617,000 tons of ore containing 44 million lbs of lead, 31 million lbs of zinc, 3.3 million ounces of silver, 31,400 ounces of gold, and 2.7 million lbs of copper. Many of the mineralized veins and shears strike about N50°E (see Figure 39), with a secondary NW strike component. This main strike direction and mineral association noted above is reminiscent of early Laramide (70-80 m.y.) vein systems elsewhere in southern Arizona (S. Keith, pers.comm.,Sept.1980). It remains to be determined whether the uranium was introduced with the other metals, perhaps during early Laramide time, or was more associated with earlier mineralization related to Jurassic magmatism. Since several of the radioactive occurrences are not associated with visible Pb-Cu minerals, the latter possibility is not dismissed. There is a strong relation between uranium and Cu-Pb-Zn-Au mineralization at Bisbee (Cochise County) where the base metal mineralization has been dated at lower- to middle Jurassic, and is related to the emplacement of the Juniper Flat granite there (see porphyry copper discussion).

There are a number of uranium occurrences in the Squaw Gulch-Temporal Gulch areas of the southern Santa Rita Mountains of Santa Cruz County (Figure 41), associated with limonite-stained shear zones cutting hydrothermally altered portions of the Jurassic-aged Squaw Gulch granite. See Blue Jay and Happy Jack occurrences . The nearby Ivanhoe Mine produced mostly gold, with other metals in low concentration. Drewes (1971) reports a 145 m.y. age on the Squaw Gulch granite, and maps two hydrothermally altered (Kaolinized) portions of this stock, the southernmost of which contains several radioactive anomalies.

See the discussion on Jurassic granites in southern Arizona in Drewes (1976), p. 24-29. The NURE Nogales NTMS quadrangle evaluation by Bendix suggests the Squaw Gulch area to be favorable for further exploration.

The potential for uranium occurrences in Jurassic-Cretaceous volcanic rocks remains poorly understood. For example, drill programs in the late 1970s in the Squaw Gulch area did not necessarily test the zones most favorable for uranium mineralization. And at the Happy Day claims (Santa Cruz County), several vertical shears trend N35-55°E, and display copper colors along the veins on the ceilings of two short adits driven along the veins. Early production from these veins was for argentiferous galena and copper. The same veins contain one-half inch wide black metallic crystalline uraninite-pitchblende lenses that count to 100-200X background. Several parallel shears and fractures in the immediate area also count abnormally high, yet virtually no assessment work and no drilling have been done.

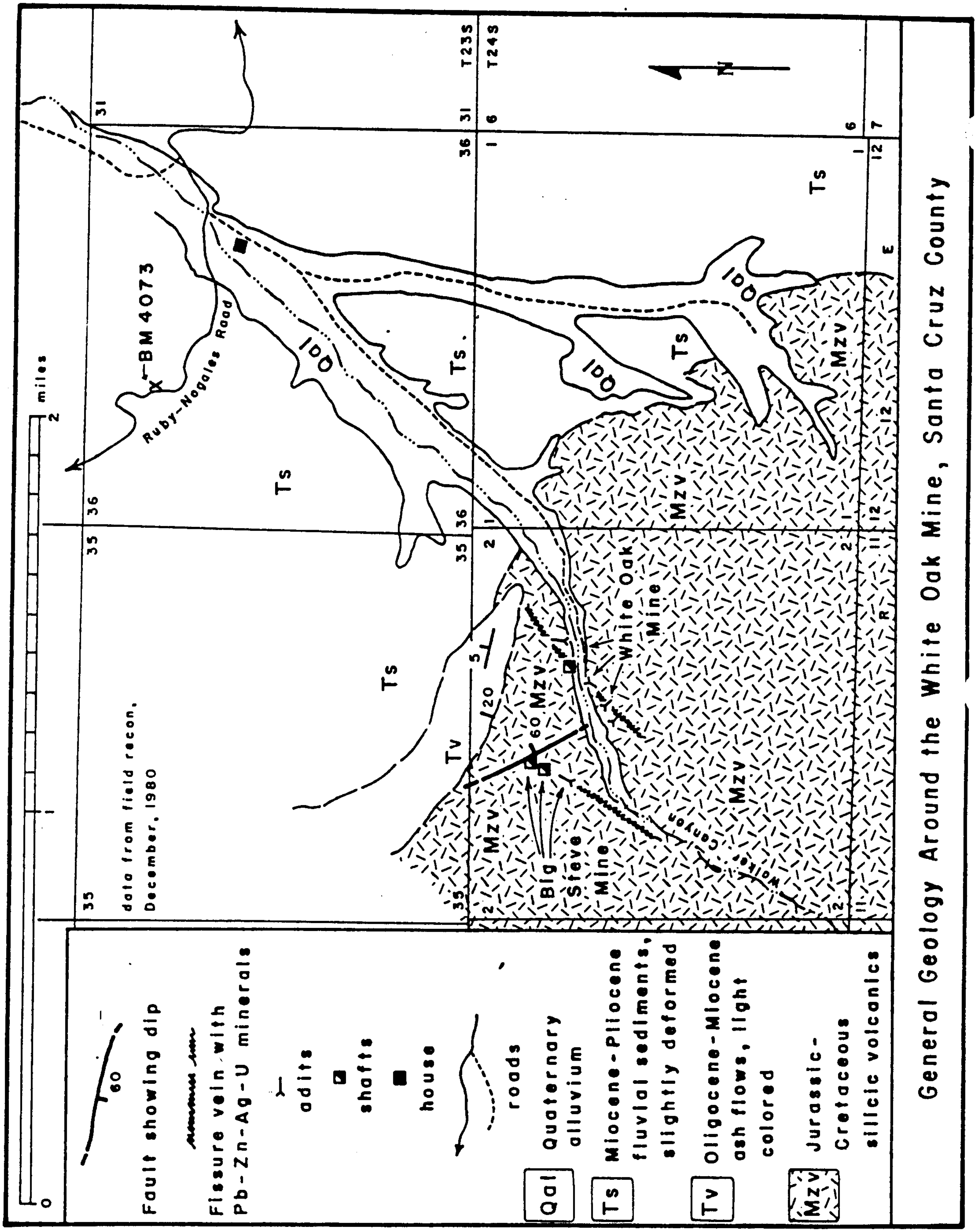

General Geology Around the White Oak Mine, Santa Cruz County
0
1
2
miles
Fault showing dip
60
Fissure vein with Pb-Zn-Ag-U minerals
adits
shafts
house
roads
Qal Quaternary alluvium
Ts Miocene-Pliocene fluvial sediments, slightly deformed
Tv Oligocene-Miocene ash flows, light colored
Mzv Jurassic-Cretaceous silicic volcanics
data from field recon, December, 1980
BM 4073
Ruby-Nogales Road
Big Steve Mine
White Oak Mine
Walker Canyon
Qal
Ts
Tv
Mzv
T23S
T24S
R
E
N

Figure 39

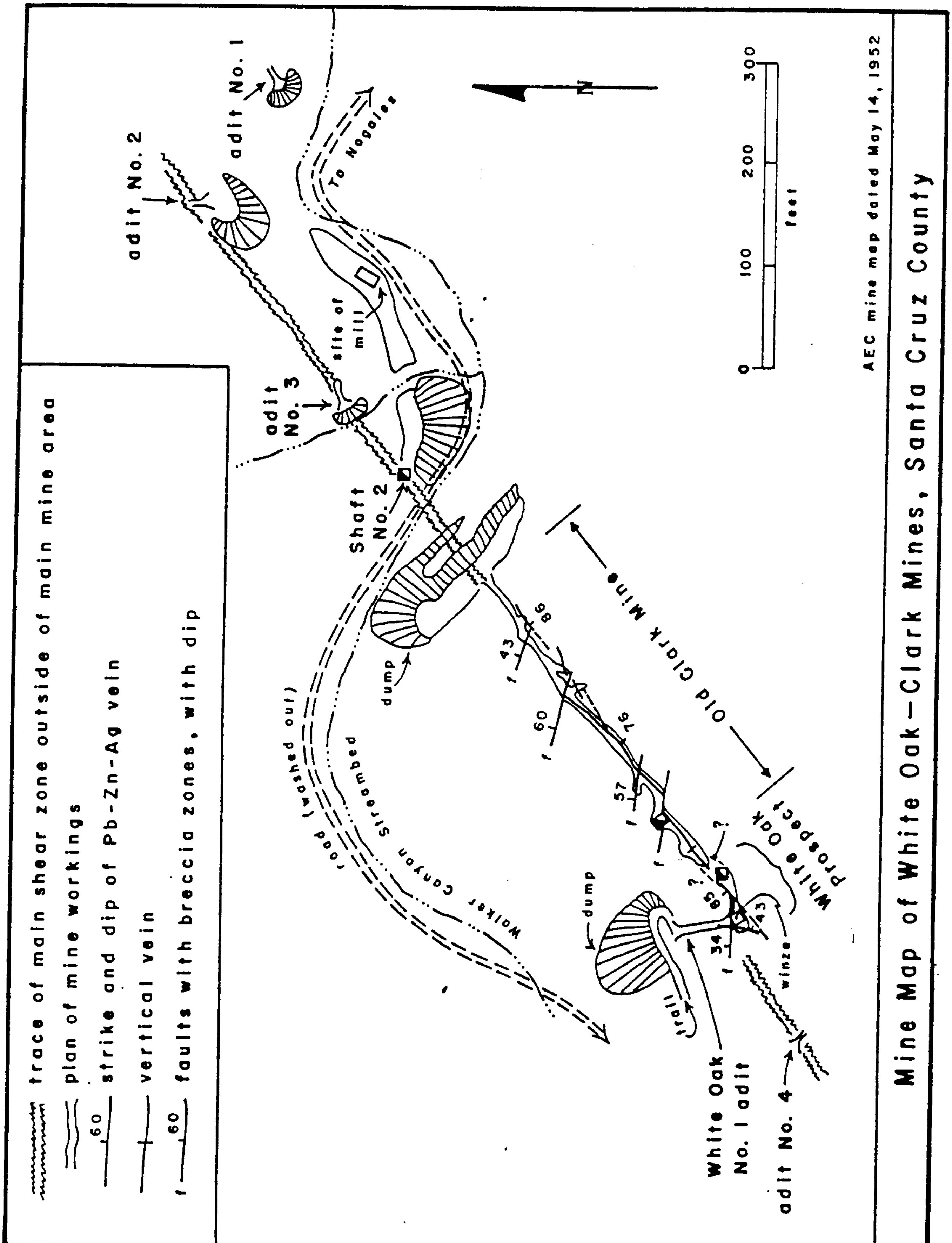
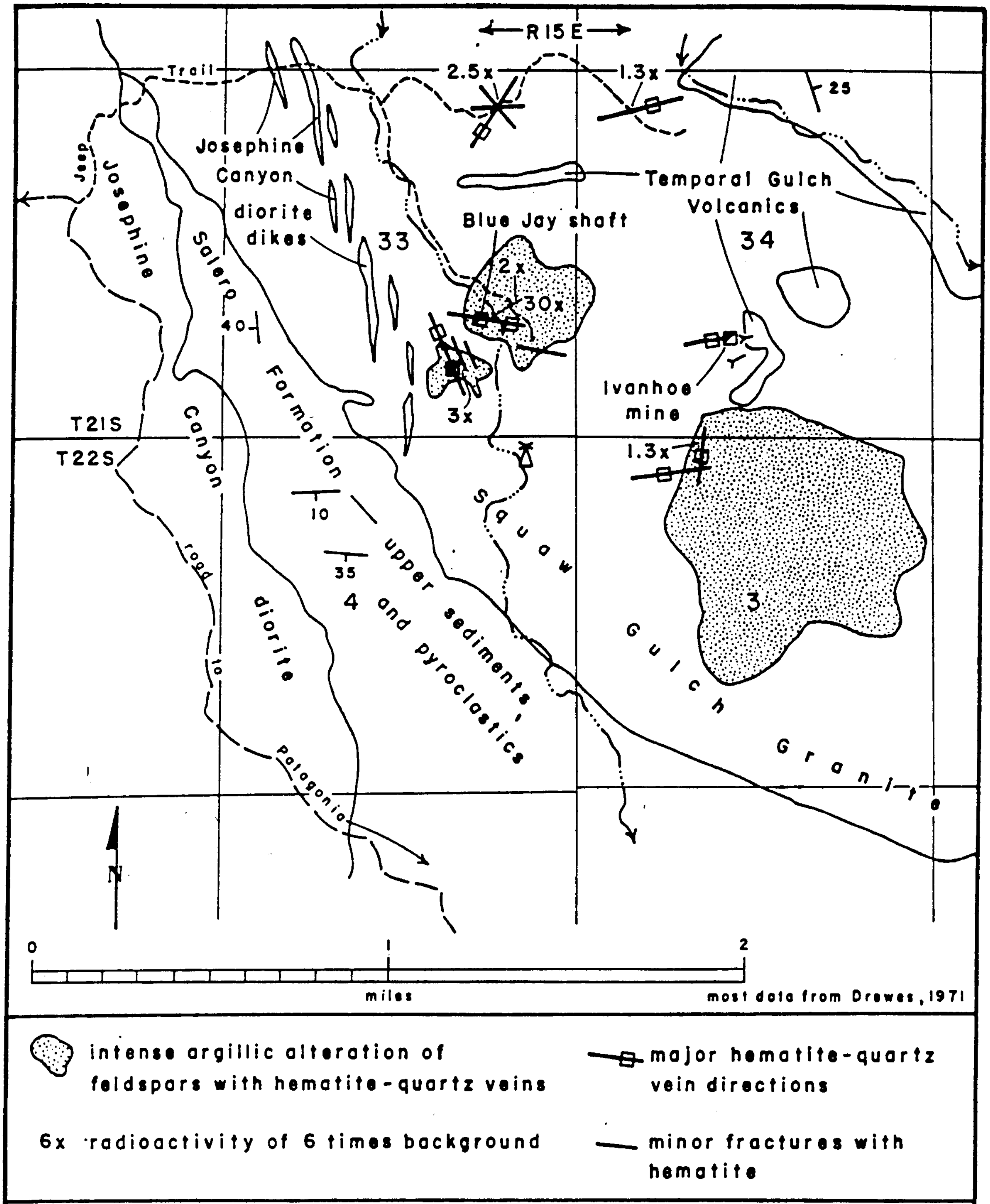

Mine Map of White Oak—Clark Mines, Santa Cruz County
AEC mine map dated May 14, 1952
0
100
200
300
feet
N
trace of main shear zone outside of main mine area
plan of mine workings
strike and dip of Pb-Zn-Ag vein
vertical vein
faults with breccia zones, with dip
60
60
adit No. 1
adit No. 2
To Nogales
site of mill
adit No. 3
Shaft No. 2
dump
Old Clark Mine
road (washed out)
Walker Canyon Streambed
White Oak prospect
dump
trail
White Oak No. 1 adit
adit No. 4
winze
86
43
60
76
57
85
43
34

Figure 40



Hydrothermal Alteration and Uranium Occurrences, Squaw Gulch Granite, Santa Rita Mtns., Santa Cruz County

Figure 41

Porphyry Copper Deposits

The Basin and Range portion of Arizona is host to a series of calc-alkalic plutons and batholiths which are well-known for their copper and molybdenum contents. Age dates on plutonic biotite and on mineralization-related chlorites and sericites generally fall in the time range 70-50 m.y. (Titley and Hicks, 1966; Jenny and Hauck, 1978), and hence place the plutonism and related tectonics into the same general time frame as the classic Laramide orogeny first defined in Wyoming.

Besides the above metals, porphyry copper deposits characteristically contain small amounts of lead, zinc and gold. However, on a more refined scale, it appears that the ores which contain primarily Pb-Zn-Ag-Au with only minor Cu-Mo are part of a spacially related, earlier Laramide mineralization episode that was followed by the Cu-Mo porphyry pluton systems (S. Keith, pers.comm.,1981). Field evidence suggests that quite often these earlier fissure vein systems are truncated by the later plutons. Some dating evidence in southeastern Arizona suggests 75-65 m.y. for the Pb-Zn mineralization and perhaps 65-50 m.y for the Cu-Mo mineralization, with ages for both categories increasing toward the northwestern part of Arizona. In Arizona, it is the Pb-Zn systems that appear to have more closely associated uranium occurrences, rather than the Cu-Mo porphyry systems.

Some Arizona porphyry copper companies are beginning programs to extract uranium from copper leach solutions percolated through oxide dumps or mill tailings. Information in GJO-100 (80) (Statistical Data for Uranium Industry), dated 1 January 1980, suggests that nationwide, 20,000 tons of U_3O_8 will be recovered through the year 2000 from "copper dump leach liquors." Mines in Arizona at which uranium extraction is ongoing or soon to be initiated include the Twin Buttes Mine in Pima County (owned by Anamax, and Phelps Dodge's Morenci deposit in Greenlee County. Anamax has announced that first yellowcake shipments were made from Twin Buttes in May, 1980. They expect to ship roughly 120,000 lbs of yellowcake (85% U_3O_8 concentrate) per year (see "Pay Dirt" for Arizona, May, 1980 issue, and Tucson Citizen newspaper, May 1, 1980 issue). Also, uranium species have been noted at several other porphyry copper mines, such as at the Silverbell Mine, Pima County (torbernite in Oxide pit), the Copper Cities Mine, Gila County (unidentified uranium minerals in shear zones in the plutonic terrain; Still, 1962), the Ray Mine, Pinal County of Kennecott Corporation, and at the Esperanza Mine, Pima County (torbernite in altered volcanics). Detailed information on the uranium geology of these deposits is lacking. Uranium seems most abundant in association with oxidized ores, supergene-enriched areas, or vein replacements in country rock, and with shear or fault zones. Within this geologic framework, the uranium cannot be demonstrated to have been derived from the hypogene sulfide systems. It could just as well have come from other sources such as externally derived groundwaters with subsequently precipitation in the oxidized zone.

The Warren mining district at Bisbee (Cochise County), under control of Phelps Dodge Corporation, although not a Laramide, but rather a Jurassic (170 m.y. age) deposit, deserves mention. The district is now inactive except for copper leach operations, but led a colorful life as a major Cu-Pb-Zn-Au-Ag producer from 1878 until 1975. Apparently, a concentration of uranium in the leach liquors exists that might be profitably extracted. Sketchy information indicates that concentration of uranium, along with copper, in replacement veins in country rock (such as Paleozoic limestones) is more important than uranium in the hypogene ores related to the Jurassic Juniper Flat granite or Sacramento stock. Certain of these vein systems with abundant and often spectacular azurite-malachite deposits count 2-5 times background on the scintillometer.

Bain (1952) published a 104 ± 6 m.y. uraninite age date from Bisbee , and Walker (1963) published two highly discordant ages of 175 and 1200 m.y. on similar material. These indicate some recent lead isotopic fractionation in the deposit. The Bisbee ores may prove to be a major Arizona source of uranium from the porphyry copper-type deposits. It is interesting that the Jurassic arc volcanism, which presumably produced the Bisbee ores, is somewhat more alkalic (higher $K_{57.5}$ values, Dickinson, 1970; Keith, 1978) than the Laramide porphyry copper-related rocks of the same region (Stan Keith, pers.comm,1980). Hence, an alkali-uranium relationship in plutonic terrains may suggest the feasibility of directing exploration energy towards areas having the more alkalic rocks.

The uranium occurrences of the Sierrita Mountains are an interesting example of probable Laramide uranium emplacement. Referring to Cooper's (1973) map of the Sierritas (USGS Map I-745), all the uranium occurrences in the main mountain range (Abe Lincoln, Black Dyke, Black Hawk, Diamond Head, Escondida, Glen, Hopeful, Leadville, Lena, etc.) are reported as vein-type occurrences in N70°E or N20°W fracture or fissure systems which cut a terrain dominated by pre-67 m.y. old early Laramide volcanics (Demetrie volcanics, Red Boy Rhyolite) and probable Triassic (?) - Jurassic (?) Ox Frame volcanics. These rocks are also the host for the Pb-Cu-Ag-Au vein systems of the area (Keystone Mine, etc.). This faulted volcanic terrain is intruded by the 59-62 m.y. old Ruby Star granodiorite which is thought to be related to the Cu-Mo porphyry sulfide systems of the Pima mining district. The uranium occurrences of these porphyry systems (Twin Buttes, Esperanza, New Year's Eve pit) are oxidized species (torbernite, etc.) which occur exclusively (?) in the oxide zones of these mines. The open pit mines lie under buried pediments on the lower flanks of the Sierrita Mountains, and have undergone extensive leaching, supergene enrichment, and erosional modification in their upper levels since Laramide time, much of it in the Miocene in response to Basin and Range pedimentation. Hence, with the numerous vein occurrences in the earlier Jurassic-Cretaceous volcanics upslope of this area, one may postulate either the environment of the hypogene sulfides of the porphyry systems or weathering of the upslope volcanics and vein systems as the source of the uranium minerals in the porphyry copper oxide zones.

Two Laramide porphyry copper-molybdenum systems at Mineral Park and Bagdad are discussed in the section on vein occurrences, but certainly substantiate an association of uranium with the peripheral Pb-Zn-Ag-Au vein systems of these Laramide deposits.

Cenozoic Volcanic Rocks

Although one of the more plentiful of the general rock types in Arizona Basin and Range country, the Cenozoic volcanic rocks contain relatively few uranium occurrences. These rocks range in chemistry from alkali olivine andesites to rhyolites, with voluminous latites and dacites, and volumetrically small proportions of alkali basalts and very alkalic trachytes (Shafiquallah and others, 1978).

Much attention has focused on the Anderson Mine area of the Date Creek Basin of Yavapai, Yuma, and Mohave County in the 1970's, during which time announcements were made of the discovery of at least 30 million pounds of U_3O_8 reserves (See the section on Cenozoic sediments for details). Many workers have hypothesized that this sedimentary uranium was ultimately derived from juxtaposed mid-Tertiary volcanic rocks in the area. Yet, the volcanics display many fewer surface anomalies than does, for example, the Precambrian crystalline terrain of the region. For instance, an alkalic series of flows in the Vulture Mountains, 40 miles southeast of the Anderson Mine, are devoid of uranium occurrences, as are similar-appearing flow sequences in the eastern arm of the Harcuvar Mountains, 25 miles farther west. At the west end of the Vulture Mountains, in a volcanic and volcanoclastic-dominated section, two uranium occurrences are noted in intercalated mudstones and thin-bedded limestone (Black Butte and Jar claims, Maricopa County), while the enclosing volcanics contain no known occurrences. Ten miles east of Wickenburg, a single area at the Golden Duck claims (Maricopa County) contains torbernite and other uranium minerals with chryscolla in shear zones cutting an alkali rhyolite vent complex of presumed early-middle Miocene age.

In the southeast part of the state, there are three large well-exposed volcanic centers of mid-Tertiary age; the Superstition Field, east of Phoenix; the Galiuro Field, east of Tucson; and the Chiricahua Field northeast of Douglas. All probably have larger exposed volumes of silicic rocks (rhyolites, dacites, latites) than andesitic rocks, yet have only rare uranium occurrences.

In the Chiricahua Mountains proper, a Late Oligocene, less deformed ignimbrite series (Rhyolite Canyon Formation of Marjaniemi, 1968) has a generally higher scintillometer count rate (300-500 cps with a Geometrics GR 101-A instrument over large areas) than a middle Oligocene, more deformed silicic flow series (Faraway Ranch Formation of Sabins, 1957, with 150-250 cps average readings), yet contains no known uranium anomalies in the main mountain mass. New NURE data on these two rock sequences indicate very similar K_2O contents, yet the younger rhyolites have four times the uranium content and twice the thorium content of the older rocks, based on a few field gamma ray spectrometric analyses. As well, a fluviolacustrine sequence intercalated into the Faraway Ranch silicic volcanics (termed "unknown C" in Cochise County listing) contains fetid thin-bedded limestones, and displays no anaomalous radioactivity. This would seem to hint that very little uranium was available in the surrounding volcanics for incorporation into the organic-rich sediments.

Elsewhere in southeast Arizona, a few radioactive occurrences are situated in mid-Tertiary volcanics. The Last Chance claims and the Little Swede Mine (Cochise County), about 10 miles east of Douglas in the Perilla Mountains occur along fractures cutting a rhyolite porphyry complex mapped as mid-Tertiary in age by Drewes (1980). The Fluorine Hills and Elanna claims near Pearce, in the Sulfur Springs valley (Cochise County) are also both in faulted rhyolite-volcanic agglomeratic rocks of mid-Tertiary age, according to Drewes (1980). All these rocks are probably cogenetic with the rhyolites of the Chiricahua Mountains. The Golondrina claims (Graham County) contain radioactive pyromophite with Cu-Pb-Ag minerals in a broad N-S shear zone cutting flow breccias and agglomerates of probable mid-Tertiary age (Drewes, 1980).

In the Atascosa-Tumacacori-Oro Blanco area northwest of Nogales, it appears that the uranium occurrences there are much more confined to an outcropping altered Jurassic-Cretaceous volcanic sequence than to a moderately sized mid-Tertiary volcanic blanket, although these volcanic sequences have not necessarily been adequately differentiated on geologic maps. The fact that no uranium occurrences are known in the Cenozoic volcanics in this region, and yet many occurrences are recorded in the underlying rocks, suggests the Cenozoic volcanics are not especially uraniferous.

The uranium-beryllium-fluorine association in volcanic rocks noted in such areas as the McDermitt and Thomas calderas (Files, 1978; Wallace, et al, 1980) has not yet been recognized in Arizona, although Burt and Sheridan (1980, p.44) list two topaz rhyolite occurrences in the State, at Saddle Mountain in the southeast, and along Burro Creek, in the west-central part. Their Figure 1, p. 41, suggests that fluorine-bearing volcanic rocks are found in an area almost entirely surrounding the Colorado Plateau. This suggests that more rocks of this type may be found in central Arizona.

Vein, Fault, and Shear Zone Occurrences

Southern and western Arizona contains numerous uranium occurrences in structurally controlled positions related to quartz-rich veins, pegmatites, faults, shear or fissure zones, and along lithologic contacts in crystalline and metamorphic terrains. These occurrences appear especially prevalent in the Precambrian granite and schist terrain of Graham, Maricopa, Yavapai, and Mohave Counties, but, as seen below, often record post-Precambrian mineralization in areas where geochronology is known. This section mentions those vein-type occurrences with scattered ages and diverse geology, which do not fit neatly into the previous sections, although the Hillside Mine and Wallapai district occurrences are most likely related to Laramide mineralization.

Walker and Osterwald (1963) list 127 vein-type occurrences in southern Arizona, and give an eight-fold classification scheme into which these described occurrences are placed. In their scheme, the most numerous Arizona occurrences are in (2) base metal sulfide veins with accessory carbonates and siliceous materials, (b) veins dominated by uranium minerals (either oxidized or reduced species) with essentially no base metal shows, but with accessory geothite and pyrite, and (c) veins with fluorite and accessory barite, calcite, and silica, and occasional Pb, Zn, Cu, or Mo.

Often in shear-or vein-type occurrences, the data suggest leaching of uranium from Precambrian host rocks and its incorporation into the vein systems at the time of mineralization, such as the many occurrences in Maricopa County where only Precambrian crystalline, metasedimentary, or metavolcanic rocks are exposed over large areas surrounding the occurrences. See Altuda, Arrowhead, Bickle and Manley, Copper Kid, Dale-Compton, Lucky Find, Napsack, and Red Rover claims in Maricopa county for examples of these occurrences. Often the time of mineralization at Precambrian host occurrences is unknown. The Big Load and Stony Peak claims in Stockton pass of the Pinaleno Mountains, Graham County, record uranium concentration along large-scale N50° W faults and in attendant spring waters. Here the only country rocks for several miles are Precambrian granitics and gneissic rocks. And at the Red Rover mine of Maricopa County where considerable copper and silver with minor gold was mined out of fissure zones in Yavapai Schist, there is no obvious evidence for the time of mineralization.

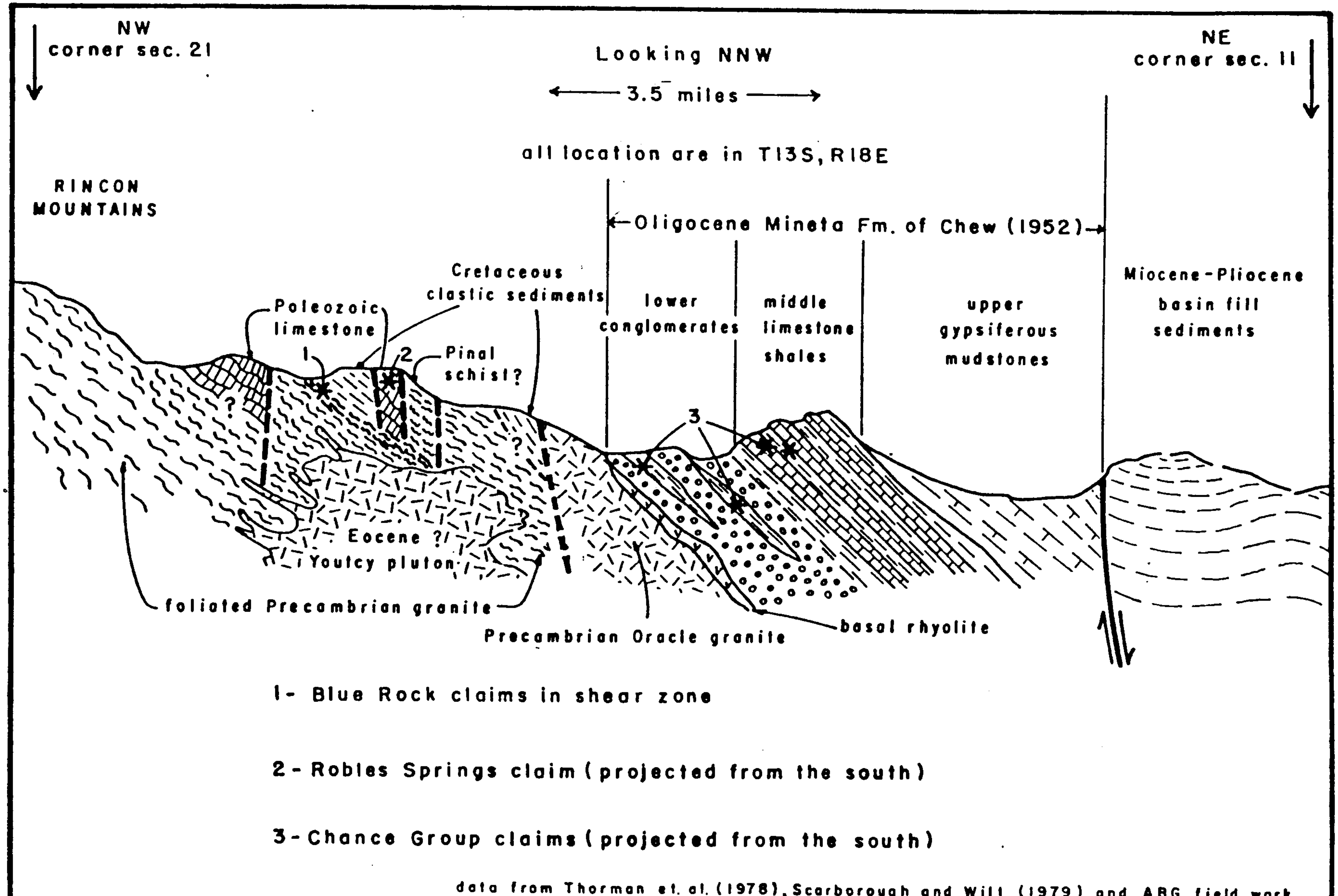
Perhaps the greatest concentration of vein-like uranium occurrences in the state is in the Wallapai mining district of the Cerbat Mountains. Here, an extensive NNW trending series of veins, mined for Pb-Zn-(Cu)-Au-Ag and with thick lenticular masses of gouge also contain many radioactive anomalies, although no uranium production is recorded. The host rocks are various Precambrian crystallines, but the veins are contiguous with the Laramide Mineral Park porphyry copper pluton system, and contain evidence of geochemical zoning with respect to that system. Eidel, et al (1968) suggest that the Pb-Zn-Ag vein system constitutes the last of three stages of hydrothermal mineralization related to the Mineral Park porphyry Cu-Mo system. See also Thomas (1949) and Dings (1951) for descriptions of mineralization studies of the Wallapi district. Damon and Mauger (1966) dated the Mineral Park porphyry at 72 m.y. by the K/Ar method.

The Hillside Mine of Yavapai County exploits a N-S trending sulfide vein system with an associated fault system (Anderson, and others, 1955) for 2,700 feet of outcrop length. Production between 1887 and 1956 amounted to 6.50 million lbs of Pb, 3.30 million lbs of Zn, 1.31 million oz. Ag, 58,700 oz. Au, and 0.40 million lbs of Cu. The mineralization is most likely Laramide in age, and is associated with the nearby Laramide Bagdad deposit. Nearby, massive sulfide mineralization associated with Precambrian volcanism in the Bagdad area consists of pyrite-chalcopyrite-sphalerite (S. Keith, pers.comm., 1981), but appears to lack radioactive anomalies. Uranium mineralization accompanies the vein system, and Anderson, et al, report a single company assay of 2.3% U_3O_8 from the now-flooded 700 foot level, directly down dip from uranium mineral occurrences on the 300 foot level studied by Axelrod, et al, (1951). Twenty-one tons of mine tailings assaying at 0.28% U_3O_8 were shipped from the mine in 1951. AEC personnel sampled the upper and lower tailings piles from the mine in 1959 and calculated 45,000 tons and 130,000 tons, respectively, of material assaying 0.06% U_3O_8 remains in the tailings.

An interesting example of a mineralized fault zone occurrence is the Blue Rock property of Redington Pass in the Santa Catalina-Rincon Mountains of Pima County. See Thorman and others (1978) for a geologic map of the area. As indicated in Figure 42, a 5-10 foot thick fault zone strikes NNW and dips 20-30° NE, and juxtaposes porphyritic granite of probable Precambrian age against a tectonically complex assemblage of Cretaceous clastic sediments, Paleozoic limestones, and Precambrian Pinal Schist (?). Quartz veins containing vugs lined with purple fluorite are found in the immediate area of the fault zone. Recent exploration drilling in the area has centered on this fault zone and possible others at shallow depths. Nearby, several other occurrences (see Robles Spring and Van Hill No. 5 claims) are in fault controlled positions with the same rock units present. The fault zone and its contained uranium mineralization is no older than mid-Cretaceous assuming a correct identification of the youngest faulted rocks as being units of the Bisbee Group. Still other uranium occurrences nearby are in Cenozoic sediments (see Chance claims, Pima County), which, from the present geologic setting, may have derived their uranium content from the upslope Blue Rock area. Coney and Reynolds (1980) have cited the Blue Rock occurrence as possibly associated with a "dislocation surface" related to the Santa Catalina-Rincon metamorphic core complex. They note (p.238-239) common hematite-chrysocolla-pyrite-barite-calcite-manganese mineralization associated with this class of faults elsewhere. The Pride Mine of northern Yuma County is developed in Cu-Fe mineralization along a dislocation surface and has minor radioactive anomalies associated with limonite pods near the fault (Scarborough and Wilt, 1979, p.69).

An area showing hydrothermal mobilization and concentration along shears of uranium mineralization is in Squaw Gulch of the southern Santa Rita Mountains. Figure 41, modified from Drewes (1971), indicates the geologic setting of the mineralized Jurassic (145 m.y.) Squaw Gulch granite. Two areas in the granite that show intense argillic alteration of feldspars (shown in the figure) contain numerous mild radioactive anomalies, as noted originally on the Blue Jay PRR (Santa Cruz County). These areas are also the loci of hematite - bull quartz veins following several major directions of shearing, especially E-W $\pm$ 10°, and N-S $\pm$ 30°. Radioactive anomalies are found most often in intensely kaolinized granite very near concentrations of these hematite veins, although often not in the veins. Also, the anomalies are most intense in valley floors, grading to barely noticeable along ridge crests. An old pre-1920 mining operation in the area at the Ivanhoe Mine recovered considerable Ag-Au-Pb-(Cu), yet is devoid of radioactive anomalies at the surface and on the mine dumps. Overall, the Squaw Gulch granite in the six square mile area centered around Figure 41 contains dozens of small discontinuous pockets of hydrothermal alteration not shown in the figure, some of which contain radioactive anomalies. It may be worthwhile to inquire about possible enrichment of uranium species near the present shallow water table in the area, since there are signs of pervasive anomalous uranium content at the surface. The age of this mineralization may best be gauged as Laramide based on (1) probable Laramide ages of E-W dikes found throughout the Santa Ritas (see Drewes, 1971) and noting that many pronounced anomalies in the Squaw Gulch area appear localized near E-W shears, and (2) the former presence of late Cretaceous volcanic cover over the Squaw Gulch granite (Temporal and Salero Formations, see Drewes, 1971) provides a mechanism for hydrothermal alteration of Laramide age in the area. Note also that the Duranium Mine (Santa Cruz County), 10 miles northwest of here, is in an E-W shear zone cutting Cretaceous sediments. That mine is discussed elsewhere in this report. The NURE Nogales quadrangle evaluation by Bendix personnel suggests the Squaw Gulch area is favorable for potential uranium resources.

The Black Dyke prospect of the Sierrita Mountains of Pima County was originally developed for copper on a NW-trending sheared contact between Paleozoic metasediments and Precambrian granitic plutons. The mined vein material contains uraninite, purple fluorite, and oxidized copper minerals. Eleven tons of ore shipped in 1957 averaged 0.18% U_3O_8. An additional 49 tons of "no pay" ore averaging 0.06% U_3O_8 and 0.04% V_2O_5 was shipped in 1956. Some potential for further mineralization remains. Most likely, the mineralization is Laramide in age, perhaps related to the extensive Pima mining district copper porphyry systems to the east. At least one of the mines in this district (Anamax's Twin Buttes Mine) is presently recovering uranium from leach circuits.



Idealized Cross-Section of Blue Rock, Robles Springs and Chance Claim Group Uranium Occurrences, Pima and Cochise Counties

Figure 42

THORIUM IN ARIZONA

Known or suspected occurrences of thorium minerals in Arizona are indicated in the geology sections of the individual listings. These fall into generally two categories, vein-pegmatite occurrences, and black placer sand deposits.

Many of the radioactive pegmatite occurrences, such as in the Aquarius Mountains and at scattered places through the Precambrian crystalline terrain of central Arizona (Yuma, Yavapai, Maricopa Counties) yield low chemical uranium analyses compared to radioactive analyses and hence probably contain thorium minerals such as euxenite, fergusonite, samarskite, or allanite. No mining of these deposits for thorium content is recorded. Staatz (1974) gives chemical and minerological analyses of two thorium vein occurrences in Arizona. The Farview claims (Yavapai County) are in a "breccia body" 100 x 60 feet across in a metamorphosed volcanic host rock, and contain rare thorite with abundant dolomite, limonite, and geothite. The Goodman Mine group of Yuma County (Staatz's Quartzite locality) has assays of up to 0.27% ThO_2 along a part of a WNW-trending shear zone which cuts Mesozoic (?) quartzose epidote schist and metasediments. He records thorite and allanite with magnetite and iron oxides from this occurrence.

The Bechetti Lease near Jerome, Yavapai County, contains a 25 foot-thick quartz vein intruding Precambrian metavolcanics and metasediments. Chemical assays on six small samples indicate ThO_2 contents of 0.2 to 1.4% and U_3O_8 contents on the same samples of 0.003-0.01%. The vein is described as containing quartz, limonite, and hematite as major minerals and is mapped for nearly 1,000 feet at the surface.

Radioactive black placer sand deposits have been noted in two environments in Arizona. These are fossil shoreline deposits related to the Mancos and Bisbee seaways of the Western Interior, and black placer sand concentrates in modern stream alluvium in the Basin and Range country of Maricopa and Pima Counties.

Cretaceous black sands of the Toreva Formation of the Black Mesa Basin are described by Murphy (1956) and Houston and Murphy (1977). They typically consist of opaque iron-titanium oxides and zircon, with minor variable amounts of rutile, monazite, sphene, apatite, allanite, niobium-bearing opaque minerals, anatase, and spinel. Radioactivity is due to variable amounts of uranium and thorium. Houston and Murphy describe three localities on Black Mesa which are thought to represent regressive beach and tide-reworked sandstones in the Toreva Formation. These deposits are 10-20 m.y. older than their geologic equivalents in the northern Rocky Mountains region.

Slightly radioactive black sand concentrates are also noted in fluvial channel deposits associated with the Petrified Forest Member of the Chinle Formation, eight miles north of Cameron, one-tenth mile east of new Highway 89.

In several parts of the Basin and Range country, modern stream alluvium containing black sands has been noted to be slightly radioactive. In Pima County, claims have been staked in the northern Sierritas (England, Will, Bixby) and in the Happy Valley area (Dollar Bill), and in the Big Horn Mountains of Maricopa County (Black Magic). The radioactivity in these deposits is probably due to both uranium and thorium in several heavy mineral species hydraulically concentrated along the stream courses. Apparently, these placers are being derived from both Precambrian and Laramide crystalline source rocks.

Individual County Listings

The following pages (p. 104-263) contain an alphabetical listing, county by county, of all known radioactive occurrences (including all producers of uranium) in the State. The guide to the kinds of information found in the individual listings is on pages 4 and 5. The first page or two of each county's listings is the number key to the NTMS (1:250,000) maps which accompany the report under separate cover. For example, in Apache County, the Etsitty Mine is plotted as #15 on the Shiprock NTMS map, which, from the Contents section, is Plate 13. These keys do not include those occurrences and mines plotted on the four district maps (Plates 18 - 21), each of which has its key included on the map.

Index for Apache County Uranium Occurrences

(Excluding Carrizo Mountains and Lukachukai Mountains District Maps)

C = Clifton
SJ = St.Johns
S = Shiprock
G = Gallup

APACHE COUNTY

Note: Apache County production details and mine locations in the Carrizo Mtns, Black Mtn, and Lukachukai Mtns areas are from the following D.O.E. publications:

Preliminary Map No. 28 (Lukachukai Mtns)
Preliminary Map No. 31 (Black Mtn area)
Chenoweth, W. (1980, TM-209), N.W. Carrizos
Chenoweth, W. (1980, TM-210), East Carrizos.

A.E.C. PLOTS - listed below, totaled 960 acres. (see Chenoweth, W., 1980, TM-209)

A.E.C. plot A - Saytah Canyon, head of canyon, east of main claim
A.E.C. plot B, C, D - Segi Ho Cho Mesa
A.E.C. plot E - Kinusta Mesa, east end
A.E.C. plot 1 - Martin Mine
A.E.C. plot 2 - North Martin Mine
A.E.C. plot 3 - Saytah Wash, just north of Carson Mine
A.E.C. plot 4 - Saytah Canyon Mine, NW of MC Mine
A.E.C. plot 5 - CBW-MC Mine (Curran Bros and Wade - main claim)
A.E.C. plot 6 - Eurida Mines
A.E.C. plot 7 - Cove Mesa Mines of VCA

AGUA SAL DRILLING PERMIT (Wilson Prospect)

LOC: Approx. Sec. 17, T8N, R9W
East bank of Agua Sal Creek

QUAD: Yellowstone Canyon 15°; Shiprock NTMS

DEVL: 20 holes drilled to average depth of 60' in 1956

ANAL: 0.33% e U_3O_8, and 0.36% U_3O_8

GEOL: Yellow uranium minerals associated with a zone of mudstone galls and splits at base of Shinarump channel 40 ft. deep, atop DeChelly Sandstone. Small monocline nearby.

REF: D.O.E.

AIR ANOMALY #2 and 3 (Charlie James #1)

AIR ANOMALY #5

LOC: Approx. Sec. 9, T33N, R23E
Black Mesa

QUAD: Tah Chee wash 7½'; Shiprock NTMS

GEOL: Uranium mineralization associated with iron oxide concretions in fractured arkosic sandstone, about 100 ft. below the contact between the lower and upper members of the Mesaverde Fm.

REF: PR-R-EDR-1293 & 1296 (#45 & 46)

AIR ANOMALY #13-15 (Claim #3)

ALCOVE-TOH ACON MESA (Refer to Chester Mud #1)

LOC: Approx. central and SE ¼ Sec. 10, NW¼ and SE¼ Sec. 13, NE¼ Sec. 23, NW¼ Sec. 24, N½ Sec. 25, T38N, R27E

QUAD: Los Gigantes Butte 15'; Shiprock NTMS

GEOL: Tyuyamunite-type mineralization in fine to medium grained sandstone with carbonized plan remains in Morrison Fm.

REF: Peirce, H.W. and others (1970)

ALKALI WATER GAP

LOC: Approx. E. center edge Sec. 9, T32N, R23E

QUAD: Blue Gap 7½; Shiprock NTMS

GEOL: Tyuyamunite replacing cement and coating grains along cross-bedding in light-gray, quartzose, fine- to coarse-grained carbonaceous sandstone inter-bedded between carbonaceous strata. Mineralized bodies 10-100 ft. long and 1-2 ft. thick possibly with some vanadium.

ALLEN GLEASON

LOC: "4.2 miles up road to Foutz-Ashcroft Mine in Carrizo Area from junction with main road, then up wash to west of road to bottom of upper basalt.

QUAD: Pastora Peak 15'; Shiprock NTMS

GEOL: Tyuyamunite-type mineralization in Salt Wash about 40 ft. above lower contact. Upper contact is basalt.

ANOMALY 15-30.1

LOC: SW¼, T2N, R9W
Nazlini Canyon-Canyon DeChelly

QUAD: Nazlini 15'; Gallup NTMS

GEOL: Uranium mineralization associated with abundant silicified and carbonized plant remains in greenish siltstone of Chinle Fm.

REF: Finch, W.I. (1967)

APACHE MINE

LOC: Unknown to BIA or Navajo Tribe

PROD: 5 tons @ 0.18% U_3O_8; 1.14% V_2O_5 in second quarter 1951 by Uranium Development Corp.

ARROWHEAD

LOC: Approx. Sec. 2, T32N, R23E
Black Mountain

QUAD: Lohali Point 7½; Shiprock NTMS

DEVL: Small adit

PROD: 6 tons @ 0.13% U_3O_8; 0.11% V_2O_5; 0.5% $CaCO_3$, 1955

GEOL: Carnotite in sandstone of the Toreva Fm.

REF: D.O.E., preliminary map No. 31

BARE ROCK MESA (Black #2)

BARTON #3 (King #8)

LOC: Approx. NE¼ Sec. 28, T41N, R27E
NW end of Toh-Atin Mesa, NW Carrizo Mtns.

QUAD: Toh-Atin Mesa 15'; Shiprock NTMS

DEVL: Adit

PROD: 31 tons @ 0.12% U_3O_8; 0.52% V_2O_5; 1954

RAD: 3 mr/hr.

ANAL: 0.01-0.61% e U_3O_8; 0.09-0.37% U_3O_8; 0.92% V_2O_5; 0.72% $CaCO_3$

GEOL: Discontinuous streaks of tyuyamunite and vanadium minerals associated with limonite and carbonaceous matter in Salt Wash sandstone.

REF: Butler, A.P. Jr. and others (1962), PRR-EDR-253, Finch, W.I. (1967)

BASALT CLAIM

LOC: "3½ miles west of Beclabito Trading Post, turn left on dirt road which leads into canyon in the Carrizo Mtns. toward Zona #1 Mine. Park car after traveling 4½ miles on dirt road and climb the hill to the NW of parked car." Might be same as Allen Gleason claim.

QUAD: Pastora Peak 15';
Shiprock NTMS

ANAL: 25.5% e U_3O_8; 24.62% U_3O_8; 0.07% V_2O_5; 0.9% $CaCO_3$

GEOL: Tyuyamunite and possibly montrosite in channel deposit in Salt Wash member between 2 dolerite sills.

REF: PRR-EDR-386

BEE SHO SHEE (Willy Waters)

BEGAY #1 (Thomas Begay #1)

BENALLY (Melvin Benally #1)

BENALLY #1-3 (Capitan Benally)

BETTIE #1

LOC: Approx. Sec. 21 and 28, T40N, R30E, East Carrizos
(AEC plot: 36°51' 15"N, 109°08' 05" W)

QUAD: Pastora Peak 15'; Shiprock NTMS

DEVL: 3 adits with about 100 ft. underground workings. Ore brought off mountain with horses.

PROD: 53 tons @ 0.18% U_3O_8; 0.91% V_2O_5, 1955-56

GEOL: Ore lenses of tyuyamunite and vanadium minerals associated with carbon matter pockets along sandstone-mudstone contact about 30 ft. above Salt Wash member basal contact.

REF: D.O.E.

BILLIE #1

LOC: Approx. NE corner of Sec. 34, SE corner of Sec. 27, T40N, R30E. N Carrizo Mtns. Beclabito Canyon - 450 ft. SE from Zona Mine, near Ruben No. 1.

QUAD: Pastora Peak 15'; Shiprock NTMS

DEVL: 75 ft. of incline adit (N75°E), driven from rim cut. Access to mine is along extension of Zona mine road.

GEOL: Ore zone 0.2-2 ft. thick in discontinuous bands and scattered patches 40 ft. above base of Salt Wash member contact with dolerite sill.

REF: D.O.E.

BILLY TOPAHA MINE (Topaha)

LOC: Approx. Sec. 28 T36N, R29E

QUAD: Lukachukai and Red Rock Valley 15'; Shiprock NTMS

DEVL; 200 ft. adit w/room and pillar workings

PROD: 703 tons @ 0.20% U_3O_8; 0.96% V_2O_5, 1959-60

GEOL: Small pods of tyuyamunite ore in Salt Wash member.

REF: D.O.E.

BLACK AND BLACKWATER CLAIMS (Blackwater)

LOC: Approx. E. central Sec. 3, NW¼ Sec. 10 and E½ Sec. 9, T41N R23E. Now a part of Monument #2 supplement.

QUAD: Dennehotso 15'; Shiprock NTMS

DEVL: Several small open pit and underground workings

PROD: 5,350 tons @ 0.30% U_3O_8 in 1952-57

GEOL: Tyuyamunite-type mineralization as fracture fillings and disseminations at the Shinarump-Moenkopi contact. Abundant carbonized and silicified plant materials in Shinarump sandstone and conglomerate.

REF: Johnson, H. & Thordarson, W. (1956, TEI-640), Finch, W. (1967)

BLACK #1 (Flag #2)

LOC: Approx. Sec. 29, T36N, R29E
Lukachukai-Flag Mesa

QUAD: Los Gigantes Buttes and Red Rock Valley 15'; Redrock Valley 15'; Shiprock NTMS

DEVL: Stopes, portions are caved.

PROD: 1,407 tons @ 0.18% U_3O_8; 0.63% V_2O_5 in 1955.

GEOL: Pods of tyuyamunite mineralization bedded in Salt Wash member

REF: D.O.E.

BLACK #2 (East) (Bare Rock Mesa)

LOC: Approx. Sec. 29, T36N, R29E
Lukachukai Mtns.-Bare Rock Mesa

QUAD: Lukachukai and Redrock Valley 15'; Shiprock NTMS

DEVL: Underground

PROD: 1,879 tons @ 0.19% U_3O_8; 1.60% V_2O_5, 1955-57 & 1963-64, includes minor production from Black #2 (West)

GEOL: Bedded and poddy tyuyamunite mineralization in Salt Wash member

REF: D.O.E.

BLACK #2 (West)

LOC: Approx. Sec. 29, T36N, R29E
Lukachukai Mtns.

QUAD: Lukachukai and Redrock Valley 15'; Shiprock NTMS

DEVL: Underground

PROD: Minor production included with east mine in 1955.

GEOL: Tyuyamunite-type mineralization in Salt Wash member

REF: D.O.E.

BLACK MTN. - Rough Rock Area

Roughly 57,600 lbs. of U_3O_8 and 26,000 lbs of V_2O_5 were mined from the Cretaceous Toreva Fm. in this area from 1951 through 1968, according to D.O.E. preliminary map No. 31 (1973). The producers are (in decreasing order of pounds of U_3O_8 production):

1. Claim 28
2. Claim 10
3. Claim 7
4. Todecheenie No. 1
5. Claim 3
6. Tom Klee (1.01% avg. U_3O_8)
7. Dan Taylor No. 1
8. Tom Wilson
9. Etsitty No. 1
10. Rough Rock Slope No. 9
11. Kasewood Bahe No. 1
12. Thomas Begay No. 1
13. Black Mtn. Vase
14. Claim 31
15. Arrowhead No. 2

BLACK MOUNTAIN VASE (Jim L. Smiley)

LOC: Sec. 3 and 10, T32N, R23E
Black Mtn.

QUAD: Lohali Point 7½'; Shiprock NTMS

DEVL: Surface scrapings

PROD: 11 tons @ 0.12% U_3O_8; 0.08% V_2O_5, 1955

GEOL: Carnotite mineralization lies near an axis of a broad synclinal through, trending NW-SE in upper part of Toreva Fm. Fairly strong fracturing.

REF: D.O.E., preliminary map No. 31

BLACK MUSTACHE

LOC: Monument Valley (unknown in Carrizos)
Not plotted on maps

DEVL: Mined by Tom Benally

PROD: 95 tons @ 0.23% U_3O_8; 1.99% V_2O_5 in 1951.

REF: D.O.E.

BLACK ROCK POINT MINE (Thomas Clani)

LOC: Approx. NW¼ Sec. 8, T40N, R29E
On north prong of Black Rock Point-NW Carrizo Mtns.

QUAD: Toh-Atin Mesa 15'; Shiprock NTMS

DEVL: Open stope on edge of Mesa - 1,365 ft. of workings

PROD: 2,025 tons @ 0.20% U_3O_8; 1.33% V_2O_5, 1951-58, 1962, 1965-66.

GEOL: Discontinuous bands and lenses of tyuyamunite ore along sandstone-mudstone bedding planes in median basal Salt Wash member. Also associated with structures and accumulations of mud and organic matter.

REF: D.O.E.

BLACKHORSE CREEK

LOC: Approx. SW¼ Sec. 13, T39N, R29E

QUAD: Pastora Peak 15'; Shiprock NTMS

GEOL: Tyuyamunite-type mineralization in Salt Wash member.

REF: Strobell, J. (1956)
O'Sullivan, R. and Beikman, H. (1963)

BLACKWATER (Black and Blackwater)

BLUESTONE #1 (Garnet Ridge Distreme, Keith Francis Claims)

LOC: Approx. Sec. 19, 20, 29, T41N, R24E
Monument Valley-Comb Ridge Area-Garnet Ridge

QUAD: Dennehotso 15'; Shiprock NTMS

DEVL: Rim cut and drilled

PROD: 53 tons @ 0.22% U_3O_8; 0.82% V_2O_5 in 1955-56.

ANAL: 0.07-1.26% U_3O_8; 0.54-1.16% V_2O_5; 6.68% Cu

GEOL: Tyuyamunite and calcocite mineralization along dike and vein in Navajo sandstone. Highly altered mica-serpentine dike strikes N75°W, dips 60°N. and extends to west end of a collapsed structure on a N50°E trending syncline Metatyuyamunite, volborthite, malachite, and chrysocolla with traces of silver, cobalt, nickel vanadium, lead and thallium are present.

REF: Shoemaker, E. (1956)
Shoemaker, E. (1955, TEI-590, P.63-65)
Malde, H. & Thaden, R. (1963)

BLOCK K

LOC: Approx. Sec. 31, T41N, R29E
NW Carrizo

QUAD: Toh-Atin Mesa 15'; Shiprock NTMS

DEVL: Inclined shaft

PROD: 2,018 tons @ 0.17% U_3O_8; 1.30% V_2O_5, 1962-64

GEOL: Tyuyamunite occurs in the basal portion of Salt Wash member on north flank of Toh-Atin anticline. Discovered beneath valley fill by AEC drilling.

REF: D.O.E.

BLUE LAKE CLAIM

LOC: On a generally NW-facing rim of Salt Wash member, according to PRR map, probably in Apache Co. (Red Point Mesa 7.5 map) in extreme NW corner somewhere; possibly in Navajo Co., (Church Rock, AZ 7.5' map) in extreme NE corner. See PRR locality. Also shown as mineralized outcrop of Salt Wash 10 miles west of Rattlesnake Mine (between "R" and "I" of "ARIZONA") on USGS map MF-16 by W. Finch (1955).

QUAD: Marble Canyon NTMS

RAD: 7X

GEOL: Yellow uranium minerals in fossil wood, lower part of Salt Wash member.

REF: PRR-GJEBR-103 (#48)
Chester, J. W. (1952, TM-12)

BRODIE #1 (Mike Brodie #1)

CAMP MINE (Refer also to Cisco #1 and Joleo Mine)

LOC: Approx. Sec. 28, T36N, R29E at SW end of ridge Lukachukai Mtns. - Camp Mesa

QUAD: Redrock Valley 15'; Shiprock NTMS

DEVL: Underground

PROD: 18,853 tons @ 0.24% U_3O_8; 0.94% V_2O_5, 1953-56, 1962-63, includes minor production from Cisco #1 in 1953.

GEOL: Associated with carbonized logs, ore zones range in thickness from 1 ft. to 10 ft. and average 3 ft. Most ore is in the lower 10 to 15 ft. of Salt Wash member with festoon and trough-type cross-stratification. Sandstone has filled channels, and scours in underlying joints filled w/tyuyamunite, indicating that some secondary distribution of ore is controlled by jointing.

REF: D.O.E.

CAPITAN BENALLY #4A and 5

LOC: Approx. Sec. 29-30, T41N, R29E
NW Carrizo

QUAD: Pastora Peak 15'; Shiprock NTMS

DEVL: Incline

PROD: 114 tons @ 0.21% U_3O_8; 1.38% V_2O_5, 1957
Includes illegal shipments by Jimmie King

GEOL: Small, discontinuous bands and lenses of tyuyamunite ore in basal Salt Wash along sandstone-mudstone bedding planes.

REF: D.O.E.

CARRIZO MOUNTAIN

LOC: Unknown; in Apache Co.? May belong to VCA West Reservation Lease.

PROD: 160 tons @ 0.29% U_3O_8, 4.44% V_2O_5 in 1950

REF: Chenoweth, W. L. (1980, TM-209) and
Chenoweth (pers. comm., 1980)

CARSON

LOC: Approx. Sec. 13, T40N, R28E
NW Carrizo Mtns.

QUAD: Toh-Atin Mesa 15'; Shiprock NTMS

DEVL: 200 ft. drifts, adits and crosscuts

PROD: 93 tons @ 0.22% U_3O_8, 1.58% V_2O_5, 1958

GEOL: Tyuyamunite ore replacing logs and associated with pockets of organic matter in lower part of Salt Wash member.

REF: D.O.E.

CATO #1 PIT

LOC: Approx. Sec. 5-8, T36N, R29E Lukachukai Mtns.

QUAD: Redrock Valley 15'; Shiprock NTMS

DEVL: Open pit

PROD: 54 tons @ 0.28% U_3O_8; 2.52% V_2O_5, 1951

GEOL: Mineralization in Salt Wash member

REF: D.O.E.

CATO #2 MINE

LOC: Approx. common corner Sec. 5,6,7,8, T36N, R29E Lukachukai Mtns.

QUAD: Los Gigantes Buttes and Red Rock Valley 15'; Shiprock NTMS

DEVL: 3 short adits

PROD: 52 tons @ 0.23% U_3O_8; 1.53% V_2O_5, 1953-54

GEOL: Mineralization in Salt Wash member

REF: D.O.E.

CATO SELLS (Cove Mesa #1)

CATO SELLS TRACTS 1S, 2W, 1N (SM Tract #2, Tract #1 & 2)

LOC: Approx. Sec. 27 and 34 T41N, R23E Monument Valley

QUAD: Dinnehotso 15'; Shiprock NTMS

PROD: Now part of Monument #2 supplement: Tract 1 south produced 8,049 tons @ 0.40% U_3O_8 in 1952-54; Tract 2 west produced 295 tons @ 0.30% U_3O_8 in 1955-58; Tract 1 north produced 17,950 tons @ 0.29% U_3O_8 in 1951-59.

REF: D.O.E.

CBW-MC MINE (AEC Plot 5) (Curran Bros. & Wade Main Claim Mine)

LOC: Approx. Sec. 31-32, T39N, R29E Carrizo Mtns.

QUAD: Toh-Atin Mesa and Pastoria Peak 15'; Shiprock NTMS.

DEVL: Small underground working

PROD: From August, 1942 to February, 1944, Wade, Curran, and Company shipped 2,942 tons @ 2.23% V_2O_5 from Martin, North Martin, CBW-MC, Saytah, Saytah Canyon and Eurida Mines.

GEOL: Mineralization in Salt Wash member

REF: Harshbarger, J. (1946, RMO-441)
Chenoweth (1980, TM-209)

CHARLIE BEKIS CLAIM (Cottonwood Butte Claim)

CHARLIE JAMES #1 (Salina #4, Ruin Mesa; Air Anomaly #2 and 3)

LOC: Approx. Sec. 28 and 29, T33N, R23E. Tsasahdi or "Ruin" Mesa - Black Mountain

QUAD: Blue Gap 7½; Shiprock NTMS

RAD: Detected by air survey

ANAL: 0.10-0.61% e U_3O_8; 0.08-0.66% U_3O_8; 0.05-0.25% V_2O_5; 0.4-0.8% $CaCO_3$

GEOL: Carnotite associated with carbon matter, as halos around limonite, disseminated interstitially and as paint with vanadium mineral coatings in a light gray sandstone about 10 ft. thick and 250 ft. above Mancos contact in Toreva Fm.

REF: PRR-EDR-1289 (#42)
PRR-EDR-238
Clinton, J. (1956, RME-91)

CHEE NEZ #1

LOC: Approx. Sec. 27 and 3,4, T41N, R23E

QUAD: Dinnehotso 15'; Shiprock NTMS

DEVL: Now part of Monument #2 supplement

PROD: 438 tons @ 0.31% U_3O_8; 1.23% V_2O_5 in 1955-57

REF: D.O.E.

CHESTER GROUP

LOC: Sec. 26, T15N, R25E

QUAD: Hunt 15'; Saint Johns NTMS

DEVL: Open pit

PROD: 7 tons @ 0.17% U_3O_8 and 0.27% V_2O_5 in 1955; 112 tons @ 0.02% U_3O_8 and 0.04% V_2O_5 probably in 1956.

GEOL: Carnotite in basal Chinle Fm., probably Mesa Redondo member.

REF: D.O.E.

CHESTER MUD #1 (Mud Mesa #1)

LOC: Approx. Sec. 11 and 12, T38N, R27E Alcove Mesa - Carrizo Mtns

QUAD: Los Gigantes Buttes 15'; Shiprock NTMS

DEVL: Underground

PROD: 159 tons @ 0.14% U_3O_8; 1.09% V_2O_5, 1955-57

ANAL: 0.11-0.28% U_3O_8

GEOL: Tyuyamunite in thin discontinuous bands along sandstone - mudstone contact, especially where carbon matter is concentrated in Salt Wash member near Bluff contact.

REF: D.O.E.

CHIMNEY #1 (H. Piet and R. Harrison)

LOC: Not located - Apache Co., Carrizo Mtns. B.I.A. Window Rock has no record of the operators having any dealings with the Navajo tribe.

PROD: 71 tons; 140 lbs. U_3O_8; 2,525 lbs. V_2O_5 in 1951

CISCO #1 (Refer to Camp Mine)

LOC: Approx. S. center Sec. 28, T36N, R29E Lukachukai Mtns.

QUAD: Redrock Valley 15'; Shiprock NTMS

DEVL: Underground

PROD: Minor production in 1953 included with Camp Mine.

GEOL: Tyuyamunite in channel fill, Salt Wash member sandstone with nodules, clay lens and abundant carbon matter. Most ore is in sandstone just above black and red claystone. Joints are well defined and paleochannel trends N-S, same as ore body elongation.

REF: Nestler, R. & Chenoweth, W. (1958, RME-118) D.O.E.

CLAIM #3 (Denny Lee, Air Anomaly #13-15)

LOC: Approx. common corners Sec. 34, 35, T33N, R23E. and Sec. 2, 3, T32N, R23E, Black Mountains

QUAD: Lohali Point 7½; Shiprock NTMS

PROD: 745 tons @ 0.15% U_3O_8, 1956

GEOL: Carnotite associated with carbon matter, pebbly zones and carbonaceous mudstones in arkosic sandstone, Toreva Fm.

REF: PRR-EDR-1292 (#44), PRR -EDR-1291 (#43) PRR-EDR-1297 (#47)

CLAIM #4

LOC: Sec. 34 & 35, T33N, R23E

QUAD: Lohali Point 7½; Shiprock NTMS

DEVL: Drilled

ANAL: 0.13% U_3O_8

GEOL: Carnotite in sandstone lenses in Toreva Fm.

REF: D.O.E.

CLAIM #7 (Homer Scott, Dry Run Canyon)

LOC: Approx. Sec. 3, T32N, R23E, adjacent to Claim #10, Black Mountain

QUAD: Lohali Point 7½, Shiprock NTMS

DEVL: Open pit and adits, drilled

PROD: 4,661 tons @ 0.14% U_3O_8, 1964 and 1967

ANAL: 0.09-0.43% U_3O_8 in drill holes

GEOL: Carnotite in sandstone lenses in Toreva Fm.

REF: D.O.E.

CLAIM #10 (Homer Scott, Dry Run Canyon)

LOC: Approx. Sec. 3, T32N, R23E. Adjacent to Claim #7 Black Mountain

QUAD: Lohali Point 7½'; Shiprock NTMS

DEVL: Open pit, adits and drilling

PROD: 5,216 tons @ 0.15% U_3O_8; 1964-67

GEOL: Carnotite in sandstone lenses in Toreva Fm. Second largest producer of uranium in Black Mtn. area.

REF: D.O.E. Preliminary Map No. 31

CLAIM #14 (Dry Run Canyon)

LOC: Approx. Sec. 33, T33N, R23E Black Mtn.

QUAD: Johali 7½'; Shiprock NTMS

DEVL: Drilled

ANAL: 0.12% U_3O_8

GEOL: Carnotite in fine-grained, cross bedded sandstone lens in Toreva Fm. Mineralization on steep flank of the Black Mtn. anticline.

REF: D.O.E.

CLAIM #16

LOC: Approx. Sec. 27, T33N, R23E Black Mtn.

QUAD: Lohali Point 7½'; Shiprock NTMS

RAD: 0.10% e U_3O_8

GEOL: Carnotite and meta-hewettite associated with carbon matter in sandstone lenses between gray shale partings in Toreva Fm.

REF: D.O.E.

CLAIM #27 (West Burnt Corn Wash)

LOC: Approx. Sec. 21 and 28, T33N, R23E, adjacent to Claim #28 Black Mtn.

QUAD: Blue Gap 7½'; Shiprock NTMS

DEVL: Drilled

GEOL: Carnotite in sandstone underlying carbonaceous seam in Toreva Fm. just below middle member.

REF: D.O.E. Clinton, J. (1956)

CLAIM #28 (West Burnt Corn Wash)

LOC: Approx. common corners Sec. 20,21,28,29 T33N, R23E adjacent to Claim #27 - Black Mtn.

QUAD: Blue Gap 7½; Shiprock NTMS

DEVL: Drilled extensively, open pit w/adit from pit wall

PROD: 4,181 tons @ 0.21% U_3O_8; 0.16% V_2O_5, 1957-58, 1966-68.

ANAL: 0.76% e U_3O_8; 0.72% U_3O_8, 0.27% V_2O_5; 1.3% $CaCO_3$

GEOL: Carnotite in quartzose Toreva sandstone beneath carbonaceous siltstone. Largest uranium producer from Black Mtn. area.

REF: D.O.E.

CLAIM #31 (Claim #35)

LOC: Approx. N½ Sec. 29, T33N, R23E Black Mountain

QUAD: Blue Gap 7½'; Shiprock NTMS

DEVL: NE-SW Trending rim cut

PROD: 15 tons @ 0.08% U_3O_8, 1958 - shipment was made as claim #31 but came from claim #35, as shown on Navajo Tribal Claim map.

GEOL: Carnotite associated with carbonaceous matter in lower sandstone member of Toreva Fm.

REF: D.O.E.

CLAIM #35 (Claim #31)

CLANI (Tree Mesa)

CLEVELAND #1 (Grover Cleveland #1)

COTTONWOOD BUTTE CLAIM (Charlie Bekis Claim)

LOC: 36°47' 32" N, 109°02' 45"W, perhaps 500 ft. west of Arizona-New Mexico boundary 3.7 miles SW of Bitlabito School.

QUAD: Pastora Peak 15'; Shiprock NTMS

DEVL: Road built to property, never developed. Located by UMDC personnel in early 1940's (UMDC location SW-40).

ANAL: 0.5 to 2.5% V_2O_5, 0.05-0.15% U_3O_8

GEOL: Tyuyamunite and dark vanadium minerals in two seams one foot apart in sandstone beds of the lower part of the Salt Wash member of Morrison Fm. Outcrop length of about 40 ft. shows analyses given above. Seams are 0.5-1.5 ft. thick.

REF: AEC file data; Coleman (1944)

COVE MESA MINES (south two-thirds of Cove Mesa) (AEC Plot 7, Navajo Permit #558)

LOC: Approx. Sec. 1, T37N, R. 28E SW Carrizo Mtns.

QUAD: Los Gigantes Buttes 15'; Shiprock NTMS

DEVL: Numerous inclines from Mesa top and adits from Mesa rim - see detailed map. AEC acquired lease from Manhattan Project and contracted with VCA to mine ore.

PROD: 35,963 tons @ 0.22% U_3O_8; 1.61% V_2O_5, 1948-1965 continuous.

GEOL: Tyuyamunite and vanadium minerals disseminated in thin-bedded, cross-bedded, fine-grain, gray calcareous sandstone, Salt Wash member.

REF: Blaybrough, J. and others (1959, RME-127)
Harshbarger, J. (1946, RMO-441), Webber, B. (1943, RMO-480), Chenoweth (1980, TM-209)

COVE MESA MINES No. 1 and 2 (north 1/3 of Cove Mesa) (Cate Sells)

LOC: Approx. S. central Sec. 36, T38N, R28E, and N. to S. central Sec. 1, N. central Sec. 12, T37N, R28E

QUAD: Los Gigantes Buttes 15'; Shiprock NTMS

DEVL: Underground -few adits

PROD: 2,531 tons, @0.14% U_3O_8; 1.51% V_2O_5, 1948-58 and 1962-63.

GEOL: Tyuyamunite, metatyuyamunite and carnotite in limy sandstone and associated with carbonized logs along flanks of paleochannels in Salt Wash member.

REF: Blaybrough, J. (1959, RME-127)
Harshbarger, J. (1946, RMO-441)
Jones, D. (1954, RME-3093)
King, J. (1951, RMO-754)
Lowell, J. (1955)
Webber, B. (1943, RMO-480)

CURRAN MESA (Segi-Ho-Cho Mesa)

DAN TAYLOR #1 (LaGloria Oil and Gas Claim; Yale Point; adjacent claims include Hillside #1, Rough Rock Group, and Dan Taylor #4)

LOC: Approx. Sec. 11, T34N, R. 23E, along rim of Black Mesa @ Yale Point.

QUAD: Sweathouse Peak 7½'; Shiprock NTMS

DEVL: Prospected - rim cut w/small adit

PROD: 290 tons @ 0.14% U_3O_8; 0.31% V_2O_5 in 1955

RAD: 0.01-0.03% e U_3O_8

ANAL: Grab samples @ 0.01-0.38 U_3O_8; 0.08-0.84% V_2O_5 as coatings on sand grains.

GEOL: Carnotite-tyuyamunite disseminated and as small pads in quartzose, fine-grained, cross-bedded sandstone with a carbonaceous seam in Toreva Fm. Two foot thick and 30-35 ft. long zone along rim.

REF: PRR-EDR-551 (41)
Clinton, J. (1956, RME-91)
D.O.E. preliminary map No. 31

DENNY LEE (Claim #3)

DODGE #1 & #2 (Highjump claims, probably Zealy-tso #1)

LOC: SE corner Sec. 25, T6N, R10W

QUAD: Chinle 4 NE 7½'; Shiprock NTMS

DEVL: Small prospect pits

ANAL: 0.06–0.31% U_3O_8

GEOL: Carnotite in basal Shinarump on crest of Chinle Monocline with fracturing and some faulting parallel to fold.

REF: D.O.E.

DRY RUN CANYON (Claims #7, 10, 14)

EAST MESA MINES

LOC: Approx. NE¼ Sec. 24, T37 N., R28E
S. Carrizo Mtns.

QUAD: Los Gigantes Buttes 15'; Shiprock NTMS

DEVL: Rim cuts and 370 ft. of underground workings

PROD: 994 tons @ 0.24% U_3O_8; 0.62% V_2O_5, 1951-55

GEOL: Tyuyamunite as discontinuous lenses along sandstone-mudstone bedding planes and scattered patches of carbonaceous mudstone lenses in Salt Wash member.

REF: Dodd, P. (1956)
Blagbrough, J. and others (1959, RME-127)
Webber, B. (1943, RMO-480)

EAST RESERVATION LEASE OF VCA, - Eastern Carrizo Mtns.

Includes early major production from:
- Plot #3 (New Mexico)

and minor production from:
- Plot #1 (New Mexico)
- Plot #2 (New Mexico)
- Plot #4 (New Mexico)
- Plot #6-9 (New Mexico)
- Plot #11-12 (Arizona)

These plots collectively produced 6,758 tons @ 0.22% U_3O_8, 2.31% V_2O_5 during 1948-1950, which was not broken down by plot number by VCA at the time. Most production from New Mexico, but probably some from East Carrizos in Arizona (none from VCA Plot 10).

EASTERN CARRIZO MOUNTAINS

Initial production from:
- Lone Star (Plot 9) (New Mexico)
- Lower Oak Creek (Plot 7) (New Mexico)
- Shadyside (Plot 3) (New Mexico)
- Syracuse (R.F. & R) (Arizona)
- Syracuse (VCA Plot 12) (Arizona)
- Sunnyside (Plot 3) (New Mexico)

Lumped as Eastern Carrizo Mtns. production by UMDC (Union Mines Development Corp.) with a total recorded production of about 1,500 tons @ 0.27% U_3O_8 and 3.0% V_2O_5 during the years 1942-1944. Production was for vanadium initially, uranium was extracted later from discarded mill tailings. Most of the production probably came from Syracuse (R.F. & R) Mine according to early reports (Coleman, 1944).

EDWARD STEVE #1

LOC: Approx. Sec. 36, T33N, R23E

QUAD: Lohali Point 7½; Shiprock AMS

DEVL: 200 ft. of rim stripping, 2 short adits, 14 holes drilled in 1954.

PROD: Owners reportedly shipped 2 loads

GEOL: Uranium occurs as discontinuous streaks along mesa rim in sandstone of upper Toreva Fm. uraniferous beds at a depth of 65 ft. and average 1 ft. thick.

REF: Clinton, J. (1956, #24 outcrop, Fig. 3, p. 7)
PRR W/o #

EMMA #1 (Zona #1)

ETSITTY #1 (M.O. 5)

LOC: Approx. Sec. 10, T33N, R23E
Burnt Corn Wash Canyon - Black Mtn.

QUAD: Sweathouse Peak 7½'; Shiprock NTMS

DEVL: 200 ft. rim stripping, 100 ft. drifting in 2 adits; 5000 ft. drilling.

PROD: 130 tons @ 0.18% U_3O_8; 0.61% V_2O_5, 1954-55.

GEOL: Carnotite, tyuyamunite, rauvite and meta-hewettite coating grains and cementing a highly carbonaceous sandstone interbedded with carbonaceous siltstone in the Toreva Fm.

REF: PRR-EDR-264 (#36)
Clinton, J. (1956, RME-91)
Clinton, J. & Carithers, L. (1956)
D.O.E. Prelim. map #31

EURIDA MINES (AEC Plot 6)

LOC: Approx. SE ¼ Sec. 11, SW¼ Sec. 12, NE¼ Sec. 13, N. border of Sec. 14 and NE¼, Sec. 15, T39N, R28E.

QUAD: Toh-Atin Mesa 15'; Shiprock NTMS

DEVL: Underground

PROD: From 1942 to 1944, Wade, Curran and Company shipped 2,942 tons @ 2.23% V_2O_5 from the Martin, North Martin, Saytah, Saytah Canyon, CBW-MC and Eurida Mines

GEOL: Mineralization in Salt Wash member

REF: Harshbarger, J. (1946, RMO-441)
Webber, B. (1943, RMO-480)

EURIDA MESA MINES (VCA west reservation plots No. 14, 15, 16)

LOC: Approx. SW¼ Sec. 12, T39N, R28E
Carrizo Mtns.

QUAD: Toh-Atin Mesa 15'; Shiprock NTMS

DEVL: Several short adits

PROD: 467 tons @ 0.17% U_3O_8; 2.86% V_2O_5; 1950-51, 1956.

GEOL: Mineralization in Salt Wash member

REF: Harshbarger, J. (1946, RMO 0-441)
Webber, B. (1943, RMO-480)

FALL DOWN MESA (Tommy James Mine)

FLAG #1 MINE

LOC: Approx. NW¼ Sec. 29, T36N, R29E, Lukachukai Mtns. on west side of ridge - Flag Mesa-near Black #1

QUAD: Los Gigantes Buttes and Red Rock Valley 15'; Shiprock NTMS

DEVL: Room and pillar underground

PROD: 11,286 tons @ 0.24% U_3O_8, 1.01% V_2O_5, 1953-57, 1964-66.

GEOL: Elongation of ore body parallel to easterly trend of paleostream deposition in cross-stratified sandstone with abundant clay chips, carbon matter and interstitial clay in Salt Wash member. Beds strike N62°W, dip 1½°NE on the Chuska Syncline and are well jointed.

REF: Nestler, R. and Chenoweth, W. (1958, RME-118)

FLAG #2 (Black #1)

FRANK #1 (Mines 4b, 709, 1207)

LOC: Approx. Sec. 8 and 17, T.36N, R29E Mesa 4½, Lukachukai Mtns.

QUAD: Los Gigantes Buttes 15'; Shiprock NTMS

DEVL: 8 adits with track and 1,200 ft. of underground room and pillar workings, operated by Climax Uranium Co.

PROD: 75,739 tons @ 0.25% U_3O_8; 1.15% V_2O_5, 1952-63, 1965-67, includes: South Portal (4B Mine)
East Portal (709 Mine)
North Portal (1207 Mine)

GEOL: Tyuyamunite-type or a zone 3 ft. thick and 150-200 ft. below surface in Salt Wash member.

REF: Dare (1959)
Dodd (1956)
Beam (1957, TM-115)

FRANK BLUEHORSE (Mesa 7)

FRANK JR.

LOC: Approx. Sec. 8, T36N, R29E, Lukachukai Mtns., Mesa V

QUAD: Redrock Valley 15'; Shiprock NTMS

DEVL: Adit and stope

PROD: 10,519 tons @ 0.31% U_3O_8; 1.70% V_2O_5, 1960-62, 1965 Small amount of ore hauled out of Mesa V Mine from this property, credited properly here.

GEOL: Tyuyamunite in Salt Wash member

REF: D.O.E.

FRANK TODECHEENIE (Todecheenie #1)

FRIDAY MESA

LOC: Approx. N. parts of Sec. 2 and 3, T38N. R28E, S. Carrizo Mtns. Segi-ho-cho Mesa, about 1.5 miles WSW of Sunnyside Mine.

QUAD: Los Gigantes Butte 15'; Shiprock NTMS

GEOL: Tyuyamunite-type mineralization associated with carbonized matter in medium-fine-grained Salt Wash sandstone.

REF: Harshbarger, J. (1946, RMO-441)
Webber, B. (1943, RMO-480)

G & C #1 (G and G)

G AND G (G and C #1)

LOC: NE¼ Sec. 18, T12N, R29E
Probably near shore of Lyman Reservoir

QUAD: St. Johns South 7½; Saint Johns NTMS

DEVL: Shallow stripped area 50 X 65 X 5 ft. deep

PROD: 3 tons @ 0.30% U_3O_8; 0.82% V_2O_5, 1956

GEOL: Mineralization in small 1.5 ft. thick limey sandstone lenses in Amejo Sandstone, Petrified Forest member. (Amejo from U. of Texas nomenclature)

REF: D.O.E.

GARNET RIDGE DIATREME (Bluestone #1)

GEORGE BELINTE #2

LOC: Approx. Sec. 22, T33N, T22E, on Apache/Navajo Co. line, Black Mtn.

QUAD: Blue Gap 7½'; Shiprock NTMS

DEVL: Drilled

ANAL: 0.08-0.19% e U_3O_8; 0.07 - 0.32% U_3O_8, 0.07-0.14% V_2O_5

GEOL: Carnotite disseminated in sandstone lenses just below carbonaceous member in upper part of lower member of Toreva Fm.

REF: D.O.E.

GEORGE SIMPSON #1 INCLINE (Geo. Simpson #1A - connects with Saytah Mine)

LOC: Sec. 11, 12, 13, 14, T40N, R28E
NW Carrizo Mtns.

QUAD: Toh-Atin Mesa 15'; Shiprock NTMS

DEVL: 600 ft. adit and 150 ft. incline. Initial access to the George Simpson #1A was thru the old Saytah Mine until the development of the incline.

PROD: 2,000 tons @ 0.20% U_3O_8; 1.40% V_2O_5, 1957-58

GEOL: Tyuyamunite in bands and lenses associated with pockets of carbon matter and sedimentary structures along sandstone-mudstone contact in Salt Wash member.

REF: D.O.E.
Harshbarger, J. (1946, RMO-441)

GOERGE SIMPSON #1A (George Simpson #1 Incline)

GEORGE SIMPSON #1B (access through Martin Mine)

LOC: Sec. 11,12,13,14, T40N, R28E
NW Carrizo Mtns.

QUAD: Toh-Atin Mesa 15'; Shiprock NTMS

DEVL: Underground - access was thru the Martin Mine

PROD: 1,697 tons @ 0.25% U_3O_8; 1.87% V_2O_5, 1957-58. Production from Geo. Simpson 1A and 1B is unclear because of confusion in the records concerning which mine was "1A" and which was "1B". The Labels shown in the accompanying figure conform to official shipping receipts; however, there is a suggestion that the "1A" and "1B" Labels need to be reversed.

REF: D.O.E.

GEORGE SIMPSON #2 (Mesa 4½ Mine)

GILA MINE (VCA Plot No. 4)

GOTHIE (GOTHE) (Henry Phillips)

LOC: NW Carrizo region; 4 miles SE of Boundary Butte along headwaters of Gothie Creek.

QUAD: Toh-Atin 15' or Walker Creek Reservoir 7.5 quads; Shiprock NTMS.

DEVL: Claim of 80 acres

PROD: 90 tons @ 0.54% U_3O_8 in 1949

GEOL: From Cooley et al USGS Prof. Paper #521-A, plate 5, there are Salt Wash outcrops in this general area which could have produced this ore.

REF: D.O.E.

GRANT PROSPECT

LOC: Approx. Sec. 1, T15N, R25E

QUAD: Hunt 15'; Saint Johns NTMS

GEOL: Tyuyamunite-type mineralization associated with carbonized plant matter in sandy clay and shale of the lower Chinle.

REF: Finch, W. (1967)

GRAVEL CAP (Oak Spring Mine)

GROVER CLEVELAND #1 (Cleveland #1)

LOC: Approx. Sec. 13, T40N, R28E,
NW Carrizo

QUAD: Toh-Atin Mesa 15'; Shiprock NTMS

PROD: 28 tons @ 0.22% U_3O_8; 1.84% V_2O_5, 1957

GEOL: Tyuyamunite ore replaced woody matter in sandstone of the Salt Wash member.

REF: D.O.E.

H. & R. NEZ (VCA Plot No. 10)

HALL MINE (Tom Naki Chee #6-8, Thirsty Mesa)

LOC: Approx. NE ¼ Sec. 11, T36N, R28E
Thirsty Mesa - Lukachukai Mtns.

QUAD: Los Gigantes Buttes 15'; Shiprock NTMS

DEVL: 100 ft. adit; 300 ft. tunnel w/stoped out area.

PROD: 2,448 tons @ 0.20% U_3O_8; 0.32% V_2O_5, 1956-58.

GEOL: Tyuyamunite and possibly pascoite, pintadoite and hewettite in discontinuous ore bodies in Salt Wash member. Ore body and pockets are horizontally lenticular in cross-section and parallel paleostream depositional trends. Thin seams of mudstone and pebble conglomerate cut through host festoon-type cross-bedded sandstone with abundant carbon matter. Ore in whitish, thin-bedded sandstone shows considerable disequilibrium with daughter products. Jointing is well defined.

REF: PRR-EDR-598
Nestler, R. and Chenoweth, W. (1958, RME-118)
Chenoweth, W. (1967)
O'Sullivan, R. and Beikman, H. (1963)

HANSEN CLAIM (Lucky Stripe Claim)

LOC: Sec. 27, T4N, R27E

QUAD: Hannagan Meadow 15'; Clifton NTMS

DEVL: 2 prospect pits

RAD: 4X 0.08-0.11% e U_3O_8

GEOL: Carnotite in limonite cemented sand and bentonitic clay in old river channel in volcanics.

REF: PRR-AP-266 (#25)

HARVEY BEGAY #3

LOC: Approx. NW¼ Sec. 12, T39N, R30E
East Carrizo Mtns.

QUAD: Pastora Peak 15'; Shiprock NTMS

DEVL: Rim cuts and short adits

PROD: 21 tons @ 0.12% U_3O_8; 2.05% V_2O_5, 1956

GEOL: Discontinuous bands of carnotite-type mineralization along mudstone layers and with carbon matter in light gray, fine-grained sandstone in 2 basal units of Salt Wash member. Sandstone is black in places, contains black mudstone galls and is strongly fractured. Diorite sill is above and a dike lies to the north.

REF: PRR-EDR-532 (#40)
D.O.E.

HARVEY BLACKWATER # 1 and 2

LOC: Approx. NW¼, Sec. 1, T41N, R23E. Monument Valley

QUAD: Dennehotso 15'; Shiprock NTMS

DEVL: Pits

PROD: 576 tons @ 0.16% U_3O_8 in 1954-57

GEOL: NW trending Shinarump channel, N.E. of Main Monument 2 Mine

REF: D.O.E.

HARVEY BLACKWATER #4

LOC: Approx. S½ Sec. 2, T41N, R23E Monument Valley

QUAD: Dennehotso 15'; Shiprock NTMS

DEVL: Room and Pillar, 10,000 ft. of drilling

PROD: 374 tons @ 0.20% U_3O_8; 0.35% V_2O_5, 1955-56

GEOL: Ore zone averages 2 ft. thick in Shinarump paleochannel at base of scour.

REF: D.O.E.

HARVEY PLATT RANCH (Possible alias for G and G claims)

LOC: Sec. T12N, R29E at edge of lava beds

QUAD: St. Johns South 7½; Saint Johns NTMS

RAD: 20X

ANAL: 0.45% e U_3O_8; 0.48% U_3O_8

GEOL: Tyuyamunite-type associated with carbon matter in Chinle Fm.

REF: PRR-EDR-258

HAZELL MINE

LOC: Approx. Sec. 19 and 30, T39N, R31E Carrizo Mtns. adjacent to Syracuse (R.F.& R.) and Plot 11 VCA

QUAD: Pastora Peak 15'; Shiprock NTMS

DEVL: Rim cuts and shallow adits with stoping parallel to rim. 19 drill holes.

PROD: 36 tons @ 0.16% U_3O_8; 1.88% V_2O_5, 1955 & 1957 Some pre-1952 shipments probably may include production from adjacent VCA Plot #11.

GEOL: Ore along mudstone-sandstone contact in Salt Wash member 40 ft. above Bluff sandstone.

REF: Blagbrough, J. & Brown, J. (1955)

HENRY PHILLIPS MINE

LOC: Approx. Sec. 21, T36N, R36E Mesa 1½, Lukachukai Mtns.

QUAD: Redrock Valley 15'; Shiprock NTMS

DEVL: Rim cut

PROD: 16 tons @ 0.27% U_3O_8; 1.04% V_2O_5, 1955

GEOL: Ore in Salt Wash member

REF: D.O.E.

HIGHJUMP CLAIMS (Probably Dodge #1 & #2)

HILLSIDE #1 (Refer to Dan Taylor #1)

HINKSON CATTLE COMPANY

LOC: SW¼ Sec. 30, T15N, R25E

QUAD: Hunt 15'; Saint Johns NTMS

RAD: 2 mr/hr. around logs

GEOL: Carnotite-type mineralization associated with silicified and carbonized logs in lower Chinle Fm.

REF: PRR-EDR-221 (#31)

HOGAN MINE (VCA Plot No. 1)

HOMER SCOTT (Claim #7 and #10)

HORSE MINE (VCA Plot No. 10)

HORSE PORTAL (VCA Plot No. 10)

HOSKIE HENRY

LOC: Approx. Sec. 6, T40N, R29E Carrizo Mtns. - just east of Pope #1

QUAD: Toh-Atin Mesa 15'; Shiprock NTMS

DEVL: Incline and stoping. Access thru Rattlesnake (VCA Plot #6)

PROD: 978 tons @ 0.20% U_3O_8, 1.29% V_2O_5 in 1964-66.

GEOL: Mineralization in Salt Wash member. A late mining permit for a horseshoe-shaped area surrounding northern part of VCA plot 6, to cover ore extensions in the subsurface to the west and east off of VCA Plot No. 6.

REF: D.O.E.

HOWARD NEZ (VCA Plot No. 10)

JEROME CHEE (Rocky Spring)

JERRY JAY #1

LOC: Poorly located - probably one of the Mesa 4 or Mesa 4½ localities. Lukachukai Mtns.

QUAD: Los Gigantes Buttes 15'; Shiprock NTMS

ANAL: 0.10-0.28% e U_3O_8; 0.12-0.33% U_3O_8; 0.15-0.43% V_2O_5; 2.2 -4.1% $CaCO_3$

GEOL: Tyuyamunite disseminated as grain coatings and filling interstices in Salt Wash member.

REF: PRR-EDR-422

JIM HATATTLY (Tom Wilson)

JIM L. SMILEY (Black Mtn. Vase)

JIM LEE #1 AND RICHARD KING #1 (Claims are contiguous and overlapping)

LOC: Approx. Sec. 27 T40N, R30E. East Carrizos (AEC plot 36° 50' 40"N, 109° 05' 35" W)

QUAD: Pastora Peak 15'; Shiprock NTMS

DEVL: Rim cuts and shallow adits

PROD: 120 tons @ 0.12% U_3O_8; 1.76% V_2O_5, 1955 from Jim Lee #1, 57 tons @ 0.18% U_3O_8; 2.78% V_2O_5, 1955 from Richard King #1.

GEOL: Thin discontinuous bands and scattered lenses of tyuyamunite about 40 ft. above Salt Wash contact with Bluff sandstone. Workings are between 2 igneous masses.

REF: D.O.E.

JIMMY BILEEN #1 and 3 (Refer to Sandy K Mine)

LOC: Approx. Sec. 8, T40N, R29E NW Carrizo Mtns.

QUAD: Toh-Atin Mesa 15'; Shiprock NTMS

DEVL: Rim cuts, 2 connecting adits, 96 ft. of drifting, and caved incline.

PROD: 67 tons @ 0.20% U_3O_8; 1.31% V_2O_5, 1955-57.

GEOL: Discontinuous, 1 ft. thick lenses of ore in sandstone in lower 30 ft. of Salt Wash member.

REF: D.O.E.

JIMMY KING #9 MINE

LOC: Approx. E. Sec. 24, T36N, R28E Lukachukai Mtns.

QUAD: Los Gigantes Buttes 15'; Shiprock NTMS

DEVL: 4 adits 10 to 120 ft. long, 100 ft. drift, 1000 ft. of rim stripping.

PROD: 80 tons @ 0.10% U_3O_8; 0.25% V_2O_5, 1956-57

GEOL: Ore is disseminated in fine-grained sandstone and as fracture coatings about 15 ft. above base of Salt Wash member. Three feet of red-gray mudstone caps ore zone — scattered with barren tree remains.

REF: D.O.E. map No. 28

JOHN KEE TRACTS #3 & 4

LOC: Sec. 10,11,14,15, T31N, R28E Carrizo Mtns. on north flank of Red Mesa syncline

QUAD: Toh-Atin Mesa 15'; Shiprock NTMS

DEVL: 300 X 300 X 10 ft. deep pit

PROD: 926 tons @ 0.51% U_3O_8; 0.91% V_2O_5, 1955

GEOL: Tyuyamunite-type ore occurs at mudstone-sandstone bedding plane interfaces, in sedimentary structures, and with carbon matter pockets - basal Salt Wash members.

REF: D.O.E.

JOHN LEE BENALLY

LOC: NE¼ Sec. 8, T40N, R27E Carrizo Mtns. - NW side of North Water Mesa

QUAD: Toh-Atin Mesa 15'; Shiprock NTMS

DEVL: 5 X 10 ft. open cut along cliff face.

PROD: 37 tons @ 0.17% U_3O_8; 0.43% V_2O_5, 1963

GEOL: Pods of ore associated with carbonaceous matter in sandstone bed of Salt Wash member. Horizontal ore horizon.

REF: D.O.E.

JOHN M. YAZZIE #1 (Now Monument #2 Supplement)

LOC: Sec. 27 and 34, T41N, R23E

QUAD: Dinnehotso 15'; Shiprock NTMS

PROD: 1048 tons @ 0.47% U_3O_8; 1.06% V_2O_5, 1952-54, by Clani and Yazzie. Lease #1 of Spencer Uranium Co. came from this property as well, and accounts for 1510 tons in 1954-1957, for a total of 2558 tons @ 0.345% U_3O_8 and 0.796% V_2O_5.

JOHNNY McCOY #1

LOC: Approx. S. central Sec. 22, T40N, R27E. NW Carrizo Mtns. On nose of divide one mile NW of Sweetwater Trading Post.

QUAD: Toh-Atin Mesa 15'; Shiprock NTMS

DEVL: Rim cut

PROD: 34 tons @ 0.06% U_3O_8; 0.09% V_2O_5, 1955

ANAL: 0.01-0.14% e U_3O_8; 0.03-0.07% U_3O_8, 0.15-0.20% V_2O_5

GEOL: Tyuyamunite-Type ore body (10 X 5 ft. X 20 inches) in large, fine-grained, light gray sandstone lenses underlain by green and red mudstone galls and partings. Abundant carbon matter and heavy limonitic staining. In Salt Wash member 20 feet above base.

REF: D.O.E.

JOLEO MINE (Refer to Camp Mine and Cisco #1)

LOC: Approx. W. Sec. 28, T36N, R29E
Lukachukai Mtns.

QUAD: Redrock Valley 15'; Shiprock NTMS

DEVL: Room and pillar underground

PROD: 10,751 tons @ 0.24% U_3O_8; 0.98% V_2O_5, 1952-54

GEOL: Tyuyamunite with pascoite, rossite, corvusite, and vanadium clays occur in Salt Wash member about 65 ft. above Bluff contact. Sandstone is trough and festoon cross-stratified. Ore is associated with carbon matter, carbonized logs, mudstone pebble conglomerate, and witb thin clay seams and galls. On the SW flank of Chuska Syncline, the beds strike N70° W, dip 2°NE. Joints are well defined and parallel two paleostream channels.

REF: Nestler, R. & Chenoweth, W. (1958, RME-118)

JUANITA

LOC: Sec. 14, T18N, R25E

QUAD: Adamana 1NW 7½; Saint Johns NTMS

DEVL: Cuts and trenches

PROD: 5 tons @ 0.13%, U_3O_8; 0.44% V_2O_5, 1954

GEOL: Small pods of carnotite associated with carbonaceous matter in argillaceous sandstone lenses just below the Sonsela unit of the Chinle Fm.

REF: D.O.E.

KASEWOOD BAHE #1 (Adjacent to and continuous with Thomas Begay #1)

LOC: Approx. Sec. 36, T34N, R23E, Black Mtn.

QUAD: Sweathouse Peak 7½; Shiprock NTMS

DEVL: Surface stripping-small open pit

PROD: 26 tons @ 0.45% U_3O_8; 0.55% V_2O_5, 1955-56

GEOL: Carnotite in upper part of lower sandstone member of Toreva Fm., overlain by 1-2 ft. bed of lignite.

REF: D.O.E.

KEITH FRANCIS CLAIMS (Bluestone #1)

KING #8 (Barton #3)

KINUSTA (Tree Mesa) (AEC Plot E)

LOC: Approx. S. center Sec. 21, SW¼ Sec. 28, N½ and SE¼ Sec. 34, S½ Sec. 33, T38N, R28E, S. Carrizo Mtns.

QUAD: Los Gigantes Buttes 15'; Shiprock NTMS

DEVL: Rim cuts

PROD: 788 tons @ 0.08% U_3O_8; 1.80% V_2O_5, 1949-52, 1958.

GEOL: Weak and irregular tyuyamunite-type specks and coatings in fine to medium grained sandstone of Salt Wash member, Carbonized matter. Best mineralization is 70-90 ft. above Bluff contact.

REF: D.O.E.

KNIFE EDGE MESA

LOC: Approx. SE¼ Sec. 29, T36N, R29E
On west side of Ridge-N. Lukachukai Mtns.

QUAD: Redrock Valley 15'; Shiprock NTMS

DEVL: Adit

PROD: 1,032 tons @ 0.19% U_3O_8; 0.50% V_2O_5, 1966

GEOL: Tyuyamunite-type in Salt Wash member

REF: D.O.E.

LA GLORIA OIL AND GAS CLAIMS (Same area as Thomas Begay #1-Kasewood Bahe #1)

LOC: Approx. N½, Sec. 2, T33N, R23E
Black Mtn.

QUAD: Sweathouse Peak 7½'; Shiprock NTMS

DEVL: Prospect pits

GEOL: Carnotite coatings on fine to coarse grained quartzose sandstone interbedded with carbonaceous siltstone just below middle member of Toreva Fm.

REF: Clinton, J. (1956, RME-91)

LA GLORIA OIL AND GAS CLAIM (Dan Taylor #1)

LAST CHANCE

LOC: Sec. 11,12,13,14, T 40N R28E, Carrizo Mtns. just south of George Simpson #1A and B

QUAD: Toh-Atin Mesa 15'; Shiprock NTMS

DEVL: Incline-entrance caved

PROD: 32 tons @ 0.17% U_3O_8; 1.34% V_2O_5, 1961-62, & 1965.

GEOL: Tyuyamunite bands and lenses localized in Salt Wash member at sandstone-mudstone contacts, sedimentary structures and pockets of carbon.

REF: D.O.E.

LEROY #1 -MP-522 (Pettigrew #1, Leroy Pettigrew #1)

LOC: Approx. Sec. 29-30, T39N, R31E, Arizona-New Mexico line - Carrizo Mtns.

QUAD: Pastora Peak 15'; Shiprock NTMS

DEVL: 32° incline, 82 ft. long with 60 ft. of drift at bottom.

PROD: 25 tons @ 0.19% U_3O_8; 2.46% V_2O_5 in 1956 & 1961

GEOL: Mineralization in lower Salt Wash member

REF: D.O.E.

LOOKOUT CLAIMS (Tomcat)

LUCKY STRIPE CLAIM (Hansen Claim)

LUKE TSOSIE #1 (Tsosie #1)

M.O. 2

LOC: Approx. SW¼ Sec. 20, T33N, R23E
Black Mtn.

QUAD: Blue Gap 7½; Shiprock NTMS

GEOL: Carnotite or tyuyamunite coating grains in bands following cross-bedding in light-gray, quartzose, fine to coarse grained sandstone interbedded between carbonaceous siltstones. Ore zone is about 450 ft. long by 1.5 ft. wide and oriented along bend in paleochannel direction. Just below middle member of Toreva Fm.

REF: Clinton, J. (1956, RME-91)
Clinton, J. & Carithers, L. (1956)

M.O. 5 (Etsitty #1)

M.O. 28

LOC: Approx. central Sec. 25, T33N, R22E
Black Mtn.

QUAD: Blue Gap 7½'; Shiprock NTMS

GEOL: Carnotite or Tyuyamunite coating quartz grains in discontinuous bands along bedding in a carbonaceous sandstone just below middle member, Toreva Fm. Ore zone is about 500 ft. long and 3 ft. thick.

REF: Clinton, J. (1956, RME-91)

MP-181 (Mesa 4½ Mine)

MARTIN MINE (AEC Plot #1, refer also to later development of George Simpson #1B)

LOC: Approx. N. central Sec. 13, T40N, R28E
On east rim of Dry Mesa - Carrizo Mtns.

QUAD: Toh-Atin Mesa 15'; Shiprock NTMS

DEVL: Underground - Martin Mine provided initial access to The Simpson #1B ore body.

PROD: From August, 1942 to February, 1944, Wade, Curran and Company shipped 2,942 tons @ 2.23% V_2O_5 from the Martin, North Martin, Saytah, CBW-MC, Saytah Canyon and Eurida Mines.

1,481 tons @ 0.26% U_3O_8; 1.93% V_2O_5, 1951, 1953-55 produced by VCA under contract with AEC; includes illegal shipment by Jimmie King in 1954-54.

GEOL: Tyuyamunite, pascoite, volborthite, and montroseite occurs in bands and lenses associated with carbon matter pockets along sandstone - mudstone contact in Salt Wash member. Montroseite occurs as masses of fine needles 0.01 to 0.03 mm. long and rimming quartz and feldspar grains plus less often disseminated in calcite cement.

REF: Chenoweth, W. (1980)
Chenoweth, W. (1955, TM-75)
Harshbarger, J. (1946, RMO-441)
Stokes, W. (1951)
Hatfield, K. & Maise, C. (1953, RME-9)

MAYBE CLAIMS (Tomcat)

McKENZIE #3

LOC: Approx. Sec. 1 & 2, T40N, R28E
NW Carrizo Mtns.

QUAD: Toh-Atin Mesa 15'; Shiprock NTMS

DEVL: Drift and adit

PROD: 504 tons @ 0.18% U_3O_8; 1.64% V_2O_5, 1955-56.

GEOL: Scattered, small, low grade pockets of tyuyamunite ore 5 ft. above base of Salt Wash member on North flank of Rattlesnake anticline.

REF: D.O.E.

MELVIN BENALLY #1 (Benally)

LOC: Approx. Sec. 31-32, T39N, R29E
SW Carrizo Mtns.

QUAD: Pastora Peak and Tol-Atin Mesa 15'; Shiprock NTMS

DEVL: Drift

PROD: 147 tons @ 0.18% U_3O_8; 1.59% V_2O_5, 1955

GEOL: Tyuyamunite-type ore occurs as pods and lenses in sandstone - median horizon of Salt Wash member

REF: Harshbarger, I. (1946, RMO-441);
Webber, B. (1943, RMO-480)

MESA 1 (Includes Mines #10-15)

LOC: Approx. SE¼ Sec. 16, SW¼ Sec. 15, and NW¼ Sec. 22, T36N, R29E. at SE end of ridge - Lukachukai Mtns.

QUAD: Redrock Valley 15'; Shiprock NTMS

DEVL: Underground

PROD: 58,082 tons from all 6 mines @ 0.33% U_3O_8; 1.07% V_2O_5, 1950-58, 1961-63, 1965-67

GEOL: Clusters of small, irregular ore bodies of carnotite-Tyuyamunite scattered in Salt Wash member.

REF: Dare, W. (1961)

MESA I½ MINE

LOC: Approx. Sec. 22, T36N, R29E
N. Lukuchukai Mtns.

QUAD: Red rock Valley 15'; Shiprock NTMS

DEVL: Underground

PROD: 132 tons @ 0.16% U_3O_8; 0.79% V_2O_5, 1957

GEOL: Carnotite-Tyuyamunite in Salt Wash member

REF: D.O.E.

MESA 1½

LOC: Approx. central Sec. 21, T36N, R29E
Lukachukai Mtns. on East side of ridge.

QUAD: Redrock Valley 15'; Shiprock NTMS

DEVL: Underground

PROD: 7,555 tons @ 0.22% U_3O_8; 0.74% V_2O_5, 1958 & 1964-67, includes minor production from the West Mine in 1956.

GEOL: Tyuyamunite in Salt Wash member. On north flank of Chuska Syncline.

REF: Dare, W. (1961)
Eppich, J. (1956, TM-107)
Stokes, W. (1954, RME-3102)
Nestler, R. & Chenoweth, W. (1958, RME-118)
Masters, J. (1953, RME-27)

REF: D.O.E.

MESA 1½ WEST MINE

LOC: Approx. Sec. 21, T36N, R29E
Lukachukai Mtns.

QUAD: Redrock Valley 15'; Shiprock NTMS

DEVL: Adit

PROD: Minor production included with Mesa 1½ Mine

GEOL: Uranium in Salt Wash member.

REF: D.O.E.

MESA 1-3/4 INCLINE

LOC: Approx. SW¼, Sec. 21, T36N, R29E
Lukachukai Mtns.

QUAD: Redrock Valley 15'; Shiprock NTMS

DEVL: 30° incline connects with Mesa II, P-21 mine

PROD: 44,174 tons @ 0.20% U_3O_8; 0.89% V_2O_5, 1956-58

GEOL: Carnotite - Tyuyamunite in Salt Wash Member

REF: Dare, W. (1961)
D.O.E.

MESA 1-3/4, MINE #2, P-150

LOC: Approx. SW¼, Sec. 21, T36N, R29E
N. Lukachukai Mtns.

QUAD: Redrock Valley 15'; Shiprock NTMS

DEVL: Adit from rim, room and pillar mining

PROD: 6,423 tons @ 0.25% U_3O_8; 0.88% V_2O_5, 1951-55, 1959-69

GEOL: Tyuyamunite-type ore in Salt Wash member. Ore body is elongated NE, parallel to sedimentary trend. Fine grain sandstone is interbedded with mudstone. Hematite and limonite stain associated with ore. The biggest part of ore is not closely associated with visible carbon but in some places is above or below sandstone with carbon matter and logs.

REF: Nestler, R. & Chenoweth, W. (1958, RME-118)

MESA 2 - MINE #1 (P-150)

LOC: Approx. Sec. 21, T36N, R29E
Lukachukai Mtns.

QUAD: Redrock Valley 15'; Shiprock NTMS

DEVL: Underground

PROD: 3,825 tons @ 0.26% U_3O_5; 1.01% V_2O_5, 1952-55

GEOL: Tyuyamunite and pascoite associated with carbon matter, interstitial fillings and diffusion bands in sandstone of Salt Wash member. Ore body parallels paleostream depositional trends.

REF: Nestler, R. and Chenoweth, W. (1958, RME-118)

MESA 2 -MINE #1 & #2 (P-21)

LOC: Approx. NW¼ Sec. 16 and NW¼ Sec. 21, T36N, R29E
N. Lukachukai Mtns. - on east side of ridge connects with Mesa 1-3/4 incline and Mesa II½ mines.

QUAD: Redrock Valley 15'; Shiprock NTMS

DEVL: 2 main adits, 2,500 ft. long - room and pillar

PROD: 274,128 tons @ 0.23% U_3O_8, 1.00% V_2O_5, 1956-67

ANAL: 15.0% V_2O_5 max

GEOL: Tyuyamunite and vanadium minerals occur in Salt Wash member as bands and streaks filling interstices between sand grains and as diffusion bands and halos. Ore body elongated parallel to paleostream depositional trend. On SW limb of Chuska Syncline, beds strike N60°NW, dip 1½°NE.

REF: Dare, W. (1961)
Nestler, R. & Chenoweth, W. (1958, RME-118)

MESA 2 - MINE 4

LOC: Approx. Sec. 21, T36N, R29E
Lukachukai Mtns.

QUAD: Redrock Valley 15'; Shiprock NTMS

DEVL: Rim cut

PROD: 36 tons @ 0.38% U_3O_8; 1.37% V_2O_5, 1952

GEOL: Ore in Salt Wash member

REF: D.O.E.

MESA 2 PIT

LOC: Approx. Sec. 16, T36N, R29E
Lukachukai MTNS

QUAD: Redrock Valley 15'; Shiprock NTMS

DEVL: Pit

PROD: 822 tons @0.20% U_3O_8; 0.61% V_2O_5, 1950-51

GEOL: Ore in Salt Wash member

REF: D.O.E.

MESA 2-½ MINE

LOC: Approx. Sec. 20, T36N, R29E
Lukachukai Mtns.

QUAD: Redrock Valley 15'; Shiprock NTMS

DEVL: Adit

PROD: 725 tons @ 0.18% U_3O_8; 0.85% V_2O_5, 1966

GEOL: Ore in Salt Wash member

REF: D.O.E.

MESA 2½ MINE

LOC: Approx. NE¼, Sec. 20, NW¼, Sec. 21, T36N, R29E
Lukachukai Mtns. on east side of ridge connects with Mesa II, P-21 mine.

QUAD: Redrock Valley 15'; Shiprock NTMS

DEVL: Drilled in 1955; over 4,000 ft. of drifts - room & pillar.

PROD: 38,343 tons @ 0.25% U_3O_8; 1.1% V_2O_5, 1956-67

GEOL: Tyuyamunite - carnotite mineralization in scattered clusters up to 13 feet thick, along a paleostream channel in Salt Wash member.

REF: Dare, W. (1961)
Stokes, W. (1954, RME-3102)
Masters, J. and Blum, R. (1951, RMO-707)

MESA 2½ - MINE #4

LOC: Approx. Sec. 20, T36N, R29E
Lukachukai Mtns.

QUAD: Redrock Valley 15'; Shiprock NTMS

DEVL: Underground short adit

PROD: 114 tons @ 0.26% U_3O_8; 1.54% V_2O_5, 1951

GEOL: Ore in Salt Wash member

REF: Dare, W. (1961)
Stokes, W. (1954, RME-3102)
Masters, J. and Blum, R. (1951, RMO-707)

MESA 3 MINE

LOC: Approx. Sec. 20, T36N, R. 29E
SE. Lukachukai Mtns.

QUAD: Redrock Valley 15'; Shiprock NTMS

DEVL: Underground room and pillar

PROD: 50,907 tons @ 0.26% U_3O_8; 1.22% V_2O_5, 1953-58, 1963-65.

GEOL: Tyuyamunite and partially oxidized uranium and vanadium minerals in Salt Wash member. Ore in a series of connected masses 30-200 ft. wide, over 1,000 ft. long and elongated SE along paleostream trend.

REF: Nestler, R. & Chenoweth, W. (1958, RME-118)
Dare. W. (1961)

MESA 3, NORTHWEST AND WEST MINES

LOC: Approx. N. central Sec. 20, T36N, R29E
Lukachukai Mtns. on east side of ridge

QUAD: Redrock Valley 15'; Shiprock NTMS

DEVL: One main adit with over 4,000 ft. of drifts, crosscuts, and stoping - room and pillars.

PROD: 735 tons @ 0.12% U_3O_8; 0.60% V_2O_5, 1954-58, 1966
Includes minor production from West Mine in 1966.

GEOL: Tyuyamunite-carnotite in sandstone with some mudstone lenses of Salt Wash member. Blue mudstone underlies most mineralization. Ore bodies elongated NW-SE along a scour or channel complex. NE joint set may have minor control on redistribution of oxidized ore.

REF: Nestler, R. & Chenoweth, W. (1958, RME-118)
Dare, W. (1961)

MESA 4 - MINE #1

LOC: Approx. NE¼ and central Sec. 16, T36N, R29E
Lukachukai Mtns.

QUAD: Redrock Valley 15'; Shiprock NTMS

DEVL: modified room and pillar

PROD: 7,648 tons @ 0.24% U_3O_8; 1.00% V_2O_5, 1950-51, 1953, 1955.

GEOL: Ore in Salt Wash member

REF: D.O.E.

MESA 4 - MINE #2

LOC: Approx. NE¼ and central Sec. 16, T36N, R29E
Lukachukai Mtns. on east side of ridge.

QUAD: Redrock Valley 15'; Shiprock NTMS

DEVL: Modified room and pillars

PROD: 3,711 tons @ 0.21% U_3O_8; 0.92% V_2O_5, 1950-51, 1953-54, 1956-59, 1962-62.

GEOL: Ore in Salt Wash member

REF: D.O.E.

MESA #4 - MINE #3

LOC: Approx. NE¼ and central Sec. 16, T36N, R29E
Lukachukai Mtns. on east side of ridge.

QUAD: Redrock Valley 15'; Shiprock NTMS

DEVL: Trackless, room and pillars.

PROD: 229 tons @ 0.38% U_3O_8; 0.91% V_2O_5, 1953

GEOL: Ore at a depth of 50-100 ft. and averaging 2.5 ft. in thickness in Salt Wash member.

REF: D.O.E.

MESA #4 - WEST MINE

LOC: Approx. E. Sec. 17, T36N, R29E Lukachukai Mtns.

QUAD: Los Gigantes Buttes & Redrock Valley 15'; Shiprock NTMS.

DEVL: Modified room and pillar.

PROD: 3,365 tons @ 0.19% U_3O_8; 0.96% V_2O_5, 1963

GEOL: Ore in Salt Wash member

REF: D.O.E.

MESA #4½ MINE

LOC: Approx. Sec. 18, T36N, R29E Lukachukai Mtns.

QUAD: Los Gigantes Buttes 15'; Shiprock NTMS

DEVL: Incline

PROD: 344 tons @ 0.15% U_3O_8; 1.16% V_2O_5, 1965 & 1968.

GEOL: Ore in Salt Wash member

REF: D.O.E.

MESA 4½ MINE (Tom Joe #1, 1212 Mine, Simpson #181, George Simpson, #2, MP-181)

LOC: Approx. Sec. 7, and 8, T36N, R29E, N. Lukachukai Mtns., connects with Mesa V mine

QUAD: Los Gigantes Buttes 15'; Shiprock NTMS

DEVL: Adit from rim with room and pillar. Operated by Kerr-McGee, later VCA.

PROD: 8,977 tons @ 0.25% U_3O_8; 1.58% V_2O_5, 1954-58, 1960, 1965, 1968. Includes production from westward extension, called Simpson #181.

GEOL: Widely scattered clusters of small bodies of meta-tyuyamunite, pascoite, melanovanadite, hummerite, rossite, and metarossite in lenticular Salt Wash member sandstone interbedded with thin bands of bluish mudstone and surrounded by barren reddish sandstone and mudstone.

Bodies are often connected by thin mineralized bands and occur in several horizons about 40 ft. above Bluff sandstone contact. Most mineralization associated with paleostream channels and carbon matter. Traces of uraninite found in carbonized wood. Fine-grained iron oxides occur as pseudomorphs after pyrite or as earthy coatings on clay galls. Thickness of ore varies from a few inches to 6 feet, average 2.5 - 3.0 feet. Ore is irregularly tabular and elongated along sedimentary structures.

REF: D.O.E.

MESA 5 MINE

LOC: Approx. Sec. 8, T36N, R29E, Lukachukai Mtns.

QUAD: Redrock Valley and Los Gigantes Buttes 15'; Shiprock NTMS

DEVL: Room and pillars on 2 levels. Operated by Kerr-McGee, some ore mined here is properly credited to Frank Jr. mine.

PROD: 55,588 tons @ 0.20% U_3O_8; 0.72% V_2O_5, 1960-68

ANAL: 0.37 - 0.50% U_3O_8; 1.0-2.0% V_2O_5

GEOL: Disseminated tyuyamunite scattered throughout bottom of 1-5 ft. of Salt Wash sandstone 65-95 ft. above its base. Thin mudstone seams, mud galls, gypsum, and calcite locally abundant. Ore bodies, cluster in several horizons, 1-5 ft. thick and up to 40 ft. long.

REF: D.O.E.

MESA 5 ADIT (MINE 1) AND INCLINE (MINE 2)

LOC: Approx. Sec. 8, T36N, R29E Lukachukai Mtns.

QUAD: Redrock Valley and Los Gigantes Buttes 15'; Shiprock NTMS.

DEVL: Modified room and pillars

PROD: 4,906 tons @ 0.21% U_3O_8; 1.38% V_2O_5, 1950-51, 1953-56.

GEOL: Ore in Salt Wash member, refer to Mesa 5 mine.

REF: King, J. (1951)

MESA 6 MINE

LOC: Approx. S. center Sec. 5 and NE¼ Sec. 7, T36N, R29E Lukachukai Mtns. on east side of ridge.

QUAD: Los Gigantes Buttes 15'; Shiprock NTMS

DEVL: One larger incline mine, one smaller adit

PROD: 8,994 tons @ 0.24% U_3O_8; 1.12% V_2O_5, 1961-64.

GEOL: Tyuyamunite, pintadoite and pascoite in limy, quartzose sandstone of the Salt Wash member. Mineralization associated with clay galls and clay seams. Lower 6-100 ft. of pink Salt Wash is barren.

REF: Ellsworth, P. and Hatfield, K. (1951, RMO-802)

MESA 7 (Frank Bluehorse)

LOC: Approx. SE¼ Sec. 36, T37N, R28E NE Lukachukai Mtns.

QUAD: Los Gigantes Buttes 15'; Shiprock NTMS

ANAL: 0.23% U_3O_8

GEOL: Tyuyamunite impregnating a light-tan sandstone of the Salt Wash member about 40 ft. above Bluff contact. Visible mineralization is 2 ft. long, 10 inches thick and underlain by barren green mudstone.

REF: King, J. and Ellsworth, P. (1951, RMO-803)

MEXICAN CRY MINE (Tom Naki Chee #1)

LOC: Approx. Sec. 2-3, T36N, R28E
Mexican Cry Mesa-Lukachukai Mtns.

QUAD: Los Gigantes Buttes 15'; Shiprock NTMS

DEVL: Drilled 1951-52, 200 ft. rim cut, 2 interconnecting adits, 220 ft. drift.

PROD: 58 tons @ 0.17% U_3O_8; 0.21% V_2O_5, 1955

GEOL: Tyuyamunite occurs as interstitial fillings and grain coatings in thin sandstone interbedded with claystone. Ore body parallel to palestream depositional trend.

REF: PRR-EDR-422
Nestler, R. & Chenoweth, W. (1958, RME-118)

MIKE BRODIE #1 (Brodie #1)

LOC: Approx. Sec. 5, T40N, R28E
NW Carrizo Mtns.

QUAD: Toh-Atin Mesa 15'; Shiprock NTMS

DEVL: Short adit and small stope

PROD: 5 tons @ 1.28% U_3O_8; 3.1% V_2O_5, 1951

GEOL: Spotty high grade tyuyamunite in Salt Wash member 3 to 4 ft. above Bluff contact and on NE edge of large scour with the Bluff. Rattlesnake-type mineralization associated with mineralized-carbonized logs. Inter-fingering mudstone and prominent iron staining.

REF: PRR-EDR-202
D.O.E.

MILDRED #1

LOC: Approx. Sec. 13-14, T38N, R28E
Segi-Ho-Cho Mesa, Carrizo Mtns.

QUAD: Los Gigantes Buttes 15'; Shiprock NTMS

DEVL: 90 ft. drift bearing S25° W from a roadcut. Only first 25 ft. of drift is mineralized.

PROD: 25 tons @ 0.05 U_3O_8, 2.68% V_2O_5, 1956

GEOL: Discontinuous bands and scattered lenses of ore along sandstone -mudstone contact and associated with carbon pockets in Salt Wash member, 30-40 ft. above Bluff contact.

REF: D.O.E.
Harshbarger (1946, RMO-441)

MONUMENT #2

LOC: Approx. W½ Sec. 27, N. central Sec. 32, T41N, R23E
36° 56' 05"N, 109° 53' 05"W - Monument Valley-Comb. Ridge.

QUAD: Dinnehotso 15'; Shiprock NTMS

DEVL: Underground and open pit

PROD: 766,998 tons @ 0.34% U_3O_8; 1.42% V_2O_5, 1948-1969 largest producer in Arizona @ 5.2 million pounds U_3O_8. Leased initially by VCA in 1942, some production by mechanical upgrader which separated ore sand from sub-ore slime.

ANAL: 0.10-0.58% U_3O_8; 1.0-2.24% V_2O_5; 0.4-1.5% $CaCO_3$.

GEOL: Principal ore is tyuyamunite and carnotite impregnating sandstone, filling fractures and replacing quartz, clay and fossil plant matter in Shinarump. Richest ore is in elongate horizontal flattened cylindrical "rods", up to 8 ft. in diameter and 100 ft. long.

Rods are aligned approximately parallel to N18°W trend of scour. Ore also extends as much as 7 ft. into DeChelly sandstone, where Shinarump paleochannel is cut down through Moenkopi and into DeChelly sandstone. Channel is about 2 miles long by 3 miles wide by 50 ft. deep and inner channel 700 ft. wide, and some 30 ft. deep. Uraninite is found in logs. Minerals identified include: montroseite, navahoite, becquerelite, fourmarierite, rauvite, volborthite, steigerite, hewettite, corvusite, uranophane, torbernite, metazeuneite, ilsemannite, autunite, pascoite, metatyuyamunite, and fernandinite.

REF: U.S.A.E.C. (1959, RME-141); Weeks, A. and others (1953-TEI-392),
McKee, E. and others (1953, RME-3089); Johnson, D. (1963)
Finnell, T (1957); Johnson, H. & Thordarson, W. (1966, TEI-640); Witkind, I. & Thaden, R. (1963);
Witkind, I. (1956);
Mitcham, T. and Evensen, J. (1955).

MONUMENT #2 SUPPLEMENT

LOC: Approx. Sec. 27 & 34, T41N, R23E
Monument Valley

QUAD: Dinnehotso 15'; Shiprock NTMS

DEVL: Open pit

PROD: 31,181 tons @ 0.293% U_3O_8; 1.312% V_2O_5, 1952-59. Includes the following former claims which are listed separately:

Black and Blackwater
Cato Sells Tracts 1N, 1S, and 2W
Chee Nez #1
John M. Yazzie #1
Willy Waters

MOUNTAIN MINING COMPANY

LOC: "19 miles north of Springerville, on U.S. 260, turn left at gate by white highway guard railpost, thence ½ mile west to rim."

QUAD: Lyman Lake SW or Salado 7½; Saint Johns NTMS

RAD: 150 c/sec.

GEOL: Tyuyamunite-type as weak fracture fillings with with chert in Chinle Fm. redbeds.

REF: PRR-EDR-261 (#33)

MUD MESA (Chester Mud #1)

N.S.M. 2

LOC: Sec. 34, T15N, R26E
North Mountain

QUAD: Hunt 15'; Saint Johns NTMS

DEVL: Rim stripping and 25' adit, caved

PROD: 57 tons @ 0.03% U_3O_8; 0.08% V_2O_5, 1953

ANAL: 4 samples @ 0.06-0.68% U_3O_8

GEOL: Carnotite in Petrified Forest member

REF: D.O.E.

NAKAI CHEE BEGAY (Tom Joe #7 permits)

LOC: Approx. Sec. 11, T36N, R28E
Lukachukai Mtns.

QUAD: Los Gigantes Buttes 15'; Shiprock NTMS

DEVL: Underground

PROD: 428 tons @ 0.14% U_3O_8; 0.51% V_2O_5, 1955-57, 1959-60, 1963, includes production from contiguous Tom Joe #7 permit.

GEOL: Discontinuous tyuyamunite ore in Salt Wash member

REF: D.O.E.

NAKAI CHEE BEGAY (Upper Red Wash)

NAZLINI TP - Ft. Defiance Area

LOC: T1,2,3N, R8W, T2N, R9W and N½ Sec. 19, T1N, R5W (see Gallup NTMS for plotted locales) total of 9 occurrences.

QUAD: Gallup NTMS

RAD: Unknown

GEOL: Radioactive fossil log and wood material in Chinle Fm., probably Monitor Butte member, according to USGS map reference below. D.O.E. has no information regarding the six occurrences plotted on the Gallup NTMS map to accompany this report.

REF: D.O.E. Hackman and Olsen (1977, USGS Map I-981)

NO. 8 MINE (VCA Plot 12)

NORTH MARTIN MINE (AEC Plot #2)

LOC: Approx. S, center Sec. 12, T40N, R28E
NW Carrizo - on rim of Dry Mesa

QUAD: Toh-Atin Mesa 15'; Shiprock NTMS

DEVL: Rim cut

PROD: 2,942 tons @ 2.23% V_2O_5 from August, 1942 to February, 1944, Wade Curran and Company shipped a combined production from Martin, North Martin, Sayteh CBW-MC, Sayteh Canyon and Buride Mines. North Martin produced less than 100 tons of ore.

GEOL: Ore in Salt Wash member

REF: Harshbarger, J. (1946, RMO-441)

NORTH MESA MINE (Rattlesnake #1)

NORTHEASTERN MEXICAN CRY MESA

LOC: Approx. SW central Sec. 25, T37N, R28E, Lukachukai Mtns.

QUAD: Los Gigantes Buttes 15'; Shiprock NTMS

GEOL: Tyuyamunite-type mineralization in fine-grained sandstone of Morrison Fm. with carbonized logs and debris.

REF: Peirce, H. and others (1970)
Webber (1943, RMO-480)

OAK SPRING MINE (Gravel Cap)

LOC: Approx. N. central Sec. 31, T39N, R31E
East Carrizo Mtns. near head of Oak Springs Wash.

QUAD: Redrock Valley and Pastora Peak 15'; Shiprock NTMS

DEVL: 400 ft. incline, 150 ft. shaft, drifts, stopes, room and pillars.

PROD: 5,112 tons @ 0.23% U_3O_8; 2.28% V_2O_5, 1949, 1954-59, 1962, 1966

ANAL: 0.1 -0.3% U_3O_8; 2.1 -3.2% -3.2% V_2O_5

GEOL: Tyuyamunite disseminated in unevenly bedded, light-gray, fine-grained Salt Wash sandstone with blue-green clay seams and carbon matter. Ore zone 54 ft. above Bluff contact and along sandstone mudstone contacts, in sedimentary structure and associated with carbon matter.

REF: PRR-CEBR-54 (#28)
Swanson, N. and Hatfield, K. (1952, RMO-811)
Dodd, P. (1952, TM-26)

OAK SPRINGS (Plot #10 VCA; East Reservation Lease)

LOC: Approx. NE¼, Sec. 31, T39N, R31E
Carrizo Mtns. - adjacent to Gravel Cap Mine

QUAD: Redrock Valley and Pastora Peak 15'; Shiprock NTMS

DEVL: Rim cuts, 350 ft. of drift, room and pillars, 50 drill holes, connects with Cato Sells Gravel Cap deposit.

PROD: 1979 tons @ 0.24% U_3O_8; 2.82% V_2O_5, 1949-50 by Cato Sells illegally, and 1955-57.

GEOL: Tyuyamunite-type ore in Salt Wash member 30-60 feet above Bluff contact.

REF: Swanson, M. and Hatfield, K. (1952, RMO-811)
Dodd, P. (1952, TM-26)

1½ WEST MINE (Mesa 1½)

1212 MINE (Mesa 4½ Mine)

PAUL BUCK (Upper Red Canyon)

PAUL SHORTY #1 (Rattlesnake #1)

PETTIGREW #1 (Leroy #1)

PHILLIP DEE #1

LOC: Approx. Sec. 20-21, T40N, R27E
NW Carrizo Mtns.

QUAD: Toh-Atin Mesa 15'; Shiprock NTMS

DEVL: 6 small pits

PROD: 154 tons @ 0.04%, 0.09% V_2O_5, 1954-55.

GEOL: Ore replaced logs and carbon matter in lower part of Salt Wash member.

REF: PRR-EDR-281
D.O.E.

PLOT #1 -- VCA RESERVATION PLOT
(Hogan Mine, West Reservation Lease)

LOC: Approx. SW¼, Sec. 1, T40N, R28E
NW Carrizo Mtns. on north prong of Dry Mesa

QUAD: Toh-Atin Mesa 15'; Shiprock NTMS

DEVL: Underground

PROD: For Plot #1, total of 3,507 tons @ 1.86% V_2O_5 mined for vanadium content in 1943-44 from VCA west reservation plots 1, 6-13. Also, minor production from here included with VCA west reservation plot 6 total. See entry on west Reservation lease for minor production in 1948-52 from plots 1 and 12.

GEOL: Tyuyamunite, schroechingerite, and metatyuyamunite in scattered, relatively small bodies in fine-grained shaly and limy sandstone of lower Salt Wash. ss. Carbonized logs and plant matter are abundant.

REF: Harshbarger, J. (1946, RMO-441)
Stokes, W. (1951)
Finch, W. (1967)

PLOT #2 - VCA West Reservation plot
(West Reservation Lease)

LOC: Approx. Sec. 1, T40N, R28E
NW Carrizo Mtns.

QUAD: Toh-Atin Mesa 15'; Shiprock NTMS

DEVL: 2 shallow pits

PROD: 163 tons @ 0.22% U_3O_8; 1.82% V_2O_5, 1960-61. Minor production in 1948-1952 reported as West Reservation Lease (see that entry).

GEOL: Mineralization in Salt Wash member

REF: D.O.E.

PLOT 3 and 5 - VCA west reservation plot
(West Reservation Lease)

LOC: Sec. 1, T40N, R28E, just north and down dip of Gila Mine

QUAD: Toh-Atin Mesa 15', Shiprock NTMS

DEVL: About 5 small prospect pits and several shallow trenches cut in shallow dip slope of Morrison Fm.

RAD: 30X max.

GEOL: In lower 20 ft. of Salt Wash member of Morrison Fm., on north flank of Toh-Atin anticline. Prospected by VCA in 1942-1943 for vanadium only.

REF: D.O.E.

PLOT #4 - VCA West Reservation Plot
(Gila Mine, West Reservation Lease)

LOC: Approx. SE¼ Sec. 1 and N. central Sec. 12, T40N, R28E, NW Carrizo Mtns. on North prong of Dry Mesa

QUAD: Toh-Atin Mesa 15'; Shiprock NTMS

DEVL: Adit

PROD: 22 tons @ 0.17% U_3O_8, 1.82% V_2O_5 in 1960-61. Portion shipped in 1949 as West Reservation lease (see that entry).

GEOL: Ore in Salt Wash member

REF: D.O.E.

PLOT #5 (Refer to Plot #3)

PLOT #6 - VCA West Reservation Plot
(Rattlesnake Incline)

LOC: Approx. Sec. 6-7, T40N, R29E
NW Carrizo

QUAD: Toh-Atin Mesa 15'; Shiprock NTMS

DEVL: Drilled, 600 X 100 ft. strip mine, adits and stopes

PROD: 7,365 tons @ 0.21% U_3O_8; 1.47% V_2O_5 in 1955-56 and 1958-59. This includes minor production from plots 1, 2, 3, 4, 7-12. Production in 1943-44 includes plots 1, 6-13, and totaled 3,507 tons @ 1.86% V_2O_5. See entry on West Reservation lease for minor production in 1948-52 from Plot 6.

GEOL: Ore in medial part of Salt Wash member

REF: Hatfield, K. and Maise, C. (1953, RME-9)
Harshbarger, J. (1946, RMO-441)

PLOT #7 - VCA West Reservation Plot (Rattlesnake #5 Mine, West Reservation Lease)

LOC: Approx. Sec. 6-7, T40N, R28E
NW Carrizo Mtns.

QUAD: Toh-Atin Mesa 15'; Shiprock NTMS

DEVL: Underground

PROD: Total of 3,507 tons @ 1.86% V_2O_5 mined for vanadium content in 1943-44 from VCA west reservation plots 1, 6-13. Also, minor production from here included with VCA west reservation plot 6 total.

GEOL: Ore in Salt Wash member.

REF: Harshbarger, J. (1946, RMO-441)

PLOT #8 (West Reservation Lease)

LOC: Approx. Sec. 6-7, T40N, R28E
NW Carrizo Mtns.

QUAD: Toh-Atin Mesa 15'; Shiprock NTMS

DEVL: Short adit

PROD: 28 tons @ 0.18% U_3O_8; 1.80% V_2O_5, 1950.
Total of 3,507 tons @ 1.86% V_2O_5 mined for vanadium content in 1943-44 from VCA west reservation plots 1,6-15. Also, minor production from here included with VCA west reservation plot 6 total.

GEOL: Mineralization in Salt Wash

REF: Harshbarger (1946, RMO-441)

PLOT #9 (VCA West Reservation Lease)

LOC: Approx. Sec. 8, T40N, R29E
NW Carrizo Mtns.

QUAD: Toh-Atin Mesa 15'; Shiprock NTMS

DEVL: Rim cut

PROD: Total of 3,507 tons @ 1.86% V_2O_5 mined for vanadium content in 1943-44 from VCA west reservation plots 1, 6-13. Also, minor production from here included with VCA west reservation plot 6 total.

GEOL: Mineralization in Salt Wash

REF: Harshbarger (RMO-441, 1946)

PLOT #10 - VCA West Reservation Plot (Horse Portal, Horse, H & R. Nez, Howard Nez, West Reservation Lease)

LOC: Approx. Sec. 8, T40N, R29E
W. Carrizo Mtn.

QUAD: Toh-Atin Mesa 15'; Shiprock NTMS

DEVL: Underground

PROD: 8 tons @ 0.10%, U_3O_8 1.19% V_2O_5, 1957 Mined from the dumps on Plot #10, but reported as H. & R. Nez. Total of 3,507 tons @ 1.86% V_2O_5 mined for vanadium content in 1943-44 from VCA west reservation plots 1, 6-13. Also, minor production from here included with VCA west reservation plot 6 total.

GEOL: Tyuyamunite-type ore as discontinuous bands and scattered lenses along mudstone-sandstone contacts, sedimentary structures and associated with carbon matter in the Salt Wash member.

REF: D.O.E.
Harshbarger (1946-RMO-441)

PLOT #11 - VCA West Reservation Plot (Two Level Mine)

LOC: Approx. SW¼ Sec. 8, T40N, R29E NW Carrizo Mtns. at head of Rattlesnake Canyon cutting into Black Rock Point.

QUAD: Toh-Atin Mesa 15'; Shiprock NTMS

DEVL: 1 portal, 2 drifts 45° apart and upper level thru raise.

PROD: Total of 3,507 tons @ 1.86% V_2O_5 mined for vanadium content in 1943-44 from VCA west reservation plots 1, 6-13. Also, minor production from here included with VCA west reservation plot 6 total.

GEOL: Mineralization in Salt Wash member

REF: Harshbarger (1946)

PLOT 11 - VCA East Reservation Plot (White Cap Lease)

LOC: 36° 45' 55"N, 109° 03' 05"W
See Figure on Syracuse Mine area

QUAD: Pastora Peak 15'; Shiprock NTMS
Carrizo Mtns.

DEVL: 2 adits totalling 25 ft. 50 X 150 ft. rim strip area; 10 barren holes on 50-100 ft. centers drilled in 1952 by AEC.

PROD: Any production in 1948-1950 included in East Reservation Lease of VCA.

RAD: 5X

GEOL: Salt Wash member of Morrison Fm., 30-60 ft. above base.

REF: D.O.E.

PLOT #12 - VCA West Reservation Plot
(Rattlesnake #8 Mine, West Reservation Lease, No. 8 Mine)

LOC: Approx. Sec. 13, T40N, R28E
Carrizo Mtns.

QUAD: Toh-Atin Mesa 15'; Shiprock NTMS

DEVL: 12 holes drilled; 3 adits, 935 ft. drifts - room and pillars.

PROD: Total of 3507 tons @ 1.86% V_2O_5 mined for vanadium content in 1943-44 from VCA west reservation plots 1,6-13. Also, minor production from here included with VCA west reservation plot 6 total. See entry on West Reservation lease for minor production in 1948-52 from plots 1 and 12.

GEOL: Ore in lenses in sandstone of lower Salt Wash member

REF: Harshbarger, J. (1946, RMO-441)
Hatfield, K. and Maise, C. (1953, RME-9)

PLOT #12 (Syracuse)

PLOT #13 - VCA West Reservation Plot
(West Reservation Lease)

LOC: Approx. Sec. 13, T40N, R28E
NW Carrizo Mtns.

QUAD: Toh-Atin Mesa 15'; Shiprock NTMS

DEVL: Shallow pits on rim

PROD: Total of 3507 tons @ 1.86% V_2O_5 mined for vanadium content in 1943-44 from VCA west reservation plots 1, 6-13.

GEOL: Mineralization in Salt Wash member

REF: Harshbarger (1946, RMO-441)

PLOT #14 (Eurida Mesa Mine)

PLOT #15 (Eurida Mesa Mine)

PLOT #16 (Eurida Mesa Mine)

POPE #1

LOC: Approx. Sec. 6, T40N, R29E
NW Carrizo Mtns.

QUAD: Toh-Atin Mesa 15'; Shiprock NTMS

DEVL: 50 ft., 50° incline, 135 ft. room and pillars; 100 drill holes.

PROD: 432 tons @ 0.33% U_3O_8; 1.80% V_2O_5, 1959

GEOL: Ore is at a depth of 30 ft. in thin argillaceous sandstone lens in Salt Wash member, 30 ft. above Bluff contact. On north flank of Rattlesnake anticline. Adjacent to VCA Rattlesnake (Plot #6).

REF: D.O.E.

PUERCO RIVER

LOC: Enters Arizona 15 miles NE of Sanders

QUAD: Gallup NTMS

RAD: In water, exceeds health standards

ANAL: Greater than 30 picocuries per liter of water

GEOL: Spill of radioactive water into Puerco River from United Nuclear Corp. mill tailings at Church Rock, NM, on 16 July 1979, at a point 50 miles upstream from Arizona border. Apache County residents are warned to not use the river water for drinking or any agricultural or livestock purposes.

REF: Arizona Dept. of Health Services
News Release - 3 June, 80.

R. F. & R (Syracuse)

RATTLESNAKE GROUP

Alias for following VCA West Reservation Mines
Plot #6
Plot #7
Plot #12

Rattlesnake #1 is not a part of the VCA Rattlesnake Group.

RATTLESNAKE INCLINE (Plot #6)

RATTLESNAKE #1 (Shorty #1, Paul Shorty #1, North Mesa Mine)

LOC: Approx. Sec. 16, T40N, R30E
Carrizo Mtns. on prong north of Black Rock Point

QUAD: Pastora Peak 15'; Shiprock NTMS

DEVL: Adits, room and pillar. Strata dip 9° due to Carrizo Laccolith.

PROD: 1,054 tons @ 0.16% U_3O_8; 1.70% V_2O_5, 1948, 1950, and 1955-56.

GEOL: Tyuyamunite ore in mud seams and carbon pockets of lower Salt Wash member.

REF: Stokes, W. (1951); Finch, W. (1967)
Harshbarger (1946, RMO-441)

RATTLESNAKE #5 MINE (Plot #7)

RATTLESNAKE #8 MINE (Plot #12)

RED FEATHER #3 (Upper Red Canyon)

RED ROCK BRIDGE

LOC: Approx. NE¼ Sec. 24, T37N, R31E
Near Redrock Trading Post, on east bank of canyon under new highway bridge.

QUAD: Redrock Valley 15'; Shiprock NTMS

RAD: to 12 X along a zone 50 ft. long and 1 ft. thick.

GEOL: One foot thick band of tyunamunite and vanadium mineralization near base of fine-grained Salt Wash sandstone interbedded with mudstone.

REF: King, J. (1951, RMO-755)

RICHARD KING (Jim Lee #1)

ROCKY SPRING (Jerome Chee)

LOC: Approx. Sec. 6-7, T36N, R31E
E. Carrizo Mtns.

QUAD: Redrock Valley 15'; Shiprock NTMS

DEVL: Rim cut

PROD: 11 tons @ 0.01% U_3O_8; 0.28% V_2O_5, 1951

GEOL: Flecks of tyuyamunite 2 ft. above base of Salt Wash member. Quartzose sandstone with carbonized plant debris and interbedded with mudstone and claystone. Pintadiote and hewettite identified.

REF: PRR-CEBR-24; King, J. (1951, RMO-755)

ROUGH ROCK GROUP (Refer to Dan Taylor#1)

ROUGH ROCK SLOPE #9

LOC: Approx. Sec. 1-2, T34N, R23E
Chilchinbito - Yale Point

QUAD: Rough Rock 7½; Shiprock NTMS

DEVL: Underground

PROD: 67 tons @ 0.25% U_3O_8; 0.94% V_2O_5; 1.15% $CaCO_3$, 1956

GEOL: Carnotite in a sandstone lens directly below a lignitic bed in upper part of the lower sandstone member of the Toreva Fm.

REF: Clinton, J. (1956, RME-91)
D.O.E. preliminary map No. 31

RUBEN #1 (at or near Billie No. 1)

LOC: Approx. Sec. 27, T40N, R30E, East Carrizos
(AEC plot 36° 50' 10"N, 109° 06'00"W

QUAD: Pastora Peak 15'; Shiprock NTMS

DEVL: Rim cut and adit

PROD: 64 tons @ 0.22% U_3O_8; 2.10% V_2O_5, 1955

GEOL: Discontinuous bands and scattered lenses of tyuyamunite along sandstone-mudstone contacts, in sedimentary structure and pockets of carbon matter in Salt Wash member.

REF: D.O.E.

RUIN MESA (Charlie James #1)

SALINA #4 (Charlie James #1)

SAM CHARLEY #1

LOC: Approx. Sec. 36, T34N, R23E
Black Mtn.

QUAD: Sweathouse Peak 7½; Shiprock NTMS

DEVL: 550 X 40 X 5 ft. deep shallow stripped area, some drilling.

GEOL: Ore bearing sandstone in the upper portion of the lower sandstone member, Toreva Fm. is overlain by a 1-2 ft. bed of lignite.

REF: D.O.E.

SAM HARVEY (Syracuse)

SANDY K MINE (Covered by Jimmy Bileen Claims)

LOC: Approx. Sec. 8, T40N, R29E
NW Carrizo - 8 miles west of Old Teec Nos Pos Trading Post

QUAD: Toh-Atin Mesa 15'; Shiprock NTMS

DEVL: 6 X 10 X 2 ft. deep shallow pit

PROD: 7 tons @ 0.13% U_3O_8; 0.57% V_2O_5, 1955

GEOL: Tyuyamunite halos around petrified logs in Salt Wash member.

REF: D.O.E.

SAYTAH CANYON (AEC Plot No. 4)

LOC: Approx. Sec. 31-32, T39N, R29E
Carrizo Mtns.

QUAD: Toh-Atin Mesa and Pastora Peak 15'; Shiprock NTMS

DEVL: Rim cut

PROD: 112 tons @ 0.18% U_3O_8; 1.71% V_2O_5, 1950-51 by VCA under contract with AEC. From 1942 to 1943, Wade, Curran and Company, shipped 2,942 tons @ 2.23% V_2O_5 from the Martin, North Martin, Saytah, Saytah Canyon CBW-MC and Eurida Mines.

GEOL: Ore in Salt Wash member

REF: Harshbarger, J. (1946, RMO-441)

SAYTAH MINE (Geo. Simpson #1A was accessed through Saytah portal)

LOC: Approx. S central Sec. 13, T40N, R28E. Head of Tsitah Wash Canyon-NW Carrizo Mtns.

QUAD: Toh-Atin Mesa 15'; Shiprock NTMS

DEVL: Underground - initial access for the George Simpson #1A was thru the Saytah Mine.

PROD: 1,926 tons @ 0.23% U_3O_8; 1.88% V_2O_5, 1956. From 1942 to 1944, Wade, Curran and Company, shipped 2,942 tons @ 2.23% V_2O_5 from the Martin, North Martin, Saytah, Saytah Canyon, CBW-MC and Eurida Mines.

GEOL: Tyuyamunite in Salt Wash member

REF: Marshbarger, J. (1946, RMO-441)

SCHOOL BOY

LOC: Approx. Sec. 33, T40N, R29E Carrizo Mtns.

QUAD: Pastora Peak 15'; Shiprock NTMS

DEVL: 200 X 30 X 15 ft. deep rim cut, 2 north trending adits from cut, 50 ft. of underground workings.

PROD: 109 tons @ 0.09% U_3O_8; 2.33% V_2O_5, 1955-56.

GEOL: Ore as thin discontinuous bands and scattered lenses along mudstone-sandstone contacts and carbon pockets in basal Salt Wash sandstone.

REF: D.O.E.

SELLS (Cove Mesa mines No. 1 and 2)

SHEEPSKIN MESA (Hanley #1 and #3 claims)

LOC: Approx. Sec. 29, T38N, R28E Carrizo Mtns.

QUAD: Los Gigantes Buttes 15'; Shiprock NTMS

DEVL: 300 ft. of rim stripping; 5 small adits. No. 1 mine on NW side of Mesa, No. 2 mine on NE side.

PROD: 80 tons @ 0.21% U_3O_8; 2.14% V_2O_5, 1950 & 1953

GEOL: Tyuyamunite associated with gray claystone, five feet above base of Salt Wash member.

REF: D.O.E.

SHIPROCK

LOC: Unknown location, possibly from White Cap or Syracuse plots, East Reservation Lease

PROD: 104 tons @ 0.16% U_3O_8; 1.94% V_2O_5 in 1948, included in total for East Reservation Lease in TM-210, (1980)

REF: W. Chenoweth, pers. comm., 1980

SHORTY #1 (Rattlesnake #1)

SILENTMAN #1

LOC: Approx. Sec. 2, T40N, R28E NW Carrizo

QUAD: Toh-Atin Mesa 15'; Shiprock NTMS

DEVL: Surface stripping

PROD: 12 tons @ 0.08% U_3O_8; 0.008% V_2O_5, 1958

GEOL: Tyuyamunite in fossil logs exposed on surface or Salt Wash Fm. Logs are silicified, nor carbonized.

REF: D.O.E.

SIMPSON #1 (George Simpson #1)

SIMPSON #181 (Mesa 4½ Mine)

SITTON LEASE

Sitton was the first white man to acquire some Lukachukai Mtns. ore bodies. Sitton shipped some ore as the Navajo Uranium Company, then sold out to Kerr-McGee, who then renamed the occurrences as Mesa numbers, i.e. Mesa 1,2,.... See RME-118 for history.

SM TRACT #2 (Cato Sells Tract 1S, 2W, 1W)

SNAKE POINT (Tom Joe #7)

STARK-LATHING COMPANY PERMIT

LOC: "Drive north from Crystal, New Mexico for 12 miles. Anomaly lies just north of Whiskey Creek in the valley of a small tributary. Approx. T5N, R5W, on Arizona-New Mexico Border.

QUAD: Sonsela Buttes 15'; Shiprock NTMS

RAD: 10X

GEOL: Basalt boulder alluvium with basalt slightly radioactive.

REF: PRR-EDR-421

STEP MESA MINE

LOC: Approx. N. central Sec. 30, T36N, R29E, Lukachukai Mtns. on west side of ridge

QUAD: Los Gigantes Buttes 15'; Shiprock NTMS

DEVL: Room and pillars

PROD: 8841 tons @ 0.20% U_3O_8; 0.43% V_2O_5, 1962-64

GEOL: Ore in Salt Wash Fm.

REF: D.O.E.

SUNNYSIDE MINE

LOC: Approx. W. side of Sec. 36, T39N, R28E
W. Carrizo Mtns. on Sunnyside Mesa. There is also a Sunnyside Mine in New Mexico

QUAD: Los Gigantes Buttes 15'; Shiprock NTMS

DEVL: Small underground

PROD: 28 tons, @ 0.16% U_3O_8, 3.10% V_2O_5, in 1955. From May to October, 1943, Wade, Curran and Company shipped 475 tons @ 2.75% V_2O_5.

ANAL: 5 samples @ 0.05-0.11% e U_3O_8; 0.03-0.15% U_3O_8; 0.94-5.00% V_2O_5

GEOL: Tyuyamunite-type ore in medium-grained, shaly Salt Wash sandstone with carbon matter and 40-50 ft. above contact with Bluff member.

REF: Webber, B. (1943, RMO-480)
Harshbarger, J. (1946, RMO-441)

SYRACUSE (R. F. & R.: Sam Harvey)

LOC: Approx. Sec. 19, 30, T39N, R31E.
East Carrizo Mtns. on south side of south Tributary of Cottonwood Wash close to New Mexico border. Adjacent to Hazell and Valley View Mines.

QUAD: Pastora Peak 15'; Shiprock NTMS

DEVL: Rim cuts and entries on SW and NE sides of mesa 3 adits on NE, one on SE side connects 2,000 ft. of workings

PROD: 23 barrels of radium ore, very probably from this mine, was shipped through Beclabito T.P. to Colorado in about 1922. The majority of 1500 tons of vanadium ore, shipped by Wade Curran and Co. in 1942-44, came from this mine. And 1954-58, 1964-66 production of 1967 tons @ 0.28% U_3O_8, 2.60% V_2O_5 is also recorded.

GEOL: Ore zone is 4.5 ft. thick in discontinuous bands along sandstone-mudstone contacts and carbon pockets in middle of Salt Wash member about 40-60 ft. above Bluff contact. Upper ore zone also mined.

REF: Stokes, W. (1951)
Finch, W. (1967)
Coleman (1944, RMO-469)

SYRACUSE (East Reservation Lease)(VCA Plot 12)

LOC: Approx. Sec. 19 & 20, T39N, R31E
East Carrizo Mtns. on Arizona-New Mexico Border

QUAD: Pastora Peak 15'; Shiprock NTMS

DEVL: 4 adits totaling about 140 ft., with some stoping, along a 250 ft. distance.

PROD: During 1943 a small amount of ore was mined from the Syracuse plot by VCA (Coleman describes the mine as extant in 1944). In 1949, VCA mined a small amount of ore bypassed in earlier operation. This ore was included in East Reservation Lease shipments mainly from Plot 3 (Shadyside). (Page Edwards, VCA field superintendent, pers. comm. to Chenoweth, 1955.) The 1949 shipment probably amounted to 225 tons @ 0.27% U_3O_8, 2.96% V_2O_5.

GEOL: Tyuyamunite-type mineralization in lower Salt Wash member. Refer to Syracuse (R.F.&R.) nearby.

REF: D.O.E.

T. J. & #9 MINE (Tommy James)

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THOMAS CLANI (VCA) (Black Rock Point)

THOMAS BEGAY #1 (Begay #1, adjacent to and continuous with Kasewood Bahe #1)

LOC: Sec. 36, T34N, R23E
Chilchinbito

QUAD: Sweathouse Peak 7½'; Shiprock NTMS

DEVL: 53 holes drilled, 600 ft. rim stripping

PROD: 12 tons @ 0.47% U_3O_8; 0.31% V_2O_5, 1956

GEOL: Carnotite in upper part of lower sandstone member of the Toreva Fm., overlain by 1-2 ft. bed of lignite.

REF: Clinton, J. (1956, RME-91)
D.O.E. Preliminary map No. 31

TODAKONZIE #1

LOC: Approx. Sec. 26-27, T40N, R30E, North Carrizos (AEC plot 36°50' 10" N, 109° 05'40"W)

QUAD: Pastora Peak 15'; Shiprock NTMS

DEVL: 20 X 10 X 6 ft. deep rim cut, heading NE-SW along mineralized outcrop.

PROD: 6 tons @ 0.21%; 1.81% V_2O_5, 1955

GEOL: Tyuyamunite-type ore in thin discontinuous bands, pods and scattered lenses along sandstone-mudstone contacts in Salt Wash member, 30-40 ft. above Bluff contact. This Salt Wash block overlies an igneous mass.

REF: D.O.E.

TODECHEENIE #1, (Frank Todeckeenie)

LOC: Approx. Sec. 35 & 36, T34N, R23E
Black Mtn.

QUAD: Sweathouse Peak 7½'; Shiprock NTMS

DEVL: 600 X 150 X 15 ft. deep, stripped area
720 holes drilled.

PROD: 1,363 tons @ 0.22% U_3O_8; 0.28% V_2O_5, 1955-56.

RAD: 20X

ANAL: Select specimen @ 2.30% e U_3O_8; 2.73% U_3O_8; 0.97% V_2O_5; 0.6% $CaCO_3$.

GEOL: Carnotite in upper portion of lower sandstone member, Toreva Fm., overlain by 1-2 ft. lignite bed. Metatyuyamunite, rauvite and metahewettite in red clay have been identified.

REF: Clinton, J. (1956, RME-91, Ref. #19, Fig. 3, p. 7)
D.O.E. preliminary map #31.

TOHE-THLANY-BEGAY

LOC: Approx. Sec. 34 & 35, T39N, R29E, and Sec. 2 and 3, To 38N, R29E, S. Carrizo Mtns.

QUAD: Redrock Valley 15'; Shiprock NTMS

DEVL: 300 X 30 X 20 ft. deep rim cut; adit with 134 ft. underground workings; 7 holes drilled.

PROD: 254 tons @ 0.16%; 2.66% V_2O_5, 1950-53.

GEOL: Tyuyamunite in lower part of Salt Wash member, adjacent to diorite porphyry intrusive.

REF: D.O.E.

TOM JOE #1 (Also Tom Joe Parcel #1) (Mesa 4½ Mine)

TOM JOE #7 (Snake Point)

LOC: Approx. Sec. 1, 2, 12, 13, T36N, R28E N. Lukachukai Mtns.

QUAD: Los Gigantes Buttes 15'; Shiprock NTMS

DEVL: 8 drill holes

GEOL: Tyuyamunite-type mineralization averaging 3 ft. thick in basal Salt Wash member about 75 ft. from surface.

REF: D.O.E.

TOM JOE #7 PERMIT (Nakai Chee Begay)

TOM KLEE #1 MINE

LOC: Approx. SE¼ Sec. 2, T35N, R22E, and SW¼, Sec. 6, T35N, R23E., about 4.5 mi. NW of Rough Rock

QUAD: Rough Rock NW 7½; Shiprock NTMS

DEVL: Few hundred feet of scattered rim stripping; 70 holes drilled.

PROD: 64 tons @ 1.01% U_3O_8; 0.04% V_2O_5, 1952, 1956-58.

GEOL: Scattered high grade tyuyamunite replacing logs in Salt Wash member sandstone rim.

REF: PRR-GJEBR-76
D.O.E. preliminary map No. 31.

TOM MORGAN #1

LOC: Approx. Sec. 29, T41N, R27E NW Carrizo Mtns.

QUAD: Toh-Atin Mesa 15'; Shiprock NTMS

DEVL: Several shallow prospect pits, 50 ft. of rim stripping.

PROD: 10 tons @ 0.24% U_3O_8; 0.76% V_2O_5, 1955

GEOL: Tyuyamunite-type ore associated with a thin clay seam 20 ft. above Bluff contact in basal Salt Wash member.

REF: D.O.E.

TOM NAKI CHEE (Mexican Cry Mine)

TOM NAKI CHEE #6-8 (Hall Mine)

TOM WILSON, (Jim Hatattly)

LOC: Approx. Sec. 6, T35N, R23E, and Sec. 1, T35N, R22E, Chilchinbito

QUAD: Rough Rock NW 7½'; Shiprock NTMS

DEVL: Pit; rim stripping, 57 holes drilled

PROD: 59 tons @ 0.45% U_3O_8; 0.03% V_2O_5, 1956

GEOL: Tyuyamunite replacing fossil logs in Salt Wash member.

REF: PRR-GJEBR-76
Anthony, M. (1955, RME-82)
D.O.E. preliminary map No. 31.

TOMCAT (Maybe Claims, Lookout Claims)

LOC: Approx. Sec. 18, T11N, R28E
10 miles south of Saint Johns

QUAD: Lyman Lake SW7½; Saint Johns NTMS

DEVL: 200 X 30 X 20 ft. deep rim cut, 2 trenches, 1955

RAD: 50X

GEOL: Carnotite-type mineralization at base of thin argillareous sandstone in lower part, Petrified Forest member, overlain by Bidahocki Fm. and underlain by gray Chinle shale. Carbonized wood fragments, gypsum and copper staining present.

REF: PRR-A-19
PRR-EDR-261 (#24)

TOMMY JAMES MINE (Fall Down Mesa, T.J. #9 Mine)

LOC: Approx. SW¼, Sec. 19, T36N, R29E
S. Lukachukai

QUAD: Los Gigantes Buttes 15'; Shiprock NTMS

DEVL: 53 holes drilled underground

PROD: 853 tons @ 0.17% U_3O_8; 0.79% V_2O_5, 1955-56.

GEOL: Bedded lenses and pods of tyuyamunite ore at an average depth of 220 ft. and average thickness of 3.2 ft. in Salt Wash member.

REF: D.O.E.

TONI TUC TRACT #1

LOC: Approx. Sec. 12, T39N, R30E, East Carrizo Mtns. (AEC Plot 36° 48' 03"N, 109° 04' 50"W)

QUAD: Pastora Peak 15'; Shiprock NTMS

DEVL: E-W rim cut 400 X 20 X (10-60) ft. deep. Two short adits.

PROD: 407 tons @ 0.18% U_3O_8, 3.28% V_2O_5, in 1953, 56-57, 1962, 1966.

ANAL: 4 samples @ 0.42-0.13% U_3O_8; 2.41-4.28% V_2O_5; 8.50% $CaCO_3$

GEOL: Tyuyamunite-type ore in bands 1-3 ft. thick in basal Salt Wash member.

REF: Coleman (1944,RMO-469) describes the outcrop.

TOPAHA (Billy Topaha Mine)

TRACT #1 AND #2 (Cato Sells Tracts 1S, 2W, 1N)

TREE MESA (Clani)

LOC: Approx. Sec. 28, T38N, R28E, Carrizo Mtns.

QUAD: Los Gigantes Buttes 15'; Shiprock NTMS

DEVL: Rim cut

PROD: 47 tons @ 0.08% U_3O_8; 0.72% V_2O_5, 1953

GEOL: basal Salt Wash.

REF: D.O.E.
Webber (1943, RMO-480).

TSOSIE #1 (Luke Tsosie #1)

LOC: Approx. Sec. 7, T40N, R28E Carrizo Mtns.

QUAD: Toh-Atin Mesa 15'; Shiprock NTMS

DEVL: 570 ft. of adits, drifts and crosscuts Located by single A.E.C. drillhole.

PROD: 25 tons @0.11% U_3O_8; 1.30% V_2O_5, 1955

GEOL: Carnotite-type ore in basal Salt Wash member with some Petrified Wood.

REF: D.O.E.

TWO LEVEL MINE (VCA West Reservation Plot 11).

UNNAMED A

LOC: NW¼, Sec. 3, T14N, R26E

QUAD: Hunt 15'; Saint Johns NTMS

RAD: 1,000 counts/min.

ANAL: 0.07-0.68% U_3O_8

GEOL: Mineralization in bleached conglomeratic sandstone and siltstone with high mud content, wood, carbon matter and iron staining. Chinle scour and fill channel with buttes capped by travertine.

REF: PRR-EDR-223 (#32); Finch, W. (1967)

UNNAMED B (Might be Hinkson Cattle Co. occurrence)

LOC: Sec. 11, T15N, R24E

QUAD: Adamana 3NE 7½; Saint Johns NTMS

ANAL: 0.031% e U_3O_8; 0.034% U_3O_8

GEOL: Carnotite, chalcedony, gypsum and carbon matter in sandy clay and shale of Chinle Fm.

REF: PRR-w/o #

UNNAMED C

LOC: Approx. W½ Sec. 1 and E½ Sec. 2, T38N, R28E - South Carrizo Mtns. on mesa between tributaries of Alcove Canyon about one mile south of Sunnyside Mesa.

QUAD: Los Gigantes Buttes 15'; Shiprock NTMS

DEVL: Prospect pits

GEOL: Mineralization in Salt Wash member

REF: D.O.E.

UNNAMED D

LOC: Approx. Sec. 13, T9N, R6W, 36° 30' 55"N, 109° 01' 35" W.

QUAD: Redrock Valley 15'; Shiprock NTMS

DEVL: Vanadium ore stockpiled

GEOL: Flecks of carnotite with pintadoite, hewettite, and vanadium minerals in gray, weakly cross-bedded Salt Wash sandstone, 3 ft. above Bluff contact.

REF: PRR-CEBR-24 (#27)

UNNAMED E

LOC: Approx. E½, Sec. 29, T33N, R23E, Caps a cliff-forming sandstone on north side of east flowing tributary to Tah Chee Wash.

QUAD: Tah Chee Wash 7½'; Shiprock NTMS

RAD: Air-borne anomaly

ANAL: 10-30% TiO_2

GEOL: Six inch thick black placer sand in Toreva Fm. and capping a small mesa. Composed of titanium rich placer concentrate with uranium-bearing zircons and thorium-bearing monazite.

REF: Murphy, J. (1956)

UNNAMED F

LOC: Approx. $N\frac{1}{2}$, Sec. 11, T32N, R23E, Black Mtn. in west flowing tributary to Burnt Corn Wash on south side of canyon, traceable for one mile.

QUAD: Blue Gap 7½'; Shiprock NTMS

RAD: Air-borne anomaly

ANAL: 10-30% TiO_2

GEOL: Very thin black sand laminae throughout a 13 ft. interval in the Toreva Fm. Uranium in zircons and Thorium in monazite.

REF: Murphy, J. (1956)

UPPER CANYON MINES

LOC: Approx. Sec. 29, and 30, T39N, R31E East Carrizo Mtns.

QUAD: Pastora Peak 15'; Shiprock NTMS

DEVL: Numerous short adits, 400 ft. incline which is flooded, newer access by adit from rim.

PROD: 2,809 tons @ 0.17% U_3O_8; 2.06% V_2O_5, 1950-56, 1961-64.

GEOL: Tyuyamunite mineralization lies in a broad, poorly defined channel in light-gray, fine-grained Salt Wash sandstone, 20 ft. above Bluff contact. Ore is exposed continuously for 85 ft. and discontinuously for 300 ft.
Pintadoite identified on several faces.

REF: D.O.E.
Blaghbrough and Brown (1955, RME-83)

UPPER RED CANYON (Paul Buck, Red Feather #3)

LOC: Approx. Sec. 12, T39N, R30E E. Carrizo Mtns.

QUAD: Pastora Peak 15'; Shiprock NTMS

DEVL: Rim cut and short adit

PROD: 26 tons @ 0.26% U_3O_8; 3.26% V_2O_5, 1950-51

ANAL: 0.08% U_3O_8; 0.7% $CaCO_3$; 0.03% Cu

GEOL: Thin discontinuous bands of tyuyamunite-type mineralization in basal Salt Wash member.

REF: Coleman (1944) discusses outcrop.

UPPER RED WASH (Nakai Chee Begay)

LOC: Approx. $SE\frac{1}{4}$, Sec. 36, T38N, R31E - E. Carrizo Mtns. near Arizona-New Mexico border about 3 miles north of Red Rock Trading Post.

QUAD: Redrock Valley 15'; Shiprock NTMS

DEVL: Underground

PROD: 378 tons @ 0.22% U_3O_8; 1.44% V_2O_5 in 1950-53. an addition 442 tons of "no pay ore" (0.08% U_3O_8, 0.21% V_2O_5) was shipped in 1951-53.

GEOL: Tyuyamunite in carbonaceous sandstone as rolls and pods near base of Salt Wash member.

REF: PRR-CEBR-23 (#26)
King, J. (1951, RMO-755)
Anderson, et al. (TM-39, 1952)
D.O.E.

VALLEY VIEW (Valley View Extension)

LOC: Approx. Sec. 19 and 30, T39N, R31E East Carrizo Mtns., adjacent to Syracuse

QUAD: Pastora Peak 15'; Shiprock NTMS

DEVL: Rim cuts and adits

PROD: 73 tons @ 0.09% U_3O_8, 2.29% V_2O_5, 1950

GEOL: Mineralization in Salt Wash member

REF: D.O.E.

VALLEY VIEW EXTENSION (Valley View)

VCA EAST RESERVATION LEASE (East Reservation Lease)

VCA PLOT #10 East Reservation (Oak Springs)

VCA PLOT #12 (Syracuse)

WAITE CLAIM (Harvey Platt Ranch)

VCA EAST RESERVATION LEASE PLOTS

New Mexico:
- Plot 1 Red Wash Point
- Plot 2 King Tutt Point
- Plot 3 Shadyside
- Plot 4 Williams Point
- Plot 5 Fissure
- Plot 6 Franks Point
- Plot 7 Lower Oak Creek (Springs)
- Plot 8 Cottonwood Butte
- Plot 9 Lone Star

Arizona:
- Plot 10 Oak Springs
- Plot 11 White Cap
- Plot 12 Syracuse (adjacent to Lone Star)

VCA WEST RESERVATION LEASE PLOTS

Plot 1 Hogan Mine
Plot 2 (no name)
Plot 3 (No name, no production)
Plot 4 Gila Mine
Plot 5 (no name, no production)
Plot 6 Rattlesnake incline, etc.
Plot 7 Rattlesnake No. 5 Mine
Plot 8 (no name)
Plot 9 (no name)
Plot 10 Horse Mine
Plot 11 Two Level Mine
Plot 12 Rattlesnake No. 8 Mine
Plot 13 (no name)
Plot 14 Eurida Mesa
Plot 15 Eurida Mesa
Plot 16 Eurida Mesa
Plot 17 No name-no production.

WARHOOP #1-8

LOC: S½, Sec. 30, T13N, R29E

QUAD: St. Johns South 7½'; Saint Johns NTMS

DEVL: Open pit

PROD: 576 tons @ 0.13% U_3O_8; 8.5% $CaCO_3$, 1957-61

GEOL: Carnotite in small discontinuous lenses in Amejo sandstone of the Petrified Forest member. Ore zone averages 1.5 ft. thick and is about 5 ft. below the surface. Zeppeite has been identified. "Amejo" is name used by Mullenberger (Texas) students.

REF: D.O.E.

WEST BURNT CORN WASH (Claim #27 & #28)

WEST MESA MINE

LOC: Approx. central Sec. 24, T37N, R28E
SW Carrizo Mtns. on east side of Mesa

QUAD: Los Gigantes Buttes 15'; Shiprock NTMS

DEVL: 65 ft. adit and small crosscut from 200' rim cut.

PROD: 72 tons @ 0.12% U_3O_8; 0.82% V_2O_5, 1955

GEOL: Tyuyamunite in discontinuous lenses along sandstone-mudstone contacts and bedding planes in Morrison Fm.

REF: D.O.E.

WEST RESERVATION LEASE

A total of 5,417 tons @ 0.20% U_3O_8; 1.81% V_2O_5, 1948-52 is reported from West Reservation Lease, including Plots #1,2,4,6-12. Most production came from Plot #6. After 1952 VCA shipped by plot numbers.

WHITE CAP LEASE (VCA East Reservation Plot 11)

WHITE CONE CLAIM

LOC: Poorly located claim reportedly by the PRR: "From Redrock drive 6 mi. to a turnoff to the west; drive a mile on this road to Baye Creek Canyon. White cone claim is west of the H.B. Roy Claim and is accessible by foot."

ANAL: Below 0.05% U_3O_8

GEOL: Mineralization in fractured calcified log and disseminated in fine-grained sandstone around log, in Recapture member of Morrison Fm.

REF: PRR-EDR-394

WILLY WATERS (Monument #2, Supplement; Bee Sho Shee)

LOC: Approx. Sec. 27 and 34, T41N, R23E

QUAD: Dinnehotso 15'; Shiprock NTMS

DEVL: Pit

PROD: 1,990 tons @ 0.23% U_3O_8; 1.23% V_2O_5 in 1954-55

GEOL: Refer to Monument #2

REF: D.O.E.

WILSON PROSPECT (Agua Sal Drilling Permit)

YALE POINT (Dan Taylor #1)

ZEALY-TSO

LOC: Approx. SE¼ Sec. 6, T5N, R9W
Nazlini Canyon

QUAD: Canyon del Muerto 15'; Shiprock NTMS

DEVL: 2 small cuts; 100 ft. of rim stripping, 72 holes drilled

PROD: None recorded by AEC - 40 tons @ .25% reported in writing by Zealy Tso.

RAD: 0.07% e U_3O_8, on ore stockpile

GEOL: Carnotite, malachite and hematite associated with carbonaceous matter in Shinarump Cg. Zone is 30-50 ft. above Moenkopi contact and is a cross-bedded, sandstone with reddish brown mud pellets.

REF: PRR-EDR-521 (#39)

ZONA #1 (Emma #1)

LOC: Approx. NW¼, Sec. 28, T40N, R30E, East Carrizo Mtns. (AEC Plot location: 36° 50' 20"N, 109° 06' 35"W.)

QUAD: Pastora Peak 15'; Shiprock NTMS

DEVL: 3 adits, over 600 ft. of underground workings.

PROD: 2,116 tons @ 0.19% U_3O_8; 2.91% V_2O_5, 1953-55.

RAD: 2 mr/hr.

ANAL: 9.63% $CaCO_3$, Max. 72.0% V_2O_5

GEOL: Tyuyamunite specks and paint in fine-grained, quartzose, sandstone with carbon matter in lower 50 ft. of Salt Wash member. Sandstone block is resting on an igneous sill, which has deformed and altered the sandstone. Barren mudstones separate one foot thick mineralized sandstone lenses. Ore zone dips 16°N and 33°E. Exceptionally rich zones of vanadium ore.

REF: 1 PRR-EDR-262 (#34)

Finch, W. (1967)
Chenoweth and Malan (1973), p. 147, and p. 5 in road log.

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	Name
D 23	Bisbee
N 16	Conlig-Tungsten Mine
N 22	Deerhead
D 26	Dipsy Doodle
D 19	Eagle
D 18	Elanna
N 11	First Chance
D 17	Fluorine Hill
T 3	Inez Ellen
D 24	Last Chance
N 13	Little David
D 20	Little Mike
D 25	Little Swede Mine
N 12	Lost Apache Girl
N(14)	Neglea
T 9	Overlook
S 7	Rattler
T 1	Robles Spring
N 15	Star
S 6	Sturgess
T 2	Terian Basin
S 8	Typest
S 5	Unnamed A
S 10	Unnamed C
S 8	Uranium Hills
S 4	Valley View
N 21	Walnut Mine
N 14	Windmill

D = Douglas
N = Nogales
S = Silver City
T = Tucson
(14)= near 14, not accurately known

COCHISE COUNTY

BADGER #1-5 CLAIMS (Star Group)

BISBEE

LOC: Sec. 16, T23S, R24E

QUAD: NACO 7½, Bisbee 15'; Douglas NTMS

DEVL: Open pit and more than 2000 linear miles of underground workings. Mined from 1878 to 1975.

PROD: Major for Cu, Pb, Zn, Ag, Au. Uranium may be extracted from acid leach solutions in leach recovery system.

RAD: In Paleozoic replacement veins - 2-5X

GEOL: Very fine grained uraninite and possibly pitchblende in slip planes or as crusts in zones through base-metal sulfide ore bodies, mostly in the Paleozoic limestones. There appears to be secondary enrichment of uranium.

REF: Bain, G. (1952)
Arizona Bureau of Geology file

BLUESTONE CLAIMS (Star Group)

CONLIG-TUNGSTEN MINE

LOC: Sec. 25, T18S, R19E
Whetstone Mtns.

QUAD: McGrew Spring 7½'; Nogales NTMS

DEVL: Trenches

ANAL: 0.009% U_3O_8

GEOL: Torbernite within and adjacent to shear zone in alaskite. Metatorbernite on fractures. Zone strikes N70° W, dips 71° N. Fluorite, scheelite, and wolframite noted.

REF: PRR-F8071-UP-542 (#50)

DEERHEAD CLAIMS

LOC: Sec. 9, 16, T23S, R20E
Ramsey Canyon - Huachuca Mtns.

QUAD: Miller Peak 7½'; Nogales NTMS

DEVL: Prospect pits

RAD: 15X

ANAL: 0.01% e U_3O_8

GEOL: Torbernite in fractures within highly fractured and jointed granite near contact with overlying quartzite of middle Cambrian Bolsa Quartzite.

REF: PRR-A-4 (#55)

DIPSY DOODLE CLAIMS

LOC: Sec. 17, T24S, R29E
Douglas area

QUAD: College Peak 15'; Douglas NTMS

RAD: 2X

GEOL: Radioactivity associated with limonite and hematite in shales and sandstone of the Bisbee Group.

REF: RRR-AP-268 (#80)
Gilluly, J. and others (1956)

DRAKE CLAIMS (Star Group)

D.O.E. files note the Drake Claims by Taylor and Drake. Taylor claimed the Star Group. The Drake Claims may be adjacent to or aliases for the Star Group. The Houston #1-3 claims are common to both Drake and Star Groups.

Black Rock #1
Houston #1-3
Santa Cruz #1-2
Santa Fe #1
Whetstone #1
White Rock #1-2

EAGLE #1 & 2

LOC: E½ Sec. 1, T18S, R25E

QUAD: Pearce and Square Top Hills 15'; Douglas NTMS

DEVL: 8 ft. shaft

RAD: 5X

ANAL: 0.20% U_3O_8

REF: D.O.E.

EAST PEAK #1

LOC: Approx. T18S, R19E
"From Richfield Station in E. Benson, go 2.6 mi. on Tombstone Hwy; turn left for 2.7 mi., take right fork for 1.6 mi. Claim is 400 yds. to W. at base of hill.

QUAD: Benson 15'; Nogales NTMS

DEVL: Pit

RAD: 0.02 Mr/hr.

GEOL: Specularite, zircon, with some radioactivity in weathered porphyritic granite.

REF: PRR-A-26

ELANNA

LOC: SW¼ Sec. 35, T17S, R25E
Sulphur Hills-Pearce

QUAD: Pearce 15'; Douglas NTMS

DEVL: Prospect pits; 20 ft. shaft

RAD: 20X

ANAL: 0.15% e U_3O_8; 0.20% U_3O_8

GEOL: Radioactive gouge in shear zone of low angle fault in silicified limey shale near contact with volcanic agglomerate. Purple fluorite.

REF: PRR-AP-335 (#83)
Scarborough, R. and Wilt, J. (1979)

FIRST CHANCE

LOC: N. center Sec. 9, T18S, R19E
Whetstone Mtns.

QUAD: Mescal 7½; Benson 15'; Nogales NTMS

DEVL: Pit

RAD: 100X

ANAL: 0.16% e U_3O_8

GEOL: Radioactivity associated with fluorite, calcite and iron oxide in shear zone in porphyritic granite. Zone strikes N50E, dips 70°N and separates two granites.

REF: PRR-A-57 (#64)
PRR-A-50 (#74)

FLUORINE HILL PROSPECTS

LOC: Sec. 33, 34, T17S, R25E
Pearce

QUAD: Pearce 15'; Douglas NTMS

DEVL: Prospect pits and shallow shaft

RAD: 3X

ANAL: 0.096% e U_3O_8; 0.11% U_3O_8

GEOL: Possibly uranophane or autunite with fluorite in a carbonate vein cutting iron stained, fractured and silicified rhyolite.

REF: PRR-M-1497 (#85)
Granger, H. and Raup, R. (1962)

GRAND JUNCTION (Little Mike Group)

HOUSTON (Star Group)

INEZ ELLEN CLAIMS

LOC: NE¼ SW¼ Sec. 8, T14S, R21E
Johnny Lyon Hills

QUAD: Dragoon 15'; Tucson NTMS

DEVL: Shaft and drift, drilled in mid-1970's

RAD: 20X

ANAL: 0.26% e U_3O_8

GEOL: Radioactivity in dark red-brown colored shear zones cutting across bedding of Martin and Percha Fms. of Paleozoic age.

REF: PRR-A-113 (#68)
Scarborough, R. and Wilt, J. (1979)

LAST CHANCE

LOC: Sec. 4, T 24S, R 29E
Douglas Area

QUAD: College Peaks 15'; Douglas NTMS

DEVL: Drift and prospect pits

RAD: 10X

ANAL: 0.02% e U_3O_8

GEOL: Uranophane along fracture planes in altered rhyolite.

REF: PRR-AP-269 (#81)

LITTLE DAVID CLAIMS

LOC: Sec. 10, T18S, R19E
Benson Area

QUAD: Mescal 7½'; Benson 15'; Nogales NTMS

RAD: 20X

ANAL: 0.052% e U_3O_8

GEOL: Probably torbernite with some malachite and limonite in fractures associated with a quartz vein in granite.

REF: PRR-AP-267 (#79)

LITTLE MIKE GROUP (Salty Dog; Silver Drift, Grand Junction, Yellow Jacket)

LOC: Sec. 22, 23, T20S, R27E

QUAD: Swisshelm Mtn. 15'; Douglas NTMS

DEVL: Prospect pit and location shaft

RAD: 20X

ANAL: 0.62% U_3O_8

GEOL: Euxenite, mica, hematite and beryl associated with alaskite dikes in quartz monzonite.

REF: PRR-A-3 (#54)

LITTLE SWEDE MINE

LOC: Sec. 9, T24S, R29E
Douglas Area

QUAD: College Peaks 15'; Douglas NTMS

DEVL: Prospect shaft

RAD: 4X

ANAL: 0.003% e U_3O_8; 0.011% U_3O_8, thorium

GEOL: Mineralized faults in rhyolite porphyry
Quartz, iron and manganese oxides.

REF: PRR-AP-5

LOST APACHE GIRL

LOC: Approx. Secs. 9, 10, T18S, R19E

QUAD: Mescal 7½; Benson 15'; Nogales NTMS

DEVL: Pits

RAD: 30X

ANAL: 0.13% e U_3O_8

GEOL: Uranophane with vanadium minerals, wulfenite, fluorite and iron oxides in veins, trending S25°W and S83°W, in granite.

REF: PRR-A-24 (#58)
PRR-A-27 (#61)

LUCKY SEVEN #1

LOC: Approx. T18S, R19E
"From Shell Station West Benson go west on Hwy. for 2.3 mi.; turn left on Whetstone Road, and proceed 0.7 mi., take right branch-rough road for 8.1 mi. — claim on right side of road.

QUAD: Benson 15'; Nogales NTMS

DEVL: 60 ft. shaft and pit

RAD: 120X

GEOL: 4 to 5 ft. vein, trending N25°W (Vertical dip) in porphyritic granite. Fluorite, galena, pyrite and wulfenite.

REF: PRR-A-23 (#57)

MARK PROSPECT (Robles Spring)

NEGLEA CLAIMS

LOC: Somewhere in T18S, R19E, near others of northern claim block.

QUAD: Benson 15'; Nogales NTMS

RAD: 2X

ANAL: 0.02% e U_3O_8

GEOL: 8 to 10 ft. wide, very altered basic dike, striking N60°W, in granite.

REF: PRR-A-2

NOLA (Star Group)

OVERLOOK CLAIM

LOC: Sec. 35, T15S, R22E
Little Dragoon Mtns.

QUAD: Dragoon 15'; Tucson NTMS

DEVL: Prospect pit

RAD: 2X

GEOL: Schist

REF: PRR-AP-288 (#82)

RATTLER GROUP

LOC: Sec. 31, T14S, R28E

QUAD: Dos Cabezas 15', Silver City NTMS

RAD: 10X

GEOL: Radioactivity along shear zones in porphyritic granite. Some aplite dikes and limonite staining.

REF: PRR-A-53 (#63)

REDFIELD CLAIMS (Robles Spring)

ROBLES SPRING CLAIMS (Mark Prospect, Redfield)

LOC: SW¼, Sec. 30, T13S, R19E

QUAD: Redington 15'; Tucson NTMS

DEVL: 10 ft. adit, 25 X 20 X 15 ft. deep pit, drilling

RAD: 50X

ANAL: 0.078% e U_3O_8; 0.004% U_3O_8

GEOL: Uraninite is in gouge and wall rock along a nearly vertical NW trending fault (north of adit) which has placed limestone in contact with schist. Greatest radioactivity is in two fault blocks of carbonaceous, fractured and iron-stained shale. Microscopic blebs of pitchblende noted. Complexly faulted terrain interpreted as Pinal Schist thrusted over Cretaceous Bisbee Group clastic sedimenta, with thrust dipping NE.

REF: PRR no # (#629)
PRR-A-50 (#62)
Granger, H. and Raup, R. (1962)
Thorman, C. and others (1978)

SALTY DOG (Little Mike Group)

SILVER DRIFT (Little Mike Group)

SKYLINE (Star Group)

SOUTH CHANCE CLAIMS (Refer to Pima Co. listing)

STAR GROUP (Badger #1-5; Bluestone; Drake Group; Houston; Nola; Skyline; Wichita #1-2)

LOC: Sec. 25, 26, T18S, R19E
Star #1 produced in center NE¼ NE¼ Sec. 26.

QUAD: McGrew Spring 7½'; Benson 15'; Nogales NTMS

DEVL: 160 ft. 25^{o} incline; inclined pit

PROD: 46.7 tons @ 0.19% U_3O_8, 1.0% $CaCO_3$. 1958-60.

RAD: 15X

ANAL: 0.14-0.22% e U_3O_8

GEOL: Uraninite or pitchblende occurs along contact between basic dike and granite. Possibly some autunite, kasolite, and tyuyamunite. Probably ground water control of secondary mineralization at shallow depths.

REF: PRR-A-25
Butler, A. & Byers, V. (1969)
D.O.E.

STURGESS PROPERTY

LOC: Sec. 7, T14S, R27E
Dos Cabezas Mtns.

QUAD: Bowie 15'; Silver City, NTMS

RAD: 3X

ANAL: 0.12% e U_3O_8

GEOL: Possibly uraninite with galena and pyrite in quartz veins and fracture fillings along a fault zone in schist and metasediments.

REF: PRR w/o # (#51); Waechter, N. (1979)

SWISSHELM VALLEY

LOC: S½, T20S, R28E
Chiricahua Mtns.

QUAD: Swisshelm Mtns. and Pedregosa Mtns. 15'; Douglas NTMS

RAD: 2X

GEOL: Radioactivity disseminated in friable white altered pumaceous devitrified tuffs and tuffaceous sediments. Faulting complicates stratigraphy.

REF: Scarborough, R. and Wilt, J. (1979)

TERAN BASIN

LOC: SW¼ Sec. 22, NW¼ Sec. 26, T13S, R20E
Southern Galiuro Mtns.

QUAD: Redington 15'; Tucson NTMS

RAD: 3X

GEOL: Radioactivity in mottled, gypsiferous mudstones high in basal half of Teran Basin Sequence. Sedimentary section of conglomerates, sandstones, mudstones and limestones dips steeply eastward and is overlain unconformably by Oligocene Galiuro volcanics.

REF: Scarborough, R. and Wilt, J. (1979)

TYPEST GROUP

LOC: Sec. 32, T14S, R28E
SW Dos Cabezas Mtns.

QUAD: Dos Cabezas 15'; Silver City, NTMS

RAD: 8X

ANAL: 0.01% e U_3O_8

GEOL: Muscovite and dark minerals concentrated along N-S shear zones in porphyritic granite.

REF: PRR-A-58 (#65)

UNNAMED A

LOC: Sec. 7, T14S, R27E
Dos Cabezas - Mineral Park Area

QUAD: Dos Cabezos 15'; Silver City NTMS

DEVL: Extensive Underground workings

RAD: 3X

GEOL: Possibly uraninite with copper carbonates and sulfides is associated with quartz veins in schist along a fault zone striking $N80^{o}W$ and dipping $85^{o}NW$. Some gold reported.

REF: PRR-AP-74 (#76)

UNNAMED B

LOC: Poorly located - "8 mi. west of Bowie"

QUAD: Silver City NTMS

ANAL: 0.24% e U_3O_8; 0.198% U_3O_8

REF: D.O.E.

UNNAMED C

LOC: SW¼ Sec. 11, T16E, R30E, along west wall of tributary canyon to Keating Creek.

QUAD: Cochise Head and Vanar 15' quads; Silver City NTMS

RAD: Faraway Ranch Fm. latites -200-250 cps, sediments-80-150 cps.

ANAL: 16 ppm Uranium in brn ls, 0.09% organic carbon.

GEOL: Fluvio-lacustrine sequence (laminar-bedded dark-colored shales, fetid cherty brown limestones) is 30-150 ft. thick, but does not count above adjacent silicic flows and tuffs of Faraway Ranch Fm., of which they are members.

REF: Sabins (1957), page 1326; and ABC file data
N.U.R.E. analysis data

URANIUM HILLS CLAIMS

LOC: Sec. 32, T14S, R28E
SW. Dos Cabezas Mtns.

QUAD: Dos Cabezas 15'; Silver City NTMS

DEVL: 3 small open pits; 4 drill holes

RAD: 5X

ANAL: 0.53-1.27% e U_3O_8; 0.32-1.09% U_3O_8

GEOL: Uranium mineralization and gangue epidote, chlorite, magnetite and fluorite blebs are concentrated in a E-W trending shear zone in a Laramide granite. Nearby to the north, the granite is in high angle fault contact with Cretaceous quartzite. One drill hole encountered shear zone material, assaying @ 0.4% U_3O_8, at depth, which indicates the shear zone is vertical. Granite also contains unmineralized NE Trending 50°NW dipping rhyolite dike and massive faulted aplite mass to the east.

REF: PRR-A-59 (#66
Bissett, D. (1958)

VALLEY VIEW CLAIMS

LOC: SE¼ Sec. 22, T13S, R26E
Dos Cabezas Mtns.

QUAD: Luzena 7½; Silver City NTMS

DEVL: Pits

ANAL: 0.04-0.19% U_3O_8

GEOL: Mineralization (some Fe, Cu, Pb sulfides) is in a dense dark gray rock surrounded by granite. Perhaps mineralized xenolith of limestone.

REF: PRR w/o # (#49)

WALNUT MINE

LOC: Sec. 17, T23S, R20E
Ramsey Canyon - Huachuca Mtns.

QUAD: Miller Peak 7½'; Nogales NTMS

PROD: Old lead - scheelite property

RAD: 12X

ANAL: 0.03% e U_3O_8

GEOL: Uraninite with copper and iron sulfides in irregular, small lenses and quartz veins along fault (N45° E, vertical dip) and fractures (N-S, 75° E dip). Lead and tungsten minerals.

REF: PRR-A-95 (#67)

WICHITA #1-2 (Star Group)

WINDMILL GROUP

LOC: Center E½ Sec. 10, T18S, R19E
Whetstone Mtns.

QUAD: Mescal 7½'; Nogales NTMS

DEVL: Several trenches, drill holes, 107 ft. incline with drifting

PROD: 15 tons @ 0.13% U_3O_8 in 1956

RAD: 60X

ANAL: 0.06-0.46% e U_3O_8; 0.07-0.55% U_3O_8

GEOL: Uranophane, autunite, uraninite, and pitchblende in limonitic fault gouge filling a series of shear zones (N70° W, dip 55°NE) in granite. Zones up to 5 ft. wide.

REF: PRR-A-1 (#52)
Arizona Bureau of Geology file

YELLOW JACKET (Little Mike Group)

Index for Coconino County Uranium Occurrences

(Excludes Cameron District Map)

G = Grand Canyon
F = Flagstaff sheet
M = Marble Canyon
W = Williams

COCONINO COUNTY

A. MALONEY (Adolf Maloney #2)

A & B #2

LOC: Central Sec. 5, T. 28N, R9E

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: Shallow open cut, 50 X 50 X 5 ft. deep

PROD: 123 tons @ 0.28%, U_3O_8, 0.13% V_2O_5, 1954

RAD: 5X

GEOL: Ore associated with fossil wood fragments in iron-stained sandstone lens in upper Shinarump member.

REF: PRR-EDR-147

A & B #3

LOC: S½, Sec. 21, T29N, R9E

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: 100 X 50 X 40 ft. deep rim cut and small surface scrapings

PROD: 586 tons @ 0.13% U_3O_8, 0.04% V_2O_5, 1954-55

RAD: 40X

ANAL: 0.03-0.18% e U_3O_8; 0.01-0.08 U_3O_8

GEOL: Mineralization in small pods within iron-stained sandstone lenses, 2-10 ft. thick, in upper Shinarump member, Radioactivity associated with fossil logs.

REF: PRR-EDR-1144

A & B #5

LOC: Sec. 3, T. 31N, R. 9E and Sec. 34, T32 N, R9E

QUAD: Moenave SW 7½; Marble Canyon NTMS

DEVL: 150 X 200 X 3 ft. deep pit

PROD: 305 tons @ 0.13% U_3O_8, 0.04% V_2O_5, 1954

RAD: Air anomaly

ANAL: 0.014% e U_3O_8; 0.08% U_3O_8; 2.80% $CaCO_3$

GEOL: Oxidized ore in Shinarump member

REF: PRR-EDR-1145

A & B #7 (Shadow Mountain Collapse)

LOC: SE¼ Sec. 20, T31N, R9E

QUAD: Moenave SW 7½, Marble Canyon NTMS

DEVL: Shallow surface pits and some rim stripping

PROD: 24 tons @ 0.08% U_3O_8; 0.28% V_2O_5, 1954

GEOL: Mineralization is in sandstone containing fossil wood in upper Shinarump Conglomerate.

REF: Chenoweth, pers. com. 1980
Bollin, E. and Kerr, P. (1958)
Kerr, P. (1958); U.S.A.E.C. (1959)

A & B #13

LOC: NW¼ Sec. 14, T31N, R9E

QUAD: Moenave SW 7½"; Marble Canyon NTMS

DEVL: One small open pit

PROD: 51 tons @ 0.09% U_3O_8; 0.09% V_2O_5, 1954

GEOL: Ore in Shinarump member

REF: D.O.E.

A & B #21 (Paul Huskie #21)

ADA AND NORDELL (Nordell)

LOC: SW¼, Sec. 6, T27N, R10E

QUAD: Wupatki NE 7½; Flagstaff NTMS

DEVL: Test pits and trenches

GEOL: Spotty oxidized uranium ore in sandstone lenses in upper Shinarump conglomerate.

REF: D.O.E.

ADOLF MALONEY #2 (Maloney, Adolf Maloney, adjacent to Amos Chee #1-3 claims)

LOC: Sec. 23 and 24, T 25N, R11E

QUAD: Standing Rocks 7½'; Flagstaff NTMS

DEVL: 75 ft. rim stripping and small open cut

PROD: 24 ton @ 0.07% U_3O_8; 0.20% V_2O_5, 1957

GEOL: Secondary minerals in sand lenses in lower Petrified Forest Member

REF: D.O.E.

AIRPORT MINE

LOC: Approx. Sec. 25 and 36, T 30N, R2E
"Mine is 200 yds. east of Grand Canyon Airport and 28 miles north of Williams."

QUAD: Williams NTMS

PROD: 500 tons of copper ore during World War II

ANAL: 0.02 - 0.07% U_3O_8

GEOL: Mineralized zone (1.5 ft. with radioactivity is in thin sandstone and mudstone of Kaibab Fm. Perhaps related to southern extension of Bright Angel fault zone.

REF: PRR-CEBR-41

ALYCE TOLINO #1 & 3

LOC: SE¼, Sec. 24, T29N, R9E

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: 2 open pits, 40 ft. deep 2 shafts 40 ft. deep replaced by 2 open pits.

PROD: 1811 tons @ 0.23% U_3O_8; 0.07% V_2O_5, 1957-60

GEOL: Autunite in north trending paleochannel in lower part of Petrified Forest member. Cobalt-rich pyrite, umohoite, and ilsemannite coatings identified.

REF: U.S.A.E.C. (1959, RME-141)
Bollin, E. and Kerr, P. (1958)

AMOS CHEE #1-3 (Bosley Claims)

LOC: Sec. 24, T25N, R11E
"4½ miles east of Black Falls T.P. on north side of L. Colo. R."

QUAD: Standing Rocks 7½'; Flagstaff NTMS

DEVL: 150 yds. of rim stripping and shallow pits

PROD: 157 tons @ 0.18% U_3O_8; 0.90% V_2O_5, 1954-57

ANAL: 0.04-0.16% e U_3O_8; 0.06-0.25% U_3O_8; 0.2-1.2% V_2O_5; 1.8-2.6% $CaCO_3$

GEOL: Secondary uranium minerals filling fractures associated with abundant carbon matter and fossil logs in Chinle Fm. Abundant gypsum and probable cobalt minerals.

REF: PRR-EDR-282
PRR-AP-42

AMOS CHEE #8

LOC: NE¼, Sec. 34, T27N, R10E

QUAD: Wupatki NE 7½'; Flagstaff NTMS

DEVL: Shallow open pit and surface scrapings

PROD: 101 tons @ 0.19% U_3O_8; 0.04% V_2O_5, 1955-58

GEOL: Ore in Petrified Forest member

REF: D.O.E.

ANITA COPPER MINE

LOC: Approx. Sec. 29, T29N, R2E
poorly located "near Anita, south of Grand Canyon Village."

QUAD: Williams NTMS

DEVL: Open cuts, short drifts, underground to depth of 25 ft.

PROD: Copper ore

RAD: 8X

ANAL: 0.002-0.006% e U_3O_8; 0.002-0.004% U_3O_8

GEOL: Copper carbonates disseminated in sandstone and limestone and concentrated along joints in Kaibab limestone. NW trenching vertical fault is similarly mineralized. Limonite pseudomorphs after pyrite. Seemingly unmineralized wall rock in drifts and stopes count 4-5 X Bkg.

REF: PRR-RG-34
Gibson, R. (1952) RMO-890

ARIZONA CLAIM (White Mesa Copper)

B & B #1 and 2

LOC: Sec. 1, T40N, R7E
"Up Paria Creek, 10 mi. from Marble Canyon lodge"

QUAD: Lees Ferry 15'; Marble Canyon NTMS

DEVL: Prospect pits

RAD: 40X

GEOL: Mineralization in sandstone and clays with scattered carbaceous matter and some petrified wood in Chinle Fm. Some copper minerals noted.

REF: PRR-RR-184

BAKER PROPERTY (Riley Baker Property)

Mill receipts record 1 ton @ 0.26%, U_3O_8; 0.17% V_2O_5 in 1950. In Marble Canyon area, exact locality unknown; may be same area as Cliff Canyon.

BARRANCA DE COLRE

LOC: T27, 28N, R2E, 38 miles north of Williams, near Willaha

QUAD: Grand Canyon NTMS

DEVL: 25 prospect pits

PROD: Some copper ore shipped to Jerome Circa 1910.

RAD: 0.25-0.30% e U_3O_8

GEOL: Pyrrhotite, chalcocite, copper oxides and uranium minerals associated with a hydrothermally altered zone, 3 ft. thick, and a low assymetrical anticline in Kaibab limestone.

REF: D.O.E.

BASS MINE

LOC: Poorly located, reportedly along Bass Trail and near Bass Rapids on North Rim of Grand Canyon

QUAD: Havasupai Point 15'; Grand Canyon NTMS

RAD: 0.12 MR/hr

GEOL: Oxide and sulfide copper minerals believed to be in upper Chuar meta-sediments. Park specimen on display showed radioactivity of 10X.

REF: Breed and Roat (1974), pg. 174

BEFUDDLED CLAIMS

LOC: Sec. 27, 28, 32, 33, T39N, R4E
Vermillion Cliffs

QUAD: Emmett Wash NE 7½'; Marble Canyon NTMS

DEVL: 17 holes drilled

RAD: 10X

GEOL: Sandstone with thin bands of yellow jasper with noted radioactivity in the Petrified Forest member. Minor copper carbonates and pyrite.

REF: PRR-RR-274 and suppl.

BIG BLUE

LOC: Sec. 2, T39N, R6E
Vermillion Cliffs- one mile North of Cliff Dwellers Lodge

QUAD: Lees Ferry 15': Marble Canyon NTMS

DEVL: Small dozer cuts

PROD: 38 tons @ 0.28%, 1954

ANAL: 1.1% e U_3O_8; 1.3% U_3O_8; 0.01% V_2O_5; 0.22% Cu

GEOL: Shaley member of Chinle Fm. contains uranium oxides in sandy lenses.

REF: PRR-RR-162 (1954)

BLACK PEAK BRECCIA PIPE

LOC: Sec. 2, T33N, R9E

QUAD: Moenave NW7½; Marble Canyon NTMS

DEVL: 6 drill holes

GEOL: Anomalous radioactivity is associated with iron-stained and silicified breccia pipe and nearby N-S trending shear zone on silicified knob of Navajo Sandstone.

REF: Barrington, J. & Kerr, P. (1961)
McBirney, A. (1963)

BLACK POINT (Murphy Mine)

BLACKHAIR #4

LOC: Approx. common corner Sec. 9, 10, T28, R9E

QUAD: Cameron 15'; Flagstaff NTMS

RAD: 40X

ANAL: 0.02-0.20% e U_3O_8; 0.02-0.19% U_3O_8

GEOL: Chinle shale on top of Shinarump member contains radioactive black carboniferous material, with possibly metatorbernite.

REF: PRR-AP-231

BLUE BONNET

LOC: Sec. 7 T28N, R2E, poorly located

QUAD: Williams NTMS

DEVL: 12 shallow pits

RAD: 2X

GEOL: Kaibab Limestone contains mineralization near crests of undulating beds. Copper oxides, iron oxides and pyrite present.

REF: PRR-AP-40

BOSLEY CLAIMS (Amos Chee#1-3)

BOSLEY #4 (Box Springs #2)

BOX SPRINGS #2 (Bosley #4, Colorado #1)

LOC: Probably Sec. 10, T25N, R11E, poorly located
Black Falls

QUAD: Standing Rocks 7½'; Flagstaff NTMS

RAD: 20X

ANAL: 0.08-0.41% U_3O_8

GEOL: Mineralization in silty sandstone of lower Chinle, containing silicified logs and carbonaceous matter. Yellow orange color observed in radioactive zone might be due to autunite and/or meta-autunite.

REF: PRR-AP-42

BOYD TISI #1

LOC: East central Sec. 31, T28N, R10E

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: Several shallow surface pits and scrapings

PROD: 37 tons @ 0.13% U_3O_8; 0.09% V_2O_5, 1957

GEOL: Uraniferous silty lenses in basal Petrified Forest member.

REF: D.O.E.

BOYD TISI #2 (Adjacent to Juan Horse #3)

LOC: SW¼ Sec. 30, T29N, R10E

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: 150 X 50 X 45 ft. deep pit

PROD: 794 tons @ 0.30% U_3O_8; 0.04% V_2O_5, 1957-58

GEOL: Ore is fine-grained sandstone of Petrified Forest member.

REF: U.S.A.E.C. (1959, RME-141)

C.O. BAR LIVESTOCK COMPANY (Section 9)

CALVIN CHEE

LOC: Approx. NW¼, T22N, R13E, poorly located

QUAD: Leupp 15'; Flagstaff NTMS

GEOL: Mineralization, possibly some schroeckingerite, in sandstone lens containing abundant carbonized plant remains, probably Petrified Forest member.

REF: PRR-EDR-255
Finch, W. (1967)

CASEY #3

LOC: Approx. north central Sec. 3, T29N, R9E

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: Open pits and cuts

PROD: 17 tons @0.12% U_3O_8; 0.04% V_2O_5, 1957

GEOL: Secondary minerals in scattered pods and along bedding planes in Shinarump member.

REF: D.O.E.

CHARLES HUSKON #1 (Huskon #1)

LOC: SE Sec. 23, T29N, R9E

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: Open pit

PROD: 23,127 tons @ 0.22% U_3O_8; 0.11% V_2O_5, 1951-61

RAD: 150X

ANAL: 0.002-0.462% e U_3O_8; 0.04-0.53% U_3O_8

GEOL: Somewhat irregular lens-like uniformly mineralized zone, 310 ft. X 200 ft., filling lower part of SW trending Scour Channel in lower Petrified Forest member. Some fracture control of mineralization at angle to channel direction. Meta-autunite occurs in sandy facies containing carbonized fossil plant matter and is highest grade at base of scour channel where bottomed in blue to red mudstone. Carnotite, limonite, halotrichite are noted and considerable Cu, Ba and Sr in ore.

REF: PRR-RA-17 and suppl.
U.S.A.E.C. (1959) RME-141
Bollin, E. and Kerr, P. (1958)
Isachsen, Y. and Evenson, C. (1956)

CHARLES HUSKON #3 (Huskon #3)

LOC: West central Sec. 7, T28N, R10E, and E. central Sec. 12, T28N, R9E

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: Open pit

PROD: 27,249 tons @ 0.20% U_3O_8; 0.02% V_2O_5, 1953-61

GEOL: Carnotite and possibly autunite uniformly distributed in narrow, lens-like bodies in lower part of scour and fill channel, trending NE to E and in lower Petrified Forest member and into Shinarump mbr. Ore zone is 100 ft. wide and over 1,000 ft. long and associated with abundant carbonaceous matter. Some minor faulting through ore body.

REF: U.S.A.E.C. (1959, RME-141)
Bollin, E. and Kerry, P. (1958)
Isachsen, Y. and Evensen, C. (1956)

CHARLES HUSKON #4 (Paul Huskie #3)

LOC: Approx. south central Sec. 11, T26N, R10E

QUAD: Wupatki NE 7½'; Flagstaff NTMS

DEVL: 35 ft. deep open pits, 1000 X 550 ft. in size

PROD: 37,746 tons @ 0.18% U_3O_8; 0.02% V_2O_5. The Charles Huskon #4 pit extends onto the Paul Huskie #3 claim. Charles Huskon production includes 3,925 tons @ 0.20% U_3O_8 from Paul Huskie #3. mined 1953-60.

GEOL: Irregular lenses and pods of oxidized minerals in scour and fill sediments in channels generally trending N to NE. Abundant carbonized logs and plant remains associated with ore in sandstone-mudstone of lower Petrified Forest member.

REF: U.S.A.E.C. (1959, RME-141)
Bollin, E. and Kerr, P. (1958)

CHARLES HUSKON #5

LOC: Approx. SE Sec. 36, T31N, R9E

QUAD: Moenave SE 7½; Marble Canyon NTMS

DEVL: Open pits

PROD: 321 tons @ 0.26% U_3O_8; 0.17% V_2O_5, 1953 & 1956

RAD: 150X

GEOL: Uraninite and secondary uranium minerals associated with petrified logs and as halos around logs in sandstone - mudstone channel of Petrified Forest member. Some malachite. Some fracturing of beds.

REF: PRR-RA-16
Bollin, E. and Kerr, P. (1958)
U.S.A.E.C. (1959, RME-141)

CHARLES HUSKON #6

LOC: NE¼ Sec. 27, T30N, R9E

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: Open pits

PROD: 747 tons @ 0.20% U_3O_8; 0.02% V_2O_5, in 1953, 56-61

GEOL: Semi-circular body of carnotite in platy, carbonaceous, argillaceous, silicified channel sandstone-mudstone in Shinarump Cong.

REF: Bollin, E. and Kerr, P. (1958)

CHARLES HUSKON #7 MP. #65 (Huskon #7)

LOC: NE ¼, Sec. 19, T28N, R10E

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: Open pit

PROD: 2501 tons @ 0.31% U_3O_8; 0.06 V_2O_5, in 1953, 1956-58

ANAL: 0.30% e U_3O_8; 0.20% U_3O_8; 1.8% $CaCO_3$

GEOL: Uraninite replaces cell walls of petrified wood in a carbonaceous, argillaceous sandstone lens in basal Petrified Forest member. Bulk ore was in a single pod with abundant carbonized plant matter. Uranospinite, uraniferous asphaltite, metatorbernite and possibly sabugalite are identified.

REF: U.S.A.E.C. (1959, RME-141)
Bollin, E. and Kerr, P. (1958)
Isachsen, Y. and Evenson C. (1956)
Austin, S. (1964, RME-99)

CHARLES HUSKON #7 MP. #357

LOC: Approx. Sec. 3, T31N, R9E

QUAD: Moenave SW 7½; Marble Canyon NTMS

DEVL: Shallow surface workings

PROD: 20 tons stockpiled

ANAL: 0.30% e U_3O_8; 0.20% U_3O_8; 1.8% $CaCO_3$

GEOL: Secondary minerals associated with fossil plent remains in Shinarump Conglomerate.

REF: D.O.E.

CHARLES HUSKON #8 (Huskon #8)

LOC: South central Sec. 30 and north central Sec. 31, T28N, R10E.

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: Trenches and pits

PROD: 626 tons @ 0.23% U_3O_8; 0.04% V_2O_5, 1953, 56, 57, 59, 60.

GEOL: Secondary minerals in petrified logs and as halos in surrounding sandstone and siltstone of basal Petrified Forest member.

REF: D.O.E.

CHARLES HUSKON #9

LOC: Approx. south center Sec. 35, T27N, R10E

QUAD: Wupatki NE 7½; Flagstaff NTMS

DEVL: Open pit

PROD: 618 tons @ 0.18% U_3O_8; 0.01% V_2O_5, 1954-58

GEOL: Secondary minerals in basal Petrified Forest member

REF: D.O.E.

CHARLES HUSKON #10 (Huskon #10)

LOC: N½, Sec. 29, T28N, R10E

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: 20 ft. deep open pit

PROD: 17,083 tons @ 0.22% U_3O_8; 0.06% V_2O_5, 1953-61
High molybdenum content hampered ore processing

GEOL: Uraninite in carbonaceous sandstone lenses in a irregularly mineralized body 1,450 ft. by about 100 ft. wide. Mineralization is controlled by concentrations of carbonized plant remains and the permeability of the sour and fill sediments in the SW-NE trending channel cut into Petrified Forest member and down into Shinarump member. Minerals noted include carnotite, schroeckingerite, coffinite, zippeite, ilsemannite stains on halotrichite; high contents of cobalt and molybedenum near ore. Carnotite associated schroeckingerite in buff-pinkish carbonaceous sandstone. Metatorbernite, meta-autinite, uranophane, sabugalite, becquerelite, torbernite, also noted.

REF: U.S.A.E.C. (1959, RME-141)
Bollin, E. and Kerr, P. (1958)
Isachsen, Y and Evensen, C. (1956)
Austin, S. (1954, RME-99)

CHARLES HUSKON #11 (Huskon #11)

LOC: SE edge Sec. 33, T28N, R10E

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: 15 ft. deep pit

PROD: 2,747 tons @0.12% U_3O_8; 1957-1961. High molybdenum content hampered ore processing.

GEOL: Carnotite-type rich lens, 500 X 100 ft. in arkosic sandstone in NE trending channel cut in upper Shinarump member. Abundant plant remains. Some metatorbernite, meta-autunite, uraninite, coffinite, ilsemannite, jordisite, and marcasite also present.

REF: U.S.A.E.C. (1959, RME-141)
Bollin, E. and Kerr, P. (1958)

CHARLES HUSKON #12 (Huskon #12)

LOC: Approx. Central Sec. 15, T29N, R9E

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: 10 ft. deep open pit

PROD: 1,780 tons @ 0.18% U_3O_8; 0.02% V_2O_5, 1954-61

ANAL: 0.21-0.98% e U_3O_8; 0.14-0.55% U_3O_8; 0.2-4.5% $CaCO_3$

GEOL: Small elongated lenses of carnotite-type in carbonaceous, argillaceous sandstone in channels cut into upper Shinarump member.

REF: U.S.A.E.C. (1959, RME-141)
Bollin, E. and Kerr, P. (1958)

CHARLES HUSKON #14 (Huskon #14)

LOC: Approx. SW¼, Sec. 36, T29N, R9E

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: Open pit, rim and dozer cuts

PROD: 47 tons @ 0.11% U_3O_8; 0.02% V_2O_5, 1956

GEOL: Secondary minerals in petrified logs in upper Shinarump member.

REF: D.O.E.

CHARLES HUSKON #17 (Huskon #17)

LOC: Approx. West central Sec. 14, T27N, R10E

QUAD: Wupatki NE 7½'; Flagstaff NTMS

DEVL: 50 ft. deep pit with adits in pit walls

PROD: 4,869 tons @ 0.21% U_3O_8; 0.01% V_2O_5, 1954-62

GEOL: Uraninite in carbonaceous sandstone-mudstone, filling N. trending paleo-channel in lower Petrified Forest member. Buff clay is illite and gray clay is montmorillontic. Boltwoodite replaces detrial grains and cobalt rich minerals noted.

REF: U.S.A.E.C. (1959, RME-141)
Bollin, E. and Kerr, P. (1958)
Austin, S. (1964, RME-99)

CHARLES HUSKON #18

LOC: Approx. SW¼, Sec. 12, T26N, R10E

QUAD: Wupatki NE 7½'; Flagstaff NTMS

DEVEL: Open pit 100 ft. X 100 ft. X 15 ft. deep, adjacent to Harry Walker #16 pit.

PROD: 563 tons @ 0.16% U_3O_8; 0.02% V_2O_5, 1956-58

GEOL: Carnotite-type and uraninite (deep ore) in carbonaceous channel-type sandstone in basal Petrified Forest member.

REF: D.O.E.

CHARLES HUSKON #19

LOC: Approx. central Sec. 11, T29N, R9E
Just N. of Jack Daniels

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: Open pit

PROD: 696 tons @ 0.14% U_3O_8; 0.03% V_2O_5, 1957

GEOL: Uraninite in sandstone of lower Petrified Forest member.

CHARLES HUSKON #20

LOC: Approx. West central Sec. 9, T29N, R10E

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: Pit

PROD: 1,038 tons @ 0.24% U_38_8; 0.06% V_2O_5, 1957

GEOL: Secondary minerals associated with petrified logs in upper Petrified Forest member. Zippeite, schroeckingerite, and atacamite identified.

REF: Austin, S. (1964, RME-99)
D.O.E.

CHARLES HUSKON #26 (Huskon #26)

LOC: SE¼, Sec. 33, T28N, R10E

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: Small rim cut; this is NE. extension of Chas. Huskon No. 11 ore body.

PROD: 18 tons @ 0.12% U_3O_8; 0.03% V_2O_5, 1957

GEOL: Shinarump member

REF: D.O.E.

CLIFF CANYON (Baker Property; Maggie Baker)

LOC: Poorly located - Marble Canyon Area

PROD: 32 tons @ 0.25% U_3O_8; 0.08% V_2O_5, 1949

GEOL: Ore associated with petrified wood in Chinle Fm.

REF: D.O.E.

CLOVER LEAF #1 MINE

LOC: Sec. 21, T25N, R6E

QUAD: Ebert Mtn. 15'; Flagstaff NTMS

RAD: 2X

GEOL: Radioactivity in basal Moenkopi sandstone and conglomerate, capped by basalt. Silicified and carbonized wood material, jarosite, and limonite present.

REF: PRR-AP-111

COLORADO #1 (Box Springs #2)

COPPER #1 (Doty Group, Willaha Group)

LOC: NW¼ SE¼ Sec. 35, T28N, R1E Willaha Gp in Sec. 26

QUAD: Williams NTMS

DEVL: 50 X 3 X 3 ft. deep pit, old copper workings. From Copper #1 or Willaha Group or both.

PROD: 29 tons @ 0.10% U_3O_8; 0.02% V_2O_5; 9.4% $CaCO_3$, 1956. Illegally shipped from pit on Copper #1 under name of Doty Group.

RAD: 10X

ANAL: 0.42% e U_3O_8; 0.48% U_3O_8

GEOL: Radioactivity concentrated in two foot thick zone in and below copper mineralization in bedded, sandy Kaibab Limestone, with chert nodules along bedding planes. Halos of azurite and malachite surround chalcocite.

REF: PRR-AP-41
Puttuck, H. (1954, RME-2018
Nielson, M. (1953, RME-31)

COPPER KING #1

LOC: Sec. 1, T39N, R6E

QUAD: Lees Ferry 15'; Marble Canyon NTMS

DEVL: Prospect pits

RAD: 25X

GEOL: Radioactivity in sandy bed in the fire clay unit Chinle Fm. Contains numerous stringers of carbonaceous matter.

REF: PRR-RR-214

COPPER MINE TRADING POST AREA

LOC: Poorly located. Trading Post location is 36° 37' 30"N, 111° 26' 50"W, or approx. T38N, R9-10E. "About 27 miles north of the Gap (Hwy. 89) on dirt road."

QUAD: Marble Canyon NTMS

DEVL: Numerous open pits, short adits and drilling holes.

RAD: 15X along fissures associated with copper minerals

GEOL: Copper mineralization (malachite, chrysocolla, calcocite, cuprite, covellite and bornite) filling fault and joint fractures and some along bedding planes in Navajo Sandstone. Fault zone trends NNW with west side down and major joint set trends NE. Sparce metatorbernite with barite.

REF: Gibson, R. (195, RMO-890)

COTTONWOOD # 1 and 2

LOC: Sec. 28, T39N, R6E

QUAD: Paria Plateau and Emmett Wash 15'; Marble Canyon NTMS

DEVL: 2 prospect pits along rim

RAD: 50X

ANAL: 2 samples @ 0.06-0.15% e U_3O_8; 0.07-0.15% U_3O_8; 0.01% V_2O_5; 0.01-0.05% Cu.

GEOL: Possibly carnotite and abundant iron oxides along contact between Moenkopi and Shinarump member.

REF: PRR-RR-160

DENETSO #1 (Jack Daniels #5)

DIAMOND URANIUM CLAIMS (Lemuel Littleman, #1-3, 6-7)

DOTY GROUP (Copper #1 and Willaha Group)

E. LEE #1 (Emmett Lee #1)

E. LEE #3 (Emmett Lee #3)

EARL HUSKON #1-2

LOC: SW¼ Sec., T32N, R9E

QUAD: Moenave SW 7½'; Marble Canyon NTMS

DEVL: Shallow open pits

PROD: 370 tons @ 0.19% U_3O_8; 0.42% V_2O_5; 8% $CaCO_3$, 1954

RAD: 30X

ANAL: 0.22% e U_3O_8; 0.26% U_3O_8; 1.35% V_2O_5

GEOL: Discontinuous carnotite-type mineralization in slabby sandstone in upper Shinarump member.

REF: D.O.E.

EARL HUSKON #3

LOC: SW¼ Sec. 26, T32N, R9E

QUAD: Moenave SW 7½'; Marble Canyon NTMS

DEVL: Open pits

PROD: 1855 tons @ 0.24% U_3O_8; 0.03% V_2O_5, 1954-55

GEOL: Discontinuous carnotite-typa mineralization in sandstone of upper Shinarump member.

REF: D.O.E.

EARL HUSKON #35 (Evans Huskon #35)

EL PEQUITO MINE (Peheu Claims)

LOC: NW corner Sec. 14 T40 N, R7E, About 2 mi. WNW of Lees Ferry - Vermilion Cliffs.

QUAD: Lees Ferry 15'; Marble Canyon NTMS

DEVL: Trench

PROD: 912 tons @ 0.17% U_3O_8; 1956-57. 0.02-0.06% V_2O_5 197 Tons of 0.09% "no-pay" ore in 1957.

ANAL: 0.22% e U_3O_8; 0.19% U_3O_8; 0.06% V_2O_5; 1.18-6.80% $CaCO_3$

GEOL: Uraninite with pyrite, chalcopyrite in calcite veinlets and oxidized uranium and copper minerals coating pebbles and sand grains and impregnating carbonized wood in spoon-shaped channel of Shinarump Member, removed by erosion both up and down channel.

REF: Phoenix, D.A. (1963)
Tagg (1951) USAEC TM-212

ELWOOD CANYON SHAFT #1

LOC: Approx. West central Sec. 19, T29N, R10E

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: 80 ft. deep shaft and drift

PROD: 874 tons @ 0.21% U_3O_8; 0.01% V_2O_5; 1957-1960

GEOL: Uraninite in carbonaceous sandstone, filling a narrow linear scour in an underlying shale of the lower Petrified Forest member.

REF: U.S.A.E.C. (1959, RME-141)

ELWOOD THOMPSON #1 (Ramco #23)

LOC: Approx. SW¼, Sec. 1, T26N, R10E

QUAD: Wupatki NE 7½'; Flagstaff NTMS

DEVL: Shaft and drift

PROD: 3,261 tons @ 0.24% U_3O_8, 1960-61

GEOL: Uraninite in sandstone lens of basal Petrified Forest member.

REF: D.O.E.

EMMETT LEE #1 (E.Lee#1, Julius Chee #3,4 common pit with Emmett Lee #1

LOC: Approx. NW¼ Sec. 11, T26N, R10E

QUAD: Wupatki NE 7½; Flagstaff NTMS

DEVL: Open pits

PROD: 840 tons @ 0.19% U_3O_8; 0.02% V_2O_5, 1956-58

GEOL: Irregular branching mineralized lenses up to 130 ft. long and 100 ft. wide oriented mainly to NE in braided scour and fill channel and modified by fracturing and permeability characteristic of sandstone and mudstone of lower Petrified Forest member. Uraninite is at depth and autunite near the surface.

REF: U.S.A.E.C. (1959, RME 141)
Bollin, E. and Kerr, P. (1958)

EMMETT LEE #3 (E. Lee #3, Julia Semallie common pit)

LOC: NE¼, Sec. 13 and SE¼ Sec. 12, T26N, R10E

QUAD: Wupatki NE 7½; Flagstaff NTMS

DEVL: 22 ft. deep pit extends onto Julia Semallie claims

PROD: 229 tons @ 0.32% U_3O_8; 0.02% V_2O_5, 1957-58

GEOL: Uraninite in sandstone lens in basal Petrified Forest member.

REF: U.S.A.E.C. (1959, RME-141)

ENGLAND GROUP

LOC: Sec. 3, T40N, R7E
Vermilion Cliffs

QUAD: Lees Ferry 15'; Marble Canyon NTMS

DEVL: Dozer roads up cliff

GEOL: Radioactivity associated with copper carbonates and carbonaceous matter along Moenkopi-Shinarump contact. See Red Wing Claim, located nearby.

REF: PRR-RR-297

EVANS HUSKON #2 (Adjacent to Yazzie #312)

LOC: SW corner Sec. 19, T29N, R10E

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: Open pit

PROD: 11,777 tons @ 0.18% U_3O_8; 0.01% V_2O_5, 1953-1961

GEOL: Secondary uranium minerals in carbonaceous sandstone lenses in Petrified Forest member are in an irregular podlike body, 110 X 300 ft.; in NW trending paleochannel. Apparent control of mineralization by presence of carbonaceous matter and variation of permeability in scour and fill sediments. Smaltite and ilsemannite have been identified.

REF: U.S.A.E.C. (1959, RME-141)
Bollin, E. and Kerr, P. (1958)
Isachsen, Y. and Evensen, C. (1956)
Austin, S. (1964, RME-99)

EVANS HUSKON #34

LOC: Approx. West central Sec. 9, T29N, R10E

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: Small pits

PROD: 1853 tons @ 0.16% U_3O_8, 0.04% V_2O_5, 1957

GEOL: Carnotite-type in sandstone of the upper Petrified Forest member.

REF: D.O.E.

EVANS HUSKON #35 (Earl Huskon #35)

LOC: Approx. North central Sec. 36 and South central Sec. 25, T28N, R10E.

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: Cuts and open pit

PROD: 64 tons @ 0.13% U_3O_8; 1958

GEOL: Uraninite in carbonaceous siltstone of upper Petrified Forest member.

REF: D.O.E.

F AND B CLAIMS

LOC: Probably approx. E½ Sec. 22, T38N, R7E Echo Cliffs

QUAD: Tanner Wash 15'; Marble Canyon NTMS

GEOL: Becqueralite with natroalunite in Chinle sandstone

REF: Gruner, J. and Knox, J. (1957), RME-3148

FEHEU CLAIMS (El Pequito Mine)

FOLEY #1

LOC: Sec. 11 and 14, T30N, R9E, less than 200 yds. east of Hwy. 89, halfway between Cameron and Tuba City.

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: Drilled only.

GEOL: Radioactivity associated with folded and slightly faulted Petrified Forest member.

REF: D.O.E.

FOLEY #5 (Yazzie #312)

FOLEY BROTHERS #9 (Pat Lynch)

GRANDVIEW MINE (Last Chance Mine)

LOC: Approx. NE¼ Sec. 5, T30N, R4E 36°01'03"N, 111°58'34"W on south side of Grand Canyon

QUAD: Vishnu Temple 15'; Marble Canyon NTMS

DEVL: Underground workings for copper between 1893 and 1916 produced a reported $100,000.

RAD: 20,000 cps.

ANAL: 2.764% e U_3O_8; 1.892% U_3O_8

GEOL: Pipe-like body in upper Redwall limestone and basal Supai Fm. Uranium minerals association with limonite, copper carbonates, silicates and sulfate minerals, also minor pyrite and other sulfides along brecciated, bleached and marblized Redwall Ls. The deposit lies along the Cremation fault which trends WNW. Presence of Kaolinite and fully hydrated zeunerite suggests a temperature of formation below 70°C. Metazeunerite/zeunerite found in limonitic gossan-type.

REF: PRR-RG-33
Gibson, R. (1952, RMO-890)
Leicht, W.C. (1971)
Waesche, H.H. (1934)
Emmons, S. (1905)
Breed and Road (1974) p. 172

GRUB #14

LOC: NE¼, Sec. 16, T27N, R10E

QUAD: Wupatki NE 7½'; Flagstaff NTMS

DEVL: 150 ft. of rim stripping; several shallow pits 60 X 20 X 10 Ft. deep and several small drilling programs.

PROD: 13.1 tons @ 0.16% U_3O_8 (42 lbs U_3O_8 total) in 1956. This is total attributed to Grub claims in W½ Sec. 16. The E½ Sec. 16 produced some of the ore for Section 9 (upgrader) production, possibly about 5-15 tons.

GEOL: Uranium mineralization in carbonaceous siltstone in the upper part of a Shinarump channel. This channel appears to be different than the ore in E½ Sec. 16, which is the southward extension of the Section 9 (upgrader) channel.

REF: D.O.E.

HARRY WALKER #16 (Ramco #24 extends onto Harry Walker #16)

LOC: North central Sec. 12, T26N, R10E

QUAD: Wupatki NE 7½, Flagstaff NTMS

DEVL: Portion of Ramco 24 pit, originally a pit 180 ft. X 70 ft. X 5 ft. deep.

PROD: 51 tons @ 0.12% U_3O_8; 0.15% V_2O_5, 1957

GEOL: Carnotite-type ore in Petrified Forest member sandstone.

REF: D.O.E.

HARVEY BEGAY #1

LOC: Approx. Sec. 19, T29N, R10E

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: Drilled

GEOL: Mineralization, probably uraninite, in Petrified Forest member.

REF: D.O.E.

HELLS HOLLOW

LOC: Approx. Sec. 13, T32N, R8W

QUAD: Vulcans Throne 7½'; Grand Canyon NTMS

DEVL: 3 holes drilled

RAD: 140 cps

GEOL: Radioactivity highest on mudstone horizons in bleached Hermit Shale with iron-manganese nodules, gypsum filled fractures and large scale liesegang rings. Mineralization is apparently associated with 100 ft. diameter sandstone mass cutting the Hermit Shale about 50 ft. below Coconino Sandstone and 800 ft. above Redwall limestone.

REF: D.O.E. data

HENRY SLOAN #1 (Sloan #1)

LOC: South central Sec. 35, T32N, R9E and north central Sec. 2, T31N, R9E.

QUAD: Moenave SW 7½'; Marble Canyon NTMS
DEVL: 2 open pits
PROD: 353 tons @ 0.18% U_3O_8; 0.05% V_2O_5, 1954-56.

ANAL: 0.30% e U_3O_8; 0.26% U_3O_8; 17.5-28.5% $CaCO_3$

GEOL: Uraninite occurs in veins and stringers and associated with marcasite in calcite cemented sandstone bordering carbonaceous wood in Petrified Forest member. Marcasite is high in arsenic.

REF: Austin, S. (1964, RME-99)

HOSTEN NEZ MINING COMPANY (Ward Terrace)

HOWARD #1

LOC: NW¼ Sec. 7, T27N, R10E

QUAD: Wupatki NE 7½'; Flagstaff NTMS

DEVL: Surface pits

PROD: 25 tons @0.26% U_3O_8; 0.10% V_2O_5, 1956

GEOL: Small pods of carnotite-type mineralization associated with carbonaceous matter in sandstone lenses of the upper Shinarump member.

REF: D.O.E.

HUSKON (Charles Huskon)

Huskon is a commonly used alias for Charles Huskon. Huskon #1,3,7,8,10,11,12,14,17,26 are listed as Charles Huskon. Charles Huskon's sons were Earl Huskon, Evans Huskon and Jack Huskon. Mines named after the sons are listed according to their first name.

ICICLE

LOC: Sec. 18, 19, T32N, R9E

QUAD: Blue Spring 15'; Marble Canyon NTMS

DEVL: Drilling and prospect pits

ANAL: 0.09% e U_3O_8; 0.12% U_3O_8; 0.7% $CaCO_3$

GEOL: Carnotite-type in Shinarump Conglomerate.

REF: D.O.E.

J. SEMALLIE (Julia Semallie)

JACK DANIELS #1-5 (Denetso #1)

LOC: South central Sec. 11, T29N, R9E, 300 ft. east of new Hwy 89.

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: Open pit - largest single producer around Cameron.

PROD: Total of 39,808 tons @ 0.22% U_3O_8, <0.05% V_2O_5. Jack Daniels #1-4 claims produced 39,440 tons in 1956-1960 from the main pit. Jack Daniels extension (claim #5, under Old Highway 89) produced 322 tons @ 0.27% U_3O_8 in 1963. No production from Jack Daniels No. 3. Jack Daniels No. 4 produced 34 tons @ 0.14% U_3O_8 and 0.07% V_2O_5 from small dozer cuts and shallow scrapings located about 250 feet south of Jack Daniels No. 1 pit.

GEOL: Mostly uraninite ore disseminated in sandstone and siltstone channel near base of Petrified Forest member. Schroeckingerite coats fractures in sandstone, undergoing oxidation. Boltwoodite has been identified. Carbonized fossil logs containing uraninite are common.

REF: U.S.A.E.C. (1959, RME-141)
Bollin, E. and Kerr, P. (1958)
Austin, S. (1964, RME-99)
D.O.E.

JACK HUSKON #1

LOC: Approx. south central Sec. 10, T28N, R10E

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: Drilled

GEOL: Two horizons of uraninite ore in Petrified Forest member. Upper ore zone is reportedly not in equilibrium.

REF: D.O.E.

JACK HUSKON #3

LOC: Approx. SE corner Sec. 9, T28N, R10E

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: One pit 400 X 100 ft. X 130 ft. deep, one 30' drift in NE pit walls drill holes. Deepest pit in Cameron area.

PROD: 1,264 tons @ 0.19% U_3O_8, 1958-59

GEOL: Uraninite in Petrified Forest member

REF: D.O.E.

JACKPOT #1

LOC: Approx. S. central Sec. 14, T27, R10E

QUAD: Wupatki NE 7½; Flagstaff NTMS

DEVL: Open pit

PROD: 151 tons @ 0.18% U_3O_8; 0.03% V_2O_5, 1956

GEOL: Secondary minerals in carbonaceous sandstone in basal Petrified Forest member.

REF: U.S.A.E.C. (1959, RME-141)

JACKPOT #5

LOC: Approx. central NE¼ Sec. 14, T27N, R10E

QUAD: Wupatki NE 7½; Flagstaff NTMS

DEVL: Open pit

PROD: 77 tons @ 0.26% U_3O_8; 0.02% V_2O_5, 1956-57

GEOL: Secondary minerals in carbonaceous sandstone in basal Petrified Forest member.

REF: U.S.A.E.C. (1959, RME-141)

JACKPOT #6

LOC: Approx. NE¼ Sec. 15, T27N, R10E "7 to 8 miles west of Hwy. 89 and about 4 miles WNW of Shadow Mtn.

QUAD: Wupatki NE 7½; Flagstaff NTMS

ANAL: 0.13% e U_3O_8; 0.17% U_3O_8

GEOL: One foot thick zone in Chinle sandstone with mud lenses. Carbonaceous muddy matter and jarosite and limonite staining.

REF: PRR-EDR-516 (#114)

JACKPOT #7

LOC: Approx. SE¼ Sec. 10, T27N, R10E "Eastside of Moenkopi Wash about 4 mi. NW from Cameron"

QUAD: Wupatki NE 7½; Flagstaff NTMS

ANAL: 0.39% e U_3O_8; 0.53% U_3O_8

GEOL: Sandy Chinle unit contains carbonaceous silty and clay lenses with some limonite-jarosite staining. About one foot zone contains some carnotite and autunite. Outcrop occurs on west side of a small N-S Trending syncline.

REF: PRR-EDR-517 (#115)

JACKPOT #8

LOC: Approx. SW¼, Sec. 11, T27N, R10E "East side of Moenkopi Wash about 3 miles NNE of Jackpot #7"

QUAD: Wupatki NE 7½; Flagstaff NTMS

RAD: 3X

GEOL: Massive Chinle sandstone with clay lenses and jarosite staining. Radioactivity associated with white efflorescence which appears to be magnesium sulfate.

REF: PRR-EDR-515 (#113)

JACKPOT #40

LOC: Approx. east central Sec. 15, T27N, R10E might be same as Jackpot #6.

QUAD: Wupatki NE 7½'; Flagstaff NTMS

DEVL: Open pit

PROD: 152 tons @ 0.20% U_3O_8; 0.07% V_2O_5, 1956-57

GEOL: Secondary minerals in carbonaceous sandstone in basal Petrified Forest member.

REF: D.O.E.

JASPER GROUP

LOC: SW¼ Sec. 27, T39N, R6E Vermilion Cliffs about ½ mile NE of Cliff Dwellers Lodge

QUAD: Tanner Wash 15'; Marble Canyon NTMS

DEVL: Blocks blasted from cliff base

RAD: 200X

ANAL: 0.14-0.16% e U_3O_8 on black carbonaceous matter

GEOL: Yellow uranium mineralization with considerable azurite and malachite and soft black carbonaceous matter in Shinarump channel deposit.

REF: PRR-RR-275 (#161)
Petersen, R (1957-TEI #690)

JAY BIRD CLAIMS (Sun Valley Mine)

JEEPSTER #1

LOC; Approx. North central Sec. 35, T30N, R9E

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: 700 X 150 X 60 ft. deep open pit

PROD: 1,128 tons @ 0.18% U_3O_8; 0.04% V_2O_5, 1956-57

GEOL: Autunite-type mineralization in carbonaceous sandstone lens in basal Petrified Forest member.

REF: D.O.E.

JEFFERSON CANYON #1

LOC: Approx. NE¼ Sec. 5, T28N, R10E

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: 210 drill holes

GEOL: Mineralization in scattered disconnected lenses in Petrified Forest member.

REF: D.O.E.

JIMMY BOONE

LOC: Approx. Sec. 1,12, T39N, R7E

QUAD: Lees Ferry 15'; Marble Canyon NTMS

DEVL: Rim stripping

PROD: 14 tons @ 0.10% U_3O_8, 1955

ANAL: 3 samples @ 0.35-0.65% e U_3O_8, 0.28-0.34% U_3O_8; 3.0-5.3% $CaCO_3$

GEOL: Autunite, malachite, ilsemannite and carbon matter in Shinarump channel cut into upper part of Moenkopi Fm.

REF: D.O.E.

JOHNSON-BARLOW

LOC: Probably near common corner Secs. 16,17,20,21, T38N, R4E, "10 miles east of Houserock Ranch and 1/8 mile south of Hwy. 89" Vermilion Cliffs

QUAD: Emmett Wash 15'; Marble Canyon NTMS

DEVL: 3 shallow dozer cuts

RAD: 30X

GEOL: Radioactivity in remnants of Shinarump Conglomerate with fire yellow sand matrix containing iron oxide, carbonaceous trash, and some petrified wood fragments.

REF: PRR-RR-250 (#157)

JUAN HORSE #3 (Adjacent to Boyd Tisi #2)

LOC: Approx. SW¼, Sec. 30, T29N, R10E

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: 50 ft. deep open pit

PROD: 2343 tons @ 0.19% U_3O_8, 1958-59

ANAL: 0.18% e U_3O_8; 0.25% U_3O_8; 1.20% $CaCO_3$

GEOL: Disseminated uraninite in carbonaceous sandstone of basal Petrified Forest member.

REF: D.O.E.

JUAN HORSE #4

LOC: Approx. NE¼, Sec. 31, T29N, R10E

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: 81 ft. deep open pit

PROD: 2418 tons @ 0.23% U_3O_8; 1958-59

GEOL: Uraninite in arkosic carbonaceous sandstone with clay pellets in sour channel of Petrified Forest member.

REF: D.O.E.

JULIA SEMALLIE (J. Semallie; common pit with Emmett Lee #3)

LOC: SE¼, Sec. 12, T26N, R10E

QUAD: Wupatki NE 7½; Flagstaff NTMS

DEVL: Open pit

PROD: 163.3 tons @ 0.25%, U_3O_8; 0.04% V_2O_5, 1957-58

GEOL: Uraninite in sandstone of the lower Petrified Forest member.

REF: D.O.E.

JULIUS CHEE #2 (Pit common to Emmett Lee #1 and Julius Chee #3 & 4)

LOC: Approx. NW¼, Sec. 11, T26N, R10E

QUAD: Wupatki NE 7½; Flagstaff NTMS

DEVL: 2 pits, 20 ft. deep; drilling. One pit common with other claims.

PROD: 637 tons @ 0.14% U_3O_8, 1957-58

GEOL: Secondary minerals in sandstone of basal Petrified Forest member. Two different sands are mineralized. Much of the radioactivity associated with oxidized logs is probably due to radioactive barite.

REF: Austin, S. (1964, RME-99, pg. 56-58)

JULIUS CHEE #3 (pit common with Julius Chee #4 and Emmett Lee #1)

LOC: Approx. NW¼, Sec. 11, T26N, R10E

QUAD: Wupatki NE 7½; Flagstaff NTMS

DEVL: SW pit (200 X 50 X 30 ft. deep); 80 X 30 X 30 ft. deep pit; drilling

PROD: 218 tons @ 0.17% U_3O_8; 0.01% V_2O_5; 1956-57, 1962-63

GEOL: Carnotite and autunite in carbonaceous sandstone in lower Petrified Forest member. Ore is reported to be out of equilibrium, radiometric readings high. 1963 shipments are the last recorded for the Cameron district.

REF: U.S.A.E.C. (1959, RME-141)

JULIUS CHEE #4 (Commonpit with Emmett Lee #1 and Julius Chee #3)

LOC: Approx. NW¼ Sec. 11, T26N, R10E

QUAD: Wupatki NE 7½'; Flagstaff NTMS

DEVL: 200 X 50 X 30 ft. deep pit, 50 ft. adit from bottom of pit.

PROD: 1042 tons @ 0.18% U_3O_8; 0.01% V_2O_5; 1957-58

GEOL: Mineralization in carbonaceous sandstone of the Petrified Forest member.

REF: U.S.A.E.C. (1959, RME-141)

JUNE CLAIMS (Navajo Springs, adjacent to Tommy)

LOC: Sec. 26, T39N, R7E

QUAD: Lees Ferry 15'; Marble Canyon NTMS

DEVL: 75 X 30 X 15 ft. deep rim stripping

PROD: 23 tons @ 0.22% U_3O_8, 1956

GEOL: Secondary minerals in basal Petrified Forest member

REF: D.O.E.

KACHINA #6

LOC: SW¼, Sec. 2, T29N, R9E

QUAD: Cameron 15½; Flagstaff NTMS

DEVL: 400 X 200 X 40 ft. deep pit with adit in wall

PROD: 1,452 tons @ 0.14% U_3O_8, 1957-60

GEOL: Sandstone lens of carnotite-type in channel deposit near base of Petrified Forest member.

REF: D.O.E.

LA SALLE MINING

LOC: Sec. 18, 21, T39N, R8E
Vermilion Cliffs

QUAD: Lees Ferry 15'; Marble Canyon NTMS. Two miles west of Marble Canyon and up draw with spring at cliff base on bench 400 ft. above Hwy. 89 and ½ mile to the north.

RAD: 8X

ANAL: 0.03% U_3O_8

GEOL: Radioactivity is near base of Shinarump member channel about 1000 ft. wide and cuts 50-70 ft. into Moenkopi. Much copper staining but carbon matter not abundant.

REF: PRR-EDR-227 (#113)

LAST CHANCE MINE (Grandview Mine)

LEHNEER PROSPECT

LOC: NW¼ Sec. 34, T41N, R7E
In Paria Canyon on North side of Paria River

QUAD: Lees Ferry 15'; Marble Canyon NTMS

DEVL: Short drift

GEOL: Small, tabular occurrence of metatorbernite, torbernite, zippeite and secondary copper minerals associated with sparse black carbonaceous matter, in thicker sandstone in upper and lower strata of Chinle Fm. above Shinarump member.

REF: Phoenix, D. (1963)

LEMUEL LITTLEMAN #1 & 7

LOC: Approx. SE¼ Sec. 27, T30N, R9E

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: Open pit

PROD: 469 tons @ 0.19% U_3O_8; 0.03% V_2O_5, 1956-58, 1960

GEOL: Uraninite with carbon matter and petrified logs in channel sandstone of basal Petrified Forest member.

REF: U.S.A.E.C. (1959, RME-141)

LEMUEL LITTLEMAN #2 (Diamond Uranium Claims)

LOC: Approx. Sec. 24, T29N, R9E

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: Shallow pits

PROD: 5,819 tons @ 0.21% U_3O_8; 0.01% V_2O_5, 1955-60

GEOL: Uraninite associated with carbon matter and petrified logs in paleochannel deposit of lower Petrified Forest member.

REF: U.S.A.E.C. (1959, RME-141)

LEMUEL LITTLEMAN #3 (Diamond Uranium Claims)

LOC: Approx. West central Sec. 35, T29N, R9E

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: Shallow pit

PROD: 12 tons @ 0.24% U_3O_8; 0.07% V_2O_5, 1955

GEOL: Carnotite staining on bedding and fracture planes in small channel deposit of upper Shinarump member.

REF: D.O.E.

LEMUEL LITTLEMAN #6

LOC: SE¼ Sec. 9, T31N, R9E

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: Prospect pits

PROD: 5 tons stockpiled

ANAL: Stockpile sample (fissile shale) @ 0.15% e U_3O_8; 0.16% U_3O_8; 0.40% $CaCO_3$

GEOL: Secondary minerals in Shinarump member

REF: D.O.E.

LIBA GROUP (New Liba)

LLOYD HOUSE

LOC: East central Sec. 27 and West central Sec. 26, T28N, R10e

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: Caved prospect shaft; some drilling

GEOL: Dominantly tyuyamunite in Petrified Forest member.

REF: D.O.E.

LUSTER #1

LOC: SW¼ Sec. 17, T27N, R9E

QUAD: Wupatki NE 7½; Flagstaff NTMS

DEVL: Open pit

PROD: 319 tons @ 0.14% U_3O_8; 0.04% V_2O_5, 1956

GEOL: Sandstone in upper part of Shinarump member

REF: D.O.E.

M. JOHNSTON (Martin Johnson #4 or (Max Johnson Mines #1-10)

M & R CLAIMS

LOC: Sec. 11, T39N, R6E
4 miles NW of Vermilion Cliffs Lodge

QUAD: Lees Ferry 15'; Marble Canyon NTMS

DEVL: Dozer cuts

RAD: 30X

ANAL: 0.45% U_3O_8; 1.7% V_2O_5; 1.0% Cu

GEOL: Mineralized sandstone is very irregular and varies from one foot to 10 feet in thickness. The white silty sandstone matrix from the Petrified Forest member contains nodules, pockets and lenses of carbonaceous muds.

REF: TRR-RR-296 (#165)

MAGGIE BAKER (Cliff Canyon)

MALONEY (Adolf Maloney #2)

MANUEL DENETSONE #2

LOC: Approx. North central Sec. 5, T28N, R10E

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: 50 ft. shaft with drifting

PROD: 338 tons @ 0.20% U_3O_8, 1959

GEOL: Spotty, lenticular occurrences of uraninite in carbonaceous sandstone of basal Petrified Forest member.

REF: U.S.A.E.C. (1959, RME-141)

MARTIN JOHNSON #4 (M. Johnson #4)

LOC: Sec. 11, T32N, R9E

QUAD: Moa Ave NW 7½; Marble Canyon NTMS

DEVL: Rim stripping and shallow pits

PROD: 38 tons @ 0.16% U_3O_8; 0.03% V_2O_5; 1956

GEOL: Secondary minerals in a platy, carbonaceous, limonite stained sandstone of the Shinarump member.

REF: D.O.E.

MAX HUSKON #1-7

LOC: Sec. 23,24,26,27,34,35, T32N, R9E

QUAD: Moa Ave NW and SW 7½; Marble Canyon NTMS

DEVL: Open pits

PROD: 57 tons @ 0.04% U_3O_8; 0.02% V_2O_5, 1955

GEOL: Secondary minerals in the Shinarump member

REF: D.O.E.

MAX JOHNSON #1 (M. Johnson #1)

LOC: Approx. West central Sec. 24, T29N, R9E

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: Open pit

PROD: 5,678 tons @ 0.23% U_3O_8; 0.02% V_2O_5, 1956-57, 1959-60

GEOL: Dominantly autunite with some uraninite in a zone 400 X 120 ft. in SW trending channel of lower Petrified Forest member. Atacamite associated with gypsum.

REF: Austin, S. (1964, RME-99)

MAX JOHNSON #4 (M. Johnson #4)

LOC: SW corner Sec. 30, T27N, R11E

QUAD: Wupatki NE 7½'; Flagstaff NTMS

PROD: 38 tons @ 0.16% U_3O_8; 0.03% V_2O_5, 1956

GEOL: Ore in Petrified Forest member

REF: D.O.E.

MAX JOHNSON #7 (M. Johnson #7)

LOC: Approx. SW¼ Sec. 35, T27N, R10E

QUAD: Wupatki NE 7½'; Flagstaff NTMS

DEVL: 15 ft. deep open pit

PROD: 280 tons @ 0.16% U_3O_8; 0.03% V_2O_5, 1957-59

GEOL: Secondary minerals in carbonaceous sandstone of lower Petrified Forest member. Ore appears to be slightly out of equilibrium in favor of the radiometric assay.

REF: D.O.E.

MAX JOHNSON #9 (M. Johnson #9)

LOC: Approx. SE¼ Sec. 24, T29N, R9E

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: 40 ft. deep open pit

PROD: 1,375 tons @ 0.19% U_3O_8, 1958-60

GEOL: Uraninite as very discontinuous and lenticular deposits in basal carbonaceous sandstone of Petrified Forest member.

REF: D.O.E.

MAX JOHNSON #10

LOC: Approx. SW¼ Sec. 24, T29N, R9E

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: Open pit

PROD: 196 tons @ 0.28% U_3O_8, 1959-60

GEOL: Uraninite in small lenses in lower Petrified Forest member. Some small en echelon faults.

REF: U.S.A.E.C. (1959, RME-141)

MEL GARDNER PROSPECT

LOC: Approx. Central west Sec. 34, T28N, R10E

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: Drilling

GEOL: Uraninite in Shinarump paleochannel

REF: U.S.A.E.C. (1959, RME-141)

MILESTONE #1 MINE (Grub #14)

MONTEZUMA #1

LOC: Approx. south central Sec. 36, T29N, R9E

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: Open pit and stripping

PROD: 11 tons @ 0.10% U_3O_8, 1959

GEOL: Metatyuyamunite in Shinarump Conglomerate

REF: Austin, S. (1964, RME-99)

MONTEZUMA #2

LOC: Approx. SW corner Sec. 3, T30N, R9E

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: Open pits

PROD: 193 tons @ 0.12% U_3O_8, 1955-57

GEOL: Secondary minerals in carbonaceous and argillaceous sandstone of upper Shinarump member. Some uranium tied up in hyalite.

REF: D.O.E.

MONTEZUMA #7A, 7B, 7C

LOC: Approx. central Sec. 4, NE¼ Sec. 5, T29N, R9E, and SW corner Sec. 33, T30N, R.9E, respectively.

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: Open pits

PROD: 57 tons, 38 tons and 36 tons @ 0.12% U_3O_8, in 1956 respectively.

GEOL: Secondary minerals in platty, carbonaceous, argillaceous upper Shinarump with some hyalite.

REF: D.O.E.

MURPHY MINE (Black Point)

LOC: NW¼ Sec. 22, T27N, R10E

QUAD: Wupatki NE 7½; Flagstaff NTMS

DEVL: Open pit

PROD: 1,769 tons @ 0.21% U_3O_8; 0.04% V_2O_5; in 1956-58

GEOL: Scattered channel deposits associated with abundant carbonized logs and plant remains in fine to medium-grained sandstone and mudstone of basal Petrified Forest member and upper Shinarump member. Some migration of uranium mineralization found in Pleistocene gravels. Minerals coating grains include, meta-autunite, uranophane, beta-uranophane, alunite, schoepite, tyuyamunite, betazippeite, cobalt and gypsum; uranium pit now destroyed by gravel operation.

REF: U.S.A.E.C. (1959, RME-14)
Austin, S (1957)
Austin, S. (1964, RME-99, pg. 36-37)

NATIONAL GROUP

LOC: Approx. Sec. 16, T30, R6W
Hualupai Indian Reservation

QUAD: Williams NTMS

PROD: Copper during W.W.I.

RAD: 4X

GEOL: Cherty Kaibab limestone is mineralized along fractures with shallow limestone gossen and copper mineralization.

REF: PRR-AP-115 (#103)

NAVAJO 26 MINE

LOC: South central Sec. 18, T27N, R10E
On north side of Black Point

QUAD: Wupatki NE 7½'; Flagstaff NTMS

DEVL: Rim Stripping and open pit

PROD: 581 tons @ 0.17% U_3O_8, 1958-59

GEOL: Secondary minerals in slump block of basal Petrified Forest member sandstone.

REF: U.S.A.E.C. (1959, RME-141)
Cheneweth and Cooley (1960.

NAVAJO SPRINGS (June and Tommy Claims)

NAVAJO SPRINGS (Tommy Claims)

NEW LIBA (Liba Group, Pretty girl)

LOC: NE ¼ Sec. 4, T27N, R10E

QUAD: Wupatki NE 7½'; Flagstaff NTMS

DEVL: Open pits

PROD: 1,829 tons @ 0.16% U_3O_8; 1955-60

GEOL: Secondary minerals in arkosic sandstone with overlying carbonaceous sandstone in upper Shinarump member. Cobalt, molybdenum and sulfates present, see also Grub #14.

REF: D.O.E.

NORDELL (Ada and Nordell)

ORPHAN LODE MINE

LOC: SW¼ Sec. 14, T31N, R2E
Grand Canyon

QUAD: Bright Angel 15'; Grand Canyon NTMS

DEVL: Vertical shaft and stoping

PROD: 509,025 tons @ 0.43 U_3O_8; (4.36 million lbs. of U_3O_8), plus 6.68 million lbs. of copper, 107,000 ounces of silver, small amounts of vanadium, from 1956-1969.

ANAL: Scattered assays from 1 to 10% U_3O_8 - range of ore shipped is 0.1-0.5% U_3O_8

GEOL: Uraninite and secondary uranium minerals in nearly vertical circular pipe-like body of brecciated, highly fractured Coconino sandstone, and Hermit Shale. Mineralization strongest around periphery and consists of disseminations and vein-like stringers of uraninite in association with sulfides of Fe, Cu, Pb, Zn, Co and Mo. pipe bottoms in Redwall limestone. More detailed information is provided in the discussion on the Orphan Mine, elsewhere in this text.

REF: U.S.A.E.C. (1959, RME-141)
Bowles, C.G. (1977)
Adler, H. (1963)
Granger, H. & Raup, R. (1962)
Miller, D. and Kulp, J. (1963)
Kerr, P. (1958)
Cornitz, V & Kerr, P. (1970)
Kofford, M. (1969)
PRR-AP-52
Magleby, D. (1961, A.E.C. TM-134)

PACKRAT

LOC: Approx. Sec. 12, T26N, R2E

QUAD: Valle 15'; Williams NTMS

DEVL: 2 shallow shafts, incline, some drifting and crosscutting.

PROD: Copper production

RAD: 12X

ANAL: 0.04% e U_3O_8

GEOL: Radioactivity and copper carbonates in a sandstone lens in Kaibab limestone.

REF: PRR-AP-44

PAT LYNCH (Foley Brothers #9)

LOC: Sec. 33, T29N, R10E

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: 90 drill holes

GEOL: Mineralization occurs in iron-stained sandstone in upper part of Petrified Forest member.

REF: D.O.E.

PAUL HUSKIE #1 & 2 (Refer to Paul Huskie #20)

LOC: NE¼ Sec. 22 and NW¼ Sec. 23, T28N, R9E

QUAD: Cameron 15'; Flagstaff NTMS

GEOL: Mineralization in Shinarump channel.

REF: D.O.E.

PAUL HUSKIE #3

LOC: South central Sec. 11, T26N, R10E
Adjacent to Charles Huskon #4

QUAD: Wupatki NE 7½; Flagstaff NTMS
DEVL: Small open pits
PROD: 3,925 tons @ 0.20% U_3O_8, in 1956, 1958
Included in Charles Huskon #4 production

REF: D.O.E.

PAUL HUSKIE #4

LOC: Approx. Sec. 5, T29N, R10E
2000 ft. north of Evans Huskon #34

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: 60 drill holes

GEOL: Bleached sandstone in upper Petrified Forest member.
REF: D.O.E.

PAUL HUSKIE #20 (Refer to Paul Huskie #1 & 2)

LOC: Approx. Sec. 22,23,T28N, R9E

QUAD: Cameron 15'; Flagstaff NTMS

PROD: 22.7 tons @ 0.15% U_3O_8, 1959

GEOL: Scattered mineralized logs in Shinarump member

REF: D.O.E.

PAUL HUSKIE #21 (A & B #21)

LOC: SW¼, Sec. 26, T32N, R9E
Adjacent to Earl Huskon #3

QUAD: Moenave SW 7½; Marble Canyon NTMS

DEVL: 90 X 70 X 8 ft. deep open pit, 6-10-20 ft. shafts

PROD: 273.4 tons @ 0.22% U_3O_8 includes illegal shipment from A & B #21.

GEOL: Uranium in dark brown limonite stained sandstone in upper Shinarump member. Ore is out of equilibrium in favor of radiometric.

REF: D.O.E.

PRETTY GIRL (New Liba)

RAINBOW CLAIM

LOC: Poorly located, Approx. T39N, R2E
Vermilion Cliffs

QUAD: Probably Lees Ferry 15'; Marble Canyon NTMS

DEVL: Dozer cuts

RAD: 200X

GEOL: Possibly Carnotite in medium-coarse sandstone and fossil logs in small channels within Chinle. Series of small E-W Trending faults in area.

REF: PRR-RR-202 (#155)
PRR-RR-106

RAMCO #20 (Common pit with Ramco #22 claim)

LOC: Central to east central edge of Sec. 11, T27N, R10E, Cameron

QUAD: Wupatki NE 7½, Flagstaff NTMS

DEVL: Open pit 70 ft. deep, over 800 drill holes

PROD: 22,642 tons @ 0.22% U_3O_8; 0.04% V_2O_5, 1956-60

GEOL: Mineralization in scour and fill sediments of a ENE Trending channel in Petrified Forest member. Some control to ore deposition along fractures at slight angle to channel. Uraninite replaces cell walls and pyrite replaces cell centers in petrified logs. Gypsum coats secondary uranium minerals in fractures. Boltwoodite and cobalt minerals identified. Same ore body as Ramco #22 and Ryan #2.

REF: Austin, S (1964, RME-99, p. 82-83)

RAMCO #21

LOC: NW¼ Sec. 11, T27N, R.10E
Cameron

QUAD: Wupatki NE 7½, Flagstaff NTMS

DEVL: 2 open pits, 600 X 150 X 40 ft. deep and 300 X 300 X 50 ft. deep and one 100 ft. adit and surface scrapings.

PROD: 5471 tons @ 0.25% U_3O_8; 0.04% V_2O_5, 1956-59

GEOL: Oxidized uranium minerals in scour and fill channels trending NW and NE and in the lower Petrified Forest member. Average thickness of ore was 2 ft. and at a depth of about 36 ft. Abundant carbonized plant debris.

REF: U.S.A.E.C. (1959, RME-141); Bollin, E. and Kerr, P. (1958)

RAMCO #22 (Common pit with Ramco #20)

LOC: Central to east central edge Sec. 11, T27N, R10E
Cameron

QUAD: Wupatki NE 7½, Flagstaff NTMS

DEVL: Open pit 70 ft. deep

PROD: 16,609 tons @ 0.23% U_3O_8; 0.01% V_2O_5, 1956-59

GEOL: Uraninite and secondary uranium minerals in channel fill of Petrified Forest member. Refer to Ramco #20.

RAMCO #23 (Elwood Thompson #1)

RAMCO #24 (Extends onto Harry Walker #16 claim)

LOC: Approx. N. central Sec. 12, T26N, R10E
Cameron

QUAD: Wupatki NE 7½'; Flagstaff NTMS

DEVL: 450 X 250 X 35 ft. deep open pit

PROD: 2,829 tons @ 0.21% U_3O_8; 0.05% V_2O_5, 1957-58

GEOL: Secondary uranium minerals in argillaceous sandstone lens in basal Petrified Forest member.

REF: D.O.E.

RED WING #4 CLAIM

LOC: SW¼ Sec. 34, T41N, R7E and SW¼ Sec. 2, T40N, R7E, Vermilion Cliffs on west side of Paria River

QUAD: Lees Ferry 15'; Marble Canyon NTMS

DEVL: Trenches and short adits

PROD: 46 tons @ 0.47% U_3O_8; 1954, 1956

RAD: 200X

ANAL: 2.3% e U_3O_8; 2.4% U_3O_8 up to 1% Cu

GEOL: Small discontinuous pods and stringers with secondary uranium minerals associated with carbonaceous matter and some copper staining in thin sandstone beds of the Chinle Fm. possibly Petrified Forest Mbr.

REF: PRR-RR-200 (#154)
Tagg (1957
USAEC TM-212

RIDENOUR MINE

LOC: NE¼, Sec. 6, T31N, R8W

QUAD: Vulcans Throne SW 7½'; Grand Canyon NTMS
Underground Inclined shaft

DEVL: 1000 tons copper ore in 1915-1916, mining began in 1870.

PROD: 14 tons @ 0.15% U_3O_8; 2.38% V_2O_5, 1962, mining began in 1870, 1000 tons of Cu in 1915-16.

RAD: 300X

ANAL: As high as 1.76% e U_3O_8; 2.11% U_3O_8; 10.83% V_2O_5 14.15% Cu, trace of cobalt.

GEOL: Uranium mineralization associated with copper carbonates, silicates and sulfides in collapsed, fractured and bleached Supai Fm. Inferred pipe-like body in the Supai Fm. Carnotite is associated with carbon. Thin coatings of metatyuyamunite on stope faces where groundwater seeps, illustrates surface concentration of uranium minerals by evaporation of mine water. Abundant volborthite (green copper vandate).

REF: Miller, R. Lovejoy, E. (1954, RME-2014)
U.S.A.E.C. (RME-2007)
Finch, W. (1967)
PRR-RA-14 (#139)
Breed and Roat (1974) p. 172
Osterwald (1965) p. 132-134

RIVERVIEW GROUP #1-9

LOC: North Central Sec. 8, T26N, R10E
Cameron

QUAD: Wupatki NE 7½; Flagstaff NTMS

DEVL: One 15' deep open pit with a 55' deep shaft from which most ore grade material came.

PROD: 508 tons @ 0.38% U_3O_8; 0.03% V_2O_5, 1956-57, low vanadium, but high copper ore.

ANAL: 3 samples @ 1.01-1.77% e U_3O_8; 1.35-2.48% U_3O_8

GEOL: Metatorbernite with considerable malachite in a 120 ft. diameter pipe-like structure. Chinle sediments have dropped into Moenkopi Fm. Ore in upper 55 ft. of pipe, mostly along a peripheral shear. Only producer pipe around Cameron.

REF: U.S.A.E.C. (1959, RME-141); Kerr, P. (1958)
Bollin, E. and Kerr, P. (1958)
Austin, S. (1964, RME-99)
Chemeweth and Blakemore (1961, Plateau)
Chenoweth (1960, TM-173)
Barrington and Kerr (1973) p. 1248.

RYAN #1

LOC: Approx. SE¼ Sec. 34, T28N, R10E

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: Open pit

PROD: 311 tons @ 0.17% U_3O_8; 0.02% V_2O_5, 1957-58

GEOL: Carnotite-type mineralization in carbonaceous sandstone in the basal Petrified Forest member.

REF: D.O.E.

RYAN #2

LOC: NE¼ Sec. 11, T27N, R10E

QUAD: Wupatki NE 7½; Flagstaff NTMS

DEVL: Open pit common with Ramco #20 and #22

PROD: 2,066 tons @ 0.25% U_3O_8; 0.10% V_2O_5, in 1956-58

GEOL: Uraninite and secondary minerals associated with logs and carbon matter plus disseminated in sandstone of the basal Petrified Forest member. Refer to Ramco #20.

REF: D.O.E.

SAM CLAIMS

LOC: SE¼, Sec. 2, T39N, R6E. Upper Badger Canyon 2 miles NW of Vermilion Cliffs Lodge.

QUAD: Lees Ferry 15'; Marble Canyon NTMS

PROD: 11 tons @ 0.08% U_3O_8; 0.18% V_2O_5, 1957 from Sam #7

RAD: 100X

ANAL: 1.03% e U_3O_8

GEOL: Betazippeite and metatorbernite are interstitial in lenticular pods paralleling bedding in 30 ft. thick gray-red siltstone near top of Petrified Forest member.

REF: PRR-SL-208
Phoenix, D. (1963)

SANDY #1-3 CLAIMS

LOC: West central Sec. 12, T40 N, R7E
Vermilion Cliffs on east side of the Paria River

QUAD: Lees Ferry 15'; Marble Canyon NTMS

DEVL: Small pit

RAD: 80X

ANAL: 0.20% e U_3O_8

GEOL: Metahewettite and possibly other uranium minerals associated with carbon matter plus copper and iron staining in Shinarump channel deposit.

REF: PRR-RR-101 (#147)
PRR-RR-146 (#151)

SAUCER #1

LOC: Approx. Sec. 21, T34N, R4E
on rim of Saddle Canyon

QUAD: Nankoweap 15'; Marble Canyon NTMS

DEVL: Prospect

RAD: 100X

ANAL: 0.02-0.07% e U_3O_8

GEOL: Lens shaped mineralized zone in Coconino sandstone at contact with Hermit Shale. Associated copper carbonates, plus iron and manganese oxides.

REF: PRR-1378
PRR-SL-131

SECTION #1

LOC: Sec. 1, T27N, R9E, near Nordell claims

QUAD: Wupatki NE 7½; Cameron 15'; Flagstaff NTMS

DEVL: Pits

PROD: 79 tons @ 0.22% U_3O_8; 0.14% V_2O_5, 1954, 1959

GEOL: Mineralization in the Shinarump conglomerate

REF: D.O.E.

SECTION 9 (Upgrader Property; C.O. Bar Livestock Company, Milestone 1)

LOC: E½ Sec. 9, T27N, R10E
Cameron

QUAD: Wupatki NE 7½; Flagstaff NTMS

DEVL: 3 small pits and low grade ore from dumps from older workings. This is the location of the 1958-1960 "upgrader machine" mail fraud scheme of John Milton Addison and associates who convinced many that the machine could produce sellable grade ore from low grade ore from dumps. A jury trial ending Feb. 17, 1961 convicted six associates of fraud, conspiracy, and federal securities laws violations.

PROD: 386 tons @ 0.13% U_3O_8, 1957-1962, includes about 5 tons from E½ of Sec. 16, south of Sec. 9, in same channel. 22 tons @ 0.16% U_3O_8 from "upgrader" scandle in 1959-60; rest of production is legitimate.

GEOL: Mineralization in southern extension of Shinarump channel containing the Huskon 26, Huskon 11, and New Liba ore bodies.

REF: D.O.E.

SHADOW MOUNTAIN COLLAPSE (A & B#7)

SILICA PLUGS

LOC: Centered 14 miles NW of Cameron townsite in unsurveyed country - see NTMS map locations below.

QUAD: Flagstaff and Marble Canyon NTMS

DEVL: Some minor drilling in 1950's.

GEOL: Radioactivity associated with 9 resistant masses probably representing hydrothermal silica plugs which crop out in Triassic Moenkopi Fm. Pyrite, Fe-Mn-Cu staining, anhydrite, and argillic alteration are associated with the plugs. Moenkopi beds bleached around plugs. Highest radioactivity at plug perimeters.

REF: Barrington and Kerr (1963)

SILVER CLOUD

LOC: Approx. T41, 42N, R12½ E
Cummings Mesa on Arizona-Utah Border

QUAD: Navajo Creek (Arizona) and Cummings Mesa (Utah) 15'; Marble Canyon NTMS

RAD: Airborne anomaly

GEOL: Cummings Mesa is capped by Salt Wash member

REF: Air anomaly map A-14-74
D.O.E.

SLOAN #1 (Henry Sloan #1)

SNAFU CLAIMS

LOC: "Take road north from Rt. 89 about 1½ miles west of Marble Canyon Lodge. Go 5 miles to claims in deeply dissected bench at the base of the Vermilion Cliffs.

QUAD: Lees Ferry 15'; Marble Canyon NTMS

RAD: 40X

ANAL: 0.004 -0.36% e U_3O_8

GEOL: Mineralized argillaceous sandstone in Petrified Forest member bounded above and below by red-purple clay beds. Red-yellow jasper displays needles of uranophane.

REF: PRR-RR-277 (#164)

SUN VALLEY MINE (Jay Bird Claims)

LOC: SW¼ Sec. 6, T38N, R6E
Vermillion Cliffs

QUAD: Emmet Wash 15'; Marble Canyon NTMS

DEVL: 400 ft. of underground workings

PROD: 286 tons @ 0.285% U_3O_8; 1955-56

RAD: 20X

GEOL: Uraninite associated with carbon matter and pyrite, sphalerite, galena. Secondary minerals include zippeite, betazippeite and uranyl phosphate. Molybdenum content is as high as 10%, as ilsemanite and unusually high rhenium @ 0.07 - 1.5%. Mineralization in a Shinarump scour channel in Moenkopi. The chert-quartz pebble conglomerate is in a U-shaped bend, 1,000 ft. long by 400 ft. wide and contains 130 ft. of Shinarump. Best ore in basal 4 feet of channel.

REF: PRR-RR-253 (#158a)
Petersen, R. and others (1959)
Petersen, R. (1960)
U.S.G.S. (1957, TEI-690)
Petersen, R. (1959, TEI-435)
Tagg (1957)
USAEC TM-212

TAYLOR REID #2

LOC: SE¼ Sec. 36, T28N, R9E

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: Shallow cuts

PROD: 91 tons @ 0.32% U_3O_8, 1954

GEOL: Secondary minerals in sandstone of the basal Petrified Forest member.

REF: D.O.E.

THOMAS #1

LOC: Sec. 22, T38N, R7E
Echo Cliffs

QUAD: Tanner Wash 15'; Marble Canyon NTMS

DEVL: 100 X 40X 20 ft. deep open pit, rim stripping, 2 small adits.

PROD: 154 tons @0.10% U_3O_8, 1954, 1958, 1960

RAD: 100X

ANAL: 0.05–0.48% e U_3O_8

GEOL: Secondary mineralization in sand and clay lenses of the Petrified Forest member. Beds dip 10 to 15°SE.

REF: PRR-RR-213 (#156)

TOMMY CLAIMS (Navajo Springs, adjacent to June Claims)

LOC: Sec. 23, T39N, R7E

QUAD: Lees Ferry 15'; Marble Canyon NTMS

DEVL: 800 ft. rim stripping with 100 X 20 X 10 ft. deep cut.

PROD: 40 tons @ 0.37% U_3O_8, 1956

GEOL: Secondary mineralization in basal sandstone of the Petrified Forest member.

REF: D.O.E.

TWIN TANKS

LOC: Sec. 14, T30N, R8W
Aubrey Cliffs - north of Peach Springs

QUAD: Prospect Point 7½'; Williams NTMS

DEVL: Small pit worked for copper, probably during WWI

RAD: 3X

GEOL: Hematite and copper carbonates near base of Kaibab limestone.

REF: PRR-AP-117 (#105)

UNNAMED A

LOC: Approx. T40N, R7E
3 miles east of Marble Canyon Lodge on left side of Lees Ferry Raod

QUAD: Lees Ferry 15'; Marble Canyon NTMS

DEVL: Small pit

RAD: 500X

ANAL: 0.12% e U_3O_8; 0.17% U_3O_8

GEOL: Radioactivity associated with copper carbonates and vanadium minerals in Shinerump Conglomerate channels cut into Moenkopi.

REF: PRR-RR-155 (#152)

UNNAMED B

LOC: SE¼, Sec. 13, T30N, R8W

QUAD: Prospect Point 7½; Williams NTMS

DEVL: 12 holes drilled

RAD: 500 cps

GEOL: Conglomerate lens in Kaibab or Toroweap limestone. Copper carbonates coat limestone clasts. Radioactivity associated with iron-stained, vuggy rock of pulverized carbonate.

REF: D.O.E.

UNNAMED C

LOC: Approx. T26N, R2E - 25 miles north of Grand Canyon Junction, ½ mile east of road near south rim of Canyon.

QUAD: Grand Canyon NTMS

DEVL: 2 open pits (10 X 20 ft.) connected by tunnel 40 ft. long and 15 ft. deep.

PROD: Shipped a few tons of copper ore about 1910-1920

RAD: 3X

ANAL: 0.10% U_3O_8; 6.3% Cu

GEOL: Radioactivity in small areas at tunnel portals in copper-stained sandstone of flat-lying Moenkopi as a 1 sq. mi. residual hill on Kaibab limestone.

REF: PRR-UP-349

UNNAMED D

LOC: Approx. 2 miles NW of Calvin Chee Claim over sand dune to prominent cliff

QUAD: Leupp 15'; Flagstaff NTMS

DEVL: Prospect pit

RAD: 20X

ANAL: 0.03% e U_3O_8; 0.03% U_3O_8

GEOL: Mineralization about 1/3 way up 150 ft. cliff of Chinle with abundant carbon matter, fossil wood and limonite staining. Uranium may be in halos around logs.

REF: PRR-EDR-255.

UNNAMED E

LOC: "Take first road west, north of bridge at Leupp, near stone house. Follow this road for 6 miles NNW of Leupp."

QUAD: Probably Grand Falls NE 7½'; Flagstaff NTMS

DEVL: Prospect pit

RAD: 70X

GEOL: Carbonaceous-rich Petrified Forest member with fossil wood, gypsum and specs of possibly schroeckingerite.

REF: PRR-EDR-254

UPGRADER PROPERTY (Section 9)

VERMILION #1 MINE

LOC: NE¼ Sec. 20, T38N, R5E
On Emmett Hill South of U.S. 89

QUAD: Emmett Wash 15'; Marble Canyon NTMS

DEVL: Open pit, 12,000 ft. of drilling

PROD: Few tons of low grade ore

GEOL: Metatorbernite in Shinarump conglomerate channel and in siltstones of the Moenkopi. Channel scour is about 300 X 50 X 20 ft. deep. Two parallel channels are present in area. Largest one trends N 25° E through center of Section 17.

REF: Petersen, R. (1957, TEI-690)
Tagg (1957)
USAEC TM-212

WARD TERRACE (Hosteen Nez Mining Company Tract)

LOC: Approx. Sec. 5, T27N, R12E

QUAD: Badger Spring 7½'; Flagstaff NTMS

DEVL: Rim stripping

PROD: 61 tons @ 0.10% U_3O_8; 0.10% V_2O_5, 1950, 1952, 1956

RAD: 6X

ANAL: 0.42% e U_3O_8; 0.44% U_3O_8

GEOL: Black carbonaceous conglomerate and sandy shales in Kayenta Fm. Manganese oxides (psilomelane) and carbonized wood with secondary uranium minerals.

REF: PRR (#89); PRR-UP-76
Ellsworth, P. (1952, TM-7)

WHITE MESA COPPER CLAIM (Arizona Claim)

LOC: Approx. S. center Sec. 5, T37N, R9E

QUAD: Marble Canyon NTMS

DEVL: Old copper mine

GEOL: Torbernite associated with oxidized copper minerals in white to gray, cross-bedded (Navajo) sandstone.

REF: PRR-RG-35-51 (#144)
Emmons, S. (1905) Hill, J. (1914)

WILLAHA GROUP (Copper #1)

YAZZIE #1

LOC: Approx. NE¼ Sec. 15, T27N, R10E
Cameron

QUAD: Wupatki NE 7½'; Flagstaff NTMS

DEVL: 100 X 150 X 30 ft. deep open pit

PROD: 343 tons @ 0.19% U_3O_8; 0.07% V_2O_5, 1956-57

GEOL: Uraninite and secondary uranium minerals in Petrified Forest member. Ilsemannite identified. Ore zone 3.5 ft. thick and at a depth of about 20 ft.

REF: U.S.A.E.C. (1959, RME-141)
Austin, S. (1964, RME-99)

YAZZIE #2

LOC: Approx. NW ¼ Sec. 14, T27N, R10E
Cameron

QUAD: Wupatki NE 7½; Flagstaff NTMS

DEVL: 2 adits in bottom of 170 X 130 X 50 ft. deep pit

PROD: 5,646 tons @ 0.20% U_3O_8; 0.01% V_2O_5, 1957-61

GEOL: Uraninite in Petrified Forest member. Ore zone 4 ft. thick and at a depth of 45 ft.

YAZZIE #101

LOC: Approx. SW¼ Sec. 19, T29N, R10E

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: Open pit

PROD: 4,955 tons @ 0.22% U_3O_8; 0.02% V_2O_5, 1956-58, 1960-61

GEOL: Lens-like mineralized NW trending scour channel in lower Petrified Forest member. Fossil logs, carbon matter, limonite, gypsum and kaolin associated with uranium minerals. Crystalline sulfur in vugs in logs. Halotrichite, jarosite and metasideronatrite identified.

REF: U.S.A.E.C. (1959, RME-141)
Bollin, E. and Kerr, P. (1958)
Austin, S. (1964, RME-99)

YAZZIE #102

LOC: E. central edge Sec. 19, T28N, R10E

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: 190 X 70 X 50 ft. deep pit

PROD: 1,610 tons @ 0.30% U_3O_8; 0.08% V_2O_5, 1956-57, 1960-61

GEOL: Uraninite associated with carbonaceous logs at an average depth of 42 ft. and with average thickness of 2 ft. Coffinite, metazippeite boltwoodite and marcasite identified.

REF: U.S.A.E.C. (1959, RME-141)
Bollin, E. and Kerr, P. (1958)
Austin, S. (1964, RME-99)

YAZZIE #105

LOC: W. central Sec. 29, T28N, R10E

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: Extension of Charles Huskon #10

PROD: Reported with Charles Huskon #10

GEOL: Uraninite in sandstone lens in basal Petrified Forest member.

REF: U.S.A.E.C. (1959, RME-141)

YAZZIE #312 (Foley #5)

LOC: Approx. NW¼ Sec. 30, T29N, R10E

QUAD: Cameron 15'; Flagstaff NTMS

DEVL: 40 ft. deep open pit filled with water

PROD: 7,376 tons @ 0.23% U_3O_8, 1956-61

GEOL: Autunite, uraninite associated with gypsum, chalcedony, jarosite, limonite, calcite and some sulfides in NNW trending paleochannel in lower Petrified Forest member. Schroeckingerite fills fractures in logs undergoing oxidation.

REF: U.S.A.E.C. (1959, RME-141)
Bollin, E. and Kerr, P. (1958)
Austin, S. (1964, RME-99)

YELLOW JEEP

LOC: Approx. Sec. 25, T29N, R11E

QUAD: The landmark 7½'; Flagstaff NTMS

DEVL: Rim stripping and several short adits

PROD: 121 tons @ 0.17% U_3O_8; 0.56% V_2O_5, 1957

ANAL: 0.037% e U_3O_8; 0.035% U_3O_8

GEOL: Uraninite, tyuyamunite and possibly becquerelite associated with carbonized wood and manganese oxides in lenticular bodies up to 70 ft. long and 12 ft. thick. Mineralization also replaces clay pebbles, coats fractures and bedding surfaces in a shaly sandstone of lower Kayenta Fm.

REF: Granger, H. (1951, TEM-304)
Granger, H. and Raup, R. (1962)

Index for Gila County Uranium Occurrences

(Excluding Gila County District Map Occurrences)

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M 46 Rick Tick and Lady Ester
M 54 Rock Canyon
H 8 Roxy
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M 35 Sally May
M 12 Sentinal
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M 60 Snakebit
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M 55 Unnamed B
M 87 Unnamed C
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M 25 Unnamed E
M 28 Unnamed G
M 33 Uranium
H 20 Walnut Creek
M 80 Yotambrien, Hamilton, Pinto, Carlotta
M 24 York

M = Mesa
H = Holbrook

GILA COUNTY

ABLE GROUP #1-15

LOC: Approx. SE¼ Sec. 25, T8N, R12E or 34° 00'20"N, 111° 04'15" W, Just SE from Buzzard Roost Camp in unnamed tributary To Rock Creek

QUAD: Diamond Butte 15'; Buzzards Roost Mesa 7½'; Holbrook NTMS.

DEVL: 60 X 30 ft. dozer cut and 50 ft. adit.

PROD: 5 tons @ 0.25% U_3O_8 stockpiled in 1957.

RAD: 22X

ANAL: 0.35% e U_3O_8

GEOL: Secondary uranium mineralization noted on floor of canyon in Dripping Spring Quartzite. No diabase closeby.

REF: PRR-AP-351
Schwartz, R. (1957, RME-2071)

ALTA VISTA GROUP

LOC: Approx. Sec. 4,5,8,9, T4N, R14E

QUAD: Rockinstraw Mtn. 15'; Mesa NTMS

DEVL: Dozer trenches and benches

RAD: 20X

ANAL: 0.056% eU_3O_8

GEOL: Radioactivity with limonite - stained N20°E trending fractures with shows of copper carbonates. Faulting to the east.

REF: PRR-AP-250
Granger, H. and Raup, R. (1969 b)

AMERICAN ASBESTOS CEMENT COMPANY CLAIMS

Includes the following claims:
- Buckhorn Mine (Buckhorn #6)
- Cherry Creek Claims
- Home Mine (Wilson #13 claim)*
- No. 1 Mine (Wilson #15 claim)
- No. 2 Mine (Vosberg #18 claim)
- No. 4 Mine (Wolf Spring #2 claim)
- No. 7 Mine (Wolf Spring #8 claim)
- Shepp #1 (Wilson Creek)*
- Smith
- Tony Mine (Wilson #4 claim)
- Walnut Creek (Vosberg claims)*
- Wilson Creek claims
- Wolf Springs Mine (Wolf Springs #4 claim)
- York #1-4 (Stockman Group)*

*Occurrence listed separately.

ANCIENT CLAIMS

LOC: Sec. 23,24, TCN, R14E

QUAD: McFadden Peak 15'; Mesa NTMS

DEVL: 28 ft. drift and pit

RAD: 20X

ANAL: 0.11% e U_3O_8; 2.25% Cu

GEOL: Radioactive zone 6 inches above thin quartz - fluorite veins with chalcopyrite in black slates of the upper siltstone member, Mescal Limestone.

REF: PRR-A-93
U.S.A.E.C. (1970, RME-156), Granger and Raup (1969a) p. 103

ANDY GUMP PROSPECT

LOC: Approx. center N½ Sec. 34, T7N, R14E or 33°54' 40'N; 110°54' 10" W.E. side of Cherry Creek Canyon 0.7 mi. S. of China Spring Creek

QUAD: McFadden Peak 15'; Mesa NTMS

DEVL: 42 ft. adit; 17 ft. crosscut

RAD: 30X

ANAL: 0.13-0.72% U_3O_8

GEOL: Metatorbernite with sparse disseminated pyrite and efflorescent white sulfate in fine-grained black facies of Dripping Spring Quartzite. A E-W trending, 25 ft. wide diabase dike is 200 ft. south of adit. Ore zone is 3 ft. wide along a fracture trending N20°E.

REF: PRR-AP-239
Swartz, R. (1957, RME-2071)
Granger, H. and Raup, R. (1969b)

ANOMALY B6-1

LOC: SW¼ of NE¼ sec 14, T5N, R13E. in west side of canyon draining Mystery Spring

QUAD: McFadden Peak 15'°, Mesa NTMS

RAD: 2X; discovered with airborne radiometric

GEOL: Upper member, Dripping Spring Quartzite, with some weak iron oxide staining.

REF: PRR-EDR-1277

ANOMALY B6-2 (Refer to Anomalies B6-3 and B6-4)

LOC: NW¼ Sec. 19, T5N, R15E

QUAD: McFadden Peak 15'; Mesa NTMS

RAD: 60X-discovered by airborne radiometric

ANAL: 0.05-0.33% e U_3O_8; 0.04-0.08% U_3O_8

GEOL: Upper member, Dripping Spring Quartzite. Limonite staining and pyrite noted.

REF: PRR-EDR-1278

ANOMALY B6-3 (Refer to Anomalies B6-2, B6-4)

LOC: North central part sec 19, T5N, R15E

QUAD: McFadden Peak 15'; Mesa NTMS

RAD: 20X - discovered by airborne radiometric

GEOL: Upper member, Dripping Spring Quartzite. Some iron oxide staining.

REF: PRR-EDR-1279

ANOMALY B6-4 (Refer to Anomalies B-62, B6-3, and Donna Lee)

LOC: East central part sec 13, T4N, R14E

QUAD: McFadden Peak 15'; Mesa NTMS

RAD: 2X - discovered by airborne radiometric

ANAL: 0.17% e U_3O_8

GEOL: Upper member, Dripping Spring Quartzite, some iron oxide staining

REF: PRR-EDR-1280

ANOMALY B6-5

LOC: SW¼, SE¼, SE¼ sec 4, T6N, R14E - near Black Brush claims. Vertical cliffs, west side Cherry Creek

QUAD: McFadden Peak 15'; Mesa NTMS

RAD: 150X - discovered by airborne radiometric
0.38% e U_3O_8; 0.35% U_3O_8

GEOL: Radioactivity in vertical fractures trending N20°E and along bedding planes in black to dark red quartzite of Dripping Spring Quartzite.

REF: PRR-EDR-1281

ANOMALY B6-6

LOC: NW¼, SE¼, SW¼ sec 12, T6N, R14E
near cliff rim, NW side Horse Camp Creek

QUAD: McFadden Peak 15'; Mesa NTMS

RAD: 10X - discovered by airborne radiometric

GEOL: Upper member, Dripping Spring Quartzite, with some iron oxide staining and calcite vein fillings.

REF: PRR-EDR-1282

ANOMALIES B6-7, 8,9,10,11

LOC: NW¼ and SE¼ of NW¼ sec 19, T6N, R14E - at Little Joe Mine, Workman Creek

QUAD: McFadden Peak 15'; Mesa NTMS

RAD: 50X - discovered by airborne radiometric

GEOL: Upper member, Dripping Spring Quartzite. Weak iron oxide staining. Six radiometric anomalies in a favorable zone of the Quartzite average 5-10X over considerable distance.

REF: PRR-EDR-1283-1287

ANOMALY B6-12

LOC: S½ sec 14, T8N, R14E

QUAD: Young 15', Holbrook NTMS

RAD: 7X

ANAL: 0.01% U_3O_8

GEOL: Upper member, Dripping Spring Quartzite. No visible uranium minerals.

REF: PRR-EDR-1303

ANOMALY B6-13

LOC: NE¼ sec 1, T6N, R12E - at Blevins Canyon claims

QUAD: Copper Mtn 7½'; Mesa NTMS

RAD: 3X

ANAL: 0.01% U_3O_8

GEOL: Highest counts obtained along vertical fractures trending N35°W and along adjacent bedding planes in the flat-lying quartzites of Dripping Spring Quartzite.

REF: PRR-EDR-1304

ANOMALY B6-14

LOC: E½ sec. 35, T8N, R11E
Near head of Del Shay Creek -1.6 miles WNW of North Star Claims

QUAD: Picture Mtn. 7½'; Mesa NTMS

RAD: 2X

GEOL: Radioactivity in flat lying beds of upper Dripping Spring Quartzite with some limonite staining.

REF: PRR-EDR-1305 (#337)

ANOMALY B6-15

LOC: 33°59'55"N; 111°2'45"W
Near Perky Butte Tank - 0.5 mi. S. of Able Group

QUAD: Copper Mtn. 7½'; Mesa NTMS

RAD: 3X - discovered by airborne radiometric

GEOL: Radioactivity along random fracture planes in upper member, Dripping Spring Quartzite. Some limonite staining present.

REF: PRR-EDR-1306

ANOMALY B6-16 (Refer to Anomaly B6-17)

LOC: Approx. sec. 23, T5N, R17E, 33°46' 08"N, 110° 30' 50" W; 0.2-0.3 miles west of Hwy. 77-60, 0.4 miles

QUAD: Blue House Mtn. 15'; N of turnoff to Regal Asbestos Mine, Mesa NTMS

DEVL: Test pit

RAD: 2X

ANAL: 0.01%, U_3O_8

GEOL: Silty arenaceous horizon at top of Mescal Limestone. Other Apache Group sediments and Redwall Limestone present nearby.

REF: PRR-EDR-1307

ANOMALY B6-17 (Refer to B6-16)

LOC: Approx. Sec. 23, T5N, R17E, 33°46' 00"N, 110° 30' 40" W

QUAD: Blue House Mtn. 15'; Mesa NTMS

RAD: 4X

ANAL: 0.01%, U_3O_8

GEOL: Silty sandy phase of upper portion of Mescal Limestone, overlain by Troy Quartzite and Redwall Limestone.

REF: PRR-EDR-1308

ANOMALY B6-18

LOC: Sec. 21, T6N, R15E, (protracted) 33°51'00" N, 110° 44' 50" W., along Mustang Ridge, 1.3 miles WNW of VABM 6171.

QUAD: Blue House Mtn. 15'; Mesa NTMS

RAD: 15X - discovered by airborne radiometric

ANAL: 0.03% U_3O_8

GEOL: Red silty layer in upper member, Dripping Spring Quartzite where it overlies Precambrian Granite.

REF: PRR-EDR-1309

ASH CREEK #1

LOC: Probably in east flowing tributaries to Ash Creek, west of Chrysotile Mine.

QUAD: Chrysotile 7½; Mesa NTMS

RAD: 3X

GEOL: Radioactivity along vertical fracture planes in the upper, thin-bedded siltstone member of the Dripping Spring Quartzite.

REF: PRR-AP-190

BEAR TRACK (BIG BUCK GROUP)

BEE CAVE #1-10

LOC: Approx. W½ sec. 18, T3N, R17E; 33°36' N; 110° 37' 05" W. South flank of Rock Springs Butte

QUAD: Sevenmile Mtns, 7½'; Mesa NTMS

DEVL: 500 ft. of rim stripping

PROD: 5 tons @ 0.04% U_3O_8; 0.02% V_2O_5, 1955

RAD: 15X

ANAL: 0.10% e U_3O_8

GEOL: Mineralization along fractures in rhyolite intrusive which cuts Precambrian Granite, also intruded by diabase and overlain by basal Apache Group.

REF: PRR-AP-395 (#317)

BIG BUCK GROUP (Bear Track, Cyprus, Snow White)

LOC: Near center S½ sec. 25, T6N, R14E, west side of Cherry Creek ½ mi. S of Cold Spring Canyon

QUAD: McFadden Peak 15'; Mesa NTMS

DEVL: 40 ft. rim stripping and 145 ft. adit trends S20°W

PROD: 279 tons @ 0.17%, U_3O_8, 1956-57

RAD: 100X

ANAL: 0.40%, U_3O_8

GEOL: Uranium along NNE trending limonite filled fractures in fine-grained black facies within silty member of Dripping Spring Quartzite. Ore zone is about 3 ft. wide. Saleeite and Bassetite noted in ore zone along with thin calcite and discontinuous purple fluorite veinlets. Mineralized fractures trend N70° W and N20°E. Deposit very near a major flexure of the Cherry Creek Monocline.

REF: PRR-A-61
Granger, H. and Raup, R. (1969a & b)
Schwartz, R. (1957, RME-2071)

BIG SIX GROUP (Citation #1-5)

LOC: West of center, sec. 4, T6N, R14E - 33°53'28" N; 110°55' 23" W. Near Sorrel Horse and Black Brush - West wall of Cherry Creek Canyon.

QUAD: McFadden Peak 15'; Mesa NTMS

DEVL: 3 adits and drill holes

RAD: 50X

ANAL: 0.16- 2.36% U_3O_8

GEOL: Spotty uranium mineralization with limonite in gray facies of Dripping Spring Quartzite, about 10-35 ft. above diabase. Highest radioactivity associated with N70°W trending fractures. One mile east of Cherry Creek Monocline.

REF: Granger, H. and Raup, R. (1969b, p.10)

BLACK BESS CLAIMS (To Tamhien)

BLACK BRUSH GROUP

LOC: SE¼ SE¼ sec. 4, T6N, R14E or 33°53'08"N; 110° 54' 53" W, near Sorrel Horse and Big Six

QUAD: McFadden Peak 15'; Mesa NTMS

DEVL: 64 ft. drift, 15 ft. crosscut; benching; 60 ft. drift

PROD: 19 Tons @ 0.09% U_3O_8; 1955-56

ANAL: 1.5% U_3O_8

GEOL: Uraninite associated with minor pyrrhotite, chalcopyrite, marcasite, galena, pyrite and torbernite near surface. Mineralization localized at the intersection of fractures in black facies of Dripping Spring Quartzite. Diabase is 80 ft. below. Ore body averages 1.5 ft. thick and trends NNE along fractures.

REF: PRR-AP-310
Granger, H. and Raup, R. (1969 a & b)
Schwartz, R. (1957, RME-2071)
Sharp, B. (1956, RME -2036)

BLACK DIAMOND GROUP

LOC: South central NE¼ sec. 32, T5N, R14E
0.5 miles NNE of Rainbow Claims

QUAD: Rockinstraw Mtn. 15'; Mesa NTMS

DEVL: Considerable workings and 10 ft. drift along N80° W fracture

PROD: Asbestos prospect

RAD: 50X

GEOL: Autunite, metatorbernite bassetite with minor pyrite and abundant limonite and white fluorescent sulfate in the upper black facies of Dripping Spring Quartzite. Vertical fractures trend WNW.

REF: PRR-AP-337
Granger, H. and Raup, R (1969b)

BLACK HAWK SHAFT (Iron Cap Mine, Williams Shaft)

LOC: Near center SW¼ sec. 15, T 1N, R15½E, 33°25' 05"N, 110°46' 05"W

QUAD: Globe 7½'; Mesa NTMS

DEVL: 700 ft. inclined shaft; drifts at 100 and 700 ft. level

PROD: Copper, gold, silver, 1912-1927

RAD: 26X

ANAL: 4% e U_3O_8; 3.67% U_3O_8
0.15-6.2% U_3O_8 - waste dump of the Williams Shaft.

GEOL: Vein along contact of Mescal Limestone and diabase intrusion contains cuprite, malachite and uranium minerals. Strike is ENE and dip 65°NW.

REF: PRR-AP-146
Schwartz, R (1957, RME-2071); Peterson, N. (1962)

BLACK INSURANCE CLAIMS

LOC: 33°31' 10"N, 110° 53'W
Along Hicks Wash, on both sides of Hwy. 88, 0.6 miles W. of BM 3075

QUAD: Rockinstraw Mtn. 15'; Mesa NTMS

RAD: 6X

ANAL: 0.12% e U_3O_8

GEOL: Vein in granite rocks

REF: PRR-AP-220

BLEVINS CANYON CLAIMS

LOC: Approx. NE¼ sec. 1, T6N, R12E or 33°53' 40"N; 111°4' 20" W

QUAD: Copper Mtn. 7½; Mesa NTMS

DEVL: 110 ft. adit; 40 ft. drift; several drill holes

RAD: 100X

ANAL: 0.03 -0.35% e U_3O_8

GEOL: Metatorbernite with abundant copper and limonite staining in fine-grained arkosic sandstone of upper member in paleo channel cut into middle member of Dripping Spring Quartzite. NW trending Copper bearing veins are nearby.

REF: PRR-AP-257
Granger, H. and Raup, R. (1969b)
Schwartz, R. (1957, RME -2071)

BLUE BONNET #1-4 (Midget #1-7)

BLUE EAGLE CLAIMS

LOC: NE¼ sec. 10, T6N, R14E
West side of Cherry Creek

QUAD: McFadden Peak 15'; Mesa NTMS

DEVL: 33 ft. drift and bench

RAD: 36X

ANAL: 0.92% e U_3O_8

GEOL: Radioactivity in a 1 ft. thick zone in the upper part of the lower Dripping Spring Quartzite. Sulphur noted.

REF: PRR-A-105

BLUE ROCK GROUPS (Cherry Creek #4; Rockslide Group)

LOC: NW¼ NE¼ sec. 36, T6N, R14E
East face Cherry Creek Canyon

QUAD: McFadden Peak 15'; Mesa NTMS

DEVL: Several benches, open cuts through slope rubble, crudely aligned in NNE direction.

RAD: 100X

GEOL: At Blue Rock #2, radioactivity surrounding N20°E trending limonite-filled fracture; at Cherry Creek #4, radioactivity in N70°W trending vertical fractures. Some metatorbernite, bassetite, gypsum, and white florescent sulfate noted. All pits in black facies, 25-70 ft. above barren quartzite. Cherry Creek Monocline about 0.5 mile east of property. Alignment of pits is N 10°E.

REF: PRR-A-106
Granger, H. and Raup, R. (1969b)

BOBCAT (Brushy Basin Trap)

BOYLE GROUP 1 & 2

LOC: South edge sec. 9, T 15, R 14E (or possibly central sec. 10, SW of Miami by 24 miles.

QUAD: Pinal Ranch, 7½'; Mesa NTMS

RAD: 40X

GEOL: Pegmatitic biotite granite with quartz veins and joints. Concentrations of smarskite crystals reported.

REF: PRR-AP-113

BRONX COPPER CLAIMS

LOC: SW¼ sec. b, T15, R 14E

QUAD: Pinal Ranch 7½'; Mesa NTMS

DEVL: 6 shafts, 4 adits, several scattered prospect pits

PROD: Copper

RAD: 16X

ANAL: 0.05% e U_3O_8; 0.08% U_3O_8

GEOL: Quartz veins in biotite, granite porphyry (Schultze Granite). Copper oxides and sulfides in veins, radioactivity is disseminated. Veins strike NE, dip 65° SE.

REF: PRR-AP-156 and 176

BRUSH CLAIMS (Promontory Butte)

BRUSHY BASIN TRAP (Bobcat; also refer to Navajo)

LOC: Approx. NW¼ sec. 27, T7N, R14E or 33°55'36"N; 110°54'20"W

QUAD: McFadden Peak 15'; Mesa NTMS

DEVL: 145 ft. (N10°E) adit; 60 ft. (S30°W) adit, 4 drill holes

RAD: 25 X

ANAL: 0.17% e U_3O_8

GEOL: Disseminated metatorbernite, pyrite, limonite, sulfates with minor bassetite, saleeite and nontronite in upper black facias of Dripping Spring Quartzite.

REF: PRR-AP-366
Granger, H. and Raup R. (1969b, p.22)

BUBBLING SPRINGS (Stago)

BUCKAROO AND MARY ANN CLAIMS

LOC: Secs. 14 and 23, T5N, R13E
on flat mesa top surrounded on 3 sides by canyon walls

QUAD: McFadden Peak 15; Mesa NTMS

DEVL: Prospect pit

RAD: 50X in one spot with disseminated pyrite

GEOL: Upper member, Dripping Spring Quartzite exposed on Mesa Top which is surrounded on 3 sides by Vertical walls. Some scattered disseminated pyrite noted.

REF: PRR-AP-200

BUCKAROO FLATS (Cataract Claims)

BULL CANYON (Sue Claims)

CARLOTTA CLAIMS (Yo Tambien)

CARROL ANN CLAIMS

LOC: Approx. NE¼ sec. 14, T2N, R14E, south of Lake Roosevelt, 1 mile west of Black Insurance Claims, 2.2 miles SSE of Salt River Peak

QUAD: Rockinstraw 15'; Mesa NTMS

DEVL: Prospect pits

ANAL: 0.30% e U_3O_8

GEOL: Thin, iron-rich, uranium bearing rhyolitic dikes are present in Precambrian Granite or near the Granite-Pioneer Shale contact.

REF: Schwartz, R. (1957, RME-2071, p. 15)
Waechter, N. (1979)

CASTLE DOME COPPER MINE (Red Hill)

LOC: 33° 24' N, 110°57' 30" W,

QUAD: Inspiration 7½'; Mesa NTMS

DEVL: Castle Dome open pit copper mine

RAD: 8X

ANAL: 0.17% e U_3O_8; 0.22% U_3O_8

GEOL: Quartz Monzonite parphyry intruded by diabase sills and dikes. N-S trending fault contains radioactivity minerals. Copper-iron sulfide and oxide minerals are mined. Metatorbernite noted.

REF: PRR-AP-135
Peterson, N. and others (1951)
Ransome (1903)
Weathers (1953)

CATARACT (Buckaroo Flats; Mike #1-4)

LOC: Approx. SE¼ SW¼ sec. 19, T7N, R13E
North slope of Cataract Canyon on southward projecting nose of Middle Mtn.

QUAD: Copper Mtn. 7½'; Mesa NTMS

DEVL: 100 ft. drift and some drilling

RAD: 35X

ANAL: 0.21% e'U_3O_8

GEOL: Metatorbernite, autunite, pyrite, limonite, malachite, chrysocolla and chalcopyrite weakly disseminated and along fractures in Dripping Spring Quartzite. Apparently in lower part of upper member in shallow channel cut in middle member.

REF: PRR-AP-353
Granger, H. and Raup, R. (1969b, p. 24)

CHARLES JR. #1-2 (Suckerite)

CHERRY CREEK #4 (Blue Rock)

CHRISTMAS COPPER MINE

LOC: 33°03' 30"N; 110°44' 30" W

QUAD: Christmas 7½'; Mesa NTMS

DEVL: Large open-pit and extensive underground

PROD: Base metals

RAD: 5X

GEOL: Mineralized Laramide intrusive into Paleozoic Limestones

REF: PRR-AP-198

CITATION #1-5 (Big Six Group)

CONWAY #1-17

LOC: Approx. South Central sec. 27, T7N, R12E, or 33° 55'05" N; 111°06' 47"W SW, slope of Copper Mtn. between Malicious gap and Mud Spring Canyon

QUAD: Copper Mtn. 7½'; Mesa NTMS

RAD: 26X

ANAL: 0.66% e U_3O_8

GEOL: Autunite, metatorbernite and disseminated sulfides in upper member of Dripping Spring Quartzite, cut by copper-bearing quartz vein.

REF: PRR-A-92

COON CREEK GROUP

LOC: 33°41' 30" to 42' 30"N, 110° 52' to 53' W

QUAD: Rockinstraw Mtn. 15; Mesa NTMS

DEVL: Discovery pits

RAD: 30X

ANAL: 0.01% e U_3O_8

GEOL: Dripping Spring Quartzite exposed in canyon walls SE side of Hackberry Mtn, with mountain capped by Mescal Ls.

REF: PRR-AP-241 and 271

COPPER CITIES COPPER MINE

LOC: Sec. 6, T1N, R15E

QUAD: Globe 7½', + Inspiration 7½'; Mesa NTMS

DEVL: Open pit copper mine

PROD: Major producer of copper

RAD: 8X

ANAL: 0.06% U_3O_8

GEOL: N-S trending shears contain metatorbernite and turquoise. And disseminated radioactivity in quartz monzonite of Laramide age in certain parts of pluton.

REF: PRR-AP-136 and 155
Still, A. (1962)

CRYING JEW (Horseshoe)

CYPRUS (Big Buck Group)

DALE 1-5

LOC: Approx. S½ sec. 10, T4S, R15E
Northslope of Tam O'Shanton Pk.

QUAD: Hayden 7½'; Mesa NTMS

RAD: 100X

ANAL: 0.05% e U_3O_8

GEOL: Radioactive zone 4 inches thick can be traced for 0.3 mi. around nose of ridge and occurs in upper Dripping Spring Quartzite. Quartzite is in intricately faulted terrain. Diabase is 2000 ft. to the north.

REF: PRR-A-74
Banks, N. and Kreiger, M. (1977)

DEEP CREEK GROUP (Lamanite Deposit)

DEFINITELY (Suckerite)

DESERT QUEEN (Refer to Interstate Group)

LOC: Central part sec. 2, T3S, R15E

QUAD: El Capitan 7½'; Mesa NTMS

DEVL: Drilling, shallow pits

ANAL: 0.29% U_3O_8

GEOL: Metatorbernite along fracture in Dripping Spring Quartzite

REF: D.O.E.

DEVILS CHASM (Devils Charm)

LOC: South central sec. 36, T6N, R14E

QUAD: McFadden Peak 15'; Mesa NTMS

GEOL: Refer to Blue Rock Group

REF: Schwartz, R. (1957, RME-2071, Fig. 4)

DON GROUP (Jon Deposit)

DONNA LEE

LOC: E½ SE¼ sec. 13, T5N, R14E
West wall of Deep Canyon near Juniper Claims

QUAD: McFadden Peak 15'; Mesa NTMS

DEVL: 3 adits and crossant

PROD: 12 tons @0.16% U_3O_8, 1959

RAD: 140X

ANAL: 0.29% e U_3O_8

GEOL: Uraninite or pitchblende in strongly weathered and oxidized black facies of the Dripping Spring Quartzite. Metatorbernite, pyrite, secondary copper minerals noted. Major fault to the west and diabase sills below.

REF: PRR-AP-262;
Granger, H. and Raup, R. (1969b, p. 27)
Schwartz, R. (1957, RME -2071)

DUTCH BOY CLAIMS

LOC: Approx. sec. 31, T3N, R16E or 33°33'N, 110° 43' 30" W, up Corral Creek 3/4 mile from old highway.

QUAD: Chrome Butte, Az. 7½'; Mesa NTMS

DEVL: Location pit

RAD: 20X

ANAL: 0.30% e U_3O_8

GEOL: Precambrian coarse grained granite intruded by thin sheets of fine-grained granophyre which carries specularite and some invisible uranium mineralization. Pioneer shale contact is 50 ft. above workings.

REF: PRR-AP-329
Waechter, N. (1979)
Schwartz & Mase (1955)

EASTER GROUP (Refer to Coon Creek Claims)

LOC: In Coon and Cougar Canyons, 2-4 miles NW of Cherry Creek Access Road, 4-6 miles east from Red Bluff deposit. Exact location not known.

QUAD: Rockinstraw Mtn. 15'; Mesa NTMS, Gila Co. detailed occurrance map.

DEVL: Discovery pit

RAD: 20X
0.1% e U_3O_8

GEOL: Upper member Dripping Spring Quartzite, 200 ft. below contact with Mescal Limestone. Highest readings from a zone 1 ft. thick.

REF: PRR-AP-223

EASY CLAIMS

LOC: Approx. SE¼ sec. 35, + 7N, R13E
SW slope of McFadden Peak, 1¼ mi. WSW of lookout Tower

QUAD: McFadden Peak 15'; Mesa NTMS

DEVL: 70 ft. opencut and drilling

RAD: 12X

ANAL: 0.02 - 0.42% e U_3O_8

GEOL: Metatorbernite, uraniferous opal, saleeite, bassetite, metazeunerite, covellite and limonite coating fractures and bedding planes in gray to pink siltstones of Dripping Spring Quartzite. Finely disseminated pyrite and chalcopyrite distributed also through 3 ft. interval of upper-part of middle member.

REF: PRR-A-6
Granger, H. and Raup, R. (1957, RME-2071)

ESCONDIDO CLAIMS

LOC: Center N½, sec. 9, T6N, R14E, on steep slopes of eastern scarp of McFadden Horse Mtn.

QUAD: McFadden Peak 15, Mesa NTMS

DEVL: Prospect pits

GEOL: See geology of nearby Sorrel Horse and Black Brush claims

REF: Schwartz, R. (1957, RME-2071, Fig. 4)

FAIRVIEW CLAIMS

LOC: Approx. South Central Sec. 12, T6N, R12E or 33°52' 19", 111° 4' 42" W

QUAD: Armer Mtn. 7½'; Mesa NTMS

DEVL: Drilling; pit

RAD: 150X

ANAL: 0.56% e U_3O_8

GEOL: Autunite, metatorbernite, bassetite, uraniferous hyalite and uranophane in 1 ft. zone of upper Dripping Spring Quartzite. Strong fracturing, Diabase above and to NE

REF: PRR-AP-336
Granger, H. and Raup, R. (1969b, p. 32)
Schwartz, R. (1957, RME -2071)
Granger, H. and Raup, R. (1959)

FIRST CHANCE DEPOSITS

LOC: NE¼ SE¼ Sec. 1, T5N, R13E
Sierra Ancha 0.4 mi. north of Parker Canyon Experimental Station

QUAD: McFadden Peak 15'; Mesa NTMS

DEVL: 3 adits (NNE trending)

PROD: 35.53 tons @ 0.08% U_3O_8, 1957

RAD: 50X

ANAL: 0.20% e U_3O_8; 0.21% U_3O_8

GEO: Metatorbernite, bassetite, uraniferous hyalite, malachite, azurite on fractures with limonite, chalcanthite, and sulfate. Chalcocite pyrite and chalcopyrite disseminated. NNE trending fractures are in black facies of Dripping Spring Quartzite.

REF: Granger, H. & Raup, R. (1969a & b)
PRR-AP-207
Granger, H e Raup, R. (1959)
Mead, W. and Wells, R. (1953, RME-4037)

FOSSIL CREEK

LOC: Elev. 5120 ft., 1.0 mile west of High Point of Nash Point, 34° 25' 15" N. 111° 33' 45" W. and at elev. 4640-80 ft. east side of Mud Tank Draw, 0.5 mile N. of Fossil Creek, 34° 26' 18"N, 111° 34' 00" W.

QUAD: Strawberry 7½"

DEVL: Prospected for coal bed in 1960's - one large open-pit

ANAL: 0.3% Cu; 3-8 ppm U by weight in sandstone.

GEOL: Supai Fm, 500-600 ft. below Ft. Apache Limestone. Associated with limestone pebble conglomerate close to carbonaceous shale and thin coaly seams.

REF: Peirce, H. and others (1970)
Peirce, H. and others (1977)

FOUR BAGGER

LOC: North central edge SW¼ sec. 2, T1N, R15½ E

QUAD: Globe 7½'; Mesa NTMS

RAD: 7X

GEOL: Dripping Spring Quartzite with iron stained fractures and intruded to the north and west by diabase.

REF: PRR-AP-131

FRAN #1-5 (Interstate Group)

FRINGE (Grand Chance)

FROG and IRON claims

LOC: Secs 3,4,9,10 and common corner Secs 8,9,16,17, T9N, R15E.

QUAD: Young 15', Holbrook NTMS

RAD: 3-5X.

GEOL: Anomalous radio activity in the upper dark member of Dripping Spring Quartzite just below iron oxide mineralization in the lower Mescal Limestone.

REF: AEC file data

GEM #2 (Hope)

GENERAL #1

LOC: Center Sec. 13, T5N, R13E
1-8 mi. NW of Asbestos Point near Buckaroo Claims

QUAD: McFadden Peak 15'; Mesa NTMS

RAD: 30X

ANAL: 0.03% e U_3O_8

GEOL: Radioactivity along fractures in Dripping Springs Quartzite. Bed strike N10°W and di- 10°NE. Fractures strike N75°E, dipping 86°SE and N20-30°E dip 80°NW

REF: PRR-AP-189

GIGER CLAIMS

LOC: SW¼ SE¼ Sec. 5 and NW¼ Sec. 8, T6N, R11E east edge of Tonto Basin - east of Punkin Center

QUAD: Picture Mtn. 7½'; Mesa NTMS

DEVL: Drilling

RAD: 400X

ANAL: 0.5% U_3O_8 in lignite

GEOL: Late Miocene - Pliocene fine grained clastic sediments are depositional on Precambrian Granite and are somewhat locally deformed. Tuffaceous clastics, mudstones, and several black lignitic beds are present. Certain mudstones and the lignitic beds count. Other radioactive lignites outcrop in NW¼ SE¼ Sec. 8, T6N, R11E.

REF: PRR-AP-339
Arizona Bureau of Geology Data
Waechter, N. (1979)

GRAND CHANCE (Fringe; Late Comer

LOC: Approx. SE¼ Sec. 25, T7N, R12E
1.2 miles NNW of Buck Pk below Buckaroo Tank

QUAD: Copper Mtn. 7½'; Mesa NTMS

RAD: 3X

GEOL: Metatorbernite in the upper member of Dripping Springs Quartzite

REF: PRR-AP-237

GRAND GAIN (Great Gain)

GRAND VIEW CLAIMS

LOC: NE¼ SE¼ Sec. 18, T5N, R14E

QUAD: McFadden Peak 15'; Mesa NTMS

DEVL: 60 ft. drift trends ENE

RAD: 14X

GEOL: Radioactivity, associated with fractures in Dripping Spring Quartzite cut by thin aplitic and pegmatitic dikes. The quartzite is metamorphosed and about 15 ft. above diabase.

REF: PRR-AP-249
Granger, H. and Raup, R. (1969b, p. 39)

GRANDVIEW (Tomato Juice)

GRANITE #1-28 CLAIMS

LOC: West edge Sec. 22 and east edge Sec. 21, T4N, R14E; 33°40' 30" N, 110° 55'10-30" W.

QUAD: Rockinstraw Mtn. 15'; Mesa NTMS

RAD: 8X

ANAL: 0.04% e U_3O_8

GEOL: Highest counts in specular hematite in "rhyolite intrusions" cutting granite. Shattered zone along low angle thrust near base of Apache Group.

REF: PRR-A-44

GRANTHAM AND MOTLEY

LOC: Approx. Sec. 36, T3N, R14E
Sierra Ancha - along Pinal Creek

QUAD: Rockinstraw Mtn. 15'; Mesa NTMS

DEVL: Prospect pits

RAD: 4X

GEOL: Calcite and chert breccia filling fractures in Mescal Limestone, trenching N55°W and dipping 40° NE. Fractures trend N30°W and dip 35° SW.

REF: PRR-AP-142

GREAT GAIN (Grand Gain; Spring Creek)

LOC: Approx. SW¼ SW¼ SE¼ Sec. 30, + 7N, R13E, 33° 54' 52"N; 111° 3' 32" W south side of JR Canyon 0.93 miles NNE of Buck Pk.

QUAD: Copper Mtn. 7½'; Mesa NTMS

DEVL: 30 ft. adit, pits, drilling

ANAL: 0.06% e U_3O_8 on stockpile

GEOL: Metatorbernite, meta-autunite, urainferous hyalite and limonite along fractures and disseminated in Dripping Spring Quartzite at bottom of middle member.

REF: Granger, H. and Raup, R. (1969b, p. 40)

GREYSTONE, DOCTOR, FRISCO, et. al.

LOC: Sec. 18-19, T. 1S, R 14E

QUAD: Pinal Ranch 7½'; Mesa NTMS

DEVL: Copper and gold mines

RAD: 9X

GEOL: Veins in granite and Pinal Schist

REF: RME-156
Waechter, N. (1979)

GRINDSTONE CLAIMS

LOC: NE¼ NW¼ Sec. 25, T6N, R14E
West side of Cherry Creek

QUAD: McFadden Peak 15'; Mesa NTMS

DEVL: Surface scrapings and pits

RAD: 100X

ANAL: 0.19% e U_3O_8; 0.11% U_3O_8

GEOL: Uraniferous hyalite, pyrite, pyrrhotite limonite along fractures trenching NNE and WNW in moderately metamorphosed back facies of Dripping Spring Quartzite.

REF: PRR-A-28
Granger, H. and Raup, R. (1969b, p. 43)

GROUP 2 (Ichi Ban #1-17)

GRUBSTEAK, IRON HILLS AND OVERSIGHT CLAIMS

LOC: Sec. 34, + 2S, R1SE and Sec. 3, T3S, R1SE

QUAD: El Capitan 7½', Mesa NTMS

DEVL: Several drifts and shafts

PROD: Gold, silver, copper

RAD: 4X

GEOL: Mineralization along faults in Dripping Spring Quartzite overlain by Mescal Limestone and underlain by diabase sill. Faults trend NNW and beds dip 20°SW.

REF: PRR-A-30

HAMILTON CLAIMS (Yo Tambien)

LOC; 33° 42' 40"N, 110° 38' W, claims up Bronson Canyon 11.0 miles is along Haystack Butte Road from Hwy. 77, about 1 mile south of Haystack Butte.

QUAD: Haystack Butte 7½'; Mesa NTMS

RAD: 4X

GEOL: Strata within silicified Pioneer Shale are anomalous, near its base of deposition upon older granites. Beds around claims dip 10-30°N. Diabase intrudes the granite in area.

REF: PRR-A-99

HARDROCK #1-12

LOC: 33° 30' 20"N; 110° 43' 40" W
1.3 miles SW of Richmond Mtn.

QUAD: Chrome Butte 7½'; Mesa NTMS

DEVL: Prospect pits

RAD: 20X

ANAL: 0.28% e U_3O_8

GEOL: Thin micropegmatitic intrusion along contact between granite capped by silicified Pioneer Shale.

REF: PRR-AP-272

HEIGH POWER CLAIMS

LOC: SE¼ Sec. 1 or NE¼ Sec. 12, T5N, R13E

QUAD: McFadden Peak 15', Mesa NTMS,

DEVL: One exploration pit, one drill hole

RAD: 50X

ANAL: 0.06% e U_3O_8

GEOL: Upper Dripping Spring Quartzite, exposed on SW flank of ridge between Carr Mt. and Grantham Pk. Iron staining, pyrite, chalcopyrite, and sparce metatorbernite noted.

REF: PRR-AP-321

HIGHGRADE (Highway)

HIGHWAY AND HIGHGRADE GROUP

LOC: NE edge of Sec. 6, T1N, R16E
about 2 mi. east of Quartzite Pk.

QUAD: Cammerman Wash 7½'; Mesa NTMS

RAD: 4X

GEOL: Tilted block of Dripping Spring Quartzite and Mescal Limestone intruded by diabase. Local dips up to 25°SW.

REF: PRR-AP-253

HILLSIDE #1-10

LOC: 33° 47-48'N, 110° 36-37'W on hilltop bounded on west by cliffs, 1.5-2 miles SSW of Regal Asbestos Mine.

QUAD: Blue House Mtn. 15'; Mesa NTMS

DEVL: Discovery pit

RAD: 20X

ANAL: 0.268% e U_3O_8

GEOL: Radioactivity associated with disseminated pyrite, gypsum and calcite in upper member of Dripping Spring Quartzite. Diabase is below and Mescal Limestone above.

REF: PRR-AP-233

HOME MINE (American Asbestos Cement Co.)

LOC: 800 ft. east of center of Sec. 20, T8N, R15E
0.5 miles west of Wilson Creek

QUAD: Young 15'; Holbrook NTMS

DEVL: Home Mine, developed for asbestos

PROD: None for uranium

RAD: 20X on limonite alteration at surface; 5X underground

ANAL: 10 samples: 0.01-0.22% e U_3O_8

GEOL: Mescal Limestone intruded by thin diabase sills one small area of intense limonite mineralization exposed near surface. Asbestos serpentine, magnetite and calcite present.

REF: PRR-AP-152

HOPE (Gem #2)

LOC: E½ NE¼ Sec. 30, TGN, R14E
NE slope of Workman Creek about 1.5 miles upstream from Young-Globe Raod

QUAD: McFadden Pk. 15'; Mesa NTMS

DEVL: 4 adits in excess of 1000 ft. of workings

PROD: 9056 Tons @ 0.30%, 1955-57 and 1960
Largest producer in Sierra Anchas.

GEOL: Uraninite is main ore mineral disseminated and as stringers and pods paralleling stratification of hornfels. Pyrrhotite, molybdenite, sphalerite, chalcopyrite, galena, pyrite, and marcasite noted. Minor uranophane and metatorbernite noted. Ore in upper member of Dripping Spring Quartzite in at least three steeply dipping vein zones of NNE trend. Adit No. 1 follows a zone of brecciation that is filled with pale red hornfels, with degree of metamorphism increasing upward. Ore zone is concentrated about 5-30 ft. above underlying diabase sill.

REF: PRR-AP-289
Granger, H. and Raup, R. (1969a & b)
Schwartz, R. (1957, RME -2071)

HORSEHOE MINE (Crying Jew)

LOC: Sec. 10, T6N, R14E
West side of Cherry Creek

QUAD: McFadden Peak 15'; Mesa NTMS

DEVL: 150 ft. drift

PROD: 23 tons @ 0.19% U_3O_8 plus
14 tons @ 0.09% U_3O_8 " no pay ore" in 1955-56.

RAD: 100X

ANAL: 0.45% e U_3O_8

GEOL: Small pods of ore and pyrite filled fractures in Dripping Spring Quartzite. Paper thin veins of Sphalerite along partings and bedding planes. Claims on down-dropped block fault. Radioactivity follows shattered and contorted strata. Ore zone is 2 to 8 ft. thick and lies within 1-4 ft. of the hanging wall of a NNE trending reverse fault which dips 45°W.

REF: PRR-A-102
Granger, H. and Raup, R. (1969a & b)
Schwartz, R. (1957, RME-2071)

HOT CINDERS 1-5

LOC: Sec. 5, T8N, R11E, in Brushy Hollow Canyon, NE of Cottonwood Mtn., 1.7 miles E of Tonto Creek.

QUAD: Gisela 7½'; Holbrook NTMS

RAD: 15X

ANAL: 0.14% e U_3O_8; 0.13% U_3O_8

GEOL: Highly metamorphased older Precambrian Quartzite, foliation strikes N40°E with vertical dip. Radioactivity in thin limonitic band. Quartz stringers parallel to foliation.

REF: Schwartz, R. (1957, RME-2071, Fig. 4)

HOT ROCK CLAIMS (Promontory Butte)

HOT SPOT

LOC: West Sec. 4.9, T6N, R14E
West wall of Cherry Creek

QUAD: McFadden Peak 15'; Mesa NTMS

RAD: 50X

GEOL: Radioactivity and iron oxides in upper member of Dripping Spring Quartzite.

REF: PRR-AP-219

HOT TOMALE CLAIMS

LOC: Sec. 33, T11N, R13E
Steep walls of Christopher Creek along N flank Christopher Mtn.

QUAD: Woods Canyon 15'; Holbrook NTMS

RAD: 3X

GEOL: Upper Dripping Spring Quartzite, beneath Troy Quartzite is thin bedded, shaley silicified siltstone with muscovite in shale partings. Units dip 40° SE. Some Limonite after pyrite noted.

REF: PRR-AP-324

ICHI BAN #1-17 (Group 2)

LOC: Sec. 14, T8N, R14E
1 mile east of Cherry Creek

QUAD: Young 15'; Holbrook NTMS

DEVL: Pit

RAD: 12X

GEOL: Anamalous radioactivity over 50 ft. stratigraphic interval in lower Dripping Spring Quartzite. Group 2 claims across Cherry Creek have high counts in Troy Quartzite.

REF: PRR-AP-365

INTERSTATE GROUP (Sky #1-5; Fran #1-5; Zora #1-5, Peanuts; see also Desert Queen)

LOC: E½ Sec. 3, W½ Sec. 2, T3S, R15E

QUAD: El Capitan 7½'; Mesa NTMS

DEVL: Short adit, shallow pit, drilling

RAD: 15X

GEOL: Metatorbernite along fractures and bedding planes in silty upper member of Dripping Spring Quartzite. Some pyrite, malachite, limonite, gypsum and barite noted. Beds dip 20 to 30°S.

REF: PRR-AP-229;
Granger, H. and Raup, R. (1969b, p. 118)
Cornwall, H. and Kreiger, M. (1978)

IRIS CLAIM

LOC: Approx. NE¼ Sec. 3, T4N, R14E
In bottom of tributary canyon ¼ mi. west of Oak Creek Canyon, one mile north of Couger Canyon

QUAD: Rockinstraw Mtn. 15'; Mesa NTMS

DEVL: Several pits; 95 ft. adit (South trending)

RAD: 100X

ANAL: 0.29% e U_3O_8; 0.24% U_3O_8

GEOL: Metatorbernite, uranophane and pyrite disseminated and along fractures in gray facies of Dripping Spring Quartzite. Beds dip 5° ENE.

REF: PRR-AP-290
Granger, H. and Raup, R. (1969b)

IRISH BARCO (Alta Vista Group)

IRON CAP MINE (Black Hawk Shaft)

IRON HILLS CLAIMS (Grubstack)

IZZY CLAIMS

LOC: Approx. in north central Sec. 28, T. 7N., R.13E
On rim of canyon at SE corner of Redman Mesa, 2.1 miles SE of hill 5954 (Middle Mtn.)

QUAD: Copper Mtn, 7½'; Mesa NTMS

RAD: 20X
0.2% e U_3O_8

GEOL: Metatorbernite, iron oxides and pyrite in upper member of Dripping Spring Quartzite.

REF: PRR-AP-369

JACK POT CLAIMS

LOC: Approx. Sec. 6, T10N, R14E
Along Chamberlain Trail in steep walled part of Haigler Creek

QUAD: Young 15'; Holbrook NTMS

RAD: 3X

GEOL: Dripping Spring Quartzite with low easterly dip

REF: PRR-AP-260

JACKIE #1-4 (Lucky Chance; Uranium)

LOC: 33° 42'10" N; 110°55' 20"W
SE of Alta Vista #2 Group, about 1.3 miles NW of Hackberry Mtn.

QUAD: Rockinstraw Mtn. 15'; Mesa NTMS

DEVL: Small pits and shallow trenches

RAD: 15X

ANAL: 0.21% e U_3O_8; 0.48% Cu

GEOL: Radioactivity and copper oxides along obscure NNE Trending vertical fracture and disseminated in a zone 0.5 to 1.5 ft. away from fractures, in upper member of Dripping Springs Quartzite.

REF: PRR-AP-180 and A-109

JIM #1

LOC: Center Southern Boundary SW¼ Sec. 30, T5N, R14E
First Water Canyon

QUAD: Rockinstraw Mtn. 15'; Mesa NTMS

DEVL: 20 ft. drift along limonite-stained fractures

RAD: 7X

ANAL: 0.045% e U_3O_8

GEOL: Irregular vein-like mineralization in lower 20 ft. of gray facies of Dripping Spring Quartzite. Some pyrite, abundant limonite and sulfate efflorescence noted.

REF: PRR-AP-238 and 202
Granger, H. and Raup, R. (1969b, p. 59)

JON MINE (Don Group)

LOC: S½ SW¼ Sec. 29, T6N, R14E, on NE side of Workman Creek about 1.7 miles upstream from Globe-Young Road

QUAD: McFadden Pk. 15'; Mesa NTMS

DEVL: 180 ft. adit with workings now flooded

PROD: 206 Tons @ 0.10% U_3O_8, 1956

ANAL: 0.06% e U_3O_8; 0.07% U_3O_8 -
chemical assays averaged 20-30% higher than radiometric assays - typical of the Workman Creek Deposits.

GEOL: Uranium, pyrite, sphalerite, galena, and pyrrhotite in NNE trending fracture fillings in hornfel and gray facies of Dripping Spring Quartzite - 12 ft. above diabase sill. Strong faulting, and some aplite dikes. Ore zone about 2 ft. thick.

REF: PRR-AP-225
Granger, H. and Raup, R. (1969a & b)
Schwartz, R. (1957; RME-2071)

JUNCTION CLAIM

LOC: 33° 44' 25"N, 110°34'05"W, along Ash Creek, about 0.7 mile south of north boundary of quadrangle, 1.0 miles SE of hill 5758.

QUAD: Chrysotile 7½', Mesa NTMS

DEVL: Trenching and benching

RAD: 3X

ANAL: 0.18% U_3O_8

GEOL: Thin bedded, upper siltstone member of Dripping Spring Quartzite contains vertical radioactive fracture planes.

REF: PRR-AP-190
Schwartz, R. (1957, RME -2071)

JUNIPER #4

LOC: NE¼ NE¼ Sec. 23, T5N, R14E, on Mesa Tops between Coon and Deep Creeks

QUAD: McFadden Peak 15'; Mesa NTMS

RAD: 20X

ANAL: 0.04% e U_3O_8

GEOL: 16 inch thick zone in upper member, Dripping Spring Quartzite, 200 ft. below Mescal Limestone. Refer to Donna Lee Claims

REF: PRR-AP-224

JUNIPER HILL 1-10

LOC: 33° 56'15", 111° 10' 30"W, on south flank of Juniper Mtn.

QUAD: Picture Mtn. 7½'; Mesa NTMS

RAD: 7X

GEOL: Radioactivity and some disseminated pyrite in unoxidized beds of upper member of Dripping Spring Quartzite.

REF: PRR-AP-312

KING 1-3

LOC: NW¼ Sec. 7T1S, R14½E.
(33° 21' 32" N, 110° 52' 45" W)
south of Miami to Cherry Flat Picnic area - up common 1/3 mile from Warnica Picnic Area

QUAD: Pinal Ranch 7½'; Mesa NTMS

DEVL: 2 adits to 280 ft., one shaft, one open trench 1000 ft. to SE along cat road.

RAD: 70X

ANAL: 0.41% e U_3O_8

GEOL: Five foot wide quartz vein trends N40°W, dips 65° NE through Precambrian Solitude Granite. 1.5 ft. wide vein counts, and has minute fractures partially sealed with copper oxides. Metatorbernite was recognized in vein system, and radioactivity has persisted along strike of the vein.

REF: PRR-AP-96; Weathers, G. (1954, RME-2016)
WAECHTER, N. (1979)

KING SNAKE CLAIM (Tomato Juice)

KULLMAN - McCOOL MINES

LOC: NE¼ of SE¼ Sec. 28, T4S, R15E.
1.6 miles due west of Toronado Peak

QUAD: Hayden 7½'; Mesa NTMS

DEVL: Kullman-McCool Mines, operated for copper and lead. Upper workings are two parallel adits 150 ft. long, 125 ft. crosscut, 100 ft. winze. Lower workings are several small adits, cuts and stopes along 400 ft. of outcrop.

PROD: Copper

RAD: 3X

GEOL: ENE trending fault contact between Miss. Penn. Limestones and late Cretaceous Volcanics, with related sills and dikes intruding the limestones. Crosscut in upper working contains pod which counts to 3X. Pyrite, chalcopyrite, cerrusite, wulfenite, vanadinite, malachite, tenorite, manganese stains.

REF: PRR-M-905
Banks, N. and Kreiger M. (1977)

L and V prospect

LOC: Secs 27, W½26, S½22, T1N, R15½E

QUAD: Globe 7.5', Mesa NTMS

DEVL: Considerable prospecting

RAD: 3X

GEOL: Radioactivity in areas of Dripping Spring and Troy Quartzites, and an anomalous vein.

REF: ABG file data

LADY ESTER (Rick Tick)

LAMANITE (Deep Creek Group)

LOC: Approx. S. Sec. 18 and N. Sec. 19, T5N, R15E and NE¼ Sec. 24, T5N, R14E.

QUAD: McFadden Peak 15'; Mesa NTMS

DEVL: Drilling

RAD: 200X

ANAL: 0.25% U_3O_8

GEOL: Uraninite with other sulfides in 1-2 ft. wide zone along NNE trending vertical fracture zone in Dripping Spring Quartzite.

REF: PRR-AP-274
Schwartz, R. (1957, RME -2071)

LATE COMER (Grand Chance)

LITTLE IODINE CLAIMS

LOC: South central Sec. 21, T11N, R12E
N. flank Saddle Mtn. about 0.5 mile S 10°E of Kohls Ranch.

QUAD: Promontory Butte 15'; Holbrook NTMS

RAD: 3X

GEOL: Red-colored granite in fault or intrusive contact with Paleozoic Limestone. Granite contains large quartz "blebs". No mineralization of copper, etc. noted.

REF: PRR-AP-325

LITTLE JOE

LOC: NE¼ SW¼ Sec. 19, T6N, R14E, on north side of Workman Creek about 0.5 mi. E of Globe-Young Road

QUAD: McFadden Peak 15'; Mesa NTMS

DEVL: 5 adits, open cuts

PROD: 2703 tons @ 0.20% U_3O_8, 1956-1960

ANAL: 0.30% e U_3O_8

GEOL: Most ore comes from NNE trending zones sometimes marked by pyrite oxidation to limonite. Obvious fractures do not seem to control mineralization. Uraninite occurs as small streaks parallel to relict bedding and as blebs in feldspar crystals in brecciated hornfels. Minor urarophane and metatorbernite.

REF: PRR-AP-311
Granger, H. and Raup, R. (1959, 1969a & b)
Schwartz, R. (1957, RME-2071)

LITTLE SIX #1 (Alta Vista Group)

LOBO (Sorrel Horse)

LONESOME JOHN

LOC: SW¼ Sec. 4, or NW¼ Sec. 9, T9N, R14E

QUAD: Young 15', Holbrook NTMS

RAD: 65X

ANAL: 0.09% e U_3O_8

GEOL: Precambrian Granite containing white quartz veins and radioactive pods or lenses of fine-grained maroon-colored intrusive material. Same occurrence type as Dutch Boy claims (A-P-329) and Hardrock claims (AP-272)

REF: PRR-AP-368

LORIAN (Lost Dog)

LOST DOG (Melinda Mine; Lorian)

LOC: SW¼ NE¼ Sec. 30, T6N, R14E
South side of Workman Creek about 1 mile upstream from Globe-Young Road near Lucky Stop.

QUAD: McFadden Peak 15'; Mesa NTMS

DEVL: 4 adits and open cut

PROD: 1562 tons @ 0.13% U_3O_8; 0.15% V_2O_5, 1954-56

ANAL: 0.04% e U_3O_8; 0.04% U_3O_8

GEOL: Metatorbernite along fractures and bedding planes in Dripping Spring Quartzite with diabase sill 10-30 ft. below. Also noted are uraniferous hyalite, pyrite, chalcopyrite and galena. Vertically tabular ore zone trends NNE.

REF: PRR-AP-232
Granger, H. and Raup, R. (1959, 1969a & B)

LOVE #1-10 CLAIMS

LOC: Approx. Sec. 23, T7N, R12E; 33°56-57'N, 111°5-6 W along Jakes Tank Canyon, 0.5 to 1 mile north of Copper Mtn.

QUAD: Copper MTN. 7½'; Mesa NTMS

RAD: 7X

GEOL: Upper Dripping Spring Quartzite overlain by Mescal Limestone and dipping gently east.

REF: PRR-A-29

LUCKY #1-8

LOC: Approx. Sec. 18, T5N, R12E

QUAD: Armer Mtn. 7½'; Mesa NTMS

RAD: 5X

GEOL: Flat lying Dripping Spring Quartzite with diabase sill below.

REF: PRR-AP-263

LUCKY BOY

LOC: North central Sec. 31, 32, T2S, R15E
¼ mile W. of Old Pioneer Stage Station Raod in Mescal Mtns.

QUAD: El Capitan Mtn. 7½; Mesa NTMS

DEVL: 2 adits and workings

PROD: 2336 tons @ 0.17% U_3O_8 1956-57
In excess of 10,000 lbs. U_3O_8 brine concentrate in 1979.

GEOL: Finely disseminated uraninite associated with mica in a chloritic shear zone with concordant bedding in Dripping Spring Quartzite. Pyrite, pyrrhotite, chalcopyrite, metatorhernite, bassetite, fluorescent opal, uranophane, limonite, gypsum and jarosite noted. Ore zone is a part of a tilted fault block, dipping 20-30°W and 50 ft. above a concordant diabase sill. Ore zone stratigraphically controlled with secondary control being along numerous NE trending fractures. Main ore body is in equilibrium, but dark zone above ore body and containing metatorbernite is out of equilibrium (high radiometric)

REF: PRR-AP-211
Granger, H. and Raup, R. (1969a & b)
Schwartz, R. (1957, RME-2071)
Cornwall, H. and Krieger, M. (1978)
Arizona Bureau of Geology Data

LUCKY CHANCE CLAIMS

LOC: Referred to as near Jackie claims of the Red Bluff Area in PRR-A-P-180 (1954)

LUCKY KING

LOC: Approx. SE¼ Sec. 36, T 2S, RISE
North slope of El Capitan Mtn.

QUAD: El Capitan Mtn. 7½'; Mesa NTMS

RAD: 20X

ANAL: 0.08% e U_3O_8

GEOL: Dripping Spring Quartzite dips 20° SW and is overlain by Mescal Limestone to the SW and intruded by diabase. Metatorbernite, pyrite, manganese and iron oxides noted.

REF: PRR-AP-355
Cornwall, H. and Krieger, M. (1978)

LUCKY STAR #1-14

LOC: Approx. 33°38'N, 110° 01'W,
along south side of Roosevelt Lake

QUAD: Windy Hill 7½'; Mesa NTMS

DEVL: Tungsten prospect

RAD: 3X

GEOL: Thin shale beds in Troy or Dripping Spring Quartzites are radioactive. Magnetite, ilmanite and Wolframite black sand in wash. Diabase exposed in canyon floor.

REF: PRR-AP-327

LUCKY STOP

LOC: NE¼ NW¼ Sec. 30, T6N, R14E,
SW side of Workman Creek about 0.6 mi. upstream from Globe-Young Road

QUAD: McFadden Peak 15'; Mesa NTMS

DEVL: 1000 ft. drift and crosscuts; 5 aits

PROD: 2847 Tons @ 0.16% U_3O_8, 1955-57

ANAL: 0.30% e U_3O_8; 0.32% U_3O_8

GEOL: Uraninite pyrite, sphene diopside marcasite along obscure NNE trending fractures and disseminated in black facies of Dripping Spring Quartzite. Some NNE veins of this property continue onto the Lost Dog property, just to the east. All the uraniferous veins on these properties terminate abruptly downward in barren quartzite and are developed vertically for no more than 40 ft. Veins appear to be in an en echelon pattern.

REF: PRR-AP-222
Granger, H. and Raup, R. (1969a & b)
Schwartz, R. (1957, RME-2071)

LUCKY STRIKE #1-25

LOC: 33° 41' 40"N; 110° 33' W
1.4 mile ENE of Timber Camp on Hwy. 60.

QUAD: Chrysotile 7½'; Mesa NTMS

DEVL: Shallow pits

RAD: 17X

ANAL: 0.042% e U_3O_8

GEOL: Highly oxidized Dripping Spring Quartzite

REF: PRR-AP-264

LULU BELLE #7 CLAIM

LOC: Probably NE¼ Sec. 21, TIS, RISE
Pinal Mtns.

QUAD: Pinal Peak, Az. 7½'; Mesa NTMS

DEVL: 2 inclined shafts, about 80 ft. deep, several drifts totalling 200 ft., portals caved in 1955.

PROD: $12,000 in Au, Ag, Cu during 1924-1927

RAD: Ore pile shaft counts 35X

ANAL: 5.2% Cu, 2.3% Ag, 0.2-0.7% e U_3O_8; 0.3-0.7% U_3O_8

GEOL: Fissure vein in Pinal sericite schists contain pyrite, chalcopyrite, bornite, galena, and gold, and is radioactive. Uranophane and uraninite noted as discontinuous blebs along fissure. Fissure vein trends E-W (± 40°), dips generally 50° northward, and is offset near bottom of mine by NNE trending fault.

REF: PRR-AP-36 (#496); Wells, (1955, RME-2026)
Waechter, N. (1979)

MACK CLAIMS

LOC: Approx. NE¼ Sec. 2, T6N, R13E; 33° 53' 80"N; 110° 59' 10"W.

QUAD: McFadden Pk. 15, Mesa NTMS

DEVL: Discovery pit

RAD: 12X

ANAL: 0.18% e U_3O_8

GEOL: Metatorbernite with iron oxides in thin silty lenses at or near the contact of upper and lower members of Dripping Spring Quartzite.

REF: PRR-A-101

MADERA #15

LOC: Sec. 24, T1S, R 14½ E, probably in Pinto Creek, SW of Madera Peak

QUAD: Pinal Ranch 7½'; Mesa NTMS

DEVL: One 40 ft. adit into hillside trends NNE

RAD: 7X

ANAL: 0.03% e U_3O_8

GEOL: Vein in Madera Diorite contains Cu, Fe minerals and anomalous radioactivity.

REF: PRR-AP-145

MAJOR HOOPLE

LOC: Near center S½ Sec. 26, T7N, R14E, on tributary of China Spring Creek about 1 mi. E of Cherry Creek

QUAD: McFadden Pk. 15'; Mesa NTMS

DEVL: 28 ft. adit (S50°E) w/ several benches

RAD: 70X

GEOL: Autunite, metatorbernite, and some pyrite along fractures and bedding planes in gray facies of Dripping Spring Quartzite. N 70° W vertical fractures are most anomalous. Major faulting to the east.

REF: PRR-AP-354
Granger, H. and Raup, R. (1969b)

MARY #1

LOC: Center of N½, Sec. 12, T5N, R13E, claim just SW of Parker Creek Forest Service Experimentation Station along Roosevelt Dam, Globe Road.

QUAD: McFadden Peak 15; Mesa NTMS

DEVL: One prospect pit

RAD: 15X

ANAL: 0.05% e U_3O_8; 0.07% U_3O_8

GEOL: Dripping Spring Quartzite broken by ENE, N-S, and WNW trending fractures with some radioactive showings.

REF: PRR-AP-132

MARY ANN (Buckaroo Claims)

MAY CLAIMS

LOC: Approx. SE¼ NW¼ Sec. 31, T7N, R13E
½ Mi. ENE of Buck Pk.

QUAD: Copper Mtn. 7½; Mesa NTMS

DEVL: 2 small pits and drill hole

RAD: 20X

ANAL: 0.08% e U_3O_8

GEOL: Uraniferous hyalite, sparse metatorbernite and disseminated pyrite in Dripping Spring Quartzite. Discordant diabase along fault 100 ft. east. Some aplitic dikes.

REF: PRR-AP-349
Granger, H. and Raup, R. (1969b)

MAY 1-6 CLAIMS (American Asbestos Cement Co.)

LOC: Near center NE¼ Sec. 1, T7N, R14E, on walls of Rough Creek Canyon, 0.7 miles upstream from confluence of Wilson Creek. 0.8 miles SSW of Shepp No. 1 claims.

QUAD: McFadden Peak 15'; Mesa NTMS

GEOL: Dripping Spring Quartzite on mid slope of canyon, with Mescal Limestone capping further up hill. Radioactive zones some distance upslope from stream bottom.

REF: D.O.E.

MAYBE (Sorrel Horse)

MELINDA MINE (Lost Dog)

MIAMI COPPER COMPANY PROPERTIES

LOC: Sec. 7-18, T1N, R 14E

QUAD: Inspiration 7½; Mesa NTMS

DEVL: Copper mines

PROD: Base metals

RAD: 3X

GEOL: Veins in quartz monzonite

REF: U.S.A.E.C. (1970, RME-156, p. 44)

MIDGET #1-7 AND BLUE BONNET #1-4

LOC: 33° 55-56'N, 111° 02-03'W
In Canyons along steep southern slope of Redman Mesa-Spring Creek

QUAD: Copper Mtn. 7½'; Mesa NTMS

RAD: 6X

GEOL: Upper member of Dripping Spring Quartzite

REF: PRR-AP-370

MIKE #1-4 CLAIMS (Cataract Claims)

MONO (Snakebit)

MOONSHINE GULCH #1-18

LOC: NE¼ Sec. 28, T6N, R15E, 33° 50' 30"N, 110° 49'W. Rounded top and upper ledges of steeply sloping Hog Mountain

QUAD: McFadden Peak 15'; Mesa NTMS

RAD: 25X

GEOL: Upper member Dripping Spring Quartzite, beneath Mescal Ls. cap on Hog Mountain. Diabase dikes appear in Moonshine Gulch. Radioactive zones up to 2 ft. thick in sandstone, and concentrated along N75°W fractures.

REF: PRR-A-75

MYRTLE CLAIMS (Promontory Butte)

NAVAJO CLAIMS

LOC: Approx. N central Sec. 27, T 7N, R14E; 33°55'25"N, 110°54' 14"WE side near bottom of Cherry Creek-0.5 mi. N. of China Spring Creek.

QUAD: McFadden Pk 15'; Mesa NTMS

DEVL: 30 ft. adit and benching

RAD: 20X

GEOL: Sparse metatorbernite, abundant limonite in black facies of Dripping Spring Quartzite. N10° E fractures are anamalous.

REF: PRR-AP-240
Granger, H. and Raup, R. (1969b, p. 92)

NEPTUNE CLAIMS (Promontory Butte)

NORTH STAR CLAIMS

LOC: Approx. Center NW¼ Sec. 6, T7N, R12E
Gun Creek; 5 mi. NW of Copper Mtn.

QUAD: Picture Mtn. 7½'; Mesa NTMS

DEVL: 40 ft. adit (SSW), drill holes

RAD: 40X

GEOL: Metatorbernite, saleeite, and bassetite with limonite and sparse pyrite in Dripping Spring Quartzite. Secondary mineralization is along NNE trending fractures in gray facies.

REF: PRR-AP-265
Granger, H. and Raup, R. (1969b, p. 94)

OAK CREEK #1-4

LOC: E½ Sec. 34, T5N, R14E
West facing wall of Oak Creek Canyon

QUAD: Rockinstraw Mtn. 15'; Mesa NTMS

DEVL: One 70 ft. drift trending east, dug in 1955 or earlier.

RAD: 4X

GEOL: In cliff face of Dripping Spring Quartzite. Diabase dikes striking N30°E are in vicinity. Hematite, limonite staining in faces of drift.

REF: PRR-A-10 (#178)

OVERSIGHT CLAIMS (Grubstack)

PAMELA CLAIMS

LOC: Near center N½ Sec. 1, T5N, R14E, about 0.5 mile NE down canyon from Moody Point

QUAD: McFadden Peak 15, Mesa NTMS

DEVL: Prospected

GEOL: Upper member Dripping Spring Quartzite

REF: Schwartz, R. (1957, RME-2071, Fig. 4)

PEACOCK CLAIMS

LOC: 33°49' 17"N, 110° 32' 45"W
Southside Salt River Canyon

QUAD: Blue House Mtn. 15'; Mesa NTMS

DEVL: 4 small cuts

RAD: 20X

ANAL: 0.04-0.08% e U_3O_8 a 0.1-0.2% U_3O_8

GEOL: Uraniferous opal, pyrite and limonite in black facies of Dripping Spring Quartzite. N18°E fracture plane most radioactive.

REF: PRR-AP-258
Granger, H. and Raup, R. (1969b, p. 95)
Schwartz, R. (1957, RME-2071)

PEANUTS CLAIM (Interstate Group)

PINTO CLAIMS (Yo Tambien)

PRANTY, SURPRISE AND SENTINAL GROUP

LOC: Approx. S. Sec. 6, T7N, R12E

QUAD: Picture Mtn. 7½'; Mesa NTMS

DEVL: Drilling

RAD: 30X

GEOL: Metatorbernite in Dripping Spring Quartzite with low dip to SE.

REF: PRR-AP-236

PROMONTORY BUTTE (Neptune; Myrtle; Brush; and Hot Rock Claims)

LOC: NW¼, NE¼ and near center Sec. 24, T11N, R12E

QUAD: Promontory Butte 15'; Holbrook NTMS

DEVL: Short adit; large open cut; numerous small cuts; drilling programs in 1970's.

PROD: Less than 500 tons of low grade ore from Neptune property in 1979.

RAD: 40X

ANAL: 0.07% e U_3O_8; 0.07% U_3O_8; 55% $CaCO_3$

GEOL: Uraninite and Copper carbonates in gray sandy shales associated with limestone pebble conglomerate lenses and interbedded sandy redbeds, ascribed to Naco-Supai Fm. Abundant carbonized plant remains noted.

REF: PRR-A-55
Finch, W. (1967)
Peirce, H. and others (1977)
Blazey, E. (1971)

Q RANCH CLAIMS

LOC: SW¼ of SW¼ Sec. 15, T8N, R15E, 1.8 miles due south of Q Ranch headquarters.

QUAD: Young 15, Holbrook NTMS

DEVL: Prospects

GEOL: Upper Dripping Spring Quartzite

REF: Schwartz, R. (1957, RME-2071)

QUARTSITE CLAIMS

LOC: NW¼ Sec. 12 and parts of Sec. 1,2,11, T6N, R14E East wall of Cherry Creek, 1 mile north of Horse Camp Creek; Mesa, between Cherry and Horse Camp Canyons.

QUAD: McFadden Peak 15'; Mesa NTMS

DEVL: 150 ft. bench; one pit

RAD: 5X

ANAL: 0.26% U_3O_8

GEOL: Metatorbernite, iron oxides, malachite and minor pyrite in black facies of Dripping Spring Quartzite. Mineralization is along bedding planes and jointing.

REF: PRR-A-87
Granger, H. and Raup, R. (1969b, p. 97)

RAINBOW

LOC: NW¼ SE¼ Sec. 32, T5N, R14E, on small nose just south of Oak Creek

QUAD: Rockinstraw Mtn. 15'; Mesa NTMS

DEVL: 70 ft. adit

ANAL: 0.50% e U_3O_8

GEOL: Metatorbernite along fractures with disseminated pyrite and some graphite. One foot zone trends NNE in partly recrystallized black facies, Dripping Spring Quartzite.

REF: PRR-AP-179
Granger, H. and Raup, R. (1969a & b, 1959)
Schwartz, R. (1957, RME-2071)

RAMON

LOC: 33°13-14'N, 110° 49-50'W, about one mile east of Pioneer Pass Road - Pinal Mtns.

QUAD: El Capitan Mtn. 7½'; Mesa NTMS

RAD: 4X

GEOL: Dripping Spring Quartzite, with some limonite staining and striking N70°W, dip 30° SW.

REF: PRR- AP-141

RED BLUFF MINE

LOC: W½NE¼ SE¼ Sec. 31, T5N, R14E West side of Warm Creek

QUAD: Rockinstraw Mtn. 15'; Mesa NTMS

DEVL: 11 adits, drilled

PROD: 3009 Tons @ 0.19% U_3O_8; 0.03% V_2O_5, 1953-55 Third largest producer in Sierra Anchas.

ANAL: 0.04 -0.70% e U_3O_8 and to 2.0% U_3O_8

GEOL: Uraninite, metatorbernite, bassetite, meta-autunite, beta-uranophane, saleeite, kasolite, uraniferous opal, malachite, pyrite, chalcopyrite, galena, limonite disseminated and along fractures in Dripping Spring Quartzite. Mineralization in upper gray facies and lower black facies, along N20°E and N70°E sets of fractures. N20°E fractures parallel fault which is intruded by 150 ft. thick diabase dike with apparent 250 ft. eastside down movement. Ore grade appears to decrease away from dike.

REF: Kaiser, E. (1951, TEM-210)
Granger, H. and Raup, R. (1969a & b, 1959)
Schwartz, R. (1957, RME -2071)

RED CLIFF #1 MINE

LOC: West central Sec. 11, T.5N, R13E in Connor Canyon

QUAD: McFadden Peak 15'; Mesa NTMS

PROD: 7.4 tons @ 0.21% U_3O_8, 1955

RAD: 15X

GEOL: Dripping Spring Quartzite dipping 15°NE along Sierra Ancha monocline

REF: PRR-AP-208
Schwartz, R. (1957, RME-2071)
Granger, H. and Raup, R. (1969a, Fig. 1)

RED HILL (Castle Dome)

REGAL ASBESTOS MINE

LOC: 110° 36'W, 33°48'N.
In Regal Canyon, south side of Salt River, about 6.5 air miles NW of Seneca on Hwy. 60-77; elevation 4300'.

QUAD: Blue House Mtn 15'; Mesa NTMS

DEVL: Area detected by airborne radiometric - 2 diamond drill holes over anomaly.

PROD: Asbestos

RAD: 50X
0.88% e U_3O_8

GEOL: Flat lying Dripping Spring Quartzite intruded by diabase dikes and sills. Asbestos mined in nearby metamorphosed Mescal Ls.

REF: PRR-AP-251 (#270)

RICK CLAIMS

LOC: Sec. 1, T7N, R13E, along Dinner Creek, N. slope of Pine Mtn.

QUAD: McFadden Peak 15', Mesa NTMS

DEVL: Dozer cuts on hillside

RAD: 25X

ANAL: 0.21% e U_3O_8

GEOL: Upper member, Dripping Spring Quartzite dips 20°E
Torbernite was noted in 8 inch silty and claying bed. Exact stratigraphic position unknown - lower DS quartzite and Mescal Ls not seen in vicinity.

REF: PRR-A-31

RICK TICK AND LADY ESTER

LOC: Central Sec. 22, T7N, R14E, on west wall of Cherry Creek Canyon, about 0.8 to 1.1 miles upstream of PB Creek.

QUAD: McFadden Peak 15'; Mesa NTMS

RAD: 55X

ANAL: 0.11% e U_3O_8

GEOL: Upper Dripping Spring Quartzite, overlain by Mescal Limestone, locally intruded by diabase. Units here dip gently SE. Autunite, metatorbernite, and limonite after pyrite were noted.

REF: PRR-AP-352

ROCK CANYON PROSPECT

LOC: 33°49'46"N; 110°37' 08"W; NW¼ Sec. 14, T5N, R16E
Bottom of Rock Creek Canyon about 0.4 mi. N. of Salt River

QUAD: Blue House Mtn. 15'; Mesa NTMS

DEVL: Open cut and 2 prospect pits

PROD: 5 tons stockpiled

RAD: 100X

ANAL: 0.4% e U_3O_8

GEOL: Ankerite -filled fractures with uraninite, limonite, sulfates and pyrite in black facies of Dripping Spring Quartzite. Mineralization controlled by N20°E trending fractures. The ankerite-pyrite rich part of NE trending fissure zone contains anamalous tin concentration, as cassiterite. Refer to Tomato Juice, with similar mineralogy. Occurrence on east flank of N-S trending Rock Canyon monocline, in strata dipping 13° towards S75°E.

REF: PRR-AP-144 and PRR-A-79
Granger, H. and Raup, R. (1969b, p. 110)

ROCKSLIDE CLAIMS (Blue Rock)

LOC: SW¼ NW¼ Sec. 34, T9N, R15E

QUAD: Young 15'; Holbrook NTMS

DEVL: Trench, open cuts

RAD: 100X - airborne anomaly #24

ANAL: 0.29% e U_3O_8

GEOL: Metatorbernite, uraniferous opal, saleeite, and limonite as coatings randomly oriented fractures in Dripping Spring Quartzite.

REF: PRR-AP-323; Schwartz, R. (1957, RME-2071)
Granger, H. and Raup, R. (1969a & b)

S.T. CLAIMS #1-4

LOC: Approx. Central Sec. 31, T7N, R13E, on east slope of Buck Peak

QUAD: Copper Mtn. 7½'; Mesa NTMS

RAD: 40X

ANAL: 0.02% e U_3O_8

GEOL: Metorbernite, autunite, meta-autunite, and pyrite in upper Dripping Spring Quartzite, dipping gently eastward.

SALLY MAY #2-5

LOC: NE¼ Sec. 2, T6N, R12E
0.5 mile SE from top of Greenback Pk

QUAD: Copper Mtn. 7½'; Mesa NTMS

DEVL: Pits

RAD: 10X

GEOL: Upper Dripping Spring Quartzite underlain by diabase and overlain by Mescal Limestone.

REF: PRR-AP-350

SENTINEL CLAIMS

LOC: Approx. 33°59' 20"N, 111°09' 30" W, on dissected mesas about 1 mile NW of Chalk Mtn.

QUAD: Picture Mtn. 7½'; Mesa NTMS

GEOL: Upper member Dripping Spring Quartzite
See Pranty and North Star Claims

REF: Schwartz, R. (1957, RME-2071, Fig. 4)

SHEPP #2 (American Asbestos Cement Co., Stockman Group, Wilson Creek)

LOC: Center Wedge Sec. 31, T8N, R15E and center edge Sec. 36, T8N, R14E.
Wilson Creek about 1.4 mi. ENE of Cherry Creek

QUAD: McFadden Peak 15'; Mesa NTMS

DEVL: 4 adits and 300 ft. tramway from creek to cliff tops.

PROD: 35 tons @ 0.15% stockpiled

RAD: 100X

ANAL: 0.17% e U_3O_8

GEOL: Uraninite metatorbernite, limonite, pyrite, chalcopyrite, and malachite in fractures and along bedding in Dripping Spring Quartzite.

REF: PRR-AP-43
PRR-D-718
Granger, H. & Raup, R. (1969a & b)
Schwartz, R. (1957, RME -2071)

SKY #1-5 (Interstate Group)

SNAKEBIT CLAIMS (Mono, Sunset)

LOC: 33°46' 38" N, 110°35', 27"W,
on North side of deep tributary to Ash Creek

QUAD: Blue Horse Mtn. 15'; Mesa NTMS

DEVL: 80 ft. adit (NW trending); bench

RAD: 20X

ANAL: 0.16% U_3O_8 from open cut

GEOL: Metatorbernite with limonite and disseminated pyrite, chalcopyrite, galena and sphalerite. Uranium along fractures in Dripping Spring Quartzite.

REF: PRR-AP-234
Granger, H. and Raup, R. (1969b, p. 120)

SNOW WHITE (Big Buck Group)

SORREL HORSE (Citation, Lobo, Maybe, T-Bone)

LOC: Center S½ Sec. 4, T6N, R14E
Tributary to Cherry Creek

QUAD: McFadden Peak 15'; Mesa NTMS

DEVL: 3 short adits and prospect pit

RAD: 14X

ANAL: 0.57% e U_3O_8

GEOL: Radioactivity in gray facies of Dripping Spring Quartzite. Some veinlets along various fractures containing quartz, siderite, fluorite, pyrite, chalcopyrite, galena and sphalerite. Some barren aplite dikes invade the sediments from the underlying diabase sill.

REF: PRR-A-62
PRR-A-100
Granger, H. and Raup, R. (1969b, p. 122)

SPRING CREEK (Great Gain)

STAGO AND BUBBLING SPRINGS GROUPS

LOC: SE¼ Sec. 10, T7N, R14E
(along Cherry Creek, 0.5 miles south of mouth of Ash Creek

QUAD: McFadden Peak 15'; Measa NTMS

DEVL: Discovery pit

RAD: 40X

ANAL: 0.02% e U_3O_8

GEOL: Flat lying upper Dripping Spring Quartzite, and radioactive springs in area.

REF: PRR-AP-235

STAR 1-3

LOC: $N\frac{1}{2}$ Sec. 15, T2S, R15E, upper steeply sloped ridges, about 0.5 miles SE of summit of Pioneer Pass of Sec. 10, T2S, R15E.

QUAD: Pinal Peak 7½'; Mesa NTMS

DEVL: Some ore stockpiled in 1955

RAD: 12X

ANAL: 0.22% U_3O_8 in select sample after magnetite removal by magnet.

GEOL: Pendant of Pinal Schist surrounded by Madera Diorite is intruded by dikes. Unidentified uranium minerals along dike contacts in Pinal and extends into the Madera Diorite for short distance. Uraniferous veins contain magnetite, rutile.

REF: PRR-A-7

STOCKMAN GROUP (Shepp #2)

Includes: Shepp #1-2
Walnut Creek #1-3
York #1-4

SUCKERITE CLAIMS (Charles Jr. #1-2; Definitely)

LOC: Approx. S. center Sec. 24, T6N, R13E, 300 ft. S. of Workman Creek and 0.3 mi. W of Globe-Young Rd.

QUAD: McFadden Pk. 15'; Mesa NTMS

DEVL: 2 adits, drill holes

PROD: 2,603 tons @ 0.23% U_3O_8; 40% C_aCO_3, 1956-57
Second largest producer in Sierra Anchas.

RAD: 30X

GEOL: Uraninite, pyrite, molybdenite, chalcopyrite, and galena in short veinlets and disseminated in Dripping Springs Quartzite - Mescal Limestone block totally enclosed in diabase. Ore zone dips 55° and is about 1-4 ft. thick.

REF: PRR-AP-252
Granger, H. and Raup, R. (1969a & b, 1959)
Schwartz, R. (1957, RME-2071)

SUE CLAIMS (Bull Canyon)

LOC: Approx. SE border Sec. 24, T5N, R14E and SW border Sec. 19, T5N, R15E. South slope of Bull Canyon.

QUAD: McFadden Peak 15'; Mesa NTMS

DEVL: 2 adits; drifting

PROD: 450 tons @ 0.21% U_3O_8; 1955-56

RAD: Apparently not in equilibrium

ANAL: 0.01-3.47%, U_3O_8

GEOL: Metatorbernite, bassetite, meta-autunite, limonite, and pyrite in fractured, weakly recrystallized black facies of Dripping Spring Quartzite. Ore zone is about 3 ft. thick and host strata dips 5°SW.

REF: PRR-AP-273
Granger, H. & Raup, R. (1969b, p. 129)
Schwartz, R. (1957, RME-2071)

SUNSET (Snakebit)

SURPRISE (Pranty)

T-BONE (Sorrel Horse)

TIPPY CLAIMS

LOC: SW¼ Sec. 16, T6N, R14E

QUAD: McFadden Peak 15'; Mesa NTMS

DEVL: Prospected

GEOL: Upper member Dripping Spring Quartzite

REF: Schwartz, R. (1957, RME-2071, Fig. 4)

TOMATO JUICE (Grandview; King Snake)

LOC: 33°49' 16"N; 110° 36' 20"W
Regal Canyon 900 ft. SE of Salt River

QUAD: Blue Horse Mtn. 15'; Mesa NTMS

DEVL: 2 adits trending NNE; 400 ft. bucket tramway

PROD: 140 tons @ 0.16% U_3O_8, 1956

GEOL: Disseminated uraninite and minor uranophane in Dripping Spring Quartzite within 10 ft. or so and symmetrically disposed about a narrow well-defined fissure vein less than 0.5 inches wide and filled with ankerite, minor sulfides, and purple fluorite. Ore zone is vertical, tabular, trends NNE, is about 1.5 ft. thick and is truncated upward by a bedding plane fault. Like the Rock Canyon occurrence, the uraninite is seen only in the adjacent quartzite and not in the fissure vein itself.

REF: PRR-AP-364
Granger, H. and Raup, R. (1969a & b)
Schwartz, R. (1957, RME -2071)

TREK CLAIMS

LOC: SE¼ Sec. 19, T8N, R10E

QUAD: Payson 15'; Holbrook NTMS

RAD: 30X

ANAL: 0.18% e U_3O_8

GEOL: Meta-volcanics and metasediments of older Precambrian Alder series, displaying WNW and NE fracture sets. Fluorescent autunite noted.

REF: PRR-AP-322

UNNAMED A

LOC: East of center, Sec. 4, T3S, R15E, probably 0.5 miles WSW of El Capitan Mine-Pinal Mtns.

QUAD: El Capitan 7½'; Mesa NTMS

DEVL: 4 short adits

RAD: 4X

GEOL: Dripping Spring Quartzite with intrusive diabase, limonite and copper oxide shows.

REF: PRR-AP-149
Cornwall, H. and Krieger, M. (1978)

UNNAMED B

LOC: Approx. T5N, R16E, 33°49' 40"N, 110° 36' 15"W about 8 miles downstream from Hwy. 77 bridge across Salt River, about 20' above river level.

QUAD: Blue House Mtn. 15'; Mesa NTMS

RAD: 14X

GEOL: Spring deposit consisting of $CaCO_3$, iron oxides, NaCL 20 ft. above Salt River on north bank. Goethite is uranium-bearing constituent.

REF: PRR-AP-144

UNNAMED C

LOC: Center Sec. 7, T1S, RISE
1.7 mi. NE of Madera Peak

QUAD: Pinal Pk 7½; Mesa NTMS

DEVL: Small adits, caved shaft

PROD: Copper

RAD: 6X

GEOL: Copper carbonate vein in Pinal Schist

REF: PRR-AP-158

UNNAMED D

LOC: SE¼ SE¼ Sec. 35, T11N, R13E
Colcord Rd.-1.5 miles NNW of Turkey Pk.

QUAD: Woods Canyon 15'; Holbrook NTMS

DEVL: One small pit just west of a N-S trending side road.

ANAL: 1.4% Cu, 0.001% Ag, 7-14 ppm U by weight in grab sample

GEOL: Pennsylvanian -Permian Naco -Supai Formations contain lenses of limestone pebble conglomerate and fossil plant trash in a sandstone section.

REF: Peirce, W. and others (1977)

UNNAMED E

LOC: 33° 58'58", 110° 17' 13"W in road cut along Highway 60-77, 0.5 mile of Highway bridge crossing of Carrizo Creek.

QUAD: Carrizo 7.5; Mesa AMS

DEVL: Highway roadcut

ANAL: 0.03-0.11% Cu, 5-15 ppm V, 10-14 ppm uranium by weight

GEOL: 30 ft. thick conglomeratic channel with rare plant impressions gives above analyses for mudstones, and conglomeratas; in Penn-Permian Naco-Supai formations.

REF: Peirce, W. and others (1977)

UNNAMED F

LOC: Center of N½ of SW¼, Sec. 24, T5N, R13E, 1.7 miles WSW of Asbestos Creek on east cliff above Parker Creek.

QUAD: McFadden Peak 15'; Mesa NTMS

DEVL: 2 shallow rim cuts, 3 prospect pits along very edge of canyon rim.

RAD: 6X, along N70° W trending fractures

GEOL: Upper member of Dripping Spring Quartzite is exposed on bench in Section 24. Prospects were cut into cliff edge along N70°W fractures (to 6X) and N65° fractures (to 4X), entire area around here slightly anomalous in radioactivity (150-300 cps on Mt. Sopris scintillometer)

REF: Kaiser (1951), p.8.
Arizona Bureau of Geology data

UNNAMED G

LOC: Sec. 7-8, T7N, R10E

QUAD: Kayler Butte 7½'; Mesa NTMS

RAD: 2X

GEOL: Rhyolite exposed in roadcut

REF: Waechter, N. (1979)

URANIUM No. 1 (Jackie)

referred to as near Jackie Claims of Red Bluff area in PRR-A-P-180 (1954)

URANIUM #1-17

LOC: Approx. NW¼ Sec. 2, T6N, R12E, W. rim of Sierra Ancha Mtns., 1.9 mi. WSW of Buck (Lauffer) Pk.

QUAD: Copper Mtn. 7½'; Mesa NTMS

RAD: 6X

GEOL: Metatorbernite in upper member of Dripping Spring Quartzite under diabase sill.

REF: PRR-AP-242

WALNUT CREEK (American Asbestos Cement Co.)

LOC: NE¼ Sec. 25, T8N, R14E, along Walnut Creek upstream from Cherry Creek

QUAD: Young 15'; Holbrook NTMS

RAD: 12X

ANAL: 0.2% e U_3O_8; 0.2% U_3O_8

GEOL: Uranophane and torbernite with limonite in upper member of Dripping Spring Quartzite.

REF: PRR-AP-43
PRR-D-717

WILLIAMS SHAFT (Black Hawk)

WILSON CREEK (Shepp)

WORKMAN MINE (Refer to Little Joe and Hope Claims)

LOC: NE¼ SW¼ Sec. 19, T6N, R14E, NE side of Workman Creek about 0.65 miles E of Globe-Young Rd.

QUAD: McFadden Peak 15'; Mesa NTMS

DEVL: 3 adits, stopes

PROD: 258 tons @ 0.11% U_3O_8, 1955-56 from W-1 adit only.

GEOL: Uraninite and coffinite are primary ore minerals and occur as veinlets and blebs along NNE trending zone. Pyrite, molybdenite, chalcopyrite, marcasite and pyrrhotite disseminated in host rock. Quartzite is beneath Mescal Limestone and underlain by diabase.

REF: PRR-AP-221
Granger, H. and Raup, R. (1959, 1969 a and b)

YO TAMBIEN, HAMILTON, PINTO, CARLOTTA, AND BLACK BESS

LOC: 33° 22' 30" to 23' 20" N; 110° 58' to 111° 00'W

QUAD: Inspiration 7½'; Mesa NTMS

DEVL: Pits, shafts, adits

PROD: Copper

RAD: 3X

GEOL: Mineralized quartz veins in granite, granodiorite, schist and limestone.

REF: PRR-AP-157

YORK #1-4 CLAIMS (American Asbestos Cement Co.)

LOC: Very near center of Sec. 31, T8N, R15E, about 0.5 miles upstream from Shepp No. 1 claims, both on Wilson Creek.

QUAD: McFadden Peak 15'; Mesa NTMS

GEOL: Dripping Spring Quartzite

REF: Arizona Bureau of Geology Data

ZORA CLAIMS (Interstate Group)

GRAHAM COUNTY

ATHABASKA CLAIMS

LOC: Sec. 33, T7S, R21E
Aravaipa

QUAD: Buford Hill 7½'; Tucson NTMS

DEVL: Prospect pit and 30 ft. adit

RAD: 5X

GEOL: Iron oxide stained quartz vein in granite

REF: PRR-AP-377 (#374)

BIG LOAD AND WHITE ROCK CLAIMS

LOC: SE¼ Sec. 20, T10S, R25E, around Cove Spring

QUAD: Stockton Pass 7½; Silver City NTMS

DEVL: Six small prospect pits

RAD: 50X on soil

ANAL: 0.26% e U_3O_8

GEOL: Most radioactivity in residual soil near spring in highly fractured Precambrian granite. Spring water at Cove Spring is radioactive due to radon, and assays to 150 ppm uranium in water.

REF: PRR-AP-358 (#368)

BLUE BIRD CLAIMS

LOC: 32° 40' 10"; 109° 44' 03"
Probably SW¼ of Sec. 6 T9S, R26E

QUAD: Artesia 7½; Silver City NTMS

DEVL: Prospect pits

RAD: 25X

ANAL: 0.07% e U_3O_8

GEOL: Pegmatite dike in Precambrian granite.

REF: PRR-AP-373 #370

BLUFF

LOC: Sec. 28, T5S, R21E
Turnbull

QUAD: Jackson Mtn. 7½'; Tucson NTMS

DEVL: Prospect pit

RAD: 11X

ANAL: 0.015% e U_3O_8

GEOL: Small mineralized fracture in coarse-grained granite.

REF: PRR-AP-275 (#361)

BRUSHY BASIN

LOC: Sec. 9, T5S, R21E
Turnbull

QUAD: Bylas 15'; Mesa NTMS

RAD: 12X

ANAL: 0.013% e U_3O_8

GEOL: Radioactivity associated with iron oxides in altered zone near contact of a diabase intrusive in Precambrian quartzite.

REF: PRR-AP-277 (#363)

CACTUS #1 CLAIM

LOC: Sec. 28, T7S, R21E
Near Larson and McBride Claims

QUAD: Buford Hill 7½; Tucson NTMS

DEVL: Shallow pit

RAD: 15X

ANAL: 0.07% e U_3O_8; 0.025% U_3O_8

GEOL: Quartz vein in granite

REF: PRR-AP-191

CANUK GROUP

LOC: Probably SW¼ Sec. 26 and NW¼ Sec. 35, T8S, R28E

QUAD: Dry Mtn. 7½'; Silver City NTMS

DEVL: Prospect pits

RAD: 20X

ANAL: 5 samples @ 0.01- 0.07% e U_3O_8

GEOL: Carnotite-type mineral coatings on fractures in opalized beds in lake sediments, tuffs and gravels of Pliocene age.

REF: PRR-AP-375 (#373)

DENNY CLAIMS

LOC: Sec. 14, T7S, R21E

QUAD: Buford Hill 7½'; Tucson NTMS

DEVL: 3 prospect pits

RAD: 40X

ANAL: 0.07% e U_3O_8

GEOL: Pegmatite with iron oxides in Precambrian granite.

REF: PRR-AP-374 (#371)

FLAT TIRE GROUP

LOC: SW¼ NW¼ Sec. 27, T8S, R28E (revised location from PRR) on old 111 Ranch (32° 42' 38"N, 109° 28' 30"W)

QUAD: Dry Mtn. 7½; Silver City NTMS

DEVL: 30 ft. shaft and 3 trenches

PROD: 4 tons @ 0.02% U_3O_8 in 1955, 9 tons @ 0.11% U_3O_8 in 1958.

RAD: 35X

ANAL: 0.81% e U_3O_8 and 1.38% U_3O_8

GEOL: Carnotite coating fractures and disseminated in 12-15 ft. bed of hard greenish-brown clay of Pliocene lacustrine and paludal sedimentary sequence. A brown hard limestone bed 5-10 ft. above mined layers counts to 10X in several adjacent areas and assays 0.1% Uran. and 0.1% organic carbon. Some strata near the claims are anomalous over a considerable area. (NURE data)

REF: PRR-AP-381 (524), ABG field work

FLUORITE CLAIMS

LOC: Sec. 29, T11S, R26E Teviston

QUAD: Luzena 15'; Silver City NTMS

DEVL: 12 ft. shaft and pits

ANAL: 0.017% e U_3O_8

GEOL: 1 ft. wide shear zone in granite with fluorite and iron oxides. Strike is NNE, dip 78°W.

REF: PRR-AP-254 (#360)

COLONDRINA CLAIMS

LOC: Approx. SE¼ Sec. 13, T11S, R25E Pinaleno Mtns.

QUAD: Luzena 15'; Silver City NTMS

DEVL: 2 shafts, caved adits, prospect pits

PROD: Small amount of Cu, Pb, Ag

RAD: 2X

ANAL: 0.26% e U_3O_8 and 0.603% U_3O_8

GEOL: Broad shear zone in dark volcanic porphry with 1 inch long feldspar phenocrysts. Porphyry is cut by granite dike nearby. Radioactive pyromorphite, quartz and limonite in cavities and fractures. Also some radioactivity in volcanic agglomerate layer. Analysis of ore indicates high Pb, Zn, As, Cd, low Mo and Cu, and 100 ppm U (NURE data).

REF: PRR-AP-68 (#356)
PRR-1940 USGS (#351)
Granger, H. and Raup, R. (1962)
Wright, R. J. (1950, RMO-590-RMO-679)
Kaiser, E. P. (TEM-219)
NURE data

HIGH NOON GROUP

LOC: Sec. 24, T11S, R26S Teviston

QUAD: Luzena 15'; Silver City NTMS

DEVL: Dozed area

RAD: 40X

ANAL: 0.05% e U_3O_8

GEOL: 1-3 ft. wide vein and altered zone in granite. Copper and iron sulfides and iron oxides.

REF: PRR-AP-380 (#377)

HOT ROCKS CLAIM

LOC: Approx. E½, T9S, R25E

QUAD: Mt. Graham 15'; Silver City NTMS

DEVL: Dozer cuts and pits

RAD: 7X

ANAL: 0.06% e U_3O_8

GEOL: Faulted rhyolite dike in Precambrian granite. Mineralization occurs in several echelon faults.

REF: PRR-AP-372 (#369)

LARSON AND MC BRIDE

LOC: Sec. 28, T7S, R21E Near Cactus Claims

QUAD: Buford Hill 7½'; Tucson NTMS

RAD: 13X

ANAL: 0.04% e U_3O_8

GEOL: Radioactivity in quartz vein with purple fluorite in altered granite.

REF: PRR-AP-165

LAST CHANCE GROUP

LOC: Probably NE¼ Sec. 28, T8S, R28E

QUAD: Dry Mtn. 7½'; Silver City, NTMS

DEVL: Location work

RAD: 42X

ANAL: 0.02% e U_3O_8

GEOL: Carnotite-type coatings in opalized seams in bedded clay and tuff, capped by rhyolite flow.

REF: PRR-AP-379 (#376)

LUCKY STRIKE #1

LOC: Sec. 28, T7S, R21E
Pinaleno Mtns.

QUAD: Buford Hills 7½'; Tucson NTMS

DEVL: Prospect pit

RAD: 3X

ANAL: Assay showed predominance of thorium

REF: PRR-AP-196 (#359)

McBRIDE (Larson)

MOSS CLAIMS

LOC: Sec. 16, T7S, R21E
Santa Teresas Mtns.-Mt. Turnbull

QUAD: Buford Hill 7½'; Tucson NTMS

DEVL: Prospect pits

RAD: 4X

GEOL: Radioactivity associated with fractures coated with hematite in a quartz vein in granite.

REF: PRR-AP-278 (#364)

PLUTO GROUP

LOC: Probably central Sec. 27, T8S, R28E

QUAD: Dry Mtn. 7½'; Silver City NTMS

DEVL: Dozer cut

RAD: 10X

ANAL: 0.01% e U_3O_8

GEOL: Radioactivity associated with interbedded clays and tuffs in Late Cenozoic sediments.

REF: PRR-AP-378 (#375)

ROYAL JOHN

LOC: Probably central Sec. 27, T8S, R28E
Gila River

QUAD: Dry Mtn. 7½'; Silver City NTMS

DEVL: Dozer cuts and pit

RAD: 10X

ANAL: 0.01% e U_3O_8

GEOL: Carnotite-type mineralization in interbedded clays and tuffs in lake bed sediments of Late Cenozoic age.

S & W CLAIM

LOC: Probably SW¼ Sec. 5, T10S, R26E
west of Baker Peak

QUAD: Gillespie Mtn. 7½'; Silver City NTMS

DEVL: One large and several small pits

RAD: 5X

GEOL: Small crystals of samarskite associated with smoky quartz and orthoclase in a pematite dike in granite.

REF: PRR-AP-313 (#365)

SKY HIGH CLAIM

LOC: Sec. 28, T7S, R21E
Klondike

QUAD: Buford Hill 7½; Tucson NTMS

DEVL: Prospect pit

RAD: 4X

ANAL: 0.081% e U_3O_8

GEOL: Radioactivity associated with smoky quartz in a quartz vein in granite porphyry. Fracture surfaces coated with hematite.

REF: PRR-AP-276 (#362)

STONY PEAK CLAIMS

LOC: NW¼ Sec. 21, T10S, R25E, at about 5,250 ft. elevation, 1.0 mile ENE of Cove Spring on hillside.

QUAD: Stockton Pass 7½'; Silver City NTMS

DEVL: Prospect pits

RAD: 200X

ANAL: 0.14 - 0.27% U_3O_8

GEOL: Radioactivity concentrated along N40-50°E striking fractures in granite. Stringers of fluorite and associated autunite and uranophane.

REF: PRR-A-110 (#354)

TRIBAL CLAIM

LOC: Approx. Sec. 33, T2S, R22E
San Carlos Indian Reservation

QUAD: Bylas 15'; Mesa NTMS

DEVL: Open cut and shallow pit

RAD: 2X

GEOL: Radioactivity in porphyritic dike associated with fault zone cutting limestone and quartzite. Stringers of chalcopyrite and copper carbonates in fault zone.

REF: PRR-D-607 (#381)

UNNAMED A

LOC: Sec. 20, T8S, R28E

QUAD: Artesia NE 7½'; Silver City NTMS

DEVL: Drilling

GEOL: Mineralization in E-W trending gravel channels in basin fill under Pleistocene gravel caps.

REF: Arizona Bureau of Geology file data

UNNAMED B

LOC: 33° 17-18'N, 110° 20-25'W
near San Carlos Lake north of Hwy. 70

QUAD: San Carlos and Mt. Triplet 7½'; Mesa NTMS

DEVL: Drilled 1977-78

RAD: 4X

GEOL: Disseminated radioactive mineral(s) in mudstones and marls of Pliocene lake beds.

REF: Arizona Bureau of Geology file data

UNNAMED C - STOCKTON PASS

LOC: Southern Sec. 16, northern Sec. 21, T10S, R25E (protracted) (See nearby Stony Peak locality)

QUAD: Mt. Graham 15'; Silver City NTMS

DEVL: Several N55°W elongate dozer cuts

RAD: 10-30X

ANAL: 0.05 - 0.10% on select along dozer cuts

GEOL: N55°W trending splinter faults of Stockton Pass fault zone cut Precambrian granite. Black uranium minerals present. Nearby Cove Spring (SE¼ Sec. 20) has radon and assays to 150 ppm chemical uranium.

REF: ABC files.

WHITE BLUFFS URANIUM AREA

LOC: NW¼ NE¼ NE¼ Sec. 33, T8S, R28E
111 Ranch Area (32° 41' 54" N, 109° 28' 49"W)

QUAD: Dry Mtn. 7½'; Silver City NTMS

DEVL: Dozer cuts, prospect pits

RAD: 3-10X

ANAL: 0.08% e U_3O_8

GEOL: Uranophane coatings along bedding planes and on fractures in siliceous lake beds interbedded with diatomaceous earth, bentonitic clay, mudstones, and thin vitric ash-fall tuffs of Pliocene paludal sediments. Yellow stained opal lenses in diatomite and disseminated radioactivity in light-colored calcic paludal beds. Dark chert contains 150-450 ppm uranium.

REF: PRR-AP-330 (#366)
ABC file data

WHITE ROCK (Big Load)

Greenlee County listing

MORENCI DISTRICT

LOC: S½, T3S, R29E, N½, T4S, R29E

QUAD: Clifton 15'; Clifton NTMS

DEVL: Major open pit copper mine operated by Phelps Dodge Corp.

PROD: Some uranium may be recoverable from leach solutions

GEOL: Uranium minerals associated with quartz monzonite porphyry copper deposit. Details lacking.

REF: PRR-AP-73 (#385)

MARICOPA COUNTY

AGUILA (Refer to Black Butte, Milton Ray and Jar)

ALTUDA MINE

LOC: SW¼ Sec. 19, T7S, R1W

QUAD: Estrello 15'; Ajo NTMS

DEVL: 150 ft. and 200 ft. shaft and incline; surface pits, gold and silver prospect.

RAD: 3X

GEOL: Quartz veins in coarsely prophyritic granitic rock in contact with schist and gneiss.

REF: PRR-AP-98 (#409)

ARROWHEAD (Faith-in-Group; Rusty Point)

LOC: Sec. 31, T1S, R3W

QUAD: Avondale SW 7½'; Phoenix NTMS

RAD: 80X

ANAL: 0.07-3.61% e U_3O_8; 0.04-2.55% U_3O_8

GEOL: Uranium-titanium rare-earth minerals in pegmatite dike and quartz veins intruding sheared and weathered granite. Pegmatite is 10-15 ft. wide and trends N3°E. Gummite, columbite, and euxenite noted. Titanium, columbium, yttrium and thorium spectroscopically identified.

REF: PRR-AP-295 (#419)
D.O.E.

B & M (Bickle and Manley)

BALANCED ROCK #1

LOC: Sec. 5, T2S, R3W

QUAD: Avondale SW7½'; Phoenix NTMS

DEVL: Discovery pit

RAD: 25X

ANAL: 0.06-0.24% e U_3O_8; 0.105-0.191% U_3O_8

GEOL: Radioactivity in pegmatite dikes up to 10 ft. wide and trending N10-20°E intruding sheared and weathered granite. Altered zircons, fergusonite and polycrase noted. Thorium also present.

REF: PRR-AP-296 (#420)
D.O.E.

BICKLE AND MANLEY (B & M)

LOC: Approx. SW¼ Sec. 12, T6N, R5E
Blue Wash Creek

QUAD: Humbolt Mtn. 7½'; Mesa NTMS

DEVL: 35 ft. vertical shaft in creek bed, now filled with sand. Surface pit on edge of creek produced ore.

PROD: 32 tons @ 0.17% U_3O_8, 1955; 2 equal size shipments of 0.06 and 0.22% U_3O_8

RAD: 500X. Some thorium in pegmatites.

ANAL: 0.01-1.52% e U_3O_8; 0.05-1.05% U_3O_8; and 0.88-1.24% ThO_2

GEOL: Mineralization occurs at the intersection of two NE and NW trending shears, 10 ft. west of vertical fault zone. Pegmatite also intrudes the coarse-grained biotite granite. Uranothorite noted. Yellow uranium mineral noted with fluorite and calcite.

REF: PRR-AP-340 (#421)
D.O.E.

BLACK BUTTE

LOC: Sec. 19, 20, T6N, R7W

QUAD: Vulture Mtns. 15'; Phoenix NTMS

DEVL: Trenching

RAD: 3X

ANAL: 0.013% e U_3O_8

GEOL: Secondary uranium minerals occur in fractures and bedding planes in basalt capped tertiary lake bed sediments and tuffs. Beds strike N20°W to N70°W and dip 25-65°S.

REF: PRR-AP-343 (#424)

BLACK MAGIC CLAIMS

LOC: Approx. S½, T4N, R9W

QUAD: Big Horn Mtns. 15'; Phoenix

DEVL: Prospect pits

RAD: 4X

ANAL: 0.012% e U_3O_8; 0.009% U_3O_8

GEOL: Radioactivity in placer sands due to uranium bearing sphene and zircon.

REF: PRR-AP-2 (#406)

BLACK MOUNTAIN #4 & 6 (Black Mtn. Vanadium #22)

LOC: Probably Sec. 14, T6N, R7W

QUAD: Vulture Mtns. 15'; Phoenix

RAD: 5X

GEOL: Carnotite and gypsum on fracture surfaces in shaley marl underlain by metamorphic rocks and overlain by thin basalt flow.

REF: PRR-189 (#387)

BLACK MOUNTAIN VANADIUM #22 (Refer to Black Mountain)

BLUE JAY CLAIMS

LOC: Probably T7N, R5W, "Go west from Wickenburg on Hwy 60-70 2.3 mi. past underpass, turn left on Vulture Mine Road, go 5.7 mi., turn left on Jeep Road; proceed 1.8 mi. to property.

QUAD: Vulture Mtns. 15'; Phoenix NTMS

RAD: 2X

GEOL: Pegmatite dike in granite

BLUE SPRINGS CANYON (Malapai)

CAVE CREEK AREA

LOC: S½ NW¼ Sec. 15, T6N, R4E
Willow Springs Wash

QUAD: Cave Creek 7½; Mesa NTMS

RAD: 7X

GEOL: Radioactivity associated with siliceous stringers and veinlets and a few limey beds. Section contains mudstones, limey beds, vitric ash beds all dipping 30-50°SW and overlain by conglomerate with clasts of Precambrian schist and Tertiary volcanics.

REF: Scarborough, R. & Wilt, J. (1979)

COPPER KID GROUP

LOC: Sec. 10, T6N, R4E

QUAD: Cave Creek and New River Mesa 7½'; Mesa NTMS

DEVL: 70 ft. shaft and pits - lead and silver prospect.

RAD: 17X

ANAL: 0.66-1.13% e U_3O_8; 0.77% U_3O_8

GEOL: Uraninite and/or pitchblende associated with base metal sulfides in aplitic and basic dikes, intruding shear zone in Yavapai schist. Red jasper zone contains uraninite, copper carbonates, galena and barite.

REF: PRR-AP-280 (#418)

COTTONWOOD CLAIMS (Lime Creek Group; Horseshoe Prospects, Fault Claims, Verde Claims)

LOC: S½ Sec. 3, T8N, R6E, and Sec. 4, T7N, R6E
Verde River-Horseshoe Dam near Maricopa-Yavapai Co. line.

QUAD: Humbolt Mtn. 7½'; Mesa NTMS

DEVL: 105 ft. drift, 70 ft. shaft, drilling

PROD: 25 tons @ 0.10% U_3O_8, 1956-57
53 tons @ 0.10-0.15% U_3O_8 stockpiled

RAD: 85X

ANAL: 0.52% e U_3O_8; 0.03-0.56% U_3O_8

GEOL: Pitchblende and autunite occurs along shear zone in Precambrian granite. Fault strikes NE and dips 80° SE. Fault breccia includes material from highly altered rhyolite dike.

REF: PRR-AP-341 (#422)
Gatten, O. (1977)
D.O.E.

COUGAR CLAIMS (Lucky Find Group)

DALE-COMPTON #5 and #8

LOC: Sec. 24, T1S, R3W and Sec. 21, T1S, R3W, respectively.

QUAD: Buckeye 7½'; Phoenix NTMS

DEVL: 2 location pits

RAD: 24X

GEOL: Possibly samarskite with copper and iron stain in a pegmatite vein cutting schistose granite.

REF: PRR-AP-133 (#415)

DREAMER GROUP #1-39

LOC: Approx. SE¼ Sec. 21, T40N, R16W
Virgin Valley

QUAD: Mesquite (Nevada-Arizona) 7½; Las Vegas NTMS

DEVL: Prospect pits

RAD: 5X

ANAL: 0.02% e U_3O_8; 0.026% U_3O_8

GEOL: Carnotite-type minerals along fracture planes in Tertiary sandstone of the "Littlefield Fm."

REF: PRR-RR-285 (#450)
Blair, W. & Armstrong, A. (1979)

DUKE, WHITE AND HYDER CLAIMS

LOC: Approx. Sec. 36, T2S, R10W

QUAD: Dendora Valley 15'; Phoenix NTMS

DEVL: Discovery shaft and drill holes

RAD: 4X

ANAL: 0.01% e U_3O_8

GEOL: Radioactivity in Tertiary shale - mudstone lake bed sediments capped by tuff and volcanics and intruded by Northwest trending dikes.

REF: PRR-AP-382 (#482)

FAITH-IN-GROUP (Arrowhead)

FAULT CLAIMS (Cottonwood Claims)

GOLDEN DUCK GROUP (Shamrock Mining and Development Co.)

LOC: E½ Sec. 19, T7N, R2W
Wickenburg area on Maricopa-Yavapai County line

QUAD: Red Picacho and Garfias Mtn. 7½', Phoenix NTMS

DEVL: Shafts, adits, prospects

PROD: Copper and gold

RAD: 100X

ANAL: 0.03-0.55% e U_3O_8; 0.14-0.57% U_3O_8

GEOL: Fractures in pegmatite cutting Precambrian complex are coated with yellow uranium minerals. Tertiary volcanic series of pyroclastics and flow with basal conglomerate covers Precambrian complex. Pods of torbernite, metaautunite, schroekingerite and uranocircite in porphyritic rhyolite tuff in vent complex. Spotty uranium minerals, chalky turquoise, chrysocolla, iron oxides, and secondary quartz disseminated in fault gouge along shear zone, trending N30°W.

REF: PRR-A-77 (#402)
PRR-AP-347 (#831)
Finch, W. (1967)
Arizona Bureau of Geology data

GYPSY QUEEN

LOC: Sec. 9, T4N, R5E

QUAD: McDowell Peak 7½'; Mesa NTMS

RAD: 4X

GEOL: Decomposed granite

REF: PRR-A-47 (#390)

HORSESHOE DAM (Refer to Horseshoe Prospects)

LOC: Approx. 33° 58.5'N, 111° 44'W
Lower Verde River

QUAD: Horseshoe Dam 7½'; Mesa NTMS

RAD: 5X

GEOL: Radioactivity in limestone beds and in silicified zones near high angle faults. Intense silicification. Tuff and limestone sequences underlain by basalts and in fault contact to the west with Precambrian granite and to south with younger flat lying basalt capped sediments.

REF: Scarborough, R. & Wilt, J. (1979)

HORSESHOE PROSPECTS (Cottonwood, Lucky Find, Cougar)

HOWELL PROSPECT

LOC: SW¼, NE ¼, Sec. 28, T7N, R4E

QUAD: New River Mesa 7½; Mesa NTMS

RAD: 6X

ANAL: 0.02% U_3O_8

GEOL: Radioactive basalt cobbles with brown bentonite matrix in 50 X 50 ft. area surrounding a spring. Dull yellow stain on rocks. Thick tuff beds to north on New River Mesa.

REF: Waechter, N. (1979)

HYDER (Duke, White and Hyder)

JAR

LOC: Sec. 13, 14, T6N, R8W
Black Butte, Vulture Mtns.

QUAD: Aguilla 15'; Phoenix NTMS

DEVL: Test pits

RAD: 7X

ANAL: 0.01% e U_3O_8; 0.01% U_3O_8

GEOL: Carnotite coating fractures and bedding planes in Tertiary lake beds. Sediments consist of marls, limestones, thinly bedded greenish mudstone and sandstone, capped by vesicular basalt and intruded by dikes. Lake beds strike NW, dip 25-45°S and are locally overturned.

REF: PRR-AP-342 (#423)

LIME CREEK (Cottonwood, Cougar)

LOS CUATROS GROUP

LOC: Sec. 32, 33, T7N, R3E, Sec. 5, T6N, R3E
New River

QUAD: Daisy Mtn. 7½'; Phoenix NTMS

DEVL: Drilled

RAD: 5X

ANAL: 0.06% U_3O_8

GEOL: Mineralization disseminated in aphanitic dolomite beds interbedded with mudstones, and sparce volcanic ash beds. This section also in fault contact to the west along west edge of Section 32 with tilted basalt-tuff-mudstone section. Section down faulted against Yavapai schist to north.

REF: PRR-A-76 (#401)
Scarborough and Wilt (1979)

LUCKY FIND GROUP (Cougar Claims; Horseshoe Prospects)

LOC: Sec. 25, 36, T8N, R6E; Sec. 31, T8N, R7E, Sec. 1, T7N, R6E, Sec. 5, 6, T7N, R7E.

QUAD: Horseshoe Dam and Chalk Mtn. 7½; Mesa NTMS
near Maricopa-Yavapai Co. line.

DEVL: Prospect pits

PROD: 5 tons @ 0.12% U_3O_8 stockpiled

RAD: 70X

ANAL: 0.06–0.49% e U_3O_8–0.26% U_3O_8

GEOL: Uraninite, allanite and secondary green fluorescent uranium mineral associated with a fault zone and altered dike in Precambrian granite.

REF: PRR-A-96 (#404)
PRR-A-48 (#400)
Gatten, O. (1977)

MALAPAI #1 (Blue Springs Canyon)

LOC: Approx. 33° 35'45"N, 111°26'15"W

QUAD: Mormon Flat Dam 7½'; Mesa NTMS

DEVL: Pits

PROD: 8 tons @ 0.02% U_3O_8; 0.04% V_2O_5, 1955

GEOL: Uranium disseminated in Precambrian granite and granite derived sediments.

REF: D.O.E.

MILTON RAY CLAIMS

LOC: Sec. 21, 22, T6N, R7W

QUAD: Vulture Mtns. 15'; Phoenix NTMS

DEVL: Numerous small cuts and trenches

RAD: 7X

ANAL: May be out of equilibrium in favor of count rate

GEOL: Carnotite occurs as fracture coatings and along bedding planes in Tertiary vitric tuff and clastic sediments. Tuffs, clastics, arkosic conglomerate and andesite flows are deposited on a granite and capped by basalt.

REF: PRR-AP-83 (#408)
Finch, W. (1967)

NAPSACK

LOC: SW¼ Sec. 33, T7N, R5E

QUAD: Humbolt Mtn. 7½'; Mesa NTMS

DEVL: 8 adits, raises and stopes

PROD: Gold

RAD: 10X

GEOL: Radioactivity associated with quartz veins and granitic intrusive in schist, capped by basalt.

REF: PRR-AP-129 (#413)

PLOW SADDLE CLAIMS #1-20

LOC: 33° 31'N, 111° 10'30" W
Superstition Mtns.

QUAD: Pinyon Mtn. 7½'; Mesa NTMS

DEVL: 2 small workings

RAD: 25X

GEOL: Radioactivity in Tertiary gravels and sands capped by basalt and appear to lie on eroded surface cut into Precambrian Apache Group.

REF: PRR-AP-367

RED ROVER MINE

LOC: Approx. 34° 35'N, 111° 50' 40" W

QUAD: Rover Peak 7½'; Holbrook NTMS

DEVL: 3 shafts (one 850 ft. deep), several adits

PROD: 760,000 lbs Cu, 300,000 oz. Ag, 73 oz Au between 1913-1970.

RAD: 3X

GEOL: Veins along fault zone in schist

REF: PRR-AP-128 (#412)

RIFLE RANGE SECTION

LOC: Sec. 3, 4, T5N, R2E, Sec. 33, 34, T6N, R2E
Isolated Hill at I-17 and Carefree Hwy.

QUAD: Biscuit Flats 7½; Phoenix NTMS

RAD: 3X

GEOL: Radioactivity associated with chert pods and stringers in 2 dolomite beds in northward dipping section of lower arkosic sediments, capped by dark volcanic section. Dolomites near base of volcanics.

REF: Scarborough, R. and Wilt, J. (1979)

RUSTY POINT (Arrowhead)

SHAMROCK MINING AND DEVELOPMENT CO. (Golden Duck)

STRIPPED MOUNTAIN CLAIMS

LOC: Sec. 10, T2S, R4W
Buckeye

QUAD: Hassayampa 7½'; Phoenix NTMS

DEVL: Small prospect pits

RAD: 100X

ANAL: 0.01-0.38% e U_3O_8; 0.006-0.018% U_3O_8
pegmatite @ 0.01-0.74% U_3O_8; 1.8% Te_2O_5; 10.5% Ni_2O_5

GEOL: Possibly euxenite, samarskite, monazite and rare earth minerals in pegmatite dike complex intruding granite.

REF: PRR-AP-1 (#405)

SUNSET #1-3

LOC: Sec. 31, T1S, R3W

QUAD: Buckeye 7½'; Phoenix NTMS

DEVL: Small pits

RAD: 0.5 mr/hr.

ANAL: 0.39% e U_3O_8; 0.38% U_3O_8

GEOL: Brannerite in quartz veins cutting granodiorite

REF: PRR-AP-243 (#416)

TELEGRAPH

LOC: Approx. 33° 43'N, 111° 32' 35"W
near Tarantula and Twin Delta Claims

QUAD: Adams Mesa 7½'; Mesa NTMS

DEVL: Location pit

RAD: 20X

GEOL: Radioactivity associated with pocket of oxidized biotite in pegmatites cutting Precambrian granite.

REF: PRR-A-68

TARANTULA AND TWIN DELTA CLAIMS

LOC: Approx. 32° 42' 30"N, 111° 33' 00"W
T4N, R7E, 8 mi. up Sycamore Creek from its junction with the Verde River.

QUAD: Adams Mesa 7½'; Mesa NTMS

DEVL: Several location pits

RAD: 50X

ANAL: 0.08-0.57% e U_3O_8

GEOL: Small pockets of allanite and oxidized biotite in pegmatite in Precambrian granite porphyry.

REF: PRR-A-80 (#403)

TWIN DELTA (Refer to Tarantula)

VALCARCE CLAIM

LOC: Sec. 4, T6N, R4E

QUAD: New River Mesa 7½'; Mesa NTMS

RAD: 4 mr/hr.

ANAL: 0.08-0.29% e U_3O_8

GEOL: Radioactivity associated with altered pink feldspar in biotite granite. Altered thorite noted.

REF: PRR-AP-279 (#417)

VERDE CLAIMS (Cottonwood)

WHITE (Duke, White and Hyder)

WHITE POINT GROUP

LOC: Approx. 33° 43' 30"N, 111° 55'W
5 miles NE of Bickle and Manley Claim

QUAD: Horseshoe Dam 7½'; Mesa NTMS

DEVL: Prospect pits and dozer cuts

RAD: 5X

ANAL: 3.92% e U_3O_8; 5.75% U_3O_8
contains U, Th, Yt, Cr, Zr, Mn, Fe

GEOL: Pegmatite cutting granite.

REF: PRR-A-11 (#388)

Index for Mohave County Uranium Occurrences

L = Las Vegas
K = Kingman
N = Needles
P = Prescott
G = Grand Canyon
W = Williams

MOHAVE COUNTY

BANNER

LOC: Sec. 4, T22N, R17W
Cerbat Mtns.

QUAD: Stockton Hill 7½'; Kingman NTMS

DEVL: Extensive surface and underground workings

PROD: Base metals

RAD: 10X in gouge and in pool of water

GEOL: Radioactivity associated with base metal mineralization along quartz veins in fault zone with much gouge and some brecciation.

REF: PRR-AR-57 (#514)

BIG LEDGE MINE

LOC: SW¼ sec. 32, T20N, R12W

QUAD: Austin Peak 7½'; Williams NTMS

DEVL: Old mine workings

PROD: Base metals

RAD: 8X

GEOL: Radioactivity in red brecciated and recemented jasper along hanging wall. Granitic rocks cut by shear zone which contains base metal sulfides and carbonates. Other shears in nearby sec. 30 do not count. Shears trend N45°W and N80°E.

REF: PRR-RA-9 (#543 and #438)
Walker and Osterwald (1963)
Wright (1950, RMO-679)
NURE data

BIG SILICA MINE

LOC: Sec. 4, T22N, R17W
Cerbat Mtns.

QUAD: Stockton Hill 7½'; Kingman NTMS

ANAL: 0.10% e U_3O_8

GEOL: Allanite, gadolinite and rare earth beryllium silicate(s)

REF: D.O.E.

BLAZING STAR GROUP

LOC: Approx. NW¼ Sec. 35, T21N, R13W

QUAD: Tin Mtn. NW 7½'; William NTMS

DEVL: 8 ft. deep pit

RAD: 10X

GEOL: Fluoritized and strongly jointed granite weakly anomalous over large area. Radioactivity probably due to accessory minerals, perhaps allanite.

REF: PRR-AP-305 (#454)
Waechter, N. (1979)

BLENDINA GROUP (Plendina)

LOC: Sec. 32, 33, T29N, R22W, and Sec. 4,5, T28N, R22W

QUAD: Willow Beach 7½'; Kingman NTMS

DEVL: Sample cuts

RAD: 15X

ANAL: 0.19% U_3O_8; 0.43% ThO_2 and rare earths

GEOL: Monazite disseminated with magnetite in quartz-feldspar pegmatite cutting granite and metamorphic rocks.

REF: PRR-C-22 (#432)
Waechter, N. (1979)

BLUE SMOKE CLAIM

LOC: NE¼ Sec. 15 and SE¼ Sec. 10, T11N, R14W
Pools Peak area

QUAD: Artillery Peak 15'; Prescott NTMS

DEVL: Drilling

RAD: 10X

ANAL: 0.07% e U_3O_8

GEOL: Radioactivity associated with a klippe of Jurassic or Precambian Granite above low angle east dipping fault or decollement zone.

REF: PRR-AP-228 (#579)
Arizona Bureau of Geology data
Waechter, N. (1979)

BOBTAIL MINE

LOC: SW¼ Sec. 31, T23N, R17W

QUAD: Cerbat 7½'; Kingman NTMS

DEVL: 85 ft. shaft; 200 ft. drift; surface pits and trenches

PROD: Zinc, copper, lead

RAD: 18X

ANAL: 0.093% e U_3O_8; 0.077% U_3O_8

GEOL: Probably uraninite occurs as finely disseminated coatings along shear planes of fault zone. Quartz veins and base metal sulfides associated with this structure which strikes N40°W and dips nearly vertical.

REF: PRR-AP-26 (#488); Hart, O. (1955, RME-2029)
Hart, O. and Hetland, D. (1953, RME - 4026)

BROOKLYN CLAIMS (Detroit Group)

BUNDY PROSPECT (Chapel)

BUNKER HILL

LOC: Sec. 6, T22N, R17W

QUAD: Cerbat 7½'; Kingman NTMS

DEVL: Two drifts and some stoping

RAD: 2X

GEOL: Radioactivity associated with fault gouge and quartz along fault, striking N70°W, dipping 70°N. Heavy bleaching and alteration borders sides of 1 to 3 ft. wide vein. Gold and copper noted.

REF: PRR-AR-71 (#528)

CANDY BAR GROUP

LOC: Approx. N½ Sec. 13, T12N, R13W

QUAD: Artillery Peak 15°; Prescott NTMS

DEVL: 10 ft. adit

RAD: 45X

ANAL: 0.07% e U_3O_8

GEOL: Radioactivity in 3 to 5 ft., thick beds of mudstones and sandstone of the Artillery Fm. overlain by red volcanic flows and underlain by red arkosic conglomerate. Step faulting indicated by repetition of beds in highly faulted area.

REF: PRR-A-81 (#428)

CATHERINE AND MICHAELS

LOC: SE¼ Sec. 35, T17N, R12W

QUAD: Tule Wash 7½'; Prescott NTMS

DEVL: Prospect pits

RAD: 5-10X

ANAL: 0.20% e U_3O_8

GEOL: Uraniferous milky-white to greenish opal with irregular patchy manganese oxide in local replacement layer in thinly laminated, poorly consolidated limestone in tilted blocks of fine grain clastics overlying Precambrian granite. The general area contains several anomalies in limestone and mudstones in Miocene-aged sediments. For details, see Scarborough and Wilt (1979).

REF: PRR-w/o# (#465)

CEDAR WASH

LOC: 36°35'18"N; 114° 00' 40"W

QUAD: Virgin Peak 15'; Las Vegas NTMS

GEOL: Carnotite - type mineralization apparently in Shinarump Member, Chinle Fm.

REF: Peirce, H. and others (1970)

CERBAT MINE

LOC: NE¼ Sec. 7, T22N, R17W

QUAD: Cerbat 7½'; Kingman NTMS

DEVL: 750 ft. shaft and drifts

PROD: Gold and silver

RAD: 40X

ANAL: 0.021% e U_3O_8; 0.021% U_3O_8

GEOL: Radioactivity associated with hematite cemented breccia in 3 to 15 ft. wide quartz and gouge filled fault fissure, striking N48°W, dipping nearly vertical.

REF: PRR-AP-7 (#469)

CHAMPION MINE

LOC: Sec. 18, T22N, R17W

QUAD: Cerbat 7½'; Kingman NTMS

DEVL: 500 ft. shaft with five levels

PROD: Gold, lead, silver, zinc

RAD: 3X

GEOL: Radioactivity is associated with mineralization in NNW striking vein, dipping 75°E, along a fault or fissure. Country rock is amphibole schist and gneiss.

REF: PRR-AR-67 (#524)

CHAPEL

LOC: NE¼ Sec. 25, T33N, R10W
Parashant Wash.

QUAD: Whitmore Point 7½'; Grand Canyon NTMS

DEVL: 50 ft. Tunnel driven southward; some drilling done.

PROD: 1.08 ton @ 0.23% U_3O_8, 4.02% Cu, 1.1% $CaCO_3$ in 1954.

RAD: 100X in 1 inch thick Cu-filled joint.

ANAL: 0.34% e U_3O_8; 0.31% U_3O_8; 0.31% U_3O_8; 1.95% Cu

GEOL: Autunite, uranophane and copper minerals in Supai Sandstone and/or Hermit Shale. Supai is bleached along bedding planes; no Redwall Ls is visible in area. Probable breccia pipe structure. Beds in area dip shallow to SE.

REF: PRR-RA-11 (#545)
D.O.E.
Mike Price, Tempe

CHERYL M #1

LOC: Sec. 28, T11N, R14W, location uncertain

QUAD: Artillery Peak 15'; Prescott NTMS

PROD: 29 tons @ 0.01% U_3O_8; 2.46% Ca CO_3 in 1958.

RAD: 20X

GEOL: Ore was apparently in granite or schist. Radioactive hematized quartz veins reportedly intrude foliated granite-gneiss.

REF: Arizona Bureau of Geology Data
D.O.E.

CHIEF CLAIMS (Democrat Mine)

CINCINNATI CLAIM (Summit Mine)

CISCO

LOC: Approx. SW¼ Sec. 23, T30N, R30W

QUAD: Senator Mtn. 15'; Kingman NTMS

DEVL: Small trenches

ANAL: 0.36% e U_3O_8; 0.348% U_3O_8

GEOL: Carnotite and radioactive opal in small, scattered pockets in a white, friable, tuffaceous limestone of late Cenozoic Age.

REF: PRR-C-96 (#433)
Blair, W. and Armstrong, A. (1979)

COPPER HOUSE #1 & 2

LOC: Sec. 1, 2, T 32N, R11W
Andrus Canyon

QUAD: Yellow John 7½'; Grand Canyon NTMS

DEVL: 30 ft. adit and pits

RAD: 50X

ANAL: 0.18% e U_3O_8; 0.165% U_3O_8; 3.99% Cu; 0.01% V_2O_5

GEOL: No. 1: Toroweap limestone has collapsed 300 ft. through Coconino Sandstone into Hermit Shale. Coconino is altered to yellow and purple. Underlying Supai is bleached. Circular bleached fracture zone reported.
No. 2: Radioactivity along fractures trending N50°W in bleached Supai Fm. Basalt (?) dikes and fault zone in immediate area of mineralization. Both structures are breccia pipes.

REF: PRR-135 (#567)
D.O.E. data

COPPER HOUSE COLITION #2

LOC: Approx. Sec. 1, 2, T 32N, R11W
near Copper House #1

QUAD: Yellow John 7½'; Grand Canyon NTMS

DEVL: Prospect pits

RAD: 5X

ANAL: 0.048% U_3O_8; 0.02% U_2O_5; 4.57% Cu

GEOL: Uranium and copper minerals associated with curving brecciated zone in bleached and fractured course-grained Supai Fm., probable Breccia pipe.

REF: PRR-RR-136 (#568)
Finch, W. (1967)

COPPER MOUNTAIN MINE

LOC: SW¼ Sec. 14, T32N, R10W

QUAD: Whitmore Point 7½'; Grand Canyon NTMS

DEVL: 210 ft. shaft and stopes

PROD: Copper production

RAD: 120X - highest at water table

ANAL: 0.13 -14.1% e U_3O_8

GEOL: Uranium and base metal mineralization in fractures around periphyry of pipe-like collapse structure. Diameter of pipe is about 700 ft. Workings are in Supai Fm., above an unformable contact with Redwall limestone. Supai is bleached. Redwall is cherty. Hermit Shale contains basic dikes. No Toroweap noted in breccia. Toroweap and most of Hermit are eroded away, probable breccia pipe.

REF: PRR-RR-99 (#561)
Finch, W. (1967)

CORLEY, LIND AND ELLINGTON MINE

LOC: Approx. Sec. 6, T 29N, R17W

QUAD: Garnet Mtn. 15'; Kingman NTMS

DEVL: Two shafts and adit

PROD: About 24 tons @ 0.25% U_3O_8 stockpiled

RAD: 30X

ANAL: 0.70% e U_3O_8; 0.70% U_3O_8

GEOL: Greenish-black resinous radioactive mineral associated with base metal-iron sulfides and oxides. Mineralization in quartz veins cutting metamorphic rocks and gneissis granite.

REF: PRR-AP-122 (#566)

CUNNINGHAM MINE

LOC: Center Sec. 16, T33N, R14W

QUAD: Grand Gulch Bench 7½'; Grand Canyon NTMS

DEVL: Short adit and incline

RAD: 16X

GEOL: Radioactivity associated with copper and iron fracture fillings in well-bedded silty facies of Redwall Ls, 150 ft. below its top. Main tunnel intersects Fe and Cu in a 1"-12" wide vein dipping 30°S.

REF: D.O.E.

CUPAL MINE

LOC: Sec. 9, T22N, R17W
Cerbat Mtns.

QUAD: Stockton Hill 7½'; Kingman NTMS

DEVL: Three shafts

PROD: Gold, silver, zinc, lead

RAD: 7X

GEOL: Mineralization and radioactivity along quartz vein in fault fissure.

REF: PRR-AR-55 (#512)

DAB #1 AND DAGMAR

LOC: Approx. E. Center Sec. 21 and SW¼ Sec. 22, T30N, R20W

QUAD: Senator Mtn. 15'; Kingman NTMS

DEVL: Adit and dozer cuts

RAD: 4X

ANAL: 0.85% e U_3O_8; 0.878% U_3O_8

GEOL: Autunite and other secondary uranium minerals occur as thin smears in Tertiary tuffaceous mudstone interbedded with tuff and clay.

REF: PRR-NSL-275 (#436 e 437)
Blair, W. and Armstrong, A. (1979)

DAGMAR (Dab #1)

DELTA GROUP

LOC: Sec. 28, T40N, R6W

QUAD: Short Creek SW 7½'; Grand Canyon NTMS

RAD: 4X

GEOL: Radioactivity along contact between Moenkopi and Shinarump Conglomerate.

REF: PRR-RR-187 (#440)

DEMO GROUP (Democrat Mine)

DE LA FONTAINE MINE

LOC: SE¼ Sec. 5, T22N, R17W

QUAD: Stockton Hill 7½'; Kingman NTMS

DEVL: Shaft, drift, crosscuts

PROD: Base metals

RAD: 50X

ANAL: 0.80% e U_3O_8; 0.93% U_3O_8; 0.5 oz/+ Ag; 0.7 oz./t Au; 2.9% Pb; 14.3% Zn.

GEOL: Probably finely disseminated uraninite associated with base metal sulfides and quartz filled fractures and shear breccia in granite and schist.

REF: PRR-35 (#495)
Hart, O. (1955, RME-2029)
Hart, O. and Hetland, D. (1953, RME-4026)

DEMOCRAT MINE (Demo Group: Chief, Mickey; Morning Star; Papoose Claims)

LOC: SE¼ Sec. 33, T20N, R15W
Hualapai Mtns.

QUAD: Dean Peak 7½'; Williams NTMS

DEVL: 3 adits and 45° inclined shaft

PROD: Silver and gold in 1860-1870's
88 tons @ 0.17%, U_3O_8, 1955-57

RAD: 75X

ANAL: 0.264% e U_3O_8; 0.11% U_3O_8; 0.21 oz/T. Au; 3.9 oz/T Ag. waste dump material 0.04% U_3O_8; chute muck in adit 0.11% U_3O_8; 1.7 Foot wide channel sample on the vein 0.05% U_3O_8.

GEOL: Uraninite occurs with arsenopyrite in fissure vein cutting Precambrian granite, gneiss, and schist. Vein trends N-S, and dips 45° easterly. Vein is 1-4 feet thick. Originally mined for gold and silver in arsenopyrite, pyrite, and chalcopyrite. There has been shearing along the vein.

REF: PRR-AP-25 (#487)
Hart, O. and Hetland, D. (1953, RME - 4026)
D.O.E.

DETROIT GROUP (Brooklyn; Hudson; New York and Palisades Claims

LOC: W. central Sec. 31, T23N; R17W

QUAD: Cerbat 7½'; Kingman NTMS

DEVL: 335 ft. crosscut, 110 ft. drift; 100 ft. winze; 50 ft. shaft

PROD: Gold and silver in 1960's

RAD: 300X

ANAL: 0.193% e U_3O_8; 0.371% U_3O_8

GEOL: Vein of base metals occurs in a fault or fissure cutting Precambrian Granite, gneiss and schist. Vein strikes N35° W and dips 75° SW. Hydrothermal mineralization occurs along footwall and hanging wall. Finely disseminated uraninite occurs in highest concentration within shattered sphalerite in the hanging-wall portion of the vein structure. Becqueralite was identified.

REF: PRR-RA-12 (#546)
Hart, O. and Hetland, D. (1953, RME-4026)
Hart, O. (1955, RME-2029)

DIPLOMAT

LOC: Sec. 13, T22N, R18W
Cerbat Mtns.

QUAD: Cerbat 7½'; Kingman NTMS

DEVL: 250 ft. inclined shaft; 67 ft. drift

PROD: Lead and silver

RAD: 4X

GEOL: Radioactivity associated with galena vein striking N50°W, dipping 60°S. Mineralized area consists of a group of lens shaped en echelon ore bodies each separated by a horse of altered and bleached gneiss.

REF: PRR-AR-65 (#522)

ESTER BASIN

LOC: SE¼ Sec. 29, T12N, R13W

QUAD: Artillery Peak 15'; Prescott NTMS

DEVL: Drilled

RAD: 4X

GEOL: Dark brown, organic-rich, siliceous mudstone just above basal arkose in Artillery Fm. exposed in hogbacks dipping 70°SW.

REF: Waechter, N. (1979)
Otton, J. (1977 b)

ESTHER (Eva)

EVA, MARION, ESTHER, AND WHITE ELEPHANT CLAIMS

LOC: Sec. 30, T22N, R17W
Cerbat Mtns.

QUAD: Cerbat 7½'; Kingman NTMS

DEVL: 35 ft. drift and 20 ft. crosscut

RAD: 6X

GEOL: Radioactivity in rare earth-bearing pegmatite dikes cutting Precambrian schist and gneiss.

REF: PRR-AR-66 (#523)

FOOLS PEAK (Blue Smoke)

FORT LEE (J. C. Claims)

FREDONIA #1

LOC: Sec. 7, T39N, R3W

QUAD: Fredonia SW 7½'; Grand Canyon NTMS

RAD: 4X

GEOL: Radioactivity associated with stringers and pockets of carbonaceous matter with copper staining in sandstones and shales of lower Moenkopi Fm.

REF: PRR-RR-203 (#442)

FRONTIER AND FRONTIER #2

LOC: Sec. 18, T22N, R17W
Cerbat Canyon

QUAD: Cerbat 7½'; Kingman NTMS

DEVL: Two 250 ft. drifts and crosscuts; several short adits, pits

PROD: Gold and silver

RAD: 15X

ANAL: 0.096% e U_3O_8; 0.063% U_3O_8

GEOL: Highest radioactivity in the schist in the footwall of a fault fissure paralleled by a pegmatite at the Frontier Claim.

REF: PRR-AP-27 (#489)

GOLCONDA GROUP (Primrose Mine)

GOLD NUGGET

LOC: Sec. 7, T22N, R17W
Cerbat Canyon

QUAD: Cerbat 7½'; Kingman NTMS

DEVL: Shaft and surface trenching

PROD: Gold and silver

RAD: 15X on ore dump

ANAL: 0.23% e U_3O_8; 0.45% U_3O_8

GEOL: Uranium in quartz and gouge filled fault fissure striking N10°W, dipping 86°W and cutting Precambrian gneiss and schist.

REF: PRR-AP-8 (#470)

GREY BOY # 1-6 (White Owl Group)

H.E.C. PROSPECT

LOC: Sec. 25, 26, T 26N, R11W. (35° 36' 35"N, 113° 24' 56"W)
Hualapai Indian Reservation

QUAD: Peach Springs 7½'; Williams NTMS

DEVL: Bulldozing

RAD: 60X

ANAL: 0.2% e U_3O_8

GEOL: Radioactivity associated with limonite and hematite in conglomeratic sandstone with silicified wood fragments. Abundant faulting along SW side of area. Hurricane fault is 1 mile to the west.

REF: PRR-AP-306 (#455)

HACK CANYON MINE

LOC: NE¼ Sec. 26, T37N, R5W

QUAD: Heaton Knolls SE 7½'; Grand Canyon NTMS

DEVL: Two shafts, tunnel, adit, and underground workings

PROD: 1,329 tons @ 0.18% U_3O_8, in 1950, 52, 53, 54, 64. 53 tons in 1954 was "no-pay" 0.08% U_3O_8 ore. copper production in 1944-45 Canyon Copper Co.

ANAL: 0.006 - 1.673% e U_3O_8; 0.009 - 1.798% U_3O_8

GEOL: Slump structure possibly involving Toroweap and Coconino Sandstones and Hermit Shale. Rock is bleached and silicified. Uraninite mixed with chalcocite is deposited in the breccia zone and in some of the coarser grained sandstones. Fractures are coated with chalcanthite, brochantite, erythrite, bieberite, zippeite, meta torbernite, torbernite, and malachite, Breccia pipe origin. See general discussion on breccia pipes for new discovery nearby this mine.

REF: PRR without # (#462,466)
Granger, H. and Raup, R. (1962)
Finch, W. (1967)
Gruner, J. & Gardiner, L. (1953, RMO-746)
Gruner, J. & Gardiner, L. (1950, RMO-747)
Dunning, C. (1948)
Rason, C. (1949)
Breed and Roat (1974), p. 177-78
Osterwald (1965) p. 132-135.

HILLSIDE GROUP AND QUARTZ MOUNTAIN GROUP

LOC: Sec. 10, 14, T28N, R16W

QUAD: Quartermaster Canyon SW7½'; Williams NTMS

DEVL: Prospect pits

ANAL: 0.007 -0.533% e U_3O_8

GEOL: Small pods of allanite, polycrase, euxenite, and monazite associated with a pegmatite dike and granitic intrusive cutting gneiss and schist.

REF: PRR-AP-261 (#447)

HOPKINS FELDSPAR CLAIM

LOC: Sec. 27, T22N, R17W
Cerbat Mtns.

QUAD: Stockton Hill 7½'; Kingman NTMS

RAD: 8X

GEOL: Radioactivity associated with pegmatite dike.

REF: PRR RA-16 or 18 (#548)

HUDSON CLAIMS (Detroit Group)

IEIVAL CLAIM (Madrill Claim)

IRIS CLAIM

LOC: North center Sec. 4, T38N, R6W
Yellowstone Mesa

QUAD: Heaton Knolls NW 7½'; Grand Canyon NTMS

DEVL: 10 ft. adit and pits

RAD: 20X

ANAL: 0.01% e U_3O_8

GEOL: Radioactivity associated with carbonaceous matter in pebble conglomerate of Shinarump member Moenkopi contact. Some fine galena disseminated in the red Moenkopi near the contact.

REF: PRR-RR-255 (#446)

J. C. AND FORT LEE CLAIMS

LOC: SE¼ Sec. 12, T22N, R18W
Cerbat Mtns.

QUAD: Cerbat 7½'; Kingman NTMS

DEVL: Two incline shafts, drifts and stoping

PROD: Gold and silver

RAD: 10X

ANAL: 0.06% e U_3O_8; 0.06% U_3O_8

GEOL: Radioactivity along mineralized quartz vein in rhyolite dike cutting Ithica Peak Granite.

REF: PRR-AP-161 (#492,569)
Hart, O. (1955, RME-2029)
Hart, O. and Hetland, D. (1953, RMO-4026)

JACOBS RANCH

LOC: South central N. Mohave Co. Sec. 4, T36N, R16W
Note: Jacobs Ranch House is on Sec. 9-

QUAD: Virgin Peak 15'; Las Vegas NTMS

DEVL: Prospecting; unknown geology

REF: Keith (1970)

JAMISON (MAMMOTH #1)

JESSIE BELLE #2-4

LOC: Sec. 31, T 29N, R21W,
East of Hoover Dam

QUAD: Black Canyon 15'; Kingman NTMS

RAD: 3X

ANAL; 0.03% e U_3O_8; 0.015% U_3O_8

GEOL: Pegmatite and basic dikes cutting gneiss and schist.

REF: PRR-NSL-160 (#534)

JIM KANE MINE (Monitor Group)

LOC: NE¼ Sec. 8, T22N, R17W

QUAD: Stockton Hill 7½'; Kingman NTMS

DEVL: Adit

RAD: 20X

ANAL: 0.08% e U_3O_8; 0.052%, U_3O_8; 6.6% Pb 3.7 oz/T Ag; 0.02 oz./T Au

GEOL: Mineralization along a shear zone in altered and brecciated granite. Fluorescent radioactive coatings on drift walls.

REF: PRR-RA-21 (#551)
Kaiser, E. (1951, TEM-216)
Wright, R. (1950, RMO-679)
Hart, O. (1955, RME-2029
Hart, O. and Hetland, D. (1953, RME-4026)

KAIBAB INDIAN RESERVATION LEASE (Piute Indian Reservation Lease)

LOC: Approx. SE¼ Sec. 6, T41N, R3W

QUAD: Short Creek 7½'; Grand Canyon NTMS

DEVL: Prospect pit

RAD: 50X

ANAL: 0.53% e U_3O_8; 0.518% U_3O_8

GEOL: Yellow radioactive mineral in small nodules and seams in pink and white gypsum and petrified logs in Petrified Forest Member, Chinle Fm. Possibly some uraninite.

REF: PRR-SL-124 (#458)

KATY J. CLAIMS

LOC: Approx. SW¼ Sec. 14, T39N, R4W

QUAD: Fredonia SW 7½'; Grand Canyon NTMS

DEVL: Drilled

RAD: 6X

ANAL: 0.016-0.224% e U_3O_8; 0.014-0.149% U_3O_8
Mineralized wood = 6.71% e U_3O_8; 6.62% U_3O_8

GEOL: Possibly torbernite with copper carbonates, carbonaceous trash and fossil wood in red sandy shale of Moenkopi Fm.

REF: PRR-RR-286 (#451, 452)

KIM CLAIMS

LOC: Sec. 22, T40N, R6W

QUAD: Short Creek SW 7½'; Grand Canyon NTMS

DEVL: Drilled

GEOL: Radioactivity noted in both drill holes at Moenkopi and Shinarump contact. Uranium mineralization exposed in low ridge about 1½ miles to the east.

REF: PRR-RR-281 (#580, 580A)

KISSEE - MITCHELL LEASE

LOC: Approx. SE¼ Sec. 23, T30N, R18W

QUAD: Garnet Mtn. 15'; Kingman NTMS

DEVL: Prospected

RAD: 14X

ANAL: 0.22% e U_3O_8

GEOL: Carnotite-type minerals and uranium-bearing fluorescent silica in marl zone between more resistant limestone beds. Tertiary sediments overly granitic schist. Minor faulting, pods of psilomelane and manganite occur in schist.

REF: PRR-A-116 (#724)
Blair, W. and Armstrong, A. (1979)

KISTLER PROSPECT

LOC: Sec. 15, T13N, R12W

QUAD: Artillery Peak 15'; Prescott NTMS

RAD: 10X

ANAL: 0.03% U_3O_8

GEOL: Radioactivity localized in biotite-rich dike or zone in granite.

REF: PRR-AP-216 (#578)
Waechter, N. (1979)

LAST CHANCE (Rainbow)

LITTLE THREE #1

LOC: Approx. Sec. 6, T39N, R3W

QUAD: Fredonia SW 7½'; Grand Canyon NTMS

RAD: 100X

GEOL: Radioactivity associated with carbonaceous debris and copper staining in brown sandstone and shale of the lower Moenkopi Fm.

REF: PRR-RR-205 (#444)

LUCKY FOUR

LOC: Approx. NE¼ Sec. 26, T12N, R13W

QUAD: Artillery Peak 15'; Prescott NTMS

DEVL: Dozer cuts

RAD: 15X

ANAL: 0.02% e U_3O_8

GEOL: Thin coatings of tyuyamunite and carnotite on fractures in a 5 ft. thick carbonaceous bed and several thick bedded limestones in a tilted, fluviolacustrine section of Artillery Fm. beneath a thrust sheet of gneiss.

REF: PRR-A-82 (#429)
Scarborough and Wilt (1979)

LUCKY 44

LOC: Approx. NE¼ Sec. 18, T30N, R20W

QUAD: Senator Mtn. 15'; Kingman NTMS

DEVL: Trenches and drilling

RAD: 10X

ANAL: 0.26% e U_3O_8; 0.51% U_3O_8

GEOL: Carnotite or uranophane coating bedding planes and in sandy pockets in Tertiary lacustrine interbedded bentonitic clay and siltstone, opalitic silica, and sandy conglomerate. Abundant gypsum and calcium carbonate.

REF: PRR-C-23 (#432)

LUCKY FRIDAY

LOC: Sec. 18, T22N, R17W

QUAD: Cerbat 7½'; Kingman NTMS

DEVL: Two short drifts and 100 ft. incline

PROD: Gold prospect

RAD: 4X

GEOL: Radioactivity associated with base metal mineralization along a quartz vein in a 15 ft. wide fault fissure. Fault trends NNW and dips vertically.

REF: PRR-AR-68 (#525)

MADRILL AND IEIVAL CLAIMS

LOC: Sec. 29, T14N, R12W

QUAD: Greenwood Peak 7½'; Prescott NTMS

DEVL: 100 ft. adit and prospect pits

PROD: Tungsten

RAD: 40X

ANAL: 0.07-8.0% e U_3O_8

GEOL: Samarskite and allanite in several large pegmatite dikes trending NE-SW through Precambian granite.

REF: PRR-A-34 (#427)

MAMMOTH #1 (Jamison)

LOC: Sec. 31, T22N, R17W

QUAD: Kingman NW 7½; Kingman NTMS

DEVL: Adit, two shafts, several pits

RAD: 20X

ANAL: 0.03% e U_3O_8; 0.001% U_3O_8

GEOL: Base metal mineralization along quartz and gouge filled fault fissure intersecting basic dike near adit.

REF: PRR-AP-28 (#490)

MARION (Eva)

MASTERSON GROUP

LOC: Central Sec. 22, T12N, R13W

QUAD: Artillery Peak 15'; Prescott NTMS

DEVL: Prospected

RAD: 300X

ANAL: 0.08% e U_3O_8; 0.10% U_3O_8

GEOL: Radioactivity associated with carbonaceous matter and palm-like plant fossils in limestone and mudstone in a tilted section of Artillery Fm. Mineralized zone appears bleached and is about 100 ft. above Precambrian Granite and just above basal conglomerate of Artillery Fm.

REF: PRR-A-68 (#431)
Scarborough and Wilt (1979)

MICKEY CLAIMS (Democrat Mine)

MIDDAY CLAIM

LOC: NW¼ Sec. 12, T22N, R18W

QUAD: Cerbat 7½'; Kingman NTMS

DEVL: Three inclined shafts and some surface trenching

PROD: Gold and silver plus lead and zinc.

RAD: 5X

GEOL: Radioactivity along mineralized quartz and gouge filled fault fissure, striking N10° W, dipping 70° NE.

REF: PRR-AR-47 (#504)

MIDIS CLAIM (Virgin Mtns.)

LOC: Sec. 1, T39N, R15W
or Sec. 1 or 2, T38N, R15W

QUAD: Cane Springs NE 7½ (T38N) or Littlefield SE 7½ for T39N; Grand Canyon NTMS

RAD: Atomic bomb fallout registered anomalous readings on geiger counters, early 1950's.

REF: PRR-P-SL-1

MINERAL X CLAIM

LOC: Approx. Sec. 3, T20N, R17W

QUAD: Kingman 7½'; Kingman NTMS

DEVL: Open cut

RAD: 3X

ANAL: 1.054% e U_3O_8; 0.48% U_3O_8; 3.4% thO_2

GEOL: Pegmatite dike in schist and granite, possibly fergusonite, thalenite, allanite, fluorite and epidote.

MOHAVE FLUORSPAR

LOC: Sec. 1, T23N, R14W

QUAD: Valentine 7½'; Williams NTMS

DEVL: 4 small prospect pits

RAD: 2X

GEOL: Purple fluorite along fissure-like structure in highly altered and silicified rhyolite.

REF: PRR-RA-20 (#550)

MOHAWK MINE

LOC: SE¼ Sec. 6, T22N, R17W

QUAD: Cerbat 7½'; Kingman NTMS

RAD: 2X

GEOL: Mineralized quartz and gouge filled fault fissure about 1 to 3 ft. wide, striking N40°W, dipping 75°N and cutting Precambrian Granite.

REF: PRR-AR-40 (#500)

MONITOR GROUP (Jim Kane)

MORNING STAR CLAIMS (Democrat Mine)

MUSTANG

LOC: Approx. SE corner Sec. 6, T37N, R5W

QUAD: Heaton Knolls 15'; Grand Canyon NTMS

ANAL: 0.05% e U_3O_8; 0.01% U_3O_8

GEOL: Radioactivity along 15 foot ridge of coarse sandstone and conglomerate of the Shinarump member.

REF: PRR-RR-254 (#445)

NAVICO GROUP #1

LOC: " going west on Alamo Rd. take right fork marked Black Diamond Rd. toward Stovall; go 1.2 miles then turn right on Mine Road, proceed 2.4 miles to property.

QUAD: Prescott NTMS

RAD: 7X

GEOL: Thin coatings of carnotite on fracture surfaces in irregular lenticular beds of arkose, ash, sand and mud, capped with basalt. Some silicified wood.

REF: PRR-A-83 (#430)

NEW YORK CLAIMS (Detroit Group)

OLD DAD MINE (Blendina Group)

PALISADES CLAIMS (Detroit Group)

PAPOOSE CLAIMS (Democrat Mine)

PIUTE INDIAN RESERVATION LEASE (Kaibab)

PLENDINA (Blendina)

PRIMROSE MINE (Golconda Group)

LOC: Sec. 6, T22N, R17W

QUAD: Cerbat 7½'; Kingman NTMS

DEVL: Adits, lower workings connect with the Prosperity Mine.

PROD: Gold, silver, copper, lead zinc

GEOL: Possibly uraninite associated with vein in fault fissure cutting gneiss. Vein strike N 14°W and dips 69°E.

REF: Hart, O, and Hetland, D. (1953, RME-4026)

PROSPERITY

LOC: North center Sec. 6, T22N, R17W

QUAD: Cerbats 7½'; Kingman NTMS

DEVL: Drifts and crosscuts

RAD: 20X over the dump

GEOL: Base metal vein along shear zone in Precambrian Granite. Radioactivity maximum close to hanging wall, where brecciation and oxidation are greatest. Possibly uraninite.

REF: PRR-RA-7 (#541)
Hart, O. (1955, RME-2029)
Hart, O. & Hetland, D. (1953, RME-4026)

QUARTZ MOUNTAIN GROUP (Hillside)

QUARTZITE

LOC: Approx. Sec. 9, T19N, R13W
"200 yds. E of Highway 93"

QUAD: Bottleneck Wash 7½'; Williams NTMS

DEVL: Prospect pits

RAD: 2X

GEOL: Possibly samarskite in pegmatite dikes cutting granite.

REF: PRR-A-69

RADON #1

LOC: SW¼ Sec. 24, T40N, R6W

QUAD: Short Creek SW 7½'; Short Creek 15'; Grand Canyon NTMS

DEVL: 2 shallow trenches, 25 and 45 ft. long.

PROD: 22.6 tons @ 0.06% U_3O_8; 0.55% V_2O_5: 1954

ANAL: 0.67% e U_3O_8; 0.19% U_3O_8

GEOL: Carnotite-type ore with Logs and carbonaceous matter in Shinarump member sediments.

REF: PRR-RR-204
PRR-RR-168
D.O.E. data

RAINBOW (Last Chance)

LOC: NW¼ Sec. 25, T40N, R6W

QUAD: Short Creek SW 7½'; Grand Canyon NTMS

DEVL: 18 ft. shaft; drill holes; copper prospect.

PROD: 30 tons @ 0.28%, U_3O_8; 1.13%, V_2O_5, 1955

ANAL: 0.02% e U_3O_8; 0.024%, U_3O_8; 0.75% Cu

GEOL: Uranium occurs in 3 ft. thick sandstone lens with carbonaceous debris and copper staining. Mineralization is apparently in the Shinarump mbr. close to Moenkopi contact. Silicified wood is abundant, copper mineral is chrysocolla.

REF: PRR-RRs-106 (#563, #426)
PRR-D-430 (#532)
D.O.E.

RAINY DAY CLAIMS

LOC: Approx. NW¼ Sec. 33, T30N, R22W or 35°57' 02"N; 114° 38' 58" W.

QUAD: Black Canyon 15'; Kingman NTMS

RAD: 200X

GEOL: Radioactive yellow mineral coating and disseminated in white aplitic rock. Very radioactive float on an alluvial fan near Precambrian schist, granite, aplite and basalt.

REF: PRR-NSL-159

RED HILLS

LOC: West central Sec. 7, T11N, R13W

QUAD: Artillery Peak 15'; Prescott NTMS

DEVL: 21 ft. shaft

RAD: Strongest at intersection of crosscutting shear zone and vein.

ANAL: 0.314% U_3O_8

GEOL: Kasolite and other secondary yellow and orange uranium minerals along fractures in chalcedonic quartz vein cutting a breccia. The breccia consists of fragments of silicified felsitic material, schist, conglomerate, limestone, cemented with silica, carbonates and manganese-iron oxides. It is probably a fault breccia at the base of the Artillery Fm. Vein strikes N85°E, dips 50-60°SE and is 6 to 20 ft. wide.

REF: PRR w/o # (#463, #890, #890a)
Granger, H. and Raup, R. (1962)
Reyner, M. and Ashwill, W. (1955)
Hart, O. (1955, RME -2029)
Kaiser, E. (1951, TEM-217)
Scarborough, R. and Wilt, J. (1979)

RED WING

LOC: N½ Sec. 23, T33N, R10W
Parashont Canyon

QUAD: Cold Spring, 7½'; Grand Canyon NTMS

DEVL: 8 ft. adit and open cut

PROD: Copper
1.4 tons @ 0.16% U_3O_8, 1956

ANAL: 0.16% e U_3O_8; 0.15% U_3O_8

GEOL: Secondary uranium minerals with copper and carbonaceous material in altered sandstone of the Upper Permian Redbeds.

REF: D.O.E.

S. S. 58

LOC: Approx. Sec. 16, T36N, R13W
Hidden Canyon

QUAD: No quad; Grand Canyon NTMS

DEVL: Extensive workings

PROD: Copper

RAD: 8X

GEOL: Copper and iron minerals filling fractures in Supai Fm.

REF: D.O.E.

SAVANNIC MINE (SAVANIC, BRONZE L MINE)

LOC: SW¼ Sec. 9, T33N, R14W

QUAD: Grand Gulch Bench 7½'; Grand Canyon NTMS

DEVL: Extensive stopes and decline on 1-3 ft. main shear.

PROD: Copper

RAD: 4X

GEOL: Copper minerals filling fractures/shears along bedding planes in Redwall limestone. Main shear is 1 to 3 ft. wide and dips 60°E. It is filled with Cu-Fe-Mg minerals, and dolomite, cemented by calcite.

REF: D.O.E.
Breed and Roat (1974), p. 171

SCHOOL SECTION

LOC: Sec. 16, T33N, R11W
Andrus Canyon

QUAD: Grassy Mtn. 7½'; Grand Canyon NTMS

DEVL: Prospect pit

RAD: 3X

GEOL: Radioactivity at the intersection of a fracture zone with a basic dike both apparently cutting Kaibab limestone.

REF: PRR-RR-303 (#453)

SECRET PASS

LOC: Approx. T21N, R18W

QUAD: Kingman NW 7½'; Kingman NTMS

DEVL: Shafts, adits and trenches

PROD: Gold & silver

RAD: 3X

GEOL: Large mineralized quartz-calcite veins cutting N-S and NW-SE through granite, capped by volcanics.

REF: PRR-AP-172

STATE MINE

LOC: SE¼ Sec. 4, T13N, R12W

QUAD: Artillery Peak 15'; Prescott NTMS

DEVL: 150 ft. crosscut, 65 ft. drift, 35 ft. shaft

PROD: Gold & Silver

RAD: 45X

ANAL: 0.30% e U_3O_8; 0.36% U_3O_8

GEOL: Fault zone with autunite in gouge and wallrock cuts quartz vein carrying gold-silver mineralization. The coarse granite porphyry wallrock is moderately altered.

REF: PRR-AP-6 (#468)
PRR-CEBR-51
Hart, O. and Hetland, D. (1953, RME-4026)

SUMMIT MINE (Cincinnati Claim)

LOC: Central Sec. 32, T23N, R17W.
Cerbat Mtns.

QUAD: Stockton Hill 7½'; Kingman NTMS

DEVL: 850 ft. of crosscut adit; drilling, drifting and stoping

PROD: 31,500 tons @ 0.65% Cu; 5.5% Pb; 6.5% Zn, 0.07 oz/t Au; 5.5 oz/t. Ag., 1936-1947. No uranium production.

RAD: 20X

ANAL: 0.64% U_3O_8

GEOL: Uraninite occurs as thin film coating base metal sulfides along shattered zones. Heavily altered shear zone parallels vein, striking N30°W, dipping 80° NE and cuts Precambrian Granite, gneiss, and schist.

REF: PRR-RA-27 (#556)
Hart, O. (1955, RME-2029)
Hart, O. and Hetland, D. (1953, RME-4026)

SUNSET

LOC: "in steep barren slopes of tertiary sediments cut by Beaver Dam Wash north of the Virgin River."

QUAD: NW corner Grand Canyon NTMS

RAD: 2X

ANAL: 0.018% e U_3O_8

GEOL: Yellow uranium mineral in tertiary sediments

REF: PRR-SL-109 (#457)

TATE (Red Hills)

TRIPLE B CLAIMS

LOC: SW¼ Sec. 17, T11N; R17W
Osborne Wash

QUAD: Monkeys Head 7½'; Needles NTMS

DEVL: 5 ft. deep pit

PROD: Stockpiled ore @ 0.42% e U_3O_8; 0.40% U_3O_8

ANAL: 0.85% e U_3O_8; 0.77%, U_3O_8; 0.6% Cu

GEOL: Uraninite is disseminated in Precambrian Gneiss adjacent to fault contact with red conglomerate.

REF: D.O.E.

U.S. GOVERNMENT PROPERTY

LOC: Sec. 28,29,32,33, T28N, R10W

QUAD: Travertine Rapids 7½; Williams NTMS

DEVL: Prospect pits

RAD: 3X

ANAL: 0.004%, U_3O_8

GEOL: Uranium mineral in fractures in sunken blocks of basal Supai Sandstone at the top of the Redwall Limestone. Alteration noted.

REF: PRR-EDR-1265

UNNAMED A

LOC: North center Sec. 10, T 38N, R15W
Virgin Mtns.

QUAD: Littlefield NW 7½'; Grand Canyon NTMS

GEOL: Carnotite-type mineralization in apparently Shinarump member, Chinle Fm.

REF: Peirce, H. and others (1970)

UNNAMED B

LOC: Sec. 5, T18N, R20W

QUAD: Boundary Cone 7½'; Needles NTMS

DEVL: Prospect shaft and trenches

RAD: 10X

GEOL: Shear zone with many small pegmatites cutting gneiss outcropping through Tertiary lavas and Quaternary sediments.

REF: PRR-AP-163 (#493)

UNNAMED C

LOC: Approx. T28N, R16½ W

QUAD: Quartermaster Canyon SW 7½; Williams NTMS

RAD: 4X

GEOL: Scheelite in granite

REF: PRR-RSL-8

URANIUM BASIN

LOC: Approx. Sec. 26, T20N, R13W

QUAD: Bottleneck Wash 7½'; Williams NTMS

DEVL: Prospect pits

RAD: 45X

ANAL: 0.45% e U_3O_8

GEOL: Uranothorite replacement of granite along shear zone and a pegmatite vein. Ore is contained in the 25 ft. zone between shear and pegmatite.

REF: PRR-A-70
Adams, I & Staatz, M. (1969)

VICTORY MINE

LOC: Sec. 33, T23N, R17W
Cerbats Mtns.

QUAD: Stockton Hill 7½'; Kingman NTMS

DEVL: Underground workings

RAD: 4X

GEOL: Base metal bearing quartz vein in a fault fissure

REF: PRR-AR-61 (#518)

WESTERN UNION

LOC: Sec. 15, T22N, R17W
Cerbat Mtns.

QUAD: Stockton Hill 7½'; Kingman NTMS

DEVL: Shaft, drifts and surface pits

RAD: 2X

GEOL: Base metal bearing quartz and gouge-filled fault

REF: PRR-AR-49 (#506)

WHARTON PROPERTY

LOC: Approx. Sec. 22, T40N, R16W

QUAD: Mesquite 15'; Las Vegas NTMS

DEVL: Prospected

RAD: 10X

ANAL: 0.02% e U_3O_8

GEOL: Carnotite-type mineralization as fracture coatings in clay, silts and sands, possibly of the Muddy Creek Fm.

REF: PRR-SL-200 (#459)

WHITE CAP

LOC: Approx. T28N, R16W
Grand Wash Cliffs

QUAD: Garnet Mtn. 15'; Quartermaster Canyon SW 7½; Kingman and Williams NTMS

DEVL: 2 pits

RAD: 70X

ANAL: 1.35% e U_3O_8; 1.23% U_3O_8

GEOL: Euxenite, hornblende and beryl in a pegmatite dike about 20 ft. wide.

REF: PRR-C-119 (#434)

WHITE ELEPHANT (Eva)

WHITE OWL GROUP (Grey Boy #1-6)

LOC: Sec. 5, T12N, R14W

QUAD: Artillery Peak 15'; Prescott NTMS

DEVL: Prospect pits

RAD: 50X

ANAL: 0.38% e U_3O_8; 0.048% U_3O_8

GEOL: Radioactivity along pegmatites and faults cutting Precambrian Schist. Fault zones contains fluorite, chalcedonic quartz and calcite.

REF: PRR-AP-307 (#456)

NAVAJO COUNTY

AIR ANOMALY #55

LOC: Probably Sec. 32, T26N, R21E
Hopi Buttes

QUAD: White Cone 15'; Flagstaff NTMS

GEOL: Collapsed Bidahochi Fm. sediments in diatreme, mineralization in slightly bleached "travertine" beds and massive dark gray agglomerate.

REF: PRR-w/o number

AIR ANOMALY #56

LOC: Sec. 16-15; T25N, R21E
Hopi Buttes

QUAD: White Cone 15'; Flagstaff NTMS

GEOL: Collapsed Bidahocki Fm. sediments associated with diatreme.

REF: PRR w/o number

AIR ANOMALY #59

LOC: Probably Sec. 9, T24N, R21E
Hopi Buttes

QUAD: Indian Wells 7½'; Flagstaff NTMS

GEOL: Collapsed Bidahochi Fm. sediments in diatreme with mineralized interbedded "travertine".

AIR ANOMALY #67

LOC: Probably Sec. 25, T25N, R19E
Hopi Buttes

QUAD: Egloffstein Butte 15'; Flagstaff NTMS

GEOL: Collapse sediments of Bidahochi Fm. associated with a diatreme. Thin to medium bedded buff "travertine" is mineralized.

REF: PRR w/o number

AIR ANOMALY #74

LOC: Probably Sec. 23 (Bobcat Butte) or NW¼ Sec. 14 and SW¼ Sec. 11 (Saddle Butte), T24N, R18E. on NE side of butte.

QUAD: Shonto Butte 7½; Flagstaff NTMS

GEOL: Collapse sediments of Bidahochi Fm. associated with a diatreme. Mineralized travertine beds form the dip slope.

REF: PRR w/o number

ALFRED MILES #1 (Todechanee, Nakai Mesa Peninsula)

LOC: Lat. 36° 59' 48"N and long 110° 28'6"W, Approx. Sec. 4, T41N, R17E, Arizona-Utah parts of Nakai Mesa - Monument Valley

QUAD: Boot Mesa 15'; Marble Canyon NTMS

DEVL: Drilled; prospect adit

GEOL: Torbernite (carnotite and autunite?) and copper mineralization associated with logs and carbon matter at the bottom of a N50° trending Shinarump paleochannel.

REF: Witkind, I.J. & Thaden, R.E. (1963, p. 145-150); Finch, W. (1967)
PRR-GJEB-130 (#615)

ALMA #4 (Alma-Seggin Mine)

ALMA-SEGGIN MINE (Alma #4)

LOC: Approx. SW¼ Sec. 11, T40N, R19E
Monument Valley

QUAD: Boot Mesa 15'; Marble Canyon NTMS

DEVL: Drilling in 1958-61, in excess of 70 holes.

PROD: 6,769 tons @ 0.19% U_3O_8 in 1965-66.

ANAL: 0.10-0.20% U_3O_8

GEOL: A N40°W trending, paleochannel of Shinarump conglomerate contains uraninite. Mineralized zone is about 5 ft. thick and between 150-200 ft. beneath the surface.

REF: D.O.E.

ANNA BERNICE CLAIMS #1-5

LOC: West central Sec. 20, T19N, R19E

QUAD: Blair Springs 7½'; Flagstaff NTMS

DEVL: Shallow prospect pit

ANAL: 5 samples @ 0.003-0.25% e U_3O_8; 0.001-0.25% U_3O_8

GEOL: Unidentified uranium minerals in thin jasper lenses in flat-lying bentonitic shale of Chinle Fm.

REF: PRR-w/o # (#582), Granger and Raup, 1962

BARTON MINE (Ruth)

BAYSHORE #2 (Little John #1-3)

BAYSHORE #3 (Ruth)

BEN #2 (Koley Black #1)

BIDAHOCHI BUTTE

LOC: Approx. SE corner Sec. 12, T23N, R21E
Hopi Buttes

QUAD: Indian Wells 7½'; Flagstaff NTMS

ANAL: 0.01% to 0.2% U_3O_8

GEOL: Extremely finely disseminated uranium in limestone and laminated siltstone and shale of the Bidahochi Fm. Associated with a diatreme feature also containing bedded tuff, evaporites and chert.

REF: Shoemaker, et al. (TEI-700, 1957)
Miller, W.C. (1957)

BIG CHIEF # 3 & 4 CLAIMS

LOC: Approx. SE¼, Sec. 21, T41N, R19E
Oljeto Creek - Monument Valley

QUAD: Boot Mesa 15'; Marble Canyon NTMS

DEVL: Underground w/ incline entry

PROD: 32,834 @ 0.23% U_3O_8, 1959-1961

ANAL: 0.31% U_3O_8; 0.50% V_2O_5; 6.00% $CaCO_3$ max.

GEOL: Uraninite is in a paleochannel of Shinarump conglomerate.

REF: D.O.E.

BIG FOUR (Sunlight, South Sunlight, East Sunlight)

LOC: Approx. the common corner of Sec. 20, 28, 29, T41N, R19E, Monument Valley

QUAD: Boot Mesa 15'; Marble Canyon NTMS

DEVL: Incline

PROD: 3,930 tons @ 0.26% U_3O_8 in 1958-65.

GEOL: Uraninite is in a paleochannel deposit of Shinarump sandstone.

REF: D.O.E.

BILL GILL (Section 33 Lease)

BLACK ROCK

LOC: Approx. NE¼ Sec. 14; T40N, R19E
Monument Valley

QUAD: Agatha Peak 15'; Marble Canyon NTMS

DEVL: Incline

PROD: 37 tons @ 0.08% U_3O_8; 0.13% V_2O_5 in 1955.

GEOL: Carnotite-type ore in a paleochannel deposit of Shinarump sandstone.

REF: D.O.E.

BOOT JACK MINE

LOC: Approx. Sec. 32, T41N, R19E
Monument Valley - Oljeto Creek

QUAD: Boot Mesa 15'; Marble Canyon NTMS

DEVL: Vertical shaft with underground workings following E-W trending paleochannel. Over 200 drill holes.

PROD: 36,662 tons @ 0.46% U_3O_8; 0.07% V_2O_8, in 1957-60 and 1965-66.

ANAL: 0.51% U_3O_8 max.

GEOL: Uraninite is in an E-W trending paleochannel, buried 350 to 400 ft. Ore zone averages 10 ft. thick and is restricted to within the channel flank, generally on the southern side and only occasionally above.

REF: D.O.E.

BRODIE #4-5

LOC: Approx. central Sec. 21, T40N, R21E
Central Monument Valley

QUAD: Agathla Peak 15'; Marble Canyon NTMS

RAD: 10X

GEOL: Carnotite-type and secondary copper minerals in 150 ft. long by 20 ft. deep paleochannel of Shinarump trending E-W in Moenkopi. Silicified wood.

REF: PRR-GJEB: R-165 and 166
Witkind and Thaden (1963)

BRUCE GARDNER CLAIM

LOC: 14 mi. SE of Woodruff, AZ. (possibly T14 or 15N, R. 23 or 24E)

QUAD: Holbrook and Saint Johns NTMS

ANAL: 0.83% e U_3O_8; 1.01% U_3O_8

GEOL: Yellow radioactive mineral associated with silicified wood.

REF: Nininger, R. D. (1950)

CABIEN

LOC: Sec. 1, T17N, R23E

QUAD: Petrified Forest 15; Saint Johns NTMS

ANAL: 0.03 - 0.06% e U_3O_8; 0.03-0.07% U_3O_8

GEOL: Probably carnotite in Chinle Shale just under a conglomerate layer. Cobalt color and jarosite yellow present.

REF: PRR-ED-R-212

CALVIN CHEE PROSPECT

LOC: Approx. Sec. 35, T25N, R22E
Hopi Buttes

QUAD: Satan Butte 7½'; Gallup, NTMS

ANAL: 0.09% e U_3O_8; 0.12% U_3O_8; 0.04% V_2O_5; 1.9% $CaCO_3$

GEOL: Uranium and copper mineralization in the Bidahochi Fm.

REF: PRR-ED:R -283

CARNOTITE CANYON

LOC: Unknown - Monument Valley?

PROD: 12 tons @ 0.35% U_3O_8, 0.01% V_2O_5 in 1952

CARRIZO CLAIM

LOC: Sec. 28, T19N, R23E

QUAD: Navajo Springs and Beacon Well 7½'; Gallup NTMS

RAD: 10X against log

GEOL: Silicified logs with minor yellow and green stains in Shinarump. Some fluorescent waxy, yellow surface coatings are tyuyamunite. Sklodowskite also present.

REF: Nininger, R.D. (1951), PRR-USBM (#11)

CECIL TODECHENEE CHANNEL (Tract 2A)

CHACO-ROBINSON (Morale)

CURRY JONES PROSPECT (Rock Garden #25, Lucky Boy 1-10, Rarezona)

LOC: Approx. N. central Sec. 22, T18N, R23E

QUAD: Petrified Forest 15'; Saint Johns NTMS

DEVL: Rim stripping

PROD: 53 tons @ 0.28% U_3O_8; 0.73% V_2O_5, 1956-57

RAD: 2 mr/hr

ANAL: 4 samples @ 0.05-0.86% U_3O_8

GEOL: Zippeite associated with carbonized trash in bentonitic sandstone of Petrified Forest member. Carnotite in mineralized logs and interstitial in sandstone.

REF: PRR-ED:R-226 (#597)
Gregg (1953)

DAYLIGHT

LOC: Approx. Sec. 20, T41N, R19E
Monument Valley

QUAD: Boot Mesa 15'; Marble Canyon NTMS

DEVL: Drilled

PROD: Unmined ore body

GEOL: Paleochannel of Shinarump

REF: D.O.E.

DOUGHNUT DIATREME

LOC: Approx. NE¼ Sec. 22, T24N, R21E,
Hopi Buttes

QUAD: Indian Wells 7½'; Flagstaff AMS

RAD: 3 X Bkg.

GEOL: Bedded pyroclastics and calcareous Bidahochi Fm. dipping inward 20 to 50°, suggesting collapse. Large portion of the limestone beds is weakly mineralized.

REF: Fair, C.L. (1956)

FERN #1 MINE

LOC: Approx. NW corner Sec. 4, T41N, R19E
West Monument Valley

QUAD: Boot Mesa 15'; Marble Canyon NTMS

DEVL: 27,000 ft. of drilling to average depth of 120 ft. Room and pillar underground mining. Cave-in in 1961 following flooding.

PROD: 10,484 tons @ 0.66% U_3O_8; 0.29% V_2O_5 in 1956, 57, 61.

GEOL: NNW trending paleochannel of Shinarump with uraninite and copper sulfides. Located on the east flank of Oljeto syncline, which is superimposed on the Monument upwarp.

REF: D.O.E.

FIRELIGHT #6 CLAIM (Naschoy Mine)

FRED ZAHNE #1-5

LOC: Approx. Sec. 22-23, T36N, R17E
Black Mesa

QUAD: Shonto SE and Long House Valley 7½'; Marble Canyon NTMS

DEVL: Ten drill holes

RAD: Weak

ANAL: 0.02 - 0.04% e U_3O_8

GEOL: About 5 ft. thick uraniferious lignitic coal bed in Dakota Fm. at a depth of about 50 ft.

REF: D.O.E.

GEORGE BELINTE #1

LOC: Approx. T33N, R22 or 21E
Near Apache County line

QUAD: Blue gap 7½ or Burnt Corn Spring 7½; Marble Canyon NTMS

GEOL: See nearby George Belinte #2 in Apache County

REF: D.O.E.

GERWITZ PROSPECT (Spurlock-Westter Ranch)

LOC: Approx. W center Sec. 26, T19N, R20E

QUAD: Lee Mtn. and Blair Springs 7½'; Flagstaff NTMS

RAD: 0.2 mr/hr.

ANAL: 4 samples @ 0.04 - 1.29% U_3O_8

GEOL: Becquerelite and fluorescence uranium mineral(s) (probably autunite and/or tyuyamunite) in light-brown, coarse grained bentonitic sandstone, containing abundant carbonized plant remains. Probably Petrified Forest member, Chinle Fm.

REF: PRR-ED:R-228 (#598)
Finch, 1967
Moore, 1953

GOLD CROWN

LOC: Approx. Sec. 24, T41N, R19E. Monument Valley
1300 ft. ESE of Monument #1.

QUAD: Agathla Peak 15'; Marble Canyon NTMS

PROD: 70 tons @ 0.12% U_3O_8 in 1955-56

GEOL: Tyuyamunite and minor autunite, carnotite, pyrite, and copper oxides in Shinarump coarse grained sandstone with clay pebbles. Abundant pockets of plant material.

REF: Witkind, R. and Thaden, R. (1963)

GOOF (Section 33 Lease)

LOC: SW¼ of NW¼ Sec. 33, T18N, R23E

QUAD: Petrified Forest 15'; Saint Johns NTMS

DEVL: Rim strip

PROD: 8.9 tons @ 0.1% U_3O_8; 0.13% V_2O_5 in 1956

GEOL: Goof is an illegal shipment of ore from the Sec. 33 lease property. Shipment came from west side of butte in SW¼ of NW¼ of Sec. 33. Legal shipments from Section 33 came from east side of another butte in SE¼ of SE¼ of Sec. 33.

REF: D.O.E.

GWEN

LOC: Approx. Sec. 29, T24N, R22E
Hopi Buttes

QUAD: Indian Wells 7½'; Flagstaff NTMS

DEVL: Prospect pits

ANAL: 0.10-0.15% e U_3O_8
0.06% e U_3O_8, 0.04% U_3O_8, 1.5% $CaCO_3$

GEOL: Six inch seam of autunite mineralization in beds of Bidahochi Fm. associated with tuffs on north perimeter of diatreme.

REF: D.O.E.

HANSON #1 (J. D. Hanson #1)

LOC: Approx. Sec. 11, T18N, R19E

QUAD: Joseph City 15'; Holbrook NTMS

DEVL: Shallow pits and trenches

PROD: 285 tons @ 0.06% U_3O_8; 0.03% V_2O_5, 1953-55

GEOL: Carnotite-type mineralization in carbonaceous siltstone with carbonized plants and petrified wood of Petrified Forest member.

REF: D.O.E.

HARVEY BLACK

LOC: Approx. SW¼ Sec. 1, T41N, R19E
West Monument Valley

QUAD: Boot Mesa 15'; Marble Canyon NTMS

GEOL: Massive medium fine grained Shinarump sandstone in paleochannel some 200 ft. wide and 50 ft. deep cut in Moenkopi. Secondary copper and uranium minerals with abundant silicified wood and carbonized material.

REF: D.O.E.

HARVEY BLACK #2 (Spencer #1)

HENRY LEE SAMPSON

LOC: Unknown - somewhere around Monument Valley

PROD: 32 tons @ 0.10% U_3O_8 in 1955 by Spencer Uranium Co.

HOPI BUTTES

The following Hopi Buttes occurrences are reported individually:

#1 Airborne #55
#2 Airborne #56
#3 Airborne #59
#4 Airborne #67
#5 Airborne #74
#8 Bidahochi Butte
#22 Doughnut Diatreme
#28 Gwen
#30 Horseshoe Diatreme
#31 Hoskie Tso #1
#42 Morale (Seth-la-Kai Diatreme)
#49 Roanhorse Diatreme
#54 Sjodin
#57 Sun #12 Claims
#59 Terry Claims
#71 Unnamed E

REF: Hack, J. T. (1942)
Shoemaker, E. (1956)

HORSESHOE DIATREME

LOC: Sec. 25, T25N, R21E, and Sec. 30, T25N, R22E, Hopi Buttes (12 mi. north of Indian Wells T.P. and 2 mi. east of Keams Canyon Road.

QUAD: White Cone 15'; Flagstaff NTMS

ANAL: 0.02 - 0.03% e U_3O_8; 18.6 - 40.8% $CaCO_3$

GEOL: Uranium mineralization is in "water-laid pyroclastics" as small channel cuts into underlying Bidahochi Fm. on north rim of bowl shaped depression of explosion breccia and adjacent to vent filling on SE point of rim.

REF: Fair, C. L. (1956)

HOSKIE TSO #1

LOC: South Sec. 24, T23N, R21E
Hopi Buttes

QUAD: Indian Wells 7½'; Flagstaff NTMS

DEVL: Prospect pit

RAD: Weak

GEOL: Autunite occurs in matrix and Wingate Sandstone blocks in breccia overlying siltstone on the east edge of diatreme.

REF: Shoemaker, E. et. al. (1957)
Shoemaker, E. et. al. (1962),
D.O.E.

J. CITY #1

LOC: Sec. 33, T19N, R19E

QUAD: Blair Spring 7½'; Flagstaff NTMS

DEVL: Shallow pit and surface scrapings

PROD: 31 tons @ 0.04% U_3O_8, 1957

GEOL: Low grade ore horizon is about 1 ft. thick and at an average depth of 2 ft. in Petrified Forest member.

REF: D.O.E.

J. D. HANSON (Hanson #1)

JOE ROCK #7-9

LOC: Approx. Sec. 31-32, T41, R19E
Monument Valley - Oljeto Creek

QUAD: Boot Mesa 15'; Marble Canyon NTMS

DEVL: 56,675 ft. of drilling in 138 holes, 1956 and 1958.

GEOL: Mineralization in paleochannels of Shinarump scoured into underlying Moenkopi Fm. Uraniferous pods are 300-400 ft. below surface and are associated mostly with depressions in the paleochannel floor. Situated on the east flank of Oljeto Syncline.

REF: D.O.E.

KOLEY BLACK #1 (Ben #2, Sam Charlie #1)

LOC: Approx. N. central Sec. 11, T39N, R.20E
Hunts Mesa - Monument Valley

QUAD: Agathla Peak 15'; Marble Canyon NTMS

PROD: 5 tons @ 0.24% U_3O_8; 1.32% V_2O_5 from Sam Charlie #1 in 1953.

GEOL: Coarse conglomerates grade upward into coarse-grained sandstone in a maze of paleochannels, 35-250 ft. wide; forms NW striking system. Tyuyamunite and copper minerals, silicified wood and coaly matter occur in paleochannel fill and partially replace clay pebbles. Moenkopi is deeply cracked with Shinarump filling cracks.

REF: PRR-GEB:R-53
Chester, J.W. (1951)
Witkind, I.J. & Thaden, R.E. (1963)
U.S.G.S., TEI-280 (p.13-14)

LEASE #1

LOC: Unknown, somewhere in Monument Valley, noted in AEC 1973 ore reserve computer list

PROD: 590 tons @ 0.17% U_3O_8; 0.49% V_2O_5

LITTLE JOHN #1-3 (Young, Bayshore #2)

LOC: NW¼ Sec. 12, T17N, R23E

QUAD: Petrified Forest 15'; Saint Johns NTMS

DEVL: Rim stripping and 10' caved adit. Merrill Young was original owner who sold to Bayshore Co. of Canada and called the mine the Little John.

PROD: 11 tons @ 0.10% U_3O_8; 0.16% V_2O_5, 1953-54
1956 production was combined with the Ruth Mine.

RAD: 1.5 mr/hr.

ANAL: 0.02-0.21% U_3O_8

GEOL: Uraninite, coffinite, zeunerite, schroeckingerite, and torbernite occurs in gray medium to coarse grained sandstone and bentonitic mudstone in Petrified Forest member. Abundant petrified logs and carbonaceous trash.

REF: PRR-EDR: 224 and 225 (#595)
D.O.E.
Finch (1967)
Gregg (1952)
Gregg and Moore (1955)

LUCKY BOY 1-10 (Curry Jones Prospect)

MAC #3

LOC: SE corner Sec. 5, T17N, R23E

QUAD: Petrified Forest 15'; Saint Johns NTMS

DEVL: Small pits along rim

PROD: 6 tons @ 0.48% U_3O_8; 0.71% V_2O_5; 1.1% $CaCO_3$, 1956

GEOL: Carnotite-type mineralization associated with a small, very radioactive pod of red jasper in the Sonsela sandstone of the Petrified Forest member.

REF: D.O.E.

MARGARITE LEASE

LOC: N½, N½, Sec. 3, T17N, R23E

QUAD: Petrified Forest 15'; Saint Johns NTMS

DEVL: 2000 ft. of rim stripping and two 25 ft. adits, drilled by A.E.C.

RAD: 100X

ANAL: 3 samples @ 0.02% - 0.77% U_3O_8

GEOL: Carnotite and possibly some pitchblende in carbonaceous sandstone lenses with carbonized wood in Petrified Forest member. Mineralized zone is at a depth of about 80 ft. and is about 1.5 ft. thick.

REF: PRR-ED:R-225 (#596)
D.O.E.
RME-51 (1955, p.10)

MITCHELL BUTTE MESA (Mitchell Mesa)

LOC: Approx. Sec. 13, T41N, R20E, or 36° 58'N, 110°06'W

QUAD: Agathla Peak 15'; Marble Canyon NTMS

DEVL: Drilled; one crosscut with tramway off Mesa.

PROD: 1,764 tons @ 0.14% U_3O_8; 1.71% V_2O_5 in 1962,65,66.

GEOL: Tyuyamunite and minor torbernite occurs in thin seams surrounded by vanadium mineralization and carbonaceous debris in Shinarump. The Shinarump grades form a massive coarse-grained sandstone downward into conglomerate sandstone with clay pebbles and lies in WNW tranding paleochannel cut into Moenkopi, up to 350 ft. wide and 75 ft. deep.

REF: U.S.G.S. (1953) TEI-280, p.13-14)
Witkind, I.J. (1956, p. 107)
Witkind, I.J. & Thaden, R.E. (1963)
Finch, W.I. (1967)

MITTEN #2 (Monument #1)

MONUMENT No. 1 (Mitten #2)

LOC: Approx. Sec. 24, T41N, R19E, or 36°57' 00"N, 110° 13' 55"W

QUAD: Agatha Peak 15'; Marble Canyon NTMS

DEVL: Underground

PROD: 29,569 tons @ 0.30% U_3O_8; 1.39% V_2O_5, in 1948-1966. V/U ratio ranged from 0.3:1 to 14:1. Mitten 2 produced in 1952-61.

GEOL: Unmineralized calcite - cemented sandstone lenses in Shinarump are surrounded by roughly concentric mineralization with tyuyamunite, metatyuyamunite, metatorbernite, corvusite, hewettite, volborthite, pyrite, azurite, chrysocolla, malachite and limonite. The conglomerate, silica-cemented sandstone and calcite-cemented sandstone with silicified wood, carbonaceous matter and clay pebbles occur in basal remnants of Shinarump paleochannels cut into Moenkopi. Two 2,000 foot long segments trend N to NW. Ore zone varies from ten to 95 feet wide and 1-18 feet thick. Uranium-vanadium and copper minerals impregnate conglomerate and silica-cemented sandstone.

REF: PRR-CEBR-3 (#589)
Witkind, I.J. (1961)
Witkind, I.J. & Thaden, R.E. (1963)

MOONLIGHT

LOC: Approx. NW¼ Sec. 16, T41N, R19E
Monument Valley-Oljeto Creek

QUAD: Boot Mesa 15'; Marble Canyon NTMS

DEVL: 145 ft. deep open pit and some room and pillar underground workings from the bottom of the pit.

PROD: 223,237 tons @ 0.26% U_3O_8; 0.21% V_2O_5, in 1956 and 1959-66.

GEOL: Uraninite in Shinarump paleochannel cut into Moenkopi-ore extends down into Moenkopi.

REF: Malan, R. C. (1968)
U.S.A.E.C. (1959, RME-141)

MORALE CLAIMS (Seth-la-Kai Diatreme, O'Haco-Robinson)

LOC; Approx. NE¼ Sec. 19, T24N, R22E
Hopi Buttes

QUAD: Indian Wells 7½; Flagstaff NTMS

DEVL: Rim stripping and 15 ft. adit with stoping. USGS drilling in 1979 revealed 100,000 tons of 0.015% U_3O_8 remaining in the diatreme.

PROD: 192 tons @ 0.15% U_3O_8; 0.04% V_2O_5, 1954-55, 1957, 1959. 0.75-1.00% P_2O_5 content makes alkaline leach difficult.

ANAL: 4 samples @ 0.05-0.17% e U_3O_8; 0.01 to 0.20% U_3O_8

GEOL: Finely disseminated, non-fluorescent uranium mineral (possibly autunite) in volcanic sandstone beds (Bidahochi Fm.) laminated with more widespread limestone, shale, siltstone and tuffs with chert and evaporites. Beds tilted toward center of diatreme. Some copper mineralization.

REF: Lowell, D. J. (1956)
Shoemaker, E. M. et. al. (1962)
Shoemaker, E. M. et. al. (1957, TEI-700)
PRR-ED-R-252
PRR-ED-R-249
Chenoweth and Malan (1975)

NAKAI MESA (Alfred Miles #1)

NASCHOY MINE (Firelight #6 Claim)

LOC: Approx. central Sec. 2, T40N, R19E
Monument Valley

QUAD: Agathla Peak 15'; Marble Canyon NTMS

DEVL: 360' incline @ 31° w/ 2 haulage drifts and stoping started Dec. 1957, abandoned in 1960-61 due to flooding.

PROD: 2,140 tons @ 0.18% U_3O_8; 0.59% V_2O_5 in 1959-60.

GEOL: About a 5 ft. thick ore zone in a N-S Trending paleochannel of Shinarump conglomerate on east flank of Oljeto syncline.

REF: U.S.A.E.C. (1959)

NAVAJO

LOC: Sec. 26, T20N, R23E
Trespass on Petrified Forest National Park

QUAD: Kachina Point 7½; Gallup NTMS

DEVL: Surface scrapings

PROD: 67 tons @ 0.12% U_3O_8; 0.15% V_2O_5, 1956

GEOL: Carnotite in petrified wood in the Petrified Forest member.

REF: D.O.E.

NAVAJO TRACT #2 (Tract #2)

NEW MEXICO AND ARIZONA LEASE (Section 33 Lease)

O'HACO RANCH

LOC: Approx. N. central Sec. 25, T19N, R16E

QUAD: Winslow 15'; Flagstaff NTMS

ANAL: 0.04% e U_3O_8; 0.03% U_3O_8

GEOL: Mineralization in siltstone - Petrified Forest member.

REF: PRR-ED-R-256

O'HACO--ROBINSON PROSPECT

LOC: Approx. SW¼ Sec. 31, T20N, R16E

QUAD: Winslow 15'; Flagstaff NTMS

ANAL: 3 samples @ 0.02 - 0.08% e U_3O_8; 0.02 - 0.18% U_3O_8

GEOL: Probably autunite and tyuyamunite or metatyuyamunite in Shinarump paleochannel cut into Moenkopi Fm.

REF: PRR-ED-R-257

P. COSTEN

LOC: NE¼ and S. central Sec. 1, T18N, R19E

QUAD: Joseph City 15'; Holbrook NTMS

GEOL: Carnotite-type mineralization, 4-5 ft. thick, in sandy orange and black shale with abundant petrified wood, close to base of Chinle. Associated with carbonized and silicified wood, gypsum, iron oxide and some erythrite (cobalt).

REF: Gregg, C.C. (1952, RMO-987)
PRR-ED-R-203 & 204 (#592 & 591)

PAINT (Charles Givens)

LOC: Monument Valley Region

PROD: 42 tons @ 0.19% U_3O_8 in 1952

PENINSULA (Alfred Miles #1)

RAINBOW SMITH #1 & 2

LOC: Sec. 36, T16N, R22E

QUAD: Hay Hollow 7½; Saint Johns NTMS

DEVL: Shallow surface scrapings for petrified wood

PROD: 14 tons @ 0.08% U_3O_8; 0.18% V_2O_5, 1956

GEOL: Carnotite in petrified wood in Petrified Forest member.

REF: PRR-ED-R-222

RAREZONA (Curry Jones Prospect)

ROANHORSE DIATREME

LOC: Approx. Sec. 10-15, T24N, R21E
Hopi Buttes

QUAD: Indian Wells 7½, Flagstaff NTMS

ANAL: 0.04% U_3O_8

GEOL: Carnotite-type mineralization in Bidahochi Fm. and Tuffs associated with diatreme. Beds dip steeply to the N-NW and contain silicified and carbonized wood.

REF: Shoemaker, E.M. et. al. (1957, TEI-700)
Shoemaker, E.M. et. al. (1962)

ROCK GARDEN #25 (Curry Jones Prospect)

RUTH #1 & 4 (Barton Mine, Bayshore #3)

LOC: Sec. 2, T17N, R23E

QUAD: Petrified Forest 15'; Saint Johns NTMS

DEVL: Adits and rim stripping

PROD: 1,268 tons @ 0.20% U_3O_8; 0.16% V_2O_5, 1953-55, 1960 and less than 500 tons/year in 1976, 1978.

RAD: 5 mr/hr. in workings

ANAL: 2 samples @ 0.12-0.35% e U_3O_8; 0.08-0.18% U_3O_8; 0.82% V_2O_5

GEOL: Carnotite-type mineralization in carbonaceous siltstone below rim of Sonsela sandstone in Petrified Forest member.

REF: PRR-UP-29 (#350)

SAIN

LOC: Approx. SE corner Sec. 23, T19N, R20E

QUAD: Lee Mtn. 7½; Flagstaff NTMS

DEVL: Rim stripping

PROD: 8 tons @ 0.08% U_3O_8; 0.04% V_2O_5, 1955

RAD: 0.2 mr/hr.

GEOL: Carnotite-type mineralization in a highly carbonaceous, muddy sandstone overlain by a zone with abundant plant fossils in the Petrified Forest member.

REF: D.O.E.

SALLY MINE

LOC: Sec. 6-7, T40N, R20E
Monument Valley

QUAD: Agathla 15'; Marble Canyon NTMS

DEVL: 60 drill holes (3000 ft. total)

PROD: 67 tons @ 0.10% U_3O_8, 0.04% V_2O_5 in 1955.

GEOL: Low-grade mineralization occurs at base of sandstone-filled Shinarump paleochannel on west limb of Agathla Anticline, superimposed on Monument upwarp. Deposit is completely oxidized autunite, low vanadium, low lime. Channel trends NNW to WNW. Channel tilted 5° toward NW.

REF: D.O.E.

SAM CHARLIE #1 (Koley Black #1)

SECTION 33 LEASE (Bill Gill, New Mexico-Arizona Lease, Goof)

LOC: SE¼ - SE¼ Sec. 33, T18N, R23E

QUAD: Petrified Forest 15'; Saint Johns NTMS

DEVL: 2000 ft. rim stripping, 15 ft. shaft into mineralized slump block, small open cut 25 X 15 x 10 ft., 6,000 ft. rotary drilling.

PROD: 29 tons @ 0.13% U_3O_8, some stockpiled on property.

GEOL: Chinle Fm., Petrified Forest member

REF: D.O.E.

SETH-LA-KAI (Morale claims)

SHARON LYNN

LOC: SW¼ Sec. 34, T16N, R23E

QUAD: Hay Hollow 7½; Saint Johns NTMS

DEVL: Scattered, shallow surface scrapings

PROD: 5 tons @ 0.08% U_3O_8; 0.03% V_2O_5, 1954

GEOL: Mineralized petrified wood in Petrified Forest member.

REF: D.O.E.

SJODIN

LOC: Approx. Sec. 24, T25N, R23E
Hopi Buttes

QUAD: Greasewood 7½; Gallup NTMS

DEVL: Drilled

ANAL: 0.09% U_3O_8; 14% $CaCO_3$

GEOL: Autunite in volcanic agglomerate and associated sediments and spring deposits in Bidahochi Fm.

REF: D.O.E.

SM TRACT #2 (Tract #2)

SONNY JAMES (James Sonny?)

LOC: Unknown

RAD: 0.87% U_3O_8, 0.08% V_2O_5, 4.68% Cu

GEOL: Channel in Shinarump with Copper, Mananese

REF: CJEB-R-71

SOUTH SUNLIGHT (Big Four Claim)

SPENCER #1 (Harvey Black #2)

LOC: Approx. Sec. 6, T41N, R20E

QUAD: Agathla 15'; Marble Canyon NTMS

DEVL: Underground

PROD: 375 tons @ 0.23% U_3O_8; 0.79% V_2O_5 in 1954,55,62.

GEOL: Carnotite hewettite, tyuyamunite, associated with iron oxides, silicified logs plus pebbles and cobbles, at base of N61°E trending Shinarump paleochannel.

REF: D.O.E.

SPURLOCK - WESTTER RANCH (Gerwitz Prospect)

STARLIGHT (Starlight 1 & 2; Starlight East)

LOC: Approx. W. central Sec. 17, T41N, R19E
Monument Valley - Oljeto Creek

QUAD: Boot Mesa 15'; Marble Canyon NTMS

DEVL: Vertical shaft plus room and pillar

PROD: 86,369 tons @ 0.30% U_3O_8; 0.06 V_2O_5 in 1958-64.

ANAL: 0.40% U_3O_8; 0.50% V_2O_5; 5.41% $CaCO_3$ max.

GEOL: Uraninite in Shinarump paleochannel

REF: U.S.A.E.C. (1959)
Johnson, H.S. Jr. & Thordarson, W. (1956, TEI-640)

SUN #12 CLAIM

LOC: Approx. Sec. 32, T23N, R21E
Hopi Buttes

QUAD: Sunflower Butte 7½; Flagstaff NTMS

GEOL: Finely disseminated uranium mineralization in limestone and concentrated in laminated siltstones and shales of the Bidahochi Fm., associated with a diatreme. Volcanic tuff, chert and evaporites associated with sediments.

REF: Shoemaker, E. M. (1955, TEI-590)
Shoemaker, et.al. (1957, TEI-700)

SUNLIGHT (Big Four Claim)

SUNRISE

LOC: Sec. 4, T17N, R23E

QUAD: Petrified Forest 15'; Saint Johns NTMS

DEVL: Rim stripping

PROD: 14 tons @ 0.10% U_3O_8; 0.21% V_2O_5, 3.4% $CaCO_3$, 1957
This ore may have come from stockpiles on the Bill Gill Lease on adjacent Section 33.

GEOL: Carnotite in upper part of Sonsela sandstone in Petrified Forest member.

REF: D.O.E.

TERRY CLAIMS

LOC: E½ Sec. 34, T25N, R22E
Hopi Buttes

QUAD: Satan Butte 7½'; Gallup NTMS

ANAL: 0.08-0.18% U_3O_8; 0.04 - 0.06% V_2O_5; 8.3- 17.5% $CaCO_3$

GEOL: Autunite in volcanic rock associated with diatreme

REF: PRR-4-14-54

TODECHENEE (Alfred Miles #1)

TRACT #1

LOC: SE¼ Sec. 1, T17N, R23E

QUAD: Petrified Forest 15'; Saint Johns NTMS

ANAL: 2 samples 0.01 - 0.02% e U_3O_8; 0.003 -0.017% U_3O_8

GEOL: Mineralization is associated with carbonized wood and plants plus silicified wood in flat-lying sandstone, bentonitic clay and conglomerate in Chinle Fm.

REF: PRR-w/o # (#585)

TRACT #2

LOC: SW corner Sec. 33, T16N, R23E

QUAD: Hay Hollow 7½; Saint Johns NTMS

ANAL: 2 samples @ 0.014-0.018% e U_3O_8; 0.007 - 0.010% U_3O_8

GEOL: Carnotite associated with silicified logs in shales of the Chinle Fm.

REF: PRR-w/o# (#586)
Granger, H. C. & Raup, R.B. (1962), Finch, W.I. (1967)

TRACT #2 (SM Tract #2, Navajo Tract #2)

LOC: Approx. SW¼, Sec. 10, T41N, R18E
Monument Valley

QUAD: Boot Mesa 15'; Marble Canyon NTMS

DEVL: Incline

PROD: 13,523 tons @ 0.34% U_3O_8, 1958-62

ANAL: 0.55% U_3O_8; 0.17% V_2O_5; 3.86% $CaCO_3$; 2.0% Cu

GEOL: Uraninite in Shinarump paleochannel.

REF: D.O.E.

TRACT 2A (Cecil Todechenee Channel)

LOC: Lat. 36° 53' 24"N and long. 110° 24' 48"W or Approx. Sec. 8, T40N, R18E. Monument Valley - Skeleton Mesa

QUAD: Boot Mesa 15'; Marble Canyon NTMS

DEVL: 20 ft. adit

PROD: Small stockpile

ANAL: Channel sample @ 0.02% U_3O_8; 1.49% V_2O_5
Crab sample @ 0.24% U_3O_8 max.

GEOL: Carnotite-type mineralization with malachite, associated with silicified and carbonize wood, is in Shinarump paleochannel, Trending E-W.

REF: Witkind, I. J. and Thaden, R.E. (1963, p. 150-151)

TRACT #11 MINE

LOC: Approx. W. central Sec. 16, T41N, R18E
Monument Valley - Hoskinnini Mesa

QUAD: Boot Mesa 15'; Marble Canyon NTMS

PROD: 12,384 tons @ 0.35% U_3O_8 in 1958-64

GEOL: Mineralization is in Shinarump paleochannel

REF: Witkind, I. J. & Thaden, R.E. (1963, p. 151-152)
U.S.A.E.C. (1959)

TRACT 17 (Tract 17-TZM)

LOC: Approx. W. Sec. 21, T41N, R17E
Monument Valley - Nokai Creek

QUAD: Cattle Canyon 7½ and Boot Mesa 15'; Marble Canyon NTMS

DEVL: 400' sublevel adit w/raise to ore horizon - Room and pillar, 41 drill holes.

PROD: 4,131 tons @ 0.41% U_3O_8 in 1959.

ANAL: 0.23% U_3O_8; 0.15% V_2O_5; 16% $CaCO_3$

GEOL: Uraninite, chalcopyrite, chalcocite, bornite and covellite in conglomerate lens of Shinarump paleo-channel. Beds strike NE, dip 2-3° NW on west flank of Organ Rock anticline. Ore body 40 ft. wide, 200 ft. long, average 4-5 ft. in thickness.

REF: D.O.E.

TWILIGHT #1

LOC: Approx. Sec. 17, T41N, R19E
Monument Valley - Oljeto Creek

QUAD: Boot Mesa 15'; Marble Canyon NTMS

DEVL: Drilled in 1959

GEOL: Uraninite in continuous ore pod 25 ft. X 175 ft. in Shinarump paleochannel.

REF: D.O.E.

'WIN BUTTES (Kay Group)

UNNAMED A

LOC: Sec. 30, T16N, R23E

QUAD: Petrified Forest 15'; Saint Johns NTMS

RAD: 12X

ANAL: 4 samples @ 0.03 - 0.39% U_3O_8

GEOL: Unidentified uranium mineralization associated with carbonaceous matter, probably in lower Chinle Fm.

REF: PRR-ED-R-222 (#594)

UNNAMED B

LOC: Approx. Sec. 23, T20N, R17E

QUAD: Holbrook 15'; Flagstaff NTMS

RAD: 6X

ANAL: 0.03% U_3O_8 around log

GEOL: Mineralization associated with petrified wood and limonite in sand and mudstones in Chinle Fm.

REF: PRR-ED-R-232

UNNAMED C

LOC: Approx. Sec. 2, T16N, R23E
1.1 miles west of south entrance to Petrified Forest National Park.

QUAD: Petrified Forest 15'; Saint Johns NTMS

DEVL: Cut

ANAL: 2 channel samples @ 0.012 -0.015% e U_3O_8; 0.008-0.014% U_3O_8

GEOL: Mineralization associated with carbonized plants in Chinle Fm.

REF: PRR-w/o # (#584)

UNNAMED D

LOC: Sec. 15, T16N, R23E

QUAD: Petrified Forest 15'; Saint Johns NTMS

GEOL: Uranium mineralization and some pyrite associated with petrified logs in lower Chinle Fm.

REF: PRR-F10102 (A.E.C.)

UNNAMED E

LOC: Approx. SE¼ Sec. F, T24N, R21E
Hogback - 1 mile NE of Na Ah Tee Trading Post

QUAD: Na Ah Tee 7½; White Cone 15'; Flagstaff NTMS

RAD: 0.15 mr/hr.

ANAL: 0.04% U_3O_8

GEOL: Mineralization occurs in Kaolin, conglomerate and marl along ridges dipping steeply N-NW. Silicified and carbonized wood plus volcanic rocks (tuffs and lava) present.

REF: PRR-ED-R-205 (#593)

UNNAMED F

LOC: Lat. 34° 03' 50"N, long. 110° 29' 55"W
Cibecue Approx. Sec. 26, T8N, R17E

QUAD: Cibecue 15'; Holbrook NTMS

GEOL: Anomalous radioactivity in conglomerate-sandstone lenses in Paleozoic Naco-Supai formations.

REF: PRR-AP-175 (#587)
Peirce, H.W. et. al. (1977, p. A-11)

UNNAMED G

LOC: Approx. NW¼ Sec. 11, T8N, R17E

QUAD: Cibecue and Chediski Peak 15'; Holbrook NTMS

GEOL: Uranium and copper mineralization in gray, limy Supi mudstone overlain by six feet of resistant thin-bedded calcerous silty sandstone.

REF: PRR-AP-175

UNNAMED H

LOC: Lat. 34° 00' 35" N and long. 110°28'10"W, near BM4840

QUAD: Cibecue 15'; Holbrook NTMS

DEVL: Highway roadcut

ANAL: 10-80 ppm uranium by weight, 0.03% Cu, trace Ag, Pb, Zn.

GEOL: Naco-Supai channel complex of sandstone and limestone pebble conglomerate inter-fingered laterally with siltstone. Anomalous radioactivity in sandstones and a 6 inch thick zone of gray, carbonaceous, micaceous shale.

REF: Peirce, H.W. et. al. (1977)

UNNAMED I

LOC: 36° 14' 50" to 15' 10"N, 110° 13' 40"W on east side of two Red Peaks Valley, 10.4 miles north of Pinon Trading Post.

QUAD: Pinon NW and To NeZhonnie Spring 7.5, Marble Canyon NTMS

DEVL: Airborne anomaly discovered in about 1955 by AEC.

RAD: Some anomalous airborne-detected radioactivity.

ANAL: None

GEOL: Very thin lens of black placer sand in walls of canyon, incorporated into Toreva Fm. of the Black Mesa Basin. Radioactivity due to uranium in zircon and Th in monazite. TiO_2 contents of placer concentrates of this age typically 10-30% by weight. This is southwesternmost known placer concentrate of this age in the regressive phase of the Bisbee-Mancos seaway.

REF: Murphy J.F. (1956)
Houston and Murphy (1977)

WINSLOW # 6 & 7 (Winslow Group)

LOC: N. central Sec. 32, T20N, R17E
Edge of Ives Mesa

QUAD: Winslow 15'; Flagstaff NTMS

DEVL: One 100 ft. adit from rim towards ore body; 64 holes drilled in 1955 for 8200 feet.

PROD: 49 tons @ 0.03% U_3O_8; 0.17% V_2O_5, 1954 reported from Winslow #7.

GEOL: Mineralization occurs in 2 sandstone lenses or paleochannels in Petrified Forest member. Ore body is at a depth of 50 ft. and averages 4-5 ft. thick. Lenses are separated by 20' stratigraphically, both trend ENE, and are superimposed.

REF: D.O.E.

YOUNG (Little John #1-3)

Index for Pima County Uranium Occurrences

A = Ajo
N = Nogales
T = Tucson

PIMA COUNTY

ABE LINCOLN

LOC: Sec. 34, 35, T17S. R11E

QUAD: Twin Buttes 15'; Nogales NTMS

DEVL: 15 ft. drift

RAD: 10X

ANAL: 0.08% U_3O_8

GEOL: Metatorbernite occurs with copper oxide and molybdenite in a quartz vein along fault zone in granite.

REF: PRR-A-90 (#651)

BABSON CLAIM GROUP (Black Dike Shaft)

BIXBY (England)

BLACK DYKE SHAFT (Babson Claim Group)

LOC: SE¼, SE¼, Sec. 23, T17S, R10E
Sierrita Mtns.

QUAD: Palo Alto Ranch 15'; Nogales NTMS

DEVL: Inclined shaft with adits

PROD: 61 tons @ 0.08% U_3O_8; 0.04% V_2O_5, 1956-57.
Only one 1957 shipment of 10.7 tons assaying 0.18% U_3O_8 was "pay" ore.
Initially developed for copper production.

RAD: 10X

ANAL: 0.01-0.16%; U_3O_8

GEOL: Uraninite, pitchblende, fluorite, copper and manganese minerals occur as veinlets and disseminated in quartz monzonite. 100 ft. to the east, the rock changes to a metamorphosed sequence of sedimentary beds, striking northward and dipping 70°. Mineralization associated with contact zone between Paleozoic sediments and granitic stocks and dikes of probable Laramide age. Also iron oxide-coated shear zones nearby in Precambrian metamorphics and chloritic Continental granodiorite.

REF: PRR-UP-646
PRR-F-9051
Granger, H. and Raup, R. (1962)
Bissett, D. (1958)
Wells, R. and Puttuck, H. (1954, RME-2019)
Drewes (USGS Map MF-538)
D.O.E.

BLACK HAWK CLAIMS (San Juan #1-2)

LOC: Sec. 16, T18S, R11E
Southern Sierrita Mtns.

QUAD: Twin Buttes 15'; Nogales NTMS

DEVL: 180 ft. and 80 ft. shaft; 300 ft. drift

PROD: Lead and silver

RAD: 80X

ANAL: 0.07% e U_3O_8

GEOL: Radioactivity is associated with base metal mineralization along a vein, striking N30°E, dip 80°SE, in rhyolite porphyry.

REF: PRR-AP-383 (#670)
PRR-RA-25 (#674)

BLUE MOON (Refer to Lena #1)

BLUE ROCK #1 & 2 (Vanover; Blueslate; Sure Fire #1 Vanhill #5, East Chance Claims)

LOC: SW¼, Sec. 15, T13S, R18E

QUAD: Redington 15'; Tucson NTMS

DEVL: 3 short adits, 160 ft. incline, open face stoping, drilling

PROD: 58 tons @ 0.09%; U_3O_8, 1956 plus some shipments in late 1970's

RAD: 200X

ANAL: 0.014- 0.50% e U_3O_8; 0.06 -0.33% U_3O_8

GEOL: Uranophane and autunite occurs with copper and iron minerals and fluorite in a 10 ft. thick shear zone that separates Precambrian Granite on the west from Cretaceous clastic sediments on the east. Shear zone trends NW and dips 25°NE.

REF: PRR-AP-177 (#658)
Granger, H. and Raup, R. (1962)
D.O.E.
Arizona Bureau of Geology Data
Thorman, C. and others (1978)
Bissett, D. (1958)

BLUESLATE (Bluerock #1 & 2)

CENTER CHANCE CLAIMS

LOC: Southern edge SE¼, Sec. 10, T13S, R18E

QUAD: Redington 15'; Tucson NTMS

DEVL: Dozer cuts in hillside

RAD: 6X

GEOL: Several areas spread over 0.5 square miles, contain radioactive shale lenses intercalated into basal conglomerate of Oligocene Mineta Fm. Kaolinization and bedding plane faults in shale indicate some hydrothermal-structural control.

REF: Bissett, D. (1958)
Scarborough, R. and Wilt, J. (1979)

CHANCE GROUP (East Chance Claims)

Claim Group includes: North Chance
Center Chance
East Chance
South Chance (Pima & Cochise Co.)
Robles Spring (Cochise Co.)

CHRISTENSEN-LANE MINE

LOC: Probably Sec. 23, T18S, R15E
Helvetia area - NW Santa Rita Mtns.

QUAD: Sahuarita 15'; Nogales NTMS

DEVL: 30 ft. incline shaft, shallow open pit

ANAL: 0.01% e U_3O_8

GEOL: Granite cut by basic dikes and quartz veins

REF: PRR-A-20 (#640)

CONTROL (Old Hat)

COPPER SQUAW

LOC: Sec. 30, 14S, R3E - 32° 09' 55"N., 112° 06' 15"W

QUAD: Quijotoa Mtns. 15'; Ajo NTMS

DEVL: 120 ft. 30° incline shaft; shallow trenches

PROD: 6 tons @ 0.12%, U_3O_8; 5.8% Cu, 0.01 oz/t Au; 2.3 oz/t Ag. stockpiled; also produced about 90 tons of ore 1948-1953.

ANAL: 0.76 - 1.4% e U_3O_8

GEOL: Uranophane and uraninite occurs with base metals in vein along shear zone in altered andesite. Zone trends N40° W, dips 30°.

REF: PRR-AP-102 (#655)
D.O.E.

COPPER U.O. CLAIMS

LOC: 32°13' 40"N; 112° 07' 04" W
Adjacent to Copper Squaw Claim

QUAD: Quijotoa Mtns., 15'; Ajo NTMS

DEVL: 50 ft. shaft; several trenches and pit

PROD: 460 tons of 2% copper and 7-10 oz. silver in 1952.

RAD: 100X

GEOL: Mineralized shear zone in altered andesite with azurite and malachite.

REF: PRR-AP-103 (#656)

DIAMOND HEAD GROUP

LOC: Near center SE¼; NW¼; Sec. 34, T17S, R11E
Fraznal Canyon - Sierrita Mtns.

QUAD: Twin Buttes 15'; Nogales NTMS

DEVL: 180 ft. adit; 20 ft. incline; 15 ft. shaft, 170 ft. drift

RAD: 300X

ANAL: 0.22-0.74%, U_3O_8

GEOL: Lenses of pitchblende (¼ inch to 1 ft. thick by 15 ft. long) occur along ENE trending fault, intersecting small cross faults in alaskite granite. Fault gouge contains much kaolinite and hematite some calcite, pyrite and sparce chalcopyrite and fluorite. Possibly some uraninite.

REF: PRR-A-94 (#652)
Bissett, D. (1958)

DOLLAR BILL CLAIMS

LOC: Sec. 23, T15S, R18E
Rincon Mtns.

QUAD: Galleta Flat West 7½, Happy Valley 15'; Tucson NTMS

RAD: 375X

GEOL: Samarskite occurs with garnet in troughs along stream bed for 2 to 3 miles. Country rock is a aplitic, fine-grained porphyroblastic granite and schist with many pegmatite bands.

REF: PRR-A-64 (#647)

DUMAR CLAIM (Lamar)

LOC: Sec. 33, T12S, R14E

QUAD: Tucson North 7½'; Tucson NTMS

RAD: 4X

ANAL: 0.02% e U_3O_8

GEOL: Hematized structured zone in Pinal Schist beneath epidotized schist with higher count.

REF: Waechter, N. (1979)
PRR-A-13

DUTCHESS CLAIM (Cardinal Ave. Limestone)

LOC: Sec. 17, T. 15S, R13E
S. Tucson Mtns.

QUAD: San Xavier Mission 7½'; Tucson NTMS

DEVL: Small pit and drill holes

RAD: 30X

ANAL: 0.06% e U_3O_8

GEOL: Radioactivity disseminated in fetid limestone with some carnotite fracture coatings. 20 ft. section of light gray limestone 2-3 ft. thick interbedded with gypsiferous mudstone and gypsum seams. Beds are folded into a shallow E-W trending syncline. The units are most probably Oligocene in age.

REF: PRR-A-65
Grimm, J. (1978)
Scarborough, R. and Wilt, J. (1979)

EAST CHANCE CLAIMS (Van Hill #7 & 8, Vanover, Chance Group)

LOC: Near mutal corner of Sec. 13, 14, 23, 24, T 13S, R18E

QUAD: Redington 15'; Tucson NTMS

DEVL: 60 ft. adit

ANAL: 0.40%, U_3O_8

GEOL: Mineralization in shales and fetid limestones in Oligocene Mineta Fm. Section strikes N30°E, dips 30° and contains shales intercalated with thin-bedded limestones and overlie a conglomerate. Shales are sheared, hydrothermally altered, contain abundant bedding-parallel slickensides and pinch out along strike.

REF: PRR w/o# (#624)
Bissett, D. (1958)

EL CONQUISTADORS

LOC: Sec. 2, T17S, R8E
Coyote Mtns.

QUAD: Baboquivari Peak and Palo Alto Ranch 15'; Nogales NTMS

DEVL: Prospect pit

RAD: 3X

ANAL: 0.01% e U_3O_8

GEOL: Pegmatite zones in biotite gneiss

REF: PRR-A-52 (#646)

ENGLAND-WILL-RIXBY GROUP

LOC: Sec. 7-10, 14-15, 17-20, 22-23, 26-27, T16S, R12E

QUAD: San Xavier Mission and San Xavier Mission SW 7½'; Tucson NTMS

DEVL: Small open pit

RAD: 10X

ANAL: Heavy mineral separate =11.8% e U_3O_8; 4.95% U_3O_8; 26% ThO_2

GEOL: Zircons and urano-thorite concentration with other heavy minerals in decomposed granite.

REF: PRR-AP-334 (#668)

ESCONDIDA

LOC: Sec. 34, T17S, R11E
Fresnal Canyon - Sierrita Mtns.

QUAD: Twin Buttes 15'; Nogales

DEVL: Two 8 ft. deep pits

RAD: 4X

ANAL: 0.06% e U_3O_8

GEOL: Uraninite with copper-iron sulfides along contact zone between basic dike and monzonite. Structures strike N70E, dip 65°N.

REF: PRR-A-35 (#642)

ESPERANZA COPPER MINE

LOC: SE¼ Sec. 8, NW¼ Sec. 16, NE¼ Sec. 17, T18S, R12E

QUAD: Twin Buttes 15'; Nogales NTMS

DEVL: Open pit copper-molybdenum mine

PROD: Major Cu-Mo producer

ANAL: 0.11-18% Z U_3O_8; on stockpiled ore

GEOL: Traces of torbernite reported associated with Cu-Mo-Ag disseminated mineralization in brecciated fissured, and jointed strongly altered Laramide intrusive complex (quartz latites-andesites) which invade Triassic-Jurassic volcanics.

REF: PRR-AP-255
Keith, S (1974) and Lynch, D. (1968)

GISMO GROUP

LOC: Sec. 5, T21S, R10E
NE Los Guijas Mtns.

QUAD: Arivaca 15'; Nogales NTMS

DEVL: Shafts and drifts, parts flooded or caved

PROD: Gold and silver

RAD: 50X

ANAL: 0.33% e U_3O_8

GEOL: Uraninite, kasolite and schroeckingerite occurs with copper-iron mineralization in vein along fault cutting granite. Veins strike NE and dip 80°N.

REF: PRR-A-114 (#722)

GLEN CLAIMS

LOC: NW¼ Sec. 30, T17S, R11E

QUAD: Palo Alto Ranch 15'; Nogales, NTMS

DEVL: Open cut about 15 ft. into hill

RAD: 2X

ANAL: 0.015-0.027%, U_3O_8

GEOL: Uraninite associated with metal sulfides disseminated in silicified breccia zone cutting granite. Feldspars altered to sericite along zone, trending N20°W.

REF: PRR-w/o# (#632, 634, 623)
Granger, H. and Raup, R. (1962)
Ransome, F. (1922)

HALF MOON #3

LOC: NE¼ Sec. 21, T11S, R18E

QUAD: Bellota Ranch 15'; Tucson NTMS

DEVL: Dozer cut

RAD: 27X

ANAL: 0.074% e U_3O_8

GEOL: Uraniferous opal in 8 ft. reddish brown opalite covered by horizontal, loosely consolidated lake beds of Pliocene age.

REF: PRR-AP-315 (#664)
Arizona Bureau of Geology data

HOLY MOTHER CLAIMS

LOC: Sec. 8, T17S, R11E

QUAD: Twin Buttes 15'; Nogales, NTMS

DEVL: Prospect pit

RAD: 3X

ANAL: 0.114%, e U_3O_8

GEOL: Specks of polycrase in granite

REF: PRR-AP-281 (#661)

HOPEFUL #1

LOC: Sec. 36, T17S, R11E
Sierrita Mtns.

QUAD: Twin Buttes 15'; Nogales, NTMS

DEVL: Location pit

RAD: 300X

ANAL: 1.35% e U_3O_8; 1.17% U_3O_8

GEOL: Secondary uranium minerals in zone cutting fractured and silicified quartzite near contact with granite.

REF: PRR-A-84 (#649)

IRIS AND NATALIA CLAIMS

LOC: SW¼ Sec. 26 T21S, R11E

QUAD: Tubac 15'; Nogales NTMS

DEVL: Old workings

ANAL: 0.76%, U_3O_8

GEOL: Shear zones in rhyolite cut by iron-stained quartz veins. Possibly kasolite associated with chalcocite.

REF: Webb, B. and Coryell, K. (1954, RME-2009)
Granger, H. and Raup, R. (1962)
Waechter, N. (1979)

JENNY #1 (Refer to Lena #1)

JUANITA

LOC: Approx. 31°54'30" N; 111°39'40" W

QUAD: Sells and Baboquivari Peak 15'; Nogales NTMS

DEVL: Prospect pit, dozer cut

RAD: 10X

ANAL: 0.003% e U_3O_8

GEOL: Radioactivity associated with limonite along small fault in rhyolite

REF: PRR-AP-316 (#665)

KING MINE

LOC: East central Sec. 24, T18S, R15E
Helvetia - North Santa Rita Mtns.

QUAD: Sahuarita 15'; Nogales, NTMS

DEVL: Underground

PROD: Silver and copper

RAD: 20X

ANAL: 0.93% e U_3O_8; 0.87% U_3O_8

GEOL: Pitchblende with base metal sulfides in pockets along contact (generally N60°E, dip 30°S) between limestone and quartz monzonite

REF: PRR-A-37 (#644)
Schrader, F. (1915)

LAMAR CLAIMS (Dumar Claims)

LEADVILLE GROUP

LOC: Sec. 10, T18S, R11E

QUAD: Twin Buttes 15'; Nogales NTMS

DEVL: Drift

RAD: 75X

ANAL: 0.01-0.05% e U_3O_8

GEOL: Radioactivity associated with pods of oxides of copper and iron along shear zone, striking N70E, through volcanics.

REF: PRR-AP-358 (#669)

LENA #1, JENNY #1, BLUE MOON

LOC: Sec. 5, 8, T18S, R11E

QUAD: Twin Buttes 15'; Nogales NTMS

DEVL: Shallow shaft and pits

ANAL: 0.19% e U_3O_8; 0.19% U_3O_8

GEOL: Probably metatorbernite pitchblende, and kasolite occurs with base metal sulfides along fractures in shear zones cutting granite.

REF: PRR-w/o # (#628); Granger, H. and Raup, R. (1962)
PRR-ASL-2 (#672); Ransome, F. (1922)

LINDA LEE CLAIMS (Quijotoa Mine)

LOC: Approx. Sec. 11, 14, T15S, R2E or 32°07'30"N; 112° 07' 30"

QUAD: Quijotoa Mtn. 15'; Ajo Mtns.

DEVL: Open cut in stream bed at rock outcrop at Linda Lee #2 (producer). Open cut and 15 ft. shaft on vein in adjacent claim to the south.

PROD: 7.8 tons @ 0.15% U_3O_8, 1955

RAD: 75X

ANAL: 0.05-0.15% e U_3O_8; and 0.08% U_3O_8

GEOL: Torbernite and gummite associated with iron oxide in a steeply deeping vein cutting an arkose near contact with a granite.

REF: PRR-A-331 (#667)
D.O.E.

LOBOS GROUP

LOC: Approx. Sec 6, T21S, R7E
S.W. Baboquivari Mtns.

QUAD: Presumido Peak 15'; Nogales NTMS

DEVL: Location pits

RAD: 35X

ANAL: 0.13% e U_3O_8

GEOL: Secondary uranium minerals associated with quartz veins and aplite-andesite dikes cutting gray quartzite with epidote alteration, and mica schist. Possibly euxenite in mica schist.

REF: PRR-A-89 (#650)
Waechter, N. (1979)

MICA MINE (San Antonio Mine)

NATALIA CLAIMS (Iris)

NEW YEARS EVE PIT

LOC: South central, Sec. 9, T18S, R12E

QUAD: Twin Buttes 15'; Nogales NTMS

DEVL: 200 ft. shaft, adits

PROD: Copper and molybdenum

RAD: 10X

ANAL: 0.18% e U_3O_8

GEOL: Uraninite, molybdenite and secondary uranium minerals along NW-SE vein in granite.

REF: PRR-AP-255 (#660)

NORTH CHANCE CLAIMS (Chance Group)

LOC: North, SW¼, SE¼, Sec. 10, T13S, R18E

QUAD: Redington 15'; Tucson NTMS

DEVL: 2 short inclined shafts or pits

RAD: 100X in shale
10X in granite

GEOL: Radioactivity in a shale sequence lens in a lower conglomerate member in the Oligocene Mineta Fm., dipping 20-40° NE. Shales are poorly exposed and appear to pinch out short distance to the south. Sediments are depositional on a Precambrian Granite which also counts to 6X in the same wash.

REF: Bissett, D. (1958)
Scarborough, R. and Wilt, J. (1979)

OLD BALDY COPPER MINE

LOC: Approx. NW¼ Sec. 19, T19S. R15E
North Santa Rita Mtns.

QUAD: Sahuarita 15'; Nogales NTMS

DEVL: 2 shafts and 65 ft. drift

RAD: 4X

GEOL: Radioactivity associated with copper, molybdenum and iron minerals in narrow quartz stringers cutting quartz monzonite.

REF: PRR-A-118 (#653)

OLD HAT (Control)

LOC: Sec. 20, T11S, R16E
North Santa Catalina Mtns.

QUAD: Bellota Ranch 15'; Tucson NTMS

DEVL: Short adits and several pits

PROD: Base metals

RAD: 3X

GEOL: Radioactivity associated with base metal sulfides in a contact metamorphic deposit in marblized Paleozoic Limestone.

REF: PRR-M-986 (#673)

PAPAGO CHIEF

LOC: Sec. 21, T20S, R7E
Baboquivari Mtns.

QUAD: Presumido Peak, Nogales NTMS

DEV: Old workings

PROD: Copper, gold, silver

GEOL: Metatorbernite occurs with base metal sulfides along fissure vein in foliated flow rock.

REF: PRR-w/o#

QUIJOTOA MINE (Linda Lee)

RED HILLS CLAIM

LOC: NW¼ Sec. 5, NE¼ Sec. 6, T16S, R17E

QUAD: Rincon Valley 15'; Tucson NTMS

DEVL: Several shallow pits

RAD: 5X

ANAL: 0.08-0.38% e U_3O_8

GEOL: Uranophane in fine-grained clastics and in weathered granite near high angle faults. Red clastic material contains brecciated quartz, pebble conglomerates and red shales, and may represent basal Apache Group (Precambrian) or basal Tertiary sediments.

REF: PRR-AP-314 (#663)
Drewes, H. (1978)
Scarborough, R. and Wilt, F. (1979)

RED HILLS #5 (Van Hill #5)

ROBLES SPRING (refer to Cochise Co. listing)

SAN ANTONIO MINE (Mica Mine)

LOC: 32°18' 30"N; 112° 57' 05" W

QUAD: Ajo 15'; Ajo NTMS

DEVL: Small pit

PROD: Silica

RAD: 10X

ANAL: 0.01% e U_3O_8

GEOL: Uranium minerals coat mineral grains and fractures in quartz-pegmatite and in granite cut by pegmatite. Mineralized zone along contact strikes N-S and dips 40-50°E.

REF: PRR-A-38 (#645)

SAN JUAN #1-2 (Black Hawk)

SHAMROCK MINE

LOC: Sec. 32, T21S, R10E

QUAD: Arivaca 15'; Nogales NTMS

DEVL: One shaft with 2 levels

PROD: lead and silver

RAD: 6X

ANAL: 0.05% e U_3O_8

GEOL: Radioactivity associated with sulfides and carbonates of lead, zinc, iron plus some quartz and barite along a shear zone in rhyolite.

REF: PRR-A-36 (#643)

SILVER BULLION MINE

LOC: Approx. 32° 11'45" N, 112° 07'08" W

QUAD: Quijotoa Mtns. 15'; Ajo NTMS

DEVL: 100 ft. shaft and workings

PROD: Silver

RAD: 100X

ANAL: 0.04 -0.19% e U_3O_8 out of equilibrium in favor of radioactivity.

GEOL: Radioactivity along fault zone in granite

SOUTH CHANCE (Chance Group)

LOC: SW¼ Sec. 31, T13S, R19E on Pima and Cochise County line

QUAD: Redington 15'; Tucson NTMS

DEVL: One adit, now flooded

GEOL: Disseminated mineralization and radioactivity along shear zone which separates deformed Precambrian granite against phyllites of the Oligocene Mineta Fm. Alternative interpretation is Pinal Schist phyllites in thrust fault contact with Cretaceous Bisbee Group sediments to the west.

REF: Bissett, D. (1958)
Thorman, C. and others (1978)
D.O.E.

SUREFIRE #1 (Bluerock #1 & 2)

TWIN BUTTES COPPER MINE

LOC: W½ Sec. 5 and NE¼ Sec. 6, T18S, R13E

QUAD: Twin Buttes 15'; Nogales NTMS

DEVL: Major Open pit copper mine

PROD: Shipments of yellow-cake initiated in late April 1980. Anamax Co. anticipates shipping 120,000 lbs. of yellow-cake in the first year.

GEOL: Uranium extracted as by product from copper leach solutions. Copper sulfides and oxides with sphalerite, molybdenite and native copper are associated with a plug of quartz monzonite porphyry intruded along S-SE flank of the Ruby Star grandiorite batholith.

REF: Kelly, J. (1977)
Cross, C. (1980)
Copper, J. (1973)
Arizona Bureau of Geology data

UNNAMED A

LOC: From Continental 6.9 mi. on Madera Canyon-Sonoita Rd. to Madera Canyon Rd., go 3.8 mi. on Canyon Rd. to Proctor Ranch Rd., go 2.8 mi. to Laos Ranch, then hike ½ mi. S to foothills below Elephant Head."

QUAD: Mount Wrightson 15'; Nogales NTMS

DEVL: Prospects

RAD: 3X

GEOL: Pyrite and some opalized zones along jointing and shearing (N45°E, dip 35°N) in quartz monzonite.

REF: PRR-A-12 (#638)

UNNAMED B

LOC: Approx. Sec. 15, T19S, R14E NW Santa Rita Mtns.

QUAD: Sahuarita 15'; Nogales NTMS

DEVL: Water well which services titan missile silo near Madera Canyon Rd.

RAD: Gross alpha= 41pc/l; U^{238}=23.6 pc/l U^{234}=27.1 pc/l Tucson area average is below 5 pc/l.

GEOL: High Fe, Mn, Mg and U in water samples from sand-gravel aquafer in subsurface draining downslope from Madera Canyon. Aquifer depth below surface probably about 50 ft.

REF: Arizona Bureau of Geology data

UNNAMED C

LOC: NE¼ Sec. 26, T16S, R8E Northern Coyote Mtns.

QUAD: Cocoraque Butte and San Vicente 15'; Tucson Mtns.

RAD: 10X

GEOL: Radioactivity along unaltered fracture zones forming natural benches in long N-S trending ridges made of granitic gneiss with muscovite.

REF: Arizona Bureau of Geology data.

UNNAMED D

LOC: N½ NW¼ Sec. 15, T19S, R18E or 31°47'18"N; 110° 29' 51" W SW. Whetstone Mtns. near Ramsey Well

QUAD: Apache Peak 7½'; Nogales NTMS

DEVL: 50 ft. inclined shaft, crosscut

PROD: Possibly copper

RAD: 2X

GEOL: Radioactivity associated with copper oxide minerals impregnating a three foot thick zone in a fluvial sandstone, probably Shellenburger Canyon FM, Bisbee Group. Chrysocolla replaces some plant imprints in sandstone.

REF: Arizona Bureau of Geology data
Creasey, S. (1967)

VAN HILL #5 (Vanover; Red Hill #5, also Bluerock and East Chance Claims

LOC: SE¼ Sec. 10 and NE¼ Sec. 15, T13S, R18E

QUAD: Redington 15'; Tucson NTMS

DEVL: Small pit in arroyo bottom

ANAL: 0.17% e U_3O_8; 0.008% U_3O_8

GEOL: Possibly autunite with purple fluorite and heavy iron and manganese staining along 4 ft. wide fracture zone cutting quartzite capped by limestone. Strong leaching of sediments in vicinity.

REF: Granger, H. and Raup, R. (1962)

VAN HILL #7-8 (East Chance Claims)

VANOVER (Bluerock #1 & 2)

Early name applied to now several claims:

Blue Rock #1 & 2
Chance Claims
Van Hill #5

WILL (Refer to England)

XMAS CLAIMS

LOC: SE¼ Sec. 21, T11S, R18E, and N½NE¼ Sec. 28, T11S, R18E

QUAD: Bellota Ranch 15'; Tucson NTMS

DEVL: Prospect pit

RAD: 20X

ANAL: 0.015% U_3O_8

GEOL: Radioactivity associated with chalcedony and calcite coatings in vugs in volcanic glass. Deposit in marginal lacustrine facies of Pliocene Quiburis Fm., with unconsolidated sandy-silty-gravelly beds containing some reworked and primary tuffaceous beds.

REF: PRR-AP-282 (#662)
Waechter, N. (1979)
U.S.A.E.C. (1970, RME-159, p. 30)

Index for Pinal County Uranium Occurrences

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M	5	Mineral Butte
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T	19	Purchell
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A	18	Reward Mine
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T	13	Waterfall
M	11	Wooley #1

T = Tucson
M = Mesa
A = Ajo

PINAL COUNTY

AMERICAN MINE

LOC: Sec. 19, T1S, R14E
Miami-Summit District

QUAD: Pinal Ranch 7½'; Mesa NTMS

DEVL: 2 shafts 60 ft. deep, 150 ft. adit

PROD: Probably copper, gold, silver

RAD: 10X

ANAL: 0.05% e U_3O_8; 0.05% U_3O_8

GEOL: Radioactivity associated with base metal mineralization along vein and shear zone in granite. Zone strikes N48° E, dips 65°NW.

REF: PRR-AP-185 (#691)

BATTLEAXE (Refer to Old Reliable)

BETTY #1

LOC: Probably SE¼ Sec. 20, T4S, R13E

QUAD: Grayback 7½'; Mesa NTMS

DEVL: Blocked shaft and drifts

PROD: Silver

RAD: 5X

ANAL: 0.07% e U_3O_8; 0.08% U_3O_8

GEOL: Radioactivity associated with mineralization along basaltic dike in Precambrian biotite granite. Dike strikes N80° W, dips 80° NE.

REF: PRR-AP-212

BUNKER HILL (Refer to Old Reliable)

CARDINAL #1-4

LOC: Hewitt Canyon area NW¼ of Picket Post Mtn. Quad.

QUAD: Picket Post Mtn. 7½'; Mesa NTMS

DEVL: 2 shallow pits

RAD: 10X

GEOL: Brecciated, sheared and weathered rhyolite flow rock.

REF: PRR-AP-162 (#737)

HILLSIDE GROUP

LOC: Sec. 35, T4S, R12E

QUAD: Grayback 7½'; Mesa NTMS

DEVL: Shaft, drift, prospect pits

RAD: Box

ANAL: 0.01-0.11% e U_3O_8

GEOL: Possibly torbernite and copper carbonates in shear zone cutting dike in granite.

REF: PRR-AP-345

HOMESTEAD CLAIMS

LOC: Approx. T1N, R12E, West of Miami on U.S. 60-70, take the Castle Dome Road; at 2.7 mi. turn left on Kennedy Ranch Rd., claims are about ½ mi. down creek from Miles Ranch (once called Kennedy Ranch)

QUAD: Haunted Canyon 7½; Mesa NTMS

RAD: 5X

ANAL: 0.01% a U_3O_8

GEOL: Radioactivity in Dripping Spring Quartzite overlain by Mescal Limestone and underlain by diabase.

REF: PRR-AP-333 (#698)

HONEY BEE AND SHORTIE GROUP

LOC: Sec. 14, 15, 16, T4S, R13E

QUAD: Kearny and Grayback 7½'; Mesa NTMS

DEVL: Surface pits and adit

RAD: 5X

ANAL: 0.05% e U_3O_8; 0.05% U_3O_8

GEOL: Mineralized shear zones with associated mafic, porphyritic dike cutting coarse grained granite.

REF: PRR-AP-4 (#678)
Granger, H. and Raup, R. (1962)

HOT SPOT CLAIM

LOC: Sec. 2, T7S, R17E
Aravaipa

QUAD: Holy Joe Peak 7½'; Tucson NTMS

DEVL: Short drift

RAD: 20X

GEOL: Few inch mineralized seam in granite. Malachite and azurite noted.

REF: PRR-AP-385 (#702)

JEEP CLAIMS

LOC: "From Florence take Ray-Kelvin Hwy. for 25.3 mi., turn up wash for 0.2 mi. Property is 100 yds. to left of wash.

QUAD: Mesa NTMS

DEVL: Small trench

RAD: 15X

ANAL: 0.103% e U_3O_8

GEOL: Radioactivity along fault zone in granite

REF: PRR-AP-318 (#318)

KATIE #3

LOC: Sec. 10, T4S, R13E

QUAD: Grayback and Kearny 7½'; Mesa NTMS

DEVL: Prospect pits and cuts

ANAL: Less than 0.01% U_3O_8; 0.2503 oz./ton Au, Ag.

GEOL: Mineralized, radioactive shear zone, striking E, dipping 80°N, in granite. Vuggy quartz stringers.

REF: PRR w/o # (#675A)

M AND M GROUP

LOC: Sec. 10, T9S, R5E

QUAD: Silver Reef Mtn.; Tucson NTMS

DEVL: Prospect pits, cuts
originally prospected for perlite

RAD: 10X

ANAL: 0.065% e U_3O_8

GEOL: Carnotite coating fractures along 30 ft. wide shear zone in altered perlite.

REF: PRR-AP-346 (#700)

MAGNA (Refer to Old Reliable)

MINERAL BUTTE GROUP (Montana, Apache, Yellow Peak, Squaw Peak)

LOC: SE¼, Sec. 36, T3S, R7E and SW¼ 31, T3S, R8E
East Santan Mtns.

QUAD: Blackwater 7½'; Mesa NTMS

DEVL: 70 ft. shaft, incline, extensive workings

PROD: Copper

RAD: 12X

ANAL: 0.15% e U_3O_8

GEOL: Torbernite occurs with copper minerals in fault gouge and along dacite dike intruding red granite. Fault zone stri es N45° W, dips 55°N.

REF: PRR-A-71

MORNING STAR CLAIMS

LOC: Sec. 16, T3S, R7E

QUAD: Chandler Heights 7½; Mesa NTMS

DEVL: 40 ft. shaft and several 10-20 ft. shafts

PROD: Gold and silver

RAD: 10X

GEOL: Spotty mineralization along narrow quartz vein, striking N70° E, dip 85°N, in Precambrian granite. Kasolite noted in dump specimens.

REF: PRR-AP-384 (#701)

OLD JONAH MINE

LOC: Sec. 23, T8S, R5E

QUAD: Silver Reef Mtns. 15'; Tucson NTMS

DEVL: Adit and open cut

PROD: Gold

RAD: 2X

GEOL: Radioactivity associated with base metal mineralization in quartz veins along shear zone between coarse grained granite and andesite. Zone strikes N87° E, dips 75°S.

REF: PRR-A-65 (#729)

OLD RELIABLE, BUNKER HILL, MAGNA, AND BATTLEAXE

LOC: Sec. 10, 11, 14, 15, T8S, R18E

QUAD: Oak Canyon and Rhodes Peak 7½'; Tucson NTMS

DEVL: Extensive underground workings

PROD: Base metals

RAD: 3X

GEOL: Radioactivity associated with base metals mineralization, in nearly vertical breccia pipe and veins intruding granodiorite and andesite tuff.

REF: PRR-M-987 (#707)

POHLE

LOC: Sec. 25, T5S, R13E

QUAD: Crozier Peak 7½'; Tucson NTMS

DEVL: Detected by A.E.C. airborne

RAD: 10X

ANAL: 0.04% e U_3O_8

GEOL: Radioactivity along contact fractured Dripping Spring Quartzite and diabase.

REF: PRR-A-66 (#679)

PURCHELL GROUP

LOC: Probably Sec. 10, 11, 15, T9S, R16E

QUAD: Mammoth 7½'; Tucson NTMS

DEVL: Pits and trenches

RAD: 2X

GEOL: Parallel veins in quartz monzonite covered by Cenozoic gravels Veins strike N80°E, dip 80°NW.

REF: PRR-AP-184 (#690)

RED DOG #1-3

LOC: Sec. 22, 23, T1S, R11E
Superstition Mtns.

QUAD: Picket Post Mtn. 7½'; Mesa NTMS

RAD: 3X

ANAL: 0.08% U_3O_8

GEOL: Highest radioactivity in brecciated limonitic rock along extensive thrust fault. Possible Dripping Springs Quartzite or silicified Pioneer Shale beneath thrust.

REF: PRR-AP-332 (#697)

RED ROCK #1-3

LOC: Sec. 12, T1S, R11E
Queen Creek, North Superstition Mtns.

QUAD: Picket Post Mtn. 7½'; Mesa NTMS

RAD: 3X

ANAL: 0.08% U_3O_8

GEOL: Radioactivity along thrust fault with extensive brecciation and re-cementation. Over thrust block may be Troy or Dripping Spring Quartzite.

REF: PRR-AP-328 (#696)

REWARD MINE

LOC: Sec. 34, T9S, R3E

QUAD: Vekol Mtns. 15'; Ajo NTMS

DEVL: Numerous pits and shafts over wide area

PROD: Base metals

RAD: 3X

GEOL: Radioactivity associated with mineralization and contact metamorphism in Paleozoic limestone.

REF: PRR-AP-67 (682 and #731)
PRR-AP-166 (#689)

SHORTIE GROUP (Refer to Honey Bee)

UNNAMED A

LOC: Sec. 26, 35, T4S, R11E

QUAD: North Butte 7½'; Mesa NTMS

DEVL: Adits and shaft

PROD: Gold

RAD: 10X

ANAL: 0.012-0.115% e U_3O_8; 0.075% U_3O_8

GEOL: Radioactivity in east-west mineralized zones in granite. Granite is intruded by aplite, diabase and porphyritic andesite.

REF: PRR-AP-291 (#693)

VALENTINE PROPERTY

LOC: Probably NE¼ Sec. 6, T3S, R13E

QUAD: Teapot Mtn. 7½'; Mesa NTMS

DEVL: Underground workings

PROD: Possible lead and silver

RAD: 6X

GEOL: Mineralization at contact between diabase and steeply dipping limestone and quartzite of the Apache Group.

REF: PRR-A-72

WATERFALL

LOC: Sec. 30, T5S, R15E

QUAD: Winkelman 7½'; Tucson NTMS

DEVL: 35 ft. adit, prospect pits

RAD: 12X

ANAL: 0.17% e U_3O_8 on dump

GEOL: 3 ft. wide vein in granite

REF: PRR-AP-298 (#694)

WOOLEY #1

LOC: NW¼ Sec. 33, T4S, R13E

QUAD: Greyback 7½; Mesa NTMS

DEVL: Shaft, adit

RAD: 6X

ANAL: 0.017% U_3O_8

GEOL: Radioactivity associated with iron and copper oxide veins cutting granite.

REF: PRR-w/o# (#677)

Index for Santa Cruz County Uranium Occurrences

Name

N = Nogales

SANTA CRUZ COUNTY

ALTO GROUP (Gold tree; El Plomo, Mineral Vein #1)

LOC: SE¼ Sec. 12, N½ Sec. 13, T21S, R14E
Patagonia

QUAD: Mt. Wrightson 15'; Nogales NTMS

DEVL: Extensive underground workings

PROD: Base metals

RAD: 12X

ANAL: 0.07% e U_3O_8

GEOL: Very fine uraninite crystals on cross fractures in quartz latite agglomerate. Vein deposit along east-west trending structure.

REF: PRR-AP-360 (#750)
PRR-M-848 (#759)

ANNIE LAURIE (Ruby Claim)

LOC: SE¼ Sec. 1, T23S, R11E

QUAD: Ruby 15'; Nogales NTMS

DEVL: Prospect pits, drill hole

ANAL: 0.01% U_3O_8

GEOL: Pitchblende, uraninite, uranophane and torbernite occurs with base metal sulfides along shear zone in highly silicified rhyolite porphyry with carbonate veins and faulted against shale and diorite dikes. Brecciated flow rock in shear zone. Uraninite is disseminated and along hairline fractures in wall rock.

REF: PRR-AR-4 (#753, 754, 710)
Granger, H. and Raup, R. (1962)
Webb, B. and Coryell, K. (1954, RME-2009)
Anderson, R. and Kurtz, E. (1955)

ATIKA PROPERTY

LOC: Approx. Sec. 7, T21S, R15E or 31° 62'N, 110° 85' W
One km. northeast of Alto Mine

QUAD: Mt. Wrightson 15'; Nogales NTMS

RAD: 5X

ANAL: 100 ppm, U_3O_8

GEOL: Base metal anomaly along a zone of stockworks in altered Laramide monzonite and granite.

REF: Arizona Bureau of Geology data

BACA-TUBAC CLAIMS

LOC: Probably Northern part Sec. 12, T21S, R14E
Just North of Alto Mine

QUAD: Mt. Wrightson 15'; Nogales NTMS

DEVL: Located by aerial radiometric survey

GEOL: Salero Volcanics consist of volcanic flows, arkoses containing large granite boulders, and some pockets of secondary uranium.

REF: Arizona Bureau of Geology data

BALD EAGLE (Duranium)

BEAR CLAW (Duranium)

BELL CLAIMS (Santa Clara Claim)

BLUE JAY

LOC: Sec. 27, 28, 33, 34, T21S, R15E
Squaw Gulch-Santa Rita Mtns.

QUAD: Mt. Wrightson 15'; Nogales NTMS

DEVL: 18 ft. and 25 ft. shafts in SE¼ Sec. 33.

RAD: 10X

ANAL: 0.04% e U_3O_8; 0.02% U_3O_8

GEOL: Possible autunite associated with strong hematite mineralization along quartz veins in granite. Strongest radioactivity along a series of N85° W trending thin quartz-hematite-limonite being over a considerable area show anomalous radioactivity. Squaw Gulch granite (Jurassic) is host rock and contains kaolinization of feldspar over about a square mile. See Drewes (1971) USGS map I-614, Mt. Wrightson quadrangle. Nearby Ivanhoe mine produced 363 tons of ore @ 1.78% Cu, 0.182% Ag (no Au) between 1908-1924.

REF: PRR-A-101
N.U.R.E.

BOWLING GREEN AND LUCKY SPUR GROUPS

LOC: Secs. 17, 20, T21S, R15E
Patagonia

QUAD: Mt. Wrightson 15'; Nogales, NTMS

DEVL: Two 50 ft. stopes, 250 ft. drift

PROD: Lead and silver

RAD: 85X

ANAL: 0.16% e U_3O_8

GEOL: Uraninite occurs with galena along vein, striking N70°E, dipping 80°S, in granite. Metatorbernite forms on fractures in highly altered shear zone.

REF: PRR-AP-359 (#749)

BRICK CLAIMS (Santa Clara Claim)

CARNARY YELLOW CLAIMS

LOC: Sec. 23, T22S, R17E
Patagonia

QUAD: O'Donnell Canyon 7½'; Nogales NTMS

DEVL: Pits

RAD: 20X

ANAL: 0.007% e U_3O_8

GEOL: Mineralized shear zone in acidic volcanic porphyry of Jurassic age.

REF: PRR-AP-320 (#748)

CAROL #9

LOC: Probably Sec. 19, T20S, R14E
Near Duranium Claims

QUAD: Mt. Wrightson 15'; Nogales NTMS

DEVL: Trenches, 3 shallow shafts, numerous pits

ANAL: 8.9% e U_3O_8

GEOL: Kasolite with minor uranophane along veins in silicified limestone conglomerate.

REF: D.O.E.

CLARK MINE (White Oak)

CRACKER JACK GROUP (Loraine #7, Remuda, Cracker Jack #1)

LOC: Sec. 29, T21S, R15E

QUAD: Mt. Wrightson 15'; Nogales NTMS

DEVL: Prospect pits

RAD: 2X

ANAL: 0.07% e U_3O_8

GEOL: Probably pitchblende with base metal sulfides in a fissure vein cutting quartz latite.

REF: PRR-A-39 (#715)

DURANIUM CLAIMS (Santa Cruz Claims, Bear Claw, Bald Eagle)

LOC: Northern SE¼, SW¼ Sec. 19, T20S, R14E

QUAD: Mt. Wrightson 15'; Nogales NTMS

DEVL: Trench 100 X 12 X 12 ft. deep, several pits
Discovered by airborne scintillometer in 1954

PROD: 677 Tons @ 0.20% U_3O_8, 1956-57
Some ore stockpiled

RAD: 75X

ANAL: 0.05-2.4% e U_3O_8

GEOL: Kasolite, uranophane, autunite and some malachite staining along cross fractures in arkosic sandstone of the Cretaceous Ft. Crittendon Fm. which strikes N30° W and dips 35° SW. Mineralized rock is faulted against Paleozoic rocks to the south and east. East-west cross fractures exert some ore control and are parallel to numerous Laramide quartz latite dikes to the east. Mineralization also along 60° NNE, NNW, and ENE shear zone in vicinity of main trench. Conglomeratic beds are radioactivity north by about 0.5 miles. Hydrothermal alteration noted, as kasolite and hematite-limonite replace calcite matrix fillings in the arkose.

REF: PRR-AP-285 (#740)
Bissett, D. (1958)
Dreves, H. (1971)
D.O.E.

EL PLOMO (Alto Group)

FOUR QUEENS

LOC: Sec. 33, T20S, R15E

QUAD: Mt. Wrightson 15'; Nogales NTMS

DEVL: Discovery pit and 2 shallow drill holes

RAD: 30X

ANAL: 0.12% U_3O_8
1% vanadium in select sample

GEOL: Autunite and torbernite along fracture zones in rhyolitic tuff-agglomerate. Hematitic alteration and radioactivity is greatest along E-W zones.

REF: PRR-A-112 (#721)

GOLD TREE (Alto Group)

GRANDVIEW GROUP

LOC: North central Sec. 20, T22S, R10E

QUAD: Arivaca 15'; Nogales NTMS

DEVL: 115 ft. shaft and open cut

RAD: 30X

ANAL: 0.08% U_3O_8

GEOL: Strong zone of cross fractures with kasolite and iron oxides in silicified volcanics. Main vein trends SE.

REF: PRR-AP-319 (#747)

HAPPY DAY CLAIMS (Silver Mine Claims; Horny Claims) (See Reactor and Opaline Group)

LOC: NW¼ SE¼ Sec. 5, T24S, R12E, adits just above stream level 0.25 miles downstream of Alamo Spring marked on Ruby quad.

QUAD: Ruby 15'; Nogales NTMS

DEVL: Several pits; 2 drifts 20 and 40 ft., developed for copper

RAD: 50-100X in veins

ANAL: 1.21% e U_3O_8; 1.05% U_3O_8

GEOL: Kasolite, autunite, uranophane, uraninite with chrysocolla and malachite in highly fractured Jurassic rhyolite porphyry. Mineralized fractures trend N10° W to N55°E. Several parallel weakly mineralized fractures are seen 50-200 ft. upstream. The veins were mined in late 1800's for their argentiferous galena content.

REF: PRR-AP-284 (#739)
PRR-AP-292 (#743, 744)

HAPPY JACK MINE

LOC: SW¼ SE¼ Sec. 16, T21S, R15E

QUAD: Mt. Wrightson 15'; Nogales NTMS

DEVL: Underground workings

PROD: Base metals

GEOL: Pitchblende with base metals in vein

REF: Schrader, F. (1915)
Schrader, F. and others (1917)
Bulter, G. and Allen, M. (1921)

HORNY CLAIMS (Happy Day)

J. B. CLAIMS

LOC: Sec. 20, 29, T22S, R11E

QUAD: Ruby 15'; Nogales NTMS

DEVL: 100 ft. incline and prospect pits

RAD: 25X

ANAL: 0.14-0.24% e U_3O_8; 0.006-0.03% U_3O_8

GEOL: Radioactivity associated with hematite.manganese nodules and strong silicification in highly altered and fractured rhyolite porphyry and volcanic tuff.

REF: PRR-A-111 (#720)

JOE PARKER No. 5 (Happy Day claim is 0.3 miles upstream)

LOC: Extreme east central edge of Sec. 5, T24S, R12E, 30 ft. south of main east-flowing stream bed, along banks of tributary stream.

QUAD: Ruby 15", Nogales NTMS

DEVL: 2 small cuts into hillside, one nearby 15-20 ft. shaft.

RAD: 2X

ANAL: 0.09% e U_3O_8

GEOL: Copper-uranium mineralization in vertical N55°E trending fractures in altered Jurassic volcanics. 0.5 tons of stockpiled ore is radioactive, and has chrysocolle-malachite colors. Shaft dug through stream terrace gravels into bedrock.

REF: PRR-AP-386 (#751)
AEC Field work

LITTLE DOC

LOC: NE¼ NW¼ Sec. 20, T22S, R10E

QUAD: Arivaca 15'; Nogales NTMS

DEVL: 2 inaccessible shafts, pits and trenches

RAD: 5-15X

ANAL: 0.04-0.13% U_3O_8

GEOL: Kasolite and possibly gummite with copper and silver mineralization along silicified, E-W trending fracture zones in Jurassic volcanics. Fractures dip 75°N. N-S fractures are not mineralized.

REF: PRR-A-SL-3 (#755, 756)
Webb, B. and Coryell, K. (1954, RME-2009)
PRR-AP-319

LITTLE JIM

LOC: Sec. 32, 33, T23S, R11E

QUAD: Ruby 15'; Nogales NTMS

DEVL: Discovery pit

RAD: 3X

GEOL: Sheared and opalized volcanic tuff

REF: PRR-A-40 (#716)

LOLITA MINE (Iris and Natalia)

LONE STAR #1

LOC: Sec. 23, T22S, R10E

QUAD: Oro Blanco and Arivaca 15'; Nogales NTMS

DEVL: Prospect pit

RAD: 40X

ANAL: 0.012% e U_3O_8

GEOL: Sooty uraninite on fracture planes in rhyolite dike

REF: PRR-AP-294 (#746)

LORAINE (Cracker Jack Group)

LUCKY SPUR (Bowling Green)

MINERAL VEIN #1 (Alto Group)

MONTANA CLAIM GROUP (Santa Clara)

Includes: Santa Clara
Bell
Brick

OPALINE (Refer to Reactor)

PENASO

LOC: Sec. 31, T23S, R12E

QUAD: Ruby 15'; Nogales NTMS

DEVL: 100 ft. adit and workings

PROD: Base metals

RAD: 3X

ANAL: 0.07% e U_3O_8

GEOL: Possibly kasolite associated with base metal sulfides (galena) on a shear in vein cutting rhyolite.
Shear zone strikes N45°E, dips 85°SE

REF: PRR-A-115 (#723)

PURPLE COW CLAIMS

LOC: Sec. 36, T22S, R10E

QUAD: Oro Blanco 15'; Nogales NTMS

DEVL: Prospect pit

RAD: 5X

ANAL: 0.03% e U_3O_8

GEOL: Torbernite crystals on fracture surfaces in steeply dipping, highly fractured dacite.

REF: PRR-AP-286 (#741)

REACTOR AND OPALINE GROUPS

LOC: Sec. 5, 8, T24S, R12E, staked later than, in vicinity of Happy Day Claims

QUAD: Oro Blanco 15'; Nogales NTMS

DEVL: Pits and cuts

RAD: 3X

GEOL: Autunite, uranophane and uraninite in shear zone cutting rhyolite porphyry.

REF: PRR-A-108 (#719)

REMUDA (Cracker Jack Group)

RUBY CLAIM (Annie Laurie)

SANTA CLARA CLAIM (Montana Group, Brick Claims; Ball Claims)

LOC: NE corner Sec. 6, T23S, R11E, 0.9 miles west of Ruby gate along main road, 30 ft. south of road in creek bottom-pits now filled in.

QUAD: Oro Blanco 15'; Nogales NTMS

DEVL: 18 ft. shaft, shallow drill holes, trench and pit Workings now covered.

PROD: 9.15 tons @ 0.28% U_3O_8; 0.40% Cu; 3.4% $CaCO_3$, 1955

RAD: Of volcanics at surface - 200-400 cps, or near the average values in area.

ANAL: 0.026-0.15% e U_3O_8

GEOL: Uraninite with sulfides in veinlets in dark colored 3 to 4 ft. wide base metal vein cutting Jurassic volcanic series.

REF: PRR-AP-293 (#745)
Fowler, G. (1938)
D.O.E.

SANTA CRUZ CLAIMS (Duranium)

Santa Cruz group includes:
- Duranium
- Bear Claw
- Bald Eagle #1-2

SILVER MINE CLAIMS (Happy Day)
Name used in early 1900's

SKYLINE

LOC: Sec. 35, T22S, R10E

QUAD: Oro Blanco 15'; Nogales NTMS

DEVL: Dozer pit on hilltop

RAD: 3X

GEOL: Torbernite and possible uraninite along fractures and joints in felsite intrusive. Joints trend S10°W, dip 65°E. Numerous quartz and iron stained veins noted.

REF: PRR-A-107 (#718)

SUNSET MINE

LOC: Sec. 3, T24S, R12E

QUAD: Ruby 15'; Nogales NTMS

DEVL: Two flooded shafts and several adits

PROD: At lease 15,500 lbs Pb, 4,640 oz. Ag, 400 lbs Cu, 19 oz. Au, between 1924-1969.

RAD 4X

GEOL: Uranium mineral associated with wulfenite and cerussite in brecciated rhyolite porphyry. Pyromorphite is moderately radioactive.

REF: PRR-AP-287 (#742)

WHITE OAK (Clark Mine) (Nearby Big Steve Mine)

LOC: NE¼ Sec. 2, T24S, R12E

QUAD: Ruby 15'; Nogales NTMS

DEVL: 6 adits, 2 shafts, 400 ft. of drifts, stopes. Both adits to main stopes caved in in Jan., 1981.

PROD: 17.6 tons @ 0.34% U_3O_8; 0.04% V_2O_5; 1951-52. At least 12,300 lbs. Pb, 70 oz. Ag between 1928-1958.

ANAL: 0.82 - 12.49% U_3O_8

Geol: Kasolite, uranophane, dumontite, autunite, pyromorphite associated with copper and lead minerals along shear zone, striking N55°E, dip 70° SE to vertical, cutting rhyolite volcanics of Jurassaic-Cretaceous age. Shear zone is up to 30 ft. wide and consists of intensively fractured, brecciated and shattered rocks. Veins contain carbonates and sulfates with rhyolite country rock altered to clay and sericite. Several local surficial radioactive shows in the area. Dump material along main stream reported to have very radioactive mineral pods. Best uranium ore came from intsection of NW and main NE trending shear zones. The nearby Big Steve mine is a parallel shear cutting the volcanics, and is truncated to the NE by a NW trending fault. It has black vein material containing psilomelane (Mn, Ba oxides) with Pb, Cu, Zn, and Mo, and radioactive yellow pyromorphite. Local anomalies of 2-3X at Big Steve mine dumps.

REF: PRR-AR-2 (#711, 752, 757)
Granger, H. and Raup, R. (1962)
Webb, B. and Coryell, K. (1954, RME-2009)
Nelson, F. (1968)
D.O.E.

Index for Yavapai County Uranium Occurrences

Ph = Phoenix
P = Prescott
H = Holbrook

YAVAPAI COUNTY

ABE LINCOLN MINE

LOC: Center S½ Sec. 11, T8N, R3W

QUAD: Morgan Butte 7½'; Prescott NTMS

DEVL: 2 caved and flooded shafts; 2 adits, 2500 ft. of inaccessible workings.

RAD: 100X

ANAL: 0.038-0.12% e U_3O_8; 0.01-0.11% U_3O_8
Select @ 0.46% U_3O_8 from dump

GEOL: Veins, narrow basaltic dike and trachyte porphyry dike occupy a fault zone that strikes N50°E, dipping 78-89°NW. Schoepite, probably uraninite and possibly pitchblende and uranophane are associated with copper and iron minerals, quartz, calcite and fluorite with traces of gold and silver in veins. Schoepite formed a coating on pyrite grains. Best assays from dump were on last material mined.

REF: PRR-M-990 (#887)
Granger, H. and Raup, R. (1962)

ANDERSON MINE (Uranium Aire Group; Date Creek basin; East End Claims; Main; Flat Top; and West)

LOC: Sec. 9-16, T11N, R10W, Mine in SW¼ Sec. 11

QUAD: Arrastra Mtn. SE 7½'; Prescott NTMS

DEVL: Open cut, stripping and benching, extensive drilling

PROD: 10,758 tons @ 0.154% U_3O_8 and 0.047% V_2O_5 in 1955-59.

ANAL: 0.60% e U_3O_8; 0.913% U_3O_8
V to U ratios vary from 1:1 to 1:2.4

GEOL: Tyuyamunite and carnotite in carbonaceous sandstone interbedded with conglomerate and ash beds in early to mid-Miocene lake sediments. Considerable faulting and minor folding. Wood fragments are opalized, carbonized and replaced by chalcedony. Green fluorescent mineral is uraniferous opal and chalcedony. Abundant limonite and hematite. Yellow encrustations on bentonite is nontronite (iron montmorillionite). Some secondary enrichment of uranium.

REF: PRR-AP-394 (#837)
Reyner, M. and others (1956, RME-2057)
Otton, J. (1977a)
Otton, J. (1977b)
A.G.S. (1978)
Sherborne, J. and others (1979)

ANTIMONY -SILVER #1 & 2

LOC: Sec. 3, T8N, R1E

QUAD: Squaw Creek Mesa 7½'; Prescott NTMS

DEVL: Caved adit and two filled shafts, worked in late 19th century. One shaft reopened to 35 ft.

RAD: 5X

ANAL: 0.03% U_3O_8

GEOL: Antimony, gold, silver and possibly meta zeunerite in two foot quartz vein in mica schist and granitic gneiss. Vein strikes N65°E, dips 70°NW.

REF: PRR-AP-91 (#804)

ARIZONA BLACK DONKEY (Black Donkey; Willbank Group)

LOC: Sec. 4, T8N, R1W
Bradshaw Mtns.

QUAD: Columbia 7½; Prescott NTMS

DEVL: Open cut, test pits, drilling

RAD: 5X

ANAL: 0.02-0.80% e U_3O_8; 0.26-0.55% U_3O_8

GEOL: Autunite and other uranium minerals in quartz veins along shear zone in complex of schist and gneiss. Vein strike N10°E, dip 80°W. Most radioactivity associated with limonite. Some barite.

REF: PRR-A-91 (#780)
PRR-A-78 (#777)

ARROWHEAD GROUP (Granite Ridge Group)

ATHENA

LOC: "Follow Black Canyon Hwy. south from Rock Spring, 3.2 mi. turn R. on Bard Ranch Rd. and proceed 8.2 mi. to property.

QUAD: Phoenix and Prescott NTMS

DEVL: 3 small prospect pits

RAD: 4X

ANAL: 0.32% e U_3O_8

GEOL: Basic volcanic flow overlying schist

REF: PRR-AP-334 (#830)

BAGDAD COPPER MINE (Black Mesa Tunnel)

LOC: Sec. 4, T14N, R9W

QUAD: Bagdad 15'; Prescott NTMS

DEVL: Open pit copper mine

PROD: Base metals

RAD: 2X

GEOL: Radioactivity associated with copper mineralization in monzonite intruding schist and gneiss.

REF: PRR-AP-75 (#793)

BAGIO #1-10 and ESPERANCE #1-10

LOC: "Take road 6 mi. past Cornville, turn L. on the Middle Verde Road and proceed about 4 mi."
Verde Valley

QUAD: Prescott NTMS

DEVL: Prospect pits

RAD: 0.2 mr/hr.

GEOL: Radioactive along contact of clay, marl and lime beds in Verde Fm. of Miocene-Pliocene age.

REF: PRR-AP-247 (#826)

BECHETTI LEASE (Silver Platte Mine)

LOC: NE¼ Sec. 35, T16N, R2E
East Mingus Mtn.

QUAD: Cottonwood 7½'; Prescott NTMS

DEVL: Crosscuts and incline, prospect pits

PROD: Copper, gold, silver

RAD: 150X

ANAL: 0.02-0.14% e U_3O_8; 0.003-0.01% U_3O_8; 0.02-1.35% ThO_2

GEOL: Mineralization associated with 25 ft. thick quartz vein (strikes S30°W, dips 45°S) in metamorphosed volcanics and sediments overlain by Paleozoic sediments and Tertiary lake sediments. Vein exposed on hillside for nearly 1,000 feet.

REF: PRR-AP-363 (#834)
D.O.E.

BLACK BUCK

LOC: Sec. 28, T8N, R1W
Castle Creek

QUAD: Columbia 7½; Prescott NTMS

RAD: 4X

GEOL: Vein type in granite, schist and metasediments

REF: PRR-AP-178 (#817)

BLACK DONKEY (Arizona Black Donkey)

BLACK MESA TUNNEL (Bagdad)

BLUE BOY

LOC: Sec.11, T9N, R3W

QUAD: Wagoner 7½'; Prescott NTMS

DEVL: Test pits and open cut

RAD: 12X

ANAL: 0.11% e U_3O_8; 0.07% U_3O_8

GEOL: Radioactivity located at intersection of shears in greenstone complex and follows N10°E, dip 75°E shear zone.

REF: PRR-A-85 (#778)

BUCKHORN MINE (Buckskin, Cuba; Lucky Day; Independence Mines)

LOC: Approx. SE¼ Sec. 8, T11N, R5W

QUAD: Weaver Peak 7½; Prescott NTMS

DEVL: Old underground workings

PROD: Copper, tungsten, gold

GEOL: Granite contains torbernite and uranophane in fractures and quartz veins. Tungsten and beryllium minerals present.

REF: Granger, H. and Raup, R. (1962)

BUCKSKIN (Buckhorn)

CAMP (Hillside Mine)

CAMP WOOD

LOC: Sec. 24, T17N, R6W

QUAD: Camp Wood 15'; Prescott NTMS

DEVL: 2 small pits

PROD: Worked for mica

RAD: 2X

GEOL: Pegmatite cutting granite

REF: PRR-A-14 (#767)

CARDINAL CLAIM

LOC: Sec. 27, T14N, R8W

QUAD: Bagdad 15'; Prescott NTMS

DEVL: Prospect pit

RAD: 50X

ANAL: 0.05-0.13% e U_3O_8

GEOL: Two foot vein striking NW-SE through Precambrian Granite. Radioactivity associated with limonite.

REF: PRR-A-41 (#771)

CHALK MOUNTAIN PROSPECT

LOC: Approx. SE¼ Sec. 14, T8N, R6E or 34°02'N, 11°42.5'W
Lower Verde River

QUAD: West Bottom Mesa 7½; Holbrook NTMS

RAD: 4X

ANAL: 0.006% U_3O_8

GEOL: Fracture coatings of carnotite in tuffaceous lacustrine marl exposed in dry wash bed. Flat lying section of tuffs, limestones and fine-grained sediments.

REF: Scarborough, R. and Wilt, J. (1979)

CONGRESS MINE

LOC: NW¼ Sec. 23, T 10N, R6W

QUAD: Congress 7½'; Prescott NTMS

DEVL: Extensive underground workings

PROD: Gold and silver

RAD: 20X

ANAL: 0.04–0.121% e U_3O_8

GEOL: Radioactivity is associated with limonite in pegmatitic and basic dikes intruding gneissic granite. Radioactive zone is also in a fault on hanging- wall of the 6 ft. white quartz Congress vein, striking N75° W, dips 25°N.

REF: PRR-AP-309 (#829)

CONTRACT #1-2 (Hillside Mine)

COPPER CHIEF

LOC: Sec. 2, T8N, R1W

QUAD: Columbia 7½'; Prescott NTMS

DEVL: Small pit

ANAL: 0.01-0.12% e U_3O_8; 0.113% U_3O_8

GEOL: Uranium, copper and iron mineralization in one foot wide quartz vein in Yavapai Schist.

REF: PRR-AP-108 (#816)

COPPER QUEEN

LOC: "South from Bagdad "Heights" approximately 1 mi. on Congress Junction Rd. to cattleguard. Immediately across cattleguard, turn right (west) for 3.8 mi. take left fork for approx. 1 mi. to mine.

QUAD: Bagdad 15'; Prescott NTMS

DEVL: Extensive underground workings

RAD: 2X

GEOL: Quartz veins with base metal sulfides in Precambrian schist.

REF: PRR-AP-61 (#791)

CUBA MINE (Buck horn, Lucky Day and Independence)

LOC: NW¼ Sec. 16, T 11N, R5W

QUAD: Weaver Peak 7½'; Prescott NTMS

DEVL: Underground

PROD: Probably gold

RAD: 15X

ANAL: 0.014% e U_3O_8; 0.009% U_3O_8

GEOL: Torbernite in quartz vein (strikes N 52° W, dips 25° NE) in weathered granite.

REF: PRR-M-981 (#882)

CURLING CLAIMS

LOC: Sec. 14, T14N, R8W

QUAD: Bagdad 15'; Prescott NTMS

RAD: 20X

GEOL: Basalt flow capped by coarse conglomerate

REF: PRR-A-86 (#779)

DATE CREEK BASIN (Anderson Mine)

DENVER GROUP

LOC: Approx. E½ Sec. 16, T8N, R3W

QUAD: Morgan Butte 7½'; Prescott NTMS

DEVL: Old underground mine

PROD: Copper

RAD: 30X

ANAL: 0.46% e U_3O_8 and 0.61% U_3O_8

GEOL: Radioactivity associated with copper mineralization in veins along fault zone, striking N54°E, dip 73° N. A basic dike trends N38W, dips 80° N. Fault is post dike and both cut Precambrian gneiss-schist complex.

REF: PRR-A-54 (#775)

DISHMAN BROTHERS CLAIMS

LOC: Sec. 1-6, T8N, R1E

QUAD: Black Canyon City and Columbia 7½'; Prescott NTMS

DEVL: Old cuts and shaft; drilled

PROD: Silver

RAD: 12X

ANAL: 0.06% e U_3O_8

GEOL: Torbernite associated with iron oxides in numerous small quartz veins, trending N-S, dipping steeply west in granite.

REF: PRR-A-73

DOROTHY FRACTION CLAIM

LOC: Sec. 25, 26, T 12½N, R2W

QUAD: Mt. Union 15'; Prescott NTMS

DEVL: Drifts, raises, and stopes

RAD: 30X

ANAL: 0.07% e U_3O_8

GEOL: Radioactivity associated with iron oxide in a narrow zone in hanging wall with several parallel veins in Precambrian Granite.

EAST END CLAIMS (Anderson Mine)

ERICKSON PROPERTY

LOC: Sec. 12, 13 T 15N, R2W

QUAD: Chino Valley South 7½'; Prescott

DEVL: Blasted face

RAD: 2X

GEOL: High background radioactivity in moderately fractured granite.

REF: PRR-AP-387 (#835)

ESPERANCE #1-10 (Refer to Bagio #1-10)

ETHIOPIA CLAIMS

LOC: Sec. 22, T15N, R9W

QUAD: Bagdad 15'; Prescott NTMS

DEVL: Two 20 ft. shafts; One 45 ft. (70°) incline and workings

RAD: 8X

ANAL: Select @ 0.13% e U_3O_8; 0.124% U_3O_8; 0.01% ThO_2

GEOL: Radioactivity associated with quartz, galena, and iron oxides in small veins along joints in Precambrian Granite.

REF: PRR-AP-99 (#810)

EXCALIBUR GROUP

LOC: SW¼ Sec. 13, T 10N, R1E
Black Canyon

QUAD: Mayor 15'; Prescott NTMS

DEVL: 15 ft. incline, shallow pits, drill holes

RAD: 25X

ANAL: 0.08% U_3O_8

GEOL: Black radioactive mineral with pyrite, iron oxide and quartz in weakly mineralized silicified shear zone (strikes N?°W, dips 75° W) in strongly foliated Yavapai Schist.

REF: PRR-A-103 (#783)

FARVIEW

LOC: Approx. NE¼, T15N, R2E, or 34°42'28"N, 112°5' 17"W
west side of Verde Valley just above Verde Fault

QUAD: Cottonwood 7½'; Prescott NTMS

DEVL: Prospect pits

RAD: 150X

ANAL: 0.01-0.24% e U_3O_8; 0.02-0.91% ThO_2

GEOL: Numerous faults and associated iron oxide - quartz veins cut metamorphosed basic volcanic flow rock. Schistosity and most fractures trend E-W. One vein and fault strikes N17° E, dips 65°SE. Yellow limonite is most radioactive. Chalcopyrite, smoky quartz, and thorite noted.

REF: PRR-AP-299
Staaz, M. (1974)

FLAT TOP (Anderson Mine)

FORD CLAIM (Gazelle Mine)

LOC: 34°10'6"N; 112° 21' 28"W

QUAD: Crown King 7½'; Prescott NTMS

DEVL: 2 drifts, prospect pits

PROD: Old gold mine

RAD: 50X

ANAL: 0.18% e U_3O_8

GEOL: Torbernite and uranophane in small quartz stringers in fault, mineralized with base metals and cutting granite.

REF: PRR-A-16 (#769)

GAMMA GROUP

LOC: Sec. 27, T15N, R9W

QUAD: Bagdad 15'; Prescott NTMS

DEVL: Several dozer cuts and prospect pits

RAD: 35X

GEOL: Radioactivity associated with iron oxide in quartz vein striking E-W through granite porphyry.

REF: PRR-A-42 (#772)

GAZELLE MINE (Ford Claims)

GOLDEN DUCK (refer to Maricopa Co. listing)

GOOD LUCK MINE

LOC: Approx. NE¼ Sec. 22, T13N, R10W

QUAD: Arrastra Mtn. NE 7½'; Prescott NTMS

DEVL: Surface cuts and 2 shallow shafts

RAD: 50X

ANAL: 0.02% e U_3O_8; 0.023% U_3O_8; 0.01% ThO_2

GEOL: Radioactivity associated with pegmatite dike cutting metamorphic complex. Quartz, tourmaline, beryl, scheelite, epidote and garnets present.

REF: PRR-AP-100 (#811)

GRANITE RIDGE GROUP (Arrowhead Group)

LOC: T10 N, R6 W

QUAD: Congress and O'Neil Pass 7½'; Prescott NTMS

DEVL: Incline shaft, adits, pits

PROD: Old gold prospect

RAD: 15X

ANAL: 0.14% e U_3O_8

GEOL: Crystalline, black radioactive mineral in quartz veins and pegmatite dikes cutting pink granite.

REF: PRR-AP-256 (#827)

GREAT SOUTHERN MINE

LOC: Sec. 32, T8N, R3W
Wickenburg Mtns.

QUAD: Red Picacho 7½'; Phoenix NTMS

RAD: 5X

ANAL: 300 ppm U_3O_8

GEOL: Sheared fault zones in Precambrian schist related to emplacement of NW trending Tertiary Lamprophyry dikes.

REF: Arizona Bureau of Geology data.

GRUBSTAKE #1-6

LOC: Sec. 27, T15N, R9W

QUAD: Bagdad 15'; Prescott NTMS

DEVL: 3 small prospect pits

RAD: 5X

ANAL: 0.01% e U_3O_8

GEOL: Narrow quartz vein in granite porphyry

REF: PRR-AP-388 (#836)

HILLSIDE MINE (Happy Jack; Camp, Contract 1-2; Seven Stars)

LOC: Sec. 16, 21, T15N, R9W

QUAD: Bagdad 15'; Prescott NTMS

DEVL: Extensive underground workings from shaft.

PROD: Base metals mine, 1930-1951
21 tons @ 0.30% U_3O_8, 0.03% V_2O_5 in 1950 was mined from Seven Stars claim along Hillside vein and hauled up through Hillside mine shaft. Two tailings ponds a short distance down Boulder Creek contain ore processed from Hillside mine have been estimated by AEC to contain 175,000 tons @ 0.06% U_3O_8 available ore.

ANAL: 0.11-2.02% U_3O_8

GEOL: Pitchblende and secondary uranium minerals (bayleyite, swartzite, andersonite, schroekingerite) associated with gold-silver-base metal-fluorite vein in Precambrian Yavapai Schist.

REF: PRR-w/o # (#765-A-C)
Wright, R. (1950, RMO-679)
Anderson, C. and others (1955)
Axelrod, J. and others (1951)
Arizona Bureau of Mines (1950)

HORSESHOE PROSPECTS (Refer to Maricopa County listing)

HUDSON (Pretty Folly)

INDEPENDENCE MINE (Lucky Day)

JEEP CLAIMS

LOC: Approx. T13N, R10W, (North on Hwy. 93 8.2 mi. from Hwy. 93 Junction turn right - 0.5 mi. to trailer house and ask directions.

QUAD: Prescott NTMS

PROD: 300 lbs. beryl

RAD: 4X

GEOL: Samarskite with beryl, tourmaline and quartz in a pegmatite vein in schist.

REF: PRR-AP-80 (#798)

KITTEN #1 CLAIM

LOC: SW¼ Sec. 27, T15N, R9W

QUAD: Bagdad 15'; Prescott NTMS

DEVL: Prospect pits

ANAL: 0.014-0.20% e U_3O_8, 0.013-0.094% U_3O_8

GEOL: Metatorbernite, pyrite and fluorite disseminated along fracture zone in porphyritic granite.

REF: PRR w/o # (#766)
Granger, H. and Raup, R. (1962)

LAKE PLEASANT PROSPECT

LOC: SW¼, NW¼ Sec. 22, T7N, R1E

QUAD: Governors Peak 7½'; Phoenix NTMS

DEVL: Drilled

ANAL: 0.02% e U_3O_8

GEOL: Carnotite occurs as fracture coatings and disseminated in clastic and tuff beds. Tuff beds contain coven-hoofed vertebrate tracks. The gently warped and folded tuffaceous and lacustrine sequence is overlain by Pliocene sediments.

REF: Scarborough, R. and Wilt, J. (1979)
Waechter, N. (1979)

LITTLE SURPRISE

LOC: Approx. 34°18' 20" N; 112° 15' 18" W

QUAD: Bottle flat 7½'; Prescott NTMS

DEVL: Prospect for silver

ANAL: 0.7% e U_3O_8

GEOL: Small quartz-barite vein cutting Precambrian rocks contains copper staining and possibly Torbernite.

REF: PRR-AP-245 (#824)

LUCKY DAY (Independence, also refer to Buckhorn; Cuba)

LOC: Sec. 9, T11 N, R5 W

QUAD: Weaver Peak 7½'; Prescott NTMS

RAD: 10X

ANAL: 0.004 -0.017% e U_3O_8; 0.016% U_3O_8

GEOL: Uranophane on exfoliation planes in coarse granite

REF: PRR-M-982 (#883)

LUCKY PROBE

LOC: Sec. 23, T 12N, R6W

QUAD: Weaver Peak and Bismarck Mesa 7½'; Prescott NTMS

DEVL: Old discovery work

RAD: 10X

ANAL: 0.04-0.27% e U_3O_8; 0.15-0.24% U_3O_8

GEOL: Radioactivity is associated with platy hematite-magnetite in pink granite with local volcanic cap rock. Spotty yellow uranium mineral and polycrase noted.

REF: PRR-A-17 (#770)

MAIN (Anderson Mine)

MAMMOTH MINE

LOC: Sec. F, T14N, R9W

QUAD: Bagdad 15'; Prescott NTMS

DEVL: 50 ft. adit, 15 ft. vertical shaft

RAD: 2X

GEOL: Radioactivity associated with copper minerals along joints and fractures in a highly altered granite.

REF: PRR-AP-86 (#803)

MILLER MINE

LOC: Probably Sec. 23, T8N, R3W

QUAD: Morgan Butte 7½'; Prescott NTMS

DEVL: Flooded incline shaft (65 ft.)

RAD: 10X

ANAL: 0.015% e U_3O_8; 0.012% U_3O_8

GEOL: Radioactivity associated with copper mineralization in a vein striking N40° W, dips steeply NE in granite.

REF: PRR-M-983 (#884)

MISS TRACEY CLAIMS

LOC: Sec. 30, T11N, R2E

QUAD: Mayer 15'; Prescott NTMS

RAD: 5X

ANAL: 0.01% e U_3O_8

GEOL: Ten foot bed of quartz latite porphyry in volcanic series.

REF: PRR-A-51 (#774)

MIXPAH (Uranus Group)

MOUNTAIN SPRING

LOC: Sec. 17, T 14N, R9W

QUAD: Bagdad 15'; Prescott NTMS

DEVL: Shaft

PROD: Lead, silver, copper

RAD: 2X

GEOL: Radioactivity, associated with mineralization with quartz veins in schist near contact with granite.

REF: PRR-AP-77 (#795)

NEST EGG (Uranus Group)

P. R. EQUITY

LOC: Sec. 26, 27 T12½N, R3W
Hassayampa

QUAD: Wilhoit 7½'; Prescott NTMS

RAD: 13X

ANAL: 0.08% e U_3O_8

GEOL: Radioactive iron oxides in a 2-4 ft. wide fault breccia in rhyolite dikes intruding granite.

REF: PRR-AP-139 (#821)

PEOPLES VALLEY MINE

LOC: "Turn left on dirt road 5.9 mi. NE of Yarnell on U.S. 89. Follow dirt road 5.5 mi. NW to property."

QUAD: Weaver Peak 7½'; Prescott NTMS

DEVL: Open cuts and 20 ft. shaft

ANAL: 0.15% e U_3O_8; 0.13% U_3O_8; 0.078% ThO_2

GEOL: Radioactivity associated with beryl bearing pegmatite, striking N40°E, dip 70° NW, in a granite.

REF: PRR-M-847 (#881)

PLANET SATURN (Uranus Group)

PRETTY FOLLY (Hudson, Smokie #1-9)

LOC: Possibly Sec. 35, T17N, R3E. (very poorly located)
Verde

QUAD: Clarkdale 15'; Prescott NTMS

DEVL: Prospected and drilled

RAD: 7X

ANAL: 0.03% e U_3O_8

GEOL: Thin coatings of carnotite on bedding planes and fractures in calcareous Pliocene lake beds of the Verde Fm.

REF: PRR-AP-247
PRR-AP-361 (#832)
PRR-AP-362 (#833)
PRR-A-56 (#776)

RIVERSIDE #1

LOC: Sec. 9, T11N, R10W

QUAD: Arrastra Mtn. SE 7½; Prescott NTMS

DEVL: Trench, 25-30 drill holes

ANAL: 0.08% e U_3O_8

GEOL: Carnotite in flat lying Tertiary sediments containing some silicified wood.

REF: PRR-A-117 (#784)

SECTION 2 CLAIMS

LOC: Sec. 2, T16N, R1W
Chino Valley

QUAD: Paulden 15'; Prescott NTMS

RAD: 2X

ANAL: 0.01% e U_3O_8

GEOL: Basalt flow capping late Paleozoic limestone

SEVEN STARS (Hillside Mine)

SHAMROCK MINING AND DEVELOPMENT CO.

LOC: Sec. 16, 17, 20, 21, T7N, R2W

QUAD: Cartias Mtn. 7½'; Phoenix NTMS

RAD: 100X

GEOL: Yellow uranium mineral coatings along fractures in large pegmatite dike, trending N75° W, in metamorphic rocks. Tungsten, beryl and lithium minerals noted.

REF: PRR-AP-347 (#831)

SILVER KNIGHT MINE

LOC: Approx. Sec. 25, 26, 36, T13N, R3W

QUAD: Wilhoit 7½; Prescott NTMS

DEVL: Adits and numerous pits

PROD: Silver

RAD: 5X

GEOL: Anomalous radioactivity confined to flat fault (N 38°W, dip 23°N) in Precambrian granite.

REF: PRR-A-98 (#782)

SILVER PLATTE MINE (Bechetti Lease)

SMOKIE #1-9 (Pretty Folly)

SPRINGFIELD MINE

LOC: Approx. 34° 12' 28" N; 112° 30' 6" W

QUAD: Crown King 7½'; Prescott NTMS

DEVL: Flooded shaft, adit

ANAL: 0.18% e U_3O_8; 0.15% U_3O_8

GEOL: Base metal mineralization associated with vein in granodiorite. Secondary uranium minerals in acidic volcanic rocks piled along mine access road.

REF: PRR-M-985 (#886)

TERMINAL (Uranus Group)

THREE BUCKS claims

LOC: Secs 10-15, and 23, T8N, R3W.

QUAD: Morgan Butte 7.5', Prescott NTMS

DEVL: Some dozer cuts

RAD: 2-5X.

ANAL: to 50 ft. of 0.02-0.04% U_3O_8 in shear zone.

GEOL: Mineralized shear zones trend NNW and NNE to NE are parallel to basic tertiary (?) dikes, and cut Precambrian granitic and amphibolitic gneisses folded along N 40-50° W trends. Shears are less than 2 feet wide.

REF: AZ Bur of Geol file data

TOTAL WRECK (Uranus Group)

UNNAMED A

LOC: NW¼ Sec. 21, T13N, R3W
Copper Basin

QUAD: Wilhoit 7½'; Prescott NTMS

DEVL: Shallow underground workings

RAD: 2X

GEOL: Copper mineralization disseminated in fluvial poorly sorted conglomerate and along fractures in underlying rhyolite porphyry.

REF: PRR-AP-137 (#819)

UNNAMED B

LOC: "From Wickenburg take Constellation Road to fork at 3.3 mi. turn left and drive 9.6 mi. to property.

QUAD: Sam Powell 7½'; Prescott NTMS

DEVL: Small shafts and prospect pits

RAD: 10X

ANAL: 0.015% e U_3O_8

GEOL: Metamorphic and pegmatite complex are cut by basic dikes.

REF: PRR-M-984 (#885)

URANIUM AIRE GROUP (Anderson Mine)

URANUS GROUP (Mizpah, Terminal, Nest Egg, Planet Saturn, Total Wreck)

LOC: SE corner T10N, R5W and SW corner T10N, R4W

QUAD: Congress and Yarnell 7½'; Prescott NTMS

DEVL: Extensive underground workings

PROD: Gold

RAD: 30X

ANAL: 0.06-0.14% e U_3O_8, 0.14% U_3O_8

GEOL: Radioactivity associated with limonite and fluorite with mineralized veins in fault zones, striking N 15° W, dipping 35-45°E, in granite. Granite intrudes metasediments. NW trending basic dike cuts granite. Thin fluorescent coatings in places.

REF: PRR-AP-15 (#768)

WEST (Anderson Mine)

WILLBANK GROUP (Arizona Black Donkey)

YUMA COUNTY

ATOM CLAIMS

LOC: Approx. S½, T4S, R22W

QUAD: Picacho and Red Hills 15'; Salton Sea NTMS

ANAL: 0.01-0.04% U_3O_8

GEOL: Weak radioactivity associated with hematite veins along footwall contact of schist inclusions in foliated granite. Quartz veins.

REF: Granger, H. & Raup, R. (1962)
Waechter, N. (1979)

B#1-3 (WILHITE AND HARRELL GROUP)

BIG CHIMNEY GROUP (Busy Bee; Lucky; Lucy Alice; Lucky Four; Katy Did #1-2; Spear-Larsen #1-5)

LOC: Secs. 9, 10, 16, 17, 21, T9S, R20W
W. Gila Mtns.

QUAD: Ligurta 7½'; El Centro NTMS

DEVL: 20 ft. shaft; 20 ft. drift; open cuts and prospect pits

PROD: 5 tons @ 0.03% U_3O_8, 1957 shipped to Cutter then removed & returned to property. 225 tons of ore now stockpiled.

ANAL: 0.10% e U_3O_8; 0.08% U_3O_8

GEOL: Davidite, allanite, samarskite and monazite occur in veins and pegmatites in granite gneiss.

REF: D.O.E.
PRR-A-49
PRR-A-45 (#892)

BLACK BEAUTY

LOC: Approx. Sec. 10, 11, T2S, R20W
Chocolate Mtns.

QUAD: Trigo Peak 15'; Salton Sea NTMS

DEVL: Discovery pit

RAD: 2X

GEOL: Sandstone interbedded with rhyolite, andesite, and obsidian flows.

REF: PRR-A-67 (#895)

BONANZA MINE

LOC: NW¼ Sec. 26, T7N, R13W

QUAD: Salome 15'; Phoenix NTMS

DEVL: Incline shaft and drifts

RAD: 3X

ANAL: 0.06%, e U_3O_8; 0.07% U_3O_8

GEOL: Uranium associated with iron oxide and secondary copper minerals along dike and fault zone in granite and gneiss. Four foot dike trends S50°E, dips 45°NE, and fault trends N50° W, dips 50°NE.

REF: PRR-AP-301 (#903)

BONNIE (Wilhite and Harrell Group)

BUSY BEE (Big Chimney Group)

CACTUS GROUP

LOC: N from Agua Caliente to S-P Railroad; cross tracks and continue N along fence; take L. fork beyond corral at end of fence, and continue northerly on bladed road, for a total of 14-16 mi.

QUAD: Hyder NE 7½'; Phoenix NTMS

DEVL: Pit

RAD: 25X

ANAL: 0.25- 2.57% e U_3O_8; 0.19- 2.53% U_3O_8

GEOL: Radioactive mineral is disseminated through pegmatite dikes and quartz veins intruding granite. Dikes trend S80E with intersecting vertical shears striking N20°E.

REF: PRR-AP-393 (#912)

DARLING MINE AREA

LOC: Approx. Sec. 28, T5N, R20W
North Dome Rock Mtns.

QUAD: Dome Rock Mtns 15'; Salton Sea NTMS

DEVL: Several mines in area

RAD: 3X

GEOL: Sheared and reworked tectonic contact between Paleozoic marbles and a porphyritic granite of probable Precambrian Age.

REF: Arizona Bureau of Geology data.

DIZZY LIZY

LOC: Approx. SE¼, T7S, R18W, Muggins Mtns.-"From Old Tacna go 4.4 mil W. on U.S. 80; Turn R opposite Bake Tanks turnoff and go 3.9 mi. on gravel road; turn L and go 2.2 mi. along N. side of canal; turn R across Gila River bottom and follow dirt road up wash for 1.3 mi.; turn R. on faint trail and proceed 3.2 mi. to property."

QUAD: Red Bluff Mtn. 15'; El Centro NTMS

DEVL: Prospected

RAD: 25X

ANAL: 0.08% e U_3O_8

GEOL: Radioactivity in tuffaceous beds in tertiary Sedimentary and volcanic sequence. Mineralized tuff strikes NE-SW, dips 30°S and is about 4 ft. thick.

REF: PRR-A-46 (#873)

FAITH AND HOPE

LOC: Sec. 35, T5N, R13W

QUAD: Hope 15'; Phoenix NTMS

ANAL: 0.22% e U_3O_8, 0.11% U_3O_8

GEOL: Disseminated radioactive heavy minerals in loosely unconsolidated granitic material.

REF: PRR-A-68 (#896)

GOODMAN MINE GROUP

LOC: SE¼ Sec. 23; NW¼ Sec. 25, T4N, R21W

QUAD: Lapaz Mtn. 7½; Salton Sea

DEVL: Numerous shafts and tunnels

PROD: Gold and silver

ANAL: 0.03-0.27% ThO_2

GEOL: Thorium along a narrow part of a 2 mile long WNW trending shear zone, dipping 30-90° and ranging 5-40 ft. in width. The shear cuts Mesozoic quartz-epidote schist and metasediments.

REF: Staaz, M. (1974)
Keith, S. (1978)

HWWR (Wilhite and Harrell Group)

HOPE (Faith)

HOT ROCK CLAIM

LOC: T8N, R12W---"From Wenden turn N. on Alamo Rd. for 13 mi. at junction turn R up gas line right-of-way for 150 yds. then turn left on old dirt road; cross wash and proceed 0.3 mi. take Rt. fork 0.7 mi. to end of road.

QUAD: Ives Peak and Salome 15'; Phoenix and Prescott NTMS

DEVL: 5 adits, 1 shaft, open cuts

ANAL: 0.02-0.05% e U_3O_8; 0.057% U_3O_8

GEOL: Fault vein of granite intruded into schist. copper and iron sulfides and oxides noted.

REF: PRR-AP-289

ISLEY-LILLARD CLAIMS

LOC: Approx. common corner Sec. 6, 7, T8S, R18W and Sec. 1, 2, T8S, R19W
Muggins Mtns.

QUAD: Red Bluff Mtn. 15'; El Centro NTMS

DEVL: Prospect pits

RAD: 6X

GEOL: Radioactive opalitic and chalcedonic white ash layers in shaly beds interbedded with Tertiary lake bed and volcanic sequence. Sediments are gently folded and cut by numerous N35°W faults and overlain to the west by obsidian and rhyolite flows.

REF: PRR-AP-389 (#908)
Rayner, M. and Ashwill, W. (1955)

JAP (Wilhite and Harrell Group)

KATY DID #1-2 (Big Chimney Group)

LA FORTUNA MINE

LOC: Approx. T10S, R20W, or 32° 33' 05"N, 114°19' 45"W
SW. flank of Gila Mtns.

QUAD: Fortuna Mine 7½'; El Centro NTMS

DEVL: One major shaft; several prospect pits

PROD: Gold, silver, copper

GEOL: Samarskite, muscovite, and possible thorium minerals associated with mineralization in pegmatites cutting small Laramide granite pluton.

REF: Keith, S. (1978, p. 150)
Raup, R. and Haines, D. (1953, TEM-679)

LAGUNA MOUNTAINS

LOC: SW¼, T7S, R21W
Adair Park Beds

QUAD: Aztec SE 7½'; Ajo NTMS

RAD: 3X

GEOL: Radioactivity in yellow-brown mottled shale-sandstone near fault. Southwest dipping redbed section of sandstone, conglomerate, mudflows and breccia in high-angle fault contact with gneiss and overlain by Kinter Fm. fanglomerates.

REF: Scarborough, R. and Wilt, J. (1979)

LAKE BED CLAIM

LOC: Approx. Sec. 2, T8S, R19W
Muggin Mtns.

QUAD: Red Bluff Mtn. 15'; El Centro NTMS

DEVL: Small pit and trench

RAD: 30X

GEOL: Uranophane, pyromorphite and chalcedony in volcanic tuffs interbedded in highly silicified Miocene lake beds. Fault separates lake beds from rhyolite on SW side of wash.

REF: PRR-AR-34

LILLIAN #1-3 (Starlight Group)

LOC: Approx. SW¼, T6N, R17W —"8 miles SW of Bouse on Hwy. 95, take unimproved dirt road and proceed west for 1 mile."

QUAD: Bouse 15'; Salton Sea NTMS

DEVL: Open pit

PROD: 125 railroad cars of hematite ore.

RAD: 2X

ANAL: 60% Fe

GEOL: Replacement deposit of hematite in limestone associated with country rocks of older granites and schists. Gypsum, gold, silver, manganese, barite, copper oxides and pyrrhotite noted.

REF: PRR-AP-230 (#901)

LINCOLN RANCH (Reid Valley)

LUCKY ALICE (Big Chimney Group)

LUCKY FOUR (Big Chimney Group)

MARVIN (Wilhite and Harrell Group)

MC MILLIAN PROSPECT

LOC: Approx. NE corner Sec. 16, T12S, R16W

QUAD: Cabeza Prieta Peak 15'; Ajo NTMS

DEVL: Pit, 2 short adits; 50 ft. shaft

RAD: 4X

ANAL: 0.032% e U_3O_8; 0.34% U_3O_8; 7.69% Cu
stockpiled ore = 0.034% U_3O_8

GEOL: Radioactive mineral associated with secondary iron and copper minerals along fracture zone in granite. Fractures strike N34°W and dip 65°SW.

REF: PRR-D-562 (#918, 919)
Granger, H. and Raup, R. (1962)
Raup, R. and Haines, D. (1953, TEM-679)

MICKEY DOLAN MINE

LOC: SE¼ Sec. 5, T6N, R13W
Harcuvar Mtns.

QUAD: Salome 15'; Phoenix NTMS

DEVL: 85 ft. incline shaft; 110 ft. drift, pits

RAD: 125X

ANAL: 0.14% e U_3O_8; 0.18% U_3O_8

GEOL: Radioactivity associated with secondary copper and iron minerals along E-W fault cutting granite and schist. Quartz is brecciated.

REF: PRR-ASL-4 (#913)

OSBORNE WASH

LOC: Approx. W½ Sec. 4 T9N, R17W
Parker Area

QUAD: Black Peak 15'; Needles NTMS

RAD: 3X

GEOL: Radioactivity in limonite altered gneiss beneath low-angle fault with overlying Tertiary limestone. Associated Cu-Fe-Mn minerals. Limestones are recrystallized and in low angle fault contact with gneiss.

REF: Scarborough, R. and Wilt, J. (1979)

PAULINE GROUP

LOC: Between Wooley and San Francisco Groups
Muggins Mtns.

QUAD: Red Bluff Mtns. 15'; El Centro NTMS

ANAL: 0.20% U_3O_8

GEOL: Quartz stringer zone and uranophane noted in float.

REF: Reyner, M. and Ashwill, W. (1955)

RADIUM HOT SPRINGS

LOC: Sec. 12, T8S, R18W

QUAD: Welton Mesa 7½; Red Bluff Mtn. 15'; El Centro NTMS

RAD: 0.2 mr/hr.

GEOL: Faulted andesite

REF: Waechter, N. (1979)

RAYVERN #2-19

LOC: NW¼ Sec. 13, T6N, R18W and W½ Sec. 7, T6N, R17W Plomosa Mtns.

QUAD: Bouse 15'; Salton Sea NTMS

DEVL: Small pits, shallow shaft, drilled

PROD: Copper and gold prospect

RAD: 15X

ANAL: 0.03-0.08% e U_3O_8

GEOL: Carnotite, uranophane, and meta-autunite associated with copper staining as fracture coatings in white, limey shales interbedded with limestones. Thick SW dipping tertiary section is complexly faulted and contains rhyolite and andesite flows.

REF: PRR-AP-348 (#907)

RED KNOB CLAIMS

LOC: Approx. Sec. 10, T8S, R19W

QUAD: Welton 7½'; El Centro NTMS

DEVL: Small drift

PROD: Ore stockpiled

RAD: 100X

ANAL: 0.28-1.55% e U_3O_8; 0.03-1.79% U_3O_8

GEOL: Uranophane, some carnotite and tyuyaminite, weeksite, vanadinite, gypsum and chalcedony in opalized Tertiary mudstone in lake bed sequence interbedded with volcanics. Mineralization occurs in high grade pockets about 1-3 ft. thick, 100 ft. long and 10 ft. wide.

REF: PRR-AP-302 (#904)
Reyner, M. and Ashwill, W. (1955)

REID VALLEY (Lincoln Ranch)

LOC: Sec. 14-16, 21-23, T10N, R13W

QUAD: Ives Peak 15'; Needles NTMS

ANAL: Less than 0.03% U_3O_8

GEOL: Tertiary lake beds, marls, mudstone and sandstone. Mineralization along sandstone-mudstone facies transition.

REF: Otton, J. (1977b)
Scarborough, R. and Wilt, J. (1979)
Waechter, N. (1979)

SAGUARO GROUP (St. Louis Group)

SAN FRANCISCO AND ST. PATRICK GROUP

LOC: Approx. Sec. 25, T7S, R19W
Muggins Mtns.

QUAD: Red Bluff Mtn. 15'; El Centro NTMS

ANAL: 0.10% e U_3O_8

GEOL: Radioactive chrysocolla, and copper carbonates occurs in thin band of mudstone, containing palm tree fragments.

REF: Reyner, M. and Ashwill, W. (1955)

SAWTOOTH MOUNTAIN

LOC: S. Sec. 31, T4N, R20W

QUAD: Dome Rock Mtns. 15'; Salton Sea NTMS

RAD: 10X

GEOL: Radioactivity along mylonitized deformed contact between 160 my. old quartz monzonite porphyry stock intruding metasedimentary sequence.

REF: Arizona Bureau of Geology data.

SILVER KING

LOC: Approx. Center Sec. 1, T4S, R23W

QUAD: Picacho 7½'; Salton Sea NTMS

DEVL: Shallow shaft and short adits

RAD: 2X

GEOL: Quartz veins in andesite flows. Some lead and possibly silver noted.

REF: PRR-RA-32 (#942)

SPEARS-LARSEN #1-5 (Big Chimney Group)

ST. LOUIS GROUP

LOC: Approx. Sec. 2, T8S, R19W

QUAD: Red Bluff Mtn. 15'; El Centro NTMS

DEVL: Dozer cuts

RAD: 100X

ANAL: 0.07-1.55% e U_3O_8; 0.03-1.79% U_3O_8 w/ThO_2

GEOL: Uranophane disseminated in shale interbedded with Tertiary lake beds, which are gently folded and broken by numerous faults, trending N35W.

REF: PRR-AP-390 (#909)
Waechter, N. (1979)
Reyner, M. and Ashwill, W. (1955)

ST. PATRICK CLAIMS (San Francisco Group)

STARLIGHT GROUP (Lillian #1-3)

STATE LEASE

LOC: Sec. 36, T4N, R20W
Dome Rock Mtns.

QUAD: Middle Camp Mtn. 7½'; Salton Sea NTMS

DEVL: Prospect pits

RAD: 50X

ANAL: 0.41-2.77% e U_3O_8; 0.22-1.25% U_3O_8 w/ThO_2

GEOL: Radioactivity associated with iron oxide in quartz veins cutting intrusive diorite and schist.

REF: PRR-AP-303 (#308)

TEN DEE'S

LOC: Sec. 7, T6N, R17W
NE Plomosa Mtns.

QUAD: Bouse 15; Salton Sea NTMS

DEVL: Prospect pit and one drill hole

RAD: 40X

ANAL: 0.10% e U_3O_8; 0.03% U_3O_8 w/ThO_2

GEOL: Radioactivity associated with pink gneiss, capped by Paleozoic sediments, intruded and then capped by Tertiary volcanics.

REF: PRR-A-18 (#891)

TOPAZ CLAIMS

LOC: Sec. 22, T4N, R20W
Dome Rock Mtns.

QUAD: Middle Camp Mtn. 7½'; Salton Sea NTMS

DEVL: Prospect pits

RAD: 2X

ANAL: 0.20% e U_3O_8; 0.14% U_3O_8

GEOL: Radioactivity in iron-quartz veinlets showing some molybdenite and scheelite.

REF: PRR-AP-308 (#906)

TWO FOOLS AND STRONGHOLD

LOC: "Go E. from Blythe on U.S. 60-70 to a point 0.7 beyond Arizona Check Station; turn R. onto Cibola Rd. and proceed from there for 2.1 mi., turn L. and continue for 6.5 mi.; turn onto dim road and continue up canyon to end of road (1.2 mi.), follow burro trail for about 2.5 mi. up (NE) wash to pit."

QUAD: Dome Rock 15'; Salton Sea NTMS

DEVL: 15 ft. and 115 ft. adit

RAD: 100X

ANAL: 2.30% e U_3O_8; 2.39% U_3O_8

GEOL: Uranophane and secondary copper in vertical quartz vein, trending S85°E in shear zone cutting slightly metamorphosed sediments.

REF: PRR-AP-392 (#911)

UNNAMED A

LOC: Approx. SW¼ Sec. 32, T3N, R20W
Tule Springs - Dome Rock Mtns.

QUAD: Cunningham Mtn. 7½'; Salton Sea NTMS

DEVL: Adit and trench

ANAL: 0.4% U_3O_8

GEOL: Yellow uranium mineral(s) along E-W trending vertical shear zone, 2-3 ft. wide, in crystalline rocks.

REF: Arizona Bureau of Geology data

UNNAMED B

LOC: Sec. 25, T4N, R20W

QUAD: Middle Camp Mtn. 7½'; Salton Sea NTMS

DEVL: 250 ft. adit, 30 ft. inclined shaft

PROD: Gold

RAD: 10X

ANAL: 0.09% e U_3O_8; 0.034% U_3O_8 w/ThO_2

GEOL: Radioactivity associated with biotite in schist, intruded by diorite and quartz veins.

REF: PRR-AP-304

VENEGAS prospect

LOC: NE¼ Sec 26, T14S, R15W

Quad: Tule Mtns 15'. Ajo NTMS

DEVL: 4 open cuts along a shear zone trending E-W

RAD: 2X in schist host rock - no radioactivity in shear.

GEOL: Radioactivity in schistose host rock very near a several foot wide shear zone mineralized with pyrite, gypsum, calcite, and brochantite. Shear is exposed along upper NE slope of NW-SE-trending ridge.

REF: Raup and Haines, USAEC TEM-679, p.13.

WILHITE AND HARRELL GROUP (Bonnie, Marvin, Jap, William, HWWR; B#1-3)

LOC: Approx. Sec. 2, 12, T8S, R19W
Muggins Mtns.

QUAD: Red Bluff Mtn. 15'; Welton 7½; El Centro NTMS

DEVL: Prospect pits

RAD: 7X

ANAL: 0.05-0.24% e U_3O_8

GEOL: Uranophane in shaly mudstone interbedded with sandstones and white ash of Miocene lake beds. Opalitic and chalcodonic material noted in sediments folded and broken by numerous faults trending N35° W.

REF: PRR-AP-390
PRR-AP-391 (#910)

WILLIAM (Wilhite and Harrell Group)

WOOLEY GROUP

LOC: Approx. Sec. 31, T7S, R18W and Sec. 6, T8S, R18W
Mugging Mtns.

QUAD: Red Bluff Mtn. 15'; El Centro NTMS

DEVL: 50 ft. drift and shallow scrapings

RAD: 100X

ANAL: 0.46% U_3O_8

GEOL: Uranophane and autunite along quartz stringers with basalt sill and disseminated in adjacent Miocene lake bad sediments.

REF: PRR-AP-300 (#902)
Reyner, N. & Ashwill, W. (1955)

APPENDIX A

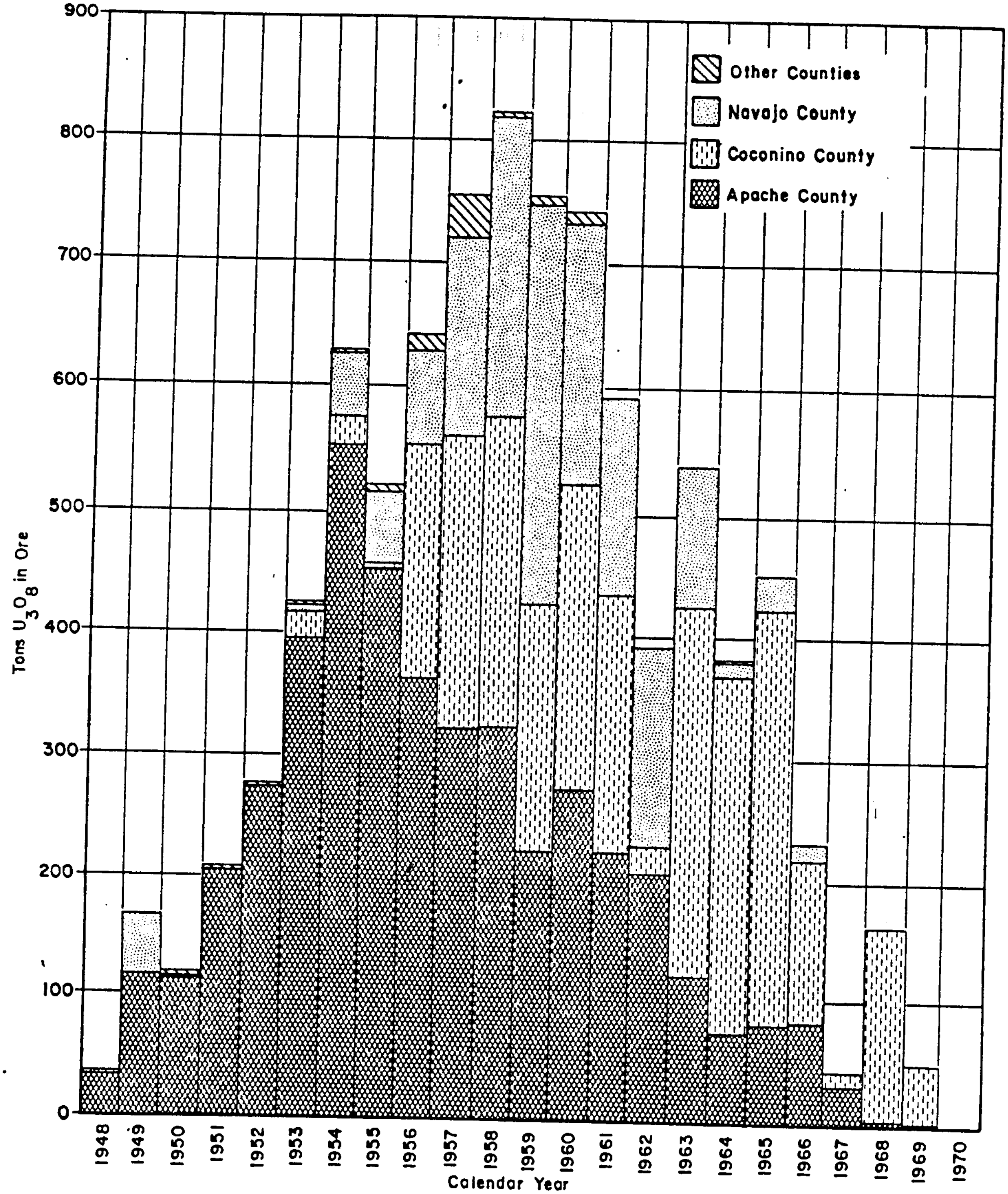
Production Tables and Histograms

ARIZONA URANIUM PRODUCTION, 1948–1970

	Tons of Ore	Pounds of U_3O_8	Average U_3O_8 Grade	Pounds of V_2O_5	Average V_2O_5 Grade	Years of Production
Black Mountain District	16,900	57,600	0.17%	26,000	0.08%	1951–1967
Plateau breccia pipes	511,000	4,374,600	0.43%	—	—	1950–1972
Cameron area[1]	295,100	1,240,000	0.21%	211,900	0.036%	1954–1963 1977–present[2]
Carrizo Mountains	90,300	364,900	0.20%	3,166,200	1.75%	1948–1966
Lukachukai Mountains	724,800	3,483,300	0.24%	14,730,000	1.02%	1950–1968
Monument Valley	1,322,000	8,670,000	0.33%	24,361,400	0.92%	1948–1969
Sierra Ancha District	25,500	115,200	0.23%	—	—	1953–1960 1977–present[3]
Southern Arizona; all sources in Cochise, Graham, Pima, Santa Cruz, Yavapai and Yuma Counties (11 producers)	11,600	36,700	—	10,300	—	1954–1959 1977–present[4]
TOTALS	2,997,200	18,342,300	0.31%	42,505,800	—	

[1] Includes Marble Canyon-Vermillion Cliffs area and one producer in the Kaibab Ls.
[2] One known producer in Holbrook area
[3] Two known producers; one in Pinal Mts., one in Sierra Ancha
[4] One known producer in Rincon Mts. area

Table 2



ARIZONA URANIUM PRODUCTION, 1948-1970

Table 3

TABLE 4
ARIZONA URANIUM PRODUCTION
1948 - 1970

Tons U_3O_8

	Apache	Coconino	Navajo	Gila	Other Counties*
1948	34.33	-	0.55	--	--
1949	116.45	0.08	0.74	--	--
1950	115.43	0.01	0.52	--	1.00 (Mo, Y)
1951	206.15	0.17	0.01	--	0.17 (S)
1952	277.02	0.03	0.12	--	0.65 (Mo, S)
1953	397.11	20.86	3.12	1.80	0.2 (Mo)
1954	552.85	26.05	47.63	3.20	0.3 (Mo)
1955	456.54	3.53	58.27	6.15	0.2 (Ma, Mo, P,S,Y)
1956	367.97	191.00	74.60	12.82	0.4 (C, Mo, P,S,Y)
1957	321.30	240.25	158.77	24.68	9.6 (Ma, P,S,Y)
1958	323.12	255.12	242.20	--	1.95 (C, Y)
1959	223.49	203.11	323.04	0.02	7.60 (C, Y)
1960	271.10	261.30	202.76	7.48	0.0X (C)
1961	224.04	211.46	159.66	--	--
1962	203.77	23.57	163.33	--	--
1963	119.93	307.42	111.64	--	--
1964	71.86	296.02	11.58	--	0.26 (Mo)
1965	82.29	340.37	27.71	--	--
1966	83.30	134.34	14.08	--	--
1967	30.68	12.78	--	--	--
1968	1.95	160.58	--	--	--
1969	0.24	49.51	--	--	--
1970	--	--	--	--	--

* C - Cochise, G - Gila, Ma - Maricopa, Mo - Mohave, P - Pima, S - Santa Cruz, Y - Yavapai
Small "no pay" shipments from Graham and Yuma counties not included.

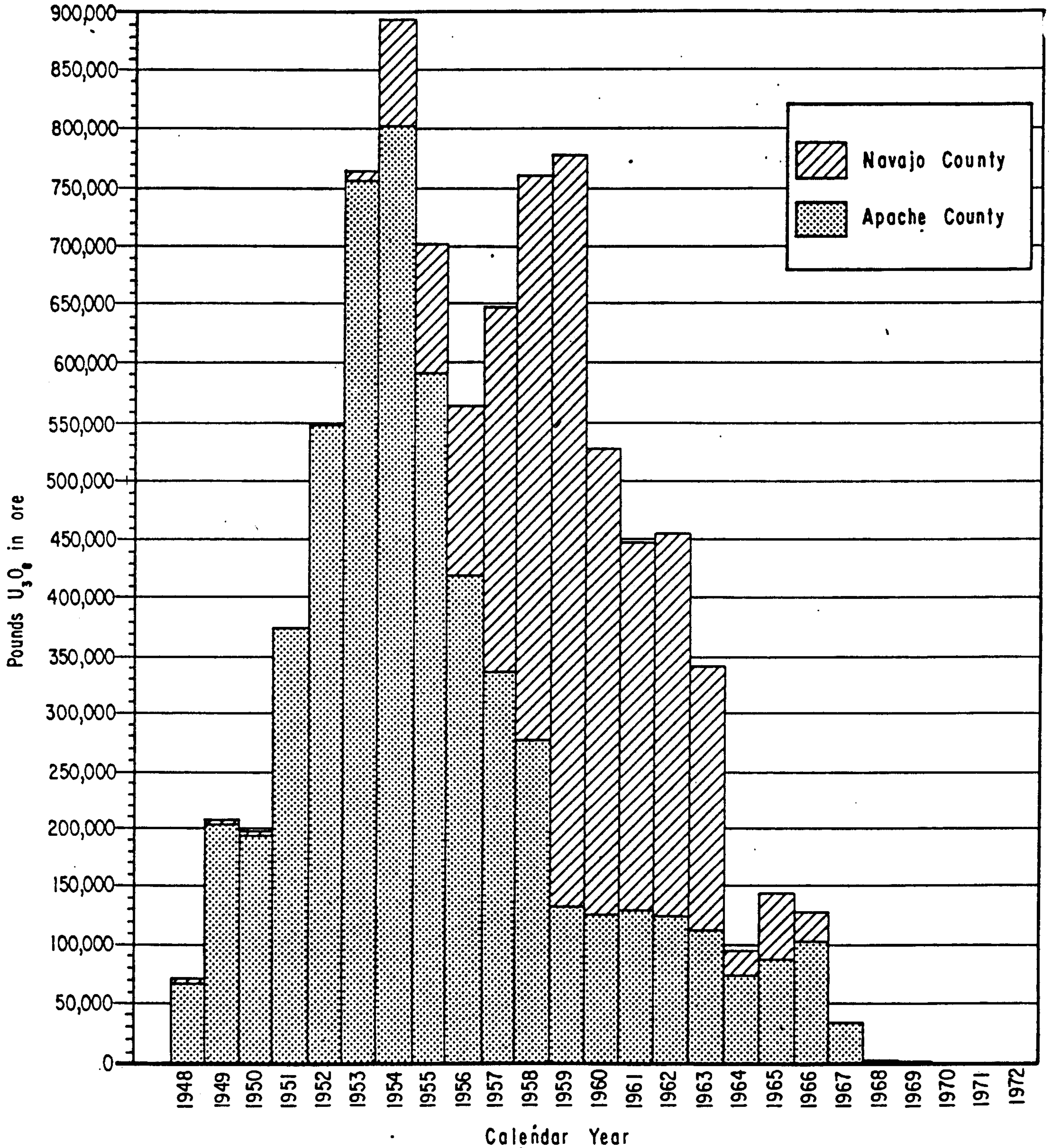
Compiled by Elizabeth A. Learned, February, 1980
U.S. Department of Energy
Grand Junction Office

TABLE 5 Summary Information of Number of Occurrences, Number of Producers, and Uranium-Vanadium Production Listed by County.

County	Total Number of Occurrences and Mines	Total Number of Producers *	Total Pounds of U_3O_8 *	Associated Pounds of V_2O_5 **
Apache	201	147	9,522,637	40,688,132
Cochise	32	2	220	93
Coconino	163	105	5,638,208	211,893
Gila	153	18	122,213	6,493
Graham	27	1	30	11
Greenlee	1	0	0	0
Maricopa	33	3	162	6
Mohave	87	8	15,204	12,091
Navajo	82	34	2,764,080	2,074,161
Pima	46	4	239	49
Pinal	23	0	0	0
Santa Cruz	26	3	2,964	2
Yavapai	55	2	33,253	10,112
Yuma	36	1	3	0
TOTAL	965	328	18,099,213	43,003,043

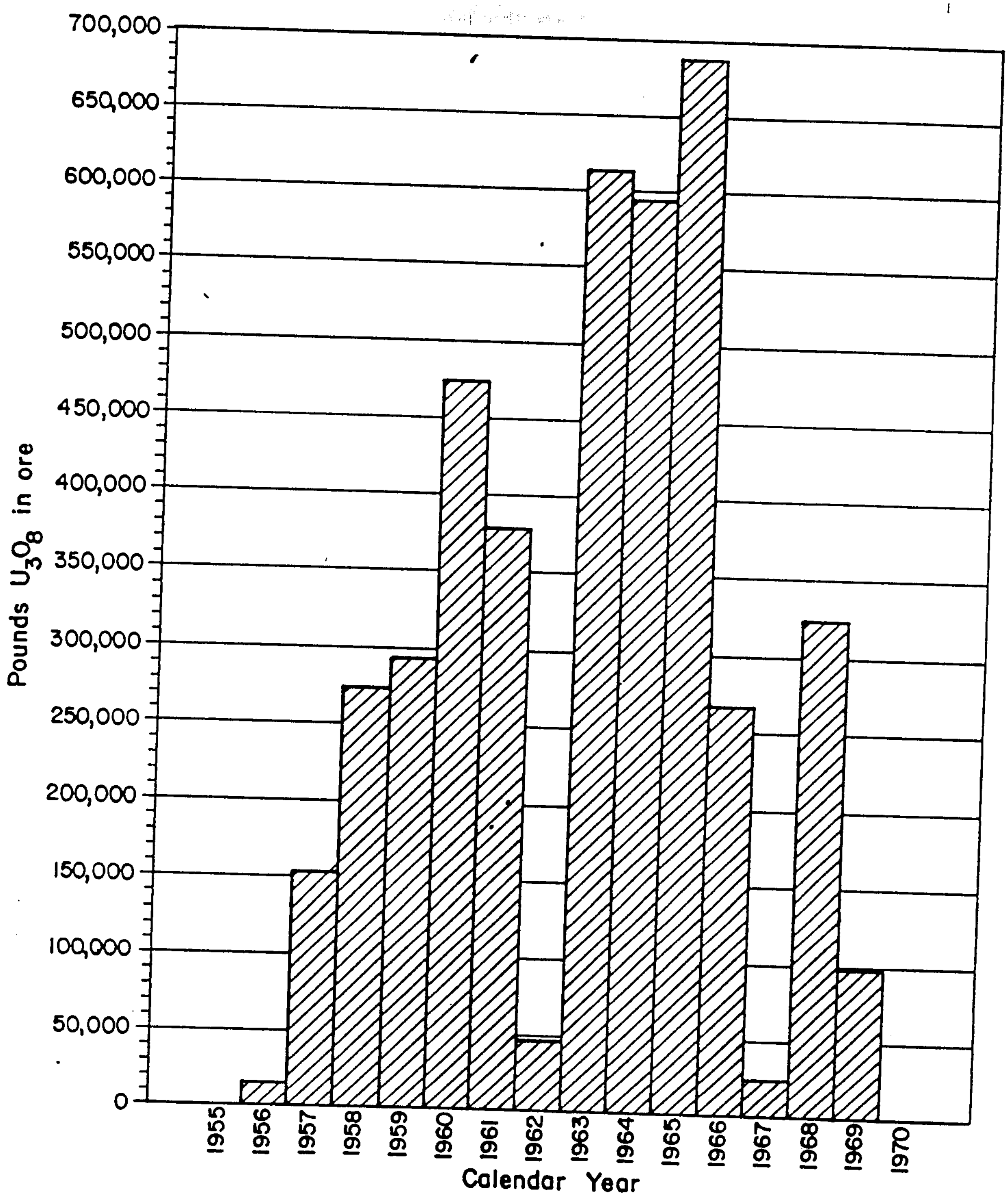
Arizona Total
(to January 1, 1970)

* Includes small amounts of no-pay (low grade) ores from certin localities.
** Only Apache County is probably complete. Not all Cameron, Anderson Mine, etc., ores were assayed for V_2O_5



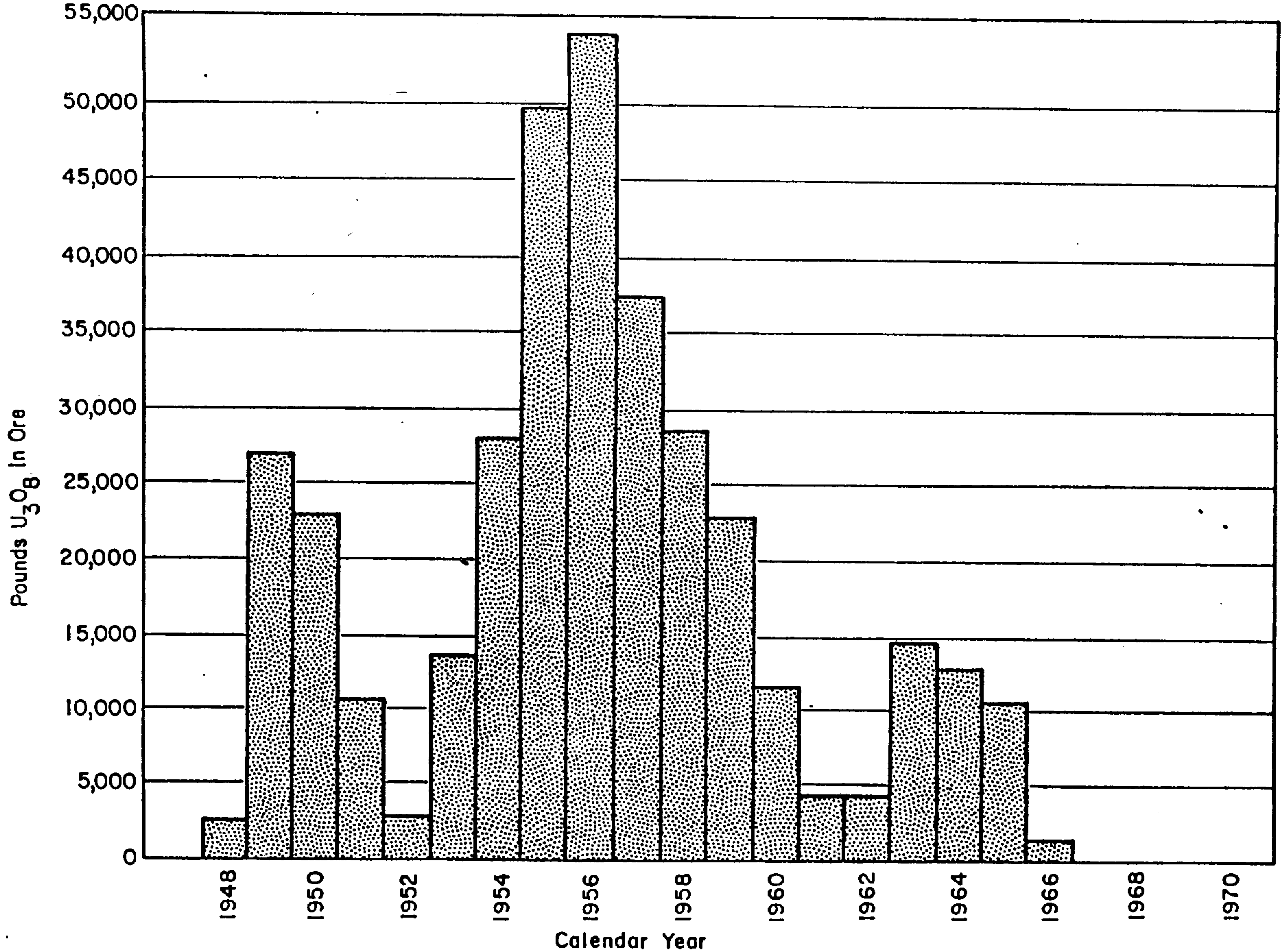
Uranium production Monument Valley, Apache and Navajo Counties, Arizona.

Table 6



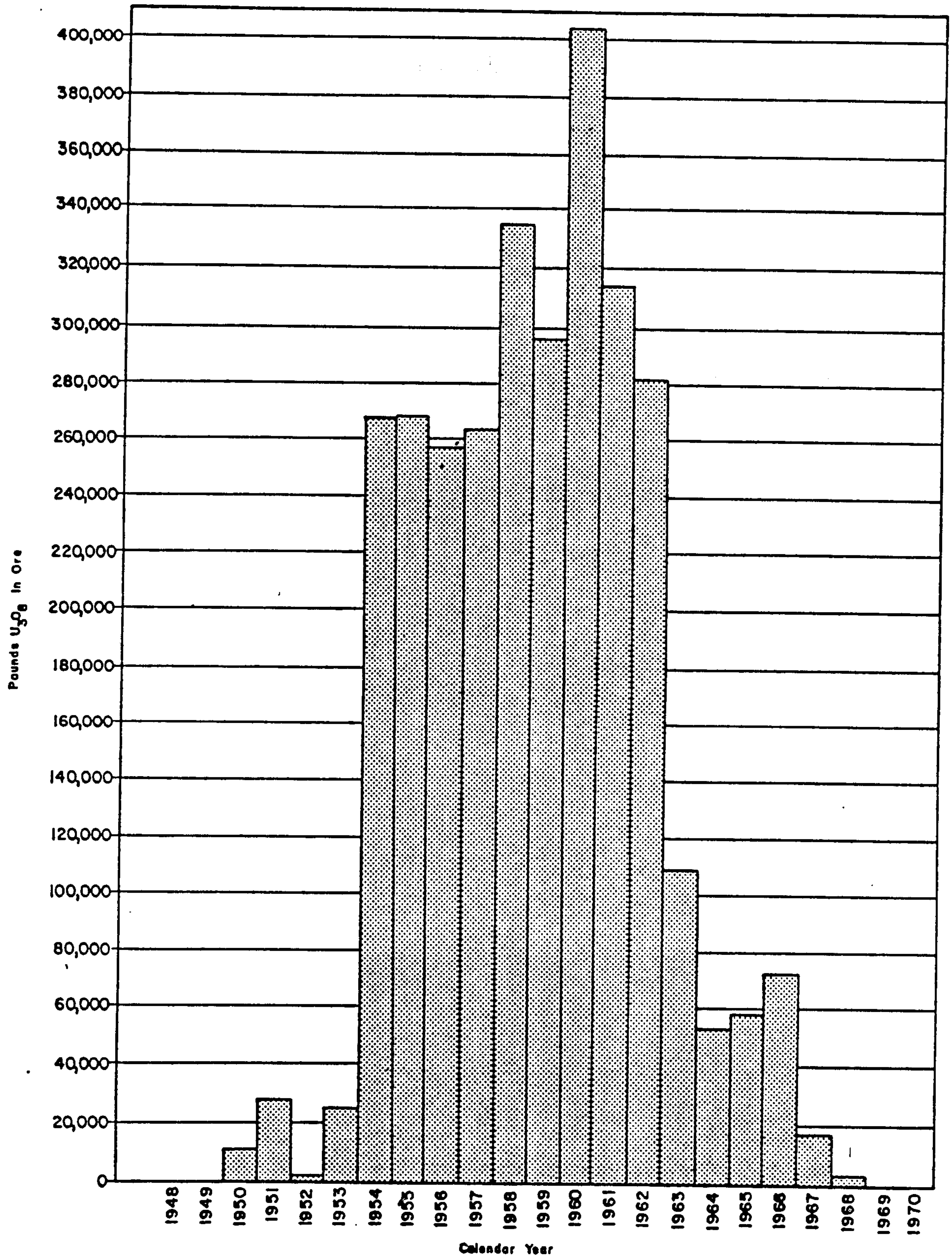
Uranium Production Orphan Lode Mine, Coconino County, Arizona

Table 7



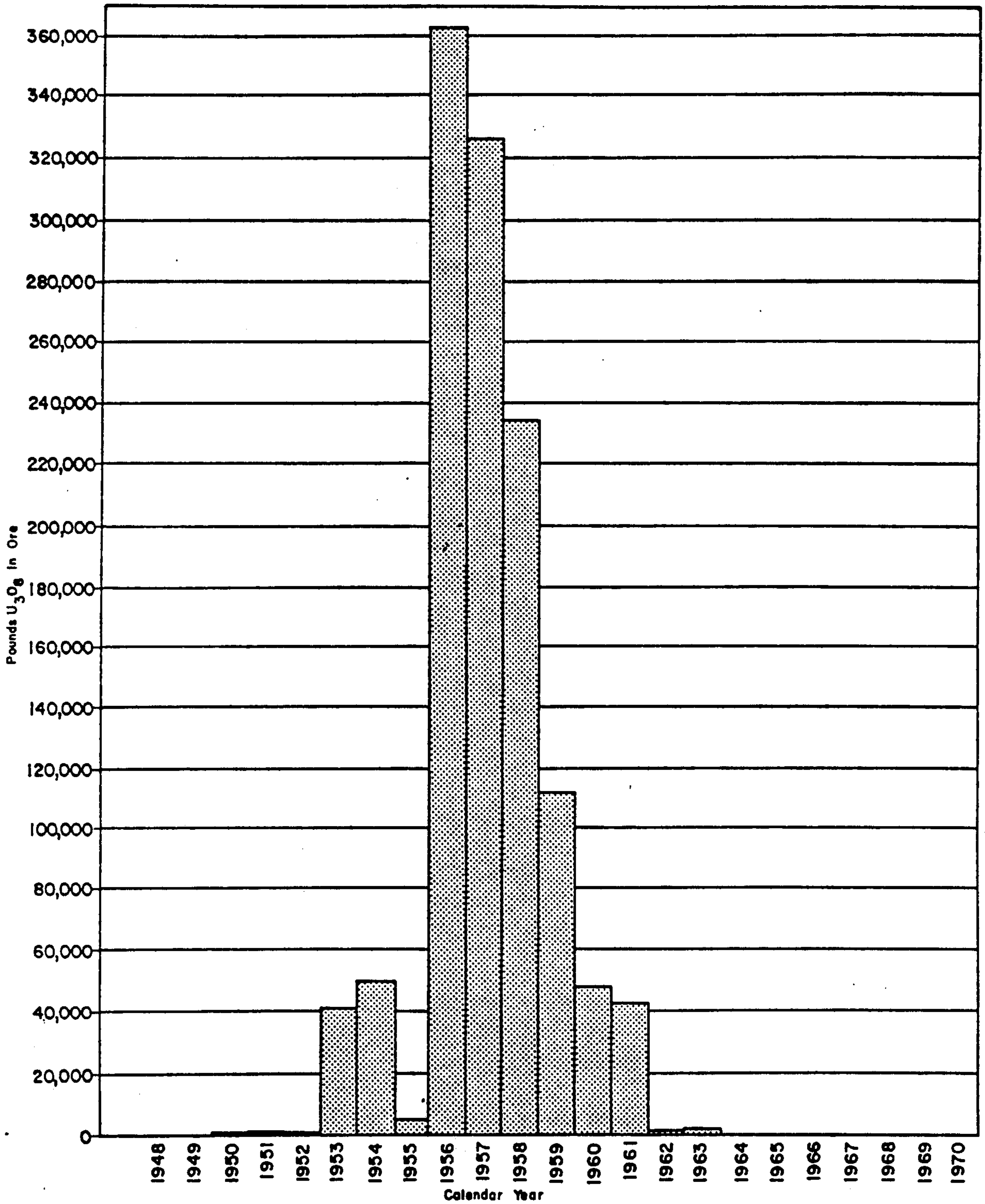
Uranium production Carrizo Mountains, Apache County, Arizona.

Table 8



Uranium production Lukachukai Mountains, Apache County, Arizona.

Table 9



Uranium production Cameron area, Coconino County, Arizona.

Table 10

ARIZONA URANIUM EXPLORATION TRENDS

Year	Year End Acres Held for Exploration and Development x 1,000	Surface Drilling	
		Number of Holes	Footage
1980*	—	601	260,508
1979	1,662	663	378,380
1978	1,282	1,372	688,291
1977	1,212	1,035	500,382
1976	1,021	1,465	544,740
1975	942	1,165	176,162
1974	819	127	52,013
1973	754	50	8,750
1972	486	37	6,000
1971	231	24	2,200
1970	221	14	3,510
1969	272	415	43,203
1968	—	881	114,705
1967	—	331	69,495
1966	—	24	5,330
1965	2	73	9,508
1964	—	102	16,913

*Statewide total of 23 drilling projects, with 5 projects in each of Gila, Mohave, and Yavapai counties, the remaining projects in Cochise, Coconino, and Navajo counties. One project in undisclosed county.

Compiled from DOE statistics by W. Chenoweth

Table II

APPENDIX B
SYNOPSIS OF HISTORY AND MINING DEVELOPMENT

Arizona Early History and AEC Involvement

1. In 1900, first recorded efforts in Colorado to extract uranium and vanadium from carnotite ores by Cashin Copper Company. Early success made the French owners form the American Rare Metals Mining and Manufacturing Company, which, in 1901, built the first mill for uranium-vanadium extraction from Colorado Plateau ores located at Stevens Camp, Summit Creek, Slick Rock mining district. Use of vanadium in hard steel alloys was becoming important, and its use in WWI war effort spurred the industry on.

2. During 1900-124 a booming industry in Colorado extracted radium from carnotite and pitchblende ores for medical use, based on pioneering work of the Curies in Paris. Between 1913 and 1919 about 39 grams of radium, valued at between 60,000 and 100,000 dollars per gram, were produced from Colorado Plateau ores. Best ores went to the Coke Ovens mill at the head of Paradox Valley, owned by Standard Chemical Company of Pittsburgh, Pennsylvania. This mill operated between 1910 and 1924. This industry sparked early exploration interest in NE Arizona. America's radium extraction industry died in 1924 upon discovery of rich Belgian Congo pitchblende ores. See Carrizo Mountains, note 2.

3. Organization in 1919 of Vanadium Corporation of America, which succeeded General Vanadium Company. They took over roscoelite properties in Placerville district, owned by Primos Chemical Company. VCA became important in the vanadium industry which was rapidly growing.

4. Earliest reports on uranium occurrences in Arizona are by Gregory (1917) and Butler and Allen (1921) for Monument Valley, and by Butler and Allen (1921) for the Tombstone area and the Santa Rita Mountains. An unpublished report by Staver (1921) discussed vanadium-uranium ores in the Salt Wash sediments of the eastern Carrizo Mountains of Arizona and New Mexico. F. L. Hess discussed Carrizo Mountains vanadium occurrences in 1933 AIME Lindgren volume.

5. Early mining for vanadium during 1942-1944 in Monument Valley and Carrizo Mountains by VCA, spurred by promotional activity in the federal government's Metal Reserves Company regarding vanadium procurement.

6. AEC (Atomic Energy Commission) was created in 1947. That year, first contracts signed with VCA for mining. Begin mining for uranium in Monument Valley and Carrizo Mountains in 1948.

7. In 1948-1949 AEC announced ore-buying schedules and other incentives which stimulated prospecting interest throughout the States (Circulars 1-5). These circulars announced, among other things, prices paid for certain types of high-grade ores and carnotite-roscoelite ores, and bonus payments for ores assaying better than certain cut-off grades, for ores purchased before March 31, 1962.

8. To encourage development of new domestic uranium supplies, AEC announced Circular 6, issued effective March 1, 1951. Circular 6 offered a bonus payment on the first 10,000 lbs of U_3O_8 supplied by any property or mine in addition to the Circular 1-5 price schedules, for those mines which had not produced any uranium prior to that time. For ores that continually maintained more than 0.20% U_3O_8, an operation could receive up to $35,000 in Circular 6 bonus payments. The original Circular 6 program ran until March 31, 1960.

9. Nationwide, the search for uranium proved so successful that in 1961 the AEC announced that purchases of uranium ore after April 1, 1962, would be limited to annual quotas allocated to individual properties. Also from that date until the end of 1966, instead of buying ore at the graduated prices previously in effect, the Commission would pay $8.00 per pound for U_3O_8 in concentrates produced mostly from reserves discovered before November 24, 1958. As a result of this change, the production of uranium in the United States declined in 1961 for the first time since 1948. In 1962, the AEC proposed to continue the purchase of uranium until 1971 from those suppliers who would agree to defer delivery of a part of their pre-1966 quotas until 1967 and 1968, with the price paid in 1969 and 1970 not to exceed $6.70 per pound of U_3O_8. This was the so-called "stretch-out" program. Since January 1, 1971, when the AEC ceased its procurement program, the only market for uranium has been the nuclear electrical power industry.

10. The Tuba City mill did not "stretch-out," and their contract with AEC expired December 31, 1966.

11. Other mills receiving Arizona production which didn't "stretch-out" were the Climax Uranium Corporation mill at Grand Junction and the Cotter Corporation mill at Canon City, Colorado. The Atlas Minerals mill at Mexican Hat closed in 1965, but their contracts were consolidated with the Moab mill contract, which "stretched-out".

12. AEC buying station and mill at Monticello, Utah, closed December 31, 1959. VCA mill at Shiprock closed 1968 due to lack of ore. Rare Metals mill at Tuba City closed September, 1966, due to closing of Orphan Lode in August, 1966.

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Carrizo Mountains

1. Uranium-bearing outcrops discovered in 1918 by John Wade of Farmington, New Mexico, who operated the Sweetwater Trading Post. He and local Navajos located numerous ore-bearing outcrops in eastern Carrizos, with best ones near MP-16.

2. Wade, operating as the Carriso Uranium Company, acquired 41 claims around MP-16 in 1920, and hired Navajos to mine high-grade ore for radium content (probably in part at Syracuse (RF&R) Mine). Thirty-seven gunny sacks were shipped to Beclabito T. P. in 1921 (?) and eventually to Colorado where several companies were buying radium ores. A probable buying point was Standard Chemical Company's Coke Ovens station near Naturita. The market for vanadium that Wade was anticipating never materialized and operations ceased. Area remained inactive until the 1940's.

3. In late 1941, VCA (Vanadium Corporation of America) entered into a lease arrangement with the Navajo Tribe for the 17 plots in the Western Carrizos which they mined during 1942-44 ("West Reservation Lease"). VCA ore was trucked to Monticello. In July 1942 they leased 12 plots in the Eastern Carrizos of Arizona and New Mexico ("East Reservation Lease").

4. In 1942 the federal government formed the Metal Reserves Company to expedite domestic vanadium production for the war effort. This program stimulated interest in the Carrizos and elsewhere. Mills were constructed at Monticello, Utah, and Durango, Colorado, and operated by VCA and USV, respectively.

5. Early in 1942, Curran Brothers and Wade (CB&W) of Farmington, New Mexico, obtained a prospecting lease from the U.S. Indian Service, Navajo agency and selected two plots, Syracuse and Valley View, for mining. Several Curran brothers had previous experience in Utah-Colorado prospecting for uranium.

6. During 1942-1944, Wade, Curran and Company developed the Martin, Saytah, Saytah Canyon, Main Claim, Eurida, and Syracuse (RF&R) Mines. Ore mined by Wade, Curran and Company was shipped by truck and rail to Metal Reserve's mill at Durango. VCA shipped ore from west reservation plots 1 and 6-13 during 1943-44 to its mill at Monticello, Utah.

7. Total 1942-44 production from the Carrizos (Martin, North Martin, Saytah, Main Claim (MC), Saytah Canyon, Eurida and Rattlesnake Mines plus mines near milepost 16 along Arizona-New Mexico border) total 8,400 tons @ 2.18% V_2O_5 and about 0.17% U_3O_8. Much of the uranium left behind in the mill tailings at Durango, Colorado and Monticello, Utah, were reprocessed at Durango for uranium in the late forties as part of the Manhattan Project. The Metal Reserve's program terminated March, 1944, resulting in shutting down of Carrizo vanadium mines.

8. Union Mines Development Corporation (UMDC) was organized in 1943 by the Army Corps of Engineers under the Manhattan Project to evaluate uranium resources of the Salt Wash Member of the Morrison Formation (and the Entrada Formation in Colorado) on the Colorado Plateau. UMDC's chief field geologist, based at their Grand Junction field office, was Benjamin N. Webber. Party chiefs in Arizona included John Harshbarger (for Eurida and Segi Ho Cho areas) and A. H. Coleman (for east Carrizo area). Elements of UMDC involvement and works are found in RMO-444 by E. H. Eakland, Jr. (1st Eurida Party chief), and RMC-437 (final report of UMDC), and RMO-1000 (summary of Colorado Plateau work). UMDC was active through 1946. UMDC geologists recommended the acquisition of 960 acres in the western and

Carrizo Mountains (continued)

northwest Carrizos by federal government leases that they thought had the best uranium potential. Although UMDC knew about Monument Valley occurrences, they did no work in that region.

9. In 1947 the AEC was created and began a procurement program on the Colorado Plateau. First procurement contracts with VCA signed May 1947.

10. Mining for uranium for the AEC was resumed by VCA in late 1948. Ore was hauled first to Naturita, Colorado, and later to Durango, Colorado. Early independent miners shipped ore to Durango.

11. In February, 1949, a contract between AEC and VCA allowing purchases of concentrates from VCA's Durango mill increased VCA Carrizo production.

12. In January, 1952, AEC opened a buying station at Shiprock, New Mexico, further boosting production from Carrizos.

13. New AEC and company drilling started in 1953, resulting in renewed mining along Saytah Wash and Cove Mesa. Most productive years were 1955-1959 for the Carrizos. Late 1954, Kerr-McGee Shiprock mill opened, which received ore from independent mines. AEC Shiprock buying station closed.

14. 1963-1966 production came from Kerr McGee's Block K Mine (discovered by a single AEC drill hole), Cove Mesa plot 7, Cato Sells' Cove Mesa Mines, VCA's Plot 6 and adjacent Hoskie Henry properties.

15. Last shipments made in 1966 as known ore bodies were depleted.

16. Total Carrizo Mountains production, including New Mexico's majority of eastern Carrizo area, is 119,558 tons containing 524,827 lbs U_3O_8 and 4,650,980 lbs of V_2O_5. Arizona's portion of this is 90,300 tons containing 364,900 lbs U_3O_8 and 3,166,200 lbs V_2O_5.

Lukachukai Mountains

1. Only the northwest tip of the mountains were examined in 1943-1946 by UMDC (Union Mines Development Corporation) personnel. Due to lack of occurrences on Mexican Cry Mesa, and the false belief that the pre-Chuska unconformity cut out all Salt Wash outcrops to the southeast, the UMDC declared the Lukachukais to be an unpromising area for further searching. (UMDC had been organized for under the directorship of the Army Corps of Engineers, and given the task of accessing the nation's uranium potential).

2. Dan Hayes, raised near Hite, Utah, prospected for copper near his home on claims originally worked by his father. In 1948 he sold the claims, located in eastern Utah's White Canyon area, to Cooper-Bronson Mining Company which developed them into the rich Happy Jack Mine, a copper-uranium association in Moenkopi Formation. Hayes also held valuable claims in Lisbon Valley next to the fabulous find in 1952 by Charlie Steen of his Mi Vida Mine.

Lukachukai Mountains (continued)

3. Dan Phillips, Koley Black (local Navajos) and Dan Hayes prospected in 1949 in the Lukachukais south of Cove School and staked claims which bore the names of the two Navajos. Willie Cisco, another Navajo prospector, showed ore samples from the southside Lukachukai mesas to geologists of the Walter Duncan Mining Company of Cortez, Colorado. F. A. Sitton of Dove Creek, Colorado, followed advice of Hayes, and negotiated with the B.I.A. and Navajo Tribe to obtain first Lukachukai mining permits. He organized F. A. Sitton, Inc. and built first roads up Mesa I in 1950 and initiated shipments of ore out of Lukachukais in that year. He shipped from Mesas I, II and IV.

4. Climax Uranium Company began prospecting about this same time and acquired mining permits on Mesa IV½ from Frank Nacheenbetah in 1950.

5. In August, 1951 the Navajo Uranium Company of Cortez, Colorado, (under R. O. Dulaney, Jr., Edward Key, Jr., and "Buffalo" Kennedy) acquired Sitton's interest and continued mining on Mesa II, etc.

6. AEC began drill projects in 1950 and built more access roads. By spring 1951, drill programs were in progress on Mesas I, II, III and IV. AEC drill programs ran until August, 1955.

7. Transfer of Navajo Uranium Company's interests to Kerr-McGee Oil Industries, Inc., approved by the B.I.A. January 26, 1953 (transfer of operations underway in fall, 1952). Kerr-McGee was the first major oil company to engage in full-scale uranium exploration. Kennedy was retained as manager of Kerr-McGee's Navajo Uranium Exploration Division.

8. AEC buying station opened in Shiprock, New Mexico in January 1952. Kerr-McGee built a mill there which began operating in October, 1954.

9. VCA acquired Kerr-McGee's Shiprock mill and Lukachukai leases in March, 1963 with B.I.A. approval on July 29, 1963. The mill finally closed in 1968 due to lack of ore.

10. Climax Uranium Corporation properties (Frank #1, Frank Jr.) shipped their ore to the Climax mill at Grand Junction, Colorado. Since Climax didn't participate in the AEC's stretch-out program (see note later), their production in 1966-67 went for non-AEC sales to electric utility companies.

11. Final shipments from the Lukachukais in May, 1968.

12. Foote Minerals of Naturita, Colorado, purchased VCA interests around 1970.

References

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Dare (1961), (USBM IC-8011)
Chenoweth (pers.comm., 1981)

Monument Valley

1. Carnotite noted by Gregory in 1917 (USGS Prof. Paper 93).
2. VCA leased ore-bearing outcrops in August, 1942 (properties became Monument #'s 1 and 2).
3. 1942-44 vanadium ores were shipped to Monticello, Utah (a few thousand tons came from Monument 1 - no Monument 2 production during 1942-44 can be confirmed).
4. Mining resumed at Monument 1 and 2 in 1948 by VCA under AEC program. Ore shipped to VCA mill at Naturita, Colorado, later Durango.
5. Early non-VCA ore shipped to AEC mill at Monticello (1948 - early 1950's).
6. Drilling in 1955-56 located large deposits in the Ojetah syncline (Moonlight, Starlight, etc.).
7. From 1955-1968, VCA operated a concentrator plant located one mile east of Monument 2 Mine, built because of high transportation costs of low-grade ores to their Durango or Shiprock mills. From summer 1955 to July 1964 a mechanical separator concentrated high grade slimes from low grade sand residues. From 1964 to 1968 a heap leach facility produced yellowcake from low grade new ore and sand residue. Monument 2 ores were further processed at VCA facilities at Naturita in 1948-1958, Durango in 1949-1963, and Shiprock in 1963-1968.
8. During 1957-1963, a mill at Mexican Hat, Utah was operated by TZ minerals (Texas-Zinc) for Texaco and New Jersey Zinc, and by Atlas Minerals in 1963-65. This mill recovered copper from Monument Valley ores. Nearly all of the Monument Valley VCA ores were processed here. Some small operators, distrustful of TZ, shipped their ores to Tuba City, Arizona.
9. Last Monument Valley ore was from Monument #2 in 1969, just after the VCA mill at Shiprock closed. This shipment went to Atlas Minerals Moab mill.

References

Chenoweth and Malan (1973)
Ford, Bacon, Davis (1977, p.2-2)

Cameron Area

1. Hosteen Nez, an independent Navajo prospector, found uranium ore in the Kayenta Formation east of Cameron in 1950 and had Mr. L. Hubbell, the trader at Winslow, confirm the identification with AEC personnel. Early shipments were made to Durango for low lime ore, and to Monticello for high lime ore.

Cameron Area (continued)

2. AEC-BIA negotiations in 1949-50 at Window Rock allowed for the hiring of local Navajo uranium prospectors by Walker-Lybarger Construction Company (AEC prime contractor). Charlie Huskon, a Cameron resident, became such a prospector and located a number of Chinle Formation occurrences in 1951. Mining permits given to him by the Navajo Tribe were used for mining the Huskon orebodies by the Arrowhead Mining Company of Grand Junction, Colorado. The Navajo prospector program was more successful at Cameron than at any other region on the Reservation.

3. Early shipments of ore went to Monticello, Utah.

4. Arrowhead Uranium Company began shipments in 1953 to Bluewater, New Mexico from Huskon 1-8, 10.

5. Production down in 1955, waiting for local market for the ore.

6. AEC opened buying station on January 12, 1956 at Tuba City. Rare Metals Corporation of America bought out Arrowhead interests (including most of the Charles Huskon properties) in February, 1955 and opened their mill at Tuba City in July, 1956. First concentrate purchased by AEC from the mill July, 1956.

7. a. The Tuba City mill was constructed to receive Cameron area ores. Its lifetime was extended as a result of agreements to process Orphan Lode ores. In early operations, about 300 tons of ore per day were processed using an acid leach, sand-slime separation and resin-in-pulp ion exchange process. High lime ores from the Orphan required the installation of a carbonate leach circuit which was operational during 1963-1965.

   b. During its lifetime, the mill received additional ores from the following areas: Independent Monument Valley producers on Mitchell Mesa and Hoskinnini Mesa, most Black Mountain ores, the last ores from the Anderson Mine and the Sierra Anchas, the Star Claims of Cochise County, and the sole shipment from the Morale Claim of the Hopi Buttes.

   c. Robert S. Shriver, operator of the Rebel Mine, Deer Flats area of White Canyon, Utah, shipped to Tuba City for six months or so. These may represent the only ores processed here which originated from outside Arizona. He also operated the Mitchell Mesa property of Navajo County, where he suffered fatal injuries while hauling ore alone at the mine in 1962.

   d. When the AEC closed the Cutter (Globe) buying station in June, 1957, stockpiles of ores from the Anderson Mine were bought by the Kerr-McGee mill at Grants, while stockpiles of Dripping Spring (Sierra Ancha) ores and miscellaneous ores were bought by Rare Metals' Tuba City mill.

   e. Mill ownership merged into El Paso Natural Gas Company in July, 1962.

Cameron Area (continued)

7. f. With the alkaline leach circuit starting in April, 1963, due to high-lime ore from the Orphan Lode, the plant treated 200 tons per day until it closed in September, 1966.

   g. During its lifetime, the Tuba City mill processed 800,000 tons of ore with average grade of 0.33% U_3O_8 and produced 2,348 tons of U_3O_8 in concentrate form.

8. Peak production in 1956 from Cameron area mines.

9. Most significant Cameron area mines were Jack Daniels (39,800 tons during 1956-1963); Charles Huskon #4 - Paul Huskie #3 (37,800 tons during 1953-1960); Charles Huskon #3 (27,300 tons during 1953-1961); Charles Huskon #1 (23,100 tons during 1951-1961); and Ramco #20 (22,600 tons during 1956-1960). Rare Metals' Ramco pits collectively produced about 47,600 tons of ore between 1956 and 1960. Rare Metals also acquired Charles Huskon Mines #1, 3, 5-8, 10-12, 14, 17 and 26 from Arrowhead in 1955. Charles Huskon Mines #4, 9, 18, 19 and 20 were operated by UTCO Uranium Corporation during 1956-1959.

10. Late production (1961-63) is recorded from Charles Huskon #1, 3, 6, 10, 11, 12 and 17; Evans Huskon #2; Jack Daniels; Julius Chee #3; Yazzie #2, 101 and 312; and Section 9.

11. Cameron discoveries in the early 1950's led to considerable prospecting around the Black Mesa basin, but no similar deposits were found outside of some already known ones around Holbrook.

References

Ellsworth (AEC TM-7, 1952)
Akers, et al (1962, GQ-162)
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Orphan Lode

1. Original Orphan Lode claim staked by Daniel L. Hogan and Henry Ward in 1893.

2. Continued copper prospecting through early 1920's. Hogan patented the claim in 1906, three years before the establishment of Grand Canyon National Park. Patent papers signed by President Theodore Roosevelt. Hogan had been one of Roosevelt's "Rough Riders" in Cuba.

3. Claim sold to Madeline Jacobs in August, 1946.

Orphan Lode (continued)

4. Radioactivity in ore samples from old workings noted by Harry Granger, USGS, in 1951. (Tested samples were in a garage in Prescott).

5. Golden Crown Mining Company acquired mineral rights in 1953. Five short jack hammer holes drilled in old Hogan adit in 1955-56.

6. Based on drilling results an early tramway was constructed in March, 1956, but proved ineffective. A second tramway was built in May, 1956.

7. First ore shipped April, 1956. Early production was about 1,000 tons per month @ 1.0% U_3O_8.

8. Drilling in 1958-59 located "B" ore zone and the annular ring ore zone.

9. A 1,600 ft shaft and 1,400 ft cross cut to the 400 ft mine level were completed in 1959. In August, 1959 initial ore removal through the shaft. Production increased to 7,000 tons per month at a lower grade of 0.40 - 0.45% U_3O_8.

10. Ore bin on headframe collapsed into shaft in December, 1961; mine shut down and Tuba City mill closed.

11. Bill to mine in Park Service land outside (north) of claim passed U.S. Congress May, 1962, in exchange for NPS ownership of the claim 25 years hence, in 1987. Tuba City mill converted to alkaline leach circuit in 1962 to handle high-lime Orphan ores, and began renewed activity in March, 1963.

12. Mining resumed at Orphan in November, 1962.

13. Tuba City mill (Rare Metals Corporation of America) contract with AEC expired at end of 1966. This plus financial troubles of Western Equities (owners since 1961) caused mine to close in August, 1966. The troubles included FTC suspension of Western Equities stock on the Exchange due to "stock manuvering" by Westex personnel.

14. Cotter Corporation of Canon City, Colorado acquired Orphan from bankruptcy court in 1967. Mine opened and shipments began to the company mill via railroad in 1967. Cotter's AEC contract had expired so they made sales to electric utilities.

15. Due to high costs, etc., Orphan closed in April, 1969.

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Magleby (AEC TM-134)
Brundy - Denver Post article
Chenoweth, pers. comm.

Other Parts of Colorado Plateau

1. Intensive prospecting throughout the Colorado Plateau located most surface occurrences by the early 1950's.
2. Uranium was discovered in the old copper mine in Hack Canyon. Initial shipments made in 1950 to AEC buying station at Marysvale, Utah.
3. Uraniferous petrified wood located in Marble Canyon area. Shipments in 1949-50 made to AEC buying station in Monticello, Utah.
4. Salt Wash deposits near Rough Rock (Black Mesa area) shipped by Tom Klee and Tom Wilson to Monticello, Utah and Durango, Colorado in 1951 and 1953.
5. USGS located several uraniferous diatremes in the Hopi Buttes in 1952. Production from Morale claim began in 1954.
6. Ruth and other deposits near Holbrook made initial shipments to Bluewater, New Mexico in 1953.
7. Toreva deposits near Tah Chee School (Black Mountain area) shown to AEC geologists in 1954. Production from the area sent to Bluewater, New Mexico starting that year.

Basin and Range Country

1. USGS reported pitchblende at the Happy Jack Mine, Wrightstown district, Santa Cruz County in 1917 (USGS Bulletin 624 by Schrader).
2. Carnotite reported near Tombstone by Butler and Allen (1921).
3. The AEC procurement program, started in 1947, initiated a massive prospecting effort throughout the Basin and Range country. By the early 1950's most of the surface occurrences had been located. Prospecting was initially confined to the ranges, with very little effort in the basin fill.
4. Early producers were:

   Hillside Mine, Yavapai County (1950),
   White Oak Mine, Santa Cruz County (1951-52) and
   Red Bluff Mine, Gila County (located 1950, produced in 1953)

   All ore was shipped to AEC buying station at Monticello, Utah where there were no restrictions on the type of ore accepted.
5. Development was hindered by lack of market (local buying station) although the AEC paid six cents per ton mile for the first 100 miles of shipping distance, to encourage mining as announced in Circular 5.

Basin and Range Country (continued)

6. Due to intense activity in the Sierra Ancha the AEC established an ore buying station at the Cutter siding just east of Globe, which opened July 5, 1955. Ores were received here from southern Arizona, southern New Mexico, and southern California. The buying station closed because of lack of ore on June 30, 1957.

7. After closure of the Cutter buying station, Sierra Ancha and Anderson Mine ores were shipped to the AEC buying station at Grants, New Mexico.

8. The Anderson Mine of Yavapai County shipped to:

   AEC Cutter during 1955-57,
   AEC Grants during 1957,
   and Rare Metals Mill at Tuba City in 1958-59.

   The Anderson Mine ore at Cutter was later purchased from AEC by Kerr-McGee at Grants; the other Cutter ores were purchased by Rare Metals' Tuba City mill.

9. Some of the last production under the AEC buying program in the Basin and Range Country came from the Hope and Little Joe Mines (Gila County) and the Star claims (Cochise County). This ore was shipped to Tuba City.

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CJBX recent reports for Arizona
(1) NURE Aerial Gamma-Ray and Magetic Reconnaissance Survey

Flagstaff	CJBX-157 (79)
Phoenix	
El Centro	CJBX-12 (80)
Lukeville	
Salton Sea.	
Ajo	
Marble Canyon	CJBX-16 (80)
Grand Canyon	CJBX-35 (80)
St. Johns	CJBX-126 (79)
Gallup	
Shiprock	CJBX-116 (79)
Mesa	
Tucson	
Clifton	CJBX-23 (79)
Silver City	
Nogales	
Douglas	
Kingman	
Prescott	
Williams	CJBX-59 (79)
Las Vegas	

(2) Hydrogeochemical and Stream Sediment Analyses (HSSR)

Salton Sea	NTMS	CJBX-113 (80)
Prescott	NTMS	CJBX-122 (79)
Williams	NTMS	CJBX-71 (79)
Las Vegas	NTMS	CJBX-123 (78)
Kingman	NTMS	CJBX-122 (78)

(3) Papago Indian Reservation, Water Sample Analysis

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ADEQ 2007

Arizona Department of Environmental Quality, Uranium Site Discovery Project, Phoenix, Arizona, September 12, 2007

Janet Napolitano
Governor

ARIZONA DEPARTMENT OF ENVIRONMENTAL QUALITY

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Stephen A. Owens
Director

September 12, 2007
SAU08.068

Ms. Nuria Muniz
Arizona Project Officer
U.S. Environmental Protection Agency, Region IX
75 Hawthorne Street, SFD-5 8th Floor
San Francisco, CA 94105-3901

Re: **Uranium Site Discovery Project**

Dear Nuria:

Enclosed please find the Uranium Site Discovery Project.

If you have any questions, please contact me at (602) 771-4195, or you may contact the Site Assessment Unit Manager Tim Erwin at (602) 771-4307.

Sincerely,

Mary Hessler
Site Assessment Unit

Enclosure (1)

cc: Site File
Reading File

File(M:\Wilbur Ellis Buckeye\Cover Letter)

URANIUM SITE DISCOVERY PROJECT

SUMMARY

The Uranium Site Discovery Project was conducted (1) to identify potential sources of uranium contamination that may merit further investigation under CERCLA, and (2) to gather readily available target information to assist the EPA in identifying sites for screening and/or inclusion on CERCLIS. This project was conducted due to uranium-related concerns expressed by the general public, media outlets, and an environmental advocacy group.

Uranium mines in Arizona were researched. There are numerous resources available for research, and not all references could be reviewed in the time available. The references are listed at the end of this summary. Most of the references were obtained from the Arizona Department of Mines and Minerals Web site (www.admmr.state.az.us).

Based on this research, 28 uranium mines were identified and are listed in Table 1. These mines have produced uranium ores. Additionally, there are 23 mines that have produced other metals, but the reported uranium content is comparable to the ores produced at the uranium mines. These mines are listed in Table 2. Also, Table 3 lists 83 other mines and prospects where uranium has been detected at levels comparable to the uranium mines. Apparently, no production has occurred at these mines, but piles of mining wastes may be present. Finally, one other location of interest was found: a tailings pile is located in Alamo Lake, a recreation area and fishery. In addition, 11 CERCLIS sites, listed in Appendix A, may have uranium issues. Finally, Appendix B lists federal facilities with uranium issues.

The tables do not list the following: (1) mines without uranium data, (2) Arizona Department of Mines and Mineral Resources files in uranium mining districts, (3) reported deposits of uranium ores, or (4) mines with uranium concentrations above the PRG but below the concentrations in uranium ores. Additional time would be necessary to tabulate this information. Finally, although this list includes Arizona tribal lands, it does not include mines located in the Navajo Nation. The Navajo Nation has already identified more than 1,000 mines and is addressing them under the Navajo Abandoned Mine Lands Reclamation Program.

A preliminary target search was conducted. Many of these mines are located in remote areas with no surface water, wells, or residents within one mile. Some are located in sparsely populated census blocks that cover several square miles, and the distance to the nearest residence is unknown.

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6. Rodinia Minerals, Inc., *Report on Workman Creek Uranium Project*, 08/01/2006.
(Obtained from rodiniaminerals.com/_resources/workman_43-101.pdf)

7. Arizona Department of Mines and Minerals (www.admmr.state.az.us)

8. www.cpluhna.nau.edu/Change/uranium.htm.

9. www.arizonadailysun.com/articles/2007/03/27/news/20070327_front%20page_3.txt.

10. www.wise-uranium.org/upusa.html.

Cadastral Location	Site Name	Site Description, Production, and Information Source	Owner	Uranium Content (Percent U3O8)	Located in a Wilderness Area? (1)	Wells within one mile (1)	Surface Water within 2 miles (1, 1A)	Residents within one mile (1)
Table 1: Uranium Mines in Arizona								
Apache County								
(A-13-29)30, south half	Warhoop # 1 - # 8	576 tons of 0.13% U3O8 mined from an open pit 1957-61. (2)	State	Not Reported	No	2 domestic	None	Town of St Johns one mile away
Cochise County								
(D-18-19)25 and 26	Star Group and Bluestone	Incline pit present, 46.7 tons of 0.19% U3O8 produced (2, 3A, 3B)	Coronado NF and Private	0.02 - 0.024	No	9 domestic	None	4
(D-18-19)10, east half	Windmill Group	Several trenches and drill holes, and a 107-foot incline with drifting, 15 tons of 0.13% U3O8 produced in 1956, uranium detected at 240-287 ppm in dump. There are several prospects in Cottonwood Canyon, but this is apparently the only one that produced uranium ore. (2, 3A, 3B)	Coronado NF and Private	0.036 - 0.083	No	One domestic	None	Unknown
Coconino County								
(A-28-01)35	Copper # 1	29 tons of 0.10% U3O8, 0.02% V2O5 ore produced in 1956 and illegally shipped off site under the name Doty Group (2)	State	0.42 - 0.48	No	None	None	None
(A-27-10)16	Grub # 14	150 feet of rim stripping, several small pits, and several small drilling programs, 13.1 tons of 0.16% U3O8 ore produced in 1956. (2)	State, bordering Navajo Nation	Not Reported	No	None	<¼ mile from Little Colorado River	Unknown
(A-27-10)7	Howard # 1	Surface pits, 25 tons of 0.26% U3O8, 0.10% V2O5 ore produced in 1956. (2)	Private	Not Reported	No	None	None	Unknown
(A-27-09)17	Luster	Open pit, 319 tons of 0.19% U3O8, 0.04% V2O5 ore produced in 1956. (2)	Private	Not Reported	No	None	None	Unknown
(A-27-10)22	Murphy	open pit, 1,769 tons of 0.21% U3O8, 0.04% V2O5 ore produced 1956-58 (2)	Private, bordering Navajo Nation	Not Reported	No	None	<¼ mile from Little Colorado River	Unknown
(A-27-10)18	Navajo # 26	Rim stripping and open pit, 581 tons of 0.17% U3O8 ore produced 1958-59 (2)	State	Not Reported	No	None	None	Unknown
(A-27-10)4	New Liba (aka Liba Group, aka Pretty Girl)	Open pits, 1,829 tons of 0.16% U3O8 ore produced 1955-60 (2)	Private, bordering Navajo Nation	Not Reported	No	None	<¼ mile from Little Colorado River	Unknown
(A-26-10)08	Riverview Group # 1 - # 9	open pit and shaft, 508 tons of 0.38% U3O8, 0.03% V2O5 ore produced in 1956-57 (2)	State and Private	Not Reported	No	None	<¼ mile from Little Colorado River	Unknown

Cadastral Location	Site Name	Site Description, Production, and Information Source	Owner	Uranium Content (Percent U3O8)	Located in a Wilderness Area? (1)	Wells within one mile (1)	Surface Water within 2 miles (1, 1A)	Residents within one mile (1)
Table 1: Uranium Mines in Arizona								
Coconino County								
(A-27-09)01	Section # 1	Pits, 79 tons of 0.23% U3O8 ore produced in 1954 and 1959 (2)	Private, bordering Navajo Nation	Not Reported	No	None	None	Unknown
(A-27-10)09	Section # 9	3 small pits and low grade ore dumps, 386 tons of 0.13% U3O8 produced 1957-62 (2)	Private, bordering Navajo Nation	Not Reported	No	None	<¼ mile from Little Colorado River	Unknown
Gila County								
(D-02-15)31-32	Lucky Boy	Development includes 2 adits and workings, 2,336 tons of 0.17% U3O8 produced 1956-57 and >10,000 pounds U3O8 brine concentrate in 1979 (2)	BLM, State, and Private	Not Reported	No	One domestic	None	Unknown
(A-06-14)30ba	Lucky Stop	Development includes a 1,000-foot drift and crosscuts, and 5 adits, 2,847 tons of 0.16% U3O8 produced 1955-57 (2) Lucky Stop Mining Co has been active at this mine, prospect pits and/or cuts present. (3C)	Tonto NF and Private	0.30 - 0.32	No	13 domestic	Workman Creek (Fisheries)	Unknown
Mohave County								
(B-40-06)24c	Radon # 1	Development includes 2 shallow trenches, 25 and 45 feet long, 22.6 tons of 0.06% U3O8, 0.55% V2O5 produced in 1954. (2)	Private	0.19-0.67	No	One domestic	None	Unknown
(B-40-06)25b	Rainbow (aka Last Chance)	Development includes an 18-foot shaft, drill holes, and a copper prospect, analysis reported 0.75% copper, 30 tons 0.28% U3O8, 1.13% V2O5 produced in 1955. (2)	Private	0.02-0.024	No	One domestic	None	Unknown
(A-18-23)33bc	Goop (aka Section 33 Lease)	Development includes rim stripping, 8.9 tons of 0.01% U3O8, 0.13% V2O5 produced in 1956. (2)	Private	Not Reported	No	None	None	None
(A-18-19)11	Hanson # 1 (aka J D Hanson # 1)	Development includes shallow pits and trenches, 285 tons of 0.06%U3O8, 0.03%V2O5 produced 1953-55. (2)	Private	Not Reported	No	None	None	At least 170
(A-19-19)33	J City # 1	Development includes a shallow pit and surface scrapings, 31 tons of 0.04% U3O8 produced in 1957. (2)	Private	Not Reported	No	None	None	Unknown
(A-17-23)05d	Mac # 3	Development included small pits along rim, 6 tons of 0.48% U3O8, 0.71% V2O5 produced in 1956. (2)	Private	Not Reported	No	None	None	None
(A-16-22)36	Rainbow Smith # 1 and #2	Development included shallow surface scrapings for petrified wood, 14 tons of 0.08% U3O8, 0.18% V2O5 produced in 1956. (2)	BLM and State	Not Reported	No	None	<¼ mile from the Little Colorado River	None

Cadastral Location	Site Name	Site Description, Production, and Information Source	Owner	Uranium Content (Percent U3O8)	Located in a Wilderness Area? (1)	Wells within one mile (1)	Surface Water within 2 miles (1, 1A)	Residents within one mile (1)
Table 1: Uranium Mines in Arizona								
Mohave County								
(A-17-23)02	Ruth #1 and # 4 (aka Barton Mine, aka Bayshore # 3)	Development included adits and rim stripping, analysis reported % 0.82 V2O5, 1,268 tons of 0.20% U3O8, 0.16% V2O5 produced 1953-55 and 1960, and less than 500 tons per year in 1976 and 1978. (2)	State	0.08-0.35	No	One domestic	None	None
(A-19-20)23d	Sain	Development included rim stripping, 8 tons of 0.08% U3O8, 0.04% V2O5 produced in 1955. (2)	Private	Not Reported	No	None	Leroux Wash (Fisheries in the Little Colorado River)	Unknown
Navajo County								
(A-18-23)33dd	Section 33 Lease (aka Bill Gill, aka New Mexico-Arizona Lease , aka Goof)	Development included 2,000 feet of rim stripping, 15-foot shaft into mineralized slump block, small open cut 25x15x10 feet, 6,000 feet of rotary drilling, 29 tons of 0.13% U3O8 produced, some stockpiled on property. (2)	Private	Not Reported	No	None	None	None
(A-16-23)34c	Sharon Lynn	Development included scattered shallow surface scrapings, 5 tons of 0.08% U3O8, 0.03% V2O5 produced in 1954. (2)	State	Not Reported	No	2 domestic	Little Colorado River	Unknown
(A-20-17)32	Winslow # 6 and # 7 (aka Winslow Group)	Development includes one 100-foot adit from rim towards ore body and 64 holes drilled in 1955 for 8,200 feet, 49 tons of 0.03% U3O8 0.17% V2O5 produced in 1954. (2)	State	Not Reported	No	None	<¼ mile from unnamed tributary to the Little Colorado River (Fisheries)	Unknown
Pima County								
(D-17-10)23d	Black Dyke Shaft (Babson Claim Group)	Development includes an inclined shaft with adits, 61 tons of 0.08 % U3O8, 0.04% V2O5 produced in 1956-57, 10.7 tons of 0.18% U3O8 shipped in 1957, originally developed for copper. (2)	State	0.01-0.16	No	16 domestic	None	At least 30
(D-13-18)15c	Blue Rock # 1 and # 2 (aka Vanover, aka Blueslate, aka Sure Fire # 1, aka Vanhill # 5, aka East Chance Claims)	Development includes 3 short adits, a 160-foot incline, open-face stoping, and drilling, 58 tons of 0.09% U3O8 in 1956 and some shipments in the late 1970s. (2)	State	0.014-0.50	No	One domestic	<¼ mile from Soza Canyon	Unknown

Table 1 Notes

ppm - Parts per Million
U3O8 - Triuranium Oxide
V2O5 - Vanadium Pentoxide

BLM - US Bureau of Land Management
NF - National Forest

References:

1. AZMapper
1A. *Arizona Atlas & Gazetteer*, DeLorme, 3rd Edition, 1999.
2. Scarborough, Robert B, Arizona Bureau of Geology and Mineral Technology, Geological Survey Branch, Tucson, Arizona, Radioactive Occurrences and Uranium Production in Arizona, March 1981.
3A. USDOI Bureau of Mines, *Mineral Land Assessment, MLA2-94, Whetstone Mountains Unit*, 1994.
3B. USDOI Bureau of Mines, *Mineral Land Assessment, MLA129-82, Whetstone Roadless* Area, 1982.
3C. USDOI Bureau of Mines, *Mineral Land Assessment, MLA34-85, Sierra Ancha Wilderness and Salome Study* Area, 1985.

Cadastral Location	Site Name	Site Description, Production, and Information Source	Owner	Uranium Content (Percent U3O8)	Located in a Wilderness Area? (1)	Wells within one mile (1)	Surface Water within 2 miles (1, 1A)	Residents within one mile (1)
Table 2: Mines Producing Other Metals, Uranium Detected								
Coconino County								
(A-28-02)27	Barranca de Colre	25 prospect pits, some copper ore shipped to Jerome about 1910 (2)	State	0.25 - 0.30	No	None	None	None
Gila County								
(D-01-14)19	American Mine	Development includes two shafts 60 feet deep and one 150-foot adit, copper, gold, and silver were probably produced. (2)	Private	0.05	No	2 municipal	Pinto Creek	Unknown
Maricopa County								
(B-07-02)19 (east half)	Golden Duck Group	Development includes shafts, adits, and prospects, copper and gold have been produced. (2)	BLM and Private	0.03-0.57	No	5 domestic	None	Unknown
Mohave County								
(B-22-17)07a	Cerbat Mine	Development includes a 750-foot shaft and drifts, gold and silver have been produced. (2)	BLM and Private	0.021	No	4 domestic	None	Unknown
(B-22-17)18	Frontier and Frontier # 2	Development includes two 250-foot drifts and crosscuts, several short adits, and pits, gold and silver have been produced. (2)	BLM and Private	0.063-0.096	No	4 domestic	None	Unknown
(B-22-17)07	Gold Nugget	Development includes shaft and surface trenching, gold and silver have been produced. (2)	BLM and Private	0.23-0.45	No	4 domestic	None	Unknown
(B-13-12)04d	State Mine	Development includes a 150-foot crosscut, 65-foot drift, and 35-foot shaft, gold and silver have been produced. (2)	BLM and Private	0.30-0.36	No	None	None	Unknown
(B-23-17)32 (center)	Summit Mine	Development includes 850 feet of crosscut adit, drilling, drifting, and stoping, 31,500 tons of 0.65% copper, 5.5% lead, 6.5% zinc, 0.07 ounces gold, 5.5 ounces silver/ton produced 1936-47. (2)	State and Private	0.64	No	One domestic	None	Unknown
Pima County								
(D-18-11)16	Black Hawk Claims (aka San Juan # 1 and # 2)	Development includes an 80-foot shaft, a 180-foot shaft, and a 300-foot drift, lead and silver produced. (2)	State	0.07	No	One domestic	None	Unknown
(D-21-10)05a	Gismo Group	Development includes shafts and drifts that are flooded or caved, gold and silver have been produced. (2)	BLM and State	0.33	No	7 domestic	None	Unknown
(D-21-10)32	Shamrock Mine	Development includes one shaft with two levels, lead and silver have been produced. (2)	State	0.05	No	27 domestic, 2 municipal	None	At least 80
Pinal County								
(D-04-13)20d	Betty # 1 Mine	Development included blocked shaft and drifts, silver has been produced. (2)	State	0.07-0.08	No	None	None	Unknown

Cadastral Location	Site Name	Site Description, Production, and Information Source	Owner	Uranium Content (Percent U3O8)	Located in a Wilderness Area? (1)	Wells within one mile (1)	Surface Water within 2 miles (1, 1A)	Residents within one mile (1)
Table 2: Mines Producing Other Metals, Uranium Detected								
Pinal County								
(D-03-07)36d and (D-03-08)31c	Mineral Butte Group (aka Montana, aka Apache, aka Yellow Peak, aka Squaw Peak)	Development includes a 70-foot shaft, incline, and workings, copper has been produced. (2)	County and Private	0.15	No	About 40 domestic	None	At least 6
(D-04-11)26 and 35	Unnamed A	Development includes adits and a shaft, gold has been produced. (2)	State	0.012-0.115	No	None	Gila River	Unknown
Santa Cruz County								
(D-21-14)12d and 13	Alto Group (aka Gold Tree, aka El Plomo, aka Mineral Vein)	Development includes underground workings, base metals have been produced. (2, 3D)	Coronado NF and Private	0.07	No	2 domestic	None	Unknown
(D-21-15)17 and 20	Bowling Green and Lucky Spur Groups	Development includes two 50-foot stopes and a 250-foot drift, lead and silver produced. (2)	Coronado NF and Private	0.16	No	None	None	Unknown
(D-23-10)13	El Oro Vein	6,250 tons of gold-silver-copper-lead ore produced in 1897. Uranium detected at <10-154 ppm in a rock sample. (3E)	Private	Not Reported	No	2 domestic	None	Unknown
Yavapai County								
(A-16-02)35a	Bechetti lease	Development includes crosscuts and incline, and prospect pits, gold, silver, and copper have been produced. (2)	Prescott NF and Private	0.003-0.14	No	4 domestic, 4 municipal	Oak Wash	At least 9
(B-11-05)16b	Cuba Mine (aka Buck Horn, aka Lucky Day, aka Independence)	Development has occurred underground, gold has probably been produced. (2)	State	0.009-0.014	No	About 70 domestic, 4 municipal	None	About 250
(B-8-03)16 (East half)	Denver Group	Development includes an old underground mine, copper has been produced. (2)	State and Private	0.46-0.61	No	One domestic	None	None
(A-08-01)01 through 06	Dishman Brothers Claims	Development includes old cuts, a shaft, and drilling, silver has been produced. (2)	BLM, State, and Private	0.06	No	3 domestic	Boulder Creek. Fisheries in Lake Pleasant	Unknown
34°10'06"N, 112°21'28" near (B-10-01)34	Ford Claim	Development includes 2 drifts and prospect pits, this is an old gold mine and gold has probably been produced. (2)	Prescott NF and Private	0.18	None	5 domestic	Jones Gulch	Unknown

Cadastral Location	Site Name	Site Description, Production, and Information Source	Owner	Uranium Content (Percent U3O8)	Located in a Wilderness Area? (1)	Wells within one mile (1)	Surface Water within 2 miles (1, 1A)	Residents within one mile (1)
Table 2: Mines Producing Other Metals, Uranium Detected								
Yavapai County								
(B-10-05) Southeast Quarter and (B-10-04) Southwest Quarter	Uranus Group (aka Mixpah, aka Terminal, aka Nest Egg, aka Planet Saturn, aka Total Wreck)	Development includes extensive underground workings, gold has been produced. (2)	BLM, State, and Private	0.06-0.14	No	58 domestic	<¼ mile from Antelope Creek, East Antelope Creek, and Lion Creek,	At least 8

Table 2 Notes

ppm - Parts per Million

BLM - US Bureau of Land Management
NF - National Forest

References:

1. AZMapper
1A. *Arizona Atlas & Gazetteer*, DeLorme, 3rd Edition, 1999.
2. Scarborough, Robert B, Arizona Bureau of Geology and Mineral Technology, Geological Survey Branch, Tucson, Arizona, Radioactive Occurrences and Uranium Production in Arizona, March 1981.
3D. USDOI Bureau of Mines, *Mineral Land Assessment, MLA11-94, Santa Rita Mountains Unit, Part 14*, 1994.
3E. USDOI Bureau of Mines, *Mineral Land Assessment MLA24-94, Atascosa-Pajarito-San Luis-Tumacacori Mountains Unit*, 1994.

Cadastral Location	Site Name	Site Description, Production, and Information Source	Owner	Uranium Content (Percent U3O8)	Located in a Wilderness Area? (1)	Wells within one mile (1)	Surface Water within 2 miles (1, 1A)	Residents within one mile (1)
Table 3: Other Mines and Prospects with Uranium Detections								
Cochise County								
(D-18-19)25	Conlig Tungsten Mine	Prospect pits (2)	Coronado NF and Private	0.01	No	9 domestic	None	4
(D-23-20)09 and 16	Deerhead Claims	Prospect pits (2)	Coronado NF and Private	0.01	Yes, Miller Peak Wilderness Area	32 domestic, one municipal	Ramsey Canyon, Intake in Carr Canyon	Unknown
(D-18-25)01, east half	Eagle # 1 and # 2	8-foot shaft (2)	BLM and Private	0.2	No	5 domestic	None	About 15
(D-17-25)35c	Elanna	Prospect pits and 20-foot shaft (2)	Private	0.15 - 0.20	No	12 domestic	None	About 70
(D-17-25)33 and 34	Fluorine Hill Prospects	Prospect pits and a shallow shaft (2)	Private	0.0096 - 0.11	No	About 33 domestic	None	About 100 residents, also Pearce Elementary School
(D-14-21)08 ca	Inez Ellen Claims	Shaft and drift (2)	State	0.26	No	None	None	None
(D-24-29)04	Last Chance	Drift and prospect pits (2)	State and Private	0.02	No	None	None	None
(D-20-27)22 and 23	Little Mike Group	Prospect pit and location shaft (2)	BLM, State, and Private	0.62	No	8 domestic	None	Unknown
(D-24-29)09	Little Swede Mine	Prospect Shaft (2)	State and Private	0.003 - 0.011	No	None	None	None
(D-13-19)30	Robles Spring Claims	20-foot adit and a 25 x 20 x 15 foot pit (2)	State and Private	0.004 - 0.078	No	One domestic	None	Unknown
(D-14-28)32	Uranium Hill Claims	3 small open pits and 4 drill holes (2, 3F)	Private	0.32 - 1.27	No	2 domestic	<½ mile from Wood Canyon	Unknown
(D-13-26)22d	Valley View Claims	Pits (2)	Private	0.04 - 0.19	No	8 domestic	None	2
Coconino County								
(A-39-06)28	Cottonwood # 1 and # 2	2 prospect pits along rim, analysis reported 0.01% V2O5 and 0.01% to 0.05% copper. (2)	BLM and Private	0.06- 0.15	Yes, Paria Canyon Wilderness Area	None	None	At least 1
(A-26-02)12	Packrat	Two shallow shafts, an incline, and some drifting and crosscutting (2)	Private	0.04	No	5 domestic, 2 municipal	None	At least 90

Cadastral Location	Site Name	Site Description, Production, and Information Source	Owner	Uranium Content (Percent U3O8)	Located in a Wilderness Area? (1)	Wells within one mile (1)	Surface Water within 2 miles (1, 1A)	Residents within one mile (1)
Table 3: Other Mines and Prospects with Uranium Detections								
Gila County								
33°24'N, 110°57'30"W (A-01-14)29	Castle Dome Copper Mine (Red Hill)	Development includes an open pit copper mine. USGS map shows tailings and a concentrator. No production reported. (2)	Tonto NF and Private	0.17 - 0.22	No	5 domestic, 2 municipal	Pinto Creek	Unknown
(D-03-15)02 (center)	Desert Queen	Development includes drilling and shallow pits, no production reported. (2)	State	0.29	No	2 domestic	None	Unknown
Unknown	Easter Group	Development includes a discovery pit, analysis reported 0.1% U3O8, no production reported. (2)	Unknown	0.1	Unknown Location	Unknown Location	Unknown Location	Unknown Location
33°44'25"N, 110°34'05"W, near (A-04.5-17)34	Junction Claim	Development includes trenching and benching, no production reported. (2)	Private	0.18	No	4 domestic	None	None
Graham County								
32°40'10"N, 109°44'03"W probably (D-09-26)06c	Blue Bird Claims	Development includes prospect pits, no production reported. (2)	Private	0.07	No	About 50 domestic	Lefthand Canyon and Unnamed Lake	At least 40
(D-07-21)28	Cactus Claim	Development includes a shallow pit, no production reported. (2)	State and Private	0.07-0.25	No	None	None	None
(D-07-21)14	Denny Claims	Development includes 3 prospect pits, no production reported. (2)	State	0.07	No	One domestic	Cottonwood Canyon	Unknown
(D-11-26)29	Fluorite Claims	Development includes one 12-foot shaft and pits, no production reported. (2)	State	0.017	No	None	None	Unknown
(D-11-26)24	High Noon Claims	Development includes a dozed area, no production reported. (2)	State	0.05	No	None	None	Unknown
(D-08-22)16-17	Lindsey Canyon	Development unknown. Uranium detected at <0.5-100 ppm in samples from dumps. (3O)	Coronado NF and Private	Not Reported	No	None	Lindsey Canyon	None
(D-07-21)28	Sky High Claim	Development included a prospect pit, no production reported. (2)	State and Private	0.081	No	None	None	None
La Paz County								
(B-08-12) (from USGS map apparently near (B-08-13)36)	Hot Rock Claim	Development includes 5 adits, one shaft, and an open cut, no production reported. Directions: From Wenden turn north on Alamo Rd for 13 miles, turn right at junction and go up gas line right-of-way 150 yards, turn left on old dirt road, cross wash, and proceed 0.3 miles, then take right fork and proceed 0.7 miles to end of road. (2)	BLM and State	0.02-0.057	No	None	None	None

Cadastral Location	Site Name	Site Description, Production, and Information Source	Owner	Uranium Content (Percent U3O8)	Located in a Wilderness Area? (1)	Wells within one mile (1)	Surface Water within 2 miles (1, 1A)	Residents within one mile (1)
Table 3: Other Mines and Prospects with Uranium Detections								
La Paz County								
Unknown	Two Fools and Stronghold	Development includes one 15-foot and one 115-foot adit, no production reported. Directions: Go east from Blythe along US 60-70 to a point 0.7 mile beyond Arizona Check Station, turn right onto Cibola Rd and proceed 2.1 mile, turn left and proceed 6.5 mi, turn onto dim road and continue up the canyon 1.2 miles to end of road, then follow the burro trail 2.5 miles up the wash to the pit. (2)	Unknown Location	2.3-2.39	Unknown Location	Unknown Location	Unknown Location	Unknown Location
Maricopa County								
(A-06-04)10	Copper Kid Group	Originally a lead and silver prospect, development includes a 70-ft shaft and pits, no production reported. (2)	Private	0.66-1.13	No	About 100 domestic, one municipal	Cave Creek	At least 200
(B-02-10)36	Duke, White, and Hyder Claims	Development included a discovery shaft and drill holes, no production reported. (2)	Private	0.01	No	7 domestic	None	Unknown
Unknown	Horseshoe Dam	Located east of Horseshoe Dam. At least 3 exploratory boreholes drilled. 165 ppm U3O8 detected in a rock sample. (3Y)	Unknown Location	Unknown Location	Unknown Location	Unknown Location	Unknown Location	Unknown Location
(A-06-03)05 and (A-07-03)32 and 33	Los Cuatros Group	Development includes drilling, no production reported. (2)	Tonto NF, State, and Private	0.06	No	At least 100 domestic, 8 municipal	None	At least 100
(C-02-04)10	Stripped Mountain Claims	Development includes small prospect pits, no production reported. Appears to be in the Buckeye Hills Recreation Area. (2)	Local Parks and Recreation	0.006-0.38	No	None	None	Unknown
33°43'30"N, 111°55' near (A-04-04)02	White Point Group	Development includes prospect pits and dozer cuts, no production reported. Location: 5 miles west of Bickle and Manley claims. (2)	State	3.92-5.95	No	5 domestic, 3 municipal	None	About 3,000
Mohave County								
(B-30-30)23c	Cisco	Development includes small trenches, no production reported. Bad Location - Not in Arizona (2)	Bad Location	0.348-0.36	Bad Location	Bad Location	Bad Location	Bad Location
(B-38-06)04 (center)	Iris Claim	Development includes one 10-foot adit and pits, no production reported. (2)	Private	0.01	No	None	None	None
(B-14-12)29	Madrill and Ieival Claims	Development includes an 100-foot adit and prospect pits, no production reported. (2)	BLM and Private	0.07-0.8	No	None	Big Sandy River, Alamo Lake (Fisheries)	Unknown
(B-22-17)31	Mammoth # 1 (aka Jamison)	Development includes one adit, 2 shafts, and several pits, no production reported. (2)	Private	0.001-0.03	No	7 domestic, one municipal	None	At least 300

Cadastral Location	Site Name	Site Description, Production, and Information Source	Owner	Uranium Content (Percent U3O8)	Located in a Wilderness Area? (1)	Wells within one mile (1)	Surface Water within 2 miles (1, 1A)	Residents within one mile (1)
Table 3: Other Mines and Prospects with Uranium Detections								
Mohave County								
(B-20-17)03	Mineral X Claim	Development includes an open cut, no production reported. (2)	Private	0.48–1.05	No	14 domestic, one municipal	None	At least 50
(B-21-13)07	Red Hills	Development includes a 21-foot shaft, no production reported. (2)	State and Private	0.314	No	One domestic	None	Unknown
(B-20-13)26	Uranium Basin	Development includes prospect pits, no production reported. (2)	State	0.45	No	15 domestic	None	Unknown
(B-28-16) near Grand Wash Cliffs	White Cap	Development includes 2 pits, no production reported. (2)	Private and BLM	1.23-1.35	No	5 domestic	None	Unknown
Navajo County								
(A-19-19)20 (west central)	Anna Bernice Claims	Development includes shallow prospect pits, no production reported. (2)	State	0.001-0.25	No	None	Cottonwood Wash	Unknown
(A-17-23)03 (north half of north half)	Margarite Lease	Development includes 2,000 feet of rim stripping and two 25-foott adits drilled by AEC, no production reported. (2)	BLM, State, and Private	0.02-0.77	No	One domestic	None	None
Pima County								
(D-17-11)34 and 35	Abe Lincoln	Development includes a 15-foot drift, no production reported. (2)	BLM, State, and Private	0.08	No	11 domestic	None	At least 15
(D-18-15)23	Christensen-Lane Mine	Development includes a 30-foot incline shaft and a shallow open pit, no production reported. (2)	Private	0.01	No	18 domestic	None	Unknown
(D-17-11)34bd	Diamond Head Group	Development includes a 180-foot adit, a 20-foot incline, a 15-foot shaft, and a 170-foot drift, no production reported. (2)	Private	0.22-0.74	No	9 domestic	None	Unknown
(D-15-13)17	Dutchess Claim	Development includes a small pit and drill holes, no production reported. (2)	Private	0.06	No	7 domestic	None	At least 4,000
(D-13-18)13, 14, 23, and 24 near corner	East Chance Claims (aka Van Hill # 7 and # 8, aka Vanover, aka Chance Group)	Development includes a 30-foot adit, no production reported. (2)	State and Private	0.4	No	One domestic	<¼ mile from Soza Canyon	Unknown
(D-17-08)02	El Conquistadors	Development includes a prospect pit, no production reported. (2)	State	0.01	No	2 domestic	None	Unknown
(D-17-11)34	Escondida	Development includes two 8-foot deep pits, no production reported. (2)	State and Private	0.06	No	9 domestic	None	Unknown
(D-17-11)30a	Glen Claims	Development includes an open cut about 15 feet into the hill, no production reported. (2)	State	0.015-0.027	No	15 domestic	None	Unknown

Cadastral Location	Site Name	Site Description, Production, and Information Source	Owner	Uranium Content (Percent U3O8)	Located in a Wilderness Area? (1)	Wells within one mile (1)	Surface Water within 2 miles (1, 1A)	Residents within one mile (1)
Table 3: Other Mines and Prospects with Uranium Detections								
Pima County								
(D-18-11)21a	Half Moon # 3	Development includes a dozer cut, no production reported. (2)	Private	0.074	No	One domestic	None	Unknown
(D-17-11)08	Holy Mother Claims	Development includes a prospect pit, no production reported. (2)	State	0.114	No	8 domestic	None	Unknown
(D-17-11)36	Hopeful # 1	Development includes a location pit, no production reported. (2)	State	1.17-1.35	No	13 domestic	None	At least 15
(D-18-11)10	Leadville Group	Development includes a drift, no production reported. (2)	BLM and Private	0.01-0.05	No	2 domestic	None	Unknown
(D-18-11)05 and 08	Lena # 1, Jenny # 1, and Blue Moon	Development includes a shallow shaft and pits, no production reported. (2)	BLM and Private	0.19	No	5 domestic	None	None
(D-16-17)05b and 06a	Red Hills Claim	Development includes several shallow pits, no production reported. (2)	State	0.08-0.38	No	12 domestic, 2 municipal	None	At least 15
(D-13-18)10d and 15a	Van Hill # 5(aka Vanover, aka Red Hill # 5, aka Bluerock, aka East Chance Claims)	Development includes a small pit in an arroyo bottom, no production reported. (2)	State	0.008-0.17	No	One domestic	<¼ mile from Soza Canyon	Unknown
(D-11-18)21d and 28a	Xmas Claims	Development includes a prospect pit, no production reported. (2)	State and Private	0.015	No	17 domestic	Edgar Canyon	Unknown
Pinal County								
(D-04-13)14, 15, and 16	Honey Bee and Shortie	Development included surface pits and adit, no production reported. (2)	State	0.05	No	2 domestic	Gila River	Unknown
Probably in (D-04-13)16 or 21	Jeep Claims	Development includes a small trench, no production reported. Directions: From Florence, take the Ray-Kelvin Highway 25.3 miles, turn up wash for 0.2 miles, property is 100 yards left of wash. (2)	State	0.103	No	One domestic	None	Unknown
(D-04-13)33d	Wooley # 1	Development includes a shaft and adit, no production reported. (2)	Private	0.017	No	One domestic	None	Unknown
Santa Cruz County								
(D-21-15)27, 28, 33, 34	Blue Jay	Development includes an 18-foot shaft and a 25-foot shaft in Sec 33d, no production reported. (2, 3D)	Coronado NF and Private	0.02-0.04	No	2 domestic	None	
(D-20-14)29	Extension Project	Development Unknown. Uranium detected at 60-105 ppm in a sample from the ore bin. (3D)	Coronado NF and Private	Not Reported	No	One municipal	Agua Caliente Canyon, Cottonwood Canyon	At least 1

Cadastral Location	Site Name	Site Description, Production, and Information Source	Owner	Uranium Content (Percent U3O8)	Located in a Wilderness Area? (1)	Wells within one mile (1)	Surface Water within 2 miles (1, 1A)	Residents within one mile (1)
Table 3: Other Mines and Prospects with Uranium Detections								
Santa Cruz County								
(D-22-10)23	Lone Star # 1	Development includes a prospect pit, no production reported. (2)	State and Private	0.012	No	4 domestic	Oro Blanco Wash	Unknown
(D-22-10)36	Purple Cow Claims	Development includes a prospect pit, no production reported. (2)	Coronado NF and Private	0.03	No	None	Oro Blanco Wash	Unknown
Yavapai County								
(B-08-03)11 (S half)	Abe Lincoln Mine	Development includes 2 caved and flooded shafts, 2 adits, and 2,000 feet of inaccessible workings, no production reported. (2)	Private	0.01-0.46	No	3 domestic	None	Unknown
(A-08-01)04	Arizona Black Donkey (aka Black Donkey, aka Willbank Group)	Development includes an open cut, test pits, and drilling, no production reported. (2)	BLM, State, and Private	0.02-0.80	No	2 domestic	Boulder Creek, Fisheries in Lake Pleasant	Unknown
Unknown	Athena	Development includes 3 small prospect pits, no production reported. Directions: Follow Black Canyon Highway 3.2 miles south from Rock Springs, turn right on Bard Ranch Rd and proceed 8.2 miles to property, approximate location. (2)	Unknown Location	0.32	Unknown Location	Unknown Location	Unknown Location	Unknown Location
(B-14-08)27	Cardinal Claim	Development includes a prospect pit, no production reported. (2)	State	0.5-0.13	No	4 domestic wells within one mile, unknown if residents live within one mile	None	Unknown
(B-15-09)22	Ethiopia Claims	Development includes two 20-foot shafts, a 45-foot incline, and workings, no production reported. (2)	State	0.124-0.13	No	None	West Clear Creek	None
(A-15-02) northeast quarter, 34°42'28"N, 112°05'17"W near (A-15-02.5)01	Fairview	Development includes prospect pits, no production reported. (2)	Prescott NF and Private	0.01-0.91	No	2 domestic, 7 municipal	None	Unknown
(B-10-06)	Granite Ridge Group (aka Arrowhead Group)	Development includes an incline shaft, adits, and pits, this is an old gold prospect and no production is reported. (2)	BLM, State, and Private	0.14	No	38 domestic, one municipal	None	About 800

Cadastral Location	Site Name	Site Description, Production, and Information Source	Owner	Uranium Content (Percent U3O8)	Located in a Wilderness Area? (1)	Wells within one mile (1)	Surface Water within 2 miles (1, 1A)	Residents within one mile (1)
Table 3: Other Mines and Prospects with Uranium Detections								
Yavapai County								
(B-15-09)27	Grubstake # 1 through # 6	Development includes 3 small prospect pits, no production reported. (2)	State and Private	0.01	No	None	Burro Creek	None
(B-15-09)27c	Kitten # 1Claim	Development includes prospect pits, no production reported. (2)	State and Private	0.013-0.20	No	None	Burro Creek	Unknown
(A-07-01)22bc	Lake Pleasant Project	Development includes drilling, no production reported. (2)	Private	0.02	No	2 domestic	Humbug Creek, Intakes and Fisheries at Lake Pleasant	Unknown
(B-12-06)23	Lucky Probe	Development includes old discovery work, no production reported. (2)	State	0.04-0.27	No	None	<¼ mile from Cottonwood Creek	Unknown
(B-08-03)23	Miller Mine	Development includes a flooded 65-foot incline shaft, no production reported. (2)	BLM and Private	0.012-0.015	No	One domestic	None	Unknown
Unknown	People's Valley Mine	Development includes open cuts and a 20-foot shaft, no production reported. Directions: Turn left on dirt road 5.9 miles northeast of Yarnell on US Hwy 89, then go 5.5 miles northwest to property. (2)	Unknown Location	0.13-0.15	Unknown Location	Unknown Location	Unknown Location	Unknown Location
(B-08-03)10-15 and 23	Three Bucks	Development includes dozer cuts, no production reported. (2)	BLM, State, and Private	0.02-0.04	No	4 domestic	None	Unknown
Unknown	Unnamed B	Development includes small shafts and prospect pits, no production reported. Directions: From Wickenburg, take Constellation Road to fork at 3.3 miles, then turn left and drive 9.6 miles to property. (2)	Unknown Location	0.015	Unknown Location	Unknown Location	Unknown Location	Unknown Location
Yuma County								
N of Agua Caliente	Cactus Group	Development includes a pit, no production reported. (2)	Bad Location	0.25-2.57	Bad Location	Bad Location	Bad Location	Bad Location

Cadastral Location	Site Name	Site Description, Production, and Information Source	Owner	Uranium Content (Percent U3O8)	Located in a Wilderness Area? (1)	Wells within one mile (1)	Surface Water within 2 miles (1, 1A)	Residents within one mile (1)
Table 3: Other Mines and Prospects with Uranium Detections								
Yuma County								
(C-07-18) southeast quarter	Dizzy Lizzy	Development includes prospecting, no production reported. Located in the Muggins Mountains. Directions: From Old Tacna go 4.4 miles west on US 80, turn right opposite Bake Tanks turnoff and go 3.9 miles on gravel road, turn left and go 2.2 miles along north side of canal, turn right across Gila River bottom and follow dirt road up wash about 1.3 miles, turn right on faint trail and proceed 3.2 miles to property. (2)	BLM, Yuma Army Proving Ground, and State	0.08	No	None	A drainage diverts runoff into the Gila River and away from the Well-ton Mohawk Canal, where the intakes are.	Unknown

Table 3 Notes

ppm - Parts per Million
U3O8 - Triuranium Octaoxide
V2O5 - Vanadium Pentoxide

BLM - US Bureau of Land Management
NF - National Forest

References:

1. AZMapper
1A. *Arizona Atlas & Gazetteer*, DeLorme, 3rd Edition, 1999.
2. Scarborough, Robert B, Arizona Bureau of Geology and Mineral Technology, Geological Survey Branch, Tucson, Arizona, Radioactive Occurrences and Uranium Production in Arizona, March 1981.
3D. USDOI Bureau of Mines, *Mineral Land Assessment, MLA11-94, Santa Rita Mountains Unit, Part 14*, 1994.
3F. USDOI Bureau of Mines, *Mineral Land Assessment MLA2-86 Dos Cabezas Mountains Wilderness Study Area*, 1986.

Cadastral Location	Site Name	Site Description, Production, and Information Source	Owner	Uranium Content (Percent U3O8)	Located in a Wilderness Area? (1)	Wells within one mile (1)	Surface Water within 2 miles (1, 1A)	Residents within one mile (1)
Table 4: Other Locations of Interest								
Mohave County								
(B-11-12)05-07	Santa Maria Area - Black Diamond, American, and Neeve Mines	1.14-10.38 ppm of U3O8 detected in rock samples. Development includes one open pit, numerous adits and prospects shown on USGS map, tailings pile in Alamo Lake occupies about 3 acres. (3G) Note: AZMapper shows that the tailings pile is on a Military Reservation, but the Alamo Lake State Park is also located on this Military Reservation. Further investigation is needed to confirm ownership. (1)	BLM and Military Reservation	Not Reported	Yes, Arrastra Mountain Wilderness Area	None	Big Sandy River and Alamo Lake (Fisheries)	At least 4

Table 4 Notes

USGS - US Geological Survey

BLM - US Bureau of Land Management

References:
1. AZMapper
1A. *Arizona Atlas & Gazetteer*, DeLorme, 3rd Edition, 1999.
3G. USDOI Bureau of Mines, *Mineral Land Assessment, MLA25-88, Arrastra Mountain Study* Area, 1988.

Cadastral Location	Site Name	Site Description, Production, and Information Source	Owner	Uranium Content (Percent U3O8)	Located in a Wilderness Area? (1)	Wells within one mile (1)	Surface Water within 2 miles (1, 1A)	Residents within one mile (1)
Table 5: Other Uranium Deposits								
Cochise County								
(D-14-27)07	Unnamed A	Underground workings, uranium minerals may be present. (2)	BLM	Not Reported	No	None	Gold Gulch	Unknown
Coconino County								
(A-27-10)06	Ada and Nordell	Uranium ore present. Development includes test pits and trenches. (2)	State land, bordering Navajo Nation	Not Reported	No	None	None	Unknown
(A-29-02)16, 17, 20 and 29	Anita, Emerald, North Star, and Tellstar	Uranium has reportedly been found (3I)	Kaibab NF	Not Reported	No	None	None	None
Unknown	Blue Mountain	Uranium ore reportedly found. Located near Diamond Creek, leased by Western Nuclear (aka Energy Fuels Nuclear), no production reported. (4)	Hualapai Reservation	Not Reported	Unknown Location	Unknown Location	Unknown Location	Unknown Location
(A-28-02)07	Copper Queen Mine	Uranium has reportedly been found (3I)	Kaibab NF and Private	Not Reported	No	None	None	None
(A-30-02)29 and 32	Eastern Star Mine	Uranium has reportedly been found (3I)	Kaibab NF and Private	Not Reported	No	None	None	None
Unknown	Sage Pipe	Uranium ore reported to be present. Reportedly discovered by Rocky Mountain Energy (aka Union Pacific Resources), Location: 10 miles south of Supai (4)	Unknown	Not Reported	Unknown Location	Unknown Location	Unknown Location	Unknown Location
Unknown	SBF Pipe	Uranium ore reported to be present. Reportedly discovered by Rocky Mountain Energy (aka union Pacific Resources), Location: Eastern edge of Hualapai Reservation (4)	Hualapai Reservation	Not Reported	Unknown Location	Unknown Location	Unknown Location	Unknown Location
Gila County								
(A-06-14)36	Blue Rock	Uranium deposits reported to be present. Prospect pits and/or cuts present. No production reported. (3C)	Tonto NF	Not Reported	Yes, Sierra Ancha Wilderness Area	None	Cherry Creek	Unknown
(A-06-14)14	Bonnie	Uranium deposits reported to be present. Development includes adit(s). No production reported. (3C)	Tonto NF	Not Reported	Yes, Sierra Ancha Wilderness Area	None	Billy Lawrence Canyon, Finton Creek, Cherrry Creek	Unknown
(A-07-12)25 and (A-07-13) 30-31	Buckaroo Flats	Numerous shallow prospects. (6)	Tonto NF and Private	Not Reported	No	4 domestic	Salome Creek	Unknown

Cadastral Location	Site Name	Site Description, Production, and Information Source	Owner	Uranium Content (Percent U3O8)	Located in a Wilderness Area? (1)	Wells within one mile (1)	Surface Water within 2 miles (1, 1A)	Residents within one mile (1)
(A-07-14)33, 34, (A-06-14)2, 3, 4, 10, 11	Mary Louise Claims	AZMapper shows this location within a uranium mining district. No production reported (1, 3C)	Tonto NF	Not Reported	Yes, Sierra Ancha Wilderness Area	None	Deep Creek, Cherry Creek, Cold Water Canyon	Unknown
(A-06-13)17	Middle Mountain	Prospect only (6)	Tonto NF	Not Reported	Yes, Salome Wilderness Area	One domestic	<¼ mile from Salome Creek, Intakes and Fisheries in Roosevlt Lake	Unknown
(A-07-14)27	Navajo	AZMapper shows this location within a uranium mining district. Uranium deposits reported to be present. Development includes adit(s). No production reported (1, 3C)	Tonto NF	Not Reported	Yes, Adjacent to Sierra Ancha Wilderness Area	None	Cherry Creek	Unknown
(A-04-14)33-34	Oak Creek	Prospects, unknown development, alternative location 33° 43' 30", 110° 55' 00" (6)	Tonto NF	Not Reported	No	4 domestic, one municipal	Salt River, Intakes and Fisheries in Roosevelt Lake	Unknown
(A-07-14)11-12	Pendleton Mesa	Prospect only (6)	Tonto NF	Not Reported	No	None	<¼ mile from Cherry Creek	None
Mohave County								
(B-37-06)02	EZ-1 Breccia Pipe	Uranium ore reported to be present. Discovered by Pathfinder Mines, See Arizona Department of Mines and Mineral Resources File (4, 7)	BLM	Not Reported	No	None	None	None
(B-37-06)03	EZ-2 Breccia Pipe	Uranium ore reported to be present. Discovered by Pathfinder Mines, See ADMMR File (4, 7)	BLM	Not Reported	No	None	None	None
Pima County								
(D-12-14)34	Unnamed Uranium Claims	Uranium not detected in rock samples. (3S)	Coronado NF	Not Detected	Yes, Pusch Ridge Wilderness Area	8 domestic	None	At least 1,000
			BLM - US Bureau of Land Management					
			NF - National Forest					

Table 5: Uranium Mining Districts								
Coconino County								
(A-29-02) and (A-30-02)	Francis Mining District	Copper, lead, gold, and silver produced. AZMapper indicates that this is a uranium mining district. (1, 3H, 3I)	Grand Canyon National Park, Kaibab NF, and Private	Not Reported	No	9 domestic	None, rain collection intake in (A-30-02)26	Unknown
(A-38-01)	Warm Springs Mining District	AZMapper shows this location within a uranium mining district. 33,000 tons of ore produced 1903-1963. Copper, lead, gold, and silver ore. (1, 3H, 3I)	Kaibab NF	Not Reported	No	2 domestic, 2 municipal	Nail Canyon, Moquitch Canyon, Warm Springs Canyon	None
Gila County								
(A-06-14)10, 11, 13-15, 24, 25, and (A-06-15)30, 31	Betsey Ross Claims	AZMapper shows this location within a uranium mining district. No production reported. (1, 3C)	Tonto NF	Not Reported	Yes, Sierra Ancha Wilderness Area	None	Deep Creek, Billy Lawrence Canyon, Finton Creek, Pueblo Canyon, Cherry Creek	Unknown
Mohave County								
(B-11-16)08	Bower Pumice	AZMapper shows this location within a uranium mining district. ADMMR has a file (1, 7)	BLM	Not Reported	No	None	None	None
(B-12-17)35	Bower Specular Hematite	AZMapper shows this location within a uranium mining district. ADMMR has a file (1, 7)	BLM	Not Reported	No	None	None	None
(B-38-07)34	CLH Breccia Pipe	AZMapper shows this location within a uranium mining district. ADMMR has a file (1, 7)	BLM	Not Reported	No	None	None	None
(B-37-07)01	John Breccia Pipe	AZMapper shows this location within a uranium mining district. ADMMR has a file (1, 7)	BLM and State	Not Reported	No	None	None	None

Cadastral Location	Site Name	Site Description, Production, and Information Source	Owner	Uranium Content (Percent U3O8)	Located in a Wilderness Area? (1)	Wells (1)	Surface Water within 2 miles (1, 1A)	Residents within one mile (1)
(B-32-10)36	Lone Mountain	AZMapper shows this location within a uranium mining district. ADMMR has a file (1, 7)	Lake Mead NRA	Not Reported	No	None	Colorado River	None
(B-12-17)17	Mohave Wash Gold Property	AZMapper shows this location within a uranium mining district. ADMMR has a file (1, 7)	BLM	Not Reported	No	None	None	None
(B-33-10)35	Parshant Pipe	AZMapper shows this location within a uranium mining district. ADMMR has a file (1, 7)	Lake Mead NRA	Not Reported	No	None	None	None
(B-37-06)11	What Breccia Pipe	AZMapper shows this location within a uranium mining district. ADMMR has a file (1, 7)	BLM	Not Reported	No	None	None	None
Yuma County								
(C-08-18)05	Days End	AZMapper shows this location within a uranium mining district. ADMMR has a file (1, 7)		Not Reported	No	None	Gila River	Unknown
(C-08-20)28	Ligurta Mill	AZMapper shows this location within a uranium mining district. ADMMR has a file (1, 7)	BLM and Private	Not Reported	No	2 domestic	A drainage diverts flow away from the Wellton-Mohawk Canal, where the intakes are	At least 15
(C-08-21)13	Marble Gully	AZMapper shows this location within a uranium mining district. ADMMR has a file (1, 7)	BLM	Not Reported	No	8 domestic	A drainage diverts flow away from the Wellton-Mohawk Canal, where the intakes are	Unknown
(C-08-21)13	McKay Prospect	AZMapper shows this location within a uranium mining district. ADMMR has a file (1, 7)	BLM	Not Reported	No	9 domestic	A drainage diverts flow away from the Wellton-Mohawk Canal, where the intakes are	Unknown
(C-08-19)23	Muggins Mountains Clinoptilolite	AZMapper shows this location within a uranium mining district. ADMMR has a file (1, 7)	BLM	Not Reported	No	None	Gila River	About 40
(C-07-18)28	Muggins Mountains Uranium	AZMapper shows this location within a uranium mining district. ADMMR has a file (1, 7)	Yuma Army Proving Ground	Not Reported	No	None	None	Unknown

(C-10-20)22	Pool Mica Mine	AZMapper shows this location within a uranium mining district. ADMMR has a file (1, 7)	Barry Goldwater Range	Not Reported	No	None	None	None
(C-08-20)11	SW Muggins Mountains Placers	AZMapper shows this location within a uranium mining district. ADMMR has a file (1, 7)	BLM and Private	Not Reported	Yes, Muggins Mountains Wilderness Area	5 domestic	None	Unknown
Cadastral Location	Site Name	Site Description, Production, and Information Source	Owner	Uranium Content (Percent U3O8)	Located in a Wilderness Area? (1)	Wells (1)	Surface Water within 2 miles (1, 1A)	Residents within one mile (1)
(C-08-20)12	Three Star Claims # 1 - 20	AZMapper shows this location within a uranium mining district. ADMMR has a file (1, 7)	BLM	Not Reported	Yes, Muggins Mountains Wilderness Area	3 domestic	None	Unknown

ppm - Parts per Million
U3O8 - Triuranium Octaoxide
BLM - US Bureau of Land Management
NF - National Forest

Cadastral Location	Site Name	Site Description, Production, and Information Source	Owner	Uranium Content (Percent U3O8)	Located in a Wilderness Area? (1)	Wells (1)	Surface Water within 2 miles (1, 1A)	Residents within one mile (1)
Table 7: Other Mines and Prospects with Uranium Detections Above Residential Preliminary Remediation Goal								
Cochise County								
(D-18-23)24	Black Diamond Mine	Between 12,000 and 37,000 tons of ore produced. Ore contained copper, gold, silver, lead, and zinc. Uranium detected at 5.5-20 ppm ina sample from the dump. (3O)	Coronado NF	Not Reported	No	None	Middlemarch Canyon	At least 5
(D-24-20)02-03	Boston, Samson, and Way Up Claims	90 tons of silver-copper ore produced in 1937. Uranium detected at 12-30 ppm in a sample from the dump. (3T)	Coronado NF and Private	Not Reported	Yes, Miller Peak Wilderness Area	7 domestic	Miller Canyon, Cave Canyon	Unknown
(D-23-20)33c	Cave Mine	565 tons of ore produced 1946-47. Ores contain copper, silver, lead, and zinc. Uranium detected at 2.4-50 ppm in samples from dumps. (3T)	Coronado NF	Not Reported	Yes, Miller Peak Wilderness Area	4 domestic	Miller Canyon	Unknown
(D-18-23)13	Christmas Prospect	About 200 tons produced 1905-1948. Uranium detected at 2.3-50 ppm in a sample from the dump. (3O)	Coronado NF	Not Reported	No	One domestic	Middlemarch Canyon	At least 5
(D-23-19)24a	Copper Glance Mine	Several hundred tons of copper-gold ore produced 1913-1915. Uranium detected at <10-17 ppm in a sample from the dump. (3T)	Coronado NF	Not Reported	Yes, Miller Peak Wilderness Area	2 domestic	Sunnyside Canyon	Unknown, but Sierra Vista is <1 mile away
(D-17-30)21c and 28b	El Tigre Mine	About 2,200 tons of gold-silver-copper ore produced 1941-1974. Five adits and 1,000 ft of underground workings. Uranium was detected at <0.5-20 ppm in a sample from one of the dumps. (3U)	Coronado NF	Not Reported	No	One domestic	Pinery Creek	Unknown

(D-18-23)12	Emma Adit	Uranium detected at 5.2-70 ppm in a sample from the dump. (3O)	Coronado NF	Not Reported	No	One domestic	<¼ mile from Middlemarch Canyon	At least 5
(D-23-20)05 and 08	James Group	Some production of lead, zinc, and tungsten. Uranium detected at 15-30 ppm in a sample from the dump. (3T)	Coronado NF and Ft. Huachuca	Not Reported	Yes, Miller Peak Wilderness Area	4 domestic	Garden Canyon and Ramsey Canyon	Unknown, but Sierra Vista is <1 mile away
(D-17-30)14	Jhus Canyon	Prospect pit. Uranium detected at <10-19 ppm in a sample from the dump. (3U)	AZ Dept. of Game and Fish, Coronado NF, and Private	Not Reported	No	None	Jhus Canyon	Unknown
(D-11-25)02c	Little Cottonwood Canyon	One 34-ft shaft. Uranium was detected at <10-17 ppm in a sample from the dump. (3P)	Coronado NF	Not Reported	No	None	None	None
(D-23-20)27a	Nellie James	One cut in the hillside 20 x 30 ft. Uranium detected at 2-20 ppm in a sample from the dump. (3T)	Coronado NF and Private	Not Reported	Yes, Miller Peak Wilderness Area	10 domestic	Miller Canyon, Intake in Miller Canyon	Unknown
(D-18-24)08	Noonan Canyon Prospects	Uranium detected at 13-30 ppm in a sample from a dump near a prospect shaft. (3O)	Coronado NF	Not Reported	No	16 domestic, one municipal	Middlemarch Canyon	Unknown
(D-18-23)24	Sala Ranch Prospects	Uranium detected at 1.1-20 pppm in a sample from the dump. (3O)	Coronado NF	Not Reported	No	None	Middlemarch Canyon	At least 5
(D-18-23)10	San Juan Mine	About 15,000 tons of lead-zinc ore produced 1913-1947. Uranium detected in samples from underground piles of waste rock at 2.4-30 ppm. (3O)	Coronado NF	Not Reported	No	None	Slavin Wash and Middlemarch Canyon	Unknown
(D-17-23)10d	Seneca Mine	About 300 tons of zinc-lead ore produced 1942-43. Uranium detected at 10-21 ppm in a sample from the dump. (3O)	Coronado NF and Private	Not Reported	No	One domestic	Dragoon Wash	Unknown
(D-18-23)24	Standard Tungsten Mine	Less than 100 tons of barite and tungsten ores produced. Uranium detected at 2.5-40 ppm in a sample from the dump. (3O)	Coronado NF	Not Reported	No	None	Middlemarch Canyon	At least 5
(D-17-23)05	Unnamed Adit	Adit in Jordan Canyon, sample from dump has 20-21 ppm of uranium. (3O)	Coronado NF	Not Reported	No	One domestic	Dragoon Wash	Unknown
(D-18-23)03d	Unnamed Area	Uranium detected at 20-29 ppm in a sample from the dump. (3O)	Coronado NF and Private	Not Reported	No	None	Slavin Wash and Middlemarch Canyon	Unknown
(D-16-23)23d	Unnamed Mine Shaft	Mine Shaft in Golden Rule District, sample from dump had 16-40 ppm uranium. (3O)	BLM	Not Reported	No	About 7 domestic	None	About 15
(D-18-23)01	Unnamed Prospect Pit	Prospect pit. Uranium detected at 14-30 ppm in a sample from the prospect pit. (3O)	Coronado NF	Not Reported	No	None	Middlemarch Canyon	Unknown

Cadastral Location	Site Name	Site Description, Production, and Information Source	Owner	Uranium Content (Percent U3O8)	Located in a Wilderness Area? (1)	Wells (1)	Surface Water within 2 miles (1, 1A)	Residents within one mile (1)
Graham County								
(D-06-20)33	Dogwater Mine	Uranium detected at 20-44 ppm in a stockpile. There is an old mill site nearby. Located near the Grand Reef Mine (previously screened). (3Q)	Coronado NF and Private	Not Reported	No	One domestic	Laurel Canyon and Klondike Wash	Unknown
(D-09-25)13d	Spring Canyon	One trench. Uranium was detected at <10-50 ppm in a sample from the dump. (3P)	Coronado NF	Not Reported	No	None	<¼ mile from Veach Canyon	Unknown
(D-10-25)21	Stony Peak Prospects	One small, open cut. Uranium detected at <10-54 ppm in a sample from the dump. (3P)	Coronado NF	Not Reported	No	None	None	Unknown
(D-10-25)20	White Rock Prospect	One shallow pit. Uranium was detected at <10-30 ppm in a sample from the dump. (3P)	Coronado NF	Not Reported	No	One domestic	None	Unknown
Mohave County								
(B-34-14)21	Grand Gulch Mine	15,701 tons of ore produced 1901-1951, ore contains silver, copper, uranium. 1-10 ppm U3O8 detected in rock samples. AZMapper indicates that this mine is in a uranium mining district. (1, 3I, 3V)	BLM and Private	Not Reported	No	None	None	None
(B-23-21)12 and (B-24-21)5 and 13	Unnamed Area	Uranium detected at 19-25 ppm in panned ore concentrate samples. (3W)	BLM	Not Reported	No	One domestic	None	Unknown
Navajo County								
34°00'35"N, 110°28'10"W near (A-07-18)18	Unnamed H	Development includes a highway roadcut, analysis reported 10 to 80 ppm uranium and 0.03% Cu, no production reported. (2)	White Mountain Apache Reservation	Not Reported	No	None	<¼ mile from Cibecue Creek	At least 70
Cadastral Location	Site Name	Site Description, Production, and Information Source	Owner	Uranium Content (Percent U3O8)	Wilderness Areas (1)	Wells (1)	Surface Water within 2 miles (1, 1A)	Residents within one mile (1)
Pima County								
(D-20-14)10d	Blacksmith Prospect	No production reported. Uranium detected at <10-17 ppm in a sample from the dump. (3D)		Not Reported	Yes, Mt Wrightson Wilderness Area			
(D-16-12)07-10, 14, 15, 17-20, 22, 23, 26, and 27	England-Will-Bixby Group	Development includes a small open pit, analysis of heavy mineral separate reported 4.95% - 11.8% U3O8, no production reported. (2)	San Xavier Reservation	Not Reported	No	About 50 domestic	None	At least 300

Cadastral Location	Site Name	Site Description, Production, and Information Source	Owner	Uranium Content (Percent U3O8)	Located in a Wilderness Area? (1)	Wells (1)	Surface Water within 2 miles (1, 1A)	Residents within one mile (1)
(D-19-14)24d and 25a	Jackson Group	Shafts, drifts, and crosscuts. Uranium was detected at <10-16 ppm in a sample from the dump. (3D)		Not Reported				
31°54'30"N, 111°39'40"W near (D-17-07)32	Juanita	Development includes a prospect pit and a dozer cut, no production reported. (2)	Tohono Reservation	0.003	No	None	None	Unknown
(D-12-16)33	Near Valerie May Prospect	Uranium detected at 10-40 ppm in a sample from the dump. (3X)		Not Reported	Yes, Adjacent to Pusch Ridge Wilderness Area			
Pinal County								
(D-10-15)23	Burney Claim	Development Unknown. Uranium was detected at 40-72 in a sample from the stockpile. (3X)	Coronado NF	Not Reported	No	None	Canada Del Oro	Unknown
(D-10-16)18	Carolina Moon Group	Uranium detected at 11-40 ppm in a samplefrom the dump. Uranium below PRG in the tailings samples. (3X)	Coronado NF and Private	Not Reported	No	8 domestic	Canada del Oro and Peppersauce Wash	At least 2
(D-10-15)14	Gold Hill Mine	Produced silica flux for the Hayden Smelter. Uranium was detected at 20-31 ppm in a sample from the dump. (3X)	Coronado NF	Not Reported	No	One domestic	Canada Del Oro	Unknown
Cadastral Location	Site Name	Site Description, Production, and Information Source	Owner	Uranium Content (Percent U3O8)	Located in a Wilderness Area? (1)	Wells (1)	Surface Water within 2 miles (1, 1A)	Residents within one mile (1)
Santa Cruz County								
(D-21-15)20	Adolfo Compromise	Development unknown. Uranium detected at 30-46 ppm in a sample from the dump. (3D)	Coronado NF and Private	Not Reported	No	None	None	Unknown
(D-23-15)26	Big Lead Mine	Development unknown. Uranium detected at 20-35 ppm in a sample from the dump. (3R)	Coronado NF	Not Reported	No	2 domestic	None	Unknown
(D-22-09)02	Big Red Tugsten	Development unknown. Uranium detected at 20-32 ppm in a sample from the dump. (3E)	Coronado NF	Not Reported	No	2 domestic	None	Unknown
(D-24-12)02	Big Steve Mine	Development unknown. Uranium detected at 20-32 ppm in a sample from the dump. (3E)	Coronado NF	Not Reported	No	One domestic	None	Unknown
(D-22-10)08	Contact Mine	Development unknown. Uranium detected at 43-50 ppm in a sample from the dump. (3E)	Coronado NF and Private	Not Reported	No	4 domestic	None	Unknown
(D-22-10)05	Deer Mine	Development unknown. Uranium detected at 40-50 ppm in a sample from the stockpile. (3E)	Coronado NF and State	Not Reported	No	18 domestic	None	Unknown
(D-21-15)08	Dixie Mine	Development unknown. Uranium detected at 17-20 ppm in a sample from the dump. (3D)	Coronado NF and Private	Not Reported	No	One domestic	None	Unknown

(D-22-16)33	Great Silver Mine	Development Unknown. Uranium detected at 30-42 ppm in the ore pile. (3R)	Coronado NF	Not Reported	No	2 domestic	None	Unknown
(D-22-17)14	Hale # 3 Prospect	Development Unknown. Uranium detected at 20-30 ppm in a sample from the dump. (3R)	Coronado NF	Not Reported	No	None	Redrock Canyon	Unknown
(D-22-17)14	La Plata Mine	Development Unknown. Uranium detected at 17-80 ppm in a sample from the stockpile. (3R)	Coronado NF	Not Reported	No	None	Redrock Canyon	Unknown
(D-19-15)01c	Lexington Mine	Development includes open cuts, an adit, and an inclined shaft. Probably produced gold, silver, and lead, Uranium detected at 4.2-60 ppm in a sample from the dump. (3D)		Not Reported	No			
(D-22-10)05	MCM Mine Group	Development Unknown. Analysis reported 34-50 ppm in a sample from the stockpile. (3E)	Coronado NF	Not Reported	No	18 domestic	None	Unknown
(D-20-15)32	Mohawk Mine	Development Unknown. Urnaium detected at 18-40 ppm in samples from the dump. (3D)	Coronado NF	Not Reported	Yes, Mt. Wrightson Wilderness Area	None	<¼ mile from Temporal Gulch	Unknown
(D-23-12)35	Morning and Evening	Development Unknown. Uranium detected at 30-70 ppm in samples from the dump. (3E)	Coronado NF	Not Reported	No	2 domestic	Pena Blanca Lake	Unknown
Cadastral Location	Site Name	Site Description, Production, and Information Source	Owner	Uranium Content (Percent U3O8)	Located in a Wilderness Area? (1)	Wells (1)	Surface Water within 2 miles (1, 1A)	Residents within one mile (1)
(D-20-14)29	Montosa Mine	Development Unknown. Uranium detected at 40-68 ppm in a sample from the dump. (3D)	Coronado NF and Private	Not Reported	No	One municipal	Agua Caliente Canyon, Cottonwood Canyon	At least 1
(D-24-12)02-03	Sunset Mine Group	Development Unknown. Uranium detected at 30-90 ppm in samples from the dump. (3E)	Coronado NF	Not Reported	No	None	Pena Blanca Lake	Unknown
(D-22-18)33	Unnamed Prospects	Development Unknown. Uranium detected at 22-250 ppm in samples from the pit. (3R)	Coronado NF	Not Reported	No	2 domestic	None	Unknown
(D-21-15)34	Unnamed Area	Development Unknown. Uranium detected at 23-30 ppm in a sample from the dump. (3D)	Coronado NF and Private	Not Reported	No	2 domestic	None	Unknown
		Ag - Silver	BLM - US Bureau of Land Management					
		Au - Gold	NF - National Forest					
		Cu - Copper	NRA - National Recreation Area					
		Pb - Lead						
		ppm - Parts per Million						
		U3O8 - Triuranium Octaoxide						
		V2O5 - Vanadium Pentoxide						

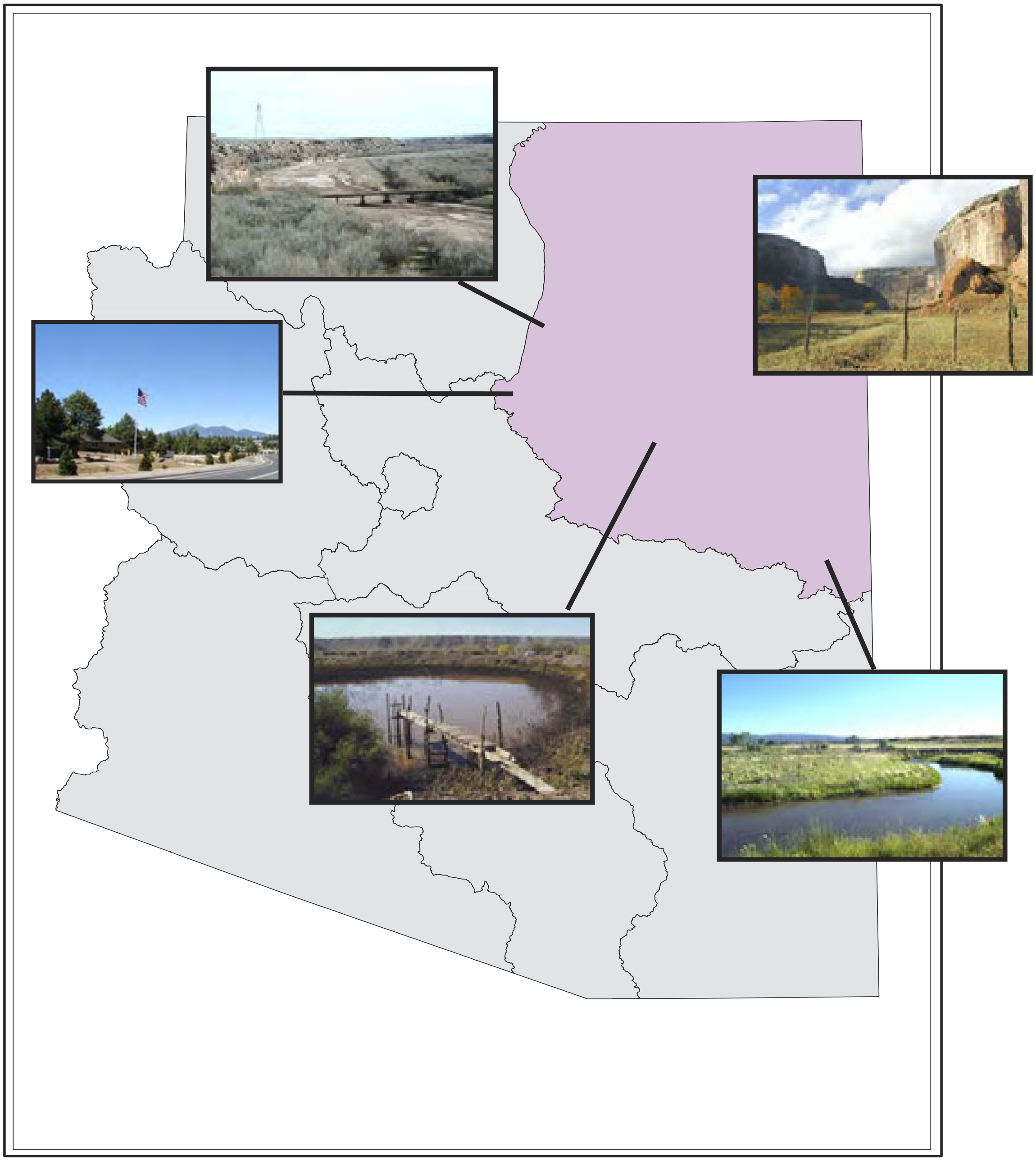
ADWR 2006

Arizona Department of Water Resources, Arizona Water Atlas, Volume 2, Eastern Plateau Planning Area, Draft, June 2006.

ARIZONA WATER ATLAS

VOLUME 2

EASTERN PLATEAU PLANNING AREA



Arizona Department of Water Resources

DRAFT

JUNE 2006

ARIZONA WATER ATLAS
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PREFACE

Volume 2, the Eastern Plateau Planning Area, is the second in a series of nine volumes that comprise the Arizona Water Atlas. The primary objectives in assembling the Atlas are to present an overview of water supply and demand conditions in Arizona, to provide water resource information for planning and resource development purposes and help to identify the needs of communities.

The Atlas divides Arizona into seven planning areas (Figure 2-1). There is a separate Atlas volume for each planning area, an introductory volume composed of background information, and an executive summary volume. "Planning areas" are an organizational concept that provide for a regional perspective on supply, demand and water resource issues. A complete discussion of Atlas organization, purpose and scope is found in Volume 1.

There are additional, more detailed data available to those presented in this volume. They may be obtained by contacting the Arizona Department of Water Resources' Statewide Conservation and Strategic Planning Division.

SECTION 2.0 Overview of the Eastern Plateau Planning Area

The Eastern Plateau Planning Area is unique in that it is composed of one groundwater basin, the Little Colorado River Plateau Basin. The planning area is relatively high in elevation and is geographically diverse with the highest peaks in the state as well as deep sandstone canyons and large mesas. Parts of three counties are contained within the Eastern Plateau Planning Area: Apache, Coconino and Navajo counties. Flagstaff is the largest metropolitan area and is growing rapidly, as are a number of communities in the White Mountains and on the Navajo Reservation. The planning area has a large industrial water use sector due to several electrical generating stations, large coal mining operations and a paper mill. Agricultural irrigation is relatively small-scale in terms of acreage but is a large water use sector. The Joseph City Irrigation Non-expansion Area (INA), an area designated as having insufficient groundwater to provide a reasonably safe supply for irrigation, is located in the Planning Area. Two-thirds of the land area is under tribal ownership. For this reason, tribal water resource and other characteristics are discussed separately in a number of cases in this volume. Major cities and towns, counties and the boundaries of the INA are shown on Figure 2-2.

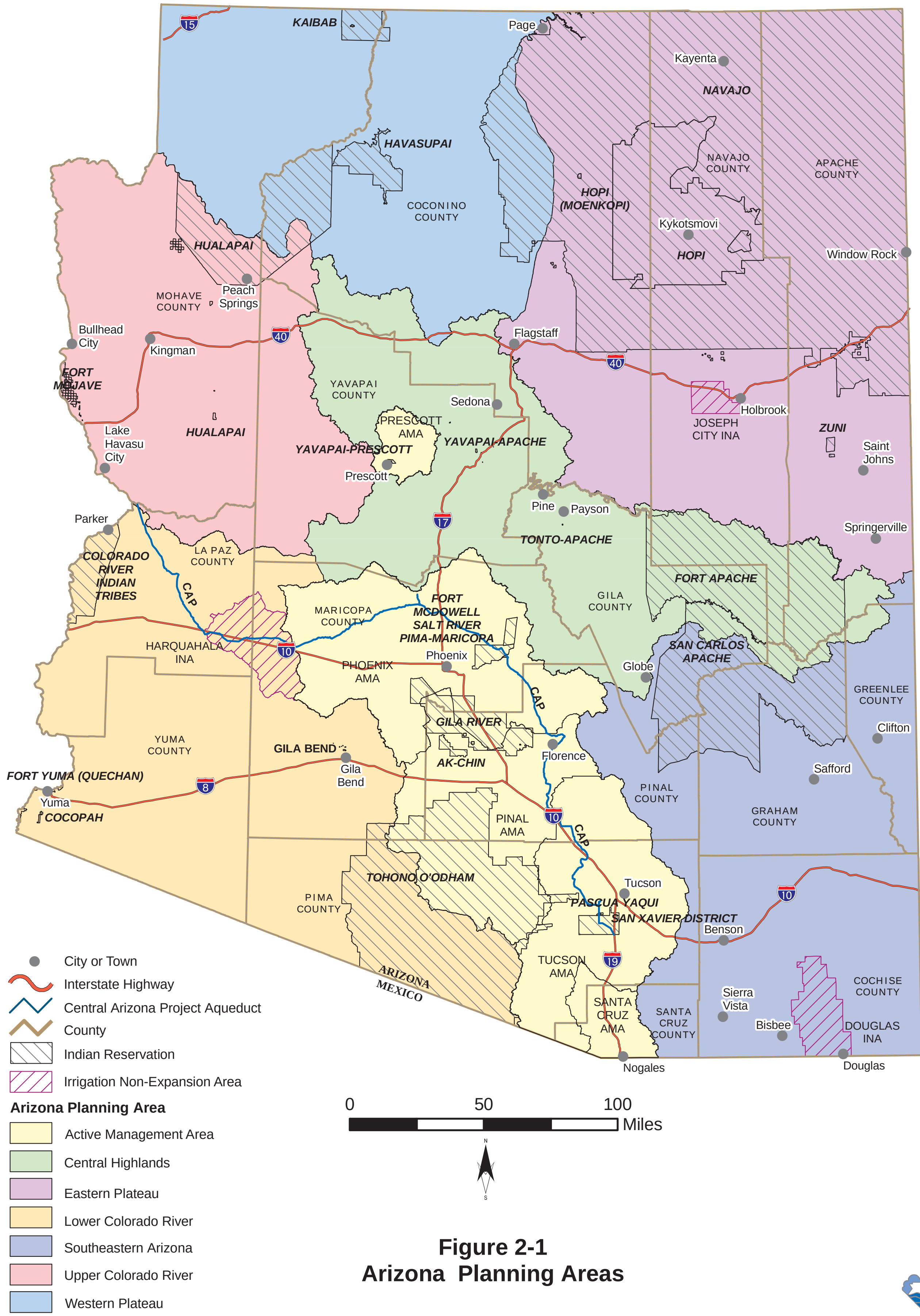

Figure 2-1
Arizona Planning Areas

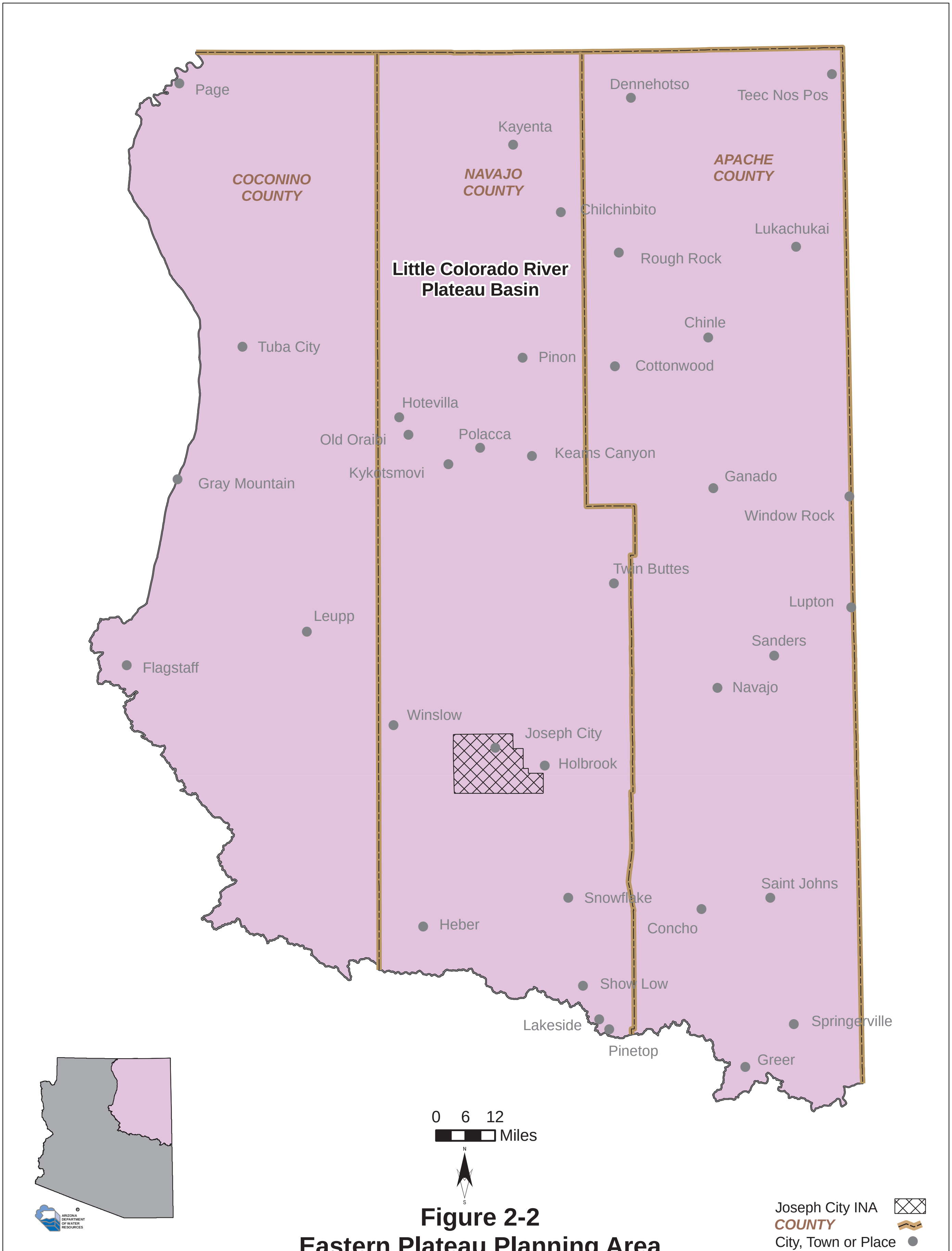

Figure 2-2
Eastern Plateau Planning Area

2.0.1. Geography[1]

The Eastern Plateau Planning Area includes the northeastern corner of the state and is within the Plateau Uplands physiographic province. This province covers the northern 2/5 of Arizona and is characterized by mostly level, horizontally stratified sedimentary rocks that have been eroded into canyons and plateaus, and by some high mountains. Major mountain ranges are the San Francisco Peaks near Flagstaff, the White Mountains in the southeastern portion of the planning area and the Chuska and Lukachukai mountains located along the Arizona-New Mexico border. The Chuskas reach an elevation of almost 10,000 feet. Much of the rain and snow that falls in the Chuskas drains westward into Canyon de Chelly. The Hopi reservation is characterized by three mesas that rise to an elevation of 7,200 feet. Elevations vary from over 12,600 feet at Humphreys Peak near Flagstaff, the state's highest point, to 4,200 feet at Cameron, about ten miles north of Gray Mountain. The average elevation of the planning area is 6,061 feet.

The planning area is about 26,700 square miles and is bounded on the south by the Mogollon Rim, on the north by the Arizona-Utah border, on the east by the Arizona-New Mexico border and on the west by the Coconino Plateau Basin and Paria Basin, whose boundaries coincide closely with U.S. Highway 89 (Figure 2-1). The Mogollon Rim is an escarpment almost 2,000 feet high in some places, extending from central Arizona to the Mogollon Mountains in New Mexico. It forms a hydrologic boundary between the Eastern Plateau Planning Area and the basins of the Central Highlands and Southeastern Arizona Planning Areas.

The Little Colorado River is the main drainage for the basin, flowing from the White Mountains area and leaving the basin near Cameron. The northern third of the Eastern Plateau Planning Area/Little Colorado River Plateau Basin drains northward toward the San Juan River as part of the Colorado River watershed. In this area, Chinle Creek collects the majority of the surface water runoff. The southern two-thirds of the basin are within the Little Colorado River watershed. Streams and runoff in this area generally flow toward the Little Colorado River.

2.0.2 Hydrogeology[2]

There are several local aquifers and 3 regional aquifers in the Eastern Plateau Planning Area that contain large amounts of groundwater in storage. (See Figure 2-19 for the location of large local and regional aquifers). These sedimentary formations of sandstone and limestone are stacked on top of one another and are generally separated by impermeable shales and siltsones. In descending order, the regional aquifers are the D-, N-, and C-aquifers. Each has a very large areal extent within the basin and except for the D and N aquifers, there is little vertical hydrologic connection between them. These water-bearing formations gain thickness towards the center of the basin resulting in artesian conditions. Main recharge areas are along the southern and eastern periphery of the planning area. It is estimated that there are about 508 million acre-feet (maf) in storage in Little Colorado River Plateau aquifers (ADWR, 1990). Figure 2-3 shows a generalized cross-section of the water bearing formations of the planning area.

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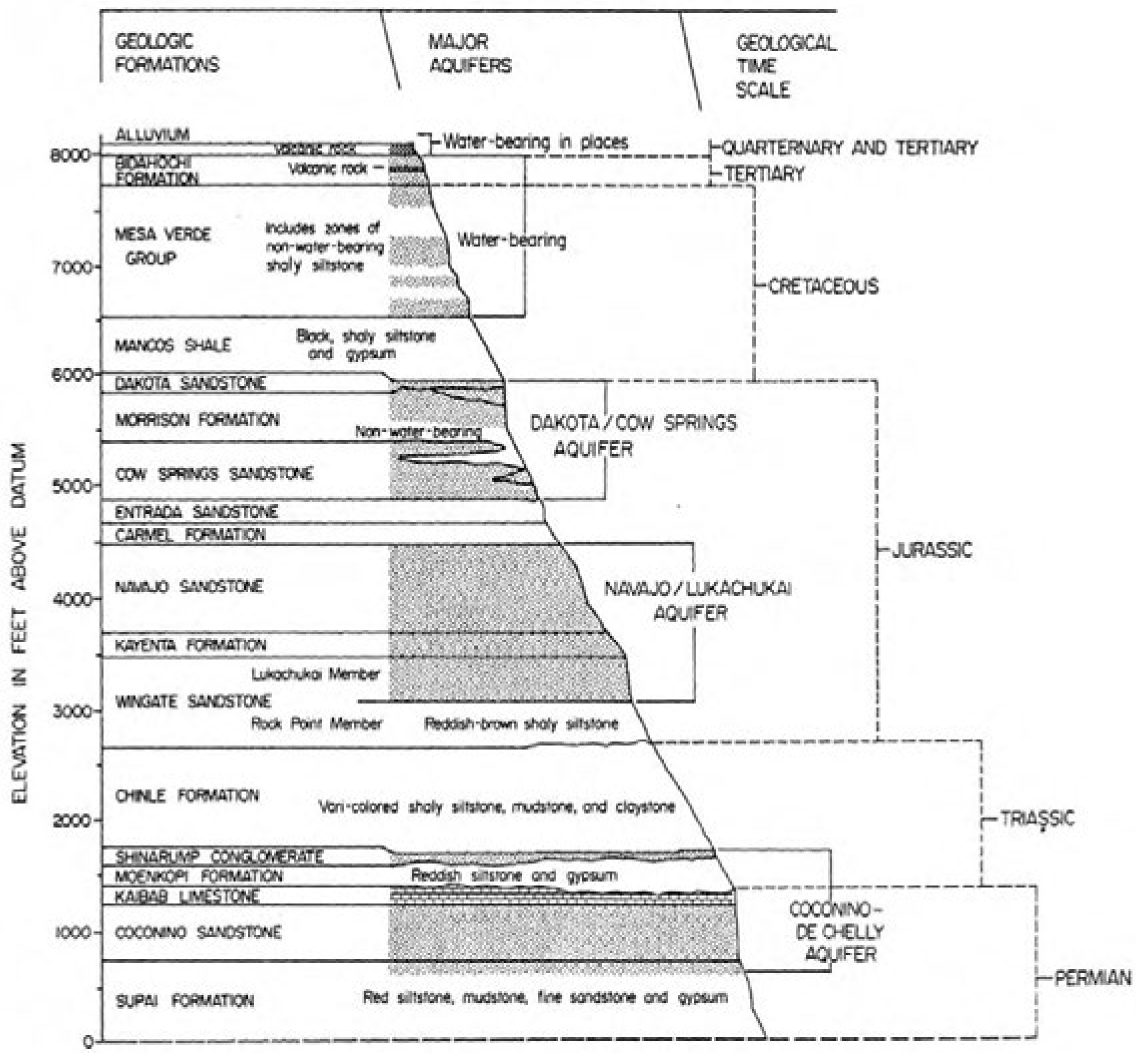
[1] Much of the information in this section is taken from the Arizona Water Resources Assessment, Volume 1, ADWR August, 1994.
[2] ibid

Figure 2-3 Water Bearing Formations of the Little Colorado River Plateau Basin



The C-aquifer is the largest and most productive aquifer in the planning area with an areal extent of 21,655 square miles. It is named for its primary water-bearing unit, the Coconino Sandstone. It is utilized as a supply south of the Little Colorado River and along the eastern edge of the basin by Flagstaff, Heber, Overgaard, Show Low, Snowflake and Concho. North of the river the C-aquifer is too deep to be economically useful or is unsuitable for most uses because of high concentrations of total dissolved solids. The Department estimated that 413 maf are stored in the aquifer (ADWR, 1989).

The N-aquifer occurs north of the Little Colorado River and has an areal extent of 6,250 square miles. Storage estimates vary from 166 maf to 293 maf (ADWR, 1989 and USGS, 1996). Navajo Sandstone and Wingate Sandstone are the main water-bearing units in the aquifer. It is generally unconfined but there are artesian conditions in the Black Mesa area and near Window Rock. This aquifer is utilized for the Black Mesa Coal Mine slurry pipeline. N-aquifer water quality is good and is a source of supply for the Navajo and Hopi reservations.

The D-aquifer is the smallest in areal extent, occurring over about 3,125 square miles. It is estimated that there are 15 maf in storage (ADWR, 1989). The D-aquifer is composed of the Dakota, Cow Springs and Entrada sandstones. There is some connection to the underlying N-aquifer. Water quality is marginal to unsuitable for domestic use due to high concentrations of dissolved solids. Nevertheless, it is utilized in the north-central parts of the planning area for domestic use.

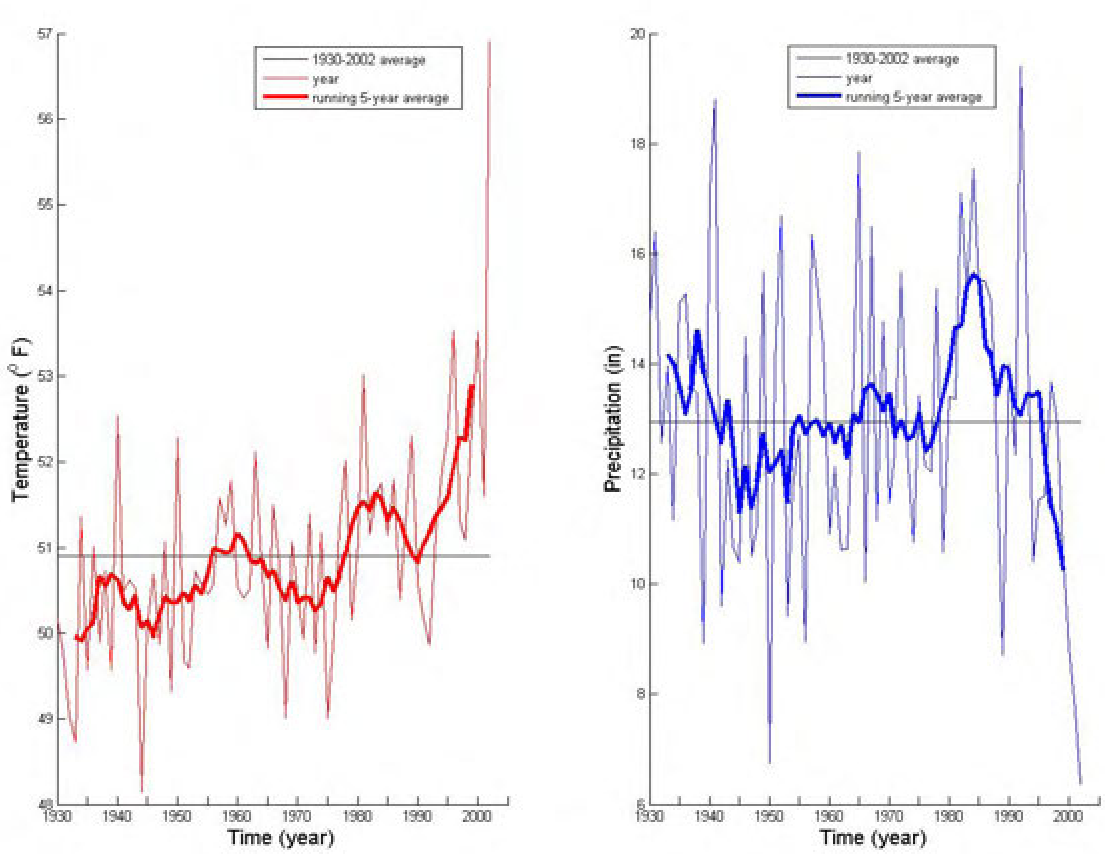
Local aquifers are important for domestic uses where the regional aquifers are too deep or have unsuitable water quality. Local aquifers include alluvial deposits that occur along washes and stream channels, including along the Little Colorado River and its tributaries, sedimentary and volcanic rocks of the Bidahochi and other formations, and some sandstones. The Bidahochi formation forms a local aquifer in the central part of Apache and Navajo Counties and south of Sanders. In the southeastern part of Navajo County, saturated basaltic rocks together with underlying sedimentary rocks are locally known as the Lakeside-Pinetop aquifer, which is an important supply for the area. Undifferentiated sandstones west of Show Low along the Mogollon Rim and in the Springerville-Eager area form aquifers that are also locally important supplies. In the Fort Valley area near Flagstaff, a perched aquifer at a depth of a few hundred feet is utilized (PMCL, 2002). The San Francisco Peaks caldera, known as the Inner Basin, contains an aquifer that supplies much of the municipal water for the city of Flagstaff (http://cpluhna.nau.edu).

Surface water is an important supply in some areas, but is geographically limited. The Little Colorado River, the main drainage in the planning area, was formerly perennial throughout its length, but it now flows perennially only from its headwaters to Lyman Lake, north of Springerville (Tellman, et al. 1997). This is primarily due to impoundments, diversions and falling groundwater levels from well pumping. On the Navajo reservation, two-thirds of the average annual surface water originates in the Chuska Mountains and the Defiance Plateau (http://cpluhna.nau.edu). Surface water at higher elevations in the southern part of the planning area is available for agricultural use. Colorado River water is the water supply for Page and neighboring LeChee. When there is sufficient rain and snow, surface water is stored in lakes near Flagstaff and used as a municipal supply.

2.0.3 Climate

The Eastern Plateau Planning Area is a semi-arid, relatively high elevation region with cooler average temperatures than in other parts of Arizona. Average annual maximum temperatures in the planning area range from 61˚ F at Greer to 82˚F at Cameron. Annual average temperature is 50.8°F, compared to the state-wide average of 59.9°F. Eastern Plateau temperatures display a long-term warming trend (Figure 2-4), as in other parts of Arizona.

Figure 2-4 Average Temperature And Total Precipitation In The Eastern Plateau Planning Area From 1930-2002.

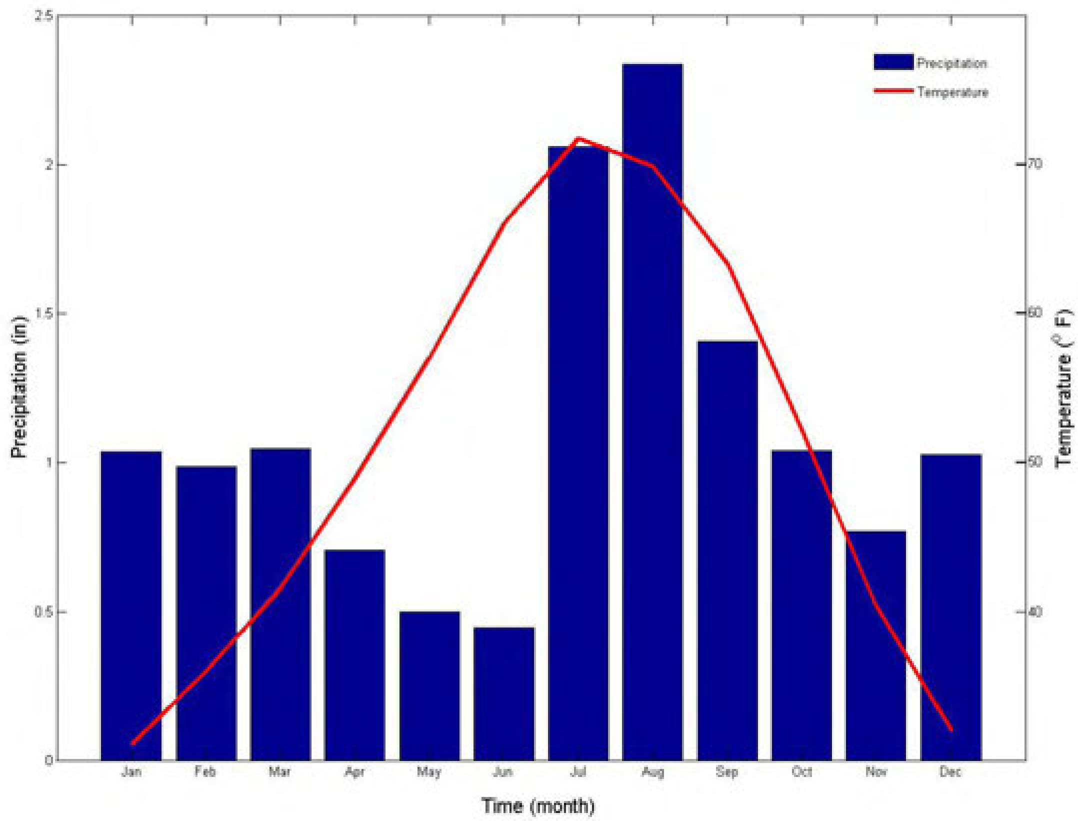


Horizontal lines are average temperature (50.8 °F) and precipitation (13.0 inches), respectively. Light lines are yearly values and highlighted lines are 5-year moving average values. Data are from selected Western Regional Climate Center cooperative weather observation stations located south of the Little Colorado River. (http://www.wrcc.dri.edu/summary/climsmaz.html). Figure author: Ben Crawford, CLIMAS

Parts of the Eastern Plateau downwind of the Central Highlands Planning Area receive diminished precipitation due to the "rain shadow effect." As moisture-laden air flows over topographic features such as mountain ranges, the air is lifted and cooled, resulting in greater precipitation on the windward side of the mountain. In contrast, the leeward side of mountain ranges receives much less precipitation as the air sinks, warms, and dries, creating a "rain shadow."

Precipitation in the Eastern Plateau is characterized by a multi-peaked distribution similar to much of Arizona (Figure 2-5). Precipitation is highest during July and August when the area receives over 43% of yearly precipitation, while the driest months on average are April, May, and June. Average annual precipitation ranges from about 4 inches at Monument Valley in the far northeastern part of the planning area to 36 inches in the White Mountains, Mogollon Rim and San Francisco Peak areas. Most of the Navajo and Hopi Reservation lands receive less than 10 inches of rainfall a year. The highest precipitation on the Navajo reservation is in the Chuska Mountains with an average annual precipitation of 25 inches (Navajo Nation, 2001).

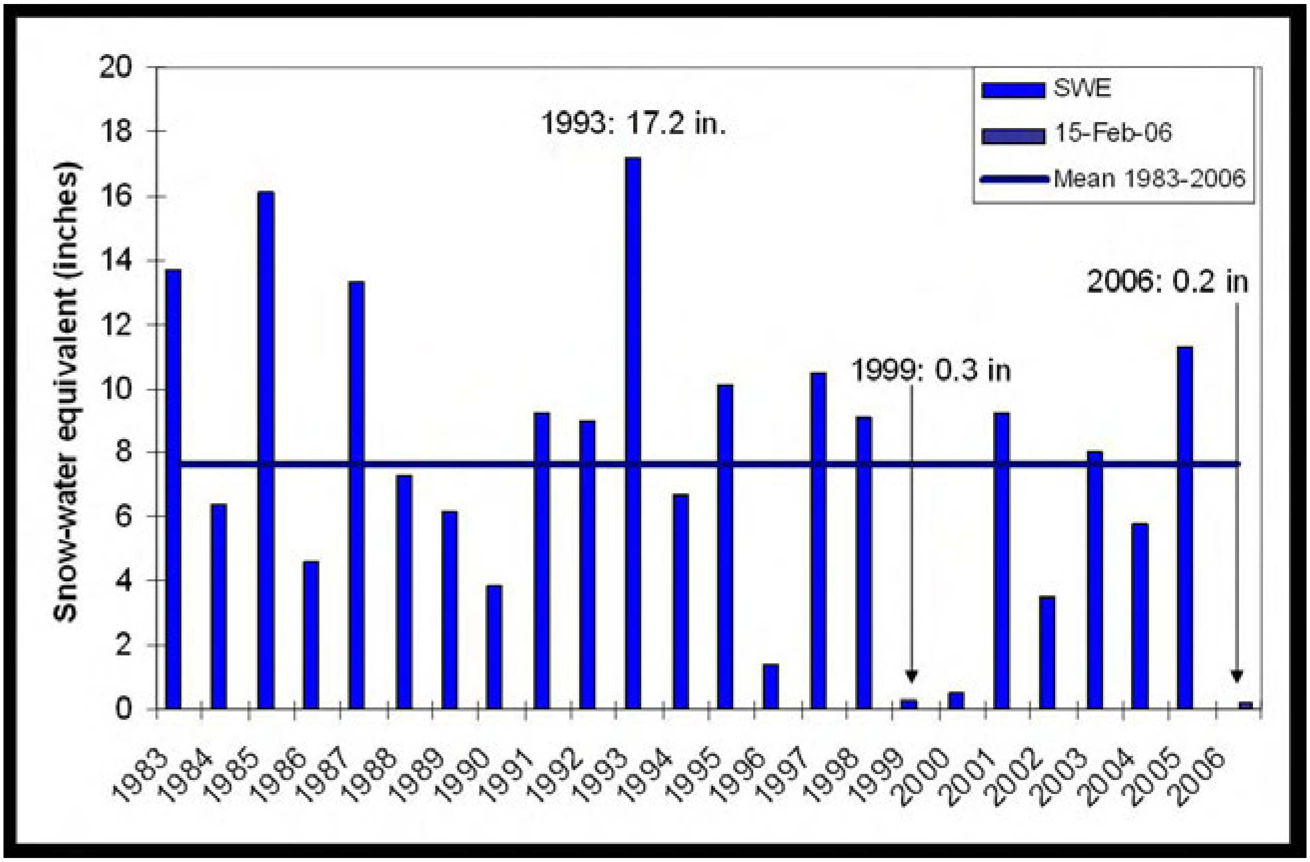
Figure 2-5 Average Monthly Precipitation and Temperature In The Eastern Plateau Planning Area, 1930-2002.



Data are from selected Western Regional Climate Center cooperative weather observation stations located south of the Little Colorado River. (http://www.wrcc.dri.edu/summary/climsmaz.html). Figure author: Ben Crawford, CLIMAS.

Much of the state's snowfall occurs along the Mogollon Rim and White Mountains in the Eastern Plateau and Central Highlands Planning Areas. Snowfall is an important water source and is often defined in terms of snow-water equivalent (SWE). SWE is dependent on snow density and describes the amount of liquid water present in a melted sample of snow; light, powdery snow yields less water than dense wet snow. Observations recorded March 1st from 1983 to 2006 at Mt. Baldy in the southeastern portion of the region show SWE variations from 1983 to the present (Figure 2-6). The Mt. Baldy record shows relatively high snow pack during the 1980s and early-to-mid 1990s, followed by substantially lower snow pack since 1999.

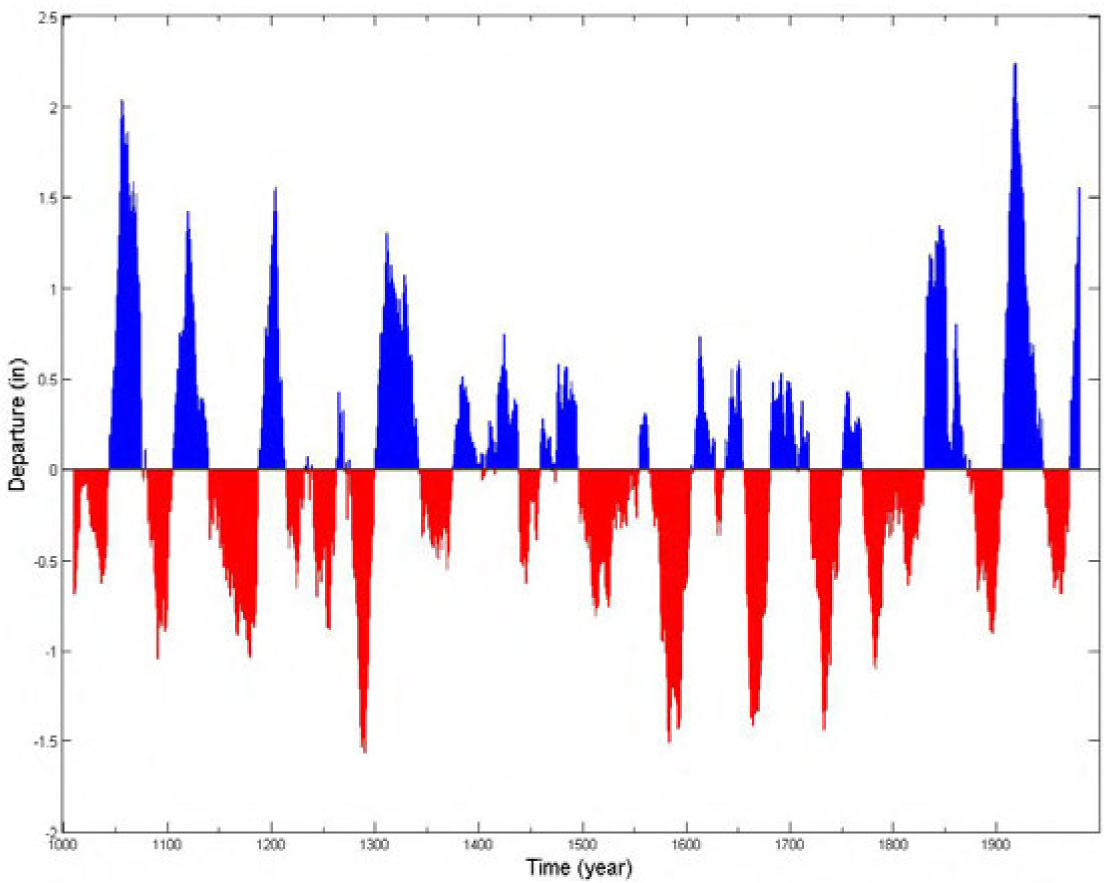
Figure 2- 6 Mt. Baldy Snow-Water Equivalent (SWE) for 1983-2006.



Observations were recorded March 1st for each year except 2006, where February 15 was used. The horizontal, bold line is average SWE from 1983-2006 and highest SWE years (1993) and lowest SWE years (1999 and 2006) are highlighted. Figure author: Casey Thornbrugh, CLIMAS

Two important features of precipitation in this region are variability between individual years, and shifts between wetter and drier than average periods on longer, 10-20 year (decadal) time scales (Figure 2-4 and Figure 2-7). For example, there have been multiple extended periods of above and below-average winter precipitation during every century since 1000 A.D. (Figure 2-7). The 1200s, 1500s, and 1700s were notably dry; in contrast, the mid-1000s, early 1300s, and early 1900s were notably wet. More recently, the 1950s were relatively dry, whereas the 1980s received above-average precipitation (Figure 2-4). These decadal shifts are related to circulation changes in the Pacific Ocean. On time scales of 2-7 years, the well-known El Niño-Southern Oscillation (ENSO) in the Pacific Ocean, with its phases of El Niño and La Niña, is associated with precipitation variations in the region, most notably during winter months (November-April). During El Niño episodes, there is a greater likelihood of increased precipitation; nevertheless El Niño winters can produce below-average precipitation. Generally, La Niña conditions are associated with drought in the region.

Figure 2-7 Arizona NOAA Climate Division 2 (Northeastern Arizona; Coconino, Navajo, and Apache Counties) winter (November-April) precipitation departures from average, 1000-1988, reconstructed from tree rings.



Data are presented as a 20-year moving average to show variability on decadal time scales. The average winter precipitation for 1000-1988 is 6.1 inches. Data: Fenbiao Ni, University of Arizona Laboratory of Tree-Ring Research and CLIMAS. Figure author: Ben Crawford, CLIMAS.

2.0.4 Environmental Conditions

A wide diversity of habitats occurs in the Eastern Plateau Planning Area. Semi-arid grasslands are the largest vegetative community. Other communities include semi-arid scrub vegetation, which predominates along the lower valley of the Little Colorado River near Holbrook, pinyon-juniper woodlands, ponderosa pine forest and mixed-conifer forest communities at high elevations. The forest stretching from near Flagstaff along the Mogollon Rim to the White Mountains region is the largest ponderosa pine forest on the continent. Above about 9,000 feet there are many subalpine grassland parks. Narrow riparian habitats are found in a few areas, primarily along the Little Colorado River and Silver Creek (Abruzzi, http://cpluhna.nau.edu/Research).

Due to grazing and fire suppression efforts, pre-settlement environmental conditions have been permanently altered in the region. Woodland communities have expanded considerably and the increase in ponderosa pine density has led to both an increase in the severity and size of wildfires, and to a decrease in stream and spring flows due to less soil absorption of precipitation (Covington, et al. http://cpluhna.nau.edu/Research).

Grazing and other activities have also impacted riparian areas. A number of riparian restoration activities in the Eastern Plateau have been funded by the Arizona Water Protection Fund Program (AWPF) since its inception in 1996. The objective of the AWPF program is to provide funds for protection and restoration of Arizona's rivers and streams and associated riparian habitats. Twenty-five projects were funded in the planning area through 2005. Many of these were for the purpose of fencing and for stream and watershed restoration. A list of projects and types of projects funded in the Eastern Plateau Planning Area through 2005 is found in Appendix A of this volume. (A description of the program, a complete listing of all projects funded, and a reference map is found in Appendix C of Volume 1).

Four applications for instream flow claims have been filed in the Eastern Plateau Planning Area, listed in Table 2-1. An instream flow right is a non-diversionary appropriation of surface water for recreation and wildlife use. As shown in Figure 2-8, the length of the instream flow claims for Chevelon Creek and East Clear Creek are extensive. All claims are located in creeks south of the Little Colorado River.

Table 2-1 Instream flow claims in the Eastern Plateau Planning Area

Map Key	Stream	Applicant	Application No.	Permit No.	Certificate No.	Filing Date
1	Billy Creek	Cartier, David N.	33-94853.0	Pending	Pending	9/14/1989
2	Billy Creek	Walker, F. Duane	33-94847.0	Pending	Pending	9/14/1989
3	Chevelon Creek	Apache-Sitgreaves National Forest	33-96707.0	Pending	Pending	2/13/2002
4	East Clear Creek	Coconino National Forest	33-90107.0	Pending	Pending	7/29/1985

There are a number of listed threatened and endangered species that may be present in the Eastern Plateau Planning Area. Those listed by the USFWS as of January 2006 are shown in Table 2-2. Presence of a listed species may be a critical consideration in water resource management and supply development in a particular area. The USFWS should be contacted for details regarding the ESA, designated critical habitat and current listings.

Figure 2-8
Eastern Plateau Planning Area
Instream Flow Applications

Table 2- 2 Listed threatened and endangered species in the Eastern Plateau Planning Area

(Source: USFWS, 2005)

Common Name	Threatened	Endangered	Elevation/Habitat
Apache Trout	X		>5000 ft./cold mountain streams
Bald Eagle	X		Varies/large trees or cliffs near water
Black-footed ferret		X	<10,500 ft./grassland plains
California Brown Pelican		X	Varies/lakes and rivers
California Condor		X	Varies/high desert canyonlands and plateaus
Chiricahua Leopard Frog	X		3,300-8,900ft./streams, rivers, backwaters, ponds stock tanks
Little Colorado Spinedace	X		4,000-8,000 ft./moderate to small streams in pools & riffles
Loach Minnow	X		<8,000ft./benthic species of small to large perennial streams
Mexican Gray Wolf		X	4,000-12,000 ft. /chapparal, woodland, forests
Mexican Spotted Owl	X		4,100-9,000 ft./canyons, dense forests with multi-layered foliage structure
Navajo Sedge	X		5,700-6,000ft./silty soils at shady seeps and springs
Peebles Navajo Cactus		X	5,400-5,600 ft/gravely soils of the Shinarump conglomerate
San Francisco Peaks Groundsel	X		10,900ft+/Alpine tundra
Southwestern Willow Flycatcher		X	<8,500 ft./cottonwood-willow and tamarisk along rivers and streams
Zuni Fleabane	X		7,300-8,000 ft./selenium-rich red or gray detrital clay soils derived from the Chinle and Baca formations

2.0.5 Population

In 2000, about 55% of the planning area population resided in the non-reservation portion. Flagstaff is by far the largest community with 38% of the non-reservation population. As shown in Table 2-3, there are many rapidly growing communities including Show Low, Pinetop-Lakeside and Taylor in the White Mountain area and Flagstaff. Some communities grew more rapidly between 2000 and 2005 than during the previous ten year period. There are also rapidly growing communities on the Navajo reservation, with high growth rates in a number of smaller communities.

Table 2-3 Communities In The Eastern Plateau Planning Area with a 2000 Census population greater than 1,000.

Communities are listed from highest to lowest population according to the most recent reported year (2000 or 2005). Source: www.workforce.az.gov

Communities	1990 Census Population	2000 Census Population	Percent Change 1990-2000	2005 Pop. Estimate	Percent Change 2000-2005
Flagstaff	45,857	52,894	15.3	61,185	15.7
Show Low	5,020	7,695	53.3	9,885	28.5
Winslow	9,279	9,520	2.6	9,835	3.3
Page	6,598	6,809	3.2	7,110	4.4
Holbrook	4,686	4,917	4.9	5,425	10.3
Snowflake	3,679	4,460	21.2	4,935	10.7
Eager	4,025	4,033	0.2	4,435	10.0
Pinetop-Lakeside	2,422	3,582	47.9	4,165	16.3
Taylor	2,418	3,176	31.3	4,100	29.1
St. Johns	3,294	3,269	-0.8	3,865	18.2
Heber-Overgaard	1,581	2,722	72.2	NA	--
Springerville	1,802	1,972	9.4	2,065	4.7
Total > 1000	90,661	105,049	15.9	NA	--
Other	20,469	33,284	62.6	NA	--
Total Non-Indian	111,130	138,333	24.5	NA	--
Hopi Reservation	7,360	6,946	-5.6	NA	--
First Mesa/Polacca	1,108	1,124	1.4	NA	--
Navajo Reservation	90,964	104,565	14.9	NA	--
Tuba City	7,323	8,225	12.3	NA	--
Window Rock/Fort Defiance	7,795	7,120	-8.6	NA	--
Chinle	5,059	5,366	6.1	NA	--
Kayenta	4,372	4,922	12.6	NA	--
Kaibito	641	1,607	150.7	NA	--
LeChee	NA	1,606	NA	NA	--
Lukachukai	113	1,565	1,284.9	NA	--
Many Farms	1,294	1,548	19.6	NA	--
Ganado	1,257	1,505	19.7	NA	--
St. Michaels	1,119	1,295	15.7	NA	--
Dilkon	NA	1,265	NA	NA	--
Pinon	468	1,190	154.3	NA	--
Tsaile	1,043	1,078	3.3	NA	--
Total Planning Area	**209,454**	**249,844**	**19.3**	**NA**	**--**

2.0.6 Water Supply

Both surface water and groundwater are important water supplies for municipal, industrial and agricultural uses in the Eastern Plateau Planning Area. Due to recent drought conditions, some communities that historically used significant amounts of surface water, such as Flagstaff, have turned to more reliable groundwater supplies. Population growth, supply reliability and the desire for economic development is spurring interest in exploring long-term water supply augmentation options such as securing Colorado River water, constructing water conveyance pipelines, and acquiring lands with groundwater supplies. Effluent is also utilized by several communities for golf course and landscape irrigation.

Surface Water

Surface water is a municipal supply for the cities of Flagstaff and Page and for the town of Eager in the southeastern corner of the planning area. It is also utilized for agricultural irrigation by Indian and non-Indian users. Surface water from the Lake Mary reservoir system is an important municipal supply for the City of Flagstaff. Because surface water is drought sensitive, it can be unreliable, which has spurred interest in additional well drilling and development of groundwater supplies in the Flagstaff area. In wet years, Lake Mary has provided 70% of the City's water supply (PMCL, 2002).

The Salt River Project acquired the rights to the surface water in the C.C. Cragin Reservoir, formerly the Blue Ridge Reservoir, from the Phelps Dodge Corporation in February 2005 as part of the Gila River Indian Water Rights Settlement Act. In addition to satisfying obligations to the Gila River Indian Community, the reservoir will be used to supplement Salt River Project shareholders' water supply and as a water supply for northern Gila County (SRP, 2006). This supply is not available to users in the Eastern Plateau Planning Area.

The domestic water supply for the City of Page and the neighboring Navajo Nation Chapter of LeChee is obtained from Lake Powell through pumping and conveyance facilities first constructed in 1957. This water is available pursuant to a Colorado River Upper basin allocation of 2,740 acre-feet of consumptive use.[3] The existing raw water supply facilities marginally meet the current peak demands of the two communities during summer months. A new lake intake to increase capacity and groundwater well development are being considered to provide a more reliable supply (TETRA TECH RMC, 2003). In addition, the City of Page has requested an additional allocation of Colorado River water.

Springs are an important water supply for habitat, wildlife, domestic and cultural/religious purposes. The communities of Tuba City, Moenkopi and Ganado rely on springs for domestic and agricultural uses.

Groundwater

[3]"Consumption of water brought about by human endeavors….along with the associated losses incidental to these uses." USBOR, 2004, Colorado River System Consumptive Uses and Losses Report 1996-2000.

It is estimated that groundwater satisfies 90% of the water demand in the planning area. Groundwater is withdrawn from both large regional aquifers and from local and perched aquifers. Flagstaff pumps groundwater from the C-aquifer (Woody Mountain and Lake Mary wellfields) and from shallow volcanic aquifers: the Inner Basin. In 2005, Flagstaff purchased the Red Gap Ranch east of the city as a potential source of groundwater supplies. The cities of Holbrook and Winslow rely entirely on groundwater pumped from the C-aquifer. Groundwater from the C-aquifer and from local aquifers (Bidahochi and Lakeside-Pinetop aquifers) is also the principal water supply for municipal use in the Mogollon Rim region, including the communities of Heber, Pinetop-Lakeside, Show Low, Snowflake, Springerville, Eager, St. Johns and Greer.

North of the Little Colorado River, including on the Navajo and Hopi reservations, the N-aquifer, which is of good quality, is the primary water supply. In this area the C-aquifer is generally too deep and saline to be used. The D-aquifer underlies much of the Hopi and Navajo reservations and is utilized in some areas, however water quality is marginal due to high concentrations of dissolved solids. The community of Cameron pumps highly saline groundwater from wells near the Little Colorado River and treats it for use.

Effluent

The communities of Flagstaff, Flagstaff Ranch, Holbrook and Page use effluent for golf course and landscape irrigation. In 2003, over 1,600 acre-feet of effluent was used in the Flagstaff area. Reclaimed water is produced by both of the City's wastewater treatment plants. A total of 10 schools, 8 parks, 2 cemetaries, 3 golf courses and a playing field at Northern Arizona University receive treated effluent. In addition, a large industrial user, SCA Tissues, uses effluent in its paper production process. In 2004, the first year of utilization, effluent accounted for 85% of its supply (about 240 acre-feet). Flagstaff also has a reclaimed water hauling program (www.flagstaff.az.gov). Other communities in the planning area discharge effluent to fields for agricultural irrigation or to support wetlands (see Table 2-16).

Contamination Sites

Sites of environmental contamination may impact water supplies. An inventory of Department of Defense, Superfund (Environmental Protection Agency designated sites), Water Quality Assurance Revolving Fund (WQARF, state designated sites), Voluntary Remediation Program (VRP) and Leaking Underground Storage Tank (LUST) sites was conducted for the planning area. There are a number of LUST sites in the planning area. Sites are clustered in urban areas as shown in Figure 2-9. As mentioned in section 1.3.4 of Volume 1, shown are LUST sites where contamination is known or suspected and where remediation is required to meet soil and water quality standards. Four VRP sites are located in the planning area. Under this program, the property owner or other interested party initiates remedial or cleanup actions at a contaminated site on a voluntary basis. VRP sites are located near Flagstaff, Winslow, Joseph City and Springerville. Uranium Mine Tailings Remediation (UMTRA) sites are located on the Navajo reservation that are not mapped on Figure 2-9.

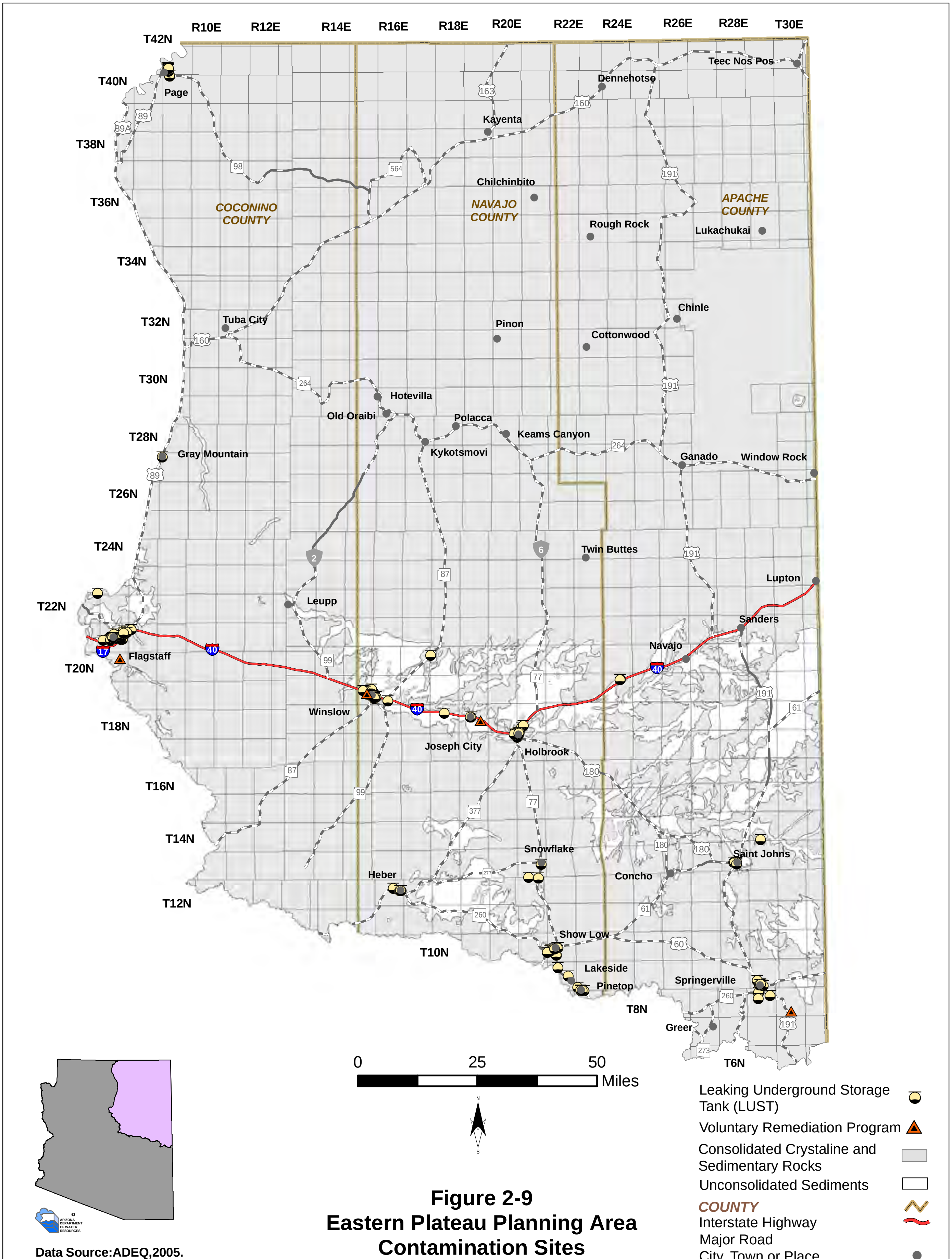
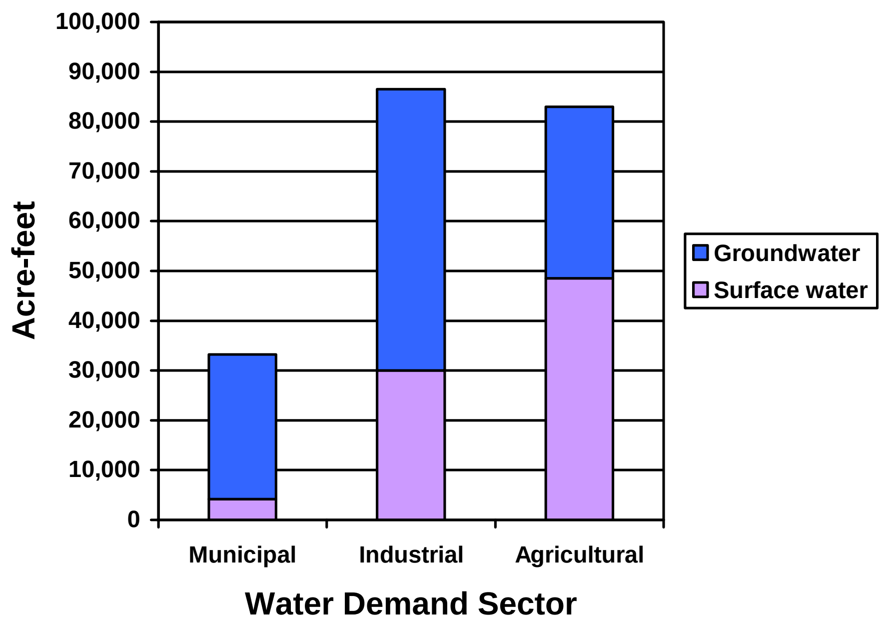


Figure 2-9
Eastern Plateau Planning Area
Contamination Sites

2.0.7 Cultural Water Demand

The municipal sector is the smallest water demand sector in the Eastern Plateau Planning Area with approximately 33,000 acre-feet of surface water and groundwater demand per year. Industrial demand is the largest use with about 86,500 acre-feet of demand a year, followed closely by agricultural use of about 83,000 acre-feet. As shown in Figure 2-10, surface water is utilized more extensively as a supply by the agricultural sector, accounting for almost 60% of the water supply. Effluent is also used to meet some demands. About 3,000 acre-feet were used in 2003 for municipal sector turf irrigation. Wastewater generated by the Abitibi paper mill near Heber is discharged to a dry lake where it is used to irrigate pasture.

Figure 2-10 Eastern Plateau Planning Area average 2001-2003 cultural water demand (acre-feet)



Municipal Demand

The primary municipal water demand centers in the planning area are located at Flagstaff, Winslow/Holbrook, Page and in the White Mountain/Mogollon Rim communities of Eager, Heber, Pinetop-Lakeside, Overgaard, Show Low, Snowflake, Springerville, St. Johns and Taylor. Estimated water demand in these areas served by public and private water providers is shown in Table 2-4 for each water demand center. Effluent is used by Flagstaff, Page, Eager and Holbrook for golf course and urban irrigation. Four golf courses, Aspen/Elden in Flagstaff, Hidden Cove Country Club in Holbrook and Lake Powell National in Page use 100% effluent from a municipal source.

An estimate of water demand associated with domestic/"self-supplied" wells is also listed in Table 2-4. This number is difficult to estimate. A population-based estimate rather than an estimate based on the number of domestic wells was used due to uncertainties regarding whether wells drilled are currently functioning. Water hauling is also common in unincorporated areas around Flagstaff and on the Navajo Reservation. Hopi and Navajo reservation demand was estimated using different per capita rates depending on the population density of the area as noted in the footnotes to the table.

Table 2-4 2003 municipal water demand in the Eastern Plateau Planning Area

WATER DEMAND CENTER	2003 Groundwater, Surface Water and Effluent Demand (acre-feet)		
Water Provider[1]	**Groundwater**	**Surface Water**	**Effluent**
Flagstaff Area	8,800	800	1,650
Heber-Overgaard/Forest Lakes	750	0	0
Page	0	3,120	440
Saint Johns/Concho	660	0	0
Show Low/Pinetop-Lakeside/Vernon	6,500	0	0
Snowflake-Taylor	2,160	0	0
Springerville/Eager	850	120	120
Winslow/Holbrook	4,200	0	75
Total Water Provider	**23,920**	**4,040**	**2285**
Domestic/Self-supplied[2]	**4,000**	**0**	**0**
Hopi Reservation[3]	**270**	**160**	**0**
Navajo Nation[4]	**6,900**	**NR**	**0**
Total Municipal	**35,090**	**4,200**	**2,285**

[1] Source; ADWR 2003 and 2004 water provider surveys; USGS and WIFA, 2005
[2] Unincorporated population of 33,284 @ 107 GPCD
[3] Moenkopi served by surface water; reported volume. Remainder of population, 6,045 @ 40 GPCD (from Table 3, Truini et al., 2005)
[4] Tuba City, Window Rock, Chinle and Kayenta population @ 94 GPCD (from pumpage data for Tuba City and Kayenta in Table 3, Truini et al., 2005). Census 2000 redistricting data for other Navajo communities found a population of 22,743 @ 65 GPCD (from pumpage data for Chilchinbito, Dennehotso and Rough Rock in Table 3, Truini et al., 2005). Remaining Navajo population of 56, 189 @ 40 GPCD (from Table 3, Truini et al., 2005).
NR = not reported; supply is utilized but volume not available.

Municipal water demand is primarily residential and commercial. Demand varies seasonally in some communities due to tourism and to summer-only landscape watering. Because of the higher elevation, shorter growing season, higher rainfall, and rural nature of many parts of the planning area, outdoor landscape watering is typically lower than that in the lower elevation, drier parts of the state. There have been significant conservation efforts in the Flagstaff area. Some of these programs target outdoor water use and landscape design, e.g. rebates for replacement of high water use landscaping. Estimated per capita usage in Flagstaff is 120 gallons per capita per day (GPCD), which is lower than many cities in Arizona (www.flagstaff.az.gov). Public municipal systems serve the majority of water demand in the planning area. Non-Indian large utility systems are listed in Table 2-5.

Table 2-5 Water providers serving 500 acre-feet or more of water per year, excluding effluent, in the Eastern Plateau Planning Area (Source: USGS, ADWR)

Water Provider	1991 (acre-feet)	2000 (acre-feet)	2003 (acre-feet)
Arizona Water Company-Lakeside	597	897	600
Arizona Water Company-Overgaard	183	337	500
Doney Park Water	455	737	751
Eager Municipal Water	680	781	685
Flagstaff, City of	8,172	9,927	8,493
Holbrook, City of	NA	NA	1,369
Page Municipal	2,740	2,740	3,000
St. Johns Municipal	NA	NA	557
Snowflake, Town of	872	1,323	1,473
Taylor, Town of	445	721	720
Winslow Municipal	NA	NA	2,762

NA = Not available

Major municipal demand centers on reservation lands include Chinle, Kayenta, Tuba City, and Window Rock/Fort Defiance on the Navajo reservation, and to a lesser extent, Polacca on the Hopi reservation. Specific amounts used in each community are not known. According to a 2002 Navajo Department of Water Resources (NDWR) report, approximately 40% of the population routinely hauls water for domestic and stock uses. According to the report, the Navajo Nation has the highest percentage of its population lacking potable water systems compared to any other region in the United States. Most municipal water supplies are groundwater (NDWR, 2002).

The Navajo Tribal Utility Authority (NTUA) is the largest public water provider on the Nation, which extends into New Mexico and Utah. Data for Arizona only was not available. Throughout the entire reservation, the NTUA operates more than 90 public water systems with approximately 24,000 connections, supplying more than 12,000 acre-feet of residential and 3,300 acre-feet of commercial water per year. It is estimated that smaller operators (NDWR and BIA) serve about 10,000 people and convey about 1,500 acre-feet of water. About 500 acre-feet of wastewater is used for dust abatement and construction. Other major uses are associated with coal mining on Black Mesa and electrical generation (NDWR, 2002).

Hopi municipal water use is assumed to be low. The Hopi village of Moenkopi, with a population of about 900, uses approximately 160 acre-feet of water from springs. Some of this may be used for irrigation. Assuming 40 GPCD (Truini, et al., 2005) for the approximately 6,000 Hopi tribal members living on other tribal lands, municipal water use is estimated at 430 acre-feet per year. The N-aquifer is the only aquifer of sufficient quality and accessibility to supply reliable drinking water to the Hopi villages on the three mesas (www.hopi.nsn.us).

Agricultural Demand

Agricultural demand is not well documented in the planning area. Estimates contained in this section are generally based on older reports or records. Cessation of some agricultural irrigation has occurred recently in the Hunt Valley area and near St. Johns due to purchase by the Zuni Tribe to preserve tribal water resources at Zuni Heaven, an historically riparian area sacred to the Zuni.

Areas of greatest non-Indian agricultural irrigation are near the communities of Saint Johns, Springerville, Snowflake/Taylor and Joseph City/Holbrook. Agricultural irrigation on the Navajo reservation is assumed served primarily by surface water and land is also dryland farmed. Dryland farming utilizes water harvesting techniques to catch and direct runoff to crops. Because there is no supplemental irrigation, both spring soil moisture and late summer precipitation are needed for success. It is estimated that approximately 34,000 acres in the planning area are actively irrigated with a combination of 83,000 acre-feet of surface and ground water. Agricultural demand is summarized in Table 2-6.

Table 2-6 Agricultural demand in selected years in the Eastern Plateau Planning Area

	1991	2000	2003
	Water Use (acre-feet)		
Non-Indian Total	**76,700**	**71,100**	**71,500**
Surface Water	39,700	37,000	37,000
Groundwater	37,000	34,500	34,500
Indian Total	**12,800**	**12,000**	**12,000**
Surface Water	12,400	11,600	11,600
Groundwater	400	400	400
TOTAL	**89,500**	**83,500**	**83,500**

Note: agricultural use and source is a general estimate derived primarily from older sources.
Estimated total 2003 active irrigated acres is 31,200 acres; 26,900 acres of non-Indian acreage and 4,300 acres of Indian acreage.

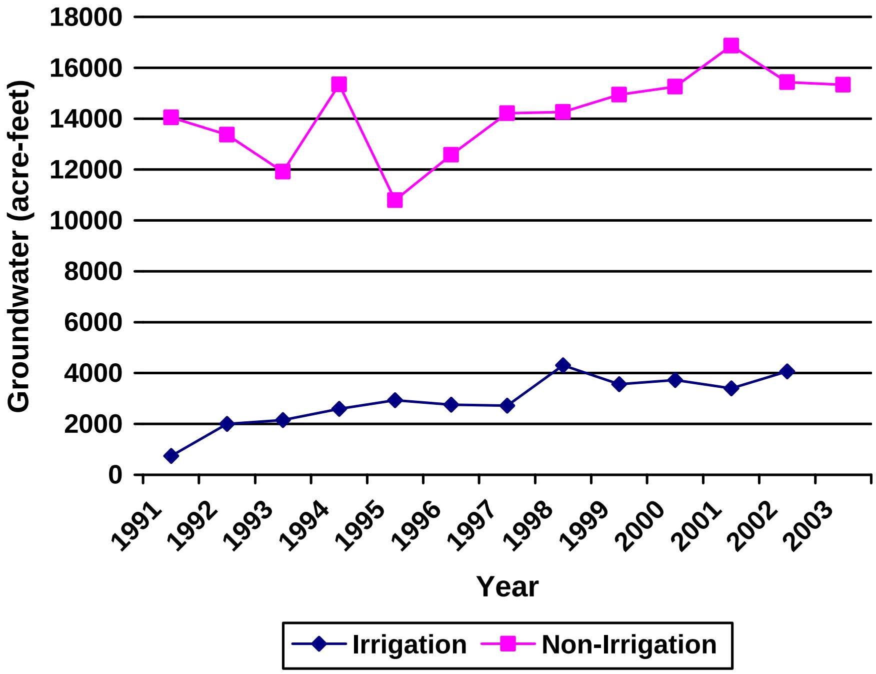
Silver Creek Watershed-Pinetop-Lakeside, Show Low, Snowflake

There are two irrigation companies in the Show Low/Pinetop-Lakeside area, the Show Low Pinetop Woodlands Irrigation Company and the Lakeside Irrigation System. The irrigation season is limited and irrigated lands are used for pasture, orchards and gardens. Commercial agriculture is declining in the area. The Silver Creek Irrigation District operates in the communities of Shumway, Taylor and Snowflake. Both areas are within the Silver Creek Watershed for which a Hydrographic Survey Report was filed with the Adjudication court in 1990. At that time, the investigations showed that almost 6,300 acres were irrigated with surface water and groundwater, using a total of almost 29,000 acre-feet per year.

Joseph City Irrigation Non-Expansion Area (INA)

The Joseph City INA was established in 1980 by the Arizona Groundwater Management Act. The area had previously been designated as a Critical Groundwater Area in 1974. Designation of an area as an INA recognizes that there is “insufficient groundwater to provide a reasonably safe supply for the irrigation of the cultivated lands at the current rate of withdrawal” A.R.S. § 45-402(22). Within an INA, irrigation with groundwater is restricted to lands that were irrigated prior to establishment of the area. Groundwater withdrawals by irrigation and large non-irrigation users, such as cities or golf-courses, must be reported annually to the Department. Irrigation and non-irrigation uses (primarily the Cholla Generating Station), are shown in Figure 2-11. Irrigation use in the INA is generally between 2,000 and 4,000 acre-feet a year, served by the Joseph City Irrigation Company. Complete data for 2003 was not available.

Figure 2-11 Groundwater withdrawals for irrigation and non-irrigation uses in the Joseph City INA, 1991- 2003.



Upper Little Colorado River-Springerville, Nutrioso, Greer, Vernon, St. Johns, Concho

The Department conducted an inventory of irrigation use in the Upper Little Colorado River watershed and published a report in 1994 (ADWR, 1994a). The inventory divided the area into ten regions: Nutrioso; Greer; Round Valley, including the Round Valley Water Users Association and Springerville Water Rights and Ditch Company; Vernon; St. Johns including Lyman Water Company and the St. Johns Irrigation Company; Concho, including Concho Water Company; Hunt; Hay Hollow; Woodruff, including the Woodruff Irrigation Company and Sanders. At that time 18,980 acres were irrigated with a total surface water and groundwater use of almost 35,000 acre-feet. The highest volumes of water use were in the St. Johns area (6,600 acre-feet) and in the Hunt Valley area, located west of St. Johns (3,800 acre-feet). The cropped acres were primarily pasture. No use was reported in the Sanders region. As mentioned previously, the Zuni tribe has recently purchased and retired agricultural lands in the Hunt Valley area and near St. Johns.

Lower Little Colorado River-Winslow, Holbrook, Heber, Flagstaff

The Department conducted an inventory of irrigation use in the Lower Little Colorado River watershed and published a report in 1994 (ADWR, 1994b). Similar to the Upper Little Colorado River watershed inventory, the area was divided into four regions, Winslow, Holbrook, Heber and Flagstaff. At the time of the inventory, (excluding the Joseph City Irrigation Company located in the Joseph City INA), about 3,700 acres were actively irrigated with a combination of 10,600 acre-feet of surface water and groundwater. Use was reported in three of the regions: 4,380 acre-feet per year at Winslow; 3,300 acre-feet per year at Heber; and 2,900 acre-feet per year at Holbrook. Pasture and alfalfa were the primary crops grown. No irrigation was reported in the Flagstaff region.

Navajo Reservation

In Arizona, Navajo reservation irrigation consists of Ak Chin (dryland farming) and small irrigation projects. Between 1910 and the late 1950's the U.S. Government built and expanded dozens of small irrigation projects amounting to about 46,200 acres reservation-wide. Because of inadequate management and funding for operation and maintenance, these small systems have deteriorated and by 1986, an SCS survey found only 16,670 acres still were farmed, a decrease of 64% (NDWR, 2002).

A field study conducted by Department staff in the portion of the Navajo Reservation in the Upper Basin portion of the Colorado River Basin, found less than 900 acres of active irrigation, entirely with surface water. Another 500 acres in the Upper Basin was identified as being dryland farmed.

Hopi Reservation

Agriculture on the Hopi reservation consists primarily of dryland farming on an estimated 300 acres of land. A survey is being conducted at the time of this publication to better quantify agricultural water demand and supply on the Hopi lands.

Industrial Demand

Industrial water demand in the planning area includes mining, electrical power generation, paper production, dairies and feedlots and golf course irrigation served by a facility water system. This demand is summarized in Table 2-7 for selected years. Industrial demand, particularly for power generation is a large cultural demand component in the planning area, representing about 30% of the total planning area demand in 2003.

Table 2-7 Industrial demand in selected years in the Eastern Plateau Planning Area

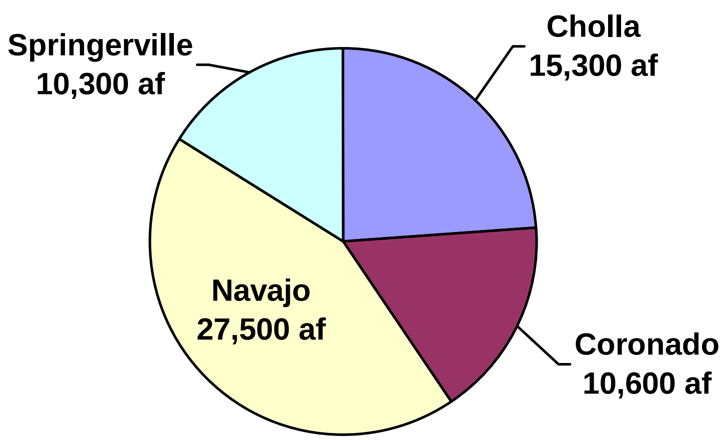
Type	1991	2000	2003
	Water Use (acre-feet)		
Mining Total	**7,052**	**6,953**	**4,700**
Surface water*	2,852	2,053	0
Groundwater	4,200	4,900	4,700
Power Plant Total	**51,366**	**61,709**	**62,484**
Surface water	23,866	28,709	26,284
Groundwater	27,500	33,000	36,200
Golf course Total	**1,679**	**1,829**	**1,692**
Surface water	87	87	87
Groundwater	1,592	1,742	1,605
Dairy/Feedlot Total	**536**	**24**	**520**
Surface water	0	0	0
Groundwater	536	24	520
Paper Mill Total	**17,677**	**13,617**	**13,562**
Surface Water	0	0	0
Groundwater	17,677	13,617	13,562
TOTAL	**78,310**	**84,132**	**82,958**

* diverted pursuant to an exchange agreement between Phelps Dodge Corporation and the Salt River Valley Water Users Association. Phelps Dodge provides water to SRP from Show Low Lake but this water is accounted for as water used by the Morenci Mine in the Southeastern Arizona Planning Area

Mine water use includes sand and gravel operations, the coal mines on Black Mesa south of Kayenta and surface water diversions from Show Low Lake and Blue Ridge/C.C. Cragin Reservoir for mining use outside the planning area. Peabody Coal company operates two mines on Black Mesa: the Black Mesa Coal Mine and the Kayenta Mine, the largest coal strip mining operation in the world. These mines annually ship approximately 12 million tons per year of low-sulfur subbituminous coal and pump approximately 4,400 acre-feet per year. Over 3.8 million gallons of groundwater per day are required to slurry coal to the Mohave Generating Station near Laughlin, Nevada. Coal is also sent to the Navajo Generating Station at Page by rail (http://cpluhna.nau.edu). At the time of publication, the 273-mile slurry pipeline was not operating because of Southern California Edison's failure to upgrade pollution control devices at the Mohave Generating Station, as required by a lawsuit brought by a consortium of environmental groups.

Powerplants include the Navajo Generating Station, the Coronado Generating Station located six miles northeast of Saint Johns, the Springerville Station located northeast of Springerville and the Cholla Generating Station near Joseph City. Use at the Cholla Generating Station for the period 1991-2003 is shown in Figure 2-11. The Navajo Generating station uses water from Lake Powell pursuant to an Upper Basin Colorado River contract which entitles it to receive up to 34,000 acre-feet of water per year. In recent years it has diverted about 27,500 acre-feet a year. All other facilities pump groundwater. Demand in acre-feet for 2003 is shown in Figure 2-12 below.

Figure 2-12 Water demand by electrical generating stations in the Eastern Plateau Planning Area in 2003.



There are eleven industrial golf courses in the planning area, including six in the Pinetop-Lakeside/Show Low area. In 2003, a total of about 1,700 acre-feet of primarily groundwater was used. Because of cooler temperatures, higher precipitation and short growing season, relatively little water is required for golf course irrigation at most locations.

In 2003, an estimated 124,000 swine were raised at four feedlot facilities near Snowflake. These feedlots have been in existence since the early 1980s. A small dairy is located near Taylor. Combined water demand by the dairy and feedlots is typically between 450 to 600 acre-feet a year.

The Abitibi paper mill, formerly Stone Container Corporation, operates about 23 miles southwest of Holbrook. Waste water from the operation is discharged to Dry Lake and is used to irrigate pasture east of SR 377. In 2005, approximately 11,900 acre-feet of effluent was generated while 14,000 acre-feet was pumped. This suggests that about 85% of the annual groundwater withdrawal is recovered and used for irrigation.

SECTION 2.1 Water Resource Characteristics of the Little Colorado River Plateau Basin

The following subsections present data and maps related to water resource characteristics of the Little Colorado River Plateau Basin, the only groundwater basin in the Eastern Plateau Planning Area. A description of the data sources and methods used to derive this information is found in Section 1.3 of Volume 1 of the Atlas.

2.1.1 Geography of the Little Colorado River Plateau Basin

The Little Colorado River Plateau Basin is the largest groundwater basin in the state. Geographic features and principal communities are shown on Figure 2-13. Located at the southern end of the Colorado Plateau, it is characterized by relatively high elevation, semi-arid mesas and several high elevation mountain ranges. Elevations generally increase from north to south.

- Principal geographic features shown on Figure 2-13 are:
  - Monument Valley north of Kayenta
  - Kaibito Plateau south of Page
  - Painted Desert, located between Gray Mountain and Winslow
  - Defiance Plateau, running north/south near Window Rock
  - Black Mesa in the vicinity of Chilchinbito
  - Canyon de Chelly, near Chinle
  - First, Second and Third Mesas on the Hopi Reservation
  - Petrified Forest located between Holbrook and Navajo
  - Mogollon Plateau or Mogollon Rim stretching 200 miles from Flagstaff to the White Mountains
  - Lukachukai and Chuska Mountains near Lukachukai
  - The Little Colorado River, which flows to the Colorado River from the headwaters near Greer, and exits the basin at Cameron north of Gray Mountain.

- Though not well shown on Figure 2-13, the San Francisco Peaks north of Flagstaff and the White Mountains along the southeastern boundary of the basin are prominent geographic features. An isolated peak, Navajo Mountain, straddles the Arizona-Utah border east of Page. Rising to over 10,400 feet it is a prominent visual feature of the basin.
- Humphreys Peak in the San Francisco Peaks is the highest point in Arizona at 12,633 feet.
- The White Mountains rise to over 11,000 feet at Mt. Baldy.
- Principal basin communities are shown and were selected based on population, cultural relevance or for locational purposes.

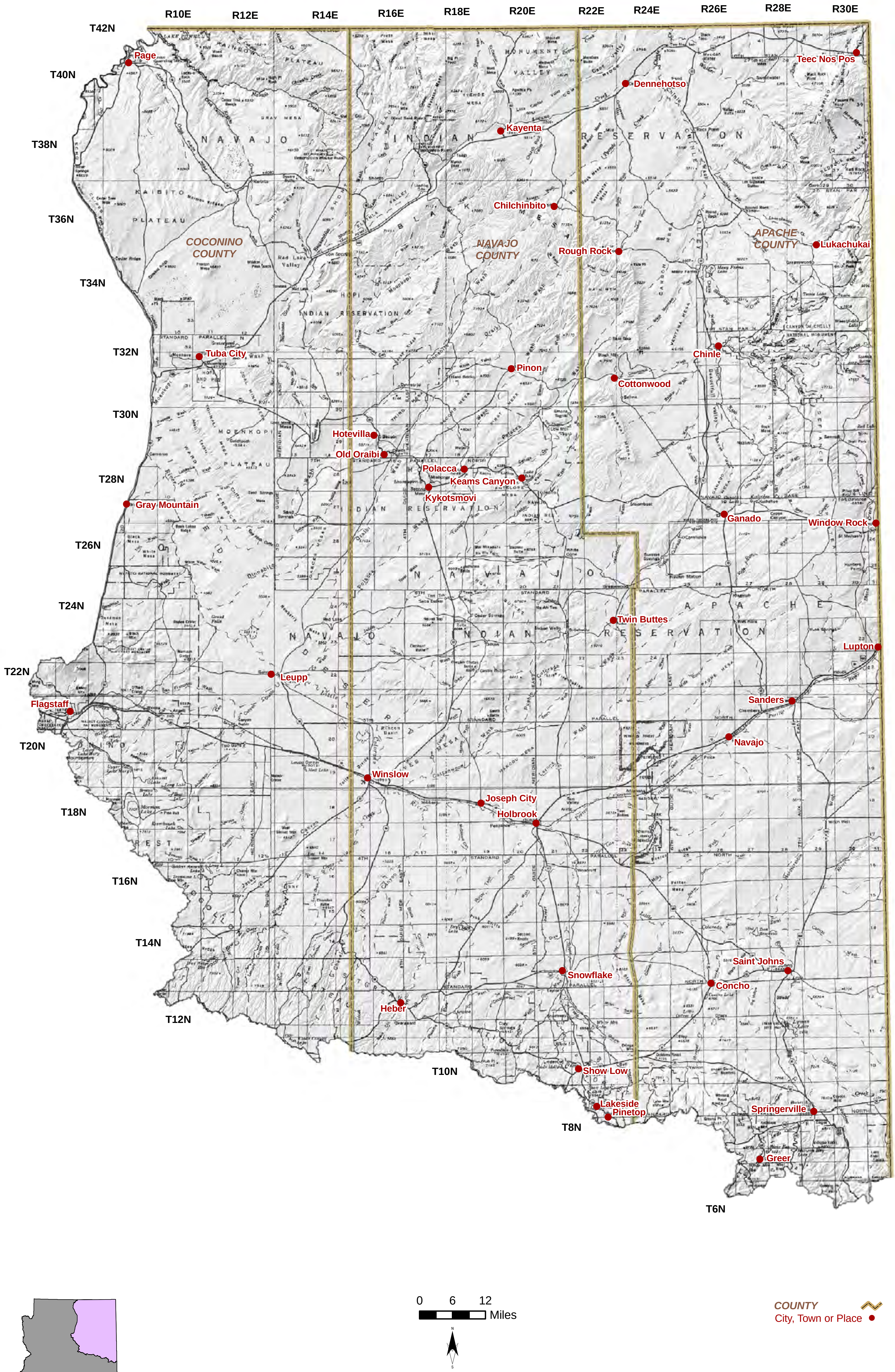


Figure 2-13
Little Colorado River Plateau Basin
Geographic Features

Base Map: USGS 1:500,000, 1981

2.1.2 Land Ownership in the Little Colorado River Plateau Basin

Land ownership, including the percentage of each ownership category is shown in Figure 2-14. Principal features of land ownership are the large amount of tribal lands, the continuous band of national forest lands along the southern and southwestern boundary of the basin, and the "checkerboard" pattern of land ownership south of the reservation lands. This distribution of land ownership has implications for land management and water development and use. A description of land ownership data sources and methods is found in Volume 1, Section 1.3.8

A key land ownership feature in the basin is the significant amount of private lands interspersed with state trust lands and to a lesser extent federal lands in a checkerboard pattern south of the Navajo Reservation. Prior to 1871, federal land grants of alternating one-square-mile sections of land along the right-of-way were given to railroads to promote railroad expansion. In addition, the State Enabling Act of 1910 and the Act that established the Territory of Arizona in 1863 set aside sections 2, 16, 32 and 36 in each township to be held in trust by the state for educational purposes. Other legislation authorized additional state trust lands. Where the "school" section lands were previously claimed or on federal reservations, national forest, park or Indian reservations, the state was given the right to select an equal amount of acreage of Federal land. The state is also allowed to trade lands for other federal lands or private lands to block up Trust land holdings (www.land.state.az.us/history.htm). These decisions have resulted in the pattern observed in the basin. Land ownership categories are discussed below in the order of percentage from largest to smallest in the basin.

Indian Reservations

- 63.9% of the land in the Little Colorado River Plateau Basin is under tribal ownership.
- Of the 27,000 square miles of Navajo nation lands in Arizona, New Mexico and Utah, more than 13,000 square miles are in Arizona.
- Navajo tribal lands include parts of Apache, Navajo and Coconino Counties.
- Window Rock is the location of the Navajo tribal headquarters.
- The Hopi reservation encompasses about 2,400 square miles (1.5 acres) in parts of Navajo and Coconino counties.
- The Hopi reservation is primarily comprised of three mesas and tribal communities at Lower and Upper Moenkopi east of Tuba City. Hopi people have continually occupied the area since 500 A.D. and the community of Old Oraibi, established as early as 1,100, is considered the oldest continuously inhabited settlement in the United States. The Hopi Tribal Headquarters are located in Kykotsmovi on Third Mesa (www.azcommerce.com).
- There are areas north of Joseph City under Hopi and Navajo ownership.
- Other tribal lands include those of the Zuni (about 8 square miles) north of Concho and White Mountain Apache lands (about 4.5 square miles) southwest of Greer. The Zuni tribal lands in Arizona, "Zuni Heaven", were formally recognized in 2004. The Zuni also hold large, non-reservation ranch holdings in and around their reservation.
- The Hopi Tribe holds large, non-reservation ranch holdings in the checkerboard lands area including deeded land, state leased property and Forest Service lands.
- Primary land uses are grazing, mining and farming.

Private

- 14.8% of land ownership in the basin is private.
- Private lands are primarily located in areas surrounding non-Indian communities and in the area between Winslow and the New Mexico border south of the Navajo reservation and north of National Forest lands.
- Private land in-holdings are located within National Forest lands in the Nutrioso area southeast of Springerville and to a lesser extent in other areas as shown.
- Primary land uses are domestic, industrial and commercial.

National Forest and Wilderness

- 10.5% of land is National forest and wilderness. There are two forest districts, the Coconino and Apache Sitgreaves.
- Forest lands contain the headwaters of most of the major streams and of the only major river in the basin.
- Primary land uses are grazing, recreation and logging.

State Trust

- 8% of lands are held in trust for public schools and 13 other beneficiaries under the State Trust Land system.
- There is a large amount of contiguous state land ownership between Springerville and Saint Johns and another contiguous area adjacent to national forest lands southeast of Flagstaff.
- Most land uses are for livestock grazing.

Parks, Monuments, Historical and Recreational Sites

- 1.4% of lands are under federal or state ownership as parks, monuments and other sites.
- Sites identified on Figure 2-14 include a small portion of the Glen Canyon National Recreation Area, Canyon De Chelly National Monument, Wupatki National Monument, Petrified Forest National Park, Sunset Crater National Monument, Walnut Canyon National Monument.
- Primary land use is for recreational purposes.

U.S. Bureau of Land Management

- 1.2% of lands are under federal ownership by the Bureau of Land Management.
- All lands are included in the checkerboard pattern of land ownership in Navajo and Apache counties.
- Primary land uses are for livestock grazing.

Other (Arizona Game and Fish, County and Bureau of Reclamation Lands)

- 0.1% is held by other landowners.
- These lands are located in the vicinity of Springerville, southeast of Flagstaff and there are a few sections scattered in the checkerboard lands.
- Primary land uses on Arizona Game and Fish lands is for wildlife conservation.

Figure 2-14
Little Colorado River Plateau Basin
Land Ownership

2.1.3 Climate of the Little Colorado River Plateau Basin

Climate data from four types of meteorological stations are compiled in Table 2-8 and their location is shown on Figure 2-16. A description of the climate data sources and methods is found in Volume 1, Section 1.3.3.

NOAA/NWS Coop Network

- Refer to Table 2-8A
- There are 56 NOAA/NWS Coop network climate stations reported in the Basin although information is not available for 2 of them.
- Stations are widely dispersed throughout the basin.
- Of the 54 stations for which information is available, data from different periods of record may be used as shown. This may be due to discontinued measurements, date of installation or other availability issues.
- Station elevation ranges from 4,160 feet at Cameron 1 NNE to 8,490 feet at Greer.
- Maximum average temperatures range from 61.5˚F at Greer to 81.7˚F at Page.
- Minimum average temperatures range from 27.0˚F at Fort Valley to 36.5˚F at Cameron 1 NNE.
- Station precipitation varies considerably with an annual average precipitation range of 4.09 inches at Monument Valley to 28.46 inches at McNary 2 N.
- Additional precipitation data shows rainfall as high as 36 inches at sites along the Mogollon Rim and near Flagstaff
- Almost all stations report highest average precipitation during the summer season (July-September).
- On average, the driest season is spring (April-June).
- Altitude is a factor in precipitation, however the rain shadow effect results in greater precipitation on the windward side as storms move northeastward. Blue Ridge Ranger Station at 6,880 feet received an average of 20.6 inches of rainfall a year while Betatakin, at 7,290 feet received only 12.81 inches.

Evaporation Pan

- Refer to Table 2-8B
- There are three sites in the basin at Flagstaff, Page and Winslow.
- Of these sites, the lowest evaporation rate is at Flagstaff, elevation 7,010 feet, and the highest is at Winslow, elevation 4,890 feet.

AZMET

- Refer to Table 2-8C
- There is one AZMET station in the basin, located at Flagstaff at an elevation of 6,747 feet. Average annual reference evaporation is similar to that at the Flagstaff WB AP site.

SNOTEL/Snowcourse

- Refer to Table 2-8D
- There are data from twenty snow measurement sites in the basin, more than any basin in the state. Four sites have been discontinued.

- Elevations at current sites range from 6,930 feet at Lake Mary to 11,200 feet at Snow Bowl #2.
- High elevation sites (>8,000 feet) in the vicinity of Flagstaff typically continue to accumulate snowpack into April.
- High elevation sites (>8,000 feet) in the Beaver Springs and Tsaile Canyon areas report highest average snowpack in March.
- Sites <8,000 feet generally show highest snowpack in March/February.
- Highest average snowpack is found at three stations near Flagstaff and a station at Mount Baldy (Baldy #2).
- There is a correlation between elevation and the average snowpack at the beginning of the month with the highest measurement as shown in Figure 2-15**.** However, location of the site, even those in close proximity to each other, and the period of record affect snowpack accumulation averages.

Figure 2-15 Relationship of elevation to highest monthly average snowpack in the Little Colorado River Plateau Basin.

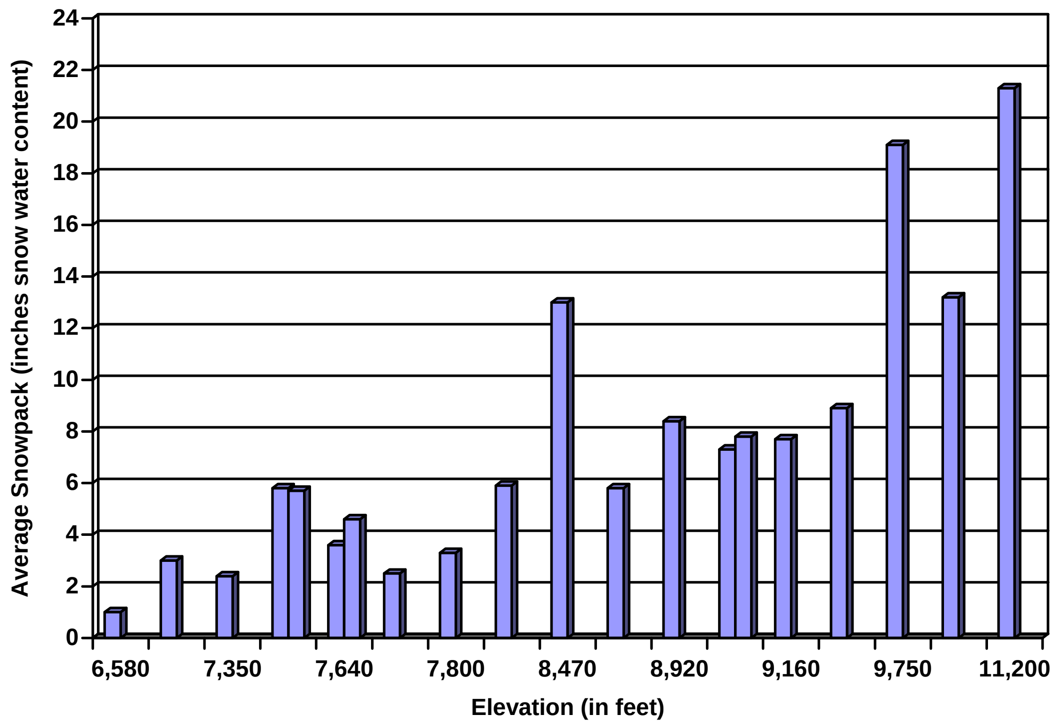


Table 2-8 Climate Data for the Little Colorado River Plateau Basin

A. NOAA/NWS Co-op Network:

Station Name	Elevation (in feet)	Period of Record Used for Averages	Average Temperature Range (in F)		Average Precipitation (in inches)				
			Max/Month	Min/Month	Winter	Spring	Summer	Fall	Annual
Betatakin	7290	1971-2000	71.9/Jul	29.8/Jan	3.24	1.71	4.25	3.61	12.81
Blue Ridge Ranger Station	6880	1971-2000	68.0/Jul	30.2/Jan	5.88	2.17	7.31	5.24	20.60
Burrus Ranch	6800	1948-1968	69.4/Jul	29.3/Jan	4.21	2.14	6.63	4.22	17.20
Cameron 1 NNE	4160	1971-2000	82.2/Jul	36.5/Dec	1.34	0.70	2.12	1.40	5.56
Canyon de Chelly	5610	1971-2000	77.2/Jul	32.0/Jan	2.18	1.48	3.34	2.53	9.53
Chevelon Ranger Station	7010	1971-2000	68.4/Jul	30.5/Jan	4.58	2.02	7.95	4.64	19.19
Chinle	5540	1908-1970	75.0/Jul	28.9/Jan	1.70	1.28	4.01	2.17	9.17
Clay Springs	6320	1971-1987[1]	70.4/Jul	32.0/Jan	4.53	2.06	6.47	4.95	18.00
Copper Mine Trading Post	6380	1948-1976[1]	75.4/Jul	30.3/Jan	1.46	0.99	1.84	2.34	6.62
Cottonwood Indian School	6050	NA[2]	Insufficient Data		No Data				
Flagstaff Airport	7000	1971-2000	66.1/Jul	29.7/Jan	7.36	2.52	7.41	5.62	22.91
Fort Valley	7350	1971-2000	62.1/Jul	27.0/Jan	7.18	2.55	7.66	4.71	22.10
Ganado	6340	1971-2000	72.0/Jul	29.2/Jan	2.61	1.57	4.37	3.04	11.59
Greer	8490	1971-2000	61.5/Jul	28.6/Jan	4.44	2.75	10.71	5.29	23.19
Heber Ranger Station	6590	1971-2000	68.3/Jul	32.7/Jan	4.75	1.82	7.94	4.66	19.17
Holbrook	5070	1971-2000	77.6/Jul	35.8/Jan	2.09	0.95	3.86	2.30	9.20
Kayenta	5710	1915-1978[1]	75.7/Jul	29.3/Jan	0.61	0.52	2.30	2.27	5.69
Keams Canyon	6210	1971-2000	72.6/Jul	30.5/Jan	2.77	1.17	3.65	2.57	10.16
Klagetoh 12 WNW	6500	1971-2000	73.7/Jul	32.6/Jan	2.29	1.17	3.27	2.61	9.34
Leupp	4700	1948-1981[1]	77.1/Jul	31.4/Jan	1.57	0.98	2.85	2.00	7.39
Lukachukai	6520	1971-2000	72.5/Jul	28.9/Jan	1.89	1.12	3.84	2.57	9.42
Many Farms School	5320	1951-1975[1]	75.9/Jul	30.4/Dec	0.89	0.48	1.58	1.86	4.80
McNary 2 N	7340	1971-2000	64.7/Jul	31.0/Jan	8.33	3.03	9.75	7.35	28.46
Monument Valley	5560	1971-2000	79.1/Jul	31.2/Jan	0.44	0.70	1.88	1.07	4.09
Navajo	5580	1961-1976[1]	74.1/Jul	28.5/Jan	2.14	0.86	3.43	3.02	9.45
Page	4270	1971-2000	81.7/Jul	34.7/Jan	1.74	1.04	1.93	2.03	6.74
Painted Desert National Park	5760	1973-2005[1]	76.0/Jul	35.5/Jan	2.58	1.32	3.97	2.96	10.83
Petrified Forest National Park	5450	1971-2000	76.0/Jul	34.9/Jan	2.04	1.23	4.40	2.77	10.44
Pinedale	6510	1912-1968	69.4/Jul	29.2/Jan	3.99	2.02	7.52	4.79	18.31
Pinetop	6960	1980-1997[1]	67.2/Jul	32.8/Jan	5.53	2.43	9.13	5.51	22.60
Saint Johns	5790	1971-2000	73.8/Jul	34.0/Dec	2.07	1.40	5.47	2.53	11.47
Sanders	5850	1971-2000	73.4/Jul	32.2/Jan	3.02	1.55	4.39	3.17	12.13
Sanders 11 ESE	6250	1961-1986[1]	71.2/Jul	29.3/Jan	4.20	1.79	4.14	3.59	13.71
Show Low Airport	6410	1971-2000	73.2/Jul	35.1/Jan	4.14	1.86	7.26	4.87	18.13
Snowflake	5640	1971-2000	73.1/Jul	34.1/Jan	2.46	1.34	5.83	3.07	12.70
Snowflake 15 W	6080	1965-1998[1]	72.6/Jul	32.3/Jan	2.22	1.50	5.78	3.03	12.52
Springerville	7060	1971-2000	66.4/Jul	32.3/Dec	1.49	1.25	7.12	2.13	11.99
St. Michaels 6 WNW	7640	1906-1927	69.3/Jul	27.6/Jan	2.85	1.33	6.35	2.89	13.42
Sunset Crater National Monument	6980	1971-2000	65.8/Jul	27.5/Jan	3.87	2.00	7.15	4.04	17.06
Teec Nos Pos	5290	1971-2000	78.4/Jul	31.4/Jan	1.81	1.30	2.80	2.17	8.08
Tonalea	5520	NA[3]	Insufficient Data		No Data				
Tuba City	5030	1971-2000	78.0/Jul	33.8/Jan, Dec	1.66	0.76	2.33	1.60	6.35
Wallace Ranger Station	7010	1916-1959	67.2/Jul	30.2/Jan	4.37	2.12	8.06	3.73	18.28
Window Rock 4 SW	6900	1971-2000	69.4/Jul	28.5/Jan	2.31	1.49	4.44	3.07	11.31
Winslow Airport	4890	1971-2000	77.5/Jul	34.1/Dec	1.60	0.93	3.51	1.99	8.03
Wupatki National Monument	4910	1971-2000	80.1/Jul	35.6/Dec	1.78	1.10	4.02	2.07	8.97

[1] Average temperature for period of record shown; average precipitation from 1971-2000
[2] Not available -Period of Record 1956-1958
[3] Not available -Period of Record 1948-1949

Table 2-8 Climate Data for the Little Colorado River Plateau Basin

B. Evaporation Pan:

Station Name	Period of Record Used for Averages	Elevation (in feet)	Avg. Annual Evap (in inches)
Flagstaff WB AP	1968 - 1978	7,010	54.00
Page	1957 - 2002	4,270	80.57
Winslow AP	1990 - 1999	4,890	84.7

C. AZMET:

Station Name	Period of Record	Elevation (in feet)	Average Annual Reference Evapotranspiration, in inches *(number of years to calculate average)*
Flagstaff	11/2003 - current	6,747	55.48 *(2)*

D. SNOTEL/Snowcourse:

Station Name	Period of Record Used for Averages	Elevation (in feet)	Average Snowpack at Beginning of Month, as Inches Snow Water Content *(Number of measurements to calculate average)*					
			Jan.	Feb.	March	April	May	June
Arbabs Forest	1985 - current	7,680	1.2*(18)*	2.5*(20)*	1.9*(19)*	0.2*(20)*	0*(0)*	2.4*(1)*
Baldy (SNOTEL)	1950 - current	9,125	3.7*(33)*	6.0*(54)*	7.8*(54)*	6.6*(54)*	0.4*(19)*	0*(17)*
Baldy #1	1950 - 1999 (discontinued)	9,125	3.7*(28)*	5.7*(49)*	7.3*(50)*	6.4*(49)*	0.8*(22)*	0*(21)*
Baldy #2	1963 - 1997	9,750	0*(0)*	12.3*(2)*	0*(0)*	19.1*(9)*	25.2*(1)*	0*(0)*
Beaver Spring	1986 - current	9,220	3.8*(16)*	*6.9(17)*	*8.9(16)*	7.3*(18)*	0*(0)*	0*(0)*
Cheese Springs	1969 - current	8,700	2.6*(26)*	4.2*(36)*	5.8*(36)*	*3.9(36)*	0*(1)*	0*(0)*
Fort Apache	1951 - current	9,160	3.7*(25)*	6.0*(52)*	7.7*(54)*	7.0*(54)*	0*(0)*	0*(0)*
Fluted Rock	1985 - current	7,800	1.3*(18)*	2.9*(20)*	3.3*(19)*	0.6*(20)*	0*(0)*	0*(0)*
Forestdale Alt.	1984 - 1989 (discontinued)	6,580	0.5*(6)*	1.0*(6)*	0.6*(6)*	0*(6)*	0*(0)*	0*(0)*
Fort Valley	1947 - current	7,350	1.3*(30)*	2.3*(58)*	2.4*(58)*	1.0*(57)*	0*(1)*	0*(0)*
Heber	1950 - 1999 (discontinued)	7,640	1.8*(23)*	3.5*(49)*	3.6*(49)*	2.1*(46)*	1.0*(2)*	0*(0)*
Heber (SNOTEL)	1950 - current	7,640	2.2*(29)*	4.5*(54)*	4.6*(54)*	2.4*(50)*	0*(22)*	0*(22)*
Lake Mary	1975 - current	6,930	1.3*(25)*	2.5*(30)*	3.0*(30)*	0.4*(30)*	0*(0)*	0*(0)*
Mormon Mountain	1950 - 1999 (discontinued)	7,500	2.8*(30)*	4.8*(49)*	5.8*(50)*	4.2*(47)*	5.1*(3)*	0*(0)*
Mormon Mountain (SNOTEL)	1950 - current	7,500	2.5*(35)*	4.5*(54)*	5.7*(55)*	4.2*(52)*	1.1*(25)*	0*(22)*
Mormon Mountain Summit #2	1975 - current	8,470	3.8*(14)*	7.5*(20)*	11.7*(22)*	13.0*(27)*	0*(0)*	0*(0)*
Snow Bowl #1 Alt.	1984 - current	9,920	5.3*(20)*	*7.9(21)*	11.7*(21)*	13.2*(20)*	0*(0)*	0*(0)*
Snow Bowl #2	1965 - current	11,200	7.8*(27)*	11.8*(39)*	16.7*(39)*	21.3*(38)*	0*(0)*	0*(0)*
Tsaile Canyon #1	1985 - current	8,160	2.6*(19)*	5.1*(20)*	5.9*(19)*	3.2*(20)*	0*(0)*	0*(0)*
Tsaile Canyon #3	1986 - current	8,920	3.6*(18)*	6.9*(19)*	8.4*(18)*	*6.6(19)*	0*(0)*	0*(0)*

WB = Weather Bureau
AP = Airport
Alt = Alternate

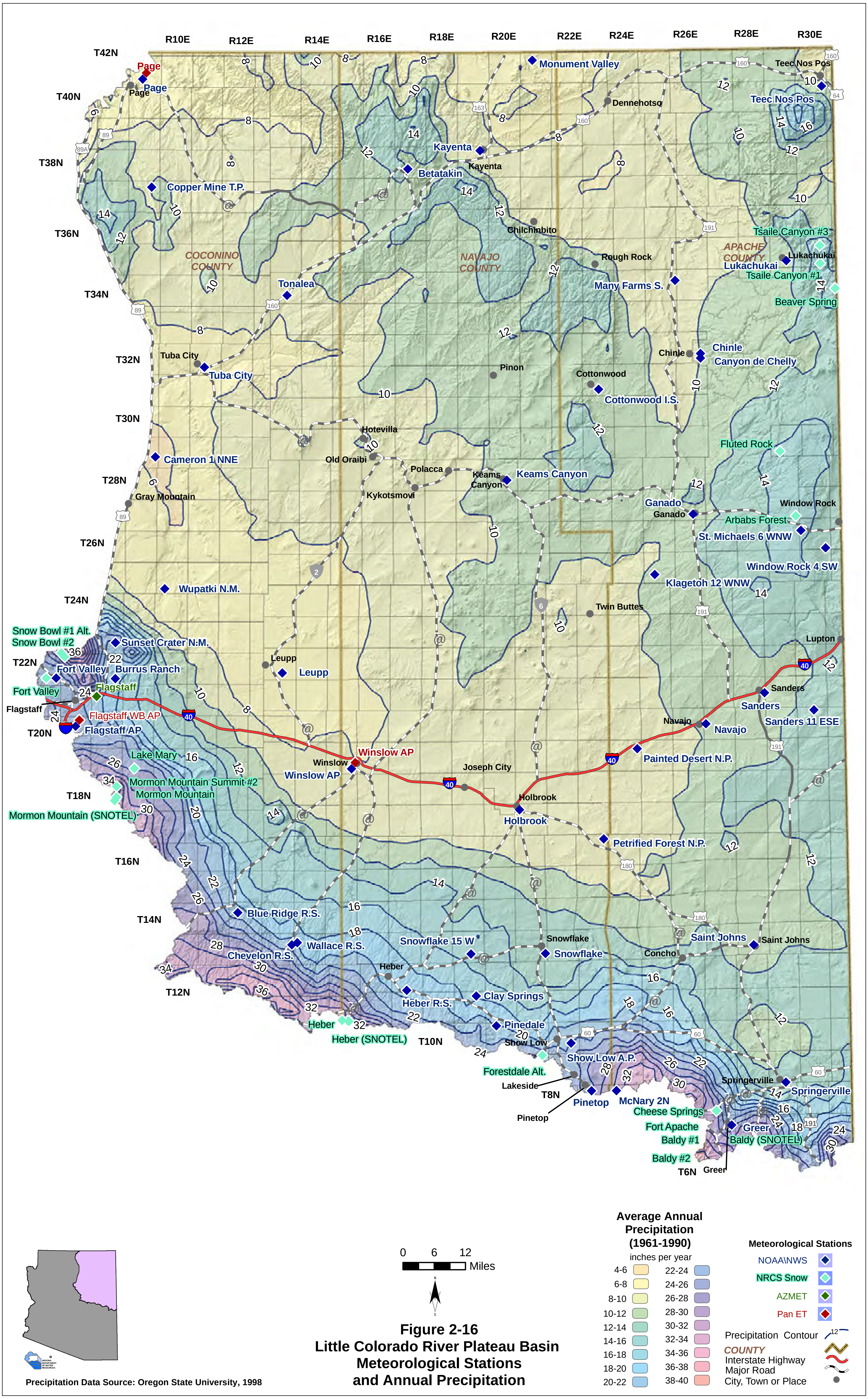


Figure 2-16
Little Colorado River Plateau Basin
Meteorological Stations
and Annual Precipitation

2.1.4 Surface Water Conditions of the Little Colorado River Plateau Basin

Streamflow data, including average seasonal flow, annual flow and other information is shown in Table 2-9. Flood ALERT equipment in the basin as of September 2004 is shown in Table 2-10. Reservoir and stock pond data including maximum storage or maximum surface area of large reservoirs and type of use of the stored water is shown in Table 2-11. The location of streamflow and flood gages, using the USGS or station ID number, is shown on Figure 2-17. The location of large reservoirs is also shown on Figure 2-17 and keyed to Table 2-11A. A description of the stream data sources and methods is found in Volume 1, Section 1.3.16. A description of reservoir data sources and methods is found in Volume 1, Section 1.3.11. A description of stockpond data sources and methods is found in Volume 1, Section 1.3.15.

Streamflow Data

- Refer to Table 2-9
- Criteria for including stations are that there is at least one year of record, and annual streamflow statistics are included only if there are at least three years of record. Seasonal flow information provides data relevant to seasonal surface water availability. Annual flow volumes (in acre-feet) provide an indication of potential volumetric availability of the surface water supply.
- Data from forty-five stations, including 21 discontinued stations, are shown in the table and on Figure 2-17.
- The average seasonal flow as a percentage of annual flow is highest in the Spring (April-June) from winter snowmelt and spring rains and in the Summer (July-September) from high intensity monsoon storms.
- High summer season percentages were noted at many gages on the Navajo and Hopi reservation. High winter flow percentages (January-March) were recorded at gages near Lakeside, Show Low and Snowflake.
- The year of minimum and maximum flow varies depending on the location and period of record. For the 11 active gages in existence prior to 1990, 8 reported that the minimum year of flow occurred during the period 1990 to 2004. For these same gages, the maximum year of flow was more variable. However, the largest percentage (36%) recorded maximum flows during the 1980s.

Flood ALERT Equipment

- Refer to Table 2-10
- There were 32 stations in the basin as of October 2005. Stations vary in type. Some are precipitation stations only while others include stage information and also serve repeater functions. Stations that are only repeaters are not included.
- Flood gage information is presented to direct the reader to sources of additional precipitation and flow information that can be utilized in water resource planning.

Reservoirs and Stock Ponds

- Refer to Table 2-11
- Surface water is stored or could be stored at 92 large reservoirs and 685 small reservoirs in the basin.

- Table 2-11A lists large reservoirs (500 acre-feet capacity or larger) by highest to lowest maximum storage capacity. Table 2-11B lists other large reservoirs (50 acres or more of surface area) from highest to lowest maximum surface area for those reservoirs for which storage volume was not available.
- Maximum storage information was available for 60 large reservoirs in the basin
- There are 32 large reservoirs for which only surface area data were available.
- 33 large reservoirs are intermittent or dry, particularly those listed in Table 11-B.
- The most common use of large reservoirs is for recreation (46), followed by fire protection, stock or farm use (33) and for irrigation (30).
- More than 40% of the reservoirs serve multiple uses. Two reservoirs, Powell and Blue Ridge are used to generate hydroelectric power.
- The highest concentrations of large reservoirs are in the high elevation areas of the White Mountain and Mogollon Rim, although a number of large reservoirs are located in the drier, lower elevation areas.
- There are 18 large reservoirs on the Navajo reservation and one (for flood control) on the Hopi. Navajo reservation reservoirs are used for the same primary purposes as those in the entire basin. Blue Canyon (#33) reservoir's reported use is for domestic water supply. Water from Lake Powell is treated at Page and delivered to the Navajo community of LeChee.
- Three reservoirs provide municipal water supply to non-reservation communities: Lower Lake Mary (Flagstaff); Powell (Page); and Blue Ridge/C.C. Cragin Reservoir, which is used as a municipal supply outside the basin.
- Capacity information was available for 416 small reservoirs, which have a combined maximum storage capacity of 13,343 acre-feet.
- There are 269 small reservoirs for which only surface area data was available with a total surface area of 3,907 acres.
- Because of the large number of small reservoirs, and less reliable data, individual reservoir data is not provided.
- Stock pond data was compiled from the ADWR surface water registry for ponds with a capacity of 15 acre-feet or less. There are an estimated 6,113 stock ponds in the basin, although this has not been field verified.

Runoff Contour

- Refer to Figure 2-17.
- Runoff contours reflect the average annual runoff in tributary streams. They provide a generalized indication of the amount of runoff that can be expected at a particular geographic location.
- Average annual runoff varies from 5 inches per year at higher elevations along the Mogollon Rim and near Greer to 0.1 inches near the Little Colorado River and along a contour stretching from near Sanders, through Polacca to the northwest corner of the basin.

Table 2-9 Streamflow Data for the Little Colorado River Plateau Basin

Station Number	USGS Station Name	Contributing Drainage Area (in sq. miles)	Mean Basin Elevation (in feet)	Period of Record	Average Seasonal Flow (% of Annual Flow)				Annual Flow in Acre-Feet (Year)				Years of Annual Flow Record
					Winter	Spring	Summer	Fall	Minimum	Median	Mean	Maximum	
9379025	Chinle Creek at Chinle[1]	639	NA	11/1999-current	49	42	6	2	905 (2002)	6,624	6,258	10,860 (2004)	5
9379050	Lukachukai Creek near Lukachukai[1]	Not determined	NA	11/1999-current	28	37	22	13	796 (2002)	1,947	1,781	2,172 (2003)	5
9379180	Laguna Creek at Dennehotso	414	NA	7/1996-current	13	4	61	22	1,694 (2004)	3,826	4,408	8,760 (1997)	6
9379200	Chinle Creek near Mexican Water[1]	3,650	6,260	10/1964-current	19	32	36	13	3,062 (1994)	15,457	20,429	67,692 (1982)	40
9379910	Colorado River below Glen Canyon Dam	107,741	NA	10/1965-9/2003	23	28	27	22	7,847,916 (2002)	8,166,466	8,382,855	9,252,432 (1971)	9
9380000	Colorado River at Lees Ferry[1]	107,841	NA	10/1921-current	16	44	24	16	1,383,521 (1963)	9,375,509	10,885,307	20,322,048 (1984)	83
9383000	Colorado River at Compact Point near Lees Ferry	108,041	NA	10/1980-9/2004	24	25	28	22	7,833,437 (1988)	8,383,659	9,876,067	18,699,615 (1986)	20
9383200	Lee Valley Creek above Lee Valley Reservoir near Greer	1.3	NA	10/1966-9/1972 (discontinued)	7	43	26	24	261 (1970)	398	405	543 (1969)	5
9383220	Lee Valley Creek Tributary near Greer	0.5	NA	10/1966-9/1972 (discontinued)	9	47	30	13	11 (1969)	94	79	130 (1969)	5
9383250	Lee Valley Creek below Lee Valley Reservoir near Greer	1.9	NA	10/1966-9/1972 (discontinued)	17	29	30	24	116 (1967)	188	191	239 (1970)	5
9383400	Little Colorado River at Greer	29.1	9,400	8/1960-9/1982 (discontinued)	12	59	20	9	5,198 (1961)	8,688	11,437	25,267 (1973)	21
9383500	Nutrioso Creek above Nelson Reservoir near Springerville	83.3	8,550	6/1967-9/1982 (discontinued)	21	63	6	10	485 (1977)	2,729	4,517	16,507 (1973)	14
9383550	Nutrioso Creek below Nelson Reservoir near Springerville	86.8	NA	7/1967-9/1982 (discontinued)	19	69	4	8	290 (1977)	2,237	4,235	17,013 (1973)	14
9384000	Little Colorado River above Lyman Lake near St. Johns[1]	704	7,760	4/1940-current	20	52	17	10	2,259 (1996)	11,113	15,588	51,258 (1941)	64
9385500	Little Colorado River below Lyman Reservoir near St. Johns	790	NA	4/1941-9/1985[2]	21	63	6	10	478 (1963)	1,509	2,722	19,547 (1973)	34
9385700	Little Colorado River below Salado Springs[1]	845	NA	3/1985-current	26	52	13	9	2,432 (2003) and 2,164 (2004)				2

Table 2-9 Streamflow Data for the Little Colorado River Plateau Basin

Station Number	USGS Station Name	Contributing Drainage Area (in sq. miles)	Mean Basin Elevation (in feet)	Period of Record	Average Seasonal Flow (% of Annual Flow)				Annual Flow in Acre-Feet (Year)				Years of Annual Flow Record
					Winter	Spring	Summer	Fall	Minimum	Median	Mean	Maximum	
9386000	Little Colorado River at St. Johns	964	NA	4/1906-4/1940 (discontinued)	24	33	27	16	2,013 (1939)	3,895	10,309	45,538 (1909)	8
9386030	Little Colorado River above Zion Reservoir near St. Johns[1]	1,005	NA	10/1975-current	29	31	16	24	94 (2004)	3,453	5,149	18,823 (1985)	29
9386250	Carrizo Wash near St. Johns[1]	Not determined	NA	8/1998-current	0	0	99	1	65 (2004)	1,596	2,082	5,169 (2002)	5
9386300	Little Colorado River below Zion Reservoir near St. Johns	NA	NA	9/1998-current	1	<1	97	2	80 (2003)	116	2,684	11,798 (2002)	6
9386500	Little Colorado River above Zuni Reservoir near Hunt	3,557	7,160	3/1940-9/1972 (discontinued)	16	10	60	14	8 (1961)	2,266	3,778	22,009 (1955)	31
9388000	Little Colorado River near Hunt	6,173	7,060	5/1929-9/1972 (discontinued)	14	12	64	10	239 (1962)	5,046	10,424	58,424 (1941)	34
9390000	Silver Creek near Shumway	119	NA	10/1944-6/1955 (discontinued)	12	44	38	6	5,575 (1951)	7,891	8,466	13,683 (1952)	10
9390500	Show Low Creek near Lakeside[1]	68.6	7,320	5/1953-current	53	19	9	19	970 (2002)	6,863	9,692	31,493 (1978)	51
9392000	Show Low Creek below Jaques Dam near Show Low[1]	73.0	NA	10/1955-current	47	25	13	14	1,405 (1990)	3,033	6,391	28,090 (1993)	49
9392500	Show Low Creek at Show Low	90.2	NA	10/1944-6/1955 (discontinued)	65	12	12	11	1,086 (1953)	4,156	6,519	24,832 (1952)	10
9393400	Cottonwood Wash at Snowflake[1]	262	NA	10/1981-8/1984	79	0	3	17	3,460 (1982) and 10,060 (1983)				2
9393500	Silver Creek near Snowflake	846	6,400	10/1950-9/1995 (discontinued)	45	8	28	19	2,020 (1990)	10,461	13,830	59,583 (1993)	44
9394000	Silver Creek near Woodruff	887	NA	4/1929-9/1952 (discontinued)	51	4	36	9	4,293 (1942)	14,914	17,902	58,642 (1932)	15
9394500	Little Colorado River at Woodruff[1]	7,775	6,810	3/1905-current	27	12	46	15	5,524 (2000)	26,860	35,839	165,791 (1919)	74
9396500	Puerco River near Adamana	2,604	6,730	4/1940-9/1949 (discontinued)	24	13	47	16	9,557 (1944)	26,642	46,732	167,963 (1941)	8
9397000	Little Colorado River at Holbrook[1]	11,115	6,730	3/1905-current	19	10	55	16	13,973 (1950)	82,533	91,138	197,646 (1968)	26
9397500	Chevelon Fork below Wildcat Canyon near Winslow[1]	271	7,030	5/1947-current	57	28	5	10	0 (1996, 2002)	22,950	30,032	97,737 (1965)	30

Table 2-9 Streamflow Data for the Little Colorado River Plateau Basin

Station Number	USGS Station Name	Contributing Drainage Area (in sq. miles)	Mean Basin Elevation (in feet)	Period of Record	Average Seasonal Flow (% of Annual Flow)				Annual Flow in Acre-Feet (Year)				Years of Annual Flow Record
					Winter	Spring	Summer	Fall	Minimum	Median	Mean	Maximum	
9398000	Chevelon Creek near Winslow[1]	781	6,440	1/1906-9/1972 (discontinued, now real-time)	49	33	6	11	10,715 (1956)	32,651	38,756	99,909 (1952)	44
9398500	Cleak Creek below Willow Creek near Winslow	317	7,100	6/1948-9/1991 (discontinued)	41	45	3	11	4,127 (1990)	36,633	59,275	168,963 (1973)	43
9399000	Clear Creek near Winslow[1]	621	6,500	1906-12/1982 (discontinued, now real-time)	39	49	2	9	3,852 (1967)	46,697	60,719	183,890 (1978)	51
9400350	Little Colorado River near Winslow[1]	16,100	NA	12/2001-current	52	9	23	16	54,009 (2003)	69,140	73,870	98,461 (2004)	3
9400562	Oraibi Wash near Tolani Lake[1]	635	NA	7/1995-current	1	0	72	19	434 (1996)	1,998	1,980	4,177 (1997)	9
9400568	Polacca Wash near Second Mesa[1]	905	NA	4/1994-current	5	1	73	21	195 (1995)	2,125	2,117	3,678 (1997)	8
9400583	Jeddito Wash near Jeddito[1]	147	NA	9/1993-current	0	1	88	11	14 (1998)	145	298	1,426 (2003)	11
9401000	Little Colorado River at Grand Falls	20,700	6,440	11/1925-9/1994 (discontinued)	39	24	30	7	18,461 (1956)	162,171	198,406	587,869 (1941)	24
9401110	Dinnebito Wash near Sand Springs[1]	473	NA	6/1993-current	5	3	78	14	311 (1994)	2,085	2,680	6,682 (2004)	11
9401226	Coal Mine Wash Tributary near Kayenta	0.6	NA	10/1977-9/1981 (discontinued)	2	4	90	4	0 (1979)	3	24	70 (1980)	3
9401239	Coal Mine Wash near Mouth near Shonto	NA	NA	5/1978-10/1982 (discontinued)	20	11	48	21	434 (1979)	775	857	1,361 (1980)	3
9401260	Moenkopi Wash at Moenkopi[1]	1,629	5,850	7/1976-current	13	4	64	18	1,376 (1994)	7,457	7,083	14,769 (2001)	28
9401280	Moenkopi Wash near Tuba City	1,904	NA	7/1926-9/1940 (discontinued)	8	2	81	9	5,408 (1928)	9,774	16,334	45,828 (1930)	13
9401400	Moenkopi Wash near Tuba City	2,492	5,820	10/1940-9/1978 (discontinued)	8	2	58	33	2,179 (1944)	8,833	11,158	44,452 (1972)	25

Sources: USGS NWIS, USGS 1998 and USGS 2003.

Notes:
NA = Not available to ADWR
Statistics based on Calendar Year
Average Seasonal Flow statistics based on monthly values
Summation of Average Annual Flows may not equal 100 due to rounding.
Period of Record may not equal Years of Annual Flow Record used for annual Flow/Year statistics due to only using years with a 12 month record

Table 2-9 Streamflow Data for the Little Colorado River Plateau Basin

Station Number	USGS Station Name	Contributing Drainage Area (in sq. miles)	Mean Basin Elevation (in feet)	Period of Record	Average Seasonal Flow (% of Annual Flow)				Annual Flow in Acre-Feet (Year)				Years of Annual Flow Record
					Winter	Spring	Summer	Fall	Minimum	Median	Mean	Maximum	

In Period of Record, current equals September 2005
[1]Real-time gage
[2]Station operated by SRP after 1985 and table statistics do not include the SRP data

Table 2-10 Flood Alert Equipment in the Little Colorado River Plateau Basin

Station ID	Station Name	Station Type	Install Date	Responsibility
1701	Little Colorado River @ Hunt	Precipitation/Stage	NA	Navajo County FCD
1715	Black Canyon Lake	Precipitation/Stage	NA	Navajo County FCD
1720	Oklahoma Flat	Precipitation	NA	Navajo County FCD
1722	Stermer Ridge	Precipitation	NA	Navajo County FCD
1724	Bunger Point	Precipitation	NA	Navajo County FCD
1725	Dreamy Draw	Precipitation/Stage	3/1/2004	Navajo County FCD
1729	Little Colorado River @ Winslow @I-40	Precipitation/Stage	10/27/1995	Navajo County FCD
1739	Cottonwood Wash - Winslow	Stage	NA	Navajo County FCD
1743	Obed Bridge over Little Colorado River @ Joseph City	Precipitation/Stage	9/5/1995	Navajo County FCD
1750	Leroux Wash	Precipitation/Stage	11/2/1995	Navajo County FCD
1764	Little Colorado River @ Holbrook	Precipitation/Stage	NA	Navajo County FCD
1771	Joseph City @ SR 66	Precipitation/Stage	NA	Navajo County FCD
1778	Pinedale Ridge	Precipitation	8/1/2001	Navajo County FCD
1785	Silver Creek at Snowflake	Precipitation/Stage	8/1/2001	Navajo County FCD
1795	Lone Pine Dam	Precipitation/Stage	8/1/2001	Navajo County FCD
1800	Chevelon Butte 20 mi. SW of Winslow	Repeater/Precipitation	7/18/1995	Navajo County FCD
1804	Porter Mountain	Repeater/Precipitation	1/18/1995	Navajo County FCD
1808	Buckskin Wash	Precipitation/Stage	NA	Navajo County FCD
1815	Schoens Dam	Precipitation/Stage	8/1/2001	Navajo County FCD

Table 2-10 Flood Alert Equipment in the Little Colorado River Plateau Basin

Station ID	Station Name	Station Type	Install Date	Responsibility
1822	White Mountain Lake	Precipitation/Stage	NA	Navajo County FCD
1829	Cottonwood Wash - Taylor	Precipitation/Stage	10/6/1995	Navajo County FCD
1843	Dutch Joe	Precipitation	8/1/2001	Navajo County FCD
1850	Morgan Wash	Precipitation/Stage	11/22/1995	Navajo County FCD
1857	Holbrook Base Station	Precipitation	NA	Navajo County FCD
1864	South County Complex	Precipitation	NA	Navajo County FCD
1871	Heber Repeater	Repeater/Precipitation	NA	Navajo County FCD
1881	Black Canyon Wash	Stage	NA	Navajo County FCD
1885	Heber SNOTEL	Precipitation	NA	Navajo County FCD
1892	Show Low Lake	Precipitation	NA	Navajo County FCD
1893	Phoenix Park Wash	Precipitation/Stage	NA	Navajo County FCD
3300	Newman Canyon	Precipitation/Stage	NA	City of Flagstaff
3310	Rio de Flag	Precipitation/Stage	NA	City of Flagstaff

FCD = Flood Control District
NA = Not available to ADWR

Table 2-11 Reservoirs and Stock Ponds in the Little Colorado River Plateau Basin

A. Large Reservoirs (500 acre-feet capacity and greater)

MAP KEY	RESERVOIR/LAKE NAME (Name of dam, if different)	OWNER/OPERATOR	MAXIMUM STORAGE (AF)	USE[1]	JURISDICTION
1	Powell (Glen Canyon Dam)	Bureau of Reclamation	20,325,000	H,I,O,R,S	Federal
2	Schoens	Navajo County	62,000	C	State
3	Lyman	Lyman Water Co	44,500	I,R	State
4	Many Farms	Navajo Nation	32,500	I,R	Tribal
5	Upper Lake Mary	City of Flagstaff	21,041	S,R	State
6	Red[2]	Navajo Nation	15,517	F,I,R	Tribal
7	Blue Ridge/C.C. Cragin	Bureau of Reclamation/Salt River Project	15,000	H,S,R	State
8	Mormon	Coconino NF	15,000	F,R	Federal
9	Lone Pine[3]	Navajo County	14,700	C	State
10	White Mountain (Daggs Dam)	Snowflake & Taylor Irrigation	13,750	I,R	State
11	Tremaine (Hay Lake Dam)	Bar T Bar Ranch	9,000	I	State
12	Chevelon Canyon	AZ Game & Fish	8,542	R	State
13	Show Low (Jacques Dam)	City of Show Low	8,160	O,R	State
14	Tsaile	Navajo Nation	8,100	I,R	Tribal
15	Wheatfields	Navajo Nation	5,700	I,R	Tribal
16	Fool's Hollow	AZ Game & Fish	5,617	R	State
17	Canyon Diablo Reservoir	Navajo Nation	4,700	I,R	Tribal
18	Willow Springs	AZ Game & Fish	4,230	R	State
19	Ashurst	AZ Game & Fish	4,164	R	State
20	Alejandro	Private	4,111	U	State
21	Ganado Reservoir	Navajo Nation	3,750	I,R	Tribal
22	Dry Lake II (Twin Lakes Dam)	Abitibi	3,700[4]	O	State
23	Hay[3]	Bar T Bar Ranch	3,530	U	State
24	River Reservoir	Round Valley Water Users	3,195	I,R	State
25	Kinnikinick	AZ Game & Fish	3,124	R	State
26	Ortega + Little Ortega (Ortega Lake Retention)	Silver Creek Flood Control	2,500	C,R	State
27	White Mountain	Round Valley Water Users	2,391[4]	I,R	State
28	Lower Lake Mary	Coconino NF	2,240	R,S	Federal
29	Rainbow (Lakeside Dam)	Show Low Irrigation	2,226	I,R	State
30	Cholla	Arizona Public Service	2,200[4]	F,O,R	State
31	Millett Swale	Silver Creek Flood Control	2,104	C	State
32	Black Canyon	AZ Game & Fish	1,900	R	State
33	Blue Canyon	Navajo Nation	1,900	S	Tribal
34	Soldier Annex	Coconino NF	1,886	F,I,P,R	Federal
35	Knoll	AZ Game & Fish	1,774	R	State
36	Scott Reservoir	Show Low Irrigation	1,740	I,R	State
37	Bear Canyon	AZ Game & Fish	1,638	R	State
38	Concho	Concho Water Co	1,560	I,R	State
39	Unnamed (Twin Dams)	Hopi Tribe	1,500	C	Tribal
40	Little Mormon	Apache Sitgreaves NF	1,400	F,R	Federal
41	Becker	Apache Sitgreaves NF	1,338	I,F,R	Federal
42	Woods Canyon	AZ Game & Fish	1,232	R	State
43	Little	St. John's Irrigation	1,200[4]	I,R	State
44	Long[3]	Apache Sitgreaves NF	1,200	F,R	Federal
45	Mexican[3]	Apache Sitgreaves NF	1,100	C,F,I	Federal
46	Round Rock	Navajo Nation	1,070	I,R	Tribal
47	Hog Wallow	Lyman Water Co	1,000	I	State
48	Pool Corral	Lyman Water Co	993	I	State
49	Nelson	AZ Game & Fish	900	R	State
50	Slade	Private	898	I	State
51	Broken Tank	AZ State Land Dept.	851[4]	P	State
52	Mexican Hay	Lyman Water Co	821	I,R	State
53	Clear Creek (Clear Creek #2)	City of Winslow	750	I,R	State
54	Tunnel	Apache Sitgreaves NF	694	I,R	Federal
55	Norton[3]	Town of Springerville	680	I	State
56	Haumont Tank[3]	AZ State Land Dept./Rancho Allegra	674	I	State
57	Lee Valley	AZ Game & Fish	640	I,R	State
58	Soldiers	Coconino NF	550	R	Federal
59	Patterson	AZ Land Dept	534[4]	P	State
60	Bunch	Round Valley Water Users	512	I,R	State

Table 2-11 Reservoirs and Stock Ponds in the Little Colorado River Plateau Basin

B. Other Large Reservoirs (50 acre surface area or greater)[5]

MAP KEY	RESERVOIR/LAKE NAME	OWNER/OPERATOR	MAXIMUM SURFACE AREA (acres)	USE[1]	JURISDICTION
61	Dry[6]	Navajo Nation	2,642	P	Tribal
62	Dry[6]	Private	1,817	P	Landowner
63	Dry	Private	1,674	P	Landowner
64	Red[6]	Navajo Nation	502	P	Tribal
65	Ortega Sink[6]	Apache Sitgreaves NF	405	P	Federal
66	Long[3]	Coconino NF	323	F,P,R	Federal
67	Long	Coconino NF	271	F,P	Federal
68	Greasewood [6]	Navajo Nation	269	P	Tribal
69	Dry [6]	Private	215	P	Landowner
70	Mud[6]	Private	168	F,P	Landowner
71	Tolani[3]	Navajo Nation	129	P	Tribal
72	Toh De Niihe[3]	Navajo Nation	121	P	Tribal
73	Dry [6]	Navajo Nation	112	P	Landowner
74	Dry [6]	Navajo Nation	110	P	Landowner
75	Mud Lake & Tank[3]	Coconino NF	106	F,P	Landowner
76	Breezy [3]	Coconino NF	101	P,R	Landowner
77	Yaeger Lake & Tank[3]	Coconino NF	96	P	Landowner
78	Dry [6]	Navajo Nation	95	P	Landowner
79	Dry Lake & Windy Tank[6]	Navajo Nation	92	P	Landowner
80	Unnamed[6]	Private	90	P	Landowner
81	Vail	Coconino NF	88	P	Federal
82	Grass Flat Tank[3]	Coconino NF	88	P	Federal
83	Dry	Navajo Nation	87	P	Tribal
84	Horse Lake & Tank[3]	Coconino NF	84	P	Federal
85	Unnamed[3]	Private	81	P	Landowner
86	Whipple[3]	Apache Sitgreaves NF	75	F,P,R	Federal
87	McDermit[3]	Private	72	P	Landowner
88	Pine Lake & Tank[3]	Coconino NF	70	P	Federal
89	Tobenayoli Pond[3]	Navajo Nation	65	P	Tribal
90	Deep[3]	Coconino NF	62	F	Federal
91	Indian[3]	Coconino NF	60	P	Federal
92	To Kla Dua Aakee	Navajo Nation	54	P	Tribal

C. Small Reservoirs (greater than 15 acre-feet and less than 500 acre-feet capacity)

Total number: 416
Total maximum storage: 13,343 acre-feet

D. Other Small Reservoirs (between 5 and 50 acres surface area)[5]

Total number: 269
Total surface area: 3,907 acres

E. Stock Ponds (up to 15 acre-feet capacity)

Total number: 6,113 (estimate based on water right filings)

Notes:

NF = National Forest
[1]C=flood control; F=fish & wildlife pond; H=hydroelectric; I=irrigation; N= navigation; O=other; P=fire protection, stock or farm pond R=recreation; S=water supply; U=unknown
[2]Dam is in New Mexico as is most of the lake
[3]Intermittent Lake
[4]Normal capacity < 500 acre-feet
[5]Capacity data not available to ADWR
[6]Dry Lake

Figure 2-17
Little Colorado River Plateau Basin Surface Water Conditions

Stream Data Source: ALRIS, 2005

2.1.5 Perennial/Intermittent Streams and Major Springs in the Little Colorado River Plateau Basin

Major and minor springs with discharge rates and date of measurement, and the total number of springs in the basin are shown in Table 2-12. The location of major springs is shown on Figure 2-18, keyed to Table 2-12A. A description of data sources and methods for intermittent and perennial reaches is found in Volume 1, Section 1.3.16. A description of spring data sources and methods is found in Volume 1, Section 1.3.14.

- Perennial streams are found at higher elevations in the basin due to winter snow and monsoon storms and where supported by spring flow. The Little Colorado River, the major drainage in the basin, flows perennially only in areas near the headwaters and below Silver Creek.
- An intermittent stream GIS cover was unavailable for tribal lands.
- There are 37 "major" springs with a measured discharge of 10 gallons per minute (gpm) or greater at any time.
- Listed discharge rates may not be indicative of current conditions. Many of the measurements were taken prior to 1990. Only 6 major and 6 minor spring measurements post-date 1990.
- Greatest discharge rates were measured in the far southeastern corner of the basin at the headwaters of Silver Creek (Silver, 3,648 gpm), south of Saint Johns (Salado, 1,730 gpm), east of Pinetop (Big, 1,211 gpm) and near Concho (Concho, 1,120 gpm). Most of the other major springs are also located in this area. A cluster of major springs is also located in the vicinity of Tuba City and the Hopi community of Moenkopi.
- Almost three quarters of the major springs discharge less than 100 gpm.
- Springs with measured discharge of 1 to 10 gpm are not mapped but coordinates are given in Table 2-12B. There are 50 "minor" springs identified in the basin.
- The total number of springs identified by the USGS varies between 1,222 to 1,305, depending on the database reference.

Table 2-12 Springs in the Little Colorado River Plateau Basin

A. Major Springs (10 gpm or greater):

Map Key	Name	Location		Discharge (in gpm)[1]	Date Discharge Measured
		Lattitude	Longitude		
1	Silver	341951	1095527	3,648	06/1990
2	Salado	342604	1092352	1,730	On or before 1990
3	Big (multiple)	340814	1095804	1,211	11/30/1990
4	Concho	342551	1093745	1,120	12/6/1951
5	Pinetop	340724	1095454	673	11/20/1990
6	Carnero	340609	1093212	400	9/24/1974
7	Adair	340825	1095727	276	11/30/1990
8	Unnamed[2]	342240	1092318	200	8/15/1985
9	Porter/Paige	341047	1095622	145	7/1/1971
10	Moenave	360840	1112005	118	2/25/1948
11	Wiltbank	341629	1092359	100	1/6/1975
12	Bourdon Ranch	342039	1095612	100	6/25/1952
13	Big Hollow Wash	343215	1092520	67	9/17/1975
14	Dotson Upper	360830	1111441	66	7/26/1954
15	Sheep	340316	1093358	60	5/22/1952
16	Unnamed	343135	1092553	50	2/12/1975
17	Sawmill	345014	1112234	40	7/18/1978
18	Whitcom	340845	1095217	40	6/11/1952
19	Danstone	340921	1094749	38	6/13/1952
20	Unnamed[2]	342251	1092251	37	8/15/1985
21	Unnamed	342247	1092254	31	8/15/1985
22	Pasture Canyon[2]	361021	1111159	31	4/26/2004
23	Davis[2]	342932	1091634	29	1/1/1957
24	Big Leroux's	351736	1114327	25	9/26/1949
25	Los Burros	340829	1094634	25	6/11/1952
26	24 Ranch	341723	1092445	20	1/6/1975
27	Oak	351438	1113521	20	9/20/1962
28	Thompson	340752	1095358	20	6/11/1952
29	Dotson Lower	360828	1111441	19	7/26/1954
30	Charlie Day	360833	1111412	16	6/10/1988
31	Hoxworth	350225	1113427	15	4/1/1996
32	Wide Reeds Ruins (right)	354237	1093312	15	11/9/2004
33	Unnamed Near Dennehotso	364656	1094254	13	04/2004
34	Moenkopi School	360632	1111311	12	3/29/2004
35	Wide Reeds Ruins (left)	354237	1093312	11	11/9/2004
36	Mineral	340939	1093645	10	11/20/1974
37	Schuster	342859	1093002	10	2/6/1975

Table 2-12 Springs in the Little Colorado River Plateau Basin

B. Minor Springs (1 to 10 gpm):

Name	Location		Discharge (in gpm)[1]	Date Discharge Measured
	Latitude	Longitude		
Little Giant	341027	1093417	8	9/24/1974
Atascacita	341007	1093100	8	9/24/1974
Neilson	341753	1092124	8	1/17/1975
Huse	354218	1144836	7	2/10/1976
CC Hall	340715	1093737	6	6/23/1952
Mud	342154	1092847	5	1/7/1975
Ortega	342657	1093555	5	1/15/1975
McIntosh	343048	1091740	5	7/1/1946
Navajo	350605	1092938	5	11/18/1975
Halleck[2]	340730	1095513	5	06/1952
Walker Wash	361056	1141732	5	3/12/1980
Unnamed	351823	1114243	5	8/23/1979
Chipmunk	340830	1095218	4	6/11/1952
Malpais	342428	1093325	4	1/15/1975
Ashurst	350131	1112949	3	7/26/1978
Bitter	363930	1113845	3	4/30/1952
Red Bluff (south)	362740	1141512	3	3/11/1980
Unnamed	340913	1092742	3	12/24/1974
Hall	341624	1092055	3	1/16/1975
Wepo (south)	355325	1102203	3	8/17/1993
Betatakin	364049	1103218	3	8/28/2002
Hotevilla	355544	1104024	3	8/16/1993
Laguna Salada	342018	1094324	3	1/15/1975
Babbitt	350401	1113216	2	3/27/2004
Unnamed	362812	1105902	2	7/8/1954
Maynard	361544	1141818	2	3/11/1980
Lizard Hill	350659	1103153	2	7/20/1972
Telephone	340842	1094837	2	6/13/1952
Fireman Cabin	340653	1093736	2	9/24/1974
Unnamed	364128	1103606	2	8/7/1954
Franey	340718	1093744	2	9/24/1974
Unnamed	363632	1103822	2	8/6/1954
Wepo (north)	355330	1102159	2	8/17/1993
Unnamed	342448	1093109	2	1/15/1975
Youngs	350517	1112838	2	7/24/1978
Nasjo Toh	363504	1100937	1	10/13/1954
Unnamed	361603	1105911	1	6/24/1954
Red Bluff (north)	362744	1141505	1	3/11/1980
Beehive	340404	1093239	1	9/23/1974
Sherwood	341715	1092115	1	1/16/1975
Clark	350402	1113444	1	3/27/2004
Salt Seeps	350625	1092706	1	11/18/1975
Coyote	351358	1113934	1	8/27/1979

Table 2-12 Springs in the Little Colorado River Plateau Basin

B. Minor Springs (con't.):

Name	Location		Discharge (in gpm)[1]	Date Discharge Measured
	Latitude	Longitude		
Trough	341937	1102448	1	11/7/1952
McCormick	340853	1094623	1	6/13/1952
Campbell	344453	1112947	1	8/6/2002
Heiser	353021	1112114	1	5/30/2002
Unnamed	362208	1094113	1[3]	11/1/1929
Unnamed[2,4]	351521	1113544	1	8/27/1949
Wupatki	353118	1112231	1[3]	8/23/1950

C. Total number of springs, regardless of discharge, identified by USGS (see ALRIS, 2005 and NHD, 2006): 1,222 to 1,305

Notes:
[1]Most recent measurement identified by ADWR
[2]Spring not displayed on current USGS topo maps
[3]Most recent measurement < 1gpm
[4]Location approximated by ADWR

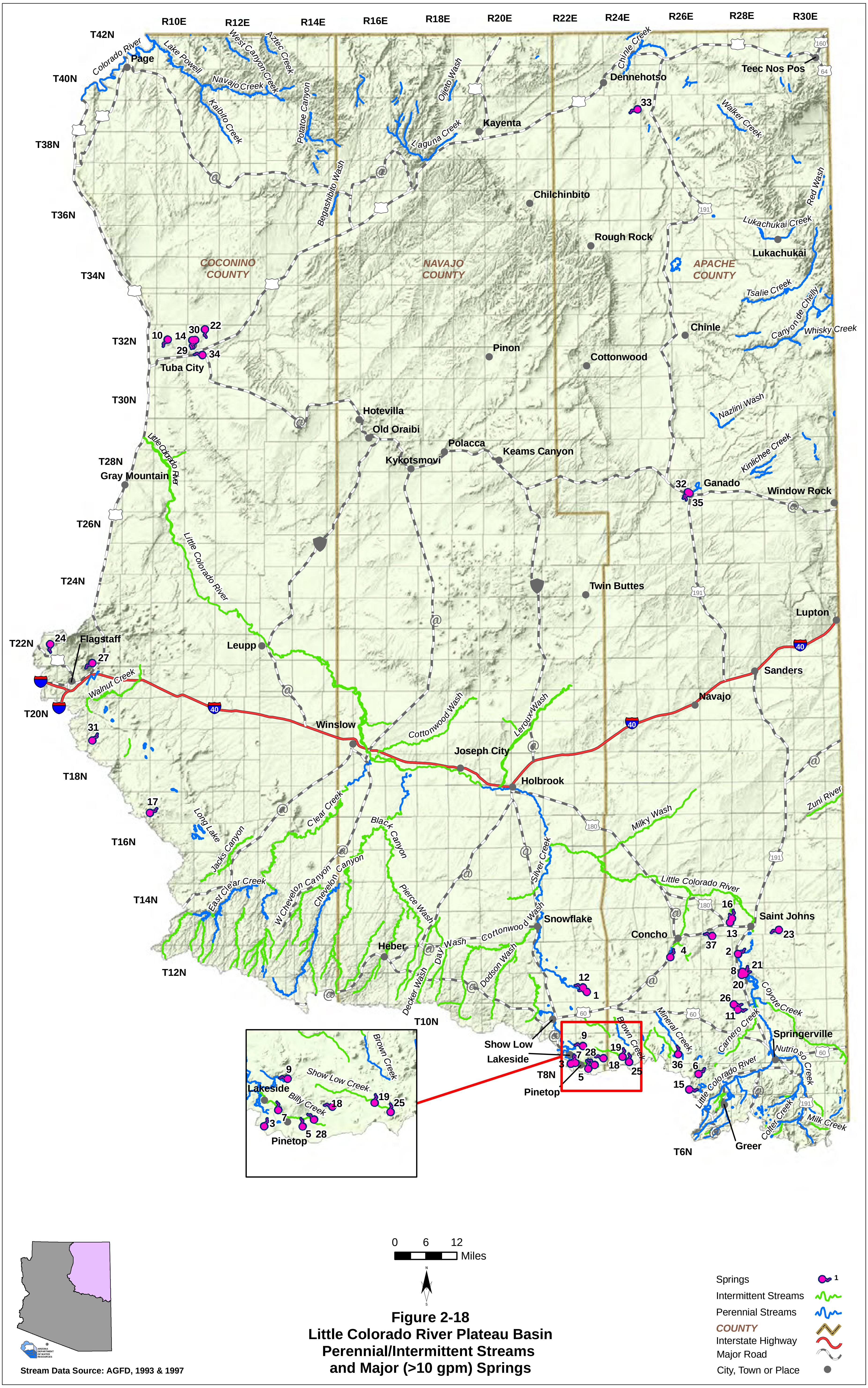


Figure 2-18
Little Colorado River Plateau Basin
Perennial/Intermittent Streams
and Major (>10 gpm) Springs

2.1.6 Groundwater Conditions of the Little Colorado River Plateau Basin

Major aquifers, well yields, estimated natural recharge, estimated water in storage, number of index wells and date of last water-level sweep are shown in Table 2-13. Figure 2-19 shows aquifer boundaries, aquifer flow direction and water-level change between 1990-1991 and 2003-2004. Figure 2-20 contains hydrographs for selected wells shown on Figure 2-19. Figure 2-19 shows well yields in 5 yield categories. A description of aquifer data sources and methods is found in Volume 1, Section 1.3.2. A description of well data sources and methods, including water-level changes and well yields is found in Volume 1, Section 1.3.19.

Major Aquifers

- Refer to Table 2-13 and Figure 2-19.
- Major aquifers, their utilization, extent and other characteristics are described in Section 2.0.2. There are several local aquifers and 3 large regional aquifers in the basin.
- Recent stream alluvium aquifers include alluvial deposits along washes and stream channels, including along the Little Colorado River and its tributaries.
- Volcanic aquifers include the Lakeside-Pinetop aquifer and the smaller aquifer inside the caldera of the San Francisco Peaks, known as the "Inner Basin".
- The large regional aquifers are located in sedimentary formations of sandstone and limestone that are stacked on top of one another and are generally separated by impermeable shales and siltsones. In descending order, the regional aquifers are the D-, N-, and C-aquifers.
- The Bidahochi formation forms a local aquifer in the central part of Apache and Navajo Counties and near St. Johns.
- Undifferentiated sandstones west of Show Low along the Mogollon Rim and in the Springerville-Eager area form local aquifers, known as the White Mountain and Springerville Aquifers, respectively.
- Flow directions are shown in Figure 2-19. Flow directions in the D-aquifer are generally from east to west. Flow in the N-aquifer varies as shown on the map. Flow direction in the C-aquifer is south to north in the southern part of the basin and generally from east to west in the northern part of the basin. The Bidahochi Aquifer flows are not mapped in the area south of Keams Canyon. Flows in the "Volcanic" aquifer are generally toward the north.

Well Yields

- Refer to Table 2-13 and Figure 2-21.
- Well yield information is generally measured when the well is drilled and reported on completion reports. Reported well yields are only a general indicator of aquifer productivity. Specific information is available from well measurements conducted as part of basin investigations.
- Yields vary greatly in the basin. In general, well yields are greatest along the Little Colorado River and in alluvial areas north of Springerville and in the vicinity of Concho, Saint Johns and Snowflake. Areas of lower yield are found in the northern part of the basin and in the volcanic aquifers around Flagstaff and Greer.

Natural Recharge

- Refer to Table 2-13
- Estimates of natural recharge for the large regional aquifers are from relatively recent estimates from USGS studies.
- Estimated natural recharge to the major regional aquifers is 173,820 acre-feet per year to the C-aquifer (areal extent 21,655 square miles), 5,392 acre-feet per year to the D-aquifer (areal extent 3,125 square miles) and between 2,500 to 4,800 acre-feet to the N-aquifer (areal extent 6,250 square miles). Main recharge areas are along the southern and eastern periphery of the basin.
- Recharge rates to other basin aquifers is not known.

Water in Storage

- Refer to Table 2-13
- Estimates of storage are based on rough estimates and considerably more studies are needed. Components of storage include aquifer depth and specific yield.
- The only storage estimate for the entire basin is 508 million acre-feet from a 1989 ADWR study.

Water Level

- Refer to Figure 2-19
- Depth to water and water-level change between 1990-1991 and 2003-2004 is shown in Figure 2-19. ADWR annually measures 57 index wells in the basin. In 2001, the year of the last water-level sweep in the basin, 932 wells were measured.
- Deep water levels are found in areas near Flagstaff where water levels as deep as 1,572 feet below land surface were measured and near Cottonwood and Pinon. Shallow water levels (<50 feet below land surface) are found along the Little Colorado River, in the Tuba City area, near Window Rock and near Dennehotso.
- Water levels can vary significantly even where wells are in close proximity based on the specific location of the well.
- Areas of most significant decline were found in the vicinity of St. Johns, Pinon, Flagstaff and Kayenta. Few wells measured showed water level rises of more than a foot. Rises were noted in individual wells near Springerville, Concho, Chilchinbito and Flagstaff.
- Hydrographs corresponding to selected wells shown on Figure 2-19 but covering a longer time period are shown in Figure 2-20. Hydrographs show the well depth, the aquifer, the well use and location identifier. Wells located off reservation have a cadastral location code.

Table 2-13 Groundwater Data for the Little Colorado River Plateau Basin

Basin Area, in square miles:	26,700	
Major Aquifer(s):	**Geologic Units and/or Name**	
	Recent Stream Alluvium	
	Volcanic Rock (Lakeside-Pinetop Aquifer)	
	Sedimentary Rock (Bidahochi Formation, C, D, N, Springerville, and White Mountain Aquifers)	
Well Yields, in gal/min:	Range 8-1,602 Median 95 (85 wells measured)	Measured by ADWR and/or USGS or NTUA[1]
	Range 1-3,000 Median 500 (386 wells reported)	Reported on registration forms for large (> 10-inch) diameter wells
	Range 30-300	ADWR (1990)
	Range 0-2,500	USGS (1994)
Estimated Natural Recharge, in acre-feet/year:	173,820 (C Aquifer)	USGS (2002)
	5,392 (D Aquifer)	USGS (2003)
	>2,500 - >4,800 (N Aquifer)	USGS (1996)
Estimated Water Currently in Storage, in acre-feet:	508,000,000 (total)	ADWR (1990)
	413,000,000 (C Aquifer)	ADWR (1989)
	15,000,000 (D Aquifer)	ADWR (1989)
	166,000,000 - 293,400,000 (N Aquifer)	ADWR (1989) and USGS (1996)
	N/A	Freethey and Anderson (1986)
	N/A	Arizona Water Commission (1975)
Current Number of Index Wells:	57	
Date of Last Water-level Sweep:	2001 (932 wells measured)	

[1]NTUA = Navajo Tribal Utility Authority

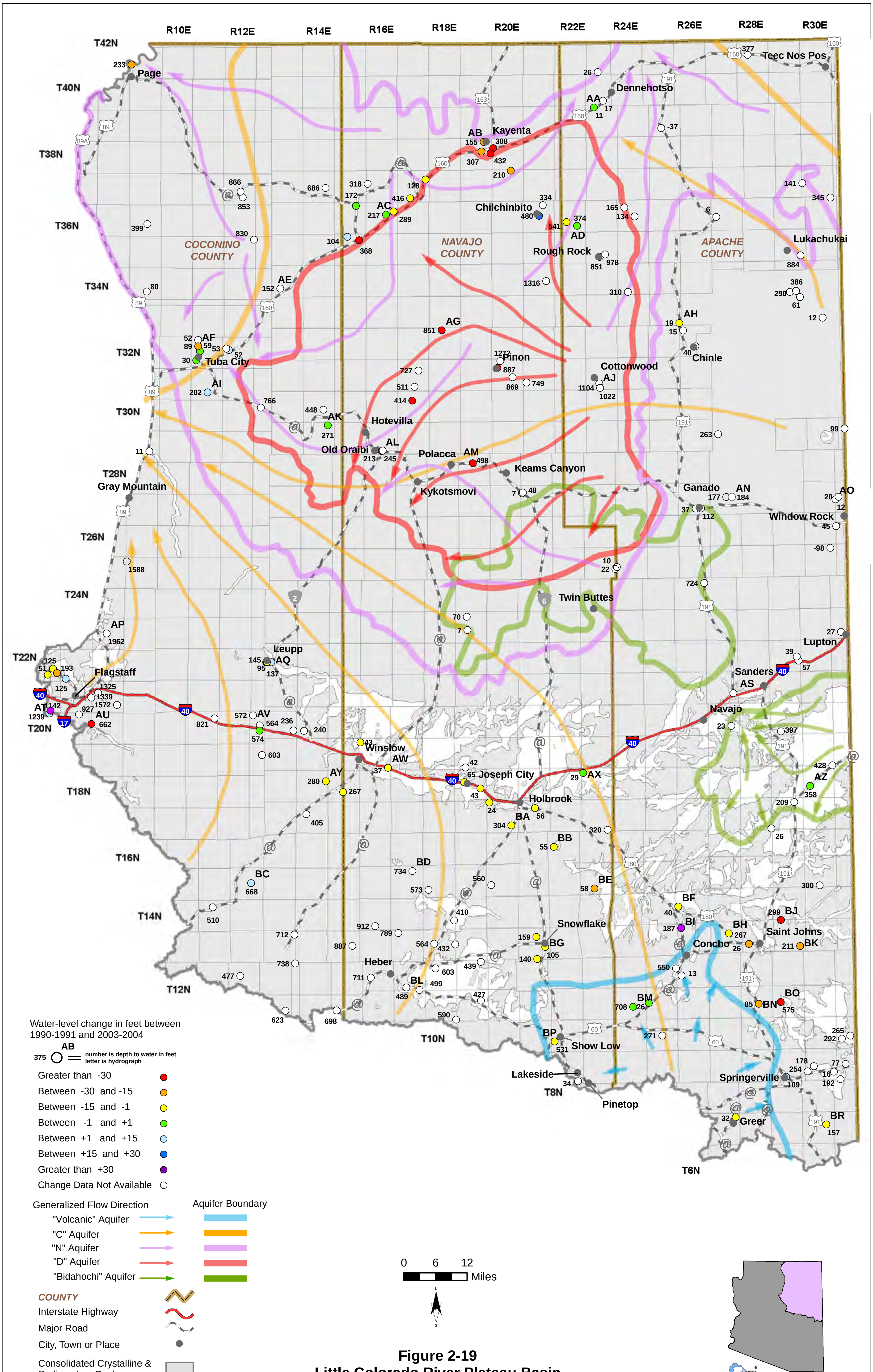


Figure 2-19
Little Colorado River Plateau Basin
Groundwater Conditions

Figure 2-20. Little Colorado River Plateau Hydrographs Showing Depth to Water in Selected Wells

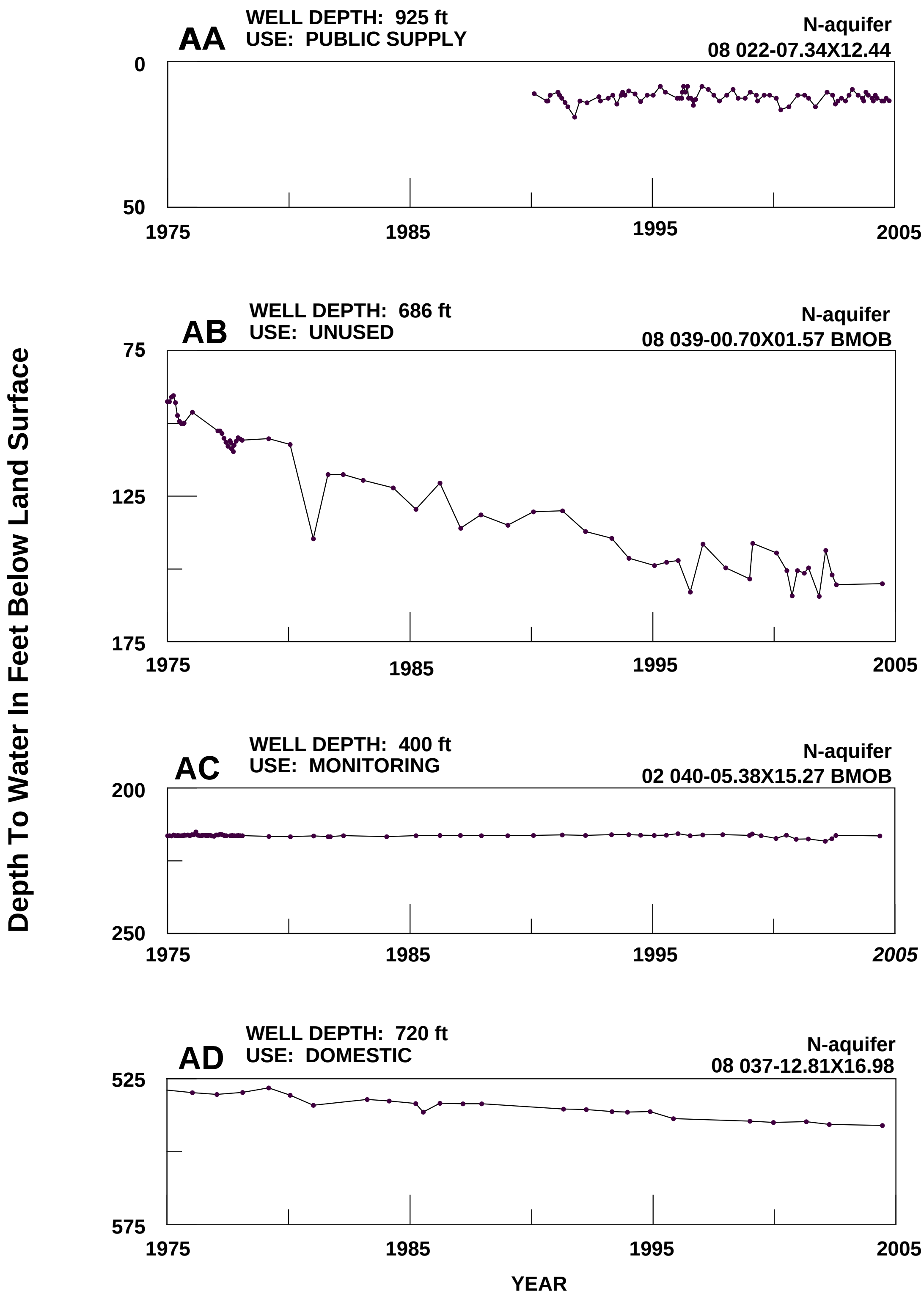


Figure 2-20. Little Colorado River Plateau
Hydrographs Showing Depth to Water in Selected Wells - continued

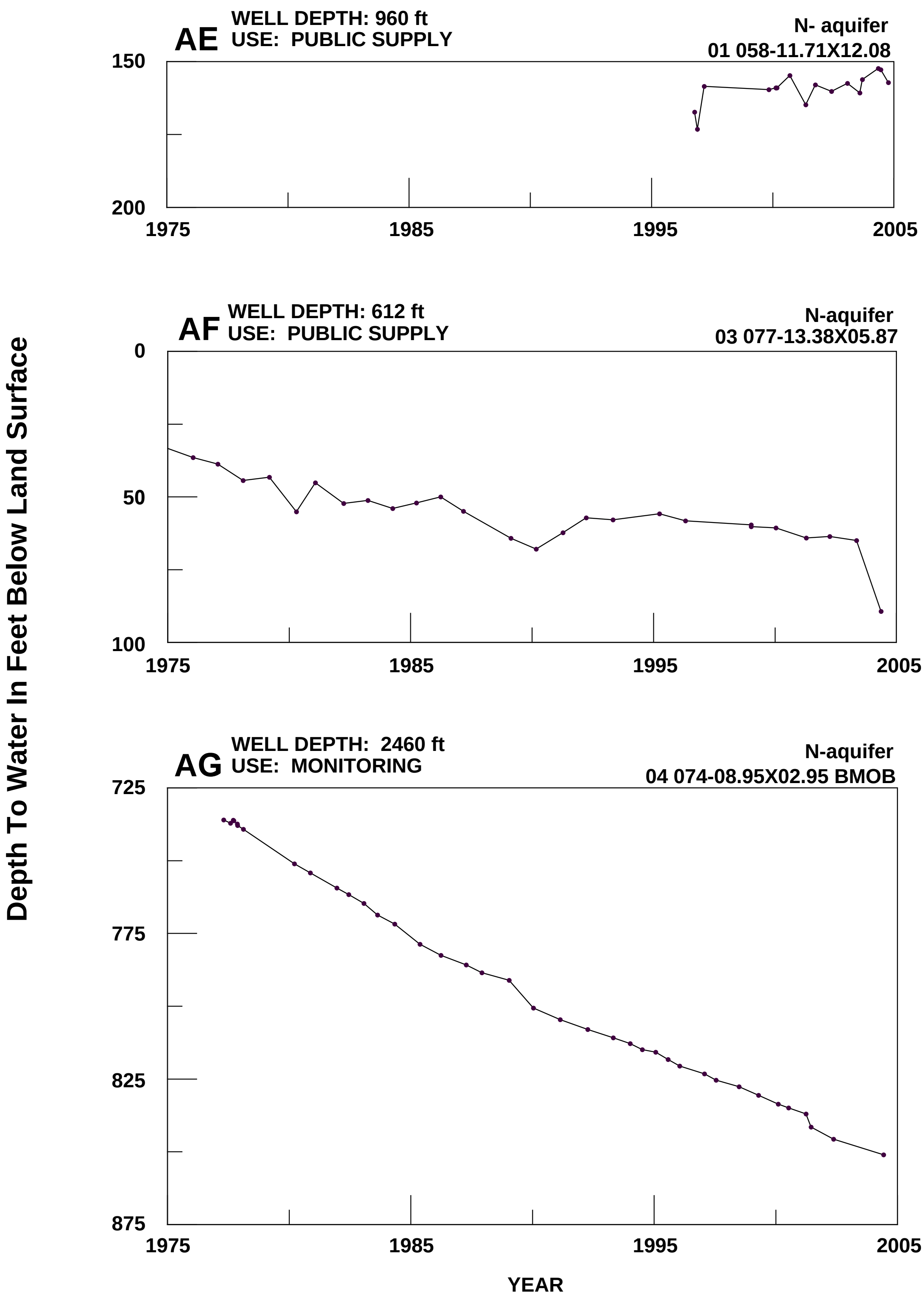


Figure 2-20. Little Colorado River Plateau
Hydrographs Showing Depth to Water in Selected Wells - continued

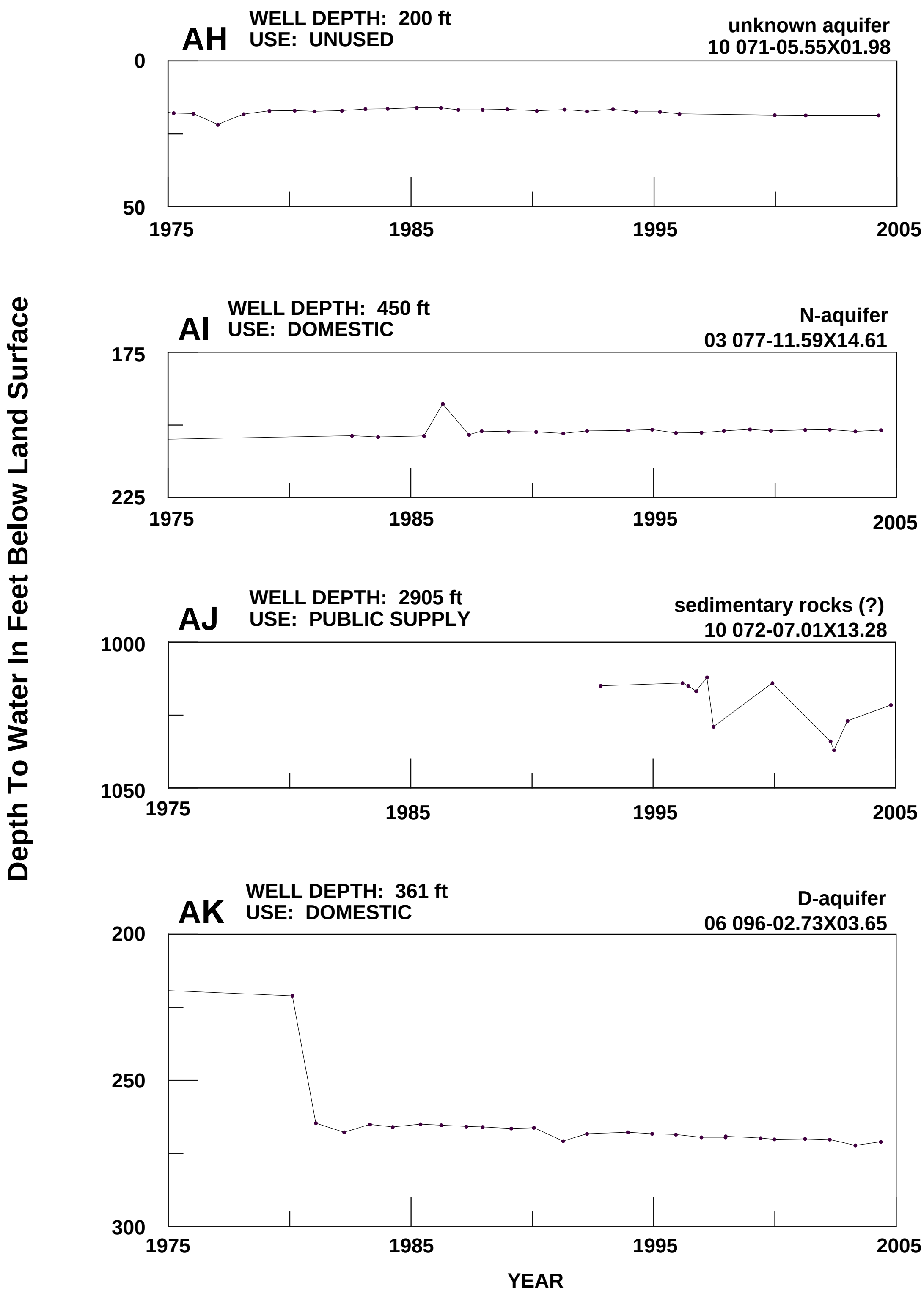


Figure 2-20. Little Colorado River Plateau Hydrographs Showing Depth to Water in Selected Wells - continued

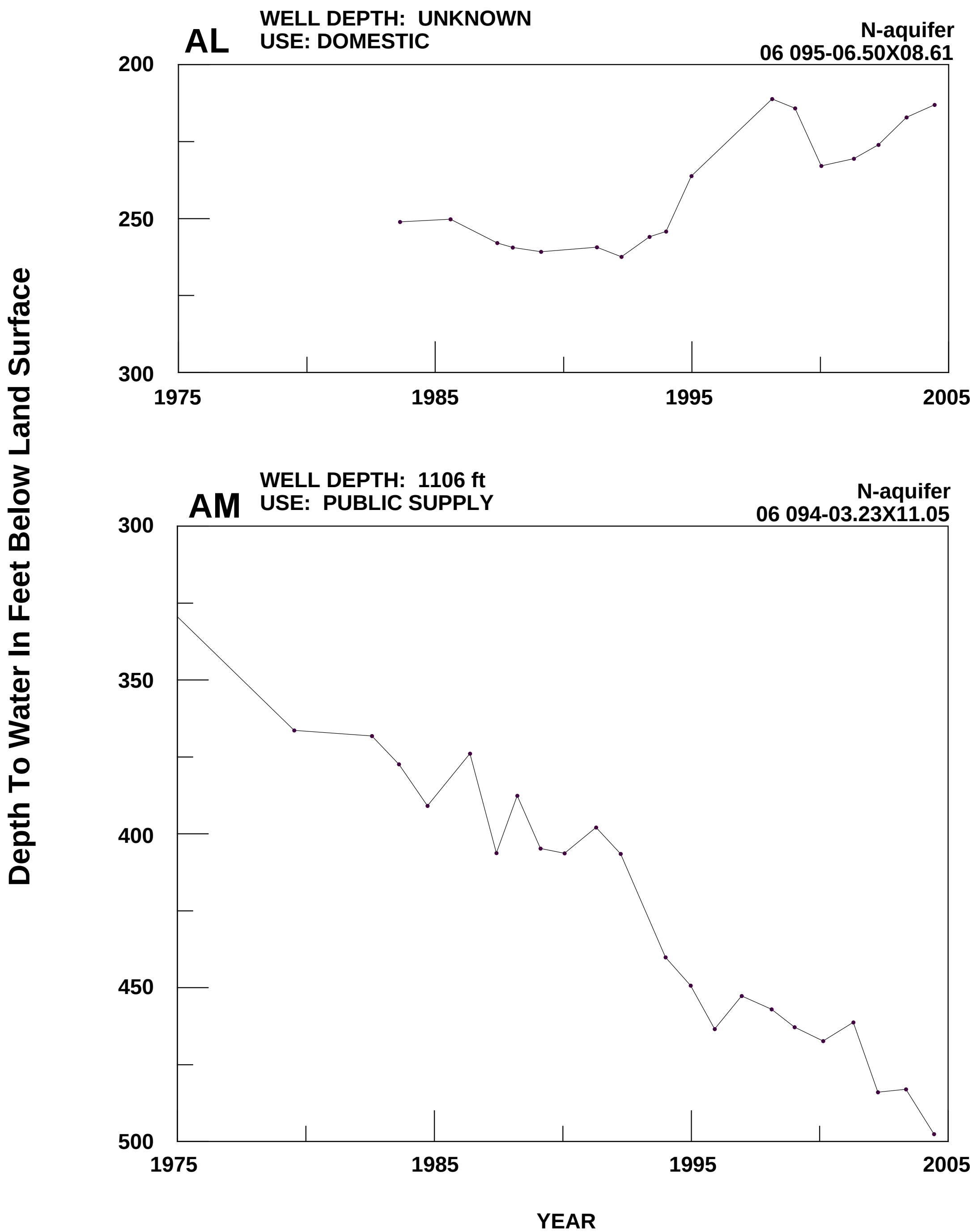


Figure 2-20. Little Colorado River Plateau
Hydrographs Showing Depth to Water in Selected Wells - continued

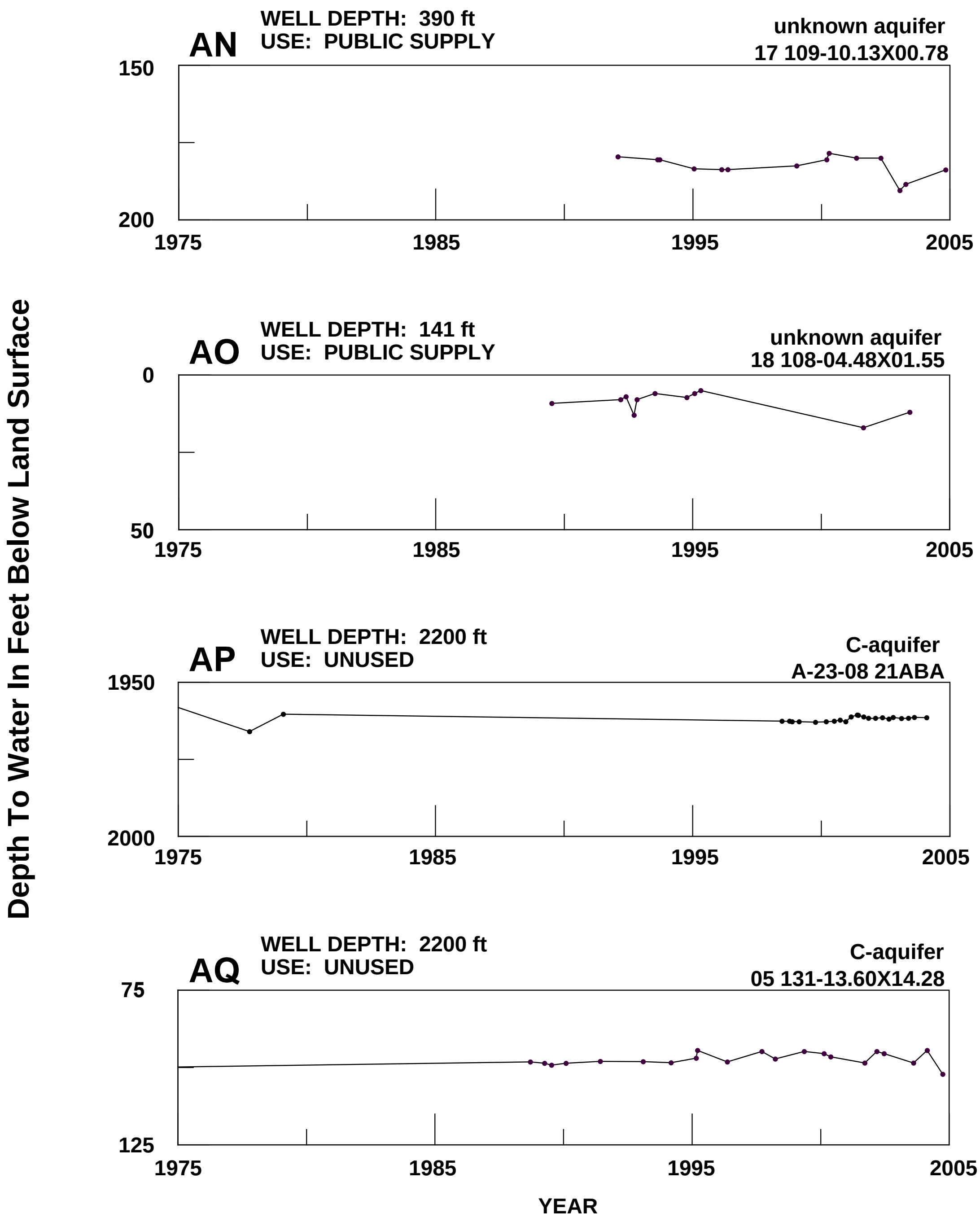


Figure 2-20. Little Colorado River Plateau
Hydrographs Showing Depth to Water in Selected Wells - continued

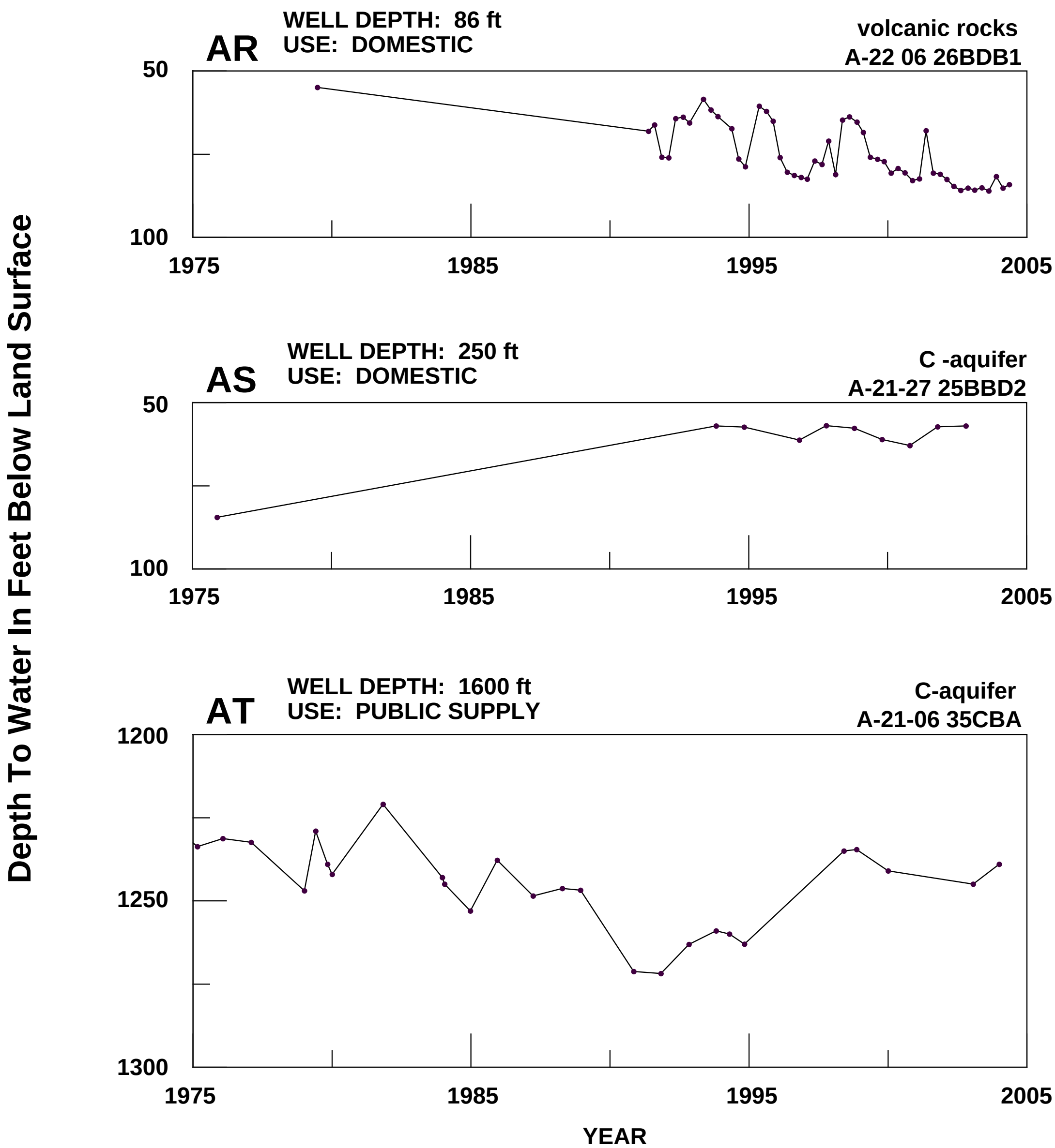


Figure 2-20. Little Colorado River Plateau
Hydrographs Showing Depth to Water in Selected Wells - continued

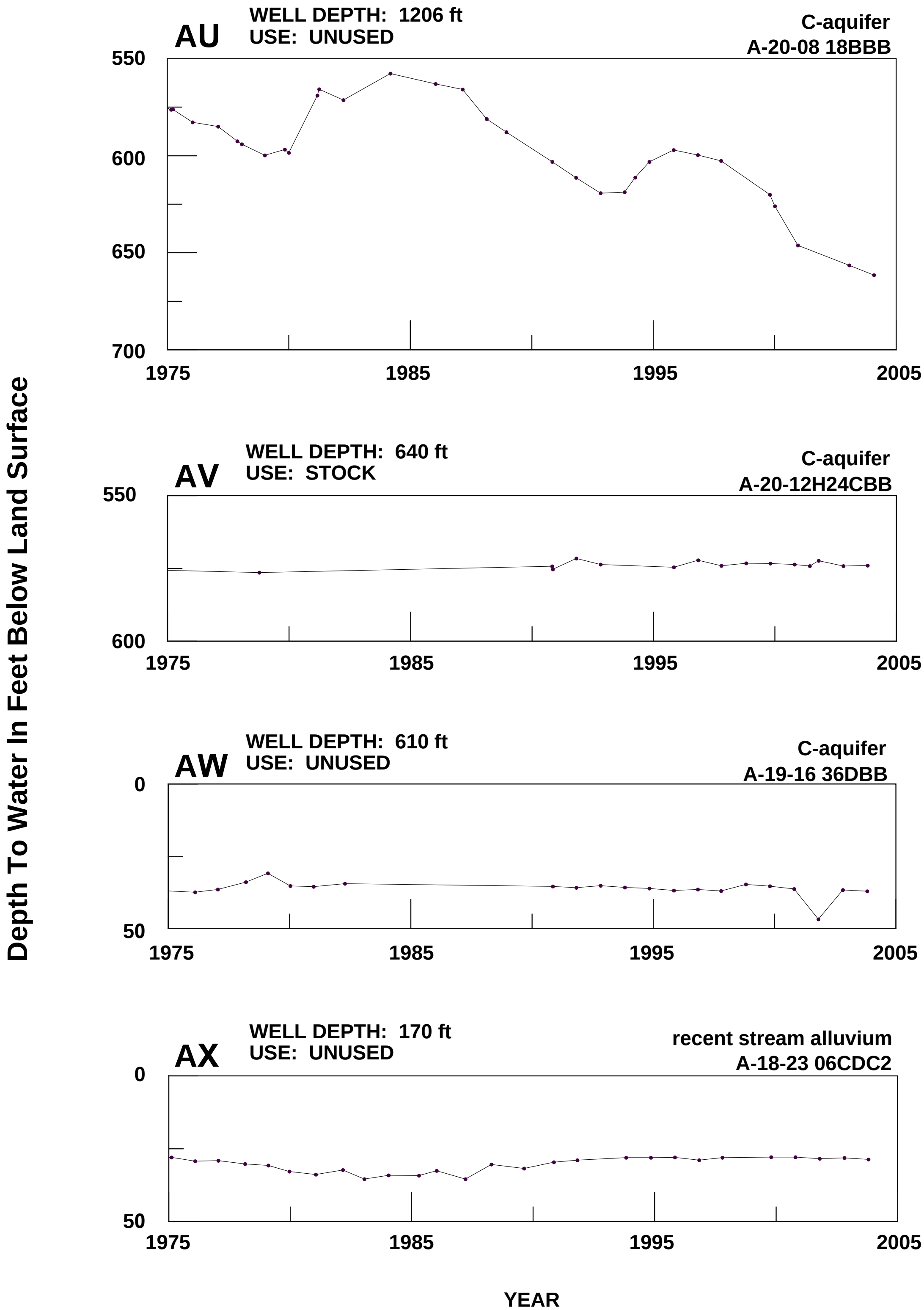


Figure 2-20. Little Colorado River Plateau
Hydrographs Showing Depth to Water in Selected Wells - continued

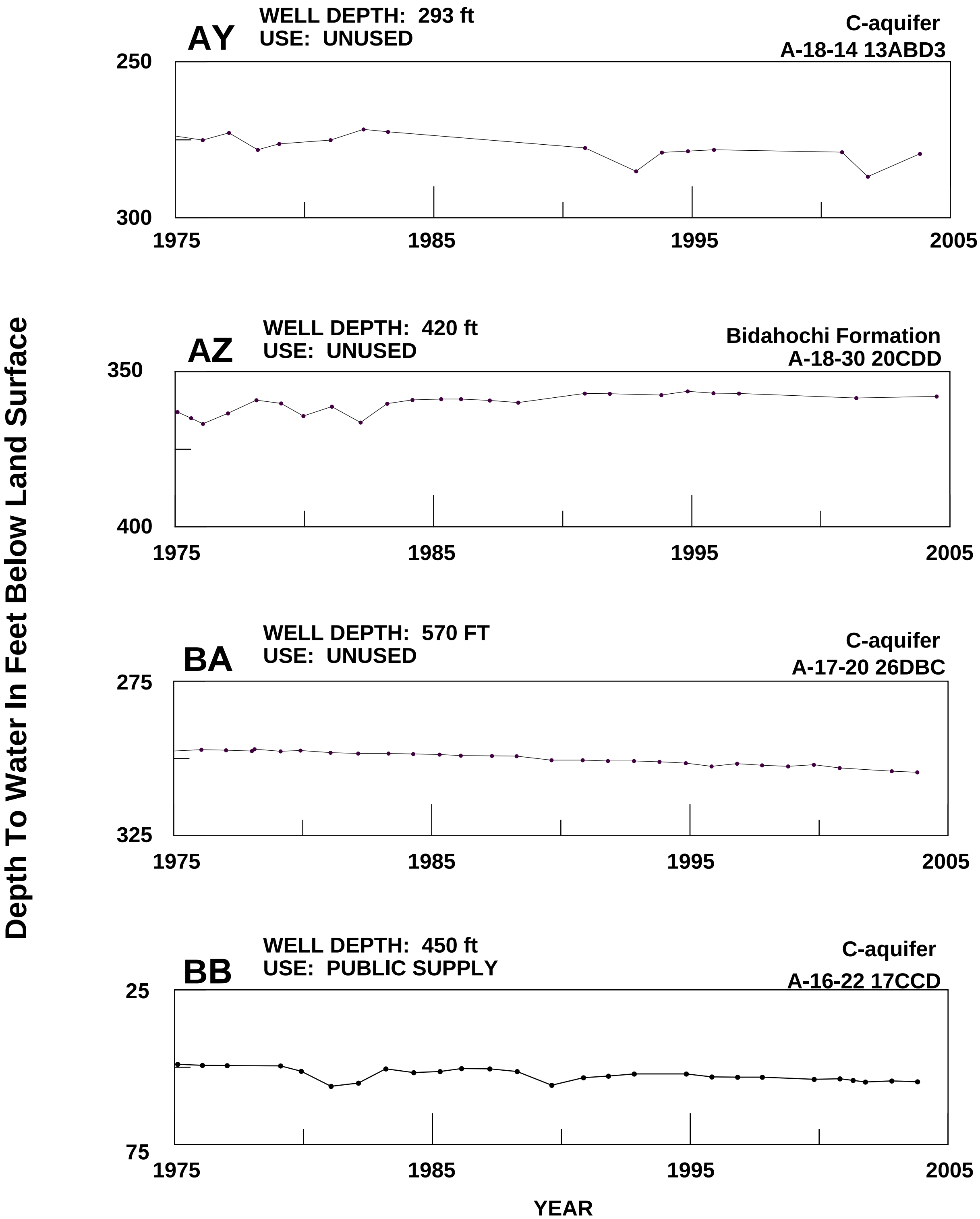


Figure 2-20. Little Colorado River Plateau
Hydrographs Showing Depth to Water in Selected Wells - continued

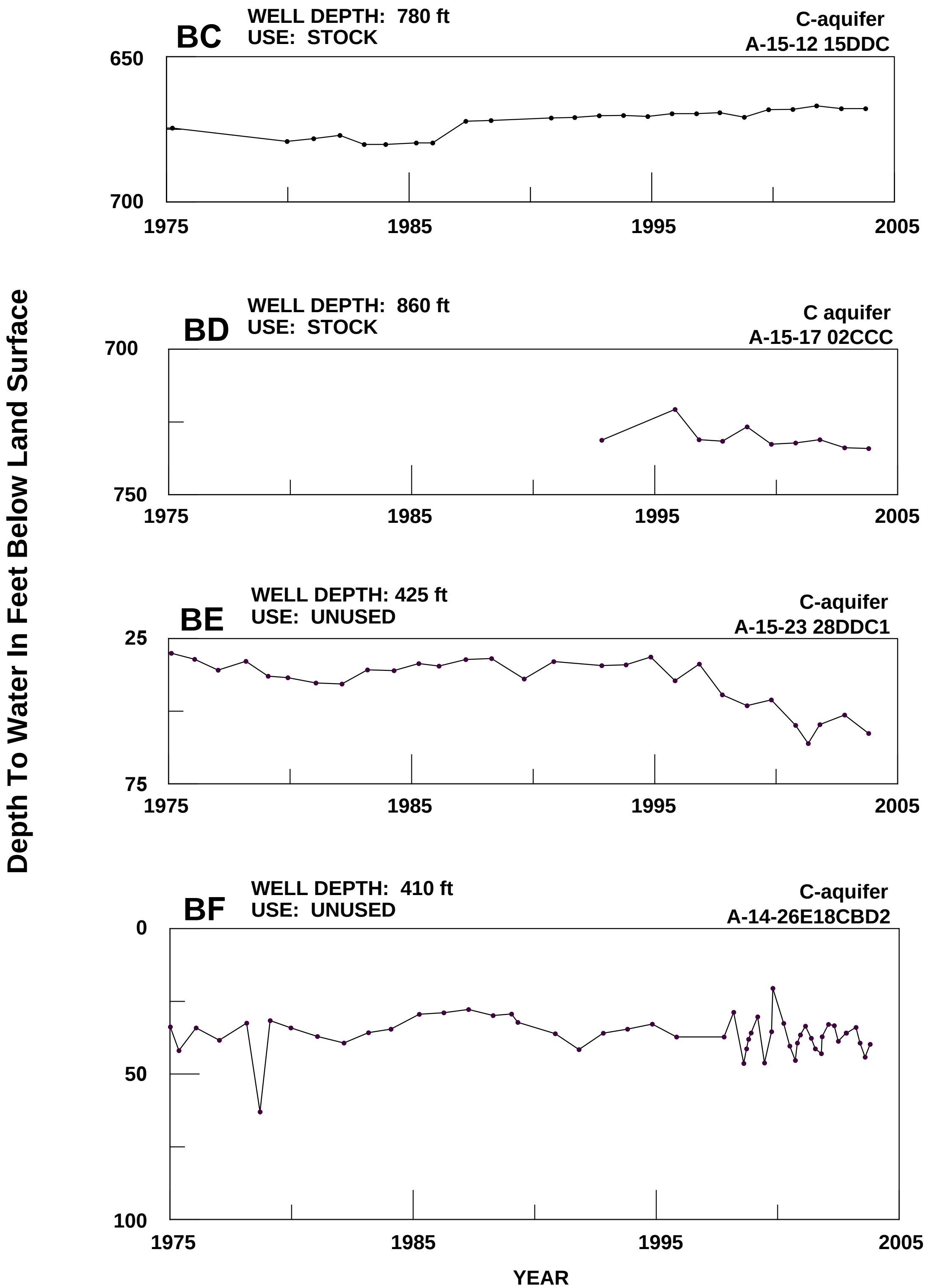


Figure 2-20. Little Colorado River Plateau
Hydrographs Showing Depth to Water in Selected Wells - continued

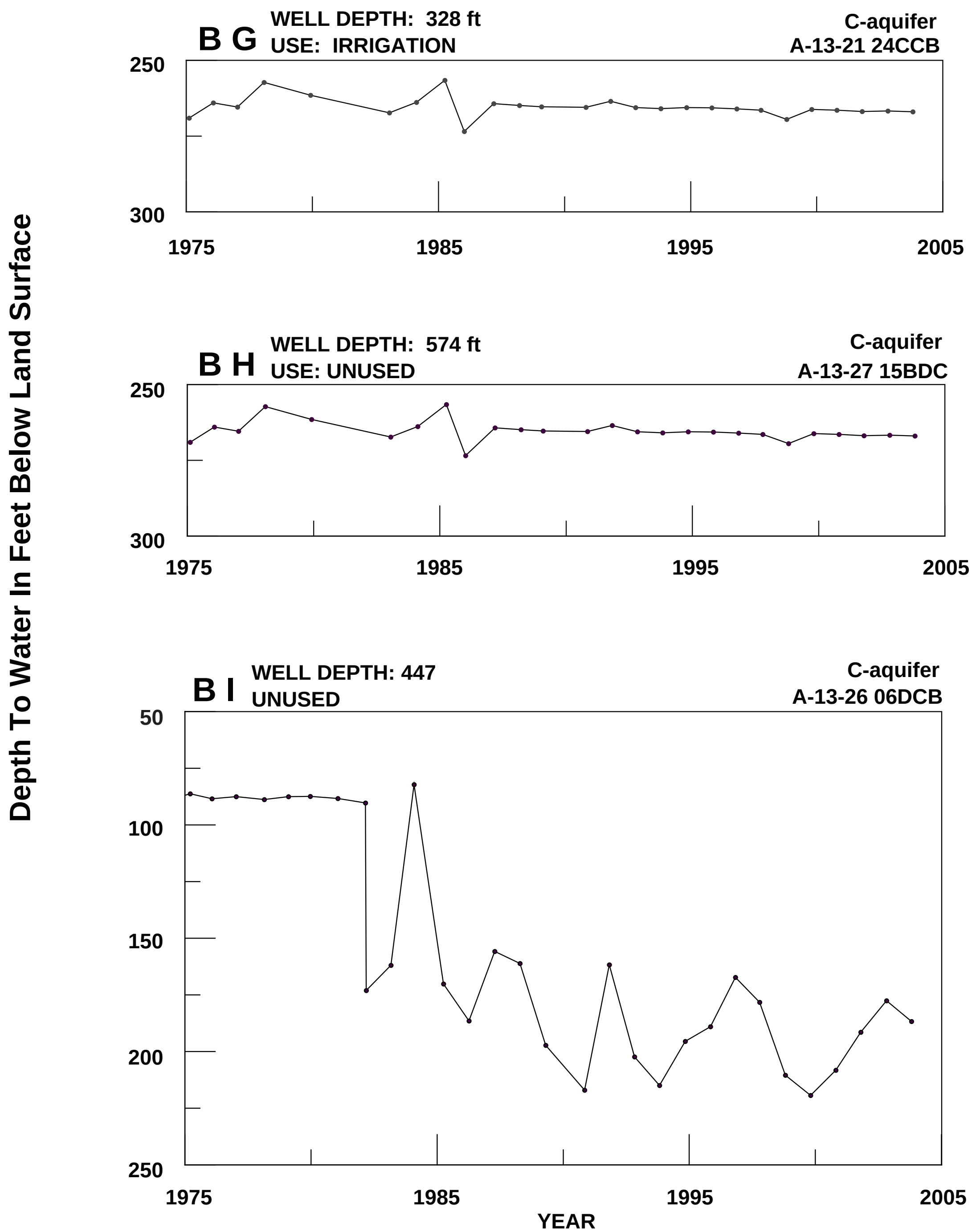


Figure 2-20. Little Colorado River Plateau Hydrographs Showing Depth to Water in Selected Wells - continued

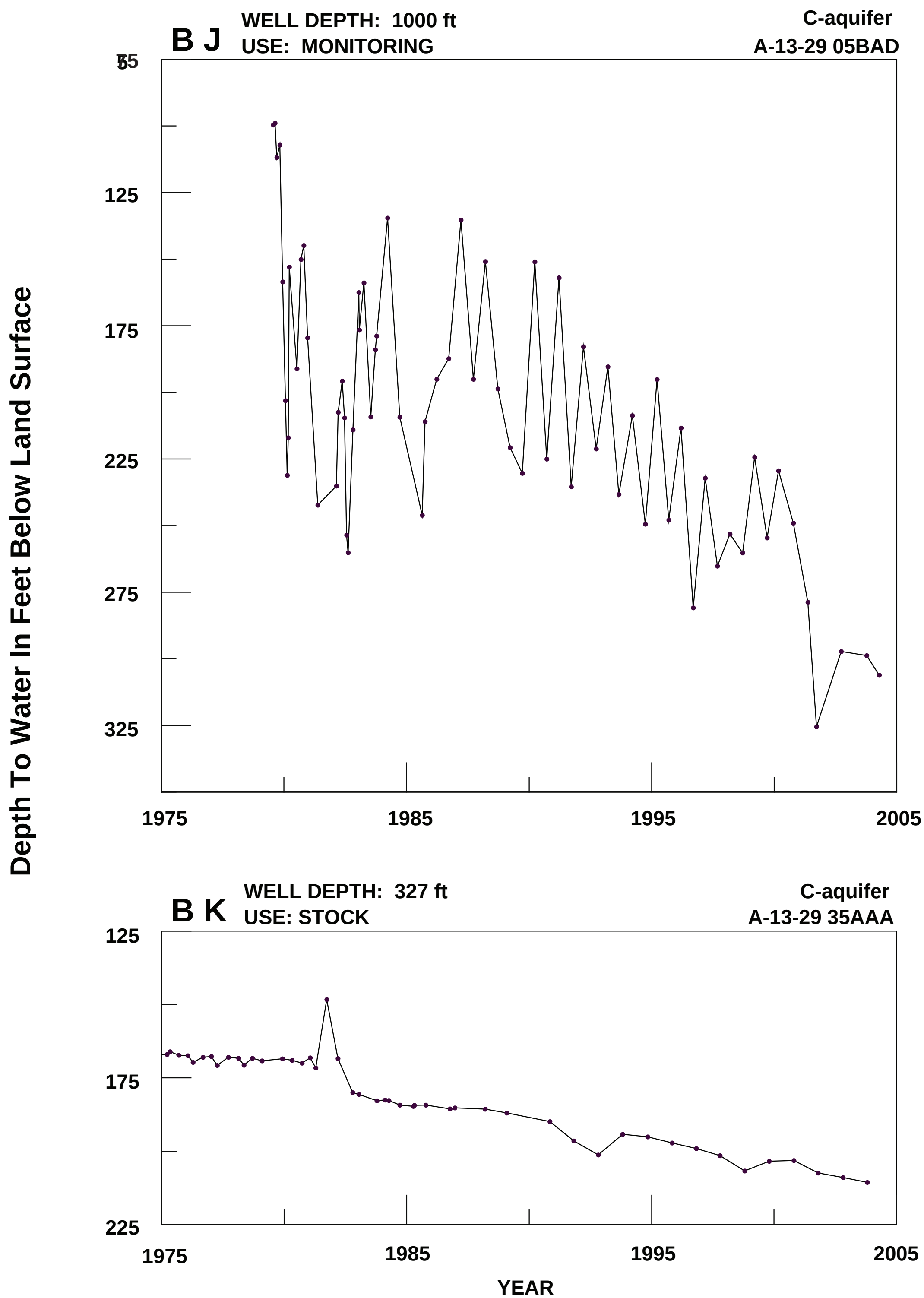


Figure 2-20. Little Colorado River Plateau
Hydrographs Showing Depth to Water in Selected Wells - continued

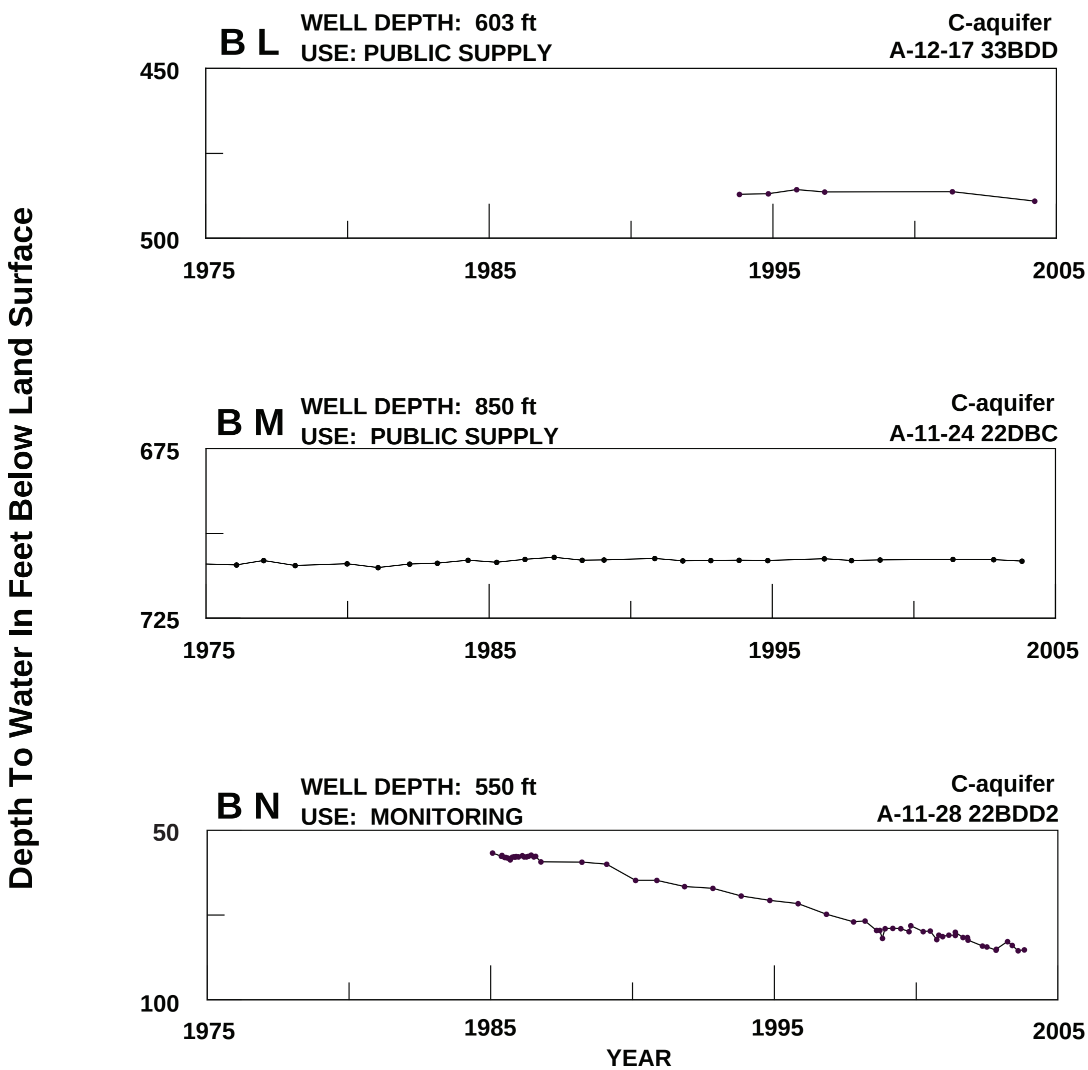
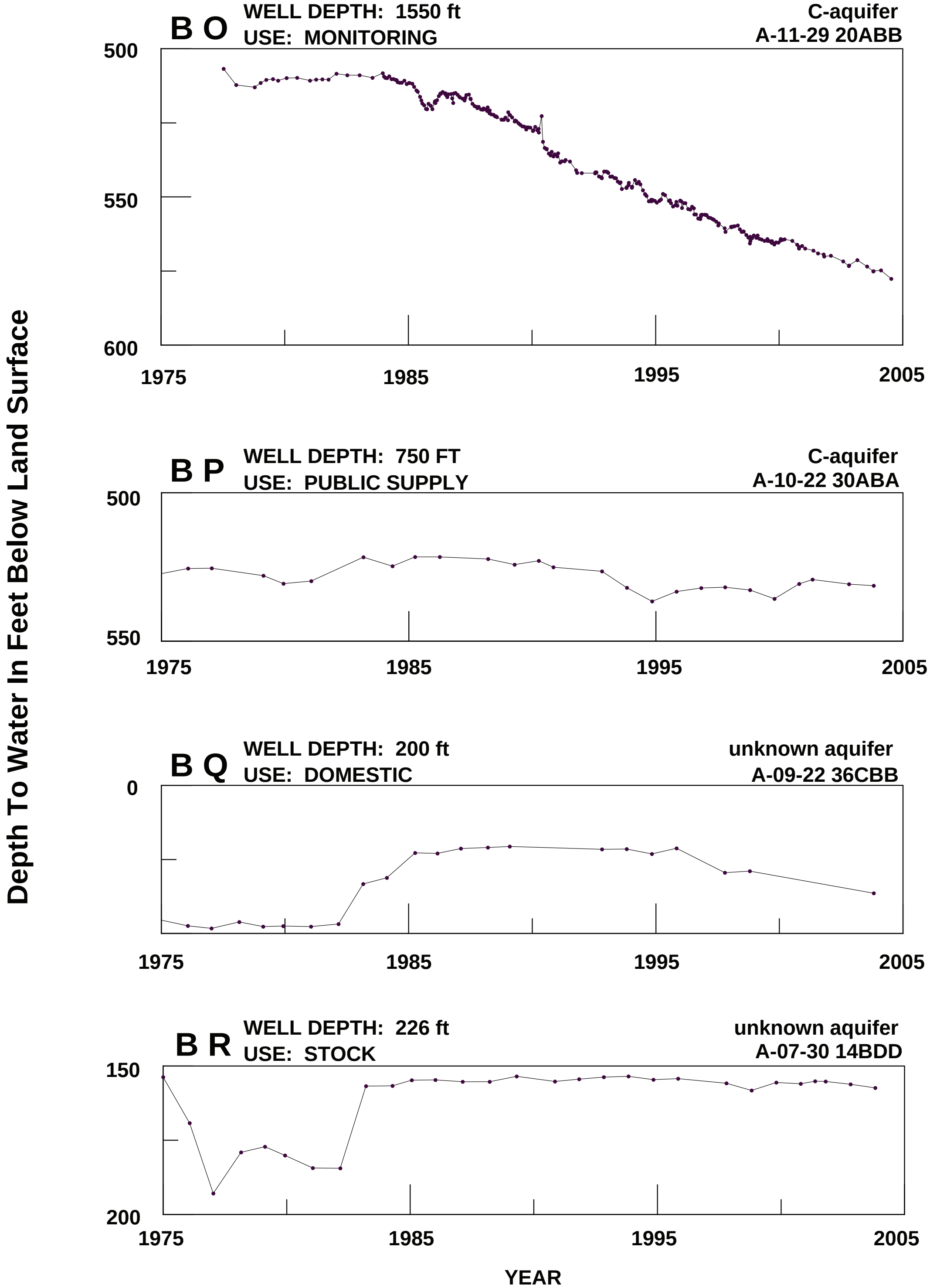


Figure 2-20. Little Colorado River Plateau
Hydrographs Showing Depth to Water in Selected Wells - continued



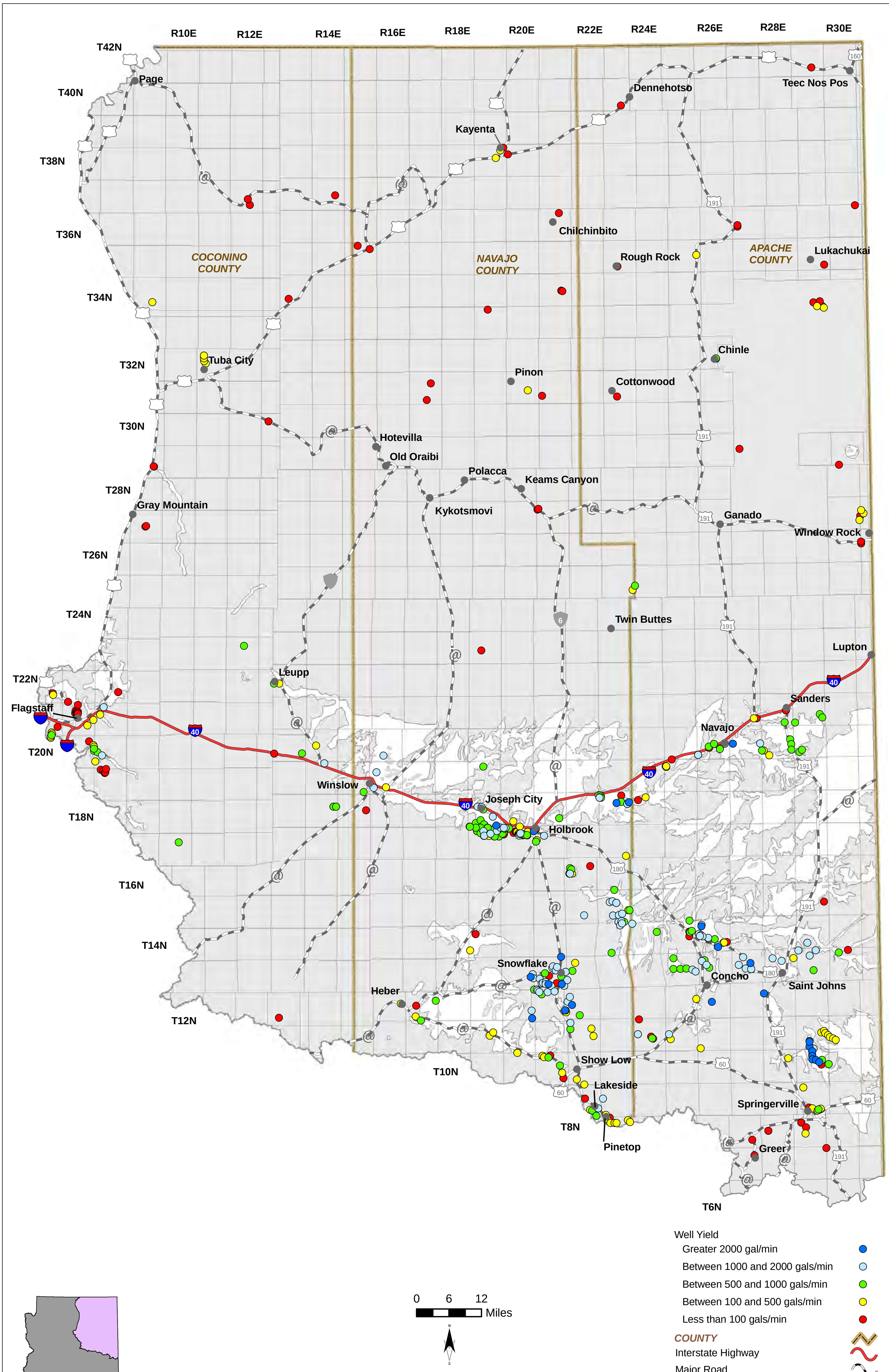


Figure 2-21
Little Colorado River Plateau Basin
Well Yields

2.1.7 Water Quality of the Little Colorado River Plateau Basin

Drinking water standard exceedences in wells, springs and mine sites including location and parameter(s) exceeded are shown in Table 2-14A. Impaired lakes and streams with site type, name, length of impaired stream reach, area of impaired lake, designated use standard and parameter(s) exceeded is shown in Table 2-14B. Figure 2-22 shows the location of exceedences and impairment keyed to Table 2-14. A description of water quality data sources and methods is found in Volume 1, Section 1.3.18. Not all parameters were measured at all sites; selective sampling for particular constituents is common.

Wells, springs and mine sites

- Refer to Table 2-14A
- Drinking water standard exceedences in wells, springs and at mine sites have been reported at 237 sites in the basin.
- North of Highway 264, the parameters most frequently exceeded in the sites measured were thallium and radionuclides in both wells and springs
- Between Highway 264 and Interstate 40, the parameter most frequently exceeded in the sites measured was arsenic. There is a notable arsenic cluster in the vicinity of the Hopi communities of Polacca, Kykotsmovi and Keams Canyon.
- South of Interstate 40 the parameters most frequently exceeded in the sites measured were arsenic and cadmium.
- For the entire basin, the most frequently exceeded constituents measured, in order of greatest occurrence were arsenic, radionuclides, thallium, lead and TDS.

Lakes and streams

- Refer to Table 2-14B
- Water quality standards were exceeded in eight lakes, and at two reaches on Nutrioso Creek and at six reaches of the Little Colorado River
- The parameter most frequently exceeded in the lakes measured was mercury.
- Turbidity was the most frequently exceeded parameter in the Little Colorado River and Nutrioso Creek.

Table 2-14 Water Quality Exceedances in the Little Colorado River Plateau Basin

A. Wells, Springs and Mines

Map Key	Site Type	Site Location			Parameter(s) Exceeding Drinking Water Standard[2]
		Township	Range	Section	
1	Well	41 North	30 East	34	Tl
2	Well	41 North	29 East	14	Tl
3	Spring	41 North	23 East	28	Pb
4	Well	41 North	19 East	21	As, Rad
5	Well	40 North	28 East	29	Rad
6	Well	40 North	28 East	18	Rad
7	Spring	40 North	28 East	13	Rad
8	Well	40 North	28 East	1	As
9	Well	40 North	27 East	26	As
10	Well	40 North	27 East	21	As
11	Well	40 North	27 East	14	Rad
12	Spring	39 North	39 East	31	Sb
13	Spring	39 North	39 East	31	Tl
14	Spring	39 North	21 East	35	Rad, Se, Tl
15	Spring	38 North	29 East	33	Tl
16	Spring	38 North	28 East	2	Rad
17	Well	38 North	20 East	23	Tl
18	Spring	38 North	7 East	28	Rad, Tl
19	Well	37 North	31 East	19	Sb, Tl
20	Well	37 North	29 East	27	Rad, Tl
21	Well	37 North	29 East	26	Sb, Rad
22	Spring	37 North	29 East	2	Tl
23	Spring	36 North	31 East	18	Rad
24	Spring	36 North	30 East	6	Tl
25	Mine	36 North	29 East	33	Rad
26	Mine	36 North	29 East	21	As, Rad, Se, Tl
27	Spring	36 North	29 East	18	Tl
28	Mine	36 North	29 East	17	As, Rad, Se, Tl
29	Spring	36 North	29 East	15	Tl
30	Spring	36 North	29 East	14	Pb
31	Well	36 North	29 East	4	Rad, Tl
32	Spring	36 North	28 East	1	Tl
33	Spring	36 North	23 East	33	Rad, Se
34	Well	36 North	23 East	18	As, Tl
35	Well	36 North	22 East	9	Pb
36	Mine	35 North	30 East	2	Rad
37	Well	35 North	23 East	27	As
38	Well	35 North	23 East	27	As
39	Well	35 North	23 East	27	As
40	Spring	35 North	23 East	18	Rad
41	Spring	35 North	23 East	8	Rad, Tl
42	Spring	35 North	23 East	7	Rad, Tl
43	Spring	35 North	22 East	17	Tl
44	Well	34 North	23 East	20	Tl
45	Well	34 North	22 East	8	Tl
46	Well	34 North	21 East	23	As
47	Well	34 North	21 East	22	As, Tl
48	Well	34 North	9 East	31	Tl
49	Spring	33 North	24 East	7	Se
50	Well	33 North	23 East	32	Tl
51	Spring	33 North	23 East	32	Rad
52	Spring	33 North	23 East	2	Rad
53	Well	33 North	11 East	27	Rad, Tl
54	Spring	32 North	23 East	33	Tl
55	Well	32 North	23 East	21	Rad
56	Well	32 North	20 East	6	Tl
57	Well	32 North	12 East	21	As, Pb, Rad
58	Spring	32 North	12 East	14	Tl

Table 2-14 Water Quality Exceedances in the Little Colorado River Plateau Basin

A. Wells, Springs and Mines cont'd.

Map Key	Site Type	Site Location			Parameter(s) Exceeding Drinking Water Standard[2]
		Township	Range	Section	
59	Spring	32 North	11 East	33	Tl
60	Well	32 North	11 East	29	Tl
61	Spring	32 North	9 East	2	As, Tl
62	Spring	31 North	24 East	5	Tl
63	Well	31 North	23 East	21	Rad
64	Spring	30 North	19 East	25	Pb
65	Spring	30 North	10 East	16	Rad
66	Well	29 North	21 East	5	AS, TDS
67	Well	29 North	19 East	33	Fl
68	Spring	29 North	18 East	26	Se
69	Spring	29 North	15 East	12	NO3
70	Well	29 North	12 East	7	Tl
71	Well	29 North	9 East	33	TDS
72	Mine	29 North	9 East	25	As, Ba, Pb, Rad
73	Well	29 North	9 East	22	TDS
74	Well	29 North	9 East	15	NO3
75	Mine	29 North	9 East	11	As, Ba, Be, Cd, Pb, Rad
76	Well	28 North	19 East	21	As
77	Well	28 North	19 East	21	As
78	Well	28 North	19 East	9	As
79	Well	28 North	19 East	9	As
80	Well	28 North	18 East	22	As, Pb
81	Well	28 North	18 East	14	As
82	Well	28 North	18 East	14	As
83	Well	28 North	17 East	28	As
84	Well	28 North	17 East	27	As
85	Well	28 North	17 East	27	As
86	Well	28 North	17 East	26	As
87	Well	28 North	17 East	26	As
88	Well	28 North	17 East	26	As
89	Well	28 North	17 East	9	As
90	Well	28 North	17 East	9	As
91	Well	28 North	10 East	5	Pb
92	Well	27 North	15 East	16	NO3
93	Spring	27 North	12 East	27	As, Rad
94	Spring	27 North	11 East	26	As, Rad, Tl
95	Well	27 North	11 East	19	As, Rad
96	Well	27 North	10 East	6	Pb
97	Well	27 North	9 East	11	TDS
98	Well	26 North	23 East	35	As, Rad
99	Well	26 North	22 East	35	As
100	Spring	26 North	22 East	31	As
101	Spring	26 North	17 East	7	TDS
102	Spring	26 North	11 East	14	As, Rad, Tl
103	Well	26 North	10 East	16	TDS
104	Well	26 North	10 East	9	TDS
105	Spring	26 North	10 East	2	Tl
106	Well	25 North	23 East	19	As, Rad
107	Well	25 North	22 East	35	As
108	Well	25 North	22 East	35	Ba
109	Well	25 North	22 East	17	Tl
110	Spring	25 North	22 East	6	As Tl
111	Well	25 North	21 East	22	Ba, Tl
112	Well	25 North	20 East	34	As
113	Well	25 North	20 East	22	As
114	Well	25 North	10 East	30	Pb
115	Well	24 North	24 East	24	As
116	Spring	24 North	23 East	1	As, Rad, Se, Tl

Table 2-14 Water Quality Exceedances in the Little Colorado River Plateau Basin

A. Wells, Springs and Mines cont'd.

Map Key	Site Type	Site Location			Parameter(s) Exceeding Drinking Water Standard[2]
		Township	Range	Section	
117	Well	24 North	18 East	11	Ba
118	Spring	23 North	23 East	4	As, Rad
119	Spring	23 North	22 East	8	As
120	Well	23 North	21 East	14	Ba
121	Well	23 North	19 East	21	Ba
122	Spring	23 North	17 East	24	As
123	Well	22 North	31 East	9	Rad
124	Well	22 North	31 East	8	Rad
125	Well	22 North	31 East	8	Cd
126	Well	22 North	31 East	8	Pb
127	Well	22 North	31 East	8	As
128	Well	22 North	31 East	8	Cd
129	Well	22 North	31 East	8	Pb
130	Well	22 North	31 East	8	Cd
131	Well	22 North	31 East	5	Rad
132	Well	22 North	30 East	27	Cd
133	Well	22 North	30 East	22	Cd, Rad
134	Spring	22 North	21 East	4	Tl
135	Spring	22 North	19 East	9	As
136	Spring	22 North	18 East	10	As
137	Well	22 North	8 East	27	Ba
138	Well	22 North	6 East	26	NO3
139	Well	22 North	6 East	26	NO3
140	Well	21 North	28 East	30	Rad
141	Well	21 North	28 East	30	Rad
142	Well	21 North	28 East	28	Cd
143	Well	21 North	28 East	24	Cd
144	Well	21 North	28 East	24	As
145	Well	21 North	28 East	23	Rad
146	Well	21 North	28 East	20	As
147	Well	21 North	28 East	13	Cd
148	Well	21 North	28 East	10	As, Cd, Rad
149	Well	21 North	27 East	35	Be
150	Well	21 North	27 East	25	Be
151	Well	21 North	27 East	25	F
152	Well	21 North	27 East	25	As, Cd
153	Well	21 North	7 East	25	Pb, NO3
154	Well	21 North	7 East	20	As
155	Well	21 North	7 East	20	TDS
156	Well	21 North	7 East	19	As
157	Well	21 North	7 East	9	As
158	Well	21 North	6 East	25	As, Sb
159	Well	21 North	6 East	23	As
160	Well	20 North	29 East	20	As
161	Spring	20 North	28 East	32	As
162	Spring	20 North	27 East	28	As
163	Spring	20 North	27 East	26	Rad
164	Well	20 North	27 East	4	As
165	Well	20 North	25 East	28	F
166	Well	20 North	25 East	15	F
167	Well	20 North	19 East	15	TDS
168	Well	19 North	28 East	4	As
169	Well	19 North	26 East	32	As
170	Well	19 North	25 East	11	Cd, Rad
171	Well	19 North	23 East	19	TDS
172	Well	19 North	23 East	3	Rad
173	Well	19 North	16 East	28	TDS
174	Well	19 North	16 East	20	TDS

Table 2-14 Water Quality Exceedances in the Little Colorado River Plateau Basin

A. Wells, Springs and Mines cont'd.

Map Key	Site Type	Site Location			Parameter(s) Exceeding Drinking Water Standard[2]
		Township	Range	Section	
175	Well	19 North	9 East	17	Ba
176	Well	18 North	24 East	16	As, Rad
177	Well	18 North	24 East	16	As, Rad
178	Well	18 North	24 East	8	Be, F, TDS
179	Well	17 North	26 East	13	F
180	Well	17 North	22 East	17	TDS
181	Well	17 North	19 East	28	Cd, Pb
182	Well	16 North	30 East	14	TDS
183	Well	16 North	28 East	35	TDS
184	Well	16 North	28 East	18	NO3
185	Well	16 North	25 East	6	F
186	Well	16 North	22 East	14	F
187	Well	16 North	18 East	9	TDS
188	Well	14 North	30 East	21	F
189	Well	14 North	30 East	7	F
190	Well	14 North	27 East	15	TDS
191	Well	14 North	27 East	1	TDS
192	Well	14 North	25 East	4	As
193	Well	14 North	16 East	9	As
194	Well	13 North	28 East	29	F
195	Well	13 North	28 East	28	TDS
196	Well	13 North	28 East	20	F
197	Well	13 North	27 East	31	NO3
198	Well	13 North	21 East	26	NO3
199	Well	13 North	21 East	26	NO3
200	Well	12 North	28 East	18	F
201	Spring	12 North	28 East	17	As
202	Well	12 North	28 East	17	F
203	Well	12 North	26 East	13	Be
204	Well	12 North	18 East	28	As
205	Well	12 North	17 East	33	Cd, Se
206	Well	12 North	17 East	32	As, Cd, Se
207	Well	12 North	17 East	30	Cd, Se
208	Well	12 North	17 East	21	Cd, Se
209	Well	12 North	16 East	15	Pb
210	Well	11 North	29 East	28	As
211	Well	11 North	29 East	7	As
212	Well	11 North	28 East	9	As
213	Well	11 North	22 East	23	As
214	Well	11 North	21 East	34	As, Cd
215	Well	11 North	20 East	29	As, Cd
216	Well	11 North	19 East	18	Cd
217	Well	11 North	14 East	11	As
218	Well	10 North	25 East	22	Cd
219	Well	10 North	25 East	22	Cd
220	Well[3]	10 North	23 East	22	Cd
221	Well	10 North	22 East	32	Cd
222	Well	10 North	22 East	14	As
223	Well	10 North	21 East	13	Pb
224	Well	10 North	21 East	3	As
225	Well	10 North	21 East	3	As, Cd
226	Well	10 North	20 East	20	Cd, Pb, Se
227	Well	10 North	20 East	13	Be, Cd
228	Well	9 North	23 East	22	Cd
229	Well	9 North	22 East	26	Pb, Cd
230	Well	9 North	22 East	25	Cd
231	Well	8 North	29 East	9	Pb
232	Well	8 North	23 East	10	Cu, Pb

Table 2-14 Water Quality Exceedances in the Little Colorado River Plateau Basin

A. Wells, Springs and Mines cont'd.

Map Key	Site Type	Site Location			Parameter(s) Exceeding Drinking Water Standard[2]
		Township	Range	Section	
233	Well	7 North	26 East	14	NO3
234	Well	NA	NA	NA	Pb, Tl
235	Spring	NA	NA	NA	As, Pb, Rad
236	Spring	NA	NA	NA	Tl
237	Well	NA	NA	NA	Tl

B. Lakes and Streams

Map Key	Site Type	Site Name	Length of Impaired Stream Reach (in miles)	Area of Impaired Lake (in acres)	Designated Use Standard[4]	Parameter(s) Exceeding Use Standard[2]
a	Lake	Bear Canyon	NA	55	A&W, AgI, AgL, FBC	DO, Se
b	River	Little Colorado River (Nutrioso Creek to Carnero Wash)	12	NA	A&W	Turbidity
c	River	Little Colorado River (Porter Tank to McDonalds Wash)	17	NA	A&W	Cu, Ag
d	River	Little Colorado River (Silver Creek to Carr Wash)	6	NA	A&W	Pb
e	River	Little Colorado River (unnamed tributary to Lyman Lake)	3	NA	A&W	Turbidity
f	River	Little Colorado River (Water Canyon Creek to Nutrioso Creek)	4	NA	A&W	Turbidity
g	River	Little Colorado River (West Fork to Water Canyon Creek	20	NA	A&W	Turbidity
h	Lake	Long Lake (lower)	NA	323	FC	Hg

Table 2-14 Water Quality Exceedances in the Little Colorado River Plateau Basin

B. Lakes and Streams cont'd.

Map Key	Site Type	Site Name	Length of Impaired Stream Reach (in miles)	Area of Impaired Lake (in acres)	Designated Use Standard[4]	Parameter(s) Exceeding Use Standard[2]
i	Lake	Lower Lake Mary	NA	764	FC	Hg
j	Lake	Lyman	NA	1,308	FC	Hg
k	Stream	Nutrioso Creek (headwaters to Picnic Creek)	27	NA	A&W	Turbidity
l	Stream	Nutrioso Creek (Picnic Creek to Little Colorado River)	4	NA	A&W	Turbidity
m	Lake	Rainbow	NA	111	A&W, AgI, AgL, FBC	DO, NO3, P, pH
n	Lake	Soldiers	NA	28	FC	Hg
o	Lake	Soldiers Annex	NA	122	FC	Hg
p	Lake	Upper Lake Mary	NA	760	FC	Hg

Notes:

NA = Not applicable

[1]Most water quality samples collected between 1975 and 2003. One sample was collected in 1951.

[2] Sb = Antimony
As = Arsenic
Ba = Barium
Be = Beryllium
Cd = Cadmium
Cu = Copper
DO = Dissolved oxygen
F= Fluoride
Pb = Lead
Hg = Mercury
NO3 = Nitrate/Nitrite
P = Phosphorous
Se = Selenium
Ag = Silver
TDS = Total Dissolved Solids
Tl = Thallium
Rad = One or more of the following radionuclides - Gross Alpha, Gross Beta, Radium, and Uranium

[3] Conflicting locational information

[4] A&W = Aquatic and Wildlife
AgI = Agricultural Irrigation
AgL = Agricultural Livestock Watering
FBC = Full Body Contact
FC = Fish Consumption

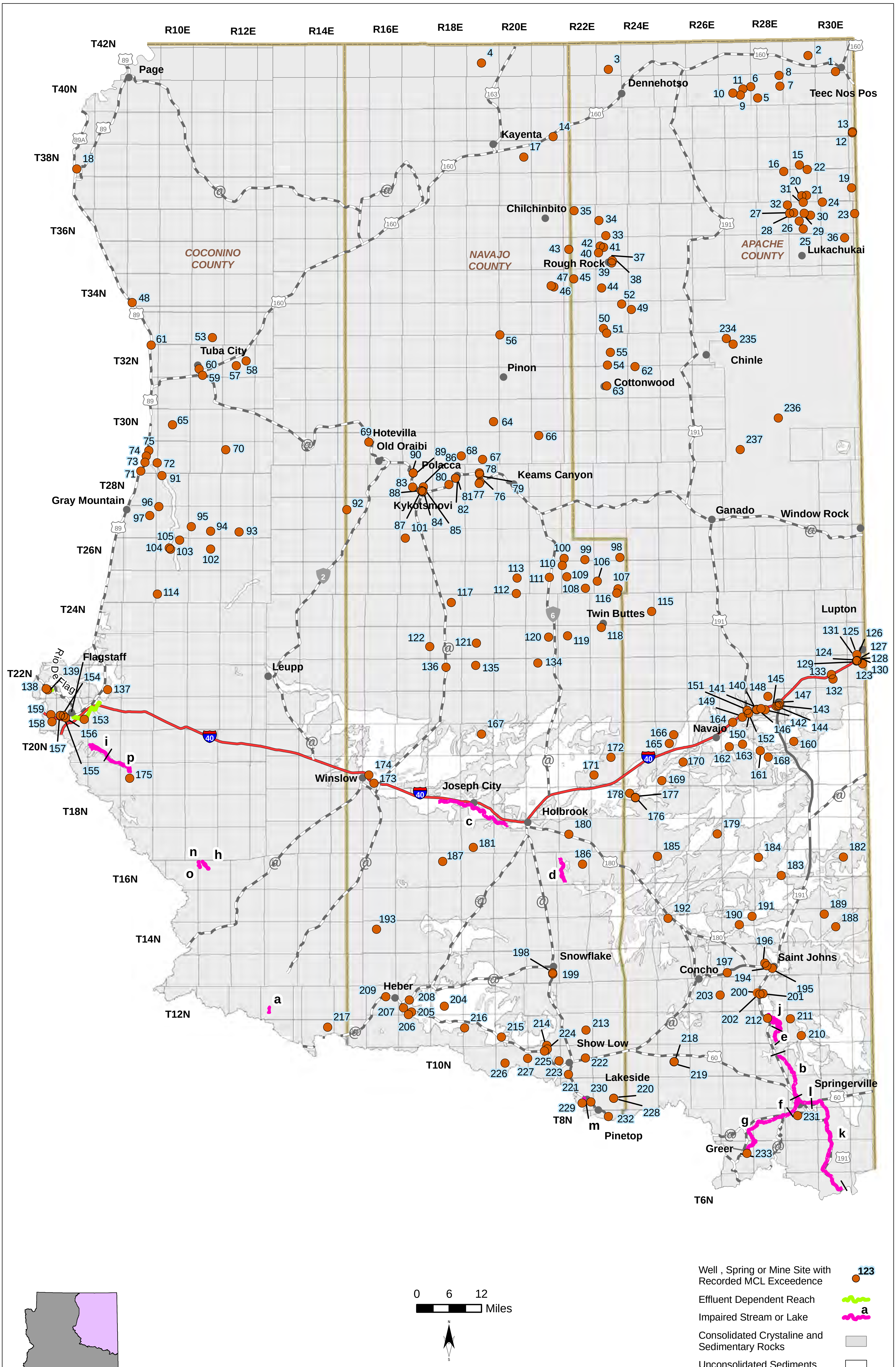


Figure 2-22
Little Colorado River Plateau Basin
Water Quality Conditions

2.1.8 Cultural Water Demands in the Little Colorado River Plateau Basin

Cultural water demand data including population, number of wells, and the average well pumpage and surface water diversions by the municipal, industrial and agricultural sectors are shown in Table 2-15. Effluent generation including facility ownership, location, population served and not served, volume treated, disposal method and treatment level is shown in Table 2-16. Figure 2-23 shows the location of demand centers. A description of cultural water demand data sources and methods is found in Volume 1, Section 1.3.5. More detailed information on cultural water demands is found in Section 2.0.7.

Cultural Water Demands

- Refer to Table 2-15 and Figure 2-23.
- Population increased by an average of 3,700 people per year between 1980 and 2000. Projections suggest a more rapid rate of growth through 2050.
- Total groundwater pumping is increasing with an average of 122,000 acre-feet pumped per year in the period from 2001-2003.
- Total surface water diversions are estimated to be comparable to historic diversion volumes with 82,500 acre-feet diverted per year in the period from 2001-2003. Municipal surface water diversions, however appear to be declining.
- Approximately 4,000 acre-feet of surface water is diverted per year for municipal use
- Most high intensity municipal and industrial (M&I) use is found in the population centers of Flagstaff, Page, Show Low/Pinetop-Lakeside, Taylor/Snowflake and Winslow/Holbrook.
- Industrial use has remained relatively constant with an average of 86,500 acre-feet of surface water and groundwater used per year during the 2001-2003 period.
- Approximately two-thirds of the industrial water supply is groundwater.
- Location of power plants and mines are shown on Figure 2-23 including the extent of the large Black Mesa and Kayenta coal mines south of Kayenta. Power plants/electrical generating stations are Cholla, near Joseph City, Coronado near St. Johns, Navajo at Page and the Springerville power plant located northeast of Springerville.
- Agricultural use is estimated to have declined slightly since 1991
- Surface water is the primary agricultural water supply, comprising about 60% of the total supply.
- Large tracts of agricultural lands are found along Highway 191 on the Navajo Reservation and in the vicinity of Snowflake, Springerville, Saint Johns and Holbrook. The large agricultural area northeast of Heber is pasture irrigated with wastewater from the Abitibi paper mill, an industrial user.

Effluent Generation

- Refer to Table 2-16.
- There are 61 wastewater treatment facilities in the basin.
- The population served appears to be overestimated for the basin as a whole. Multiple databases were used to compile the effluent generation information and may contain flawed population estimates.
- More than 36,000 acre-feet of effluent per year are generated in the basin. Almost a third of this volume is generated by a single facility, the Abitibi paper mill.
- Nine facilities discharge waste water for irrigation.

- Effluent is used to irrigate seven golf courses.
- Discharge from 14 facilities recharges the aquifer through an unlined impoundment. There are no facilities permitted by the Department as Underground Storage Facilities.

Table 2-15 Cultural Demands in the Little Colorado River Plateau Basin[1]

Year	Recent (Census) and Projected (DES) Population	Number of Registered Water Supply Wells Drilled		Average Annual Demand (in acre-feet)						
				Well Pumpage			Surface-Water Diversions			Data Source
		Q < 35 gpm	Q ≥ 35 gpm	Municipal	Industrial	Irrigation	Municipal	Industrial	Irrigation	
1971										
1972										
1973				60,000			85,000			
1974										
1975										
1976		2,865[2]	745[2]							
1977										
1978				77,000			85,000			
1979										
1980	175,451									ADWR (1994)
1981	178,851									
1982	182,252									
1983	185,652	892	88	90,000			85,000			
1984	189,052									
1985	192,452									
1986	195,853									
1987	199,253									
1988	202,653	691	36	93,000			85,000			
1989	206,053									
1990[3]	209,454									
1991	213,493									
1992	217,532									
1993	221,571	768	31	21,000	53,000	35,500	7,100	30,500	50,000	ADWR (2003, 2004a,b & 2005), Truini (2005), USGS (2005), WIFA (2005)
1994	225,610									
1995	229,649									
1996	233,688									
1997	237,727									
1998	241,766	1,181	39	24,500	54,000	34,500	5,500	32,000	48,500	
1999	245,805									
2000	249,844									
2001	255,141									
2002	260,437	467	15	29,000	56,500	34,500	4,000	30,000	48,500	
2003	265,734									
2010	302,811									
2020	342,207									
2030	381,697									
2040	423,531									
2050	473,296									
ADDITIONAL WELLS:[4]		**553**	**4**							
WELL TOTALS:		**7,417**	**958**							

[1] Does not include evaporation losses from stockponds and reservoirs.
[2] Includes all wells through 1980.
[3] In 1990, 113,000 acre-feet were used for municipal and industrial demands and 89,000 acre-feet were used for irrigation.
[4] Other water-supply wells are listed in the ADWR Well Registry for this basin, but they do not have completion dates. These wells are summed here.

Table 2-16 Effluent Generation in the Little Colorado River Plateau Basin

Facility Name	Ownership	City/Location Served	Population Served	Volume Treated/Generated (acre-feet/year)	Disposal Method							Current Treatment Level	Population Not Served	Year of Record
					Water-course	Evaporation Pond	Irrigation	Wildlife Area	Golf Course/Turf Irrigation	Discharge to Another Facility	Groundwater Recharge			
Abitibi	Private	Industrial	NA	11,862			X					Primary	NA	2005
Bacobi WWTP	Hopi Tribe	Bacobi	550	62							X	NA	70	2000
Bison Ranch WWTP	Private	Overgaard	NA											
Black Mesa Ranger District	Apache Sitgreaves National Forest	Forest Service Facilities	NA											
Black Mesa Sewer System	Navajo Nation	Black Mesa	305	34							X	Secondary	100	2000
Cameron WWTF	Navajo Nation	Cameron	190	11							X	NA	380	2000
Chilchinbito Sewer System	Navajo Nation	Chilchinbeto	150	17		X						Secondary	600	1999
Chinle WWTP	Navajo Nation	Chinle	7,775	493		X						Secondary	750	1998
Cottonwood Sewer System	Navajo Nation	Cottonwood	1,000	112		X						Secondary	645	2000
Dennehotso	Navajo Nation	Dennehotso	1,000	112	X							Secondary	1,115	2000
Dilkon WWTF	Navajo Nation	Dilkon	1,408	134	X							Secondary	850	2000
Eager WWTP	Town of Eagar	Eagar	4,500	269	NA							Adv. Trt.II	1,400	2001
Flagstaff Ranch Development WWTP	Private	Flagstaff	NA						Flagstaff Ranch			NA		
Fort Valley Meadow Subdivision	Private	Flagstaff	NA											
Ganado Burnwater Phase IX	Navajo Nation	Ganado	3,000	336							X	Secondary	500	1998
Ganado WWTP	Navajo Nation	Ganado	851	157							X	Secondary	51	1996
Ganado Wood Springs II	Navajo Nation	Ganado	NA	45							X	NA		2000
Glen Canyon NRA WWTF	National Park Service	Recreation Area	NA											
Greenhaven WWTP	Private	Page	26	13		X						NA		2003
Greer WWTP	Little Colorado SD	Greer	600	56							X	Secondary	300	2000
Houck Burnwater Phase I	Navajo Nation	Houck	300	34							X	Secondary	300	2001
Inscription House Septics	Navajo Nation	Inscription House	1,000	112		X						Secondary	250	2000
Joseph City WWTF	Town of Joseph City	Joseph City	1,300	314		X						Secondary	60	2000
Kachina Village WWTP	Kachina Village ID	Kachina Village	5,000	426			X					Secondary	NA	2001
Kayenta WWTP	Navajo Nation	Kayenta	3,270	627	Laguana & Chinle Washes							Secondary	750	2000
Le Chee Sewer System	Navajo Nation	Le Chee	150	17		X						Secondary	165	2000
Leupp WWTF	Navajo Nation	Leupp	400	45		X						Secondary	NA	1999
Linden Trails WWTP	NA	Show Low	NA											
Livco Sewer Co.	Private	Concho	NA	3		X						NA		2003
Lukachukai	Navajo Nation	Lukachukai	200	22		X						Secondary	1,540	2000
Many Farms	Navajo Nation	Many Farms	685	34	X							Secondary	620	2000
Moenkopi WWTF	Hopi Tribe	Moenkopi	1,385	NA		X						NA		
Navajo Govt. Complex	Navajo County	Holbrook	700	45		X						Secondary	NA	2004

Table 2-16 Effluent Generation in the Little Colorado River Plateau Basin

Facility Name	Ownership	City/Location Served	Population Served	Volume Treated/Generated (acre-feet/year)	Disposal Method							Current Treatment Level	Population Not Served	Year of Record
					Water-course	Evaporation Pond	Irrigation	Wildlife Area	Golf Course/Turf Irrigation	Discharge to Another Facility	Groundwater Recharge			
Nazali WWTF	Navajo Nation	Ganado	1,493	157		X						Secondary	NA	2000
Oraibi	Hopi Tribe	Oraibi	500	56		X						Secondary	NA	2000
Page WWTF	City of Page	Page	7,500	1,120					Lake Powell	X		Adv. Trt. I	NA	2000
Painted Mesa WWTF	City of Holbrook	Holbrook	6,000	728		X	X		Hidden Cove			Adv. Trt.I	NA	2004
Pinetop Lakeside WWTF	Pinetop-Lakeside SD	Pinetop-Lakeside	20,000	1,792							X	Adv. Trt. II	2,200	2004
Pinon WWTP	Navajo Nation	Pinon	2,050	213	NA							Secondary	700	2000
Rio De Flag WWTP [1]	City of Flagstaff	Flagstaff	20,000	2,722	Rio De Flag		X	X	X			Adv. Trt. II	NA	2004
Rough Rock WWTF	Navajo Nation	Rough Rock	839	11	NA							Secondary	635	2000
Sanders Unifed School District	NA	Sanders	NA											
Show Low WWTF	City of Show Low	Show Low	8,800	896	X	X						Secondary	1,500	2004
Shungopavi WWTF	Hopi Tribe	Shungopavi	400	45		X						Secondary	NA	2000
Sipaulovi WWTF	Hopi Tribe	Sipaulovi	500	56		X						Secondary	200	2000
Snowflake WWTF	Town of Snowflake	Snowflake	3,600	282			X					Adv.Trt.I	600	2000
Springerville WWTF	Town of Springerville	Springerville	1,400	224	NA							Secondary	NA	2000
St. Johns WWTP	Town of St. John's	St.Johns	3,340	446			X					Secondary	159	2000
St. Micheals WWTF	Hopi Tribe	St.Micheals	500	50		X						Secondary	450	1999
Sweetwater Sewer System	Navajo Nation	Sweetwater	200	22							X	Secondary	200	2001
Taylor WWTF	Town of Taylor	Taylor	2,400	202		X						Secondary	1,200	2004
Tec Nos Pos WWTF	Navajo Nation	Tec Nos Pos	400	22							X	Secondary	1,399	2000
Tolani-Red Lake Sewer System	Navajo Nation	Tolani-Red Lake	100	11							X	Secondary	100	2000
Tsaile WWTF	Navajo Nation	Tsaile	4,861	448							X	Secondary	500	2000
Tuba City WWTF	Navajo Nation	Tuba City	12,443	448			X					Secondary	350	2000
Waweep WWTF	National Park Service	Park	NA											
Wide Ruins Sewer System	Navajo Nation	Wide Ruin	245	11							X	Secondary	245	1999
Wildcat WWTP	City of Flagstaff	Flagstaff	60,988	8,177	Rio De Flag		X		X			Adv. Trt II	NA	2004
Window Rock WWTP	Navajo Nation	Window Rock	10,650	986	Black Creek							Secondary	2,215	2000
Winslow WWTF	City of Winslow	Winslow	9,800	2,016	Ruby Wash		X					Adv. Tr. I	NA	2004

Notes:
NA: Data not currently available to ADWR
NRA: National Recreation Area
WWTF: Waste Water Treatment Facility
WWTP: Waste Water Treatment Plant
WRP: Water Reclamation Plant
SD: Sanitation District
ID: Improvement District
Adv. Tr. I: Advanced treatment level I
Adv. Tr. II: Advanced treatment level II

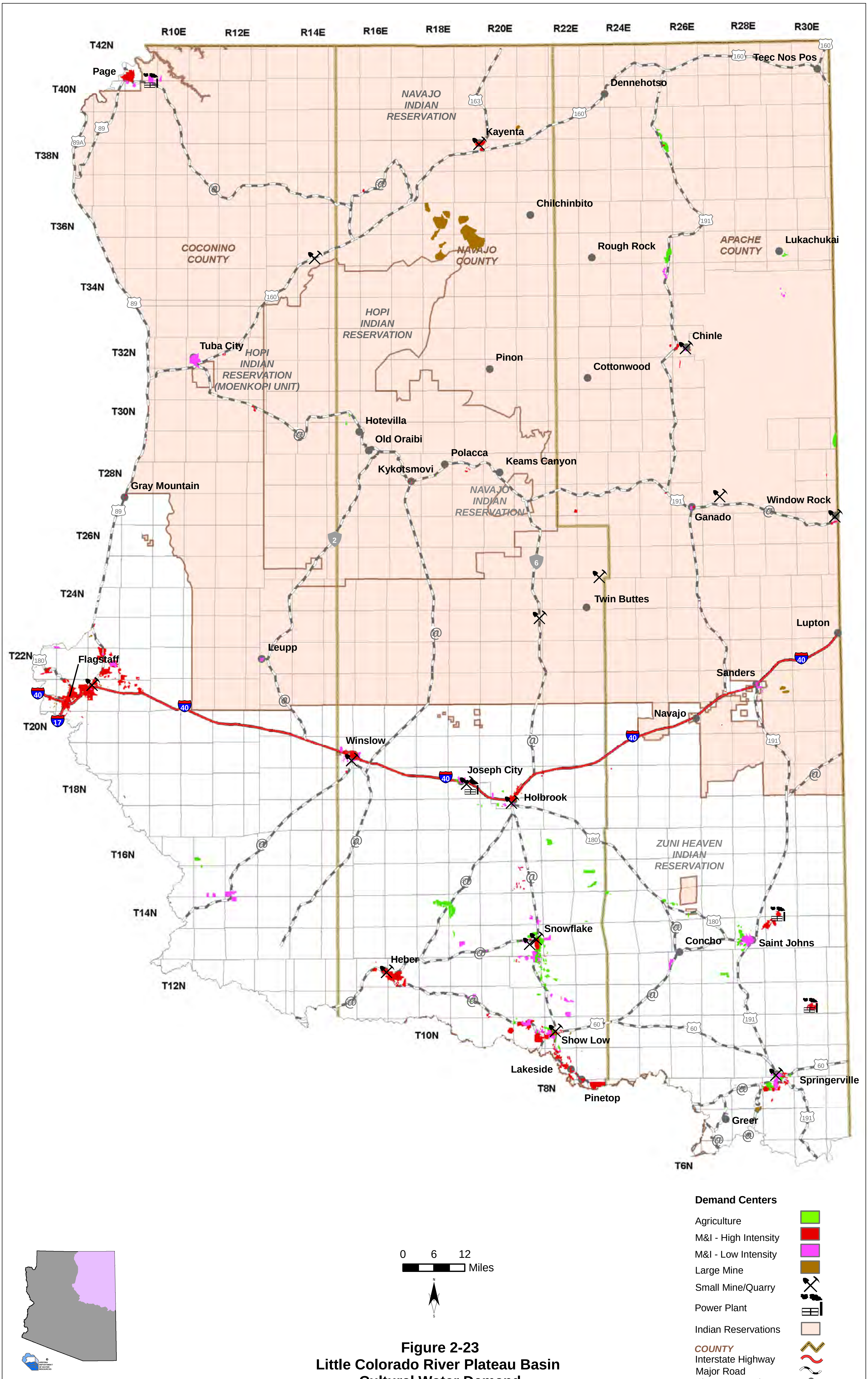


Figure 2-23
Little Colorado River Plateau Basin
Cultural Water Demand

2.1.9 Water Adequacy Determinations in the Little Colorado River Plateau Basin

Water adequacy determination information including the subdivision name, location, number of lots, adequacy determination, reason for the inadequacy determination, date of determination and subdivision water provider are shown in Table 2-17. Figure 2-24 shows the location of subdivisions keyed to the Table. A description of the Adequacy Program is found in Volume 1, Appendix A. Briefly, developers of subdivisions outside of AMAs are required to obtain a determination of whether there is sufficient water of adequate quality available for 100 years. If the supply is determined to be inadequate, lots may still be sold, but the condition of the water supply must be disclosed in promotional materials and in sales documents. Adequacy determination data sources and methods are found in Volume 1, Section 1.3.1.

- A total of 245 determinations of water adequacy have been made through May, 2005.
- 104 determinations of inadequacy have been made, primarily in the vicinity of Flagstaff, Show Low and Pinetop-Lakeside.
- The primary reason for a determination of inadequacy was insufficient data on physical and continuous water availability.
- The number of lots receiving an adequacy determination, by county, are:

County	Number of Subdivision Lots	Number of Lots Determined to be Adequate	Percent Adequate
Apache	4,387	2,973	68
Coconino	3,597	2,312	64
Navajo	7,750	5,187	67
Total	**15,734**	**10,472**	**66**

Table 2-17 Adequacy Determinations in the Little Colorado River Plateau Basin[1]

Map Key	Subdivision Name	County	Location			No. of Lots	ADWR File No.[2]	ADWR Adequacy Determination	Reason(s) for Inadequacy Determination[3]	Date of Determination	Water Provider at the Time of Application
			Township	Range	Section						
1	A-1 Ranch	Coconino	21 North	6 East	15	33	22-401052	Inadequate	A1, A2	05/07/04	A-1 Ranch Homeowners
2	Amity Estates	Apache	8 North	29 East	7	23		Adequate	---	12/02/76	Town of Eager
3	Anasazi Trails	Coconino	22 North	8 East	10, 15	17	22-401071	Inadequate	A1, A2	10/14/03	Doney Park Water Company
4	Apache Trails Unit One (amended)	Apache	10 North	24 East	11	94	22-400112	Inadequate	C	07/30/99	Cedar Grove Water Company
5	Arizona Rancheros, Rancho 36	Navajo	18 North	22 East	9	21	22-400335	Inadequate	C	06/28/00	Sun Valley Utilities
6	Arrowhead Estates	Coconino	21 North	7 East	9	8		Inadequate	A2, A3	08/08/88	Dry Lot Subdivision
7	Aspen Glen	Coconino	22 North	8 East	27	28	22-300069	Inadequate	A1	12/05/95	Doney Park Water Company
8	Aspen Shadows	Coconino	21 North	6 East	25	390	22-300242	Adequate	---	08/11/97	Flagstaff Ranch Water Company
9	Bar D Ranches	Coconino	22 North	8 East	23	15	22-400979	Inadequate	A1, A2	07/30/03	Doney Park Water Company
10	Bear Country Estates	Navajo	12 North	17 East	33	22	22-400036	Adequate	---	03/24/99	Arizona Water Company
11	Belair Estates	Apache	10 North	24 East	9	10		Inadequate	D	03/02/87	Belair Estates HOA
12	Benny Jay Heights	Apache	8 North	29 East	17	9	22-400431	Inadequate	A1	12/01/00	Town of Eager
13	Bent Oak	Navajo	8 North	23 East	2, 11	71		Adequate	---	06/21/89	Ponderosa DWID
14	Bison Cabin Resort II	Navajo	12 North	17 East	34	33	22-400516	Adequate	---	04/02/02	Arizona Water Company
15	Bison Ranch	Navajo	12 North	17 East	33	39	22-400080	Adequate	---	06/02/99	Arizona Water Company
16	Bison Ranch Resort Suites	Navajo	12 North	17 East	34	88	22-401659	Adequate	---	05/25/05	Arizona Water Company
17	Bison Ranch, Parcel C3	Navajo	12 North	17 East	34	22	22-400572	Adequate	---	09/21/01	Arizona Water Company
18	Bison Resort Cabins	Navajo	11 North	17 East	3	57	22-400257	Adequate	---	03/06/00	Arizona Water Company
19	Bison Resort Cabins III	Navajo	12 North	17 East	34	57	22-400691	Adequate	---	04/02/02	Arizona Water Company
20	Bison Town I (Parcels B1 & B2)	Navajo	12 North	17 East	33, 34	34	22-400447	Adequate	---	01/19/01	Arizona Water Company
21	Bison Town II (Parcels B3 & B4)	Navajo	12 North	17 East	33, 34	25	22-400446	Adequate	---	01/19/01	Arizona Water Company
22	Blue Ridge Estates	Coconino	15 North	12 East	32	193	22-300463	Adequate	---	06/12/98	Starlight Water Company
23	Blue Valley	Apache	8 North	29 East	16	8		Adequate	---	05/14/76	Town of Eager
24	Brewer Acres	Navajo	13 North	21 East	23	20		Adequate	---	11/03/75	Town of Snowflake
25	Burdon Ranch Estates	Navajo	11 North	22 East	25	131		Inadequate	A1	12/06/84	Dry Lot Subdivision
26	Bushman Acres	Navajo	13 North	21 East	26	48		Adequate	---	08/11/76	Town of Snowflake
27	Casitas of Pinetop	Navajo	9 North	23 East	32	28		Inadequate	A1	10/31/80	Pinetop Water Company
28	Cedar Ridge	Apache	8 North	29 East	10	49		Adequate	---	08/22/83	Town of Eager
29	Cedar Ridge #1	Apache	10 North	24 East	10	13		Inadequate	A1	11/06/91	Dry Lot Subdivision
30	Cedar Ridge #2	Apache	10 North	24 East	4	5		Inadequate	A1	07/09/87	Dry Lot Subdivision
31	Central Center	Navajo	10 North	22 East	20	10		Inadequate	A1	06/21/84	City of Show Low

Table 2-17 Adequacy Determinations in the Little Colorado River Plateau Basin[1]

Map Key	Subdivision Name	County	Location			No. of Lots	ADWR File No.[2]	ADWR Adequacy Determination	Reason(s) for Inadequacy Determination[3]	Date of Determination	Water Provider at the Time of Application
			Township	Range	Section						
32	Cheney Ranch	Navajo	10 North	21 East	8, 9	168		Adequate	---	04/17/86	White Mountain Water Company
33	Cholla Subdivision	Navajo	13 North	21 East	36	12		Adequate	---	03/04/81	Town of Taylor
34	Chu-Vista Estates	Navajo	12 North	22 East	30	NA		Inadequate	D	05/12/87	Dry Lot Subdivision
35	Cinder Forest Estates	Coconino	22 North	8 East	26, 27, 35, 36	82		Inadequate	A2	01/16/74	Dry Lot Subdivision
36	Cinder Mountain	Navajo	8 North	23 East	11	65		Adequate	---	09/17/73	Ponderosa Water Company
37	Circle G at Temple Hill Estates	Navajo	13 North	21 East	22	23	22-400715	Adequate	---	05/22/02	Town of Snowflake
38	Cobblecreek Development	Navajo	11 North	20 East	32	47		Adequate	---	05/12/87	Pinedale DWID
39	Concho Valley # 1B	Apache	12 North	26 East	18	21		Adequate	---	05/11/82	LIVCO Water Company
40	Concho Valley # 5A	Apache	12 North	26 East	19	108		Adequate	---	07/16/79	LIVCO Water Company
41	Concho Valley # 5B	Apache	12 North	26 East	19	192		Adequate	---	06/23/80	LIVCO Water Company
42	Concho Valley # 9	Apache	12 North	26 East	29	181		Adequate	---	08/23/89	LIVCO Water Company
43	Concho Valley # 9A	Apache	12 North	26 East	19	117		Adequate	---	05/23/91	LIVCO Water Company
44	Concho Valley # 10	Apache	12 North	26 East	7, 8	193		Adequate	---	05/23/91	LIVCO Water Company
45	Concho Valley # 12	Apache	12 North	26 East	8	303		Adequate	---	07/30/92	LIVCO Water Company
46	Concho Valley # 18	Apache	12 North	26 East	8, 9	203		Adequate	---	03/05/93	LIVCO Water Company
47	Concho Valley # 33	Apache	12 North	26 East	33	82		Adequate	---	01/15/85	LIVCO Water Company
48	Condominium at Pine Creek	Navajo	9 North	23 East	31	101		Inadequate	A1	10/03/86	Pinetop Water Company
49	Cool Water Acres	Navajo	17 North	19 East	12	25		Adequate	---	05/23/84	Dry Lot Subdivision
50	Cosnino Equestrian Estates	Coconino	21 North	9 East	7, 8	30		Adequate	---	08/28/73	Black Bill & Doney Park WUA
51	Cosnino Equestrian # 2	Coconino	21 North	9 East	8, 9	77		Adequate	---	03/21/79	Black Bill & Doney Park WUA
52	Cottonwood Ranch	Navajo	19 North	16 East	7	47		Inadequate	A1	06/19/85	Dry Lot Subdivision
53	Country Club Estates # 1	Navajo	13 North	21 East	21	18		Adequate	---	10/31/83	Town of Snowflake
54	Country Club Manor # 1	Navajo	10 North	21 East	14	60		Adequate	---	09/13/78	City of Show Low
55	Country Estates	Apache	8 North	29 East	10	20		Adequate	---	09/11/80	Town of Eager
56	Eagle Ridge	Apache	11 North	24 East	34	54	22-300464	Adequate	---	12/28/98	Cedar Grove Water Company
57	Eagle View Park	Coconino	22 North	8 East	10	11	22-401404	Inadequate	D	09/02/04	Doney Park Water Company
58	East Highland Estates	Navajo	13 North	21 East	23	49		Adequate	---	05/23/79	Town of Snowflake
59	East Valley Acres	Apache	8 North	29 East	2	12		Inadequate	A1	08/21/86	Town of Eager
60	El Rancho Grande	Navajo	12 North	21 East	6	46		Inadequate	A1	03/14/84	Dry Lot Subdivision
61	Elk Crest Estates	Apache	8 North	29 East	18	72	22-400164	Inadequate	A1	11/30/99	Town of Eager
62	Elk Meadow	Apache	6 North	29 East	1	8		Adequate	---	05/30/89	Elk Meadow HOA

Table 2-17 Adequacy Determinations in the Little Colorado River Plateau Basin[1]

Map Key	Subdivision Name	County	Location			No. of Lots	ADWR File No.[2]	ADWR Adequacy Determination	Reason(s) for Inadequacy Determination[3]	Date of Determination	Water Provider at the Time of Application
			Township	Range	Section						
63	Ellkins Acres	Navajo	10 North	21 East	24	51	22-401991	Inadequate	A1	08/18/03	Park Valley Water Company
64	Escondido	Apache	8 North	29 East	7, 8	48		Adequate	---	08/22/79	Town of Eager
65	Escondido # 2 (amended)	Apache	8 North	29 East	18	57		Adequate	---	05/21/82	Town of Eager
66	Escudilla Mountain Estates Units 1, 2 & 3	Apache	7 North	30 East	31	74	22-300583	Inadequate	A1	12/15/98	Dry Lot Subdivision
67	Evergreen Estates Unit I	Navajo	9 North	22 East	4	24	22-400725	Inadequate	A1	05/22/02	Pineview Water Company
68	Fairway Park Center	Navajo	10 North	21 East	23	26		Adequate	---	09/24/76	Fairway Park
69	Foothills # 2	Apache	8 North	29 East	9	36		Adequate	---	12/21/79	Town of Eager
70	Forest Trails # 1	Navajo	12 North	17 East	28	170		Adequate	---	07/20/84	Arizona Water Company
71	Forest Trails # 2	Navajo	12 North	17 East	28	207		Adequate	---	05/13/85	Arizona Water Company
72	Forest Trails # 3B	Navajo	12 North	17 East	28	49	22-300004	Adequate	---	04/03/95	Arizona Water Company
73	Fort Valley Meadows-Lots 56-65	Coconino	22 North	6 East	26	10	22-400139	Inadequate	A2	07/30/99	Community well
74	Fort Valley Pines	Coconino	22 North	6 East	34	11	22-400898	Inadequate	A1	03/12/03	Dry Lot Subdivision
75	Frontier Estates	Navajo	13 North	21 East	22	202	22-400564	Adequate	---	08/30/01	Town of Snowflake
76	Frontier Hills	Coconino	22 North	8 East	24	33		Inadequate	A1, A2	05/04/94	Doney Park Water Company
77	G Flake Subdivision	Navajo	13 North	21 East	22	NA	22-400583	Adequate	---	09/28/01	Town of Snowflake
78	Gobbler Peak Estates	Apache	6 North	29 East	1	28		Adequate	---	10/24/91	Dry Lot Subdivision
79	Golden Lockett	Coconino	21 North	7 East	3	14	22-400951	Inadequate	A1, A2	05/23/03	NA
80	Grand View Estates # 1	Apache	8 North	29 East	18	58		Adequate	---	07/26/82	Town of Eager
81	Green Valley Acres	Apache	8 North	29 East	16	198		Adequate	---	02/26/75	Town of Eager
82	Green Valley Ranches	Navajo	11 North	22 East	6	22		Adequate	---	09/01/76	Subdivision wells
83	Greer Acres	Apache	7 North	27 East	2	14	22-400209	Inadequate	A1	12/08/99	Dry Lot Subdivision
84	Greer Lodge Estates	Apache	7 North	27 East	14	16		Adequate	---	09/13/94	Greer Meadows HOA
85	Greer Mountain Subdivision	Apache	7 North	27 East	14	24		Adequate	---	07/11/95	Greer Mountain Subdivision Joint Venture
86	Greer View Estates	Apache	7 North	27 East	12	22	22-400001	Adequate	---	03/04/99	Dry Lot Subdivision
87	Hacienda Pines-Unit 1	Navajo	10 North	21 East	25	68	22-300448	Adequate	---	04/23/98	City of Show Low
88	Harvest Valley	Navajo	12 North	21 East	5	10		Adequate	---	02/24/76	Dry Lot Subdivision
89	Hidden Meadow Ranch	Apache	9 North	27 East	30	52	22-400654	Inadequate	B	05/13/02	Club at Hidden Ranch HOA
90	High Country Pines II - Unit I	Navajo	12 North	16 East	15	n/a	22-300405	Adequate	---	01/08/98	High Country Pines Water Company
91	High Country Pines II - Unit 2	Navajo	12 North	16 East	15	74	22-400127	Adequate	---	07/21/99	High Country Pines Water Company
92	High Country Pines Inc.	Navajo	12 North	16 East	15	142		Adequate	---	04/26/85	High Country Pines Water Company
93	Highland Park-Unit 5, Phase 1	Navajo	13 North	21 East	26	12	22-300161	Adequate	---	06/24/96	Town of Snowflake

Table 2-17 Adequacy Determinations in the Little Colorado River Plateau Basin[1]

Map Key	Subdivision Name	County	Location			No. of Lots	ADWR File No.[2]	ADWR Adequacy Determination	Reason(s) for Inadequacy Determination[3]	Date of Determination	Water Provider at the Time of Application
			Township	Range	Section						
94	Hillcrest	Apache	8 North	29 East	3, 4	36		Adequate	---	01/29/76	Town of Eager
95	Homestead at Torreon-Unit 1	Navajo	10 North	21 East	25, 26	109	22-300437	Adequate	---	03/31/98	City of Show Low
96	Hutchinson Acres	Coconino	22 North	8 East	9, 16	95	22-400459	Inadequate	A1	03/23/01	Doney Park Water Company
97	J. L. Subdivision	Apache	8 North	29 East	4	11		Adequate	---	07/23/76	Town of Eager
98	Koch Field East	Coconino	22 North	8 East	25	10		Inadequate	A2	04/26/93	Doney Park Water Company
99	Laguna Estates # 1	Navajo	11 North	22 East	25	151		Inadequate	A1	07/07/86	High Country Water
100	Linden Trails	Navajo	10 North	21 East	3, 4	96	22-401605	Adequate	---	03/16/05	Mountain Glen Water Service
101	Lockett Estates	Coconino	21 North	7 East	4	16	22-400415	Inadequate	A1, A3	11/13/00	Community well
102	Mahogany Run Subdivision	Coconino	21 North	7 East	3, 4	7	22-400716	Inadequate	A3	05/21/02	Dry Lot Subdivision
103	Majestic Views Estates	Coconino	22 North	6 East	26	28	22-401616	Inadequate	A1	01/12/05	Majestic Views DWID
104	Mogollon Airpark	Navajo	12 North	17 East	33	27		Adequate	---	01/03/86	Arizona Water Company
105	Mogollon Airpark # 3	Navajo	12 North	17 East	33	59		Adequate	---	05/15/87	Arizona Water Company
106	Mogollon Airpark # 4A	Navajo	12 North	17 East	34	52		Adequate	---	10/06/93	Arizona Water Company
107	Mogollon Air Park # 4B	Navajo	12 North	17 East	27, 34	36		Adequate	---	04/06/94	Arizona Water Company
108	Mogollon Airpark # 6	Navajo	12 North	17 East	27, 34	52	22-300042	Adequate	---	07/25/95	Arizona Water Company
109	Mogollon Airpark Properties	Navajo	12 North	17 East	33	54		Adequate	---	03/06/85	Arizona Water Company
110	Mogollon Estates	Navajo	12 North	17 East	27, 34	70	22-300167	Adequate	---	07/15/96	Arizona Water Company
111	Mountain Pine Ranch- Unit I	Apache	10 North	24 East	5	57		Inadequate	A1	04/13/93	Dry Lot Subdivision
112	Mountain Pine Ranch-Unit II	Apache	10 North	24 East	5	57	22-400107	Inadequate	A1	06/29/99	Dry Lot Subdivision
113	Mountain Pines Estates	Navajo	8 North	23 East	2	86		Adequate	---	09/01/83	Ponderosa Water Company
114	Mountain View	Apache	12 North	28 East	4	55		Adequate	---	12/30/76	Mountain View Water Company
115	Mountain View # 2	Apache	12 North	28 East	4	32		Adequate	---	08/18/78	Mountain View Water Company
116	Mountain View Ranchos	Coconino	21 North	9 East	6	28		Adequate	---	07/19/73	Subdivision wells
117	Needles Creek Subdivision	Navajo	10 North	21 East	13	57	22-400451	Inadequate	A1	01/19/01	Fools Hollow Water Company
118	Nicoll Subdivision	Apache	8 North	29 East	9	20		Adequate	---	02/06/80	Town of Eager
119	Noble Mountain Estates (amended)	Apache	6 North	30 East	7	65		Inadequate	A1	07/26/94	Dry Lot Subdivision
120	North Peak	Coconino	22 North	8 East	28, 29	18		Inadequate	A2	01/24/92	Doney Park Water Company
121	North Peak # 2	Coconino	22 North	8 East	28	11		Inadequate	A2	02/23/93	Doney Park Water Company
122	Northern Taylor	Navajo	13 North	21 East	36	14		Adequate	---	08/15/77	Town of Taylor
123	Northfork Ranches # 1	Apache	10 North	24 East	7	93		Inadequate	A1	04/10/85	Dry Lot Subdivision
124	Ojo Bonito Estates	Apache	10 North	25 East	19	63		Adequate	---	09/10/81	Ojo Bonito HOA

Table 2-17 Adequacy Determinations in the Little Colorado River Plateau Basin[1]

Map Key	Subdivision Name	County	Location			No. of Lots	ADWR File No.[2]	ADWR Adequacy Determination	Reason(s) for Inadequacy Determination[3]	Date of Determination	Water Provider at the Time of Application
			Township	Range	Section						
125	Park Place	Navajo	10 North	21 East	24	78	22-300341	Inadequate	A1	08/15/97	Park Valley Water Company
126	Park Place III	Navajo	10 North	21 East	24	35	22-400331	Inadequate	A1	07/17/00	Park Valley Water Company
127	Park Place IV	Navajo	10 North	21 East	24	16	22-401172	Inadequate	A1	01/12/04	Park Valley/Fool Hollow Water Company
128	Park Plaza # 1	Navajo	13 North	21 East	21	31		Adequate	---	05/23/86	Town of Snowflake
129	Park Show Low # 1	Apache	10 North	24 East	1	20		Inadequate	A1	06/22/94	Dry Lot Subdivision
130	Park Show Low # 1-4	Apache	10 North	24 East	1	140		Inadequate	A1	11/06/91	Dry Lot Subdivision
131	Park Show Low # 3, 4	Apache	11 North	24 East	1, 11	47		Inadequate	A1	06/22/94	Dry Lot Subdivision
132	Park Show Low # 4,5,6	Apache	11 North	24 East	1, 13, 15	62		Inadequate	A1	12/22/86	Dry Lot Subdivision
133	Park Valley # 3	Navajo	10 North	21 East	24	86		Inadequate	A1	10/05/83	Park Valley Water Company
134	Park Valley # 4	Navajo	10 North	21 East	25	189		Inadequate	A1	10/08/86	City of Show Low
135	Petrified Forest Estates # 2	Apache	18 North	24 East	5	133		Inadequate	C	01/14/87	Dry Lot Subdivision
136	Pine Canyon Estates	Coconino	14 North	12 East	6	385	22-300466	Adequate	---	06/24/98	Starlight Water Company
137	Pine Meadows Country Club Estates	Navajo	12 North	17 East	33	116		Adequate	---	05/30/86	Arizona Water Company
138	Pine Mountain Estates	Coconino	22 North	8 East	9	36	22-300065	Inadequate	A1	12/05/95	Doney Park Water Company
139	Pine Oaks	Navajo	10 North	22 East	29	78	22-300200	Inadequate	A1	09/27/96	City of Show Low
140	Pine Ridge # 1	Navajo	8 North	23 East	4, 5	73		Inadequate	A1	01/08/86	Pinetop Water Company
141	Pine Rim Forest	Navajo	12 North	17 East	30	56		Inadequate	A1	09/01/83	Arizona Water Company
142	Pineaire	Navajo	10 North	22 East	32	160		Adequate	---	10/25/73	Pineview Water Company
143	Pinecrest Lake	Navajo	12 North	17 East	33	200		Adequate	---	08/05/86	Arizona Water Company
144	Pineglen Park	Navajo	9 North	22 East	4	94		Inadequate	A1	12/05/83	Pineview Land and Water Company
145	Pineglen Village # 1	Navajo	9 North	22 East	4	84		Inadequate	A1	12/05/83	Pineview Land and Water Company
146	Pinegrove Park	Navajo	10 North	21 East	24	37		Inadequate	A1	08/10/83	Park Valley Water Company
147	Pines at Show Low Condominiums	Navajo	10 North	22 East	32	132		Adequate	---	02/18/87	Pineview Water Company
148	Pinetop Country Club Village	Navajo	8 North	23 East	11	n/a		Adequate	---	09/17/73	Ponderosa Water Company
149	Pinetop Lakes Plaza # 2, 3	Navajo	8 North	23 East	2	53		Adequate	---	10/06/83	Ponderosa Water Company
150	Pinetop Lakes, Mountain Homes	Navajo	8 North	23 East	11	111		Adequate	---	02/06/74	Ponderosa Water Company
151	Pioneer Subdivision	Apache	8 North	29 East	4	20		Adequate	---	06/08/81	Town of Eager
152	Pioneer Valley # 1	Coconino	22 North	8 East	14, 23	35		Inadequate	A2	12/04/92	Doney Park Water Company
153	Pioneer Valley # 3, 2B	Coconino	22 North	8 East	23	83		Inadequate	A2	10/03/94	Doney Park Water Company
154	Randall	Navajo	18 North	19 East	15	36		Adequate	---	09/06/73	Joseph City Water Company
155	Rendezvous at Torreon-Unit 1	Navajo	10 North	21 East	23	113	22-300436	Adequate	---	03/31/98	City of Show Low

Table 2-17 Adequacy Determinations in the Little Colorado River Plateau Basin[1]

Map Key	Subdivision Name	County	Location			No. of Lots	ADWR File No.[2]	ADWR Adequacy Determination	Reason(s) for Inadequacy Determination[3]	Date of Determination	Water Provider at the Time of Application
			Township	Range	Section						
187	Snowflake Heights	Navajo	13 North	22 East	17	90		Adequate	---	01/27/84	Town of Snowflake
188	Snowflake Heights # 2	Navajo	13 North	22 East	17	131		Adequate	---	06/06/84	Town of Snowflake
189	Stardust Meadows	Coconino	22 North	8 East	24	9	22-300002	Inadequate	A1	04/10/95	Doney Park Water Company
190	Starlight Pines # 1	Coconino	15 North	12 East	31	154		Adequate	---	05/23/83	United Utilities Company
191	Starlight Pines #2	Coconino	15 North	12 East	31	176		Adequate	---	04/24/86	Mogollon Water Company
192	Starlight Pines # 3	Coconino	15 North	12 East	31	n/a		Adequate	---	10/24/86	Mogollon Water Company
193	Starlight Pines # 4	Coconino	15 North	12 East	31	248		Adequate	---	11/09/88	Mogollon Water Company
194	Starlight Pines # 5	Coconino	15 North	12 East	31	17		Adequate	---	02/09/95	Starlight Water Company
195	Starlight Pines Ranchettes	Coconino	14 North	12 East	7	125	22-300093	Adequate	---	07/30/96	Starlight Water Company
196	Starlight Ridge Estates-Unit 1	Navajo	9 North	22 East	8	48	22-401400	Inadequate	D	07/20/04	Pineview Water Company
197	Starwood Estates	Navajo	8 North	23 East	1	65	22-400300	Inadequate	D	05/03/00	Ponderosa DWID
198	Summer Meadows	Apache	8 North	29 East	4	17		Adequate	---	06/08/81	Town of Eager
199	Summer Meadows #3	Apache	8 North	29 East	4	7		Inadequate	A1	08/21/86	Town of Eager
200	Summer Place	Navajo	12 North	16 East	24	36		Adequate	---	10/08/85	Arizona Water Company
201	Summer Place North	Navajo	12 North	16 East	24	45	22-300369	Adequate	---	11/17/97	Arizona Water Company
202	Summer Place North-Unit 2	Navajo	12 North	16 East	24	40	22-400412	Adequate	---	11/17/00	Heber DWID
203	Sun Valley Highlands # 2	Navajo	18 North	22 East	5	58	22-300308	Inadequate	A1	06/03/97	Dry Lot Subdivision
204	Sundance Springs Community	Navajo	13 North	21 East	13	257	22-401743	Adequate	---	08/04/05	Snowflake Municipal Water Company
205	Sunrise Vista Estates	Apache	10 North	24 East	9	24		Adequate	---	10/26/93	Cedar Grove Water Company
206	Sunset Vista Estates	Coconino	22 North	8 East	31	24	22-300390	Inadequate	A1	12/10/97	Doney Park Water Company
207	Tall Pine Estates # 2	Coconino	18 North	9 East	28	44		Inadequate	A1	08/10/89	Tall Pines Estates Water & Improvement
208	Tamarron Pines	Coconino	15 North	12 East	32	411	22-400100	Adequate	---	07/02/99	Starlight Water Company, Inc.
209	The Village	Navajo	10 North	21 East	24	17	22-401373	Inadequate	D	08/04/04	Park Valley Water Company.
210	Thunder Run Estates	Navajo	12 North	17 East	30	41	22-400132	Adequate	---	07/28/99	Arizona Water Company
211	Timberline Estates # 3	Coconino	22 North	8 East	9	10		Inadequate	A2	10/03/89	Doney Park Water Company
212	Timberline Estates-Unit 4	Coconino	22 North	8 East	9	25	22-400187	Inadequate	A1, A2	10/20/99	Doney Park Water Company
213	Town and Country # 1	Navajo	18 North	19 East	15	33		Adequate	---	05/07/79	Joseph City Utility Company
214	Udall Estates	Apache	8 North	29 East	7, 18	37		Adequate	---	12/05/83	Town of Eager
215	United Estates # 1	Navajo	12 North	17 East	30	35		Adequate	---	05/23/79	Arizona Water Company
216	Valley View Estates	Apache	8 North	29 East	8	11		Adequate	---	09/01/76	Town of Eager
217	Valley View Estates	Navajo	13 North	21 East	26	49		Adequate	---	09/26/77	Town of Snowflake

Table 2-17 Adequacy Determinations in the Little Colorado River Plateau Basin[1]

Map Key	Subdivision Name	County	Location			No. of Lots	ADWR File No.[2]	ADWR Adequacy Determination	Reason(s) for Inadequacy Determination[3]	Date of Determination	Water Provider at the Time of Application
			Township	Range	Section						
187	Snowflake Heights	Navajo	13 North	22 East	17	90		Adequate	---	01/27/84	Town of Snowflake
188	Snowflake Heights # 2	Navajo	13 North	22 East	17	131		Adequate	---	06/06/84	Town of Snowflake
189	Stardust Meadows	Coconino	22 North	8 East	24	9	22-300002	Inadequate	A1	04/10/95	Doney Park Water Company
190	Starlight Pines # 1	Coconino	15 North	12 East	31	154		Adequate	---	05/23/83	United Utilities Company
191	Starlight Pines #2	Coconino	15 North	12 East	31	176		Adequate	---	04/24/86	Mogollon Water Company
192	Starlight Pines # 3	Coconino	15 North	12 East	31	n/a		Adequate	---	10/24/86	Mogollon Water Company
193	Starlight Pines # 4	Coconino	15 North	12 East	31	248		Adequate	---	11/09/88	Mogollon Water Company
194	Starlight Pines # 5	Coconino	15 North	12 East	31	17		Adequate	---	02/09/95	Starlight Water Company
195	Starlight Pines Ranchettes	Coconino	14 North	12 East	7	125	22-300093	Adequate	---	07/30/96	Starlight Water Company
196	Starlight Ridge Estates-Unit 1	Navajo	9 North	22 East	8	48	22-401400	Inadequate	D	07/20/04	Pineview Water Company
197	Starwood Estates	Navajo	8 North	23 East	1	65	22-400300	Inadequate	D	05/03/00	Ponderosa DWID
198	Summer Meadows	Apache	8 North	29 East	4	17		Adequate	---	06/08/81	Town of Eager
199	Summer Meadows #3	Apache	8 North	29 East	4	7		Inadequate	A1	08/21/86	Town of Eager
200	Summer Place	Navajo	12 North	16 East	24	36		Adequate	---	10/08/85	Arizona Water Company
201	Summer Place North	Navajo	12 North	16 East	24	45	22-300369	Adequate	---	11/17/97	Arizona Water Company
202	Summer Place North-Unit 2	Navajo	12 North	16 East	24	40	22-400412	Adequate	---	11/17/00	Heber DWID
203	Sun Valley Highlands # 2	Navajo	18 North	22 East	5	58	22-300308	Inadequate	A1	06/03/97	Dry Lot Subdivision
204	Sundance Springs Community	Navajo	13 North	21 East	13	257	22-401743	Adequate	---	08/04/05	Snowflake Municipal Water Company
205	Sunrise Vista Estates	Apache	10 North	24 East	9	24		Adequate	---	10/26/93	Cedar Grove Water Company
206	Sunset Vista Estates	Coconino	22 North	8 East	31	24	22-300390	Inadequate	A1	12/10/97	Doney Park Water Company
207	Tall Pine Estates # 2	Coconino	18 North	9 East	28	44		Inadequate	A1	08/10/89	Tall Pines Estates Water & Improvement
208	Tamarron Pines	Coconino	15 North	12 East	32	411	22-400100	Adequate	---	07/02/99	Starlight Water Company, Inc.
209	The Village	Navajo	10 North	21 East	24	17	22-401373	Inadequate	D	08/04/04	Park Valley Water Company.
210	Thunder Run Estates	Navajo	12 North	17 East	30	41	22-400132	Adequate	---	07/28/99	Arizona Water Company
211	Timberline Estates # 3	Coconino	22 North	8 East	9	10		Inadequate	A2	10/03/89	Doney Park Water Company
212	Timberline Estates-Unit 4	Coconino	22 North	8 East	9	25	22-400187	Inadequate	A1, A2	10/20/99	Doney Park Water Company
213	Town and Country # 1	Navajo	18 North	19 East	15	33		Adequate	---	05/07/79	Joseph City Utility Company
214	Udall Estates	Apache	8 North	29 East	7, 18	37		Adequate	---	12/05/83	Town of Eager
215	United Estates # 1	Navajo	12 North	17 East	30	35		Adequate	---	05/23/79	Arizona Water Company
216	Valley View Estates	Apache	8 North	29 East	8	11		Adequate	---	09/01/76	Town of Eager
217	Valley View Estates	Navajo	13 North	21 East	26	49		Adequate	---	09/26/77	Town of Snowflake

Table 2-17 Adequacy Determinations in the Little Colorado River Plateau Basin[1]

Map Key	Subdivision Name	County	Location			No. of Lots	ADWR File No.[2]	ADWR Adequacy Determination	Reason(s) for Inadequacy Determination[3]	Date of Determination	Water Provider at the Time of Application
			Township	Range	Section						
218	Valley View Estates # 2	Apache	8 North	29 East	8	21		Adequate	---	07/26/82	Town of Eager
219	Vein of Gold-Unit IV	Navajo	18 North	22 East	5, 8	332	22-300309	Inadequate	A1	06/03/97	Dry Lot Subdivision
220	Vernon Valley II	Apache	10 North	25 East	22	28		Adequate	---	10/15/86	Serviceberry Water Company
221	Vista San Juan # 1	Apache	13 North	28 East	31	45		Adequate	---	12/06/76	Developer water company
222	Wenima Village Project	Apache	9 North	29 East	8, 17, 18	221		Adequate	---	05/17/89	Town of Springerville
223	West Gardens	Navajo	13 North	21 East	16	43		Adequate	---	12/09/76	Town of Snowflake
224	West Peak	Coconino	21 North	6 East	23, 24	12		Inadequate	A2, A3	08/11/94	Dry Lot Subdivision
225	West View Subdivision	Navajo	13 North	21 East	23	12	22-401498	Adequate	---	01/18/05	Town of Snowflake
226	Westbrook Addition-Vernon Townsite	Apache	10 North	25 East	21	8	22-400494	Adequate	---	04/18/01	Vernon DWID
227	Westwood Estates	Coconino	21 North	6 East	23	78	22-300012	Adequate	---	06/21/95	Flagstaff Ranch Water Company
228	Whispering Pines Townhouses	Navajo	9 North	23 East	31	89		Inadequate	A1	07/03/84	Pinetop Water Company
229	White Mountain Lakes #1 8	Navajo	11 North	22 East	10, 14, 15	132		Inadequate	A1	09/27/84	White Mountain Lake Water Company
230	White Mountain Lakes Estates	Navajo	11 North	22 East	3, 4, 10, 11, 12, 13, 14, 23, 24	NA		Adequate	---	06/27/85	White Mountain Lakes Estates Utility
231	White Mountain Resort	Apache	9 North	24 East	17	54	22-300007	Inadequate	A1	06/16/95	Dry Lot Subdivision
232	White Mountain Vacation Village	Navajo	10 North	22 East	32, 33	117	22-400626	Inadequate	A1	11/08/01	Pineview Water Company
			9 North	22 East	4, 5,			Inadequate	A1		
233	White Mountain Vacation Village Unit 2, Phase 3	Navajo	9 North	22 East	4	7	22-401415	Inadequate	A1	08/15/04	Pineview Water Company
234	Wilderness	Apache	10 North	24 East	12	115		Adequate	---	07/10/91	Lord Arizona Water Systems
235	Winchester Trails Ranches	Apache	10 North	25 East	17	135		Adequate	---	03/03/87	Lord Arizona Water Systems
236	Winchester Trails Ranches # 2	Apache	10 North	25 East	17	68		Inadequate	C	01/28/85	Dry Lot Subdivision
237	Wing Mountain Ranch-Unit 1	Coconino	22 North	6 East	27	16		Inadequate	A1	04/11/90	Dry Lot Subdivision
238	Wing Mountain Ranch-Unit 2	Coconino	22 North	6 East	27	15		Inadequate	A1	07/07/92	Dry Lot Subdivision
239	Wing Mountain Ranch-Unit 3	Coconino	22 North	6 East	27	15	22-300534	Inadequate	A1, A2	09/22/98	Dry Lot Subdivision
240	Wing Mountain Ranch Unit 3, Phase 2	Coconino	22 North	6 East	27	15	22-401217	Inadequate	A1	03/02/04	Dry Lot Subdivision
241	Wolf Pines-Unit 1	Navajo	9 North	22 East	9	26	22-400565	Inadequate	A1	10/02/02	Pineview Water Company
242	Woodland Acres	Navajo	12 North	17 East	33	19	220400043	Adequate	---	03/24/99	Arizona Water Company
243	Woodland Hills Subdivision	Navajo	8 North	23 East	6	152	22-300514	Inadequate	A1, C	08/27/98	Pinetop Water Company
244	Wupatki Trails	Coconino	23 North	8 East	29, 32, 33	41	22-400517	Inadequate	A1	05/14/01	Doney Park Water Company
245	Wye Subdivision	Apache	8 North	29 East	11	18		Adequate	---	08/22/83	Town of Eager

Notes:

[1]Each determination of the adequacy of water supplies available to a subdivision is based on the information available to ADWR and the standards of review and policies in effect at the time the determination was made. In some cases, ADWR might make a different determination if a similar application were submitted today, based on the hydrologic data and other information currently available, as well as current rules and policies.

Table 2-17 Adequacy Determinations in the Little Colorado River Plateau Basin[1]

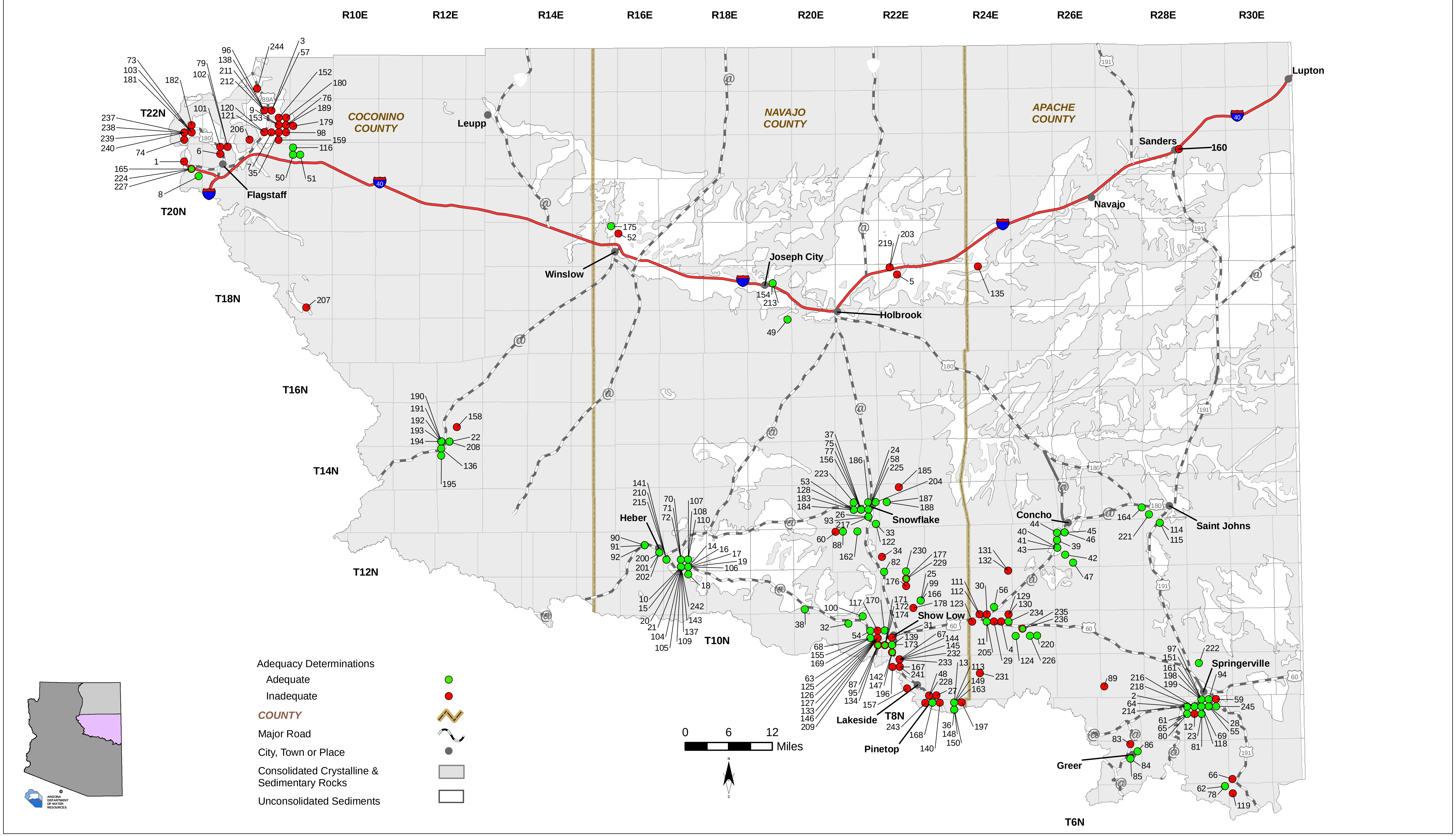
Map Key	Subdivision Name	County	Location			No. of Lots	ADWR File No.[2]	ADWR Adequacy Determination	Reason(s) for Inadequacy Determination[3]	Date of Determination	Water Provider at the Time of Application
			Township	Range	Section						

[2] Prior to February 1995, ADWR did not assign file numbers to applications for adequacy determination.

[3] A. Physical/Continuous
1) Insufficient Data (applicant chose not to submit necessary information, and/or available hydrologic data insufficient to make determination)
2) Insufficient Supply (existing water supply unreliable or physically unavaible;for groundwater, depth-to-water exceeds criteria)
3) Insufficient Infrastructure (distribution system is insufficient to meet demands or applicant proposed water hauling)
B. Legal (applicant failed to demonstrate a legal right to use the water or failed to demonstrate the provider's legal authority to serve the subdivision)
C. Water Quality
D. Unable to locate records

DWID = Domestic Water Improvement District
NA = Data not currently available to ADWR

Figure 2-24
Little Colorado River Plateau Basin
Adequacy Determinations



SECTION 2.2 Water Resource Issues in the Eastern Plateau Planning Area

A number of water resource issues have been identified in the planning area by community groups, through the distribution of surveys, and from other sources. Primary issues are the accessibility of groundwater supplies in some areas due to hydrologic conditions and water quality problems. There are also infrastructure deficiencies that influence access to water supplies. A number of communities lack financial resources for infrastructure development or repair and drought has impacted surface water supplies. The ability to meet future water demands is a concern for many communities. Many Navajo communities currently face critical water shortages. Water hauling is commonplace on the reservation, in part because widely scattered housing makes direct water delivery impractical in many areas. Hauling is also common at some locations outside of the reservation.

Several watershed groups have formed in the Eastern Plateau Planning Area to address a variety of water resource issues. Some groups encompass areas outside of the Eastern Plateau Planning Area. Groups that are currently active in various locations within the basin are the Coconino Plateau Advisory Council, Northern Arizona Municipal Water Users, Little Colorado Watershed Coordinating Council (formerly the Little Colorado River Multi-Objective Management Partnership (LCRMOM)), Show Low Creek Watershed Partnership, the Silver Creek Watershed Partnership, the Upper Little Colorado River Watershed Partnership and the Navajo Nation. A complete description of participants, activities and issues is found in Appendix B. Primary issues identified by these groups that apply to the Eastern Plateau Planning area can be summarized as follows:

Growth:
- Excessive growth in some areas
- Proposed development in Greer and impacts on the Little Colorado River
- Unregulated lot splits

Water Supplies and Demand:
- Limited and deep groundwater supplies
- Drought sensitive supplies
- Numerous water haulers and few hauling stations which are sometimes cutoff during drought
- Limited surface water supplies for Page
- Limited groundwater data for entire region
- Potential impacts on groundwater system from power plants
- Seasonal demands impacting ability to meet peak demands

Legal:
- Potential limitation of groundwater usage resulting from Indian reserved groundwater rights
- Uncertainty of Indian water right settlements (Little Colorado River & Colorado River)
- Access to water development activities on public lands
- Competition from Phoenix/Tucson for CAP reallocation water
- Upper Basin/Lower Basin Colorado River issues affecting potential for use
- Unresolved surface water adjudication

Water Quality:
- Minor arsenic issues in Woody Mtn. Well field (9-14 ppb)
- Arsenic and TDS in some areas

Environmental:
- Endangered Species Act implications on groundwater usage and impacts on perennial streams

- Impact of invasive species (Tamarisk)

Funding:

- Limited funding resources for planning, projects, infrastructure and studies
- Extremely high cost of water augmentation projects
- Funding for Colorado River water infrastructure
- Funding for water delivery infrastructure

Drought:

- Drought impacts on surface water supplies and springs resulting in impacts on agriculture and cattle ranching
- Potential impacts on tourism due to drought

Other:

- Political differences between some communities
- Perception of no real water supply problem
- Several high hazard unsafe dams

Potential future and current water supply shortfalls have lead to discussions among the Coconino Plateau Advisory Council regarding water supply development/augmentation alternatives. Among the proposed alternatives is a water pipeline from Lake Powell to communities in both the Eastern and Western Plateau Planning Areas (Heffernon and Muro, 2001). A study to identify potential supply alternatives for the area was completed by the Bureau of Reclamation in 2005 and an appraisal level is expected to be completed in 2006.

The Department conducted a rural water resources survey in 2003 to compile information to provide to the public and help identify the needs of growing communities. This survey was also intended to gather information on drought impacts to incorporate into the Arizona Drought Preparedness Plan, adopted in 2004. Questionnaires were sent to almost 600 water providers, jurisdictions, counties and tribes. A report of the findings from the survey was completed in 2004 (ADWR, 2004).

Thirty-seven water providers and jurisdictions in the Eastern Plateau Planning Area responded to the survey and of these, 23 ranked issues. Respondents were asked to rank eighteen issues which can be compressed into three categories: infrastructure, water supply and water quality. In the planning area, both infrastructure and water supply issues were ranked among the top five issues by a majority of respondents. In addition, a majority of respondents noted at least one drought impact. Primary drought impacts noted were increased demand, increased peak demand and lowered groundwater levels.

The Department conducted another, more concise survey of water providers in 2004. This was done to supplement the information gathered in the previous year in support of developing the Arizona Water Atlas, and to reach a wider audience by directly contacting each water provider. Through this effort, 44 water providers in the Eastern Plateau Planning Area, with a total of approximately 46,500 service connections, were willing to participate and provide information on water supply, demand, infrastructure and to rank a list of seven issues.

In regard to the question of groundwater level trends in their service area, the 33 respondents reported as follows: 20 stable; 8 falling, 3 don't know, 2 variable. None reported rising water levels.

Water providers were asked to rank issues from 0 to 4 with 0 = no concern, 1 = minor concern, 2 = moderate concern and 3 = major concern. Of the 44 water providers that responded to the survey, 39 ranked issues. These respondents include most of the largest water providers in the planning area including City of Flagstaff, City of Holbrook, City of Show Low, Town of Snowflake, Winslow Municipal Water and Doney Park Water Company.

Table 2-18 Water resource issues ranked by 2004 survey respondents in the Eastern Plateau Planning Area (39 water providers)

Issue	Moderate concern	Major concern	Total	Percent of respondents reporting issue was a moderate or major concern
Inadequate storage capacity to meet peak demand	6	6	12	31
Inadequate well capacity to meet peak demand	7	4	11	28
Inadequate water supplies to meet current demand	4	1	5	13
Inadequate water supplies to meet future demand	9	3	12	31
Infrastructure in need of replacement	11	8	19	49
Inadequate capital to pay for infrastructure improvements	10	12	22	56
Drought related water supply problems	6	4	10	26

Although responses to the 2003 questionnaire are not directly comparable to the 2004 survey due to differences in the form and wording of the surveys, responses to the same issues are similar as shown in Table 2-19.

Table 2-19 Water resource issues ranked by 2003 survey respondents in the Eastern Plateau Planning Area (17 water providers and 6 jurisdictions)

Issue	Ranked as one of the top 5 issues (of 18)	Percent of respondents
Inadequate storage capacity to meet peak demand	9	39
Inadequate well capacity to meet peak demand	6	26
Inadequate water supplies to meet current demand	4	17
Inadequate water supplies to meet future demand	9	39
Infrastructure in need of replacement	13	52
Inadequate capital to pay for infrastructure improvements	10	43
Drought related water supply problems	8	35

Tribal Issues

A Navajo Department of Water Resources (NDWR) White Paper identified the need for an increased water supply to help support needed basic services on the reservation (NDWR, 2002). The tribe is investigating the feasibility of transporting water by pipeline to several areas and is conducting groundwater development investigations. NDWR, USBR and BIA have cooperated on a plan to investigate the alluvial aquifer in the Bird Springs area located east of Leupp at the southern edge of the Navajo Reservation Boundary northwest of Winslow, to analyze the feasibility of well field development (NDWR, 1999).

One of the water development challenges on the Navajo reservation is that resolution of problems requires the coordination of multiple agencies and private resources. In addition, the population has limited economic resources that make large capital investments difficult and the widely dispersed population results in large distances between water sources and water users. Although the Navajo Nation has adopted a Drought Plan and conducts numerous planning activities, additional regional water planning, investigation of a regional conveyance system, improving water service to domestic water haulers and water conservation and reuse were also identified as needs (NDWR, 2002)

The Hopi and Navajo are concerned about the impact to their water supply by Peabody Coal Company extracting N-aquifer water to transport coal from the Black Mesa Coal Mine to the Mohave Generating Station at Laughlin, Nevada. The N-aquifer is the only source of drinking water for the Hopi. This pumping is believed to be affecting water supplies in some areas (www.hopi.nsn.us). The USGS, in cooperation with the Bureau of Reclamation, is evaluating the C-aquifer near Leupp on the Navajo Reservation for potential use as a water supply for Peabody Coal and for the Navajo and Hopi (USGS, 2005). The Hopi tribe has recently purchased off-reservation ranches near Winslow and Springerville for potential irrigation development or other purposes (www.hkminc.com/Hopi.htm).

Resolution of Indian water rights settlements is a critical issue in the planning area. The Navajo Nation, Hopi Tribe, Zuni Tribe and the San Juan Southern Piaute Tribe have been negotiating with non-Indian water users in the Little Colorado River Plateau basin, the State of Arizona and the federal government for several years in a settlement committee appointed by the Little Colorado General Stream Adjudication Court.

The non-Indian parties reached agreement with the Zuni Tribe over protection of its Zuni Heaven lands in Arizona, resulting in congressional approval in 2003. Talks in a less formal setting have continued with the Navajo Nation and Hopi Tribe about possible settlement of the Little Colorado River Basin claims. Additionally, the Navajo Nation filed a lawsuit in April of 2003 against the Secretary of the Interior over the operation of the Colorado River. A Federal judge has entered a stay in that case to allow negotiations with the State of Arizona and non-Indian water users about possible Navajo Nation claims to the Colorado River.

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ACRONYMS AND ABBREVIATIONS

A.R.S.	Arizona Revised Statutes
ADEQ	Arizona Department of Environmental Quality
AF	Acre-feet
AGFD	Arizona Game and Fish
ALERT	Automated Local Evaluation in Real Time
ALRIS	Arizona Land Resource Information System
AMA	Active Management Area
ASLD	Arizona State Land Department
AWPF	Arizona Water Protection Fund
AWS	Assured Water Supply
AZMET	Arizona Meteorological Network
BIA	Bureau of Indian Affairs (U.S.)
BLM	Bureau of Land Management (U.S.)
BOR	Bureau of Reclamation (U.S.)
CAP	Central Arizona Project
CDP	Census Designated Place
CLIMAS	Climate Assessment for the Southwest
CODE	Arizona Groundwater Management Act - A.R.S. § 45-401 *et seq.*
COE	Corps of Engineers (U.S.)
Department/ADWR	Arizona Department of Water Resources
ENSO	El Nino/Southern Oscillation
EPA	Environmental Protection Agency (U.S.)
ESA	Endangered Species Act - 7 U.S.C. 136; 16 U.S.C. 460 *et seq.*
ft bls	Feet below land surface
GPCD	Gallons Per Capita Per Day
gpm	Gallons per minute
HSR	Hydrographic Survey Report
ID	Irrigation District
INA	Irrigation Non-expansion Area
LCR	Little Colorado River
LUST	Leaking Underground Storage Tank
maf	Million acre-feet
mg/l	Milligrams per liter
mgd	Million gallons per day
NDEQ	Navajo Department of Environmental Quality
NDWR	Navajo Department of Water Resources
NHA	Navajo Housing Authority
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service (U.S.)
NRA	National Recreation Area
NRCD	Natural Resources Conservation District
NRCS	Natural Resources Conservation Service
NTUA	Navajo Tribal Utility Authority
NWS	National Weather Service
Pan ET	Pan evaporation
P.L.	Public Law

RCD	Resource Conservation District
RVID	Round Valley Irrigation District
SLD	Arizona State Land Department
SNOTEL	SNOwpack TELemetry
SRP	Salt River Project
TDS	Total dissolved solids
TEPCO	Tucson Electric Power Company
TNC	The Nature Conservancy
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VOC	Volatile organic compound
WIFA	Water Infrastructure Funding Authority
WQARF	Water Quality Assurance Revolving Fund
WRCC	Western Regional Climate Center
WWTP	Wastewater Treatment Plant

APPENDIX A: Arizona Water Protection Fund Projects in the Eastern Plateau Planning Area Through 2005

Project Title/Grant #	Project Category
Lake Mary Watershed Streams Restoration/00-108	Channel Restoration
Little Colorado River Riparian Restoration Project/99-079	Constructed Wetland & Revegetation
Talastima (Blue Canyon) Watershed Restoration Project/97-037	Exotic Species Control & Fencing
Continued Enhancement of Pueblo Colorado Wash at Hubbell Trading Post National Historic Site/00-104	Exotic Species Control & Stream Restoration
Saffell Canyon and Murray Basin Watershed Restoration/96-0022	Feasibility Study
Town of Eager/Round Valley Water Users Association Pressure Irrigation Feasibility Study & Preliminary Design/99-089	Feasibility Study
Town of Eagar/Round Valley Water Users Association Pressure Irrigation Feasibility Study and Preliminary Design – Additional Mapping for Water Quality Improvements in the Watershed/00-112	Feasibility Study
Completion Phase: Hi-Point Well Project/96-0002	Fencing
EC Bar Ranch Water Well Project/98-046	Fencing & Water Developments
Brown Creek Riparian Restoration/99-095	Fencing & Water Developments
Upper Fairchild Draw Riparian Restoration/00-110	Fencing & Revegetation
Polacca Wash Grazing Management/00-113	Fencing & Exotic Species Control w/ Revegetation
Wet Meadows for Water Quality and Wildlife – A Riparian Restoration Project/03-119	Fencing & Habitat Protection
EC Bar Ranch Wildlife Drinker Project/99-067	Livestock & Wildlife Water Developments
Evaluation of Carex Species for Use in Riparian Restoration/98-051	Research
Assessments of Riparian Zones in the Little Colorado River Watershed/99-084	Research

Project Title/Grant #	Project Category
Hubbell Trading Post Riparian Restoration with Treated Effluent/00-105	Revegetation
Wilkins' family Little Colorado River Riparian Enhancement Project/05-125	Stream Restoration
X Diamond Ranch LCR Riparian Enhancement Project/05-126	Stream Restoration
Hoxworth Springs Riparian Restoration Project/96-0003	Stream Restoration
Demonstration Enhancement of Pueblo Colorado Wash at Hubbell Trading Post/97-029	Stream Restoration & Revegetation
Little Colorado River Enhancement Demonstration Project/99-092	Stream Restoration
EC Bar Ranch Reach 8 Water Well and Drinker Project/05-127	Water Developments
Tsaile Creek Watershed Restoration Demonstration/96-0025	Watershed Restoration
Murray Basin and Saffell Canyon Watershed Restoration Project/00-101	Watershed Restoration

APPENDIX B: Watershed Partnerships in the Eastern Plateau Planning Area (2005)

MULTI-PLANNING AREA - **Eastern Plateau, Western Plateau and Central Highlands**

Watershed Partnership	Primary Participants	Projects & Accomplishments	Issues
Coconino Plateau Water Advisory Council	Flagstaff, Coconino County, Williams, Sedona, Page, Tusayan TNC, Grand Canyon Trust, Doney Park Water Co. Navajo Nation, Hopi Tribe, Havasupai Tribe, Hualapai Tribe ADWR, ADEQ, State Land, NRCD, NAU USBoR, USGS, USFS, BLM, Grand Canyon National Park, Glen Canyon NRA, NRCS	• 4 categories of potential water augmentation projects have been identified along with their associated costs. • Groundwater study and conceptual model completed • Phase I Water Demand Study for Coconino Plateau • Growth Impacts Study • Western Navajo Pipeline Study • Development of study for importing C aquifer groundwater east of Flagstaff has been completed. • Flagstaff, Hopi and Navajo are exploring cooperative opportunities for developing C aquifer groundater. • Flagstaff purchased Red Gap Ranch for possible future development of groundwater. • Hopi HSR initiated. • Conducting Water Appraisal Study to identify current & future demands and alternatives for meeting projected demands. • Developing numeric model	• Excessive growth throughout entire plateau • Limited and deep groundwater supplies. • Drought sensitive surface water supplies of Williams, Flagstaff and others • Unsafe dam issues in Williams • Groundwater salinity issues in northeastern part of plateau • Numerous water haulers with few hauling stations that are sometimes cutoff during drought • Unable to get adequate water supply designation under current definition • Growth in Page with no means of additional supply • ESA issues with groundwater usage and impacts on perennial streams • Potential limitation of groundwater usage • from reserved groundwater rights of Indians • Uncertainty of Indian water right settlements (LCR & Colorado River) • Proposed San Juan Paiute reservation west of Flagstaff • Potential impacts on springs in Grand Canyon and also on supplies to Havasupai and Hualapai reservations • Access to water development on public lands • Limited groundwater data for entire region • Minor Arsenic issues in Woody Mtn. Well field (9-14 ppb) • Unregulated lot splits • Limited funding resources for planning, projects, infrastructure and studies • Extremely high cost of water augmentation projects

MULTI-PLANNING AREA – **Eastern Plateau, Western Plateau and Central Highlands (continued)**

Watershed Partnership	Primary Participants	Projects & Accomplishments	Issues
Northern Arizona Municipal Water Users Association (NAMWUA)	Prescott, Prescott Valley, Flagstaff, Williams, Cottonwood, Clarkdale, Sedona, Payson, Chino Valley	? Projected water demands through 2040 have been identified ? A request for 70,000 acre-feet of CAP reallocation water has been submitted to ADWR for consideration.	? Limited supplies to meet projected demands ? ESA issues impacting potential ground and surface water supplies ? Limited funding resources for planning, projects, infrastructure and studies ? Competition from Phoenix/Tucson for CAP reallocation water ? Funding for Colorado River infrastructure ? Water quality issues in Verde Valley and Flagstaff ? Upper Basin/Lower Basin issues with Colorado River affect potential for use

EASTERN PLATEAU PLANNING AREA

Watershed Partnership	Primary Participants	Projects & Accomplishments	Issues
Little Colorado Watershed Coordinating Council (Formerly Little Colorado River Multi-Objective Management Partnership (LCRMOM))	Winslow, Holbrook, Navajo County, NRCD/RCD, NAU, USBoR, COE	? Development and Ecosystem Restoration Program study for the Montane Forest Regimes completed. ? Watershed reconnaissance study	? Potential impacts on groundwater system from power plants ? Water quality issues involving arsenic and TDS ? Unresolved adjudication and Indian water rights settlements ? Limited groundwater data for entire region ? Invasive species (Tamarisk) ? ESA issues ? Drought impacts on surface water supplies ? Limited funding resources for planning, projects, infrastructure and studies

EASTERN PLATEAU PLANNING AREA (continued)

Watershed Partnership	Primary Participants	Projects & Accomplishments	Issues
Navajo Nation	NDWR NTUA NDEQ NHA ADWR USBoR COE BIA HIS	? Survey of agricultural lands in Upper Basin ? Groundwater elevation survey of NTUA wells ? Water Quality ATLAS ? Navajo Drought Report ? Western Navajo Water Supply Study	? Lack of technical groundwater data ? Limited groundwater supplies to meet projected demands ? Water quality issues ? Prone to impacts from drought ? Unresolved water right claims to LCR and Colorado R. ? Upper Basin/Lower Basin issues with Colorado River ? Gallup to Window Rock Pipeline in jeopardy (financial, upper/lower basin issues, ESA and others)
Show Low Creek Watershed Partnership	Show Low Lakeside-Pinetop Navajo Cty Show Low Creek Irrigation District Local Citizenry ADWR AZ Game & Fish	? Groundwater elevations study ? GPS survey of agricultural lands ? Development of a water resources management plan initiated. ? Development of a water budget initiated.	? Drought impacts on surface water supplies and springs resulting in impacts on agriculture and cattle ranching ? Seasonal demands impacting peak demands ? Growth ? Unresolved adjudication and Indian water rights settlements ? Limited funding resources for planning, projects, infrastructure and studies
Silver Creek Watershed Partnership	Snowflake Taylor Holbrook Winslow Show Low Navajo County Silver Creek ID Show Low Creek Watershed Partnership ADWR NAU	? Silver Creek channel and riparian restoration study completed. ? Value Engineering Analysis of Unsafe Dams completed ? Silver Creek HSR ? Development of a water budget initiated.	? Limited groundwater data ? Potential impacts on groundwater system from Cholla Power plant ? Drought impacts on surface water supplies for agriculture ? Several high hazard unsafe dams ? Unresolved adjudication and Indian water rights settlements ? Perception of no real supply problem ? Water quality concerns in some areas (salinity) ? Limited funding resources for planning, projects, infrastructure and studies

EASTERN PLATEAU PLANNING AREA (continued)

Watershed Partnership	Primary Participants	Projects & Accomplishments	Issues
Upper Little Colorado River Watershed Partnership	Springerville Eagar Greer Nutrioso Apache County Round Valley Irrigation District Local Citizens and Special Interest Groups ADWR ADEQ AZG&F NRCS/RCD USFS USBoR	? Aerial mapping survey and GIS coverage of the Little Colorado River (LCR) and its tributaries completed. ? Geomorphic and biological assessment of the LCR completed. ? Stream riparian restoration project ? Round Valley Irrigation Delivery System partially upgraded. ? Preliminary water budget completed ? Reconstruction of River Reservoir Dam completed. ? The interconnection of Springerville and Eagar's wastewater treatment facilities is being pursued.	? Limited groundwater data ? Potential impacts to the groundwater system from TEPCO generating station. ? Unresolved adjudication and Indian water rights settlements ? Proposed development in Greer and impacts on Little Colorado River ? Drought impacts on forage for grazing and surface water availability for agriculture ? Potential impacts on tourism due to drought ? Funding issues for water delivery infrastructure ? Political differences between Springerville and Eagar ? Perception of no real supply problem ? Limited funding resources for planning, projects, infrastructure and studies

AEC

United States Atomic Energy Commission, The Uranium Deposits of Northern Arizona, By Willaim L. Chenoweth and Roger C. Malan, Grand Junction, Colorado.

THE URANIUM DEPOSITS OF NORTHEASTERN ARIZONA*

by

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INTRODUCTION

In northeastern Arizona and adjacent areas in Utah and New Mexico significant amounts of uranium have been produced from deposits in the Chinle and Morrison formations. Minor deposits occur in the Bidahochi, Kayenta, Moenkopi and Toreva formations. A total of 14,017,000 pounds of U_30_8 has been produced to date. Although this is only a fraction of the total U.S. production, the Chinle here represents approximately 13 percent. Production from the Morrison Formation in northeastern Arizona, and the adjacent area in New Mexico, is restricted to the Salt Wash Member and represents approximately 5 percent.

All of the mines, with the exception of those in the Winslow-Holbrook-St. Johns area and those near Black Point in the Cameron area, are on the Navajo Indian Reservation. On the reservation, mining permits and leases are granted by the Navajo Tribal Council at Window Rock, Arizona. Uranium mining has provided the tribe with significant income from royalties and rentals, as well as employment for the members of the tribe. At the present time, the area is inactive and there are no leases in effect on the reservation in northeastern Arizona and adjacent areas.

DEPOSITS IN THE CHINLE FORMATION

Exposures of the Chinle Formation in northeastern Arizona occur in Monument Valley on the Monument uplift, along the west and south flanks of the Black Mesa basin, and on the Defiance uplift on the east side of the basin. In Monument Valley, the formation is composed of five members which, in ascending order, are: the Shinarump, Monitor Butte, Petrified Forest, Owl Rock and Church Rock. Uranium deposits in northeastern Arizona occur in the Shinarump and Petrified Forest members and in an equivalent of the Monitor Butte Member.

Shinarump Member—The Shinarump consists of fluvial sediments which were deposited in stream channels and flood plains. These sediments are composed of lenticular beds of sandstone, conglomerate, siltstone and mudstone; they contain abundant fragments of carbonized wood and minor amounts of silicified wood. This resistant unit generally forms a broad bench and in Monument Valley it caps mesas and buttes. The sandstone is commonly light tan to light gray in color, cross-stratified, medium- to coarse-grained and usually conglomeratic at the base. The conglomerate is composed of well-rounded to sub-angular pebbles and cobbles of quartzite, quartz, chert with some limestone, sandstone, siltstone and mudstone. Calcite is the most common cementing material in the sandstone and conglomerate. Mudstone in the member consists of lenses varying in color from pale red to greenish gray. The thickness of the member varies greatly as it fills valleys and scours eroded into the underlying rocks. In Monument Valley, the thickness of the Shinarump ranges from approximately 10 feet to nearly 250 feet.

The recognition of Shinarump channels and channel patterns is important, because all of the significant uranium deposits in Monument Valley are located in these features.

Monitor Butte Member—The Monitor Butte intertongues with the Shinarump and consists of red to greenish-gray mudstone and siltstone with some light brown to gray, very fine- to coarse-grained sandstone. The member ranges in thickness from 50 to 200 feet. Lateral equivalents of the Monitor Butte in northeastern Arizona include the sandstone and mudstone member, the lower red member, and the Mesa Redondo Member (Stewart and others, 1972). Minor uranium deposits in the Cameron area occur in the sandstone and mudstone member.

Petrified Forest Member—Overlying and gradational with the Monitor Butte and its correlatives is the Petrified Forest Member. The lower part of the member is comprised of blue, gray and white mudstone and tuffaceous siltstone. Lenticular sandstones are present in the lower part of the member in the Cameron area. The upper part of the member consists of grayish red, pale reddish-brown, and pale reddish-purple mudstone, siltstone and sandy siltstone. In the eastern part of the Black Mesa basin the Sonsela Sandstone Bed separates the two parts of the member. The Petrified Forest Member ranges in thickness from 500 to 1,200 feet in northeastern Arizona.

Monument Valley Area

The Monument Valley area is in the southern portion of the Monument upwarp where erosion has dissected a high tableland. The name of the mining area is derived from Monument Valley where erosion of massive eolian sandstones has produced spectacular monolithic landforms. Here, the Shinarump Member of the Chinle Formation crops out around the perimeter of the uplift and also caps mesas within Monument Valley (fig. 1).

A brightly-colored outcrop of uranium-vanadium minerals, which was to become the Monument No. 2 mine, was brought to the attention of the Vanadium Corporation of America, who leased the area in August, 1942. This discovery resulted in additional prospecting which found other exposures in the central part of the area. Although some vanadium ore was produced during 1942-1944, significant production did not begin until 1948 when uranium became important. In the late 1940s and early 1950s, many deposits, small to medium in size were discovered in paleochannel exposures at rim outcrops. In

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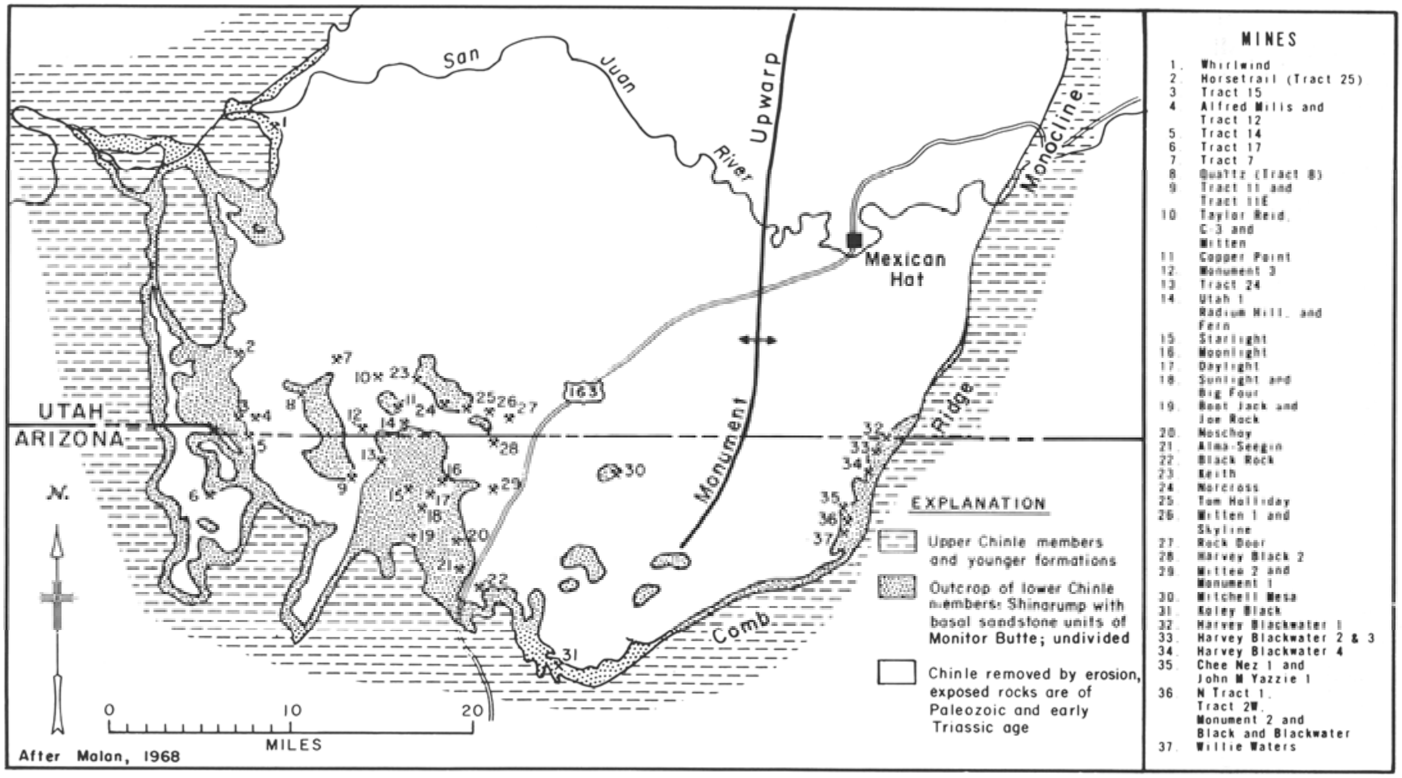

Figure 1.
Mine locations: Monument Valley, Navajo and Apache counties, Arizona, and San Juan County, Utah.

1955 and 1956, a cluster of important deposits including the Moonlight mine was discovered in buried channels at moderate depths in the central portion of Monument Valley. Production in Monument Valley reached a peak in 1955, when 14 mines were operating, and gradually declined until the last shipment was recorded in late 1969. During this period, a total of 1,362,000 tons averaging 0.32 percent U_3O_8 and containing 8,730,000 pounds U_3O_8 were produced from 53 properties. Vanadium which was recovered from 97 percent of this production averaged 0.94 percent V_2O_5 and aggregated 24,780,000 pounds V_2O_5 . Most of the ore that was produced from the Monument No. 2 mine was beneficiated in an upgrader located at the mine site.

Shallow deposits at or near an outcrop were mined by adit or open pit, depending on the size of the deposit. Deeper deposits up to the economic limit of about 600 feet were developed and mined by shafts or inclines. At the Monument No. 2 mine, which produced more than half of the total production from the district, most ore was mined by open-pit methods.

The uranium deposits of Monument Valley have been studied by many geologists; more recent reports include those by Witkind and Thaden (1963), Young (1964) and Malan (1968).

As used in this paper, Shinarump channels are the courses of paleostreams which were incised into the underlying Moen kopi Formation and which were filled with fluvial sediments. Scours are the discontinuous, stream-incised, cut-and-fill components within the channels. These scours developed at stages during the lateral shifting of the main stream channel. Sediments in scours in the lower portions of channels are the hosts for the uranium deposits. Channels in Monument Valley are U-shaped in cross section, contain mainly sandstone and conglomerate, are quite narrow, and commonly contain only one ore-bearing scour. Not all scours in paleochannels contain uranium mineralization. Uranium deposits are primarily restricted to favorable carbonaceous sandstone and conglomerate beds in the lower part of the Shinarump Member of the Chinle Formation; however, in a few mines ore extends downward as much as 15 feet into underlying beds.

Ore bodies consist of closely-shaped, lenticular ore pods which are generally concordant with bedding. Single ore pods range from a few feet to a few hundred feet in length and from less than one foot to 12 feet in thickness. As viewed in plan, more ore deposits are linear. The ratio of length to width is commonly 5 to 1 and may reach 50 to 1. Deposits range in size from a few tons to approximately 800,000 tons of ore. About half of the deposits are smaller than 1,000 tons in size and all but two are smaller than 50,000 tons.

The deposits contain variable amounts of copper and vanadium. Ores from the Monument No. 2 mine contained an average of 1.40 percent V_2O_5 and little or no copper. In the other deposits for which some data are available, vanadium ranges from 0.22 percent to 0.81 percent and copper ranges from 0.29 percent to 2.50 percent; weighted averages are 0.60 percent V_2O_5 and 0.71 percent copper. These averages are not representative, because they are based solely on production from mines for which the vanadium and copper content was recorded. In general, the vanadium content of ores decreases from east to west, but copper increases from east to west.

In the unoxidized parts of the Monument No. 2 mine, uraninite and coffinite are associated with vanadium minerals such as montroseite, corvusite, doloresite and vanadium hydromica. Sulfides of iron, copper and lead are also present. Oxidized ore minerals from this mine are tyuyamunite, carnotite, hewettite and navajoite. All of these minerals are associated with oxides of iron. In other mines in Monument Valley, the suite of unoxided minerals is the same as that at the Monument No. 2 mine, but copper sulfide minerals are more abundant, and montroseite is less abundant. The uranium minerals, torbernite, uranophane, uranopilite, betazippeite and johannite have been identified in samples from oxidized deposits. Malachite, azurite and hydrous copper and iron sulfates are common accessory minerals.

Calcium carbonate is present in ore mostly as cementing material in the sandstone host rock. In Monument Valley mines, calcium carbonate ranges from 1.4 percent to 10.3 percent and averages 4.6 percent. Calcium carbonate content generally is inversely proportional to vanadium content but it does not correlate with copper.

Cameron Area

The Cameron area is on the southwest flank of the Black Mesa basin. Here, the Chinle Formation crops out in a broad belt nearly parallel to the Little Colorado River. The main mining area forms a curved belt approximately 2 miles wide extending 6 miles north of Cameron along U.S. Highways 89 and 164, and 5 miles wide extending 18 miles southeast along the Little Colorado River (fig. 2). However, several additional deposits occur outside this area. The principal host rock in the area is the Petrified Forest Member. Underlying the Petrified Forest Member is the sandstone and mudstone member. The sandstone and mudstone unit has been included in the Shinarump by Akers and others (1962); however, recent mapping by the USGS in the Black Point area identifies this unit as a separate member (D. V. Haines, personal communication, 1970). Uranium deposits previously reported as occurring in the Shinarump are actually located in the sandstone and mudstone member.

Uranium was first reported in the Cameron area in 1950 in the Kayenta Formation of Early J urassic(?) age. As a result of the discovery, the AEC employed Navajos to prospect the entire area. The first discovery of commercial importance was made by Charlie Huskon, an AEC prospector, in the Petrified Forest Member of the Chinle Formation in early 1952. Surface prospecting supplemented by airborne radiometric surveying led to the discovery of additional ore bodies in 1953. As the area developed, many deposits having no surface expression were located by shallow exploration drilling. Initial production from the area was in late 1950 from the Hosteen Nez property in the Kayenta Formation. Production reached a peak in 1957 and gradually declined until the last shipment which was recorded in January 1963. During that period a total of 289,300 tons averaging 0.21 percent U_30_8 and containing 1,211,800 pounds U_30_8 were produced from 98 separate properties. Mining has been by open pits ranging in size from small shallow trenches containing a single mineralized fossil log to a large pit complex 2,400 feet long and 250 feet wide. Underground mining from the walls of the pits to recover additional ore was a common practice. Four vertical shafts were also used in the area.

The deposits have been described by Hinkley (1957), Bollin and Kerr (1958) and Chenoweth (in Akers et al., 1962). Chenoweth and Magleby (1971) prepared a map showing the location and relative sizes of the deposits, and Austin (1964) has described the mineralogy of the deposits. Sixty-seven deposits, that occur in the lower part of the Petrified Forest Member, have yielded 1,177,500 pounds U_30_8 or 97 percent of the area's total production. The ore occurs within elongated, lenticular deposits of poorly consolidated, cross-stratified, fine- to medium-grained sandstone, clay-pellet sandstone and clay-pellet conglomerate which contain varying amounts of carbonaceous matter, including carbonaceous fossil logs. The sandstone lenses were deposited in irregular depressions cut into bentonitic claystones and mudstones and are probable ancient fluvial channel fills. The maximum observed thickness of the lenses is approximately 35 feet; the average thickness is approximately 20 feet. The continuity of the sandstone lenses is poor, but individual lenses have been traced for more than a mile. Ore consists chiefly of secondary uranium minerals filling pore spaces in sandstone and in places uraniferous fossil logs. The ore tends to occur in abrupt depressions along channels or at changes in a channel's direction, and favors the more carbonaceous layers. Ore bodies are usually elongated parallel to the trend of the channels, but some ore bodies are oriented nearly normal to the sedimentary trends. Each ore body is encased in an alteration halo consisting of bleached sandstone and mudstone. Ore bodies and halos terminate abruptly downward against impervious mudstone. The most visible bleaching effect is a change from gray or occasionally red to yellowish or buff.

Ore bodies occur from the surface to a depth of 130 feet. As many as three ore zones may be present in 100 feet of section. Individual ore bodies range in size from a single mineralized fossil log to the Jack Daniels ore body, the largest known in the area, which was a nearly continuous body 450 by 300 feet containing 178,000 pounds U_3O_8. By comparison, the second largest deposit is the Charles Huskon 4-Paul Huskie-3 from which was produced 135,600 pounds U_3O_8 from a cluster of ore pods occurring in an area 1,000 by 550 feet. The most productive area is east of Cameron where 10 properties, within one square mile, have been the source of 264,100 pounds or 22 percent of the total production.

Twenty-seven deposits in the sandstone and mudstone member occur with carbonaceous material in a thin-bedded, cross-stratified, medium- to fine-grained sandstone in the upper 30 feet of the member. Uranium-bearing fossil logs are common. The largest deposit in this member is Huskon-11 from which 6,600 pounds U_3O_8 were produced. The three small deposits in the Kayenta Formation occur in fine-grained sandstone lenses in the middle part of the formation. Total production from the Kayenta Formation in the Cameron area is 550 pounds U_3O_8.

The Riverview mine occurs in a breccia pipe located within the Moenkopi Formation. Blocks of sandstone lithologically similar to sandstone in the Shinarump Member of the Chinle Formation fill the top of the pipe, and uranium minerals occur in these sandstone blocks, as well as in a siltstone and mudstone breccia, derived from the Moenkopi (Chenoweth and Blakemore, 1961).

A characteristic feature of the Cameron ores is their complex mineralogy. Uraninite is present in the unoxidized zone and also occurs in and near unoxidized logs in the oxidized zone in association with pyrite and marcasite. Oxidation has produced a complex suite of uranium oxides, sulfates, silicates, phosphates, carbonates, molybdates and rate vanadates (Austin, 1964). The yellowish-gray alteration associated with all deposits at or near the surface has been used as a

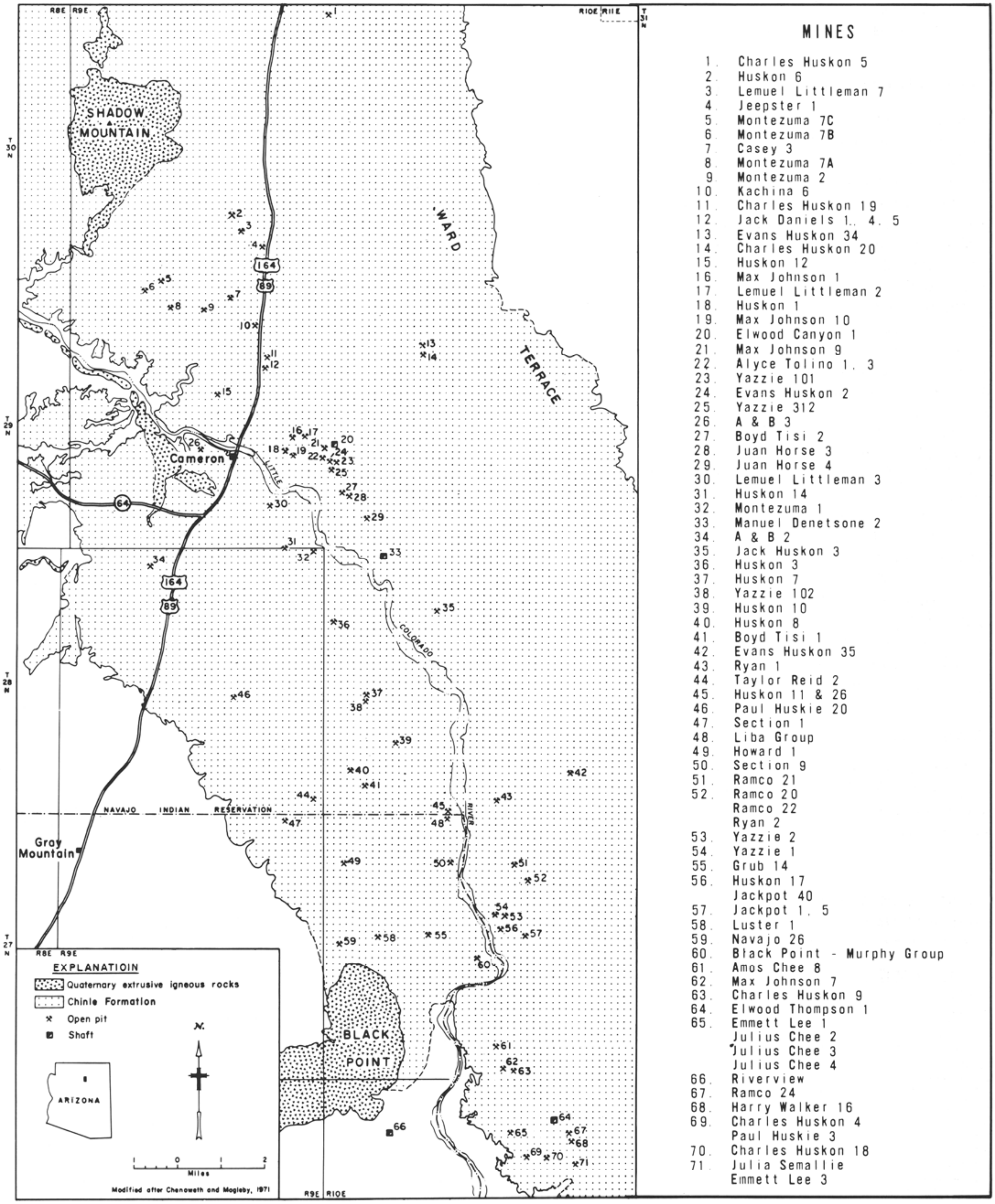

Figure 2.
Mine locations: Cameron area, Coconino County, Arizona.

ing guide. According to Austin (1964) this so-called bleaching is chiefly due to oxidation products of sulfides but some actual bleaching of the clay has occurred.

Winslow-Holbrook-St. Johns Area

Deposits similar to those near Cameron occur in the upper Little Colorado River drainage from near St. Johns, Arizona, to the vicinity of Winslow, Arizona (table 1). The deposits, which are generally smaller than those at Cameron, occur in sandstone lenses in the lower part and in the Sonsela Sandstone Bed of the Petrified Forest Member.

Many of the deposits were located in the early 1950s by prospectors who were exploring exposures of the Chinle which was known to be productive elsewhere. Over two dozen uranium-bearing outcrops were located. During the period 1953 to 1960, 20 properties (table 1) produced 2,690 tons grading 0.15 percent U_3O_8 and containing 8,020 pounds U_3O_8. Mining methods used have included shallow open pits and trenches, rim cuts and short underground adits. The most productive area is east of Holbrook in the SE1/4 T. 18 N., R. 23 E. and NE$^1/_4$, T. 17 N., R. 23 E., where seven properties produced 1,400 tons containing 0.21 percent U_3O_8 and 0.20 percent V_2O_5. Of this total, 86 percent came from the Ruth claims.

The uranium deposits occur in sandstone lenses that are generally less than 200 feet wide and 10 feet thick. Some of these lenses have been traced for a distance of nearly one-half mile. Within the sandstone lenses, uranium is nearly always associated with carbonaceous plant material, often in the form of fossil logs. Uranium minerals identified from the Ruth claims include metatorbernite, metazeunerite, uraninite and coffinite (Gruner and others, 1954), and schroeckingerite, zippeite and autunite (Gregg and Moore, 1955).

Chinle Area

Uranium occurs in the Shinarump Member at the Zhealy Tso property, 6 miles northeast of Chinle, Arizona, adjacent to Canyon de Chelly National Monument. At four locations in the NW$^1/_4$. 5 N., R. 9 W., secondary yellow uranium minerals have been observed in association with copper carbonates and carbonaceous plant debris in sandstone lenses in the upper part of the Shinarump. Exploration drilling during the middle 1950s, however, failed to locate any commercial ore.

Table 1.
Mine locations: Winslow-Holbrook-St. Johns area, Navajo and Apache counties, Arizona.

PROPERTY NAME	LOCATION			
	SECTION		T.(N)	R.(E)
Winslow 7	S 1/2, NE, NW	32	20	17
Navajo	S 1/2, SW, NW	26	20	23
J. City 1	S 1/2, NW, SW	33	19	19
Sain	NE, NW, SW	24	19	20
Rock Garden 25	E 1/2, SE, SW	22	19	23
Hansen 1	E 1/2, SW	1	18	19
Kay Group	N 1/2, SE, NW	28	18	23
NMA Lease (Sec. 33)	SW, SE, SE	33	18	23
Juanita 3	S 1/2, NW, SE	14	18	25
Ruth 1	SW, NW, NW	2	17	23
Ruth 4	NW, NW, NW	2	17	23
Mac 3	NW, SW, SW	4	17	23
Sunrise	NE, SW, NW	4	17	23
Little John 2	SE, NW, NE	12	17	23
Rainbow Smith 1 & 2	NE, SE	36	16	22
Sharon Lynn	SW, SW	34	16	23
Chester 25	SW, SW, SW	26	15	25
[illegible] 2	SW, SW	34	15	26
[illegible]	SW, NE, SW	[illegible]	13	29
G & C 1	S 1/2, NW, NE	[illegible]	12	29

DEPOSITS IN THE MORRISON FORMATION

Exposures of the Morrison Formation in northeastern Arizona occur on the north and east sides of Black Mesa, on the periphery and within the Carrizo Mountains and in the Lukachukai Mountains. The formation is composed of four members. In ascending order, they are the Salt Wash, Recapture, Westwater Canyon and Brushy Basin. Major uranium deposits are restricted to the Salt Wash Member.

Salt Wash Member—The Salt Wash consists of sandstone with lesser amounts of claystone and siltstone, which form resistant ledges, steep cliffs and cap broad benches and mesas. The sandstones are fine- to very fine-grained, well sorted, with rounded to subrounded grains of predominantly quartz with some chert and feldspar. Colors of the sandstone vary from pale gray to greenish gray to light pink. These lenses are generally gently cross-stratified and obscurely interfinger with flat, even-bedded flaggy layers, some of which are ripple-marked. A few steeply cross-stratified, laminated or platy, medium-grained beds occur locally. Lenses of sandstone are generally between 10 and 40 feet thick. The sandstone is generally friable with interstitial clay. Locally the sandstone is very competent because of secondary calcite cement. Calcareous layers are common in or near ore deposits but are not confined to them.

The siltstone and claystone separating the sandstone lenses constitute between 5 to 50 percent of the member and are distributed throughout the member. They occur as, (1) galls dispersed through the sandstone, (2) thin partings and contorted bands up to 3 inches thick, and (3) beds up to several feet thick. The claystone and siltstone vary in color from gray to greenish gray to reddish brown. There are no continuous siltstone and claystone layers as they pinch, swell, split and coalesce along bedding.

Thin beds of hard, blocky limestone occur within the Salt Wash Member and probably represent a lacustrine environment. Fossil logs and carbonaceous plant debris are common throughout the member. Fragmental particles and flakes of carbon form seams along the bedding and finer particles are disseminated throughout the sandstone.

The Salt Wash Member ranges in thickness from zero to approximately 220 feet. In the uranium areas it is usually at least 180 feet thick. North of the Carrizo Mountains the Salt Wash Member is absent. To the south, it cannot be recognized south of Sanostee, New Mexico, and on the east side of Black Mesa it is absent north of Rough Rock. According to Craig and others (1955), the Salt Wash was deposited by an aggrading, braided system on a massive alluvial fan system, the apex of which was near where the Colorado River now enters Arizona. Easterly and southeasterly sedimentary trends in the Carrizo and Lukachukai mountains substantiate this concept. However, since the Salt Wash is absent by non-deposition both to the north and south, it appears that the member of northeastern Arizona represents a separate lobe of the main fan which is farther to the north. This lobe of Salt Wash contains significant uranium deposits in the Carrizo and Lukachukai mountains.

Lukachukai Mountains

The Lukachukai Mountains are the northwest spur of the Chuska Mountains and are on the northern tip of the Defiance uplift. Lukachukai Pass on the road between Red Rock and Lukachukai, Arizona, forms a separation from the main Chuska range. A flat-topped ridge with an elevation of approximately 8,800 feet forms the main mountain mass. Finger-like mesas and deep, steep-walled canyons form rugged topography on the perimeter of the mountains. Except where they join the Chuskas, the Lukachukais terminate as precipitous cliffs.

The finger-like mesas were named and numbered as such by AEC personnel in late 1950. The prominent mesas on the north side of the mountains are numbered I through VII toward their northwest terminus at Mexican Cry Mesa. The southside mesas bear such descriptive names as Two Prong, Camp, Cisco, Three Point, Knife Edge, Bare Rock, Flag, Step, Fall Down, Navajo Chair and Thirsty. In general, the mines are named for the mesas on which they occur and hence such minor divisions as Mesas $1^{1}/_{2}$, $1^{3}/_{4}$, $11^{1}/_{2}$ and $1V^{1}/_{2}$ do occur on the north side (fig. 3). Access to the mines is by a system of unimproved roads leading from Cove, Arizona.

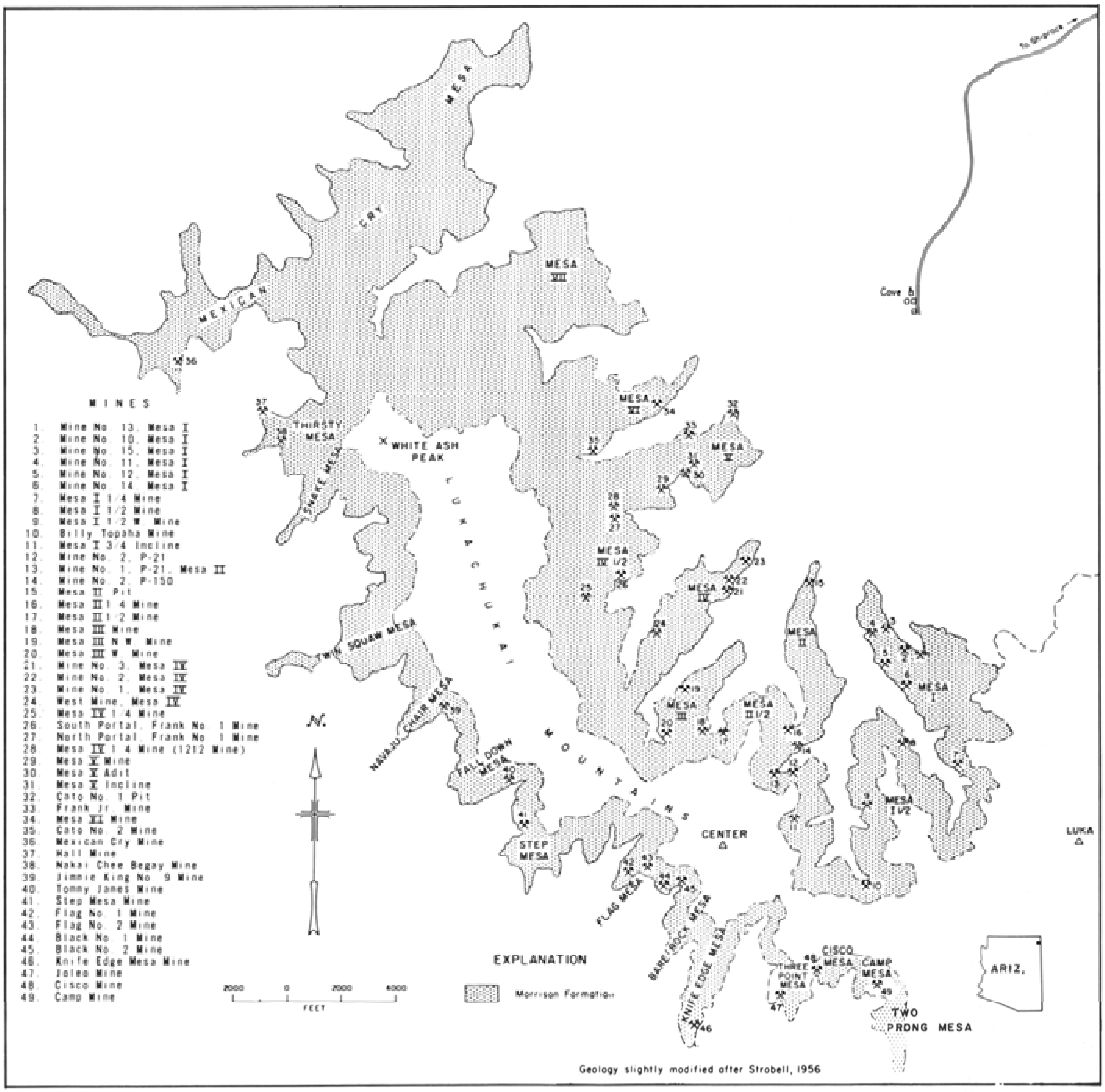

Figure 3.
Mine locations: Lukachukai Mountains, Apache County, Arizona.

Uranium-bearing outcrops in the vicinity of Mesa I were brought to the attention of prospectors from Colorado by local Navajos in 1949. An access road was built up Mesa I and production began in early 1950. In September, 1950, the AEC began the first drilling project which was followed by five others that continued intermittently to August, 1955. During this time, mine operators expanded exploration and development activities, and production increased steadily. Production reached its peak in 1960 and began to decline slowly until the last shipment was recorded in May, 1968. During these 19 years, some 50 separate mines produced 724,800 tons of ore grading 0.24 percent U_30_8 and 1.02 percent V_20_5 and containing 3,483,300 pounds U_30_8 and 14,730,100 pounds V205. Although some shallow or exposed ore bodies in the mountains have been successfully mined by stripping and open-pit methods, most ore bodies are mined underground by the room and pillar method, or modifications of it.

The ore bodies have been described by Nestler and Chenoweth (1958) and Chenoweth (1967). Paleodrainage patterns of the Salt Wash Member streams have been described by Stokes (1954). Dare (1959 and 1961) reported on two operations and gives an excellent review of the problems and costs.

The mountains are capped by the Chuska Sandstone of early Tertiary age which unconformably overlies a wedge of the Morrison Formation. The Salt Wash Member crops out continuously around the mountains. East of Mesa I and south of Two Prong Mesa, it has been removed by pre-Chuska erosion. In all, only 12.5 square miles of the mountains are underlain by this member of the Morrison.

Ore bodies occur some 30 to 80 feet above the base of the Salt Wash which is roughly the middle half of the member. All of the significant deposits are located in a well-defined belt which trends nearly north-south across the southeast end of the mountains (Chenoweth, 1969). This belt accounts for 99.6 percent of the total production and includes an area of 6.5 square miles. The ore bodies are elongate and horizontally lenticular in shape and consist of one or more ore pods surrounded or separated protore. The composite length of ore bodies consisting of two or more ore pods separated by protore ranges up to 1,100 feet; individual ore pods range up to 350 feet in length. The length is usually at least three times the width and is parallel to paleostream depositional trends measured in and near the ore bodies. Thicknesses of the ore bodies range from 1 to 22 feet. Claystone and/or siltstone beds nearly always underlie and frequently overlie the host sandstone units.

Ore occurs most commonly in trough-type, cross-stratified sandstone which fills scours and channels in the underlying claystone. Lithofacies maps and mine mapping by Nestler and Chenoweth (1958) show that ore bodies are restricted to areas of rapid lateral color change which in general are also areas of rapid change in the ratio of mudstone to sandstone. It is common for the elongation of ore pods to deviate from the paleostream depositional trend and parallel the prominent joint set. This feature suggests some redistribution of the ore.

One of the most striking ore trends in the mountains is the trend from the Mesa III mine through the Mesa I PA mine to the north ore bodies of the Mesa II (P-21) mine. Striking N. 25° W. and extending for 4,200 feet with a width of 200 to 400 feet, this trend was the source of approximately 180,000 tons averaging 0.24 percent U_3O_8 and 1.08 percent V_2O_5. The ore bodies occurred in a 25 to 30-foot thick sandstone lense, the base of which is appoximately 50 feet above the Salt Wash-Bluff contact.

Tyuyamunite, the calcium uranium vanandate, is the most common ore mineral. It occurs irregularly disseminated, concentrated in lenses, or distributed in bands. It may fill the sand interstices, or only coat sand grains, or it may replace calcite and carbon. Other vanadium minerals include corvusite, pascoite, hewettite, metarossite, vanadium clays and possibly montroseite (S. R. Austin, personal communication, 1967). In addition, Gruner and others (1954) identified the vanadium minerals melanovanadite and hummerite. Laverty and Gross (1956) identified uraninite as replacing carbonaceous material and as a cement in some ore bodies that are not completely oxidized. Calcite is the usual cementing agent in the ore bodies. Pyrite and iron oxides are present.

Carrizo Mountains

The Carrizo Mountains are in extreme northeastern Arizona on the northeast margin of the Black Mesa basin. The mountains are an irregularly-shaped intrusive mass composed of a central stock and several sills of light-gray diorite porphyry that have been injected laterally into the surrounding sedimentary rocks. The mountains are about 13 miles in diameter and rise 2,000 to 3,000 feet above the surrounding plain. Pastora Peak, elevation 9,420 feet, is the highest point in the Carrizos. Access to the mining areas is by a network of unimproved dirt roads that crisscross the area surrounding the mountains.

The uranium-bearing vanadium deposits of the Carrizo Mountains were discovered about 1918 by John Wade. By 1920, Wade had 41 claims in the Carrizo Mountains (personal communication, 1955). Because of the lack of demand for domestic vanadium, little mining was done until 1942, when war conditions increased the demand for vanadium ores. In December 1941, the Vanadium Corporation of America leased 17 plots in the northwest Carrizo and Eurida Mesa areas, and in July, 1942, they also leased 12 plots in the east Carrizo area. Early in 1942, Wade, Curran, and Company leased 14 plots in the east, northwest, west and south Carrizos. Mining by these two companies was from surface exposures on the east, northwest and west sides of the mountains. According to Stokes (1951), during the period May, 1942, through February, 1944, the Carrizos yielded approximately 22,000 tons averaging 2.25 percent V205.

Mining activity resumed in 1948 with the emphasis on uranium and continued until June, 1968, when the last shipment was recorded. During this period 120,600 tons grading 0.22 percent U_3O_8 and 1.93 percent V_2O_5 and containing 525,800 pounds U_3O_8 and 4,659,200 pounds V_2O_5 were produced from over 100 properties (fig. 4). Mining methods used include adits from mesa rims, inclined shafts and a few vertical shafts. Surface exposures were exploited using rim cuts, trenches and small open pits. In the larger underground mines, room and pillar methods or modifications of it were used.

The ore deposits of the Carrizo Mountains were first studied by geologists of the Union Mines Development Corporation who evaluated the uranium resources of the area for the Manhattan Engineer District. The results of their appraisal are summarized by Webber (1943), Coleman (1944), Eakland (1946) and Harshbarger (1946). Stokes (1954) studied the relation of sedimentary trends and structure to uranium deposits in three areas of the Carrizos. As the result of AEC

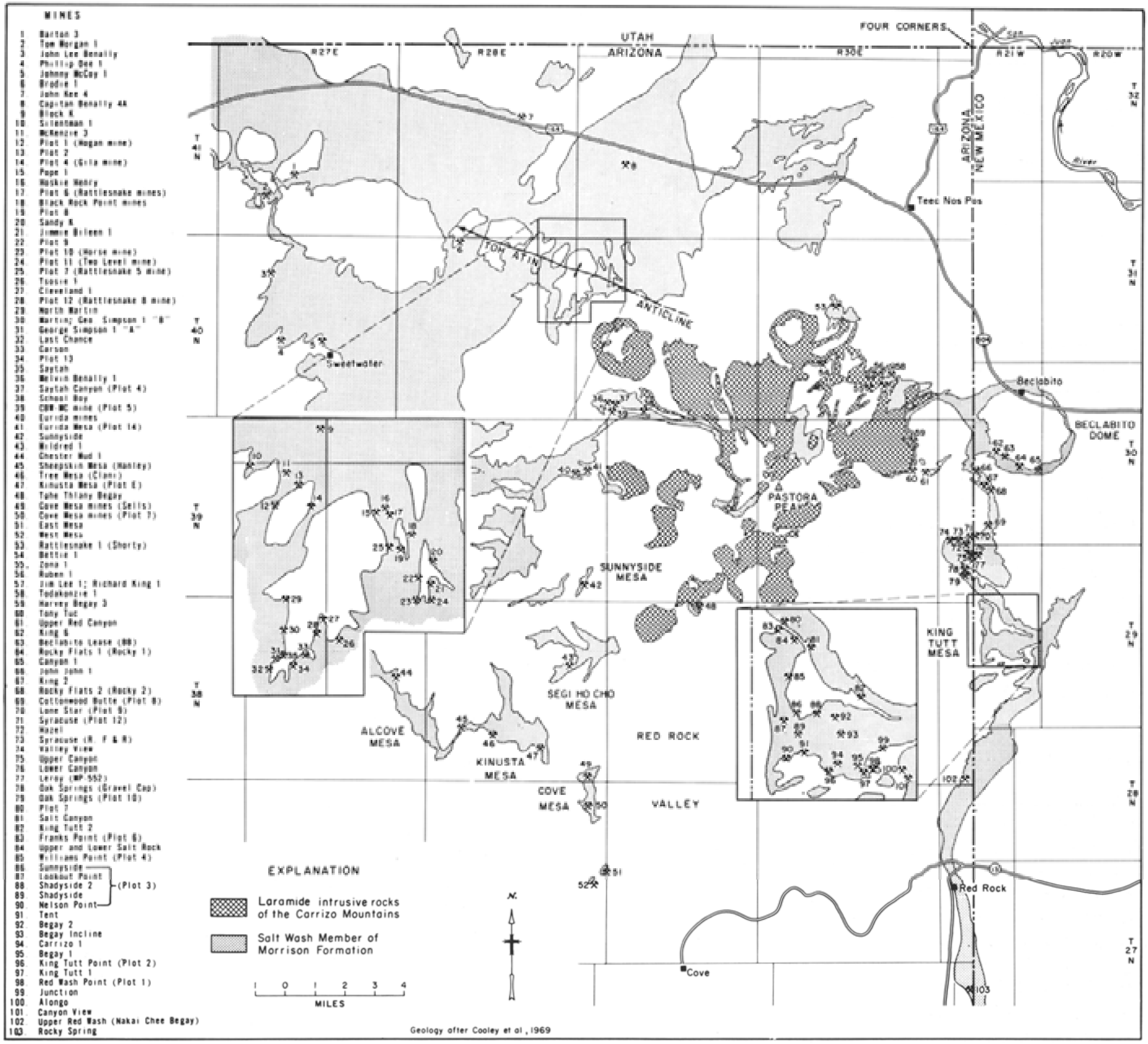

Figure 4.
Mine locations: Carrizo Mountains, Apache County, Arizona, and San Juan County, New Mexico.

investigation, the deposits in more productive areas have been described by Chenoweth (1955), Masters and others (1955) and Blagbrough and others (1959).

The uranium deposits generally occur in clusters. Because of the clustering of deposits on the northwest, north and east flanks of the mountains, these areas have been designated localities. There are also the west and south localities which do not contain the clusters present in the other localities. Isolated deposits are known in all of the localities. Important features of the five localities are given in Table 2.

The Carrizo ore bodies are similar to those in the Lukachukai Mountains except that they are smaller and contain more vanadium. The vanadium to uranium ratio of the Lukachukai ores is 4:1 whereas the ratio for the Carrizo ores is 9:1.

Ore bodies and clusters of ore bodies are elongated and parallel to paleostream channels and redistribution of ore along fractures is not as noticeable in the Carrizos as in the Lukachukais. Also, ore roles are common in the Carrizo deposits.

Tyuyamunite and metatyamunite are the only uranium minerals identified in the Carrizo deposits, Gruner and others (1954), Corey (1956, 1958), and S. R. Austin (written communication, 1967). Vanadium clay and montroseite are present. These minerals have been oxidized to form a large number of secondary vanadium minerals which include sherwood i te, duttonite(?), hewettite, metahewettite, rossite, metarossite and hendersonite. All of these minerals were identified by Corey (1958) in her studies of the Nelson Point mine. The vanadium minerals pascoite, volborthite and montrosite

Table 2.
Significant features of deposits in the Carrizo Mountains.

LOCALITY	NO. OF PROPERTIES	MAP NOS. (FIG. 4)	TOTAL PRODUCTION TONS	%U_3O_8	%V_2O_5	LOCATION OF ORE ZONES (FT. ABOVE Jb-Jms)	MOST PRODUCTIVE AREA NAME	AREA	TONS	%U_3O_8	%V_2O_5
East	45	59-103	47,100	0.23	2.42	30-80	King Tutt Mesa	1.4 sq. miles	27,200	0.24	2.48 1/
North	7	53-58	3,700	0.17	2.30	30-40	--				
Northwest	36	1-36	27,400	0.21	1.54	1-40	Plot 6	52 acres	11,000	0.20	1.52 2/
West	11	37-47	2,200	0.13	2.03	40-95	--				
South	5	48-52	40,200	0.22	1.58	20-100	Cove Mesa	0.76 sq. miles	38,800	0.22	1.61

1/ Does not include production during 1940s from Plot 3

2/ Does not include 2,500 tons at 0.15% U_3O_8 and 1.86 % V_2O_5 produced in 1942-44 (Harshbarger, 1946)

also have been identified by Corey (1956) from the Martin mine. Calcite is a common cementing agent in ore. Pyrite, iron oxides and gypsum may also be present.

Field relationships of the Zona 1 and adjacent mines indicate the intrusion of the sills faulted and fractured the existing ore deposits in the Salt Wash Member. Paragenetic studies by E. B. Gross (written communication, 1954) indicate that silicification of the Salt Wash Member took place after deposition of the uranium and vanadium minerals. Both field and laboratory evidence indicate that the intrusion of the Carrizo laccolith took place after the deposition of the uranium-vanadium deposits.

Chilchinbito Area

Uranium occurs in the Salt Wash Member at the northeast foot of Black Mesa between Chilchinbito and Rough Rock, Arizona, where Navajo prospectors discovered uranium-bearing outcrops in late 1950. During the 1951 to 1958 period, several small shipments were made from two properties (fig. 5). Total production is 123 tons containing 0.74 percent U_3O_8 and 0.03 percent V_2O_5. The grade of individual shipments has ranged from 0.18 to 1.79 percent U_30_8.

The Salt Wash in the Chilchinbito area consists of approximately 130 feet of interbedded fine- to very fine-grained grayish-brown sandstone and gray, green and reddish-brown siltstone and mudstone. Secondary uranium minerals are associated with carbonaceous fossil logs and other plant debris in sandstone lenses 10 to 40 feet above the base of the Salt Wash Member. Fossil logs, observed during mining operations, have been at least 14 inches in diameter and over 10 feet in length. Calcite crystals associated with the logs were responsible for ore shipments averaging 31 percent $CaCO_3$. Mining has been entirely by shallow rim cuts.

DEPOSITS IN THE TOREVA FORMATION

Rocks of the Mesaverde Group of Upper Cretaceous age occur in the central portion of the Black Mesa basin. Repenning and Page (1956) subdivided these rocks into three formations; in ascending order they are: Toreva Formation, Wepo Formation and Yale Point Sandstone. They represent a complex intertonguing of marine and non-marine beds.

Uranium deposits are known in the Toreva Formation in the northeastern corner of Black Mesa in the Lohali Point-Yale Point area. The Toreva Formation in the Yale Point area is composed of the main ledge which is separated from an upper cliff-forming sandstone by a marine tongue of the Mancos Shale. South of Yale Point, the tongue of Mancos Shale pinches out and a non-marine tongue of the Wepo Formation, at a slightly higher stratigraphic horizon, separate the main ledge of the Toreva from the upper cliff-forming sandstone. All of the uranium deposits occur in the main ledge of the Toreva, a name used by O'Sullivan and others (1972) to distinguish this unit from the lower sandstome member of the Toreva found elsewhere. The main ledge consists of 140 to 170 feet of fine- to medium-grained sandstone with lenses of coarse- to very coarse-arkosic sandstone in the upper part. Small amounts of coal, carbonaceous shale and siltstone occur in the beds in the upper part of the main ledge.

Uranium-bearing outcrops in the vicinity of Burnt Corn Wash was brought to the attention of the AEC in January, 1954. Following this discovery, an AEC ground and airborne reconnaissance of the area was made and some 25 radioactive anomalies were located in Lohali Point-Yale Point area. Also three anomalies were indicated along Oraibi Wash, north of Pinon, Arizona (Clinton, 1956). Although several of the anomalies were caused by radioactive heavy mineral accumulations, many of the anomalies were developed into prospects and mines. During the 1954 to 1968 period, 16,800 tons grading 0.17 percent U_3O_8 and containing 55,700 pounds U_3O_8 were produced from 13 properties. Ore was mined by shallow open pits, rim cuts and in two places by underground methods. With the exception of two properties near Yale Point, all of the production came from properties located on both sides of the upper drainage of Burnt Corn Wash (fig. 5).

The uranium deposits occur in a quartzose zone in the upper part of the main ledge of the Toreva. Lenses of carbonaceous shale and siltstone are common in the ore-bearing zone. Some uranium occurs in the carbonaceous material but the majority of it occurs disseminated in the sandstone. In general, the ore occurs immediately below carbonaceous beds. The deposits consist of pods of ore grade material surrounded by protore. Clusters of these pods may occur to form an ore deposit within an area of 400 feet by 100 feet, having an average thickness of less than 2 feet.

Uranium minerals include tyuyamunite and metatyuyamunite, and vanadium minerals include vanadium clay, metahewettite and melanovanadite (E. B. Gross, written communication,

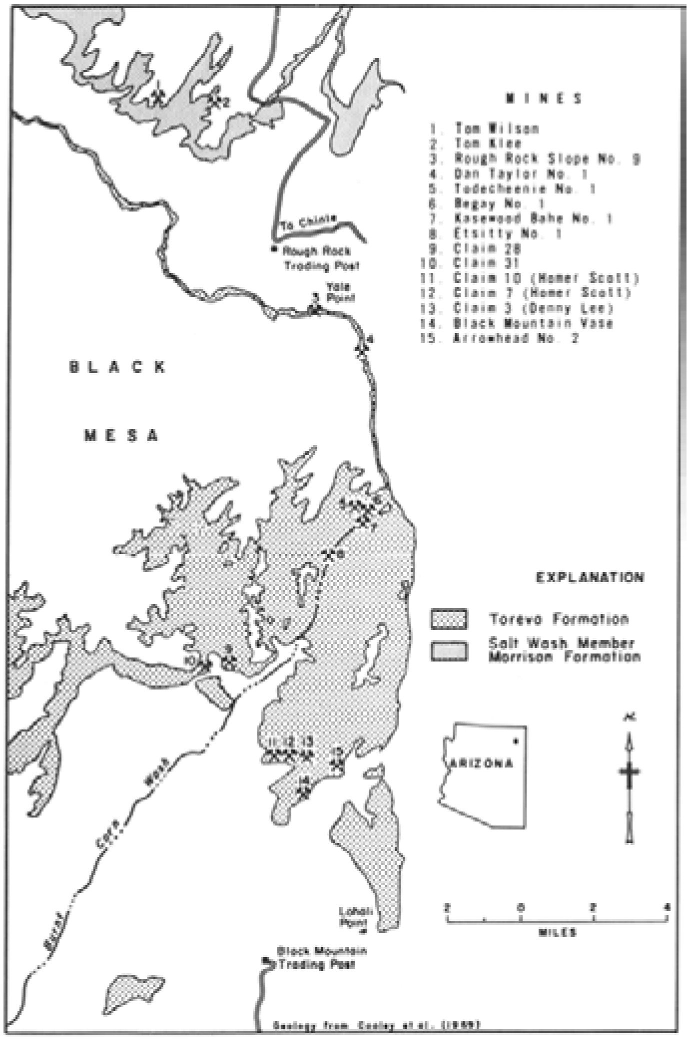

Figure 5.
Mine locations: Chilchinbito and Black Mesa areas, Apache County, Arizona.

1956). Production records on the initial 4,750 tons of ore shipped indicated an average vanadium content of 0.27 percent $V2O_5$ and an average uranium content of 0.24 percent U308.

DEPOSITS IN THE BIDAHOCHI FORMATION

The Bidahochi Formation of Pliocene age is present in the southeastern part of Black Mesa basin and unconformably overlies older rocks. The Bidahochi consists of fluvial and lacustrine sedimentary rocks and basaltic volcanic rocks. Repenning and Irwin (1954) have subdivided the formation into three members: a predominantly lacustrine lower member, a medial volcanic member and an upper, chiefly fluvial, member. Associated with the volcanic member are approximately 150 diatremes of the Hopi Buttes volcanic field which have been described in detail by Hack (1942). Uranium in the Hopi Buttes is associated with these diatremes.

Uranium was first discovered in the Hopi Buttes in 1952 by E. M. Shoemaker of the USGS. Airborne radiometric reconnaissance by the AEC and private interests showed that the occurrence of radioactivity in the diatremes was widespread. Detailed geologic studies by the USGS have been summarized by Shoemaker and others (1962). Minor AEC investigations have been reported on by Fair (1955) and Lowell (1956).

Uranium occurrences are restricted to diatremes containing bedded carbonate rocks. The uranium content of the carbonate rocks is low, generally 0.001 to 0.02 percent U308. Uranium of higher grade, occurs in non-volcanic elastic rocks, tuffs, and sedimentary rocks derived from the wall of the vents within the diatremes.

Although 35 diatremes contain significant uranium, from only one, Seth-la-kai, located five miles northeast of Indian Wells, Arizona, has ore grade material been produced. The Morale property at this diatreme produced 192 tons grading 0.15 percent U_30_8 during 1954 to 1959. Unidentified uranium minerals occur in a 6- to 8-inch thick, coarse-grained, non-volcanic sandstone and in adjacent calcareous tuff beds within the diatreme. The high phosphate content of the Morale ore, 0.75 to 1.00 percent P_2O_8, made it unacceptable to processing in an alkaline leach circuit. The ore was mined from a rim cut and a short adit on the southeast rim of the diatreme.

Schroeckingerite has been identified by Shoemaker and others (1962) at the Hoskie Tso claim at a diatreme 2 miles southeast of Indian Wells, and carnotite has been identified by Gruner and Smith (1955) at the Horseshoe diatreme, 9 miles north of Indian Wel ls.

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GEOLOGY AND PRODUCTION HISTORY OF THE URANIUM ORE DEPOSITS IN THE CAMERON AREA, COCONINO COUNTY, ARIZONA

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Geology and Production History of the Uranium Ore Deposits in the Cameron Area, Coconino County, Arizona

ABSTRACT

Uranium ore deposits in the Cameron area have been mined from sandstone lenses in the Shinarump and Petrified Forest Members of the Upper Triassic Chinle Formation and in the Lower Jurassic Kayenta Formation. Uranium was also produced from a breccia pipe in the Lower Triassic Moenkopi Formation. Most of the ore was mined from carbonaceous sandstones in the lower part of the Petrified Forest Member. The deposits were oxidized and mineralogically complex.

Uranium was first reported in the Cameron area in 1950 in the Kayenta Formation on Ward Terrace. As a result of this discovery, the U.S. Atomic Energy Commission (AEC) employed Navajos to prospect the entire area. The first discovery of commercial importance was made in June 1952 by Charles (Charlie) Huskon, an AEC prospector, in the Petrified Forest Member of the Chinle Formation. Surface prospecting supplemented by airborne radiometric surveying led to the discovery of additional orebodies in 1953, including a few in the Shinarump Member. As the area was developed, many deposits having no surface expression were located by shallow exploration drilling.

Production in the Cameron area began in August 1951 from the Kayenta Formation on the Hosteen Nez property. Production reached a peak in 1956 and gradually declined until the latest shipment, which was recorded in January 1963. During that period, a total of 289,247.96 tons of ore, averaging 0.21 percent U_3O_8 and containing 1,211,812.48 pounds of U_3O_8, was produced from 100 separate properties. The ore was mined in open pits, which ranged in size from a small shallow trench containing a single mineralized fossil log to a large pit complex 2,400 feet long and 250 feet wide. Underground mining of the pit walls was commonly practiced to recover additional ore. Four vertical shafts were also mined in the area.

INTRODUCTION

The Cameron uranium-mining area is centered around the settlement of Cameron, Arizona, which is 52 miles north of Flagstaff (Figure 1). This area contains numerous uranium ore deposits in the Upper Triassic Chinle Formation. Cameron is the fourth largest area on the Colorado Plateau that produced uranium from this geologic unit. The largest area is the Lisbon Valley in Utah, followed by the greater White Canyon and San Rafael Swell areas in Utah (Chenoweth and McLemore, 1989). Two other geologic units in the Cameron area also produced ore: the Lower Jurassic Kayenta Formation and a breccia pipe in the Lower Triassic Moenkopi Formation (Table 1).

This report is the result of the author's field work in the Cameron area during the late 1950's and early 1960's for the AEC. The Navajo Tribal Mining Department in Window Rock, Arizona, provided information on the Navajo Tribal Mining Permits (MP's) to the AEC Flagstaff Field Office.

LOCATION

The main mining area forms a curved belt that is approximately 2 miles wide in a 6-mile stretch north of Cameron along U.S. Highway 89 and 5 miles wide in an 18-mile stretch southeast of Cameron along the Little Colorado River (Plate 1). A few small properties, however, are as far north as Bitter Springs, as far south as the Grand Falls of the Little Colorado River, and as far east as Ward Terrace (Figure 1).

Unimproved dirt roads that leave U.S. Highway 89 provided access to the mines. The principal access road follows the east bank of the Little Colorado River south from Cameron. Another access road, which is graded, leaves U.S. Highway 89 6 miles south of Cameron and heads southeast to a large sand and gravel pit, which lies northeast of Black Point (Plate 1).

LAND STATUS

All but nine properties[1] in the Cameron area are on the Navajo Indian Reservation (Plate 1). Within the reservation, mining permits were issued by the Navajo Tribal Council and approved by the Bureau of Indian Affairs (BIA), U.S. Department of the Interior. Permits could be obtained by individual Navajos only. Permit holders, however, could assign the mining rights to another individual or a company; like the permits, these assignments had to be approved by the Tribal Council and the BIA. Mining permits were issued for 2-year terms but could be renewed for an additional 2-year period. The tribe also issued drilling and exploration permits. These permits were good for 120 days and were not renewable.

The BIA encouraged operators to convert their mining assignments to 10-year leases once large amounts of ore had been developed. Many of Charlie Huskon's properties and all of the Ramco properties were converted to leases in the mid-1950's. Leases could be issued directly by the BIA. No more than 960 acres of tribal land could be held by any one company or individual. For companies with a mill on the reservation, the 960-acre limitation was waived.

Both the permittee and the tribe received royalties from ore production. Based on the mine value of the ore, the tribe received between 10-percent and 20-percent royalties and the permittee between 2-percent and 5-percent royalties.

In the Cameron area, the name of a mine on the Navajo Indian Reservation was usually the name of the individual who held the mining permit. Exceptions to this practice are listed in Table 2.

South of the reservation and west of the Little Colorado River, every odd-numbered section was owned by the C O Bar Livestock Company of Flagstaff. With the exception of sections 2, 16, 32, and 36, which are State-owned land, the remaining even-numbered sections are federally owned. Many of the even-numbered sections adjacent to the Little Colorado River were subject to a Federal powersite withdrawal and were closed to claim staking. These lands were restored to the public domain and thus opened to claim staking in April 1957.

PREVIOUS STUDIES

The uranium deposits in the Cameron area were described by Bollin and Kerr (1958), the AEC (1959a), and Chenoweth (in Akers and others, 1962). Hinkley (1957) described the Charles Huskon No. 1 deposits, and Gray (1957) described the deposits on the Liba claims. Chenoweth (1988) described the Riverview breccia pipe, and Scarborough (1981) tabulated information on individual properties. Chenoweth and Magleby (1971) prepared a map showing the location and relative sizes of the deposits, and Austin (1964) described the mineralogy of the deposits.

The geology of the main mining area was mapped by Akers and others (1962) and Billingsley (1987). Plate 1 is Chenoweth and Magleby's (1971) map, which Scarborough (1981, Plate 20) modified to show unmined uranium deposits in the main mining area.

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[1] As used in this report, a "property" is an individual mining permit, lease, or group of claims. A mining permit might contain several orebodies and separate open pits, as did Ramco No. 20 (MP-349; Figure 2).

GEOLOGIC SETTING OF THE ORE DEPOSITS

The Cameron area is on the southwest flank of the Black Mesa Basin, where erosion of the Little Colorado River valley has exposed the Chinle Formation in a broad belt approximately parallel to the river. In this area, the Chinle is composed of three members, in ascending order: Shinarump, Petrified Forest, and Owl Rock. The Shinarump Member forms cliffs along the Little Colorado River, and resistant beds of the Owl Rock Member cap Ward Terrace (Plate 1). Between the river and Ward Terrace, the Petrified Forest Member is exposed in an expanse of badlands.

The principal host rocks for the uranium deposits in the Cameron area are fluvial sandstones in the lower part of the Petrified Forest Member. Other deposits have been mined from the upper part of the underlying Shinarump Member. Two deposits in the Kayenta Formation on Ward Terrace have been mined, as was a breccia-pipe deposit in the Moenkopi Formation.

Deposits in the Chinle Formation

The Petrified Forest Member of the Chinle Formation contained most of the uranium deposits in the Cameron area. The member is composed of multicolored claystone and siltstone with some light-gray, fine- to coarse-grained sandstone, especially in the lower part of the member. The Petrified Forest Member erodes into badlands and has brilliant variegated colors typical of the Painted Desert. In the Cameron area, the member is up to 900 feet thick.

Orebodies were present at the surface down to a depth of 130 feet. As many as three ore zones were within 100 feet of section. Orebodies ranged in size from a single mineralized fossil log to the Jack Daniels orebody (Plate 1, No. 24), the largest known in the area. This latter deposit was a nearly continuous body, 450 feet by 300 feet, and contained 178,059 pounds of U_3O_8. By comparison, the second largest deposit was the Charles Huskon No. 4 - Paul Huskie No. 3 (Plate 1, Nos. 97 and 98): 135,616 pounds of U_3O_8 was produced from a cluster of ore pods within an area 1,000 feet by 550 feet. The most productive area lies east of Cameron, where 10 properties within 1 square mile were the source of 264,100 pounds, or 22 percent of the total production from the Cameron area.

The ore consisted of elongated, lenticular deposits within poorly consolidated, cross-stratified, fine- to medium-grained sandstone, clay-pellet sandstone, and clay-pellet conglomerate that contain varying amounts of carbonaceous matter, including carbonaceous fossil logs. The sandstone lenses were deposited in irregular depressions cut into bentonitic claystones and mudstones and are probably ancient fluvial channel fills. The sandstone lenses are up to 6 feet thick and are not continuous, although individual lenses have been traced for more than 1 mile. Secondary uranium minerals fill pore spaces in the sandstone, and uraniferous fossil logs are locally present. The ore was concentrated in abrupt depressions along channels or at changes in channel direction and favored the more carbonaceous layers. The highest grade ore was associated with fossil logs. Most orebodies were elongated parallel to the channel trends, but some were oriented nearly perpendicular to these trends. Each orebody was encased in an alteration halo consisting of bleached sandstone and mudstone. The most visible bleaching effect was a change from gray to locally red to yellowish or buff. Orebodies and haloes abruptly terminated downward against impervious mudstone.

With the exception of the Evans Huskon No. 34 and Charles Huskon No. 20 mines (Plate 1, Nos. 21 and 22), all of the deposits in the Petrified Forest Member were within the lower 150 feet of the member. The other two deposits were associated with uraniferous fossil logs in the upper part of the member.

Seventy properties in the Petrified Forest Member yielded 278,616.46 tons of ore that averaged 0.21 percent U_3O_8 and contained 1,186,889.66 pounds of U_3O_8 (Table 1). This amounts to 98 percent of the total uranium produced in the area.

The Shinarump Member of the Chinle Formation rests unconformably on the Middle Triassic Moenkopi Formation. In the Cameron area, the Shinarump Member is composed of yellowish-gray to pale-red, medium- to coarse-grained, crossbedded, fluvial sandstone and conglomerate with some interbedded, greenish-gray and pale-red mudstone lenses. In the upper part of the member, the sandstones are thin bedded and are mottled pale red to light gray. The Shinarump Member is up to 100 feet thick in the Cameron area. Billingsley (1987) included in the Petrified Forest Member some of the beds that Akers and others (1962) and Haines and Bowles (1976) previously mapped as Shinarump Member. The Shinarump - Petrified Forest contact shown on Plate 1 was based on the earlier mapping.

Twenty-seven properties in the Cameron area were within the Shinarump Member. The host rocks for these deposits were carbonaceous, thin-bedded, cross-stratified, medium- to fine-grained sandstones in the upper 30 feet of the member. Uranium-bearing fossil logs were common in the orebodies. Deposits in the Shinarump Member were similar to those in the Petrified Forest Member, but were smaller.

The largest deposit in the Shinarump Member was the Charles Huskon No. 26 - Charles Huskon No. 11 (Plate 1, Nos. 65 and 66), from which 6,561.41 pounds of U_3O_8 was produced. Total production from the Shinarump Member was 9,941.05 tons of ore, which averaged 0.10 percent U_3O_8 and contained 20,535.00 pounds of U_3O_8.

A characteristic feature of the Chinle uranium ores at Cameron was their complex mineralogy. Uraninite was present in the unoxidized zone, as well as the oxidized zone in and near unoxidized logs in association with pyrite and marcasite. Oxidation produced a complex suite of uranium oxides, sulfates, silicates, phosphates, carbonates, molybdates, and rare vanadates (Austin, 1964). The ore was also rich in cobalt. A sample that Karen J. Wenrich (U.S. Geological Survey [USGS]) collected from the Charles Huskon No. 1 (Plate 1, No. 29) dump contained pink, platy, and fibrous crusts of moorhouseite ($[Co, Ni, Mn^{+2}]\ SO_4 \cdot 6H_2O$) and a cobalt-pickeringite ($[Co, Mg, Al_2]\ [SO_4]_4 \cdot 22H_2O$). The sample also contained alunogen ($Al_2\ [SO_4]_3 \cdot 17H_2O$; Wenrich and others, 1989). The yellowish-gray alteration associated with all deposits at or near the surface was used as a prospecting guide and was chiefly due to oxidation products of sulfides (Austin (1964), although some bleaching (reduction of the ferric iron) of the mudstones and siltstones also occurred.

Deposits in the Kayenta Formation

The Lower Jurassic Kayenta Formation is exposed at the foot of the Adeii Eechii Cliffs, which form the west escarpment of the Moenkopi Plateau (Figure 1). The formation is composed of pale-red fluvial siltstone, fine-grained silty sandstone, and interbedded purplish-red shale and is about 650 feet thick in the Cameron area. A 150-foot-thick zone at the top of the formation contains tongues of the overlying Navajo Sandstone. The Moenave Formation and Wingate Sandstone, in descending order, underlie the Kayenta Formation and separate it from the Chinle Formation.

Two areas in the Kayenta Formation have been mined: the Yellow Jeep claims, 14 miles east-southeast of Cameron, and the Hosteen Nez claim, 18 miles southeast of Cameron. These deposits were in limy, fine-grained sandstone lenses in the middle part of the formation. A yellow uranium mineral, probably tyuyamunite ($Ca\ [UO_2]_2\ V_2O_8 \cdot 5\text{-}8H_2O$), was disseminated throughout the sandstone in association with fossil logs. Total production from the two areas was 182.04 tons with an average grade of 0.15 percent U_3O_8 (Table 1).

Deposit in a Collapse-Breccia Pipe

The Riverview mine (Plate 1, No. 93) was developed in a collapse-breccia pipe south of Black Point in T. 26 N., R. 10 E., sec. 8. The pipe is collared in the Wupatki Member of the Moenkopi Formation. The deposit was discovered when prospectors noted the presence of large mineralized blocks of sandstone, many standing vertically, which seemed to fill a "sinkhole" in the Wupatki Member 45 feet above the base of the member. These blocks appear to be lithologically similar to sandstone in the upper part of the Shinarump Member of the Chinle Formation. The pipe contact at the surface is irregular in shape and measures 135 feet in its maximum north-south dimension and 95 feet in its east-west dimension. Mining at the surface stripped as much as 25 feet of the upper part of the pipe. A shaft was sunk to a depth of 125 feet within the pipe near its south margin on a strong northwest shear.

The blocks of the upper(?) part of the Shinarump Member, which originally capped the pipe, indicate that the pipe was higher than its present elevation of about 4,505 feet. If one assumes a thickness of 365 feet for the Moenkopi Formation and 80 feet for the Shinarump Member, the blocks have been displaced downward about 360 feet from their initial stratigraphic position.

The core of the pipe is irregular in shape and consists of blocks of arkosic, coarse- to very coarse-grained sandstone and conglomerate of the Shinarump Member and sandstone and siltstone of the Moenkopi Formation. A concentric ring of collapsed greenish-gray and reddish-brown siltstone and mudstone of the Moenkopi Formation encircles the core. At the east margin of the pipe, the mudstone is stained with manganese.

Uranium minerals reported from the Riverview mine include uranophane and sporadic grains of carnotite and metatorbernite, as well as minute grains of uraninite in the lower parts of the mine (Chenoweth, 1988). L.E. Evans (in Chenoweth, 1988) reported that the uranophane, carnotite, and malachite were associated with clay, calcite, and iron oxide that cemented a fine-grained quartz sandstone. Some azurite was present in subgrade ore material on the property. More copper was present in this deposit than in other uranium deposits in the Cameron area.

MINING METHODS

Most of the mining was by open pits, which ranged in size from a shallow trench containing a single fossil log to pits as deep as 130 feet. On the Ramco Nos. 20 and 22 and Ryan No. 2 properties (Plate 1, Nos. 74, 73, and 75), a large pit complex was developed that was 2,400 feet long, an average of 250 feet wide, and an average of 70 feet deep (Figure 2). Operators found it uneconomic to exceed a stripping ratio of 13 feet of waste to 1 foot of ore in the Cameron deposits. A contractor stripped away the overburden with bottom scrapers. In 1959 stripping costs were about $0.30 per cubic yard.

Three mines in the Petrified Forest Member (Plate 1, Nos. 32, 45, and 92) and one in the breccia pipe (Plate 1, No. 93) were serviced by vertical shafts. These deposits were too small to be stripped economically. In several pits, ore outside the pit outline was mined underground by modified room-and-pillar methods from adits in the pit walls (Figure 3). Ore grade was controlled by Geiger-counter testing because the ore could not be readily distinguished by eye. By careful blending, most operators tried to maintain their shipping grade at 0.20 percent U_3O_8. Shipman (1957) described the exploration and mining methods used at Cameron, and the AEC (1956b) described the operations at 40 of the active mines.

PRODUCTION HISTORY

Early Activities, 1950-55

In the summer of 1950, Hosteen Nez, a Navajo, found an outcrop containing yellow-colored material on the Ward Terrace at the foot of the Moenkopi Plateau. He took samples to the Lorenzo Hubbell Trading Post in Winslow, Arizona. Roman Hubbell sent a sample to the AEC, which confirmed that it contained uranium and vanadium.

The remote locality where the material was found was examined by Harry C. Granger of the USGS and John W. King of the AEC in March 1951. Hubbell formed the Hosteen Nez Mining Company and bulldozed a trail from the top of the Moenkopi Plateau down through the Adeii Eechii Cliffs to reach the deposit. The Hosteen Nez Mining Company shipped 1.05 tons of ore to the AEC's ore-buying station at Monticello, Utah, in August 1951. This shipment averaged 0.41 percent U_3O_8, 0.23 percent V_2O_5, and 9.00 percent $CaCO_3$ (Table 3). On January 14, 1952, Philip C. Ellsworth of the AEC examined the prospect and sampled the mineralized exposures (Ellsworth, 1952). He determined the host rock to be a limy siltstone in the Kayenta Formation. The location was determined to be approximately 18 miles southeast of Cameron. The site was later determined to be SW$^1/_4$ sec. 33, T. 27 N., R. 12 E., projected.

On February 11, 1952, an additional 5.35 tons of ore averaging 0.29 percent U_3O_8 and 0.20 percent V_2O_5 was delivered to the Monticello station. On March 24 and 31, 11.52 tons averaging 0.11 percent U_3O_8 and 0.19 percent V_2O_5 was delivered to the AEC's newly opened ore-buying station at Shiprock, New Mexico. Due to the high lime ($CaCO_3$) content of the shipments, no payment was made for the vanadium. (At AEC ore-buying stations, vanadium in carnotite-type ore was purchased for $0.31 per pound, but with some limitations.)

During the early 1950's, the AEC employed Navajos as prospectors. At least 20 men in all parts of the Navajo Indian Reservation were put on the payroll of the Walker-Lybarger Construction Company, the prime contractor to the AEC's Grand Junction office. These prospectors were given Geiger counters and told to look for the "yellow rocks." They were contacted every 2 weeks by AEC field representatives Jack Leonard and Winston Marks. Both of these men had grown up in the Farmington, New Mexico, area and could speak fluent Navajo.

Charlie Huskon was employed to prospect the Cameron area. He was supervised by Leonard, who was known to the Navajos as "Loose Ears" because of the way he could wiggle his ears, to the delight of the Indian children. On June 26, 1952, Charlie Huskon and his son Evans showed AEC geologist Jack Chester and Leonard the uranium-bearing outcrops in the Chinle Formation about 1 mile east of the bridge over the Little Colorado River at Cameron (Chester and Leonard, 1952a). This deposit would later become the Charles Huskon No. 1 mine (Plate 1, No. 29). On that same day, the two Navajos also showed Chester and Leonard another uranium-bearing outcrop in the Chinle Formation 6 miles southeast of Cameron (Chester and Leonard, 1952b). This exposure would later become the Paul Huskie No. 20 mine (Plate 1, No. 52). During this visit to the Cameron area, another Navajo prospector, Chee Paddock, showed Chester and Leonard some uranium-bearing fossil logs in the Chinle Formation, about 17 miles by road southeast of Cameron (Chester and Leonard, 1952c). It is probable that this deposit was later named the Evans Huskon No. 35 mine (Plate 1, No. 60).

Charlie Huskon applied to the Navajo Tribal Mining Department for a mining permit on June 29, 1952, and contacted the Arrowhead Uranium Company of Grand Junction, Colorado, which was exploring for uranium in the Monument Valley area. He quit Walker-Lybarger in July 1952 and began to prospect for Arrowhead. The company also conducted aerial radiometric surveys in the Cameron area using a Piper Cub airplane and a handheld Halross scintillation counter. This ground-air reconnaissance was very successful, and many uranium-bearing outcrops in the Chinle Formation were discovered. Leonard (1952) noted that Charlie Huskon was very successful at finding uranium-bearing outcrops because he recognized the relationship between yellow-colored alteration in the Chinle sediments and uranium minerals.

On August 6, 1952, Charlie Huskon was issued Mining Permit (MP) No. 46 for the Charles Huskon No. 1 deposit. MP-64 covering the No. 2 property was issued to Evans Huskon on September 26, 1952. MP-65 covering the Charles Huskon Nos. 3 through 8 was issued to Charlie on the same day. Charlie and Evans signed operating agreements with Arrowhead on September 29, 1952. Arrowhead commenced mining at the Charles Huskon No. 1 property and delivered 8.21 tons of ore averaging 0.18 percent U_3O_8 and 0.15 percent V_2O_5 to the AEC's ore-buying station at Bluewater, New Mexico, on October 16, 1952.

Between late December 1952 and March 2, 1953, the AEC made a systematic aerial radiometric survey of the Cameron area covering all exposures of the Chinle Formation. A total of 43 radiometric anomalies were detected (Williams and Barrett, 1953).

During 1953, Arrowhead continued to develop ore on the Huskon properties. MP-76 for the Charles Huskon Nos. 9, 10, and 11 properties was issued to Charlie on April 8, 1953, and an operating agreement was signed with Arrowhead on April 24. Shipments to the Bluewater ore-buying station were made from Nos. 1 through 8 and No. 10 (Table 4). The ore was trucked to a railhead at Flagstaff and then shipped by the Atkinson Topeka and Santa Fe Railway to a siding near Bluewater, where the ore was transferred to trucks for the short haul to the buying station. Shipments in 1953 totalled 8,104.54 tons of ore, which averaged 0.26 percent U_3O_8 and 0.08 percent V_2O_5 (Table 3).

Arrowhead's activities created much interest in the Cameron area. Other Navajos who found uranium deposits and applied for mining permits were Paul Huskie (another son of Charlie), Harry Walker, Earl Huskon, Ancil Thomas, and Taylor Reid.

The AEC rim stripped and trenched 15 deposits in the Cameron area between January 19 and February 3, 1954 (Hinkley, 1955). This was done to expose the dimensions of the orebodies for ore-reserve estimates and geologic studies. A total of 45,000 lineal feet of trenching and stripping was done, exposing 1,500 tons of ore (Hinkley, 1955).

During 1954, six operators besides Arrowhead began shipping ore from the Cameron area (Table 4). Arrowhead developed enough ore on its holdings to get a commitment from the AEC for a contract to sell concentrates from a proposed processing mill. After Arrowhead received this commitment, the Navajo Tribe lifted its 960-acre limit on property held by one company or individual. Arrowhead increased its holdings to several thousand acres, including the Charles Huskon Nos. 12 through 17 properties. Production in 1954 from the Cameron area totalled 11,366.50 tons of ore, which averaged 0.23 percent U_3O_8 and 0.08 percent V_2O_5 (Table 3). Of this amount, 8,133.97 tons was produced by Arrowhead from the Charles Huskon Nos. 1 through 4, 9 through 11, and 17 properties.[2]

Arrowhead's increasing activities caused many companies and individuals to prospect in the Cameron area. Dozens of drilling permits were issued. The resulting discoveries meant that mining permits were issued to Navajos, who assigned them to operators. Navajos with important discoveries included William Robbins, Max Johnson, Max Huskon, and Lemuel Littleman. Claims were also staked on Federal land south of the reservation, on the west side of the Little Colorado River. The odd-numbered sections in that area were leased from the C O Bar Livestock Company.

Arrowhead's holdings were acquired by the Rare Metals Corporation of America of Salt Lake City, Utah, in December 1954 (G.E. Morehouse, oral commun., 1991). The BIA approved this transaction in February 1955.

Exploration and development drilling in the Cameron area increased during 1955 as operators were waiting for the AEC to establish an ore-buying station in the area. Foley Brothers drilled in the area between Tohachi and Nahakaad Washes and located the orebodies known as the Yazzie Nos. 1 and 2, covered by Maxwell Yazzie's MP-261 (Plate 1, Nos. 79 and 80). Foley Brothers also made a discovery near the Evans Huskon No. 2 mine, on Maxwell Yazzie's MP-312. This deposit was originally named the Foley No. 5 mine but was later changed to the Yazzie No. 312 mine (Table 5; Plate 1, No. 37). Chesser and Company also made a discovery near Evans Huskon No. 2, which was called Yazzie No. 101 (Plate 1, No. 36) and was covered by George D. Yazzie's MP-302. Chesser made another discovery north of the Charles Huskon No. 10 mine. This discovery was named Yazzie No. 102 (Plate 1, No. 54) and was covered by George D. Yazzie's MP-311.

Early in 1955, Rare Metals dropped the assignment of the Charles Huskon No. 5 property (a portion of MP-63). The assignment was picked up by B C Associates of Phoenix, Arizona, which shipped 162.72 tons averaging 0.17 percent U_3O_8 early in 1956.

MP-360 was issued to Denetso on April 10, 1955, for the Jack Daniels No. 1 ore deposit (Table 2; Plate 1, No. 24). This discovery was named for a bourbon bottle found near the surface anomaly, which led to the discovery of the orebody. The anomaly, which lay in cuttings from a powerline pole at Milepost 469 on U.S. Highway 89 north of Cameron, was discovered by two prospectors who were slowly driving down the highway. The assignment of MP-360 to the Marcy Exploration and Mining Company of Durango, Colorado, was approved on November 15, 1955. Drilling and mining showed that the Jack Daniels No. 1 property contained the largest orebody in the Cameron area (Table 5).

On July 15, 1955, Rare Metals signed a contract with the AEC to produce uranium concentrates (yellowcake) from a mill to be built 5 miles northeast of Tuba City, Arizona (Albrethsen and McGinley, 1982). The site was selected because of the availability of ground water from the Navajo Sandstone. Construction of the mill began in August 1955. Exploration by Rare Metals located significant orebodies near the Yazzie Nos. 1 and 2. These deposits would be named the Ramco Nos. 20, 21, and 22 on MP-349, 350, and 351, which were issued to Calvin Semallie, Dan McClellan, and Elvin Gordy, respectively (Table 2; Plate 1, Nos. 74, 72, and 73).

During the summer of 1955, Rare Metals cancelled its assignments to the Charles Huskon Nos. 4 and 9 mines (portions of MP-65 and 76). These assignments were picked up by Utco Uranium Corporation on August 1955. Utco also acquired the assignments of the Charles Huskon Nos. 18, 19, and 20 properties (MP-388, 461, and 465). Exploration by Utco determined that the orebodies on the Charles Huskon No. 4 permit extended off the permit area. The ground surrounding Charles Huskon No. 4 was claimed by Paul Huskie as MP-377 (Paul Huskie No. 3; Plate 1, No. 98), which was issued on November 16, 1955.

Ryan Oil Company located an east extension of the orebody on Ramco No. 22. This ground was claimed by Clay Bigman as MP-410. The orebody, known as Ryan No. 2 (Table 2), was mined by a single large open pit covering the Ramco Nos. 20 and 22 and Ryan No. 2 orebodies (Figure 2). Total production during 1955 was only 1,606.53 tons of ore, which averaged 0.21 percent U_3O_8 (Table 3). Seven companies besides Rare Metals made shipments during the year (Table 4). Several of these operators shipped their ore to the ore-buying station at Monticello.

The Boom Years, 1956-58

The AEC opened an ore-buying station at the mill site on February 1, 1956. Rare Metals built the station and leased it to the AEC (Albrethsen and McGinley, 1982). AEC ore-purchasing schedules provided for payment of uranium and vanadium in carnotite-type ore down to 0.10 percent each of U_3O_8 and V_2O_5. Because the Cameron ores contained very little vanadium, no payment was received for the vanadium. The ore-buying station, which provided a market for the Cameron ores, greatly stimulated production in the area. Ores that had been stockpiled during 1955 were shipped in 1956. During 1956, uranium ore production from the Cameron area reached an all-time annual high point: 84,799.13 tons of ore averaging 0.21 percent U_3O_8 was produced by 19 companies from 55 properties (Tables 3 and 4).

During February 1956, Rare Metals commenced shipments from the Ramco Nos. 20, 21, and 22 open-pit mines, which had been discovered the previous year. Shipments from the Ryan No. 2 orebody, an east extension of the Ramco No. 22, commenced in the spring of 1956. The east-trending pit on the Ramco Nos. 20 and 22 and Ryan No. 2 was the deepest deposit to be mined to date in the Cameron area. Ore depths ranged from 60 feet on Ramco No. 20 to 97 feet on Ryan No. 2 (Figure 2). Exploration drilling continued throughout the mining area, and many additional discoveries were made. Mining permits were issued to Alyce Tolino, Julius Chee, Elwood Canyon, and Emmett Lee.

The Tuba City mill, owned by Rare Metals, began operating in June 1956. The plant used an acid-leaching process; uranium was recovered through a resin-in-pulp ion-exchange process. The plant had an initial processing capacity of 260 tons of ore per day, which was increased to 300 tons per day

(Albrethsen and McGinley, 1982). No attempt was made to recover vanadium from the ore. With the mill operating, the AEC turned over the ore buying and sampling to Rare Metals in the fall of 1956. Rare Metals would not accept ores containing less than 0.20 percent U_3O_8, computed on a monthly average basis per property. Monthly quotas were established to give each independent producer an equal share of the available milling capacity.

During 1956, uranium production commenced at the Black Point-Murphy group of claims northeast of Black Point in T. 27 N., R. 10 E., sec. 22 (Plate 1, No. 88). Terrace gravels of the Little Colorado River overlying the ore deposit proved to be more valuable than the uranium. The property became one of the largest sand and gravel operations in Coconino County, Arizona.

An orebody in the south part of the area under the corner common to Julius Chee No. 2 (MP-315), Emmett Lee No. 1 (MP-445), Julius Chee No. 4 (MP-446), and Julius Chee No. 3, (MP-444) was mined by a single, shallow open pit (Plate 1, No. 94). During 1956, shipments commenced from the Jeepster No. 1 mine on William Robbins MP-347 (Table 2; Plate 1, No. 13).

Two companies made shipments in 1956 from non-Chinle properties. United Exploration Syndicate made a "no-pay" shipment (42.89 tons averaging 0.09 percent U_3O_8) from the inactive Hosteen Nez property in the Kayenta Formation. Utco commenced production from the Riverview breccia pipe in December 1956. Production from this pipe lasted less than a year. Of the total uranium shipped in 1956 (363,508.40 pounds U_3O_8), 35 percent was produced by Rare Metals, 27 percent by Utco, 20 percent by Marcy Exploration and Mining Company (from the Jack Daniels No. 1 mine), and 8 percent by Chesser (Table 4).

Uranium ore production in 1957 declined slightly from the previous year: 78,219.55 tons of ore averaging 0.21 percent U_3O_8 was produced (Table 3). Exploration and development drilling continued to increase to the average rate of 7,500 feet per month (Table 7). Woodson Exploration Company discovered a deep (130-foot) orebody, which it planned to mine as an open pit. The orebody was covered by the Jack Huskon's No. 3 permit (MP-493).

During the year, Utah Southern Oil Company took over the assignments of the Foley Brothers and continued mining at the Yazzie No. 312 mine. Diamond Uranium Company commenced mining at the Lemuel Littleman No. 2 orebody (MP-225), which had been discovered in previous years. Skiles Oil Company sank an 80-foot-deep shaft on the Elwood Canyon No. 2 (MP-421) property and commenced shipments. An orebody in the south part of the area was located on two adjacent permits, Emmett Lee No. 3 (MP-466) and Julia Semallie (MP-479). The ore was mined by a single, shallow open pit (Plate 1, No. 100). Other significant mines commencing shipments in 1957 were the Alyce Tolino Nos. 1 and 3 (MP-412) and Kachina No. 6 (MP-457).

Rare Metals commenced shipments from the Ramco No. 24 open pits on Daniel Webster's MP-464. The ore in the south pit extended to the adjacent Harry Walker No. 16 (MP-443), which was controlled by Utco. In April 1956, Rare Metals made an initial shipment from Charles Huskon No. 11 (MP-76) in the upper part of the Shinarump Member. This was the last of Charlie Huskon's original Arrowhead properties to obtain production. A northeast extension of the ore off the old permit area was acquired by Rare Metals as Charles Huskon No. 26 (MP-427; Plate 1, No. 65). On the same Shinarump channel, 1 mile to the south, Rare Metals leased the $E^1/_2$ sec. 9, T. 27 N., R. 10 E. from the C O Bar Livestock Company and made a small, low-grade shipment (17.95 tons averaging 0.09 percent U_3O_8).

During 1957, Yellow Jeep Mining Company made a shipment from Ben and Pete Semallie's MP-437, which was called Yellow Jeep Nos. 7A and 7B. This property was in the Kayenta Formation, 14 miles southeast of Cameron (Table 6). The location of the small rim-stripped area is approximately $SW^1/_4$ sec. 10, T. 28 N., R. 11 E., projected. The property was accessed via a road bulldozed up Landmark Wash to the top of Ward Terrace. Utco commenced production from Charles Huskon No. 19 (MP-461), Charles Huskon No. 20 (MP-465), and Evans Huskon No. 34 (MP-489). The latter two properties (Plate 1, Nos. 22 and 21) were in the upper part of the Petrified Forest Member near the foot of Ward Terrace.

The uranium content of the ore produced in 1957 was 326,236.75 pounds U_3O_8 (Table 3). Of this amount, Rare Metals produced 52 percent, the Jack Daniels No. 1 mine, 19 percent, and Utco, 14 percent. Rare Metals and Utco operated 16 and 8 separate properties, respectively (Table 4).

Uranium ore production continued to decline in 1958 as the larger orebodies, such as those on Jack Daniels No. 1, Yazzie No. 312, Yazzie No. 101, and Ramco Nos. 20, 21, 22, and 24, were depleted. Production in 1958 was 57,347.84 tons of ore with an average grade of 0.20 percent U_3O_8 (Table 3). Rare Metals stopped analyzing the ore for vanadium on July 1, 1958 (Table 3). Rare Metals produced 53 percent of the uranium that was shipped, Utah Southern Oil Company produced 9 percent, and Steinberger Drilling Company produced 6 percent (Table 4).

During the summer of 1958, production commenced at the Juan Horse No. 3 (MP-502), the Juan Horse No. 4 (MP-497), and the Evans Huskon No. 35 (MP-489) mines. The latter deposit was located in the upper part of the Petrified Forest Member of the Chinle Formation northeast of the Ramco Nos. 20, 21, and 22, and Ryan No. 2 mines (Plate 1). At about the same time, shipments commenced from the Max Johnson No. 9 (MP-498) mine. This orebody was discovered in the area between the Elwood Canyon and Alyce Tolino mines (Plate 1, No. 31). In August, shipments began from the deep Jack Huskon No. 3 pit. Errors in calculating ore grades and thicknesses from the gamma-ray logs greatly overestimated the size and grade of this orebody. The mine closed in slightly more than a year.

C.L. Rankin acquired the former Rare Metals lease on T. 27 N., R. 10 E., sec. 9 from the C O Bar Livestock Company. In the fall of 1958, Rankin shipped 87.21 tons of ore averaging 0.12 percent U_3O_8 from a short decline in the northeast quarter of the section (Plate 1, No. 71). Rankin and W.W. Stevenson, Rankin's attorney, made small shipments from the Navajo No. 26 claim in T. 27 N., R. 10 E., sec. 18 (Plate 1, No. 81). Pleistocene cinder dunes overlie the ore-bearing sandstone in the Petrified Forest Member on the terrace surface of the Little Colorado River at the Navajo No. 26 mine (Chenoweth and Cooley, 1960).

Larger mines from which final shipments were made during 1958 included Jack Daniels No. 1, Charles Huskon No. 7, Ryan No. 2, Julius Chee Nos. 2 and 4, Julia Semallie, Paul Huskie No. 3, and Ramco No. 24. Exploration and development drilling increased to between 12,000 and 13,000 feet per month in 1958 (Table 7). Operators looked for the extensions of known orebodies as well as new orebodies missed by previous drilling.

On November 24, 1958, the AEC announced that after April 1, 1962, it would only purchase uranium concentrate (yellowcake) derived from ores that had been discovered before November 24. The procurement program was curtailed because more uranium had been discovered in the United States, especially in New Mexico and Wyoming, than the agency could buy. Beginning in April 1962, all independent producers would be given an annual allocation (market quota) based on ore reserves discovered before November 24, 1958. Because many operators did not develop large ore reserves before mining them, allocations were also based on historical ore production during the period from July 1, 1956, through June 30, 1960.

As controller of the mineral rights on the Navajo Indian Reservation, the Navajo Tribe applied to the AEC for a blanket allocation for all reservation properties in the Cameron area. The AEC gave the tribe an annual allocation (A-249) to produce up to 177,252 pounds U_3O_8 in ore. It was hoped that this large allocation would prolong mining near Cameron after 1961.

The Final Years, 1959-63

Uranium production from the Cameron area in 1959 declined by nearly 50 percent from the previous year. In 1959, 27,705.79 tons of ore averaging 0.20 percent U_3O_8 was shipped (Table 3). Seventy-three percent of the uranium in the shipments came from the properties controlled by Rare

Metals. An additional 6 percent was shipped by Utah Southern Oil Company and Wells Cargo, Inc. (Table 4).

In April 1959, Rare Metals stopped all mining and turned over its properties to the Cameron Mining Company for cleanup mining on a contract basis. When Rare Metals terminated operations, the firm had produced a total of 116,448.58 tons of ore averaging 0.215 percent U_3O_8 from its Cameron mines (AEC, unpublished records).

On November 25, 1958, Page Blakemore (president of Cameron Mining Company) obtained the assignment of Elwood Canyon's MP-421. In early 1959, he resumed underground mining on the property. Wells Cargo, Inc. sank a 50-foot-deep shaft on the Manuel Denetsone No. 2 property (MP-508) and mined out a small orebody during 1959 (Table 5).

The AEC investigated the Liba claims in T. 27 N., R. 10 E., sec. 4 and determined that the claims were invalid because that section had been withdrawn from mineral entry by the First Form Reclamation Withdrawal Act of June 17, 1902. Hence, shipments made in 1955 and 1956 were trespassing (Tables 4 and 5). On April 22, 1957, the land was restored to mineral entry and claim location (*Federal Register,* March 26, 1957, p. 1,991). On that date, the New Liba Nos. 1 through 22 claims were located. Sustained mining commenced in section 4 in the fall of 1959. Cameron Mining Company operated the mine for the claim owners, L.L. Travis and others. Initial shipments were made from the No. 17 claim.

During 1959, production ceased at the Jack Huskon No. 3 pit, Ramco No. 22 pit, and Juan Horse Nos. 3 and 4 pits. Underground mining in the adit off the wall of the Ramco No. 21 pit also ceased (Figure 3).

In September 1959, C.L. Rankin's lease in T. 27 N., R. 10 E., sec. 9 was acquired by Murchison Ventures, Inc. of Denver, Colorado. The firm built a "Benson Upgrader" on the property near the old Rare Metals open pit. This plant, designed by Ross L. Benson of Boulder, Colorado, used a wet, mechanical, sand-slime separation to concentrate the uranium minerals in the slime fraction. The sand fraction, or tailings, was deposited on the bank of the Little Colorado River. According to Benson (oral commun., 1959), the plant could treat 1,000 to 1,500 tons per day of material averaging 0.01 to 0.03 percent U_3O_8 and produce 200 to 300 tons per day of material containing 0.25 to 0.30 percent U_3O_8. John Milton Addison, a Texas promotor, was in charge of the operation. After processing some low-grade ore from section 9, Murchison Ventures made a shipment of concentrate to the Tuba City mill in December 1959. This 10.76-ton shipment, made under the name of the C O Bar Livestock Company lease, averaged 0.16 percent U_3O_8.

The plant was modified. In April 1960, another shipment was made to the mill. This shipment consisted of 11.31 tons of material, which averaged 0.16 percent U_3O_8. After much legal action by the investors, the company was reorganized in June 1960 into Milestone Hawaii, Inc. In February 1961, Addison and six associates were convicted in a Texas court of mail fraud, conspiracy, and Federal security-law violations (*Arizona Daily Sun,* February 17, 1961).

Production in 1960 continued to decline by about 50 percent from 1959. In 1960 a total of 13,029.03 tons of ore averaging 0.19 percent U_3O_8 was produced (Table 3). For the first time since shipments began in 1951, the average grade of the ore dropped below 0.20 percent U_3O_8 (Table 3). During the year, final shipments were made from the Alyce Tolino No. 1, Lemuel Littleman No. 2, Max Johnson No. 9, Kachina No. 6, Charles Huskon No. 8, and New Liba open-pit mines. Final shipments were also made from the Elwood Canyon shaft and from the underground workings off the pit wall of the Ramco No. 20 (Figure 3).

The assignment of the mining rights to MP-360 (Jack Daniels No. 1) to Page P. Blakemore were approved on December 3, 1959. Marcy Exploration and Mining Company had cancelled its assignment on September 17, 1959. During 1960, Blakemore shipped 993.73 tons of ore averaging 0.18 percent U_3O_8 before closing the mine late in the year.

A new permit, MP-542, was issued to George D. Yazzie on February 15, 1960. This permit covered the same ground as the former MP-311, which was held by Chesser and Company. The assignment of the mining rights to Harold F. Rodgers was approved on March 1, 1960. Rodgers mined 123.10 tons averaging 0.24 percent U_3O_8 during 1960, and then abandoned the mine.

The Twilight Company acquired the mining rights to Elwood Thompson's MP-462 (formerly Ramco No. 23) on December 22, 1959. The company sank a 90-foot-deep shaft and began shipments in March 1960. The orebody on MP-462 had been discovered by Rare Metals in 1957 but had never been mined. During 1960, as the operators sought to locate additional ore, drilling averaged approximately 16,300 feet per month, the greatest amount of drilling in the Cameron area during any year (Table 7).

Annual production again declined by 50 percent in 1961. A total of 6,397.62 tons of ore, containing 24,186.29 pounds of U_3O_8 and averaging 0.19 percent U_3O_8, were shipped (Table 3). Final shipments were made from the Charles Huskon Nos. 1, 2, 3, 6, 10, 11, and 12, Yazzie No. 2, Max Johnson No. 1, and Yazzie Nos. 101 and 312 open pits. Final shipments were also made from the Elwood Thompson No. 1 shaft (Table 4).

On December 14, 1960, Charlie Huskon was issued MP-550 to cover the Charles Huskon No. 4 property, which Utco had abandoned in early 1960. Harold F. Rodgers was assigned the mining rights on February 8, 1961. Rodgers produced 1,245.64 tons of ore averaging 0.13 percent U_3O_8 in 1961 before cancelling his assignment in early 1962.

In January 1962, the final shipment of 167.69 tons averaging 0.25 percent U_3O_8 was made from Charles Huskon No. 17. This was the last of the Huskon mines to close. During March 1962, Milestone Hawaii, Inc. made a 23.93-ton shipment from its remodeled upgrader in section 9. This shipment averaged 0.10 percent U_3O_8. Material that was processed for this shipment came from shallow pits in T. 27 N., R. 10 E., secs. 9 and 16 and was labeled Milestone No. 1.

Because production at Cameron had steadily declined since 1957, the Orphan Lode mine in Grand Canyon National Park became the principal source of mill feed for the Tuba City mill (Chenoweth, 1986). A collapsed ore bin and resulting shaft damage forced the Orphan Lode mine to close on December 22, 1961, causing the mill to run out of ore. Rare Metals' ore-buying station at the mill would not accept any ore after March 31, 1962. The mill closed in May 1962.

In July 1962, Rare Metals was merged into the El Paso Natural Gas Company. On November 19, 1962 (effective September 10, 1962), El Paso signed a new contract with the AEC to produce concentrates from the Orphan Lode mine, as well as other ores, through December 31, 1966 (Chenoweth, 1986).

At Cameron, Julius Chee was issued MP-575 on July 23, 1962, to replace MP-444, which covered the Julius Chee No. 3 open pit that had been operated by L.V. Trettle. The assignment of the mining rights were approved to Leon Sterling, Jr., on August 16, 1962. With a new contract with the AEC, the El Paso mill began receiving ore in November 1962. Later that month, Sterling made a 45.57-ton shipment that averaged 0.16 percent U_3O_8 from the clean up of the old pit. Total production in 1962 declined to only 235.19 tons of ore averaging 0.22 percent U_3O_8 (Table 3).

While operating the Jack Daniels No. 1 mine in 1960, Page Blakemore determined that the orebody in the southwest portion of the pit extended west under the right-of-way of U.S. Highway 89. After the highway was relocated in 1961, Denetso was issued MP-559 (Jack Daniels No. 5) on July 19, 1961, covering 40 acres where ore was projected. The assignment of the permit to Blakemore was approved on August 14, 1962. In January 1963, Blakemore shipped 322.32 tons averaging 0.27 percent U_3O_8 from a small open pit he had excavated on the former highway right-of-way. Also in January 1963, Leon Sterling, Jr., shipped 22.67 tons averaging 0.13 percent U_3O_8 from the Julius Chee No. 3 open pit. These two shipments in January 1963 represent the last uranium ore production from the Cameron area. Production in 1963 totalled 344.99 tons, which averaged 0.26 percent U_3O_8 (Table 3). Shipments from the Jack Daniels No. 5 and Julius Chee No. 3 in 1962 and 1963 were made under the Navajo Tribe's blanket allocation.

SUMMARY

During the 13 years (1951-63) that the mines in the Cameron area were active, 100 separate properties produced 289,247.96 tons of ore containing 1,211,812.48 pounds of U_3O_8 and averaging 0.21 percent U_3O_8 (Tables 1, 3, and 4). The bulk of the ore was mined from the Petrified Forest Member of the Chinle Formation: 70 properties produced 98 percent of the uranium (Table 1). Twenty-seven properties in the Shinarump Member of the Chinle Formation produced 2 percent of the uranium (Tables 1 and 8). Two properties in the Kayenta Formation and a single mine in a breccia pipe produced the remaining uranium (Table 1). Properties acquired by Charlie Huskon produced 474,121.16 pounds of U_3O_8, or 39 percent of the total uranium mined in the Cameron area (Table 9). The AEC purchased all of the uranium concentrate produced from the Cameron ores.

Mining in the Cameron area diminished in the early 1960's when operators could not maintain sufficient volume of ore to continue economic mining operations. The mechanical upgrading of low-grade uraniferous material in the Shinarump Member northeast of Black Point was also found to be uneconomical.

The density of past drilling precludes the possibility of discovering additional large, shallow deposits similar to those that were mined. If the price of uranium increases, however, considerable material that is now considered to be uneconomic might become ore.

AEC records indicate that between July 1953 and December 1962, inclusive, approximately 1,005,000 feet of surface drilling was performed in the Cameron area (Table 7). This footage was attributed to approximately 20,000 holes. It included exploration drilling to locate new deposits and development drilling to delineate orebodies before mining commenced. Drillers commonly used a grid pattern, spacing the drill holes 500 feet apart and then decreasing the spacing to 50 feet when they found ore-grade material. They drilled with a noncore rotary rig, typical of those used in seismograph surveys, and rarely saved the cuttings. Uranium values were interpreted from meter readings of an electronics system using a Geiger-Müller tube lowered into the drill hole on a cable.

The drilling was initially centered around outcropping deposits and radioactive anomalies in both the Petrified Forest and Shinarump Members of the Chinle Formation. Expanding from the surface deposits, usually along the strike of the beds, explorationists found many additional deposits that had no surface exposure. The most intensely drilled area was on the northeast side of the Little Colorado River between Moenkopi Wash on the north and Tohachi Wash on the south (Plate 1). North of Cameron, the drilling extended to Five Mile Wash but was generally limited to a belt 1 to 1.5 miles wide on the east side of the river. The intensely drilled area extended south of Baah Lakaa Ridge near Kish Zhini Wash, where the Charles Huskon No. 4 deposit had been previously discovered. This drilling tested the basal Petrified Forest Member and rarely exceeded 100 feet in depth, the limit at which most operators felt they could economically mine. Some minor drilling occurred near the foot of Ward Terrace at anomalies and deposits, but rarely did this drilling exceed 50 feet in depth.

The orebodies in the lower part of the Petrified Forest Member were contained in lenticular channel sandstones. The channel sandstone containing the Yazzie No. 312, Juan Horse Nos. 3 and 4, Boyd Tisi No. 2, and Manuel Denetsone No. 2 ore deposits was plotted from logs of drill-hole cuttings. This channel was traced for 4 miles in a N. 18° W. direction before it lost its entity. The average width of this channel was 5,000 feet, and it had a maximum thickness of 35 feet. Smaller channels are present, and several have been noted in the open pits, but the subsurface information to trace them for any distance was unavailable. Within the lower part of the Petrified Forest Member, ore-bearing channel sandstones have been delineated near the Little Colorado River. Past exploration did not test these host rocks at any depth. The possibility is good that additional ore-bearing channel sandstones are present at depth in the lower part of the Petrified Forest Member, east of the Little Colorado River.

Almost without exception, in the well-explored uranium districts on the Colorado Plateau, the shallow, oxidized, near-surface deposits were smaller and of lower grade than their unoxidized counterparts at depth. There is no known reason to expect any difference at Cameron. Possible higher grade and more continuous orebodies should present an attractive exploration target in the future.

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Table 1. Uranium ore production by host rock, Cameron area, Coconino County, Arizona.

HOST ROCK	TONS OF ORE	POUNDS U_3O_8	PERCENT U_3O_8	POUNDS V_2O_5	PERCENT[1] V_2O_5
Kayenta Formation	182.04	547.68	0.15	1,494.04	0.40
Petrified Forest Member, Chinle Formation	278,616.46	1,186,889.66	0.21	203,680.11	0.05
Shinarump Member, Chinle Formation	9,941.05	20,535.99	0.10	6,608.62	0.10
Moenkopi Formation (breccia pipe)	508.41	3,839.15	0.38	331.00	0.03
TOTAL	289,247.96	1,211,812.48	0.21	212,113.77	0.05

[1] Grade based on actual tons analyzed for vanadium oxide.
Source: Unpublished records, U.S. Atomic Energy Commission, Grand Junction, Colorado.

Table 2. Uranium mines in the Cameron area, Navajo Indian Reservation, with names other than the Navajo permittee.

MINE NAME	PERMITTEE
A & B Nos. 2, 5	Harry Walker
A & B Nos. 3, 7, 13	Paul Huskie
Casey No. 3	Scott Preston
Jack Daniels Nos. 1, 2, 4, 5	Denetso
Jackpot Nos. 1, 5, 40	Ned Hatathli
Jeepster	William Robbins
June	Jessie Sloan
Kachina No. 6	William Robbins
Martin Johnson No. 4	David Tsosie, Willie John
Montezuma Nos. 1, 2, 7A, 7B, 7C	William Robbins
Ramco No. 20	Calvin Semallie
Ramco No. 21	Dan McClellan
Ramco No. 22	Elvin Gordy
Ramco No. 24	Dan Webster
Ryan Nos. 1, 2	Clay Bigman
Thomas No. 1	Ancil Thomas
Tommy	Jessie Sloan
Ward Terrace	Hosteen Nez
Yazzie Nos. 1, 2, 312	Maxwell Yazzie
Yazzie Nos. 101, 102	George Yazzie
Yellow Jeep Nos. 7A, 7B	Ben and Pete Semallie

Source: Navajo Tribal Mining Department, unpublished records; in files of U.S. Atomic Energy Commission, Grand Junction, Colorado.

Table 3. Annual uranium ore production, Cameron area, Coconino County, Arizona.

YEAR	TONS OF ORE	POUNDS U_3O_8	PERCENT U_3O_8	POUNDS V_2O_5	PERCENT V_2O_5	NO. OF OPERATORS	NO. OF MINES SHIPPING ORE
1951	1.05	8.65	0.41	4.85	0.23		1
1952	90.20	386.43	0.21	214.56	0.56	2	2
1953	8,104.54	41,713.56	0.26	13,725.88	0.08	1	9
1954	11,366.50	51,550.00	0.23	17,234.47	0.08	7	20
1955	1,606.53	6,756.56	0.21	1,756.01	0.05	7	11
1956	84,799.13	363,508.40	0.21	80,101.00	0.05	19	55
1957	78,219.55	326,236.75	0.21	85,684.00	0.05	18	51
1958	57,347.84[1]	233,994.08	0.20	13,393.00	0.03	17	42
1959	27,705.79	111,983.06	0.20	NA	—	16	31
1960	13,029.03	48,667.05	0.19	NA	—	16	25
1961	6,397.62	24,186.29	0.19	NA	—	5	14
1962	235.19	1,032.96	0.22	NA	—	3	3
1963	344.99	1,788.69	0.26	NA	—	2	2
TOTAL	289,247.96	1,211,812.48	0.21	212,113.77	0.05		

[1] Only 22,321.67 tons were analyzed for vanadium oxide in 1958.
NA: No analysis.
Source: Unpublished records, U.S. Atomic Energy Commission, Grand Junction, Colorado.

Table 4. Operators and mines, showing year of ore production. Source: Unpublished records, U.S. Atomic Energy Commission, Grand Junction, Colorado.

- Hosteen Nez Mining Co.
  - Hosteen Nez

1952

- Arrowhead Uranium Co.
  - Charles Huskon No. 1
- Hosteen Nez Mining Co.
  - Hosteen Nez

- Arrowhead Uranium Co.
  - Charles Huskon Nos. 1, 2, 3, 4, 5, 6, 7, 8, 10

- A and B Mining Co.
  - A and B Nos. 2, 3, 5, 7, 13
  - Earl Huskon No. 1
  - Henry Sloan No. 1
- Arrowhead Uranium Co.
  - Charles Huskon Nos. 1, 2, 3, 4, 9, 10, 12, 17
- Bloomfield, J.W.
  - Earl Huskon No. 1
- F and B Mining Co.
  - Thomas No. 1
- Five Star Mining Co.
  - Amos Chee No. 3
- Nordell, A.C.
  - Section 1
- Wilson, Howard
  - Taylor Reid No. 2

- A and B Mining Co.
  - A and B No. 3
  - Earl Huskon No. 3
- Arrowhead Uranium Co.
  - Charles Huskon Nos. 1, 2, 17
- Diamond Uranium Corp.
  - Lemuel Littleman No. 3
- Five Star Mining Co.
  - Amos Chee Nos. 3, 8
- Kachina Uranium Corp.
  - Montezuma No. 2
- Shooting Star Uranium Co.
  - Liba Group
- Vermillion Cliffs Uranium Co.
  - Max Huskon Nos. 1-7

1956

- B C Associates
  - Charles Huskon No. 5
  - Julius Chee No. 2
  - June
  - Tommy
- Black, C.S.
  - Liba Group
- Chesser and Co.
  - Yazzie Nos. 101, 102
- Diamond Uranium Corp.
  - L. Littleman No. 7
- Filmore, Robert
  - Grub No. 14 (Section 16)
- Five Star Mining Co.
  - Amos Chee Nos. 2, 8
- Foley Brothers, Inc.
  - Foley No. 5
  - Yazzie No. 1
- Harbough and Chinn
  - Henry Sloan No. 1
  - Jackpot Nos. 1, 5, 40
  - Paul Huskie No. 21
- Howell and Glasscock
  - Murphy Group
- Johnson, Martin
  - Martin Johnson No. 4
- Kachina Uranium Corp.
  - Jeepster No. 1
  - Montezuma Nos. 1, 2, 7A, 7B, 7C
- Lauderdale Mining and Development Corp.
  - Howard No. 1
  - Luster No. 1
- Marcy Exploration and Mining Co.
  - Jack Daniels Nos. 1, 3, 4
- Maynard and Ryan
  - Ryan No. 2
- Rare Metals Corp. America
  - Charles Huskon Nos. 1, 2, 3, 6, 7, 8, 10, 12, 14, 17
  - Ramco Nos. 20, 21, 22
- Trettle, L.V.
  - Julius Chee No. 3
- United Exploration Syndicate
  - Ward Terrace Tract (Hosteen Nez)
- Utah Southern Oil Co.
  - Emmett Lee No. 1
  - Julius Chee No. 4
  - Max Johnson No. 1
- Utco Uranium Corp.
  - Charles Huskon Nos. 4, 9, 18
  - Paul Huskie No. 3
  - Riverview

1957

Diamond Uranium Corp.
  L. Littleman No. 2
Foley Brothers, Inc.
  Yazzie Nos. 1, 2
Harbough and Chinn
  Jackpot Nos. 5, 40
Kachina Uranium Corp.
  Jeepster No. 1
  Kachina No. 6
  Montezuma Nos. 2, 7A
Kaibab Uranium Corp.
  Casey No. 3
Klaner and Associates
  Boyd Tisi No. 2
Marcy Exploration and Mining Co.
  Jack Daniels No. 1
Mescalero Mining Co.
  Emmett Lee No. 3
Pelan, Dave
  Boyd Tisi No. 1
Rare Metals Corp. America
  Charles Huskon Nos. 1, 2, 3, 6, 7, 8, 10, 11, 12, 17, 27
  Ramco Nos. 20, 21, 22, 24
  Section 9
Ryan and Maynard
  Ryan Nos. 1, 2
Sequoia Mining Co.
  A. Maloney No. 2
Skiles Oil Co.
  Elwood Canyon No. 2
Steinberger Drilling Co.
  Alyce Tolino Nos. 1-3
  Julia Semallie
Trettle, L.V.
  Julius Chee No. 3
Utah Southern Oil Co.
  Emmett Lee No. 1
  Julius Chee No. 4
  Max Johnson Nos. 1, 7
  Yazzie Nos. 101, 312
Utco Uranium Corp.
  Charles Huskon Nos. 4, 9, 18, 19, 20
  Evans Huskon No. 34
  Harry Walker No. 16
  Riverview
Yellow Jeep Mining Co.
  Yellow Jeep Nos. 7A-B

1958

Diamond Uranium Corp.
  L. Littleman No. 2
Foley Brothers, Inc.
  Yazzie No. 2
Howell, Sheppard and Bosley
  Murphy group
Kachina Uranium Corp.
  Kachina No. 6
Klaner and Associates
  Boyd Tisi No. 2
Marcy Exploration and Mining Co.
  Jack Daniels No. 1
Mescalero Mining Co.
  Emmett Lee No. 3
Navajo Leytso Mining Co.
  Thomas No. 1
Rankin, C.L.
  Navajo No. 26
  Section No. 1
  Section No. 9
Rare Metals Corp. America
  Charles Huskon Nos. 1, 2, 3, 6, 7, 10, 11, 12, 17
  Ramco Nos. 20, 21, 22, 24
Ryan and Maynard
  Ryan Nos. 1, 2
Steinberger Drilling Co.
  Juan Horse No. 4
  Julia Semillie
Stevenson, W.W.
  B.P. Group (Navajo No. 26)
Utah Southern Oil Co.
  Emmett Lee No. 1
  Julius Chee No. 4
  Max Johnson No. 7
  Yazzie Nos. 101, 312
Utco Uranium Corp.
  Charles Huskon Nos. 4, 9, 18
  Evans Huskon No. 35
  Julius Chee No. 2
  Paul Huskie No. 3
Wells Cargo, Inc.
  Juan Horse No. 3
  Max Johnson No. 9
Woodson Exploration Co.
  Jack Huskon No. 3

1959

Blakemore, Page P.
  Elwood Canyon No. 2
Cramer, Louis W.
  Max Johnson No. 10
Diamond Uranium Corp.
  L. Littleman No. 2
Domino Mining Co.
  Charles Huskon No. 8
  Paul Huskie No. 20

Foley Brothers, Inc.
  Yazzie No. 2
Kachina Uranium Corp.
  Kachina No. 6
  Montezuma No. 1
Lynch, J.W.
  Jack Huskon No. 3
Murchison Ventures, Inc.
  C O Bar Livestock (Section 9)
Rankin, C.L.
  Section 9
Rare Metals Corp. America
  Charles Huskon Nos. 1, 2, 3, 6, 10, 11, 12, 17
  Ramco Nos. 20, 21, 22
Steinberger Drilling Co.
  Alyce Toleno No. 1
  Juan Horse No. 4
Travis, L.L.
  Liba group
Utah Southern Oil Co.
  Max Johnson Nos. 1, 7
  Yazzie No. 312
Utco Uranium Corp.
  Charles Huskon No. 4
Wells Cargo, Inc.
  Juan Horse No. 3
  Manuel Dentsone No. 2
  Max Johnson No. 9
Woodson Exploration Co.
  Jack Huskon No. 3

1960

Blakemore, Page P.
  Elwood Canyon No. 2
  Jack Daniels No. 1
  Liba Group
Cramer, Louis W.
  Max Johnson No. 10
Diamond Uranium Corp.
  L. Littleman Nos. 2, 7
Domino Mining Co.
  Charles Huskon No. 8
Foley Brothers, Inc.
  Yazzie No. 2
Kachina Uranium Corp.
  Kachina No. 6
Murchison Ventures, Inc.
  C O Bar Livestock (Section 9)
Navajo Leytso Mining Co.
  Thomas No. 1
Rare Metals Corp. America
  Charles Huskon Nos. 1, 2, 3, 6, 11, 17
  Ramco No. 20
Rogers, Harold F.
  Yazzie No. 101
Steinberger Drilling
  Alyce Toleno No. 1
Travis, L.L.
  Liba Group
Twilight Co.
  Elwood Thompson No. 1
Utah Southern Oil Co.
  Max Johnson No. 1
  Yazzie Nos. 101, 312
Utco Uranium Corp.
  Charles Huskon No. 4
Wells Cargo, Inc.
  Max Johnson No. 9

Foley Brothers, Inc.
  Yazzie No. 2
Rare Metals Corp. America
  Charles Huskon Nos. 1, 2, 3, 6, 10, 11, 12, 17
Rodgers, Harold F.
  Charles Huskon No. 4
Twilight Co.
  Elwood Thompson No. 1
Utah Southern Oil Co.
  Max Johnson No. 1
  Yazzie Nos. 101, 312

Milestone Hawaii, Inc.
  Milestone No. 1
Rare Metals Corp. America
  Charles Huskon No. 17
Sterling, Leon, Jr.
  Julius Chee No. 3

Blakemore, Page P.
  Jack Daniels No. 5
Sterling, Leon Jr.
  Julius Chee No. 3

Table 5. Uranium-vanadium production of mines in the Cameron area, Coconino County, Arizona, shown on Plate 1

No. on Plate 1[1]	Mine Name	Tons of Ore	Pounds U_3O_8	Percent U_3O_8	Pounds V_2O_5	Percent V_2O_5[2]	Operator(s)	Year(s) of Production
	Earl Huskon No. 1	369.95	1426.03	0.19	3,111.31	0.42	J.W. Bloomfield	1954
							A & B Mining Corp.	1954-55
2	Paul Huskie No. 21	12.40	64.48	0.26	5.00	0.02	Harbough & Chinn	1956
3	Earl Huskon No. 3	1,835.36	8,826.28	0.24	.,198.54	0.03	A & B Mining Corp.	1954-55
4	A & B No. 5	304.68	788.40	0.13	243.74	0.04	A & B Mining Corp.	1954
5a,b	Henry Sloan No. 1	352.87	1,273.00	0.18	322.52	0.05	A & B Mining Corp.	1954
							Harbough & Chinn	1956
7	A & B No. 13	50.82	91.48	0.09	91.48	0.09	A & B Mining Corp.	1954
8	A & B No. 7	24.49	39.18	0.08	132.22	0.27	A & B Mining Corp.	1954
9	Charles Huskon No. 5	320.86	,668.26	0.26	1,103.32	0.17	Arrowhead Uranium Co.	1953
							B.C. Associates	1956
11	Charles Huskon No. 6	746.99	3,023.69	0.20	229.33	0.05	Arrowhead Uranium Co.	1953
							Rare Metals Corp. Amer.	1956-61
12	Lemuel Littleman No. 7	98.54	181.86	0.09	13.00	0.03	Diamond Uranium Corp.	1956,60
13	Jeepster No. 1	1,127.58	4,061.91	0.18	848.00	0.04	Kachina Uranium Corp.	1956-57
14	Montezuma No. 7C	365.96	93.52	0.13	43.00	0.06	Kachina Uranium Corp.	1956
15a,b,c	Montezuma No. 7B	38.01	91.22	0.12	38.00	0.05	Kachina Uranium Corp.	1956
16	Montezuma No. 7A	57.34	131.71	0.11	53.00	0.05	Kachina Uranium Corp.	1956-57
17a,b	Montezuma No. 2	192.63	475.01	0.12	200.79	0.05	Kachina Uranium Corp.	1955-57
18	Casey No. 3	16.50	39.60	0.12	13.00	0.04	Kaibab Uranium Corp.	1957
19	Kachina No. 6	1,451.70	4,043.87	0.14	65.00	0.02	Kachina Uranium Corp.	1957-60
21	Evans Huskon No. 34	1,853.07	6,017.51	0.16	1,452.00	0.04	Utco Uranium Corp.	1957
22	Charles Huskon No. 20	1,037.56	4,996.09	0.24	1,320.00	0.06	Utco Uranium Corp.	1957
23	Charles Huskon No. 19	696.35	1,903.17	0.14	275.00	0.02	Utco Uranium Corp.	1957
24	Jack Daniels No. 1	39,440.14	176,208.84	0.22	40,779.00	0.06	Marcy Explor. & Mining Co.	1956-58,60
24	Jack Daniels No.3	12.22	26.89	0.11	10.00	0.04	Marcy Explor. & Mining Co.	1956
24	Jack Daniels No. 4	33.85	94.78	0.14	47.00	0.07	Marcy Explor. & Mining Co.	1956
24	Jack Daniels No. 5	322.32	1,728.40	0.27	N/A		Page P. Blakemore	1963
25	Charles Huskon No. 12	1,779.66	6,293.97	0.18	207.99	0.27	Arrowhead Uranium Co.	1954
							Rare Metals Corp. Amer.	1956-59,61
26	A & B No. 3	585.97	1,457.87	0.12	514.95	0.04	A & B Mining Corp.	1954-55
27	Max Johnson No. 1	5,678.29	25,818.29	0.23	2,815.00	0.03	Utah Southern Oil Co.	1956-57,59-61
28a,b	Lemuel Littleman No. 2	5,819.05	23,966.36	0.21	758.00	0.02	Diamond Uranium Corp.	1957-60
29	Charles Huskon No. 1	23,126.98	100,406.62	0.22	51,691.68	0.14	Arrowhead Uranium Co.	1952-55
							Rare Metals Corp. Amer.	1956-61
30	Max Johnson No. 10	195.78	1,094.10	0.28	NA		Louis W. Cramer	1959-60
31	Max Johnson No. 9	1,374.55	5,264.60	0.19	NA		Wells Cargo, Inc.	1958-60
32	Elwood Canyon No. 1	874.42	3,638.36	0.21	81.00	0.02	Skiles Oil Corp.	1957
							Page P. Blakemore	1959-60
34	Alyce Tolino Nos. 1,3	1,811.17	8,114.75	0.22	2,478.00	0.06	Steinberger Drilling Co.	1957,60
35	Evans Huskon No. 2	11,776.55	42,692.27	0.18	3,051.55	0.02	Arrowhead Uranium Co.	1955
							Rare Metals Corp. Amer.	1957-61
36	Yazzie No. 101	4,954.54	21,702.47	0.22	1,884.00	0.02	Chesser & Co.	1956
							Utah Southern Oil Co.	1957-58,60-61
37	Yazzie No. 312	7,376.46	32,242.97	0.22	628.00	0.03	Foley Brothers, Inc.	1956
	(Foley No. 5)						Utah Southern Oil Co.	1957-61
38	Boyd Tisi No. 2	793.61	4,758.43	0.30	599.00	0.06	Klaner & Assoc.	1957-58
39	Juan Horse No. 3	2,342.80	9,070.37	0.19	NA		Wells Cargo, Inc.	1958-59

No. on Plate 1[1]	Mine Name	Tons of Ore	Pounds U_3O_8	Percent U_3O_8	Pounds V_2O_5	Percent V_2O_5[2]	Operator(s)	Year(s) of Production
40	Lemuel Littleman No. 3	11.88	54.63	0.23	16.63	0.07	Diamond Uranium Corp.	1955
41	Juan Horse No. 4	2,418.09	11,171.79	0.23	NA		Steinberger Drilling Co.	1958-59
43	Charles Huskon No. 14	46.54	102.39	0.11	19.00	0.02	Rare Metals Corp. Amer.	1956
44	Montezuma No. 1	10.66	21.32	0.10	NA		Kachina Uranium Corp.	1959
45	Manuel Denetsone No. 2	337.82	1,332.99	0.20	NA		Wells Cargo, Inc.	1959
47	A & B No. 2	121.90	679.70	0.28	318.74	0.13	A & B Mining Corp.	1954
48	Jack Huskon No. 3	1,263.95	4,606.48	0.19	NA		Woodson Exploration Co.	1958-59
							J.W. Lynch	1959
49a,	Charles Huskon No. 3	27,249.05	110,261.19	0.20	8,267.82	0.02	Arrowhead Uranium Co.	1953-54
b,c,d							Rare Metals Corp. Amer.	1956-61
52	Paul Huskie No. 20	22.72	68.16	0.15	NA		Domino Mining Co.	1959
53	Charles Huskon No. 7	2,500.73	15,306.31	0.31	2,871.13	0.06	Arrowhead Uranium Co.	1953
							Rare Metals Corp. Amer.	1956-58
54	Yazzie No. 102	1,610.38	9,574.64	0.30	2,529.00	0.09	Chesser & Co.	1956
							H.F. Rogers	1960
55a,b	Charles Huskon No. 10	17,084.39	75,036.72	0.22	20,599.80	0.07	Arrowhead Uranium Co.	1953-54
							Rare Metals Corp. Amer.	1956-59,61
58a,b	Charles Huskon No. 8	626.20	2,901.73	0.23	474.81	0.07	Arrowhead Uranium Co.	1953
							Rare Metals Corp. Amer.	1956-57
							Domino Mining Co.	1959-60
59	Boyd Tisi No. 1	37.22	96.78	0.13	67.00	0.09	Dave Pelan	1957
60	Evans Huskon No. 35	63.71	169.89	0.13	NA		Utco Uranium Corp.	1958
63	Ryan No. 1	311.08	1,086.89	0.17	137.00	0.02	Ryan & Maynard	1957-58
64	Taylor Reid No. 2	91.30	587.77	0.32	199.00	0.11	Howard Wilson	1954
65	Charles Huskon No. 26	18.06	43.35	0.12	11.00	0.03	Rare Metals Corp. Amer.	1957
66	Charles Huskon No. 11	2,776.92	6,518.06	0.12	92.00	0.02	Rare Metals Corp. Amer.	1957-61
67a,b	Section 1 Lease	43.92	197.32	0.22	113.59	0.16	A.C. Nordell	1954
							C.L. Rankin	1958
68a,b	New Liba Group	1,845.42	5,917.91	0.16	183.64	0.04	Shooting Star Uranium	1955
							C.S. Black	1956
							L.L. Travis	1959-60
							Page P. Blakemore	1960
70	Howard No. 1	24.59	127.87	0.26	49.00	0.10	Lauderdale Mining & Dev.	1956
71a,b,c	Section 9 Lease	361.55	916.87	0.13	4.00	0.01	Rare Metals Corp. Amer.	1957
							C.L. Rankin	1958-59
							Murchison Ventures	1959-60
72a,b	Ramco No. 21	5,471.48	26,825.11	0.25	3,903.00	0.08	Rare Metals Corp. Amer.	1956-59
73,75	Ramco No. 22	16,608.94	77,040.28	0.23	4,828.00	0.05	Rare Metals Corp. Amer.	1956-59
74,75	Ramco No. 20	22,642.06	99,226.33	0.22	19,259.00	0.05	Rare Metals Corp. Amer.	1956-60
75	Ryan No. 2	2,066.35	9,422.40	0.23	2,897.00	0.08	Maynard & Ryan	1956-58
79	Yazzie No. 1	342.51	1,310.85	0.19	447.00	0.07	Foley Brothers, Inc.	1956-57
80	Yazzie No. 2	5,646.11	22,668.78	0.20	1,337.00	0.03	Foley Brothers, Inc.	1957-61
81	Navajo No. 26	94.61	341.65	0.18	NA		W.W. Stevenson	1958
							C.L. Rankin	1958
82	Luster No. 1	319.61	929.08	0.14	219.00	0.03	Lauderdale Mining & Dev.	1956
83	Grub No. 14	13.14	42.04	0.16	8.00	0.03	Robert Fillmore	1956
84	Charles Huskon No. 17	4,868.83	20,234.26	0.21	1,218.80	0.02	Arrowhead Uranium Co.	1954-55
							Rare Metals Corp. Amer.	1956-62
85	Jackpot No. 40	152.07	599.13	0.20	215.00	0.07	Harbough & Chinn	1956-57
86	Jackpot No. 1	151.39	540.19	0.18	79.00	0.03	Harbough & Chinn	1956

No. on Plate 1[1]	Mine Name	Tons of Ore	Pounds U_3O_8	Percent U_3O_8	Pounds V_2O_5	Percent V_2O_5[2]	Operator(s)	Year(s) of Production
87	Jackpot No. 5	77.39	405.22	0.26	26.00	0.02	Harbough & Chinn	1956-57
88	Black Point-	.,768.57	7,470.30	0.21	.,378.00	0.04	Howell & Glassock	1956
	Murphy Group						Howell, Sheppard, & Bosley	1958
89	Amos Chee No. 8	100.86	391.86	0.19	85.76	0.04	Five Star Mining Co.	1955-56
90	Max Johnson No. 7	280.34	901.97	0.16	149.00	0.03	Utah Southern Oil Co.	1957-59
91	Charles Huskon No. 9	617.17	2,215.58	0.18	177.55	0.02	Arrowhead Uranium Co.	1954
							Utco Uranium Corp.	1956-58
92	Elwood Thompson No. 1	3,261.32	15,548.16	0.24	NA		Twilight Co.	1960-61
93	Riverview	508.41	3,839.15	0.38	331.00	0.03	Utco Uranium Corp.	1956-57
94	Emmett Lee No. 1	839.56	3,158.11	0.19	306.00	0.02	Utah Southern Oil Co.	1956-58
94	Julius Chee No. 4	1,042.27	3,835.59	0.18	264.00	0.01	Utah Southern Oil Co.	1956-58
94	Julius Chee No. 3	217.56	757.69	0.17	30.00	0.01	L.V. Trettle	1956-57
							Leon Sterling, Jr.	1962-63
94,95	Julius Chee No. 2	637.44	2,211.22	0.17	231.00	0.02	B.C. Associates	1956
							Utco Uranium Corp.	1957-58
96a,b	Ramco No. 24	2,828.04	12,013.08	0.21	NA		Rare Metals Corp. Amer.	1957-58
96b	Harry Walker No. 16	50.98	121.28	0.12	50.00	0.05	Utco Uranium Corp.	1957
97,98	Charles Huskon No. 4	33,821.10	121,244.63	0.18	13,709.61	0.02	Arrowhead Uranium Co.	1953-54
							Utco Uranium Corp.	1956-60
							H.F. Rodgers	1961
98	Paul Huskie No. 3	3,925.32	14,371.72	0.18	2,472.00	0.03	Utco Uranium Corp.	1956,58
99	Charles Huskon No. 18	613.70	1,965.14	0.16	353.00	0.03	Utco Uranium Corp.	1956-58
100	Julia Semallie	1,622.78	8,193.49	0.25	1,229.00	0.05	Steinberger Drilling Co.	1957-58
100	Emmett Lee No. 3	228.69	1,469.84	0.32	104.00	0.03	Mescalero Mining Co.	1957-58
	Milestone No. 1[3]	23.93	47.86	0.10	NA		Milestone Hawaii, Inc.	1962

[1] The following numbers are not listed in this table (see first column) but are listed on Plate 1: 6, 10, 20, 33, 42, 46, 50, 51, 56, 57, 61, 62, 69, 76, 77, and 78. The missing numbers refer to uranium deposits that were never mined because of their small size or low grade.

[2] Grade based on actual tons analyzed for vanadium oxide.

[3] Upgraded material from T. 27 N., R. 10 E., secs. 9 and 16 (Nos. 71 and 83).

Source: Unpublished records, U.S. Atomic Energy Commission, Grand Junction, Colorado.

Table 6. Uranium-vanadium production of mines not shown on Plate 1.

Mine Name	Location T R S	Tons of Ore	Pounds U_3O_8	Percent U_3O_8	Pounds V_2O_5	Percent V_2O_5	Operators(s)	Year(s) of Production
Tommy	39 7 23	39.93	295.35	0.37	16.00	0.02	B.C. Associates	1956
June	39 7 26	22.67	99.75	0.22	9.00	0.02	B.C. Associates	1956
Thomas No. 1	38 7 22	153.85	294.38	0.10	NA		F & B Mining	1954
							Navajo Leytso	1958, 1960
Martin Johnson No. 4	32 9 11	37.51	120.04	0.16	23.00	0.03	Martin Johnson	1956
Max Huskon Nos. 1, 5	31 9 26	56.71	45.13	0.04	22.69	0.02	Vermillion Cliffs Mining	1955
Hosteen Nez	27 12 33	60.81	142.25	0.12	147.04	0.12	Hosteen Nez Mining	1951-52
							United Exploration	1956
Yellow Jeep No. 7A,B	28 11 10	121.23	405.43	0.17	1,344.00	0.55	Yellow Jeep Mining	1957
Amos Chee Nos. 2, 3	25 11 24	88.98	299.28	0.17	2,395.73	1.35	Five Star Mining	1954-56
A. Maloney No. 2	25 11 24	23.52	32.93	0.07	98.00	0.21	Sequoia Mining	1957

NA: No analysis.
Source: Unpublished records, U.S. Atomic Energy Commission, Grand Junction, Colorado.

Table 7. Surface drilling for uranium, Cameron area, Coconino County, Arizona.

YEAR	FOOTAGE
1953	135,000
1954	40,000
1955	48,000
1956	70,000
1957	90,000
1958	150,000
1959	150,000
1960	196,000
1961	96,000
1962	30,000
1963	0
TOTAL	1,005,000

Source: Unpublished field notes, U.S. Atomic Energy Commission, Grand Junction, Colorado.

Table 8. Mines in the Cameron area that have produced from the Shinarump Member, Chinle Formation.

NAME	TONS OF ORE	POUNDS U_3O_8	PERCENT U_3O_8	POUNDS V_2O_5	PERCENT V_2O_5[1]
A and B No. 2	121.90	679.70	0.28	318.74	0.13
A and B No. 3	585.97	1,457.87	0.12	514.95	0.04
A and B No. 5	304.68	788.40	0.13	243.74	0.04
A and B No. 7	24.49	39.18	0.08	132.22	0.27
Casey No. 3	16.50	39.60	0.12	13.00	0.04
Charles Huskon No. 6	746.99	3,023.69	0.20	299.33	0.05
Charles Huskon No. 11	2,776.92	6,518.06	0.12	92.00	0.02
Charles Huskon No. 12	1,779.66	6,293.97	0.18	702.99	0.27
Charles Huskon No. 14	46.54	102.39	0.11	19.00	0.02
Charles Huskon No. 26	18.06	43.35	0.12	11.00	0.03
Earl Huskon No. 1	369.95	1,426.03	0.19	3,111.31	0.42
Grub No. 14	13.14	42.04	0.16	8.00	0.03
Howard No. 1	24.59	127.87	0.26	49.00	0.10
L. Littleman No. 3	11.88	54.63	0.23	16.63	0.10
Liba Group	1,845.42	5,917.16	0.16	183.64	0.04
Luster No. 1	319.61	929.08	0.15	219.00	0.03
Max Huskon Nos. 1, 7	56.71	45.13	0.04	22.69	0.02
Milestone No. 1	23.93	47.86	0.10	NA	
Montezuma No. 1	10.66	21.32	0.10	NA	
Montezuma No. 2	192.63	475.01	0.12	200.79	0.05
Montezuma No. 7A	57.34	131.71	0.12	53.00	0.05
Montezuma No. 7B	38.01	91.22	0.12	38.00	0.05
Montezuma No. 7C	35.97	93.52	0.13	43.00	0.06
Paul Huskie No. 20	22.73	68.16	0.15	NA	
Section 1	43.92	197.32	0.22	113.59	0.16
Section 9	361.55	916.87	0.12	4.00	0.01
Taylor Reid No. 2	91.30	587.77	0.32	199.00	0.11
TOTAL	9,941.05	20,535.99	0.10	6,608.62	0.10

[1] Grade based on actual tons analyzed for vanadium oxide.
NA: No analysis.
Source: Unpublished records, U.S. Atomic Energy Commission, Grand Junction, Colorado.

Table 9. Uranium production from mines on Charles Huskon's mining permits, ranked by size.

MINE NO	TONS OF ORE	POUNDS U_3O_8	PERCENT U_3O_8
4	33,821.10	121,244.63	0.18
3	27,249.05	110,261.19	0.20
	23,126.98	100,406.62	0.22
10	17,084.39	75,036.72	0.22
17	4,868.83	20,234.26	0.21
11	2,776.92	6,518.06	0.12
7	2,500.73	15,306.31	0.31
12	1,779.66	6,293.97	0.18
20	1,037.56	4,996.09	0.24
6	746.99	3,023.69	0.20
19	696.35	1,903.17	0.14
8	626.20	2,901.73	0.23
9	617.17	2,215.58	0.18
18	613.70	1,965.14	0.16
5	320.86	1,668.26	0.26
14	46.54	102.39	0.11
26	18.06	43.35	0.12
TOTAL	117,931.09	474,121.16	0.20

Source: Unpublished records, U.S. Atomic Energy Commission, Grand Junction, Colorado.

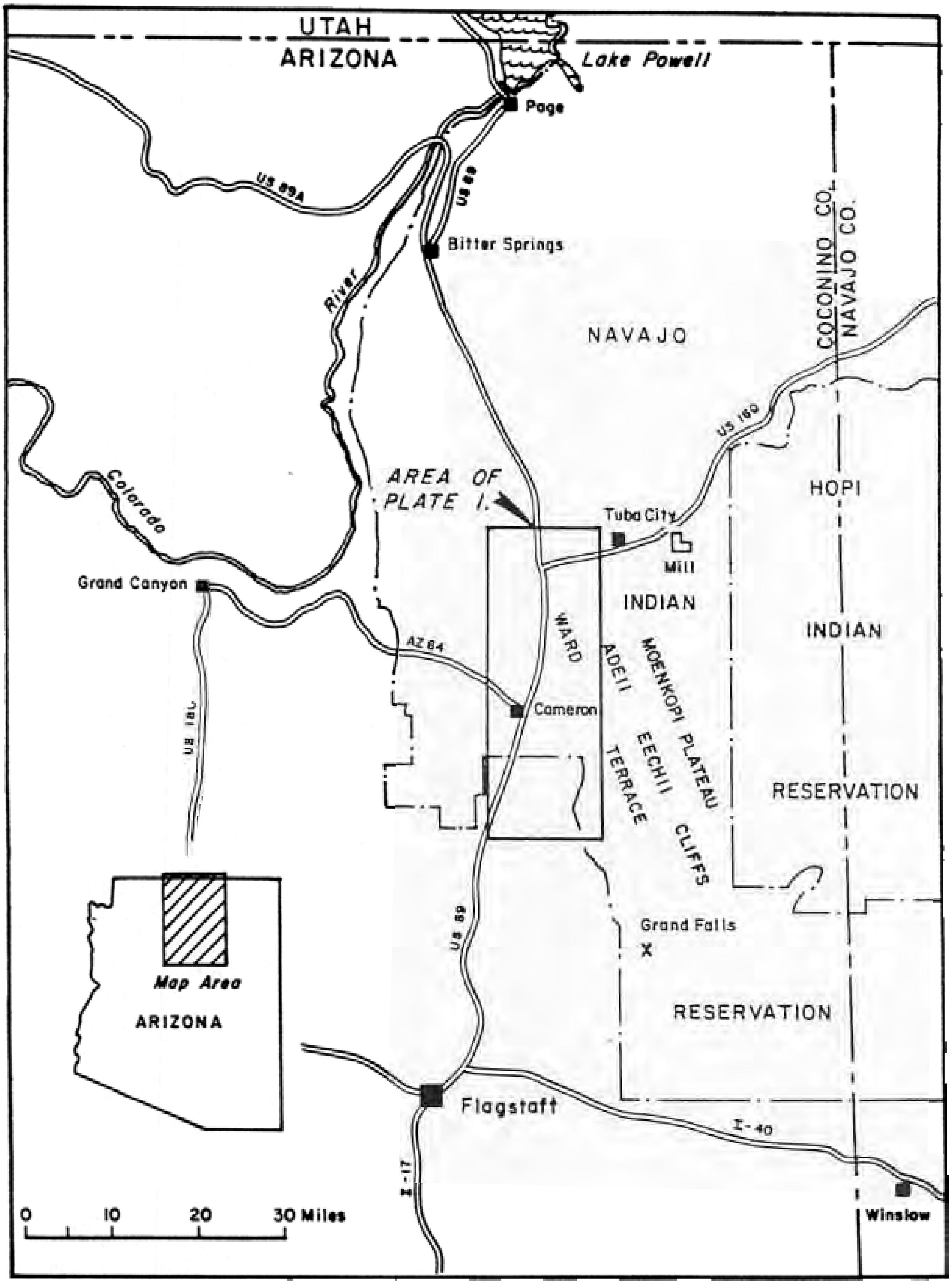

Figure Index map of north central Arizona showing the location of the Cameron uranium mining area

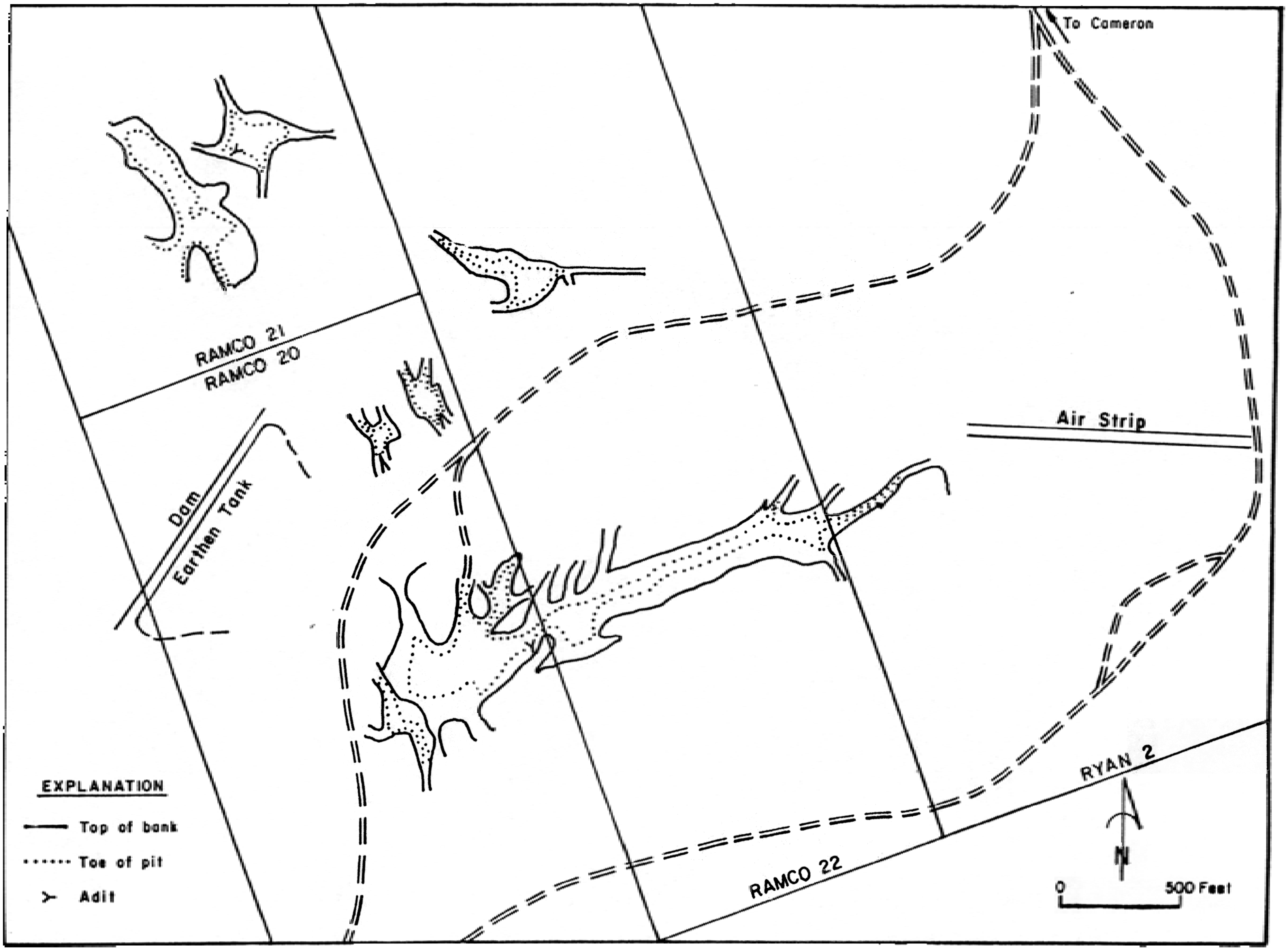

Figure 2. Map showing the mines on the Ramco 20,21,22 and Ryan 2 mining permits, Cameron area, Coconino County, Arizona

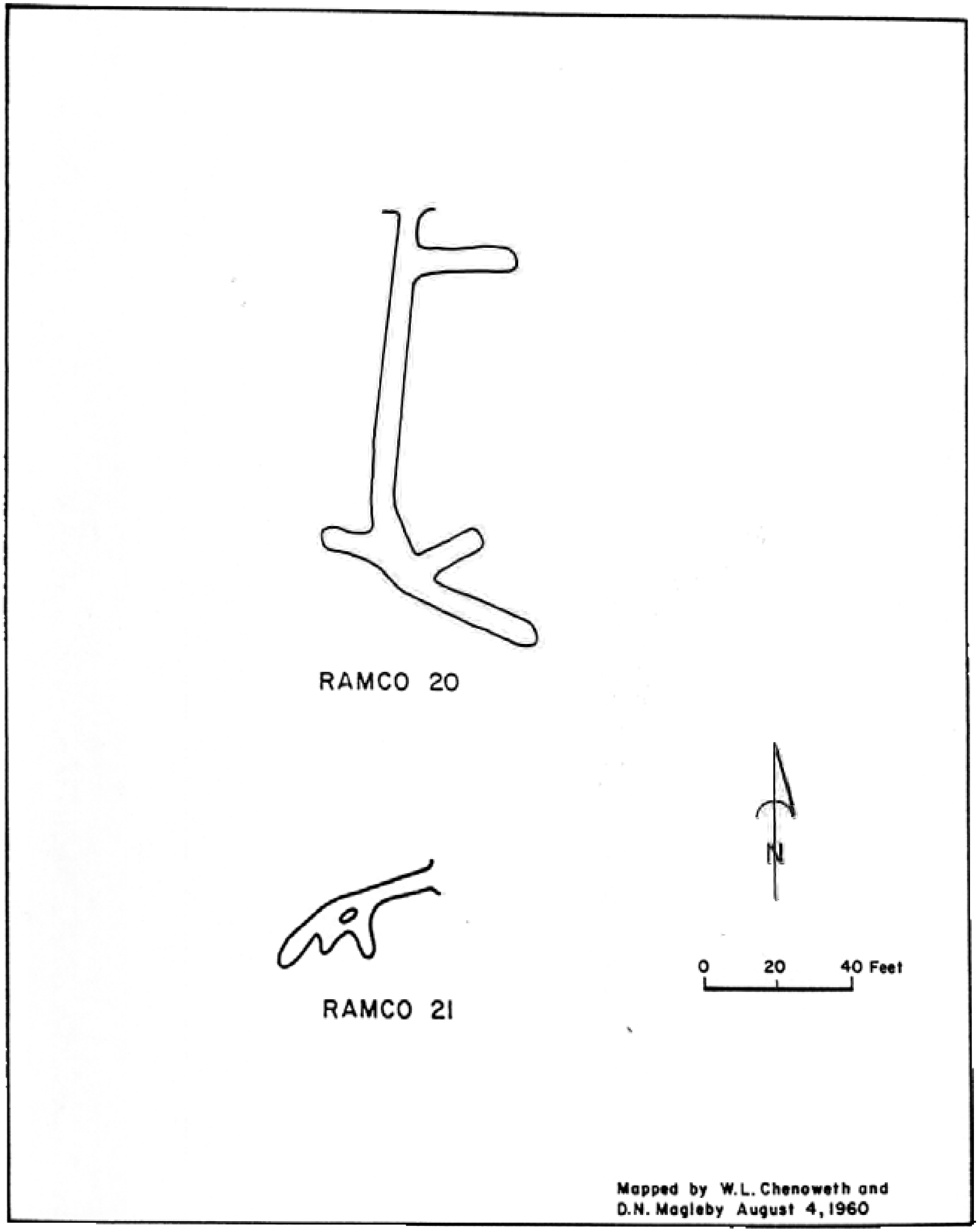

Figure 3. Maps of the underground mines, Ramco 20 and 21 mining permits, Cameron area, Coconino County, Arizona

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INDEX	NAME
47	A & B No. 2
26	A & B No. 3
4	A & B No. 5
8	A & B No. 7
7	A & B No. 13
69	Ada and Nordell
34	Alyce Tolino No. 1 & 3
89	Amos Chee No. 8
51	Blackhair No. 4
59	Boyd Tisi No. 1
38	Boyd Tisi No. 2
18	Casey No. 3
29	Charles Huskon No. 1
49	Charles Huskon No. 3
97	Charles Huskon No. 4
9	Charles Huskon No. 5
11	Charles Huskon No. 6
53	Charles Huskon No. 7 (MP-65)
5	Charles Huskon No. 7 (MP-357)
58a, b	Charles Huskon No. 8
91	Charles Huskon No. 9
55a, b	Charles Huskon No. 10
66	Charles Huskon No. 11
25	Charles Huskon No. 12
43	Charles Huskon No. 14
84	Charles Huskon No. 17
99	Charles Huskon No. 18
23	Charles Huskon No. 19
22	Charles Huskon No. 20
65	Charles Huskon No. 26
1	Earl Huskon No. 1
3	Earl Huskon No. 3
32	Elwood Canyon No. 1
92	Elwood Thompson No. 1
94	Emmett Lee No. 1 and Julius Chee No. 3 & 4
100	Emmett Lee No. 3 and Julia Semallie
35	Evans Huskon No. 2
21	Evans Huskon No. 34
60	Evans Huskon No. 35
10	Foley No. 1
83	Grub No. 14
96a, b	Harry Walker No. 16 and Ramco No. 24
33	Harvey Begay No. 1
5a, b	Henry Sloan No. 1
70	Howard
24	Jack Daniels No. 1-5
50	Jack Huskon No. 1
48	Jack Huskon No. 3
86	Jackpot No. 1
87	Jackpot No. 5
78	Jackpot No. 6
76	Jackpot No. 7
77	Jackpot No. 8
85	Jackpot No. 40
13	Jeepster No. 1
46	Jefferson Canyon No. 1
39	Juan Horse No. 3
41	Juan Horse No. 4
100	Julia Semallie/Emmett Lee No. 3
95	Julius Chee No. 2
94	Julius Chee No. 3,4 and Emmett Lee No. 1
19	Kachina No. 6
12	Lemuel Littleman No. 1 & 7
28a, b	Lemuel Littleman No. 2
40	Lemuel Littleman No. 3
6	Lemuel Littleman No. 6
57	Lloyd House
82	Luster No. 1
45	Manuel Denetsone No. 2
27	Max Johnson No. 1
61	Max Johnson No. 4
90	Max Johnson No. 7
31	Max Johnson No. 9
30	Max Johnson No. 10
62	Mel Gardner
44	Montezuma No. 1
17a, b	Montezuma No. 2
16	Montezuma No. 7A
15a-c	Montezuma No. 7B
14	Montezuma No. 7C
88	Murphy mine (Black Point)
81	Navajo 26
68a, b	New Liba
42	Pat Lynch
52	Paul Huskie No. 1 & 2
98	Paul Huskie No. 3
20	Paul Huskie No. 4
52	Paul Huskie No. 20
2	Paul Huskie No. 21
74	Ramco No. 20
72a, b	Ramco No. 21
73	Ramco No. 22
96a, b	Ramco No. 24 and Harry Walker No. 16
93	Riverview
63	Ryan No. 1
75	Ryan No. 2
67a, b	Section No. 1
71a-c	Section No. 9
64	Taylor Reid No. 2
79	Yazzie No. 1
80	Yazzie No. 2
36	Yazzie No. 101
54	Yazzie No. 102
56	Yazzie No. 105
37	Yazzie No. 312

Uranium Mines and Deposits, Cameron Area, Coconino County, Arizona

Arizona Geological Survey
Contributed Report CR-93-B
Plate 1

Base map from U.S. Geological Survey topographic quadrangle maps. Most data from Chenoweth and Magleby (1971); other data from unpublished records, U.S. Atomic Energy Commission.

compiled by Peter Kreson, Arizona Bureau of Geology, August, 1980

DOE 2001

Department of Energy, An Aerial Radiological Survey or Abandoned Uranium Mines in The Navajo Nation, Bechtel Remote Sensing Laboratory, October 1994 to October 1999.

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Bechtel Nevada
REMOTE SENSING LABORATORY
Operated by Bechtel Nevada for the
U.S. Department of Energy
National Nuclear Security Administration

DOE/NV/11718--602
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An Aerial Radiological Survey of Abandoned Uranium Mines in the Navajo Nation

Overview of Acquisition and Processing Methods
Used for Aerial Measurements of Radiation Data
for the U.S. Environmental Protection Agency
by the U.S. Department of Energy
under IAG DW 8955235-01-5
October 1994 - October 1999

Survey conducted in
Arizona, New Mexico, Utah

Thane J. Hendricks
Bechtel Nevada
Las Vegas, Nevada

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This document is UNCLASSIFIED

David P. Colton
Derivative Classifier

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Abstract

Aerial radiological surveys of forty-one geographical areas in the Navajo Nation were conducted during the period of October 1994 through October 1999. The surveys were conducted at the request of the U.S. Environmental Protection Agency (EPA) Region 9 and were performed by personnel of the Remote Sensing Laboratory (RSL) located in Las Vegas, Nevada, a facility of the U.S. Department of Energy, National Nuclear Security Administration Nevada Operations Office.

The aerial survey and subsequent processing characterized the overall radioactivity levels and excess bismuth 214 activity (indicator of uranium ore deposits and/or uranium mines) within the surveyed areas. A total of 772,000 aerial gamma spectra and associated position parameters were obtained and analyzed during the multi-year operation. The survey determined that only 15 square miles (39 square kilometers) of the 1,144 square miles (2,963 square kilometers) surveyed (approximately 1.3 %) had excess bismuth indications above the minimum reportable activity, thus reducing the area requiring further investigation by a nominal factor of 76.

Radiation contour data files, produced by RSL, were converted to Geographic Information System-compatible digital files and provided to EPA and EPA contractors for inclusion in numerous reports and graphics products.

Acronyms and Abbreviations

cps	counts per second
ENR	enhanced natural radiation
FWHM	full width at half maximum
GIS	geographical information system
MMR	man-made radiation
MRA	minimum reportable activity
Na(Tl)	thallium-activated sodium iodide
NOR	naturally occurring radiation
RDGPS	real-time global positioning system
REDAC	Radiation and Environmental Data Analysis Computer
REDAR	Radiation and Environmental Data Acquisition and Recorder System
RSL	Remote Sensing Laboratory
EPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey

Contents

1.0 Introduction

This report documents work conducted in the Navajo Nation for the U.S. Environmental Protection Agency (EPA) by Remote Sensing Laboratory (RSL), a facility of the U.S. Department of Energy, National Nuclear Security Administration Nevada Operations Office.

Since 1958, Aerial Measuring System capabilities have been used to document radiological conditions at hundreds of locations both within and outside the continental United States. These study areas include power plants, manufacturing and processing plants, research laboratories, medical facilities, etc., which produce or use man-made nuclear materials, and mines and mills which extract or concentrate naturally occurring radioactive materials.

Aerial radiological surveys of forty-one geographical areas in the Navajo Nation were conducted during the period of October 1994 through October 1999. The surveys were conducted at the request of EPA Region 9 and were performed by personnel of the RSL located in Las Vegas, Nevada.

Areas within the Navajo Nation were mined in the 1940s through the 1960s. Concern about the risk of excessive exposure to radiation from remaining mining debris led the Navajo Environmental Protection Agency Superfund Program to ask the EPA to assess the risks in mined areas and determine what action, if any, was needed.

While considerable historical information regarding the general mining areas was available, specific location and relative radiological activity information, suitable for defining risk-assessment areas, was not generally available. Spatial uncertainties in the location of mines of large fractions of a mile were not uncommon, and radiological information existed for very few of the study areas. These uncertainties created severe problems for the risk assessment process.

Aerial radiological technology was identified as the most likely solution to the EPA spatial and radiological uncertainty problem. Such surveys have been used for many years to fully characterize larger areas and to identify smaller areas requiring higher spatial resolution measurements. The EPA initially requested that demonstration aerial surveys be conducted over three small areas in the Four Corners region. These demonstration surveys validated the applicability of aerial surveys to the EPA task, and additional survey activities were initiated throughout the Navajo Nation. Survey parameters were chosen to record aircraft location and the radiological activity averaged over an area of approximately 1 acre (4,050 square meters), balancing resolution and productivity considerations. Special processing identified sites of mines, spoils piles, transfer stations, high natural uranium deposits, and other activities potentially related to uranium mining, by identifying locations where uranium radioactivity is out of balance with radioactivity from other naturally occurring isotopes (potassium and thorium).

2.0 Study Area Description

The study areas are shown in the wide-area map of the Navajo Nation and surrounding areas, Figure 1.

Locations for the general regions of interest defined by EPA were extracted from every source imaginable. U.S. Geological Survey (USGS) official reports, EPA source material, letters, telephone communications, and personal communications were all used. Virtually none of these sources had quoted uncertainties; most were simply spots on maps or locations relative to some known landmark. Map information often showed every indication of being redrawn, copied, drawn as artists' conceptions rather than maps, etc. Every point from these resources (including questionable data) was extracted and placed on working maps. Many points in each given area were likely duplicates of each other, looking like additional points because of the positional uncertainties. Boundaries were drawn around these clusters of locations, leaving wide boundary tolerances to allow for individual point spatial uncertainties. Flights were conducted over these defined boundaries. Individual point locations, used to determine survey boundaries, are not presented in this report because of the high potential of misinterpretation of their locations.

Many other areas of known mining activity were considered for future surveys but were dropped because of jurisdictional considerations and termination of the overall project. The areas not surveyed comprise a significant fraction of the total mining activities conducted in the Navajo Nation.

3.0 Radiation in the Environment

The primary purpose of the aerial survey activities in the Navajo Nation was to specifically identify areas of excess bismuth (an indicator of uranium) as pointers to areas of mining and associated activities. Aerial gross count activity is also important as it looks at total activity in much the same way as many instruments used for ground measurement. That is, it measures the total activity without specifically identifying the contributor. Because bismuth is not the only radioactive material in the environment, a brief discussion of the other contributors seems appropriate.

Radiation in the environment takes several forms, among which are alpha, beta, gamma, x-ray, cosmic ray, and neutron radiation. Alpha and beta radiation have little penetrating power and cannot be seen by the airborne radiological measurement system. X-ray and neutron radiation are man-made. Naturally occurring and enhanced

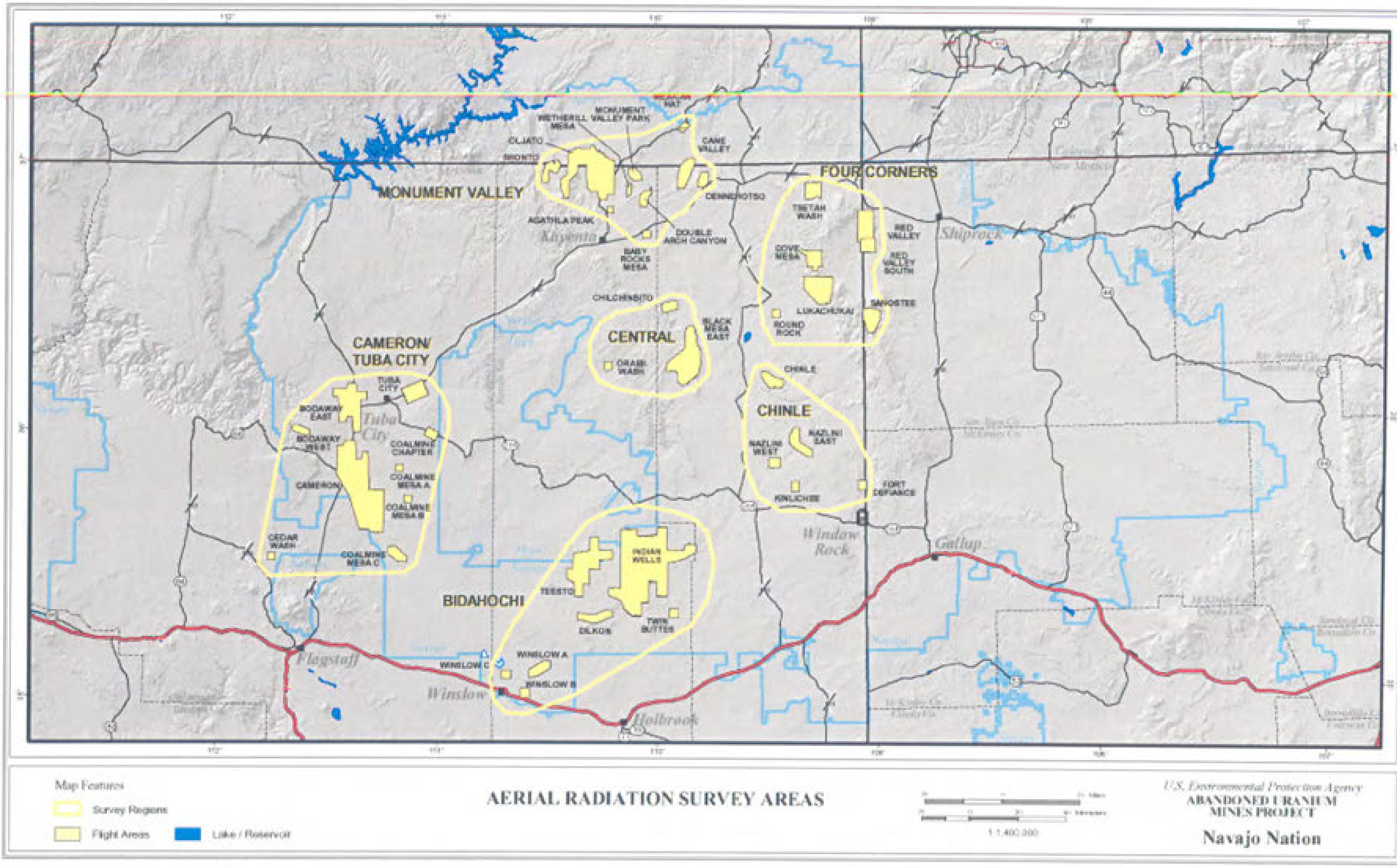

Figure 1. Wide-area Map of the Navajo Nation and Surrounding Area.

natural radiation are the primary contributors to radioactivity in the Navajo Nation. With the exception of insignificant trace amounts of fallout cesium-137, man-made radioactivity was not expected nor was it detected during Navajo survey activities. For report completeness, each contributor found in the modern environment is briefly described in this section. The contributors are discussed in order of their relative likelihood of occurrence in the Navajo project, with the highest likelihood being listed first.

3.1 Naturally Occurring Radiation

Naturally occurring radiation (NOR) originates from three main sources: radioactive elements present in the soil and rock, airborne radon, and cosmic rays of extraterrestrial origin.

Gamma radiation from soil and rock comes from the radioactive decay of elements found therein, namely, radioactive potassium and radioactive components of naturally occurring uranium and thorium. Soil and rock-originated natural radiation levels at the surface typically range from 1 to 15 μR/h throughout much of the world. However, many anomalous areas exist where natural levels far exceed these nominal values. In some parts of Brazil and India, natural levels exceed 100 μR/h. In the southwestern United States, high natural concentrations of uranium, thorium and potassium (occurring singly or together) create local anomalies with radiation levels nearly as high as those occurring in Brazil and India.

One radioactive member of the NOR group is radon, a gas that can diffuse through the soil and travel through the air. Because radon can travel through the air, the activity attributable to radon and its daughter products depends on a variety of factors, including meteorological conditions (winds, air temperature, atmospheric pressure, rainfall during or immediately preceding the survey), mineral content of the soil, and soil permeability. Typically, airborne radiation from radon and daughter products contributes from 1 to 10 percent of the natural background radiation activity. The airborne radiation from radon is typically higher in the generally calm morning hours than later in the day after winds have mixed the air over the survey area.

Cosmic rays (high-energy radiation originating from outer space) interact with elements of the earth's atmosphere and soil, producing an additional source of gamma radiation. Across the United States, radiation levels due to cosmic rays vary with altitude from 3.3 μR/h at sea level to 9.8 μR/h at elevations of 9,000 feet (2,700 meters).

3.2 Enhanced Natural Radiation

Enhanced natural radiation (ENR) is radiation from natural materials but it is generally of a higher level than typical NOR because of human intervention.

Many human activities enhance the external radiation originating from naturally occurring radioactive materials. While the materials producing ENR are natural, the enhancements are such that ENR is discussed separately from NOR. ENR has been observed in debris piles from mining operations for uranium, coal, iron, rare earth elements, and fertilizers; in mineral deposits from geothermal wells where subsurface minerals are deposited on the surface; in oil extraction operations where naturally radioactive materials plate out in pipes; in ash piles from conventional coal fired plants; and in separation operations which intentionally concentrate uranium, thorium and potassium. ENR is often orders of magnitude greater than NOR in the same area.

3.3 Man-Made Radiation

Man-made radiation (MMR) is defined as radiation that comes from man-made materials or processes not of natural origin. The sources of MMR may be a radioactive material used for radiography or medical treatment, an x-ray or similar machine, a research accelerator, or a nuclear power plant.

Cesium 137, a by-product of nuclear fission, is the only source of MMR that is present worldwide. It exists as fallout from aboveground nuclear weapon tests conducted prior to the early 1960s by the United States and the former Soviet Union and, subsequently, by China and France. External radiation rates due to cesium 137 in the environment, outside of isolated weapons test areas, are a small fraction of NOR and ENR (typically less than 1 μR/h). The quantities of cesium 137 detected during the Navajo uranium mines surveys were negligible.

4.0 Survey Operations

Data were acquired utilizing helicopter-based acquisition platforms equipped with custom flight-path steering systems, gamma detectors, and data acquisition systems. Survey altitude, line spacing, and speed were chosen to examine approximately 1 acre (4,050 square meters) of survey area every second. The data were verified and analyzed in the field using a vehicle-mounted or a motel-based multi-task analysis system.

4.1 Data Acquisition

The medium-altitude aerial surveys were flown using either a Messerschmitt-Bolkow-Blohm BO-105 helicopter (Figure 2), or a Bell B-412 helicopter (Figure 3). Both are twin-engine helicopters which carry a pilot(s), an instrument operator, and a version of the Radiation and Environmental Data Acquisition and Recorder System, Version IV (REDAR IV) or Version V (REDAR V). Detector pods mounted on the sides of the skid rack on the helicopter contained 2- x 4- x 16-inch log-type thallium-activated sodium

Figure 2. Messerschmitt-Bolkow-Blohm BO-105 Helicopter.

Figure 3. Bell B-412 Helicopter.

iodide (NaI[Tl]) scintillation detectors. The BO-105 was outfitted with a total of 8 log detectors; the B-412 had 12 log detectors.

4.2 Flight Procedures

Helicopters were flown at an altitude above the terrain of 150 feet (46 meters). At the 150-foot (46-meter) altitude, the nominal footprint of the detector is 300 feet (91 meters). Please refer to Section 6.0, *Spatial Considerations* for details. The normal line spacing for a detailed survey is the width of the footprint – for this survey, 300 feet (91 meters). Anticipating some difficulty in flying accurate parallel lines in mountainous terrain, a conservative line spacing of 250 feet (76 meters) was initially chosen for the demonstration surveys to assure that 300-foot (91-meter) coverage would be achieved. Evaluation of the data from the demonstration surveys showed that the 250-foot (76-meter) conservative line spacing was unnecessary. The remaining surveys were flown using a normal grid pattern of parallel flight lines spaced 300 feet (91 meters).

Aircraft position was established using a Real-time Differential Global Positioning System (RDGPS) and a radar altimeter. In the early surveys, a GPS base station transmitted a positional correction to a GPS unit housed in the helicopter. In later surveys, positional corrections were transmitted by a space-based system. The transmitted correction received by the helicopter's GPS unit minimized the relative positional uncertainty to +/- 15 feet (5 meters). The position was processed and directed into the steering indicator, which was used by the pilot to guide the aircraft along a predetermined set of flight lines.

4.3 Data Recording

The signals produced through interaction of gamma rays with the NaI(Tl) detectors are digitized and sorted in the REDAR acquisition system to produce second-by-second records which contain the number of gamma rays detected at each specific gamma ray energy. This record is called a spectrum. As every radioactive material, natural or man-made, has its own unique set of gamma rays, a spectrum can be used to identify and separate the sources of the detected gamma radiation.

The REDAR, which produces the gamma spectra described above, is a multi-processor data acquisition and real-time analysis system custom designed by the RSL to operate in the severe environments associated with platforms such as helicopters, fixed-wing aircraft, and various ground-based vehicles. The system displays radiation and positional information in real time to the operator via video displays and multiple LED readouts. Archival gamma-ray spectra, aircraft position, meteorological parameters, real-time clock and other data reference information (survey area names, specific flight lines, labels) are recorded at one-second intervals on digital data storage devices for postflight analysis on a ground-based minicomputer system. The digitally recorded data are archived at the RSL in Las Vegas, Nevada.

4.4 Data Verification and Analysis System

A Radiation and Environmental Data Analysis Computer (REDAC) was located at each base of operation. Different bases of operation were chosen for the different survey regions. Depending on the location, different REDAC configurations were used either a 1) mobile laboratory, based on a large Airstream Recreational Vehicle (Figure 4), or 2) portable system, set up in a motel room.

Figure 4. Mobile Data Laboratory.

A standard REDAC system has a Data General MV computer, SCSI disk subsystem for mass storage, numerous tape drives for data transfer and archiving, a 36-inch-wide plotter for data mapping, a laser printer, and two IBM personal computers for terminal emulation.

The REDAC uses an extensive software library developed by the RSL for analysis of REDAR data. The library utilizes industry standard operating systems and programming languages to support custom application software specifically designed by the RSL to perform gamma-ray spectral analysis, flight path recovery, parameter cross-timing, calibration, presentation of acquired/processed data, and conversion of processed/analyzed data to standard Geographic Information System (GIS)-compatible data files. The system provides full-function analysis (data qualification, parameter examination and correction, spectral analysis and interpretation, spectral plotting, contour mapping, etc.) of data acquired and recorded by the REDAR. Documentation for both industry standard software and custom applications software is archived at the RSL in Las Vegas, Nevada.

Prior to and immediately following each flight, extensive diagnostic processes, tailored to the specific survey and system characteristics, were used to evaluate data acquired from the REDAR system to verify proper operation of the system and validate operating procedures. These processes are designated as "preflight" and "postflight."

For the preflight sequence, the calibrated flight-ready system is run for 5 minutes at a stationary ground location. By taking static data, one produces data sets that are easily evaluated by statistical means for proper values and for acceptable data variability. The preflight data file is read into the analysis system where pre-programmed validation analyses are automatically performed for every appropriate acquisition parameter. For the Navajo surveys, the evaluated parameters were position (differential GPS), radar altitude, outside air temperature, absolute pressure, gamma count rate, gamma spectral information, labels, and "on-tops" (specific event markers). Results of the preflight evaluation are produced both as Pass/Fail printed information and as second-by-second parameter plots. Results are reviewed by the data analyst and the mission manager. If the acquisition system fails a critical test in the preflight, the flight will be postponed until the equipment malfunction is corrected. Hardcopies of the preflight procedures and results are permanently retained in the data books archived at the RSL.

For the postflight sequence, the entire data set acquired during the flight (2-3 hours) is read into the analysis system. A pre-programmed validation process (similar but not identical to the preflight process) is automatically run on the flight data. The same parameters are evaluated in the postflight as in the preflight but the emphasis is somewhat different. Each parameter is tested for validity. In addition, the parameters must also be evaluated in relation to the intended mission (for example, good data taken in the wrong location does not satisfy mission requirements). In addition to parameter evaluation, postflights are also designed to derive data (such as isotope extraction coefficients) to be used in further analysis Results are reviewed and data are archived as with the preflight.

5.0 Data Analysis

Gross count and excess bismuth data were derived from the measured gamma spectral information.

Gross count measures total terrestrial gamma activity, without considering its source, much like a hand-held Geiger counter. Aerial gross count data documents the wide range of radioactivity present even in areas not associated with uranium mining activities.

The excess bismuth extraction shows only those areas where uranium concentrations are out of balance with the other naturally occurring radioisotopes (potassium and thorium). The excess bismuth parameter thus identifies areas of interest which are rich in uranium due to natural deposition or because human intervention has occurred.

Products of the gross count and excess bismuth analyses done in the field and at the RSL include contour maps, spectral data, summary tables, and GIS-compatible data files. All these files are archived at the RSL. Following EPA direction, only GIS .gen contour vector files were delivered to EPA and their subcontractors.

Detailed information for Gross Count and Excess Bismuth extractions follows.

5.1 Aerial Gross Count Data

From recorded spectral information, all gamma events of energy 38 keV through 3026 keV are summed to create the observed aerial gross counts per second.

Converting observed aerial count rate to local exposure rate requires consideration of 1) location-dependent factors, and 2) location-independent factors. The location-dependent factors include radon background, meteorological conditions, cosmic activity, and second-by-second elevation of the aircraft above the terrain. The location-independent factors are functions of the aircraft, detector size and configuration, and properties of the acquisition system.

Prior to field deployment, many measurements were made with the different helicopter systems in the Las Vegas area over land surfaces whose radiation properties have been carefully measured on the ground. Aerial measurements over these land surfaces were meticulously corrected for the location-dependent parameters present at the time of the calibration flights to derive the location-independent conversion parameters for each aircraft. Observed count rates are adjusted in the field for second-by-second altitude, meteorological conditions, radon contributions, cosmic activity, and aircraft backgrounds before applying the location-independent conversion parameters. Precise relative measurements for each survey area are assured by conducting flights over a standard test line at the beginning and end of each flight and by normalizing residual flight-to-flight differences.

The aerial count rate-to-surface exposure rate factor assumes a uniformly distributed source covering an area large compared with the field of view (footprint) of the detector. For sources of spatial extent smaller than the detector footprint, observed aerial values may differ appreciably from values measured at ground level (see Section 6).

5.2 Excess Individual Isotope Activity

Relative contributions of the natural radioisotopes to the total background are stable over large geographical areas. This results in a spectral shape that remains essentially constant over large count rate variations. This property allows one to measure the integral count rate in a reference energy region (e.g., from energy c through energy d) and multiply it by an appropriate constant to estimate the integral count rate that should appear in any other energy region (e.g., from energy a through b). One may then detect an excess count rate that appears in an energy region of interest by a simple relation:

EXCESS(a thru b) = MEASURED(a thru b)-ESTIMATED(a thru b)

Because the shape of the normal spectrum is relatively constant,

ESTIMATED(a thru b) = K * MEASURED(c thru d)

One may then write the equation for excess activity in terms of all measured quantities:

EXCESS(a thru b) = MEASURED(a thru b) - K * MEASURED(c thru d)

The most likely value of EXCESS within any large survey area will be zero. The value for K is then determined as the statistically most likely value of MEASURED(a thru b) divided by MEASURED(c thru d).

To account for different meteorological conditions and other factors, K is determined for each flight. A single flight includes takeoff, survey activity, and return to the operations base. Typical flight duration varies from 1½ hours to 3 hours depending upon helicopter loading, weather, survey terrain, and other considerations.

Bismuth 214, of the uranium family, was selected as the indicator of choice because of a gamma-ray photopeak at 1760 keV which is 1) prominent in the spectrum, 2) fairly high in energy, and 3) in a portion of the gamma spectrum which is not complicated by competing gamma peaks. Energy limits (in keV) for the bismuth 214 excess activity extraction were a=1574, b=1946, c=2342, and d=2882.

Because measured radiological data are statistical by nature, second-by-second values of excess bismuth observed in background areas are not each zero but are statistically distributed about zero. For the Navajo excess bismuth extraction, the most likely value of excess bismuth activity (background) was zero with a measured standard deviation (sigma) of +/- 20 counts per second (cps). To virtually eliminate false indications of excess bismuth caused by background statistical variations, minimum reportable activity (MRA) in this document was set to 80 cps (4 sigma). This level corresponds to approximately 3.5 uR/h.

6.0 Spatial Considerations

An airborne detector system, flown at 150-foot (46-meter) altitude over a point radiation source, will observe ½ the maximum activity at a horizontal distance of 150 feet (46 meters) prior to passing over the source, maximum activity directly over the source, and ½ the maximum activity at 150 feet (46 meters) after the source passing. By convention, the horizontal distance between the ½ maximum points is the diameter of the circular detector "footprint." The description of the exact surface-to-air transport mechanism is not within the scope of this document, but the bottom line is that the aerial system records the average surface activity over the extent of the footprint.

Standard ground-based environmental exposure rate measurements are taken at 3 feet (1 meter) above ground level. The footprint of these measurements is about 6 feet (1.8 meters) in diameter. By convention, the RSL aerial measurements are normalized to this standard. Occasionally, non-standard measurements are made with instruments within 2 inches (5 centimeters) of ground level (footprint approximately 4 inches [10 centimeters] in diameter) when one is trying to find the "hottest" area. If ground activity varies significantly over any of these footprints, activity will not agree among the three referenced measurements. It is not unusual to have orders of magnitude differences between such measurements. Therefore, it is very important to consider effects.

When the spatial extent of excess ground level activity (source) is appreciably less than the detector footprint, the average activity seen by the detector is weighted heavily by the large relative contribution of normal activity surrounding the source. This creates an underestimation of the peak source activity. Bull's-eye rings, which appear spatially centered on the location of a small source, do not indicate contamination on the ground but essentially are a spatial picture of the detector footprint. A familiar analogy is that of a campfire - the campfire exists only at a small fixed location, its effect can be felt some distance away, and the effect diminishes with distance from the fire.

Table 1 is useful for understanding spatial effects. The relationships are accurate only if the detector footprint and the ground deposition pattern are of Gaussian shape. This criterion is not exactly met, but the relationships are close enough to provide one with considerable insight into interpretation of the aerial data.

> For ground depositions of FWHM (Full Width at Half Maximum amplitude) from 10 to 100 feet (3 to 30 meters), the aerial FWHM changes only from 300 to 316 feet (91 to 96 meters). Such measured widths are really indistinguishable from each other and from the detector footprint within the positional uncertainty of the aerial measurement. Over this indistinguishable width range, the aerial-to-ground peak activity factor changes from 10 to more than 900. In this situation, aerial and ground measurements cannot be expected to be in agreement.
>
> Given that one cannot tell the difference between a ground area of 10-foot (3-meter) extent and 100-foot (30-meter) extent, it also follows that one cannot tell the difference between a

uniform deposition of 100-foot (30-meter) extent and a similar-size area made up of many smaller areas. Such might well be the case where several small debris piles are in close proximity on the ground. At the other extreme, for uniform ground depositions of FWHM 1000 feet (300 meters) or greater, the aerial and surface measurements will be in good agreement.

Risk from radiation exposure is a complex mixture of activity levels, region of occupancy, and time of occupancy. A large-footprint aerial measurement, while not completely sufficient for risk evaluations, has tremendous utility in targeting areas for further work. For the Navajo survey activities, the MRA for excess bismuth was approximately 3.5 μR/h. While 3.5 μR/h excess ground exposure would not generally be considered a risk, the level identifies areas that are either naturally rich in uranium or have had man-made activities that concentrated uranium. For example, the small level of 3.5 μR/h, estimated from aerial data, could represent an actual 3,150 μR/h if all activity were contained in a 10-foot (3-meter)-diameter area such as a small hogan built of uranium tailings. Therefore, one should carefully evaluate all areas reaching this MRA threshhold.

Table 1. Spatial Relationships for Aerial and Ground Correlation*

S Surface Deposition Pattern (FWHM in Feet)	**A** Aerial Pattern Seen from Altitude = 150' (FWHM in Feet)	**M** Multiplier to Obtain Ground Activity from Aerial Activity Estimate	**E** Exposure at Ground Level That Looks Like 3.5 μR/h from Aerial Platform Data (μR/h)
10	300.2	901	3,150
30	301.5	101	350
100	316.2	10.0	35
300	424.3	2.00	7.0
1000	1044.0	1.09	3.8
3000	3015.0	1.01	3.5

* Note: Spatial relationships which accurately correlate ground and aerial activity are very complex and are beyond the scope of this document. The relationships presented here are first order approximations useful for providing insight. The relationships should not be used to attempt aerial-to-ground corrections.

Definitions

- S = **S**urface deposition pattern FWHM amplitude
- A = **A**pparent deposition pattern FWHM when viewed from 150 feet (46 meters) above ground level
- D = **D**etector footprint FWHM at 150 feet (46 meters) above ground level = 300 feet (91 meters)
- M = **M**ultiplier to obtain ground activity from aerial activity estimate
- E = **Ex**posure level on the ground that looks like 3.5 μR/h (minimum reported excess bismuth value) at 150 feet (46 meters) above the ground

Relations used to generate Table 1

$A = SQRT(S^2 + D^2) = SQRT(S^2 + 300^2)$

$M = (A/S)^2$

$E = M * 3.5$ μR/h

7.0 Aerial Survey Results

This section shows typical products which can be produced from the data acquired by RSL. Such maps, without the USGS overlay, were produced for all 41 survey areas as part of the quality control process. Because the primary product requested by EPA was GIS-formatted .gen files to be used by other contractors, final overlay maps were not produced by the RSL for all surveyed areas.

The reader is referred to the document:

Abandoned Uranium Mines Project
Arizona, New Mexico, Utah – Navajo Lands
1994-2000
Project Atlas

The document presents data from all the surveyed areas in various GIS formats and is available from:

U.S. EPA Region 9
Superfund Records Center
95 Hawthorne Street, Suite 403 S
San Francisco, CA 94105-1985

7.1 Sample Flight Area

The area selected as a data sample is the Cameron Flight Area taken from the Cameron/Tuba City Region (see Figure 1). The RSL field-chosen name was Cameron E. The survey was conducted during the period September 25, 1997 through October 3, 1997. The area covered 166.7 square miles (431.8 square kilometers) and was irregular in shape. The area was bounded on the west by longitude –111.4690 degrees (111 deg, 28 min, 8.4 sec West), on the east by longitude –111.2532 degrees (111 deg, 15 min, 11.5 sec West), on the south by latitude +35.6260 degrees (35 deg, 37 min, 33.6 sec North), and on the north by latitude +35.9686 degrees (35 deg, 58 min, 7.0 sec North).

The average gross exposure rate was determined to be 8.3 μR/h (standard deviation 2.4 μR/h) with a minimum of 2.4 μR/h and a maximum of 66.7 μR/h. There were 110,803 one-second spectra acquired in this flight area by the acquisition system. Of these measurements, 2734 indicated excess bismuth activity greater than 80 cps (approximately 3.5 μR/h). The samples indicating excess bismuth represent approximately 2.5% (or 2638 acres [10.7 square kilometers]) of the total area of the Cameron flight area.

The data were collected by the B-412 helicopter with twelve 2- x 4- x 16-inch Na(Tl) detectors flown at 150 feet (46 meters) above the terrain at a line spacing of 300 feet (91 meters).

Note: The information presented in the preceding narrative for the Cameron Survey Area is presented in concise spreadsheet form for all 41 flight areas in Table 3.

7.2 Typical Terrestrial Exposure Rate Map

The terrestrial exposure rate plot (Figure 5) includes contributions from all natural terrestrial contributors (potassium, uranium, thorium) and possible man-made contributors. Aircraft, airborne radon, and cosmic contributors have been removed.

7.3 Typical Excess Bismuth Activity Plot

The excess bismuth plot (Figure 6) shows bismuth activity in excess of that expected from a normal distribution of natural contributors. Excess bismuth 214 activity indicates high uranium activity due either to previous mining activity or to high natural uranium activity. Only ground-truth activities can completely determine which case applies to a specific area.

7.4 Typical Spectral Plots

Spectral plots are shown in Figure 7. Figure 7a is typical of normal background areas. Figure 7b is typical of survey areas which show excess bismuth activity. Figure 7c is an overlay of Figures 7a and 7b, which illustrates the large difference between a typical background spectral sum and a spectral sum which has excess bismuth. Figure 7d is the net spectrum produced when the background spectrum (Figure 7a) is subtracted from the excess bismuth spectrum (Figure 7b).

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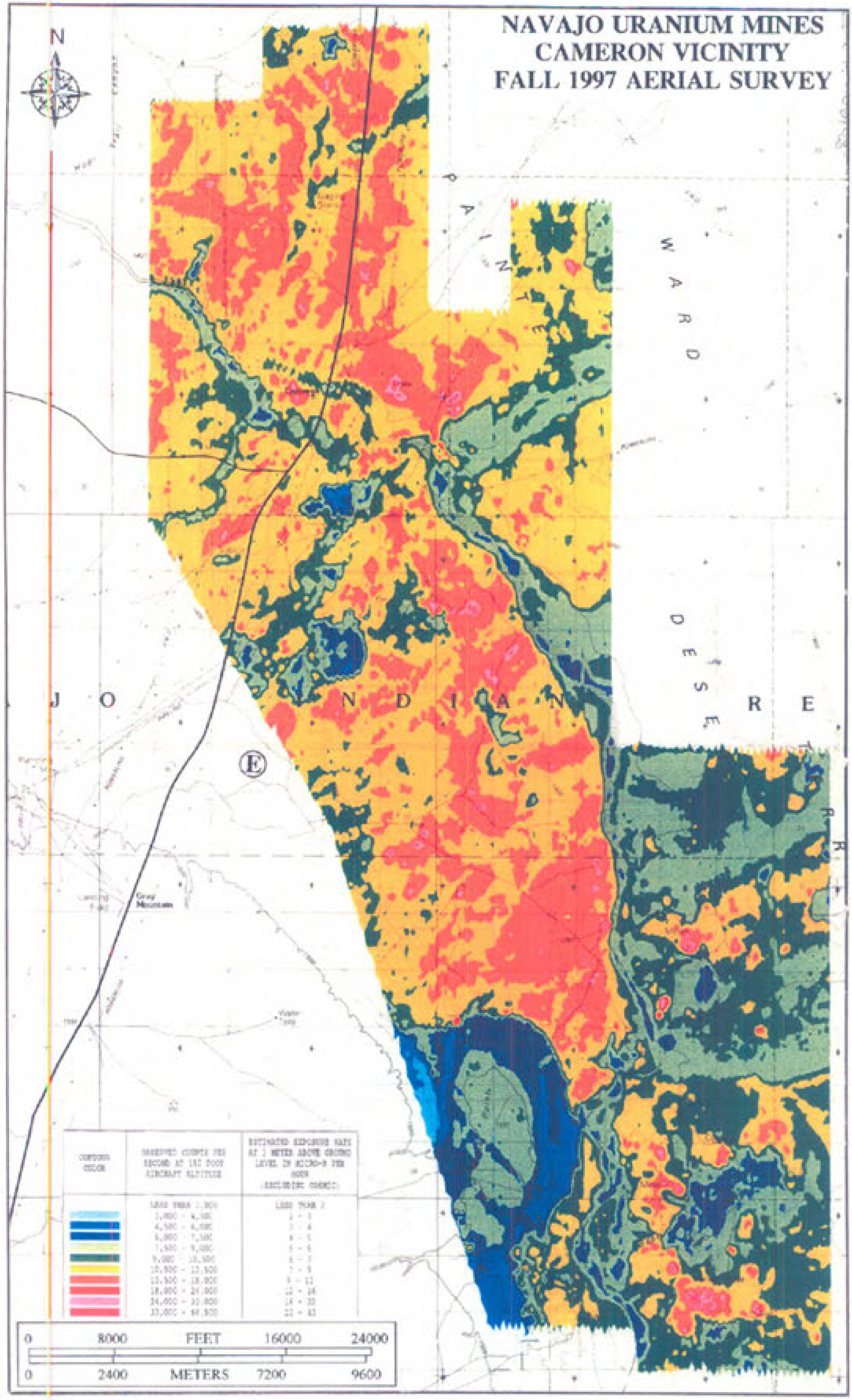

Figure 5. Typical Terrestrial Exposure Rate Plot.

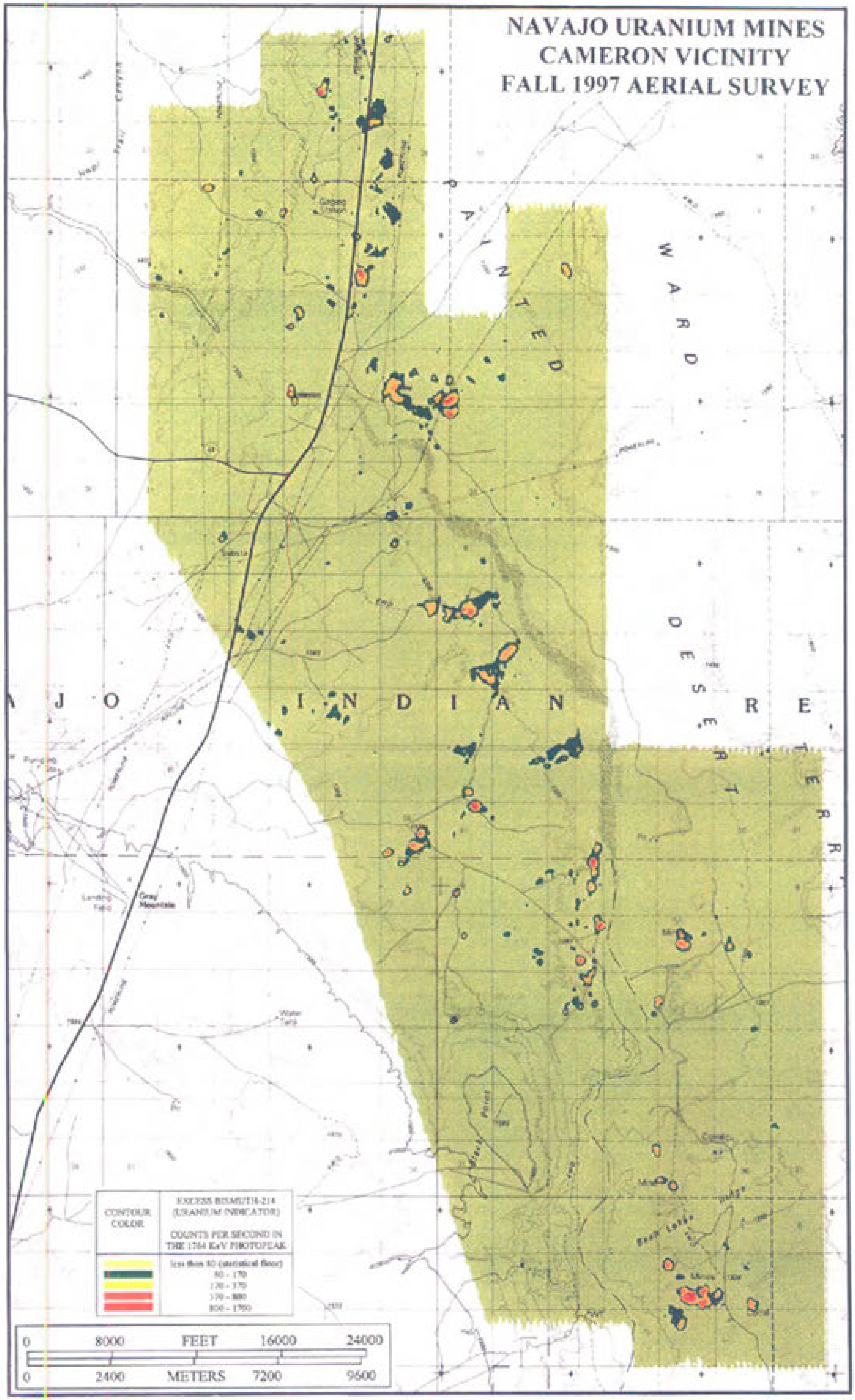

Figure 6. Typical Excess Bismuth Plot.

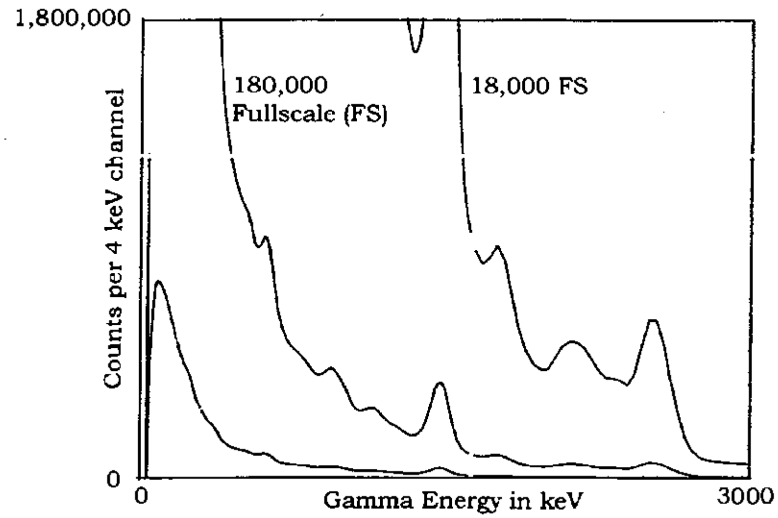

Figure 7a. Typical Sum Spectrum in Background Area

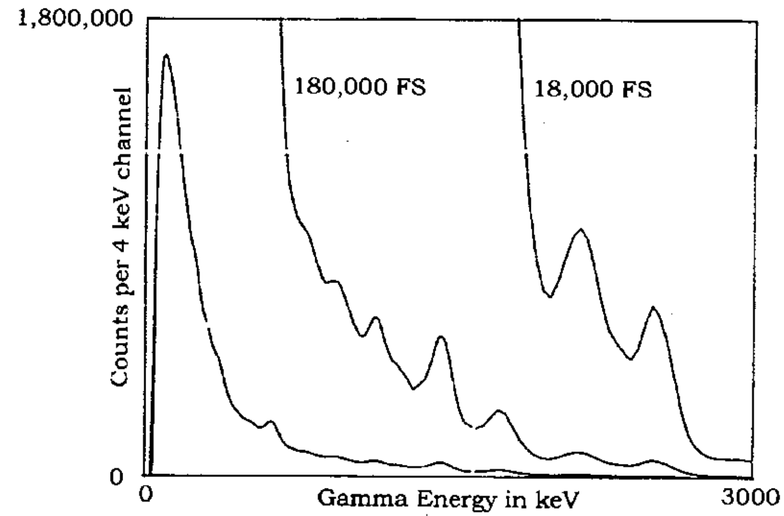

Figure 7b. Typical Sum Spectrum in Excess Bismuth Area

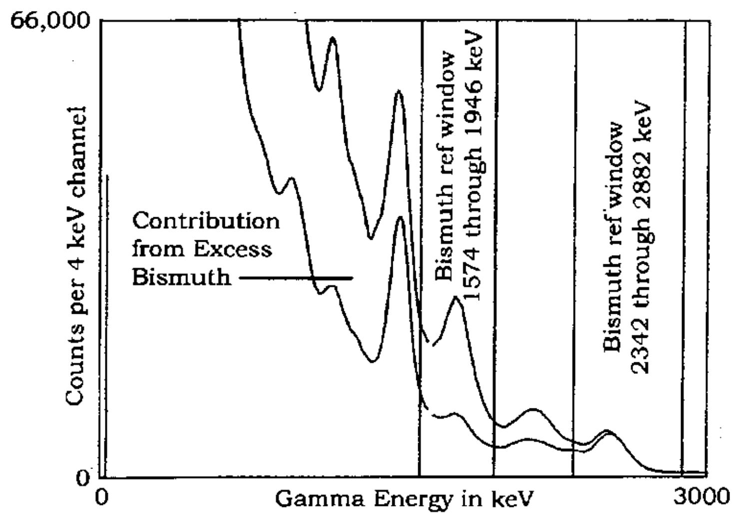

Figure 7c. Excess Bismuth Area (upper trace)
Background Area (lower trace)

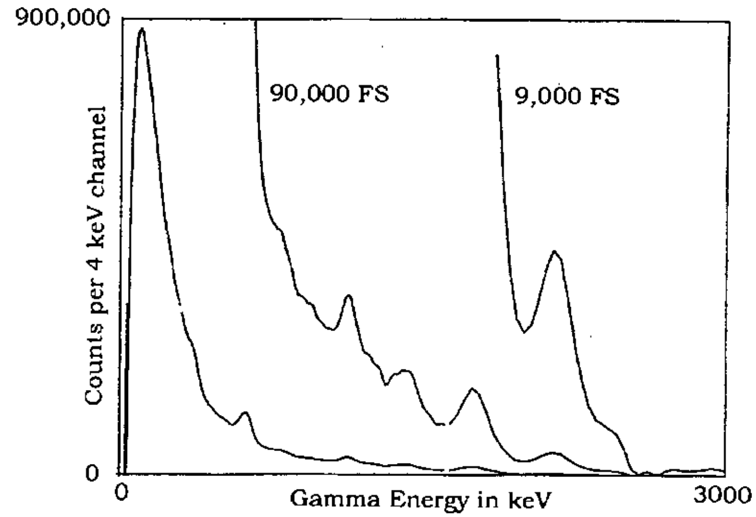

Figure 7d. Net Bismuth Spectrum (Background, Figure 7a, Removed from Excess, Figure 7b)

Figure 7. Typical Spectra for Navajo Abandoned Uranium Mines Surveys

7.5 Navajo Abandoned Uranium Mines Summary Information

Table 2 presents a project overview.

Table 2. Summary of Navajo Survey

Survey Parameter	
Overall survey period	Oct 1994–Oct 1999
Total number of areas surveyed	41
Total analyzed gamma spectra	771,964
Total area surveyed	1144.3 mi^2 (2963 km^2) (or 732,160 acres)
Area showing excess bismuth/uranium	15.0 mi^2 (39 km^2) (or 9600 acres) (1.3 percent)

Table 3 gives a detailed summary for all areas.

The following parameters are tabulated in Table 3.

Area Name – The name in this column is the final USEPA geographical designation.
Sub-Area Name – The name in this column is the final USEPA survey area designation.
Original Survey Name – Survey area name used during all field operations. All archived data at RSL have these designations.
Survey Start – Date the individual survey area began
Survey End – Date the individual survey area was completed
Survey Area – Total square miles covered in the individual survey area
Survey Shape –Shape of the individual survey (either rectangular or irregular)
Longitude Min – Extreme minimum longitude (westernmost boundary) within the individual survey
Longitude Max – Extreme maximum longitude (easternmost boundary) within the individual survey
Latitude Min – Extreme minimum latitude (southernmost boundary) within the individual survey
Latitude Max – Extreme maximum latitude (northernmost boundary) within the individual survey
Terrestrial Exposure Rate in µR/h (average) – Average exposure rate for the individual survey area
Terrestrial Exposure Rate in µR/h (deviation) – Standard deviation of the average exposure rate for the individual survey area
Terrestrial Exposure Rate in µR/h (minimum) – Minimum exposure rate found in the individual survey area
Terrestrial Exposure Rate in µR/h (maximum) – Maximum exposure rate found in the individual survey area
Total Number of Survey Samples – Total number of 1-second aerial sampled points for which full gamma spectral data were acquired for the individual survey area
Excess bismuth greater than 80 cps, approximately 3.5 µR/h (number of samples) Total number of 1-second bismuth-extracted values which exceeded the MRA level for the individual survey area
Excess bismuth greater than 80 cps, approximately 3.5 µR/h (approximate acres) Total number of acres which had bismuth extracted values which exceeded the statistically significant level for the individual survey area
Notes – Reference information relating to helicopter, detector configuration, and survey line spacing

1 = BO-105 helicopter with eight 2- x 4- x 16-inch Na(Tl) gamma detectors
2 = B-412 helicopter with twelve 2- x 4- x 16-inch Na(Tl) gamma detectors
3 = 250-foot (76-meter) survey line spacing
4 = 300-foot (91-meter) survey line spacing

Table 3. Navajo Abandoned Uranium Mines Summary Information

Area Name	Sub Area Name	Original Survey Name	Survey Start End	Survey Area (sq miles)	Survey Shape	Longitude Min	Longitude Max	Latitude Min	Latitude Max	Terrestrial Exposure Rate in uR/hr Does not include cosmic values of 5.1 @ 4000 ft to 9.7 @ 9000 ft elevation				Total # Survey Samples	Excess Bismuth Greater than 80 cps (Approx 3.5 uR/hr)		Notes
										avg	dev	min	max		# of samples	Approx acres	
Bidahochi	Dilcon	Winslow C	05/17/98 05/18/98	18.58	irregular	-110.3669	-110.2077	35.2856	35.3353	6.48	0.84	3.73	10.61	12,004	5	5.0	2,4
	Indian Wells	Winslow A	05/18/98 06/06/98	248.68	irregular	-110.2238	-109.8235	35.3132	35.6470	7.63	1.57	3.93	49.77	157,299	1,916	1938.6	2,4
	Teesto	Winslow B	05/13/98 05/18/98	75.42	irregular	-110.4133	-110.2057	35.3863	35.6080	6.77	1.46	3.68	24.13	47,990	376	378.2	2,4
	Twin Buttes	Winslow K	05/18/98 06/06/98	5.09	rectangle	-109.9448	-109.9034	35.3049	35.3363	5.93	1.11	3.84	8.86	3,232	0	0.0	2,4
	Winslow A	Winslow D	06/06/98	14.47	irregular	-110.5841	-110.4869	35.0831	35.1455	6.34	1.46	3.98	16.05	9,212	4	4.0	2,4
	Winslow B	Winslow H	06/07/98	5.28	rectangle	-110.6221	-110.5816	35.0080	35.0418	4.77	0.84	3.31	7.18	3,435	0	0.0	2,4
	Winslow C	Winslow G	06/06/98 06/07/98	5.21	rectangle	-110.7078	-110.6751	35.0774	35.1114	6.37	0.53	4.45	8.26	3,423	0	0.0	2,4
Cameron	Bodaway East	Cameron D	09/23/97 09/25/97	60.52	irregular	-111.4872	-111.3350	35.9989	36.1818	9.21	3.04	2.40	47.00	40,868	2,732	2589.3	2,4
	Bodaway West	Cameron F	09/10/97	7.48	irregular	-111.6657	-111.5922	35.9886	36.0278	5.65	1.69	2.42	11.70	5,203	8	7.4	2,4
	Cameron	Cameron E	09/25/97 10/03/97	166.72	irregular	-111.4690	-111.2532	35.6260	35.9686	8.26	2.41	2.43	66.66	110,803	2,734	2632.8	2,4
	Cedar Wash	Cameron G	09/09/97 09/10/97	3.58	rectangle	-111.7802	-111.7434	35.5197	35.5469	5.68	1.16	2.54	9.50	2,595	0	0.0	2,4
	Coalmine Chapter	Cameron I	09/11/97	7.52	rectangle	-111.0713	-111.0008	35.9684	36.0194	4.56	0.58	3.32	7.77	4,984	0	0.0	2.4
	Coalmine Mesa A	Cameron B	09/10/97	3.80	rectangle	-111.1991	-111.1626	35.8530	35.8806	4.75	2.23	2.30	11.22	2,658	0	0.0	2.4
	Coalmine Mesa B	Cameron A	09/23/97 09/24/97	3.69	rectangle	-111.1594	-111.1248	35.7380	35.7660	6.90	1.01	4.69	10.19	2,678	0	0.0	2,4
	Coalmine Mesa C	Cameron C	09/11/97 09/23/97	12.88	irregular	-111.2296	-111.1437	35.5160	35.5756	6.43	1.04	2.06	15.33	8,768	6	5.6	2,4
	Tuba City	Cameron H	09/11/97 09/12/97	24.78	rectangle	-111.1771	-111.0490	36.1055	36.1957	3.42	1.30	1.57	10.22	16,339	58	56.3	2,4

Key for notes: 1 = BO105 helicopter with 8(2x4x16) gamma detectors, 2 = B412 helicopter with 12(2x4x16) gamma detectors, 3 = 250 foot line space, 4 = 300 foot line space

Table 3. Navajo Abandoned Uranium Mines Summary information (continued)

Area Name	Sub Area Name	Original Survey Name	Survey Start End	Survey Area (sq miles)	Survey Shape	Longitude Min	Longitude Max	Latitude Min	Latitude Max	Terrestrial Exposure Rate in uR/hr Does not include cosmic values of 5.1 @ 4000 ft to 9.7 @ 9000 ft elevation				Total # Survey Samples	Excess Bismuth Greater than 80 cps (Approx 3.5 uR/hr)		Notes
										avg	dev	min	max		# of samples	Approx acres	
Central	Black Mesa East	Chinle CE	10/10/98 05/25/99	72.56	irregular	-109.9569	-109.7990	36.1759	36.3956	9.03	1.86	3.31	30.51	47,475	236	230.8	2,4
	Chilchin-bito	Chinle A	05/24/99	11.53	irregular	-109.9792	-109.9058	36.4454	36.4880	6.96	1.81	3.70	22.45	6,553	377	424.5	2,4
	Oraibi Wash	Chinle D	05/24/99 05/25/99	4.02	rectangle	-110.2420	-110.2071	36.2334	36.2641	10.02	1.12	7.24	15.97	2,859	0	0.0	2,4
Chinle	Chinle	Chinle F	05/25/99 05/26/99	15.00	irregular	-109.5180	-109.4195	36.1625	36.2240	6.74	1.03	3.49	16.37	10,278	47	43.9	2,4
	Fort Defiance	Chinle I	05/19/99 05/21/99	4.51	rectangle	-109.0784	-109.0420	35.7782	35.8116	5.76	0.89	3.48	8.82	3,243	0	0.0	2,4
	Nazlini East	Chinle G	05/22/99	19.92	irregular	-109.3939	-109.2878	35.9039	36.0116	6.15	0.94	2.27	10.86	13,617	0	0.0	2,4
	Nazlini West	Chinle H	05/21/99 05/22/99	7.11	rectangle	-109.4875	-109.4336	35.8642	35.8999	6.84	1.28	1.59	14.66	4,857	29	27.2	2,4
	Kinlichee	Chinle J	05/21/99	4.81	rectangle	-109.3853	-109.3479	35.7760	35.8110	6.93	1.69	3.17	17.51	3,340	4	3.7	2,4
Four Corners	Cove Mesa	Cove Mesa	10/25/94 10/26/94	20.11	irregular	-109.1877	-109.0862	36.5778	36.6613	5.58	1.2	3.47	52.69	18,499	65	45.2	1,3
	Lukachu-kai	Lukachu-kai	10/14/99 10/20/99	42.29	irregular	-109.3206	-109.1884	36.4706	36.5756	6.89	1.7	3.23	34.68	27,623	202	197.9	1,4
	Red Valley	Beclabito	10/22/94 10/25/94	33.04	rectangle	-109.0695	-108.9968	36.7005	36.8203	5.37	2.38	2.69	41.52	30,156	292	204.8	1,3
	Red Valley S	Red Valley S	10/15/99 10/18/99	13.50	rectangle	-109.0577	-108.9893	36.6639	36.7156	5.36	1.27	2.92	42.23	9,756	81	71.7	1,4
	Round Rock	Chinle B	05/25/99	4.35	rectangle	-109.4675	-109.4314	36.4227	36.4545	5.45	1.39	2.55	13.22	2,998	1	0.9	2,4
	Sanostee	Sanostee	10/13/99 10/14/99	21.27	irregular	-109.0500	-108.9713	36.3638	36.4547	7.1	3.02	3.08	82.62	15,440	81	71.4	1,4
	Tsetah Wash	Rattle-snake	10/20/94 10/22/94	16.18	irregular	-109.3119	-109.2389	36.8665	36.9275	5.27	1.19	3.54	38.62	15,048	100	68.8	1,3

Key for notes: 1 = BO105 helicopter with 8(2x4x16) gamma detectors, 2 = B412 helicopter with 12(2x4x16) gamma detectors, 3 = 250 foot line space, 4 = 300 foot line space

Table 3. Navajo Abandoned Uranium Mines Summary information (continued)

Area Name	Sub Area Name	Original Survey Name	Survey Start End	Survey Area (sq miles)	Survey Shape	Longitude Min	Longitude Max	Latitude Min	Latitude Max	Terrestrial Exposure Rate in uR/hr Does not include cosmic values of 5.1 @ 4000 ft to 9.7 @ 9000 ft elevation				Total # Survey Samples	Excess Bismuth Greater than 80 cps (Approx 3.5 uR/hr)		Notes
										avg	dev	min	max		# of samples	Approx acres	
Monument Valley	Agathla Peak	Monument Valley I	09/04/97	2.59	rectangle	-110.2301	-110.2004	36.8177	36.8416	10.19	4.72	4.08	24.25	1,804	0	0.0	2,4
	Baby Rocks	Monument Valley F	08/27/97	3.97	rectangle	-110.0678	-110.0297	36.7228	36.7521	3.65	0.57	2.65	6.79	2,711	0	0.0	2,4
	Cane Valley	Monument Valley G	09/03/97	21.94	irregular	-109.9050	-109.8235	36.9083	37.0214	4.16	1.87	1.74	32	14,999	312	292.1	2,4
	Denne-hotso	Monument Valley H	09/03/97 09/04/97	8.77	irregular	-109.8091	-109.7597	36.9118	36.9679	3.91	0.77	2.5	7.14	5,971	0	0.0	2,4
	Double Arch Cnyn	Monument Valley E	09/04/97	9.55	irregular	-110.0804	-110.0236	36.8398	36.9181	3.63	1.1	1.57	12.4	6,493	0	0.0	2,4
	Mexican Hat	Monument Valley K	09/05/97	4.61	rectangle	-109.9003	-109.8440	37.1147	37.1600	6.06	1.07	2.79	10.19	3,180	6	5.6	2,4
	Monument Valley Prk	Monument Valley D	08/26/97 08/27/97	8.51	irregular	-110.1331	-110.0730	36.9372	36.9848	4.68	1.44	1.98	13.06	5,953	11	10.1	2,4
	Oljato	Monument Valley BC	08/28/97 09/02/97	113.59	irregular	-110.4480	-110.1980	36.8670	37.0698	4.4	1.57	1.66	57.95	76,290	266	253.5	2,4
	Shonto	Monument Valley A	09/05/97	14.01	irregular	-110.5326	-110.4488	36.9326	37.0157	5.44	1.69	2.44	12.51	9,376	0	0.0	2,4
	Wetherill Mesa	Monument Valley J	09/05/97	2.88	irregular	-110.1388	-110.1199	36.8774	36.9268	4.46	0.95	2.48	8.53	1,954	0	0.0	2,4

Key for notes: 1 = BO105 helicopter with 8(2x4x16) gamma detectors, 2 = B412 helicopter with 12(2x4x16) gamma detectors, 3 = 250 foot line space, 4 = 300 foot line space

8.0 Summary

The aerial survey and subsequent processing characterized the overall radioactivity levels and excess bismuth 214 activity (indicator of uranium ore deposits and/or uranium mines) within the surveyed areas. A total of 772,000 aerial gamma spectra and associated position parameters were obtained and analyzed during the multi-year operation. The survey determined that only 15 square miles (39 square kilometers) of the 1,144 square miles (2,963 square kilometers) surveyed (approximately 1.3 %) had excess bismuth indications above the minimum reportable activity, thus reducing the area requiring further investigation by a nominal factor of 76.

Radiation contour data files, produced by RSL, were converted to GIS-compatible digital files and provided to EPA and EPA contractors for inclusion in numerous reports and graphics products.

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An Aerial Radiological Survey of
Abandoned Uranium Mines in the Navajo Nation
Arizona, New Mexico, Utah
DOE/NV11718--602
Date of Surveys: 1994-1999
Date of Report: August 2001

EPA 2012a

United States Environmental Protection Agency (EPA), Envirofacts Warehouse RCRAInfo Query Results, http://oaspub.epa.gov/enviro/fii_query_dtl.disp_program_facility?pgm_sys_id_in=NNN000909110&pgm_sys_acrnm_in=CERCLIS, data extracted May 15, 2012.

Facility Detail Report

FRS

SECTION 9 LEASE AUM SITE

N/A

FLAGSTAFF, AZ 86001

EPA Registry Id: 110045521397

There is no valid (quality assured) locational data currently available in the FRS database for this facility.

Environmental Interests

Information System	Information System ID	Environmental Interest Type	Data Source	Last Updated Date	Supplemental Environmental Interests:
COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION AND LIABILITY INFORMATION SYSTEM	[illegible]	SUPERFUND	CERCLIS		

Additional EPA Reports: MyEnvironment

Standard Industrial Classification Codes (SIC)

No SIC Codes returned.

Facility Codes and Flags

EPA Region:	09
Duns Number:	
Congressional District Number:	
Legislative District Number:	
HUC Code/Watershed:	
US Mexico Border Indicator:	NO
Federal Facility:	
Tribal Land:	

Alternative Names

No Alternative Names returned.

Organizations

No Organizations returned.

National Industry Classification System Codes (NAICS)

No NAICS Codes returned.

Facility Mailing Addresses

No Facility Mailing Addresses returned.

Contacts

No Contacts returned.

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EPA 2012b

EPA, Region 9, Geographical Information Systems (GIS) Center, Section 9 Lease,
May 23, 2011.

The EPA Region 9 GIS Center Report for the Section 9 Lease site is included in the confidential information packet

EPA 2012c

EPA, Superfund Site Information
http://cfpub.epa.gov/supercpad/cursites/srchrslt.cfm?start=1&CFID=87629763&CFTOKEN=97782841&jsessionid=4e30f51f84c26ec8d8b513b1b235d44592e6, data extracted June 1, 2012.

Superfund Site Information

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Data Element Dictionary (DED)

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Search Results

Search Criteria:

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Found **0** site(s) that match your search criteria listed above.
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NMGS 1958

New Mexico Geological Society, Uranium Mineralization Near Cameron, Arizona,
By E. M. Bollin and Paul F. Kerr, Columbia University, 1958.

URANIUM MINERALIZATION NEAR CAMERON, ARIZONA

by E. M. BOLLIN and PAUL F. KERR
Columbia University

INTRODUCTION

The Cameron uranium mining district lies along the southwestern boundary of the Navajo Indian Reservation within the valley of the Little Colorado River. The town of Cameron is at the intersection of U. S. Highway 89 and the Little Colorado River 52 miles north of Flagstaff, Arizona (Fig. 1). Mining activity is restricted to a curved belt approximately two miles wide extending six miles north of Cameron along U. S. Highway 89 and 18 miles southeast along the Little Colorado River. The area encompasses portions of townships 27 to 29N., Ranges 9-10 E. (Gila and Salt River meridians). Ore is beneficiated at Tuba City, Arizona, 28 miles north and east of Cameron.

Structure and erosion have combined to expose a wide belt of nearly flat-lying Chinle sediments near the base of the formation south and west of the Black Mesa basin. The rock is a fluvatile, medium to coarse grained, poorly sorted, arkosic sandstone deposited in a series of channel scours or depressions in bentonitic claystones and mudstones. Loci of ore deposition occur in abrupt depressions along the channel or at changes in direction. Higher grade ore generally occurs on the steepest bank of the channel reflecting the method of entrapment of carbonaceous material within the lens.

A complex mineral suite with soluble uranium constituents and heavy metal sulphides suggests that the ore-bearing solutions did not move far along channels from points of introduction. The absence of altered channel sand away fom the depression indicates that the channels were not completely saturated.

Primary ore bodies are closely associated with organic detritus and mineralization consists of uraninite with minor amounts of coffinite. Alteration accompanying primary mineralization has been slight and consists of the redistribution or removal of hematite.

Oxidized ore bodies are influenced by the permeability of the host rock which regulated migration from the unoxidized centers. Clay pellets have served to some extent as loci for replacement. Alteration has produced profound effects on the color, cementation, permeability, and composition of the host rock.

The discovery of uranium in the Cameron district was made early in 1952 by Charlie Huskon, an Indian prospector. The Arrowhead Uranium Company was named lessee and developed the major portion of the exposed ore bodies. Development ore was shipped to the Blue Water mill in New Mexico. Activity in the area was accelerated by the purchase of the Arrowhead Uranium holdings and the construction of a mill at Tuba City, Arizona, by the Rare Metals Corporation of America. Milling facilities were in operation by June of 1956, but production was limited by mill capacity. Subsequent enlargement of the mill has permitted development of the Cameron properties at the discretion of the individual mine operators.

Nearly all commercial ore bodies in the Cameron district lie just within the southwest corner of the Navajo Indian Reservation (Fig. 2). Exploration, mining activity, and land status are governed by the Tribal Council at Window Rock, Arizona.

STRATIGRAPHY

Permian to late Tertiary formations are exposed in the Cameron district. The Permian Kaibab formation is composed of light yellowish arenaceous dolomite overlain by the Triassic Moenkopi formation of red sandstones, shales, silts, mudstones, and limestones. A marked depositional break occurs at the base of the conglomeratic Shinarump member of the Chinle formation. Upwards through the Chinle the greatest percentage of the sequence is composed of bentonitic muds and clays of the variegated "Painted Desert." Intercalated with this volcanic debris is a normal detrital component gradational from the bottom of the Shinarump as a conglomerate; the grain size decreases upward and culminates in limestone at the top of the formation (Wilson, 1955). Sedimentation trends from the Permian to the close of the Triassic were dominantly north-northeast. The massive sandstones and shales of the Jurassic Glen Canyon Group overlie the Chinle and have a dominantly southwesterly trend (Harshbarger and others, 1955). Cretaceous to early Tertiary rocks are absent. Late Tertiary rocks are composed of basaltic lavas and cinder cones (Colton, 1937). Numerous deposits of well rounded gravels from resistant portions of older formations cap remnants of pediments (Childs, 1948).

STRUCTURE

The dominant regional structure near Cameron is the East Kaibab monocline (Babenroth and Strahler, 1945). South of the Grand Canyon the structure curves to the east beyond the Coconino salient. The eastern continuation of

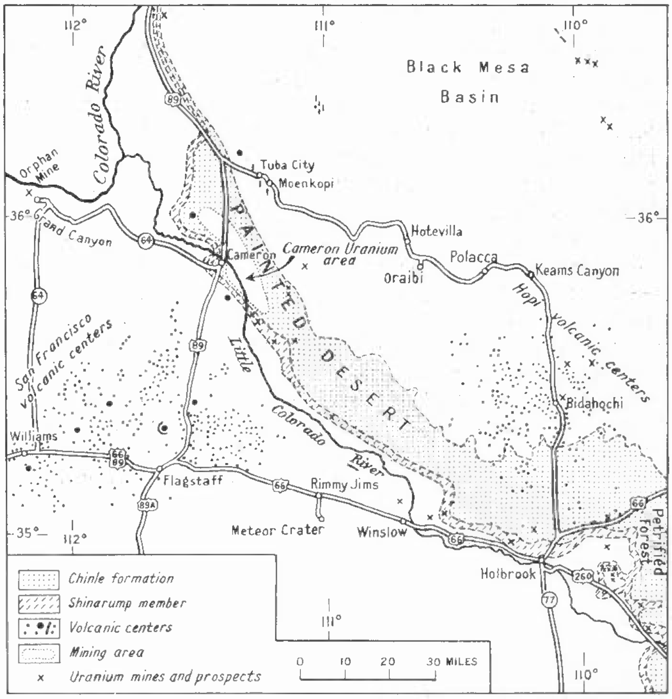

FIGURE 1. Index and location map of the Cameron uranium area.

the structure, the Black Point monocline, forms the southern limit of the district.

The western boundary of the district is formed by marginal arching and erosion peripheral to the Coconino salient and the gradual rise of the Marble platform. The northern and eastern boundary is formed by upper Chinle and Jurassic rocks which overlie the productive portion of the Chinle in a series of cliffs which border the Black Mesa basin. The cliffs are known as Wards Terrace, Wingate Cliffs, and Navajo Cliffs.

Structurally the district constitutes the southwest corner of the Black Mesa basin with a dip of 1-1½ to 3 degrees to the northeast. Superimposed on this regional dip are two sets of small undulations oriented north-northeast and west-northwest. These gradually disappear to the east from a maximum development near the western border of the district in the vicinity of Shadow Mountain. The largest undulations are shown on the structural diagram (Fig. 2) to the southeast of Shadow Mountain. The general eastward extension across the district is established by drill data. The local structures postdate Pleistocene gravels (Reiche, 1937).

URANIUM DEPOSITS

Stratigraphically, uranium ore is found from the Moenkopi formation to the Kayenta formation with the major portion of commercial ore in the lower part of the Petrified Forest member of the Chinle formation. Primary mineralization throughout the sequence consists of uraninite with copper the dominant accessory in the Moenkopi and upper Chinle, cobalt-manganese in the Petrified Forest member proper, and manganese in the Kayenta formation. Lateral distribution shows no distinct variation aside from a minor appearance of phosphate at the eastern end of the district.

Nearly all deposits are highly oxidized with small remnants of high grade primary uraninite. Drilling and mining of one ore body shows that the ore remains in an unoxidized condition under sufficient cover; the grade becomes higher, but the size becomes correspondingly smaller. The total amount of uranium remains relatively the same, indicating that secondary enrichment has not occurred and movement during oxidation has yielded some lateral expansion.

Distribution of oxidized ore within an individual lens is controlled by the method of introduction, the range in permeability, and to a great extent, the distribution of carbonaceous material. The latter two variables have been greatly influenced by the configuration of the channel scour and the velocity of transport as filling occurred. The asymmetry of the channel scour and the corresponding distibution of uranium concentration is shown in Figure 3.

Distribution of primary minerals within the ore lenses is controlled by a combination of fracturing and faulting providing access of solutions to the lens where sufficient carbonaceous material was present to accelerate precipitation. A two-fold orientation of a major part of the ore bodies is observed with lineation at large angles to the sedimentary trends (Fig. 4). This suggests a linear introduction mechanism. Faulting with mineralization halos, and faulting with an established connection with the underlying Shinarump artesian springs points to localization of primary introduction.

A large amount of pyrite and marcasite was formed with the uraninite. During oxidation sulphuric acid reacted with carbonate to produce gypsum and limonitic alteration halos. The carbonate content of the oxidized ores is low — generally in the range of 0.01-0.4 percent. Appreciable carbonate is found only in small veinlets cutting the unoxidized uraninite logs and in one or two relatively unoxidized ore bodies. Here the carbonate content may run as high as 65 percent.

The primary mineralization is found associated with organic detritus. Unoxidized logs may contain as much as 35 percent uranium and 50 percent pyrite or marcasite. Small amounts of copper, cobalt, manganese, and molybdenum mineralization are noticeable in many of the mines.

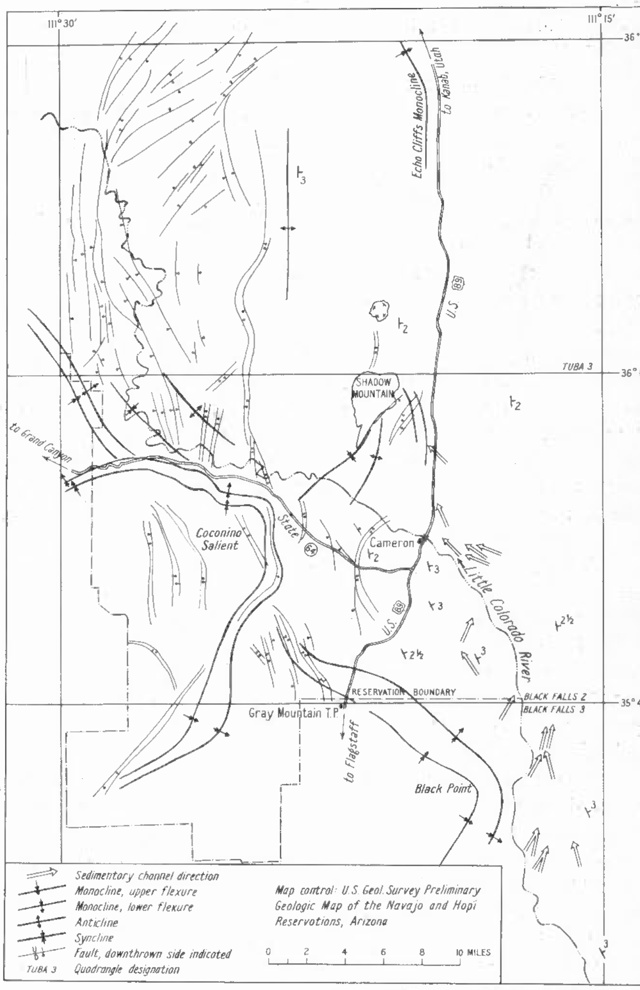

FIGURE 2. Structural diagram showing sedimentary directions of the Petrifed Forest member of the Chinle formation.

The absence of vanadium has been reflected in a complex suite of highly soluable oxides and sulphates of uranium. The uranium minerals tend to be the same color as the abundant limonite and jarosite and the bright colors of the vanadian ores are not observed.

A rather comprehensive description of the mineralogy was prepared by Austin in 1958 and is as yet unpublished. Notes on mineralogy have been furnished by Hinckley (1955 and 1957); Williams and Barret, (1953); Gruner and others (1954); and Austin (1957). The following list is a summary of the above sources coupled with field identification:

Uranian		Non-uranian
	Primary Minerals	
Uraninite, Coffinite		Barite, Bornite, Calcite, Chalcopyrite, Covellite, Dolomite, Galena, Greenockite, Hematite, Marcasite, Pyrite, and Smaltite
	Secondary Minerals	
Andersonite, Autunite, Beta-uranophane, Beta-zippeite, Boltwoodite, Carnotite, Gummite, Meta-autunite, Meta-torbernite, Metauranocircite, Phosphuranylite, Sabugalite, Schroeckingerite, Schoepite, Torbernite, Tyuyamunite, Uranophane, and Zeunerite		Alunite, Atacamite, Azurite, Barite Bieberite, Chalcedony, Copiapite, Covellite, Ferrimolybdite, Gypsum, Halotrichite, Hematite, Ilsemannite, Jarosite, Jordisite, Limonite, Malachite, Metasideronatrite, Opal, Pyrolusite, and Sphaero-cobaltite

ROLE OF SOLUTIONS IN EMPLACEMENT

Syngenetic origin and leaching of volcanic ash have been mentioned as possible souces of uranium (Hinckley, 1957; and Wilson,1956). However, the known associations in the Cameron district only serve to confirm the numerous objections summarized by McKelvey, Everhart, and Garrels (1955, p. 498-50). These objections are valid for the Cameron district and have become so well recognized that their restatement here would be superfluous.

A channel network provides the most likely conduits for ore solutions to reach permeable host sandstone lenses which form the loci of mineralization. Deposition of uranium in the scour depressions only, makes it unlikely that the porous sands were entirely saturated with ore-bearing solutions. Only a small portion of the pemeable host lithology is altered even by secondary bleaching which diminishes rapidly away from the ore bodies.

Sandstone lenses with channel scour bottoms are seldom continuous for more than a mile. Barren lenses with suitable lithology and carbonaceous material are found between ore-bearing lenses even in an intermediate position in a cluster of ore bodies. Such distribution precludes extensive mass migration laterally through the paleo-hydrological network.

Tectonic Influence

Strata surrounding the host lithology are largely impermeable and the channel sands are disconnected (Fig. 5). Access of solutions has been restricted to a minor portion of the host lithology. The permeability range of the host rock and the distribution of the carbonaceous material are directly controlled by the sedimentary conditions during deposition. The distribution of oxidized ore depends largely on the distribution of cabonaceous material. Thus uranium concentrations should tend to parallel sedimentary directions (Fig. 3).

The orientation diagram (Fig. 4) of the ore bodies of the district indicates a dominant orientation nearly normal to the sedimentary trends. Such a configuration is inconsistent with a distribution of mineralization by sedimentary features. Comparison of the structural diagram of the district (Fig. 2) with these orientations shows that one dominant structural trend to the northeast nearly parallels certain ore body orientations. The existence of an orientation at variance with the factors of the sedimentary environment is a major feature. A trend which overcomes the combined effects of pemeability orientation and carbonaceous distribution is strong. The parallelism of this orientation with one of the major fault directions of the district constitutes further evidence for assuming fault or fracture control of solutions as a major factor in the Cameron district.

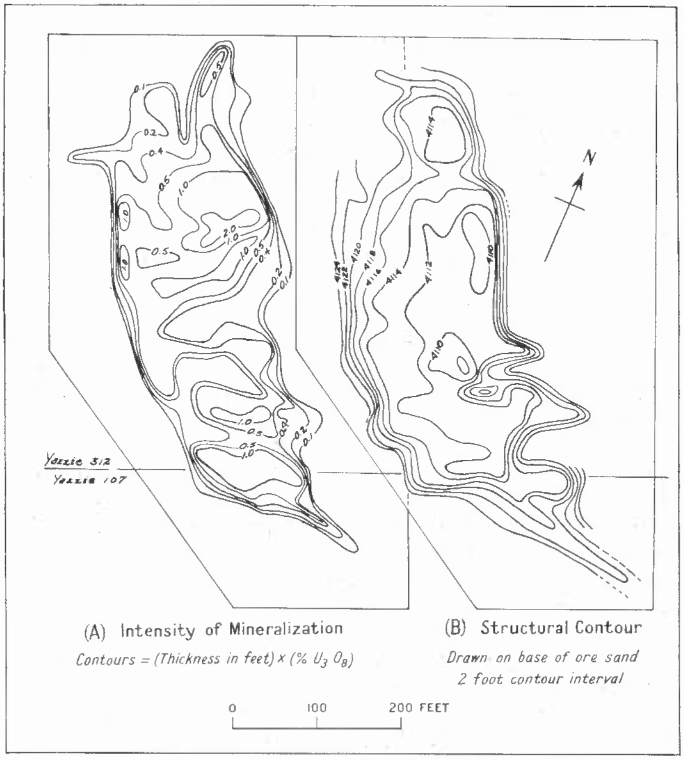

FIGURE 3. A comparison of the intensity of mineralization (A) with channel configuration (B).

Access of Shinarump Solutions to Chinle Host Rock

The possibility should be considered that the Shinarump member provided major access for the ore-bearing solutions to the sandstones in the Petrified Forest member. The Shinarump is an excellent aquifier in the Cameron area and is only slightly silicified. Mineralization or highly radioactive aeas occur in nearly every outcrop and are more abundant than mineralized areas in the Petrified Forest member. Because of a large amount of leaching and unfavorable equilibrium ratios ore bodies are few and only scattered production has resulted. Uranium has been preserved only in areas where silicification has restricted ground-water leaching. The Shinarump is highly altered where no ore or mineralization is now noticeable. Evidence suggests that the Shinarump member at one time contained considerably larger amounts of uranium than the Petrified Forest member .

The hydrostatic head in the Shinarump would provide adequate pressure for positive flow of solutions from the Shinarump to the Chinle ore sands dependent upon the presence or absence of a passageway between the Shinarump and the ore sands. The almost universal shattering of the mudstones surrounding the host lithology would provide such a passageway. Faulting is also believed to provide a passageway in some mines (Huskon 1 and 5; and RAMCO 20-22-Ryan-2). Also, some of the channels of the Petrified Forest member are in direct contact since they are scoured downward into the Shinarump (Huskon 3,4, and 10). The presence of a passageway is well shown in the Alyce Tolino No. 1 mine. When the mine was opened it was found that a series of flowing springs issued from the bottom of the mine along a fault line which traversed the pit (Fig. 6). The highest uranium content is along the fault and presumably represents introduction along the fault. However, as the sedimentary channel is parallel to the fault the channel could be a major controlling factor.

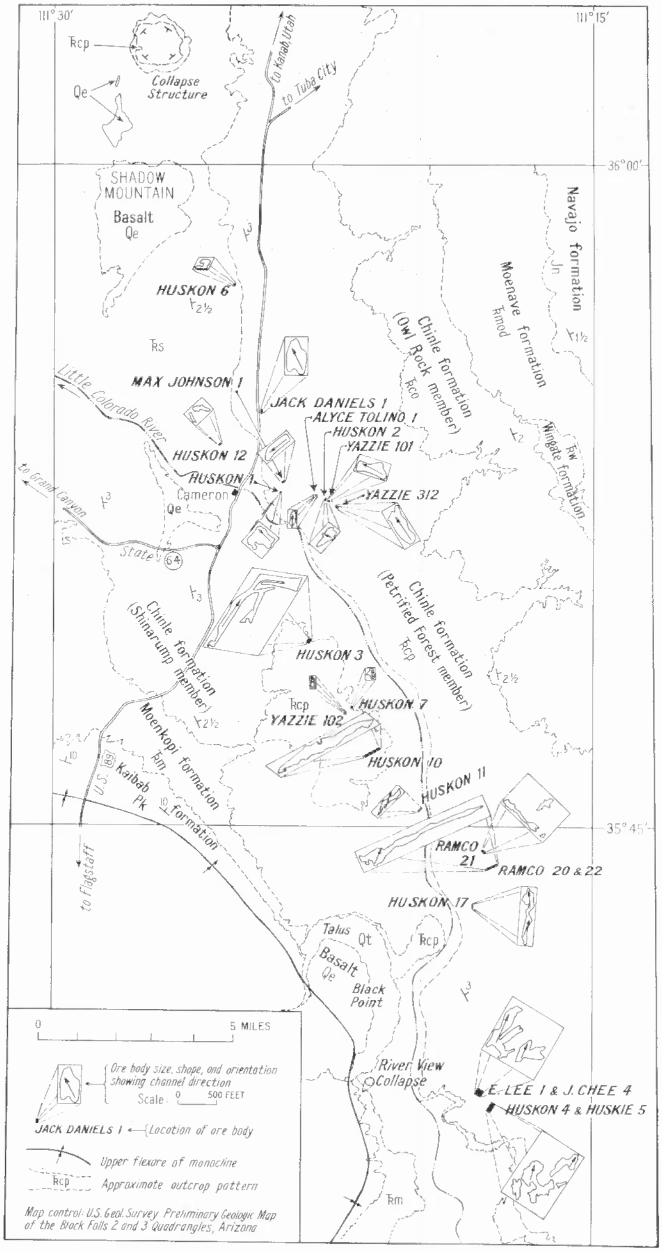

FIGURE 4. A diagram showing the size, shape, and orientation of the Cameron ore bodies.

Source of Solutions

A source of uranium-bearing solutions discharging into the Shinarump artesian system is readily available in the Cameron district. Igneous extrusives are pesent at both ends of the district with closely associated uranium-bearing collapse structures. The igneous sources are apparently post-ore; however, they indicate that weakness in the crust existed at the point of rupture and may represent rejuvenation of previous weaknesses present during the ore episode.

Detailed work on the purity and sedimentary structure of the bentonite in the Chinle by Wilson (1955) suggests a local source of volcanism in the vicinity of Shadow Mountain for at least a part of the Chinle ash. This would

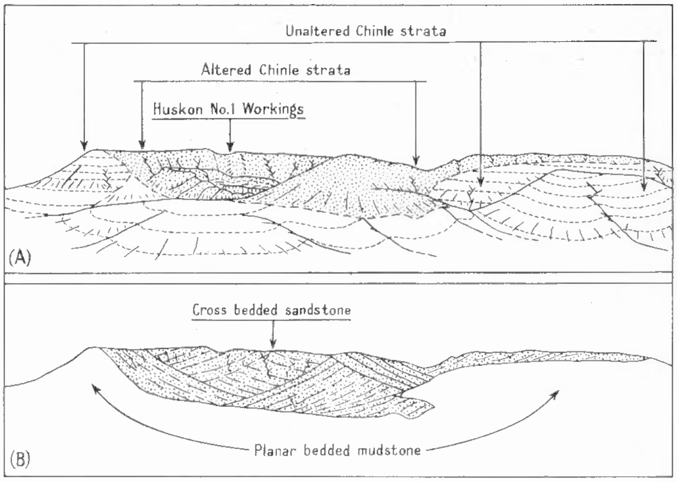

FIGURE 5. Channel development in bentonitic mudstones at the Huskon No. 1 mine.

imply that a structural weakness sufficient to allow volcanism existed in the Cameron area as early as the Triassic.

Both of the known mineralized collapse structures within the district contain ore grade material and the River View collapse, located at the point where the axis of the Black Point monocline is sharply deflected to the southwest (Fig. 4), has produced commercial ore. The collapse at the north end of the district is located at the northern end of a series of cinder cones and flows known as Shadow Mountain (Fig. 4). The collapse is approximately two miles in diameter and contains Chinle sediments in its center. Extensive exploration drilling indicates, however, that mineralization is too deep to be profitably exploited.

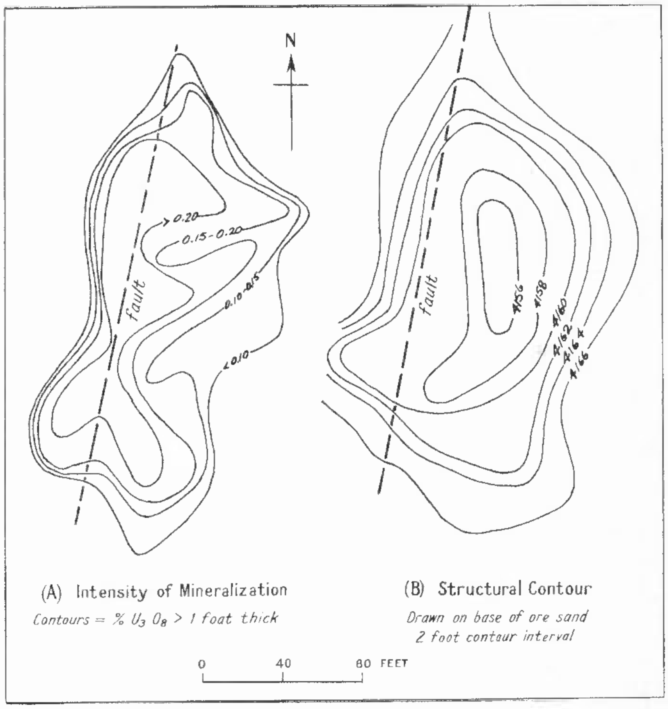

FIGURE 6. Comparison of uranium distribution (A) along faulting and channel scour (B).

A third collapse, the Orphan Lode mine (Fig. 1), is located 42 miles from the center of the district in the Grand Canyon National Park. This collapse is located at the base of the Permian Coconino formation and extends downward for an unknown distance containing high grade uranium ore. Mineralogy in the upper portions of the mine is genetically compatible with the mineralogy of the Cameron area in most of its accessory elements and assumes a characteristic hydrothermal character at depth.

The collapse structures in the Cameron district have not been opened to sufficient depth to confirm or deny a definite hydrothermal source, but the possibility of such a source exists. The significance of these collapse structures has only recently been realized, and active exploration is in its initial stages. A cursory reconnaissance has revealed that additional collapse structures occur in the district, and mineralization and bleaching or alteration of considerable extent is associated with them.

ACKNOWLEDGMENTS

This paper has been made possible through the cooperation of the U. S. Atomic Energy Commission. Both the Division of Research and the Division of Raw Materials have assisted this work in many ways.

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NNEPA 1992a

Navajo Superfund Program, Yazzie No. 1 Mine, Preliminary Assessment, February, 1992

4058

NAVAJO SUPERFUND PROGRAM

PRELIMINARY ASSESSMENT SUMMARY REPORT

YAZZIE NO. 1 MINE

February 1992

J.T. Morris

THE NAVAJO NATION

P.O. BOX 308 • WINDOW ROCK, ARIZONA 86515 • (602) 871-4941

PETERSON ZAH
PRESIDENT

MARSHALL PLUMMER
VICE PRESIDENT

March 9, 1992

Paul LaCourreye, Project Officer
Site Assessment, H-8-1
U.S. Environmental Protection Agency
75 Hawthorne Street
San Francisco, California 94105

Dear Mr. LaCourreye:

Please find enclosed the Preliminary Assessment Summary Report package and HRS Scoresheets for the **Yazzie No. 1 Mine** near Cameron, Arizona. This report has received NSP internal approval and is now ready for your review and comment.

Please call myself or J.T. Morris, the scientist who prepared the package, with any questions you may have regarding the report. We would appreciate a response in the form of comments or approval at your earliest convenience. You may reach myself or staff at: (602) 871-6859.

Sincerely,

THE NAVAJO NATION

JoAnne A. Manygoats, Manager
Navajo Superfund Program

Enclosure

4058

PURPOSE: CERCLA **Preliminary Assessment Summary** Report

SITE: Yazzie No. 1 Mine
Cameron, Navajo Nation
Coconino County, Arizona 86020

Site EPA ID Number: NND983466764

NSP Investigators : J.T. Morris

Date of Inspection: No Site Inspection

Report Prepared By: J.T. Morris, NSP

Through: Joanne Manygoats, Program Mgr.
Navajo Superfund Program

Report Date: February 26, 1992

Submitted To: Paul LaCourreye
Site Assessment Manager
U.S. EPA, Region 9

PA1 / COMP / DEFERRED / STATE LEAD
LAT = 35° 48' 27" N
LONG = 111° 18' 26" W

OK – 3/23/92
JM2

NND983[illegible]6764
YASSIE [illegible] MINE

NAVAJO - YAZZIE NO. 1 ABANDONED URANIUM MINE

PRELIMINARY ASSESSMENT SUMMARY REPORT

1. SITE DESCRIPTION

The Yazzie No. 1 abandoned uranium mine is a 15 acre site which includes a pit 100 feet long, 50 feet wide, and 30 feet deep (Appendix A). It is located in Coconino County, Arizona approximately 12.6 miles southeast of Cameron, Arizona and 0.5 miles east of the Little Colorado River (Fig. 1&2, Appendix A). Three hundred forty-three (343) tons of production-grade ore were removed during 1956-57. Site location is Township 27N, Range 10E, Section 15 (1, Appendix A). Geographic coordinates for the site are: Latitude 35°43'27" North, Longitude 111°18'26" (1, Appendix B).

2. REGULATORY INVOLVEMENT

The site has been inventoried by the Navajo Abandoned Mine Lands Department (NAML), and has been classified as a Priority 2 site (Appendix A). NAML is currently conducting a reclamation program of abandoned uranium mines in the Cameron area. The Yazzie No. 1 mine site is scheduled to be reclaimed in 1994 (Appendix A).

3. HAZARD RANKING SYSTEM FACTORS

* Moderate potential for livestock and area fauna contamination from pit surface water impoundment
* Low potential for groundwater contamination
* Low potential for surface water contamination of the Little Colorado River
* Moderate potential for soil exposure contamination
* Low potential for airborne particulate contamination

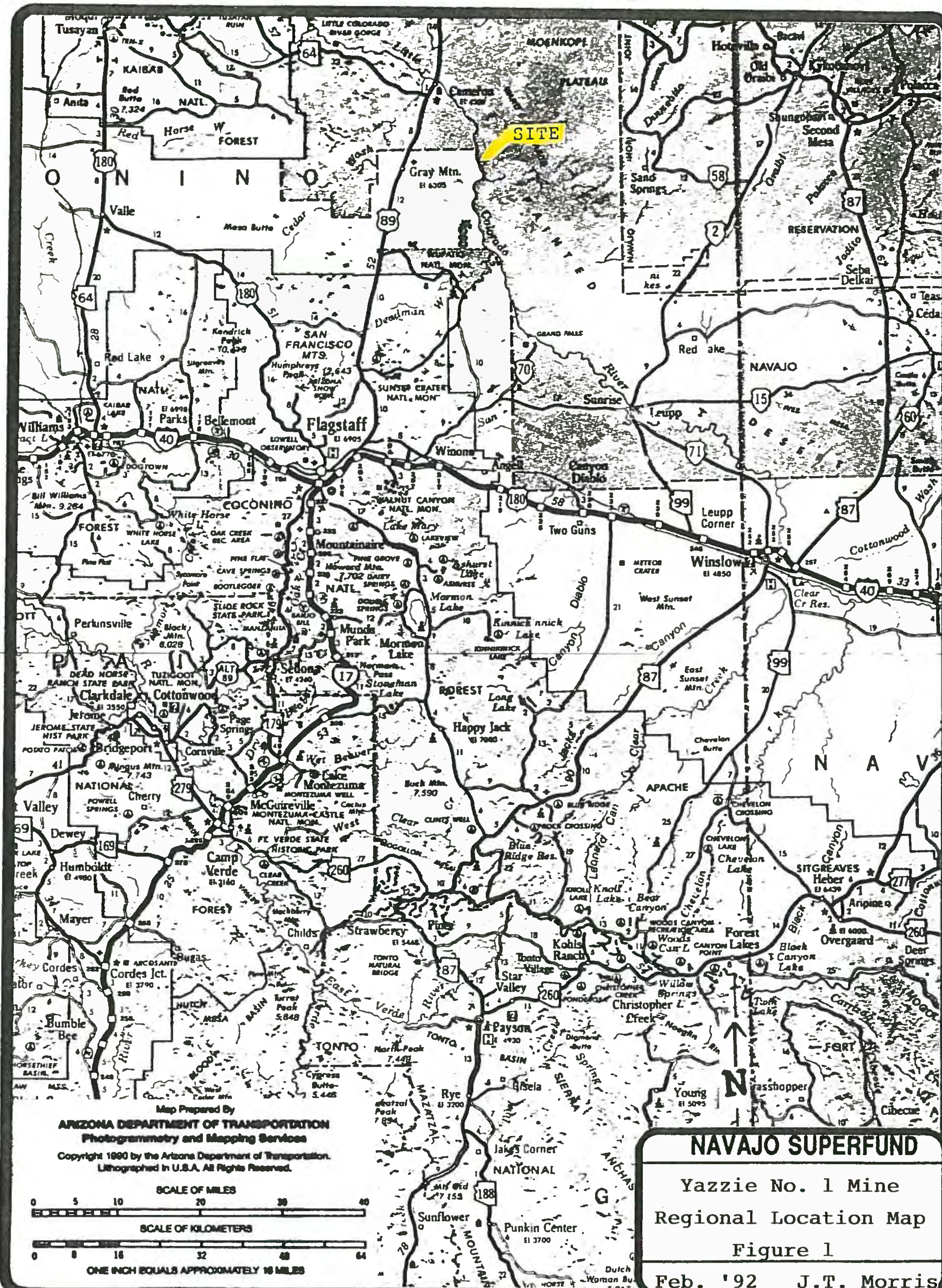
4. EMERGENCY RESPONSE CONSIDERATIONS

None

5. EPA RECOMMENDATIONS

	Initial	Date
No Further Remedial Action Under CERCLA		
Higher Priority <SSI or LSI> Under CERCLA		
Lower Priority <SSI or LSI> Under CERCLA		
Defer To Other Authority	[illegible]	3.23.92

NOTES: Defer to AML for follow up.



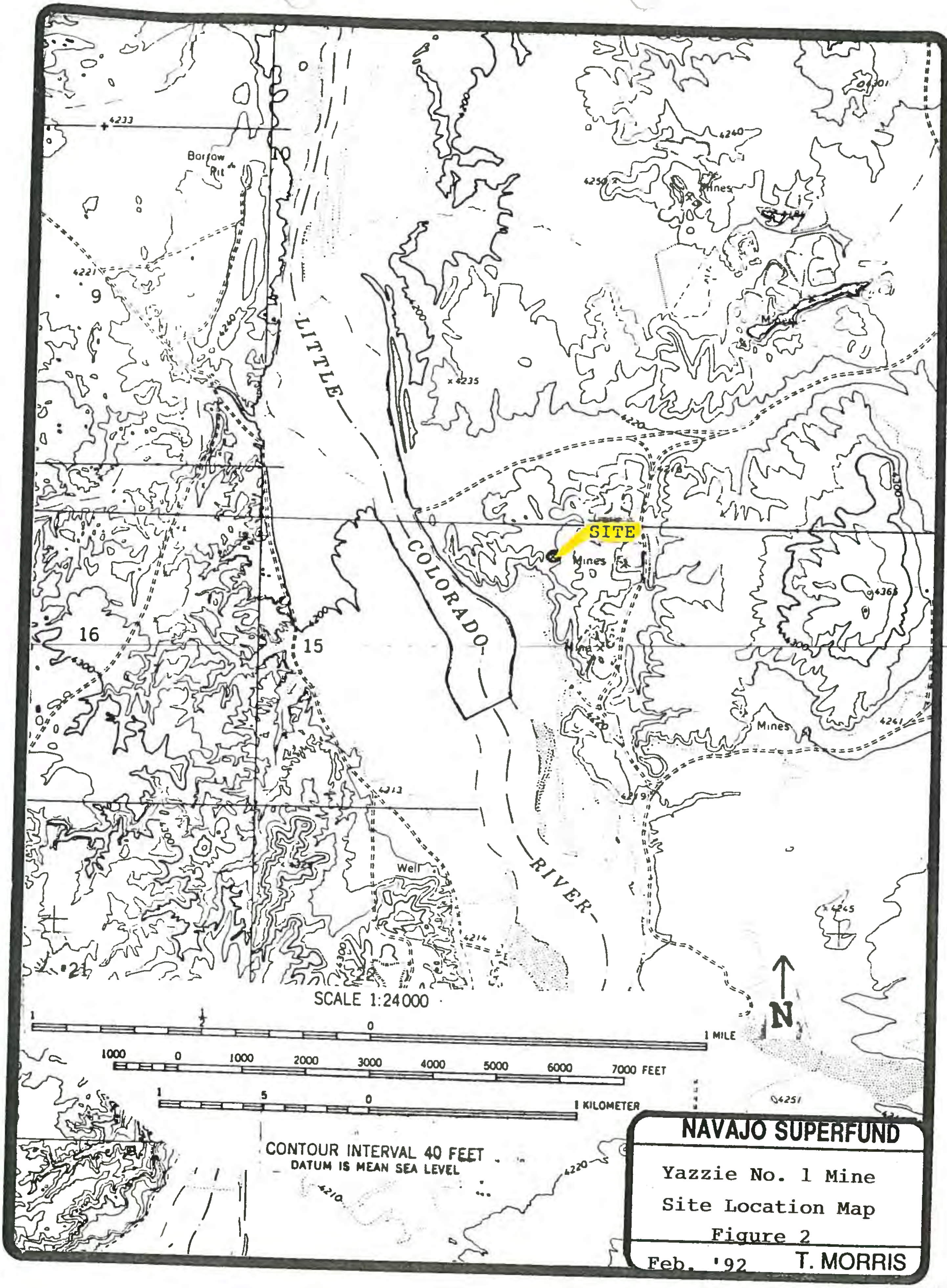
NAVAJO SUPERFUND

Yazzie No. 1 Mine

Regional Location Map

Figure 1

Feb. '92 J.T. Morris



NAVAJO SUPERFUND

Yazzie No. 1 Mine

Site Location Map

Figure 2

Feb. '92 T. MORRIS

REFERENCES

1. United States Geological Survey 7.5 minute quadrangle, Wupatki NE, Ariz. 1969.

APPENDIX A

CONTACT REPORTS

CONTACT REPORT

Meeting: (   ) **Telephone: (X)** **Other: (   )**

CONTACT LOCATION: Navajo Superfund Office

ADDRESS: P.O. Box 2946, Window Rock, AZ 86515

PERSON CONTACTED AND TITLE : Eunice Tso-dotson, Geologist
Navajo Abandoned Mine Lands Dept.

PHONE: 602/283-4845, 4847

FROM (Contacting Party) : J.T. Morris, NSP

DATE: 1/22/92

SUBJECT: Cameron Abandoned Uranium Mines: A&B No. 3, Boyd Tisi No. 2, Charles Huskon No. 26, and Yazzie No. 1.

CONTACT SUMMARY REPORT:

Boyd Tisi No. 2 mine site is scheduled for reclamation in 1993.

Yazzie No. 1 mine site is scheduled for reclamation in 1994.

CONTACT REPORT

Meeting: ( ) **Telephone: (X)** **Other: ( )**

CCONTACT LOCATION: Navajo Superfund Office

ADDRESS: P.O. Box 2946, Window Rock, AZ 86515

PERSON CONTACTED AND TITLE : John O'Brien, Mining Engineer
Navajo Abandoned Mine Lands Dept.

PHONE: 602/283-4845, 4847

FROM (Contacting Party) : J.T. Morris, NSP

DATE: 1/24/92, 2/7/92

SUBJECT: Cameron Abandoned Uranium Mines: A&B No. 3, Boyd Tisi No. 2, Charles Huskon No. 26, and Yazzie No. 1

CONTACT SUMMARY REPORT:

Navajo AML is conducting an abandoned uranium mine reclamation program on certain mines in the Cameron area.

John provided NSP with the Problem Area Data Sheets (PADS) for the four mines. See attached.

The A&B No. 3 mine site is an ore outcrop. The waste rock and low grade ore were dumped over the side of the mesa where the outcrop occurred. The other three sites are surface pit mines.

The A&B No. 3 mine site is not to be included in reclamation activities due to cost prohibitive accessibility to site waste and the lack of a pit to deposit the waste. The site has little human visitation and is barren of vegetation that would attract grazing livestock. No fencing or signs are to be erected that might draw attention to the site. Surface runoff from the site would either not make it to the Little Colorado River or would be greatly diluted upon entering the river depending on precipitation.

Area precipitation is 6 inches per year.

The A&B No.3 site has approximately 40 homes within 1 mile. The entire population of Cameron would be within the four mile radius.

There are no permanent populations within 4 mile radii of the Charles Huskon No. 26 and the Yazzie No. 1 sites.

The Huskon No. 26 site will be reclaimed with the adjacent Huskon No. 11 site in 1993 if monitoring shows radionuclide migration to the Little Colorado River.

C-77

DEPARTMENT OF THE INTERIOR
Office of Surface Mining
ABANDONED MINE LANDS INVENTORY UPDATE FORM

A. GENERAL AND LOCATIONAL DATA

1. Date Prepared: 10 / 11 / 88
2. Prepared by: C.M. Heaton
3. State/Tribe Name: Navajo
4. Telephone Number: (602) 729-2294
5. Problem Area (PA) No. ____
6. PA Name: Yazzie #1
7. N (Y/N) This PA has been previously submitted and is included in the National AML Inventory (If YES, skip to Part B).
8. Planning Unit (PU) No. ____
9. PU Name: ____
10. County Coconino
11. FIPS CODE (five digit) ____
12. ____ Congressional District Number
13. ____ 8-Digit Water Cataloging Unit (WCU) No. in which PA is located.
14. USGS Quadrangle(s) Wupatki NE (Principle Quad) ____ (Secondary Quad)

____ Other Quad(s)

15. 7½' Map Series (Enter 7.5', 15', or other basis)
16. ____ Map Sector (Enter NW, NC, NE, WC, CS, EC, SW, SC, or SE)
17. Principal Quadrangle Coordinates (found on SE map corner)

N ____ W ____

18. This PA is located ____ (Distance) Miles ____ (Direction)

NE¼ S15 T27N R10E

19. S (S/U/B/P) Type of last coal mining?

(S) Surface (U) Underground (B) Surf/Udgrd (P) Coal Processing

B. REASONS FOR UPDATE

20. B-1 Enter a letter and an applicable number.

A. Annual Submission of Projects. New Problem Area.

B. Construction Grant Application.

1. New Problem Area
2. New cost estimates
3. Existing Problem Area - new or more serious problems

C. Completion Report.

____ 1. State Reclamation ____ 2. Emergency

____ 3. Federal Reclamation ____ 4. RAMP

D. New Problem Area

E. New or more serious problems(s) at existing Problem Area.

F. Site visit indicates no problem changes.

C. DESCRIPTION OF HEALTH, SAFETY, AND GENERAL WELFARE PROBLEMS (HS&GW)
Priority 1 and 2 Problems (Check the space if the keyword is present)

21.	Extreme Danger Problems	Other HS&GW Problems		Extreme Danger Problems	Other HS&GW Problems
	Priority 1	Priority 2		Priority 1	Priority 2
VO	______	______	PWAI	______	______
P	______	______	PWHC	______	______
SB	______	______	S	______	______
GUB	______	______	HEF	______	______
GHE	______	______	IRW	______	______
DPE	______	______	HWB	______	______
DI	______	______	DH	______	______
DS	______	______	CS	______	______
			N (None)	______	______

PRIORITY 1 and 2 CRITERIA

22. N (Y/N) Has there been any occurrences of injury or death to a person, or accident or damage to property due to HS&GW problems.
23. N (Y/N) Have local residents/officials been interviewed regarding HS&GW problems in this PA.
24. Y (Y/N) Is there corrorborative evidence concerning the HS&GW problems?
25. Y (Y/N) Is there evidence of site visitation?
26. Y (Y/N) Are the HS&GW problems in this PA easily accessible?
27. 1.9 (Mi.) Distance to nearest population from this PA?
28. N (Y/N) Is this PA visible from public use areas?
29. 2 (0-3) How many people are directly impacted by the HS&GW problems?
(0) None (1) 1-10 (2) 11-100 (3) More than 100
30. S (S,M,O,U) Is there local support for reclamation of the HS&GW problems?
(S) Support (M) Mixed (O) Opposition (U) Unknown

D. EVIDENCE OF HEALTH, SAFFTY, AND GENERAL WELFARE PROBLEMS

31. Narrative evidence of Priority 1 problems: NA

AML INVENTORY UPDATE FORM

32. Narrative evidence of Priority 2 problems: (Pit 100 x 50 x 30') SWI, GWC?
TDA 15 acres much livestock use highwall on S side of pit
fencing, drainage req. Radiation readings at the perimeter of site
average at 30 µR and through the mine range between 120-300.
Anomalies through out the site ranged between 700 and
1000 µR. Water in the mine site

F. ENVIRONMENTAL RESTORATION PROBLEMS (Land and Water)

Problem Keyword		PRIORITY 3 Problems		Problem Keyword		PRIORITY 3 Problems	
33. Spoil Area	(SA)		acres	Mine Openings	(MO)		number
Bench	(BE)		acres	Slump	(SP)		acres
Pits	(PI)		acres	Highwall	(H)		Len. in ft.
Gob	(GO)		acres	Equip/Facil	(EF)		number
Slurry	(SL)		acres	Ind/Res Waste	(DP)		acres
Haul Road	(HR)		acres	Water Problems	(WA)		Gal/min.
				Other	(O)		
				NONE	(N)		
Total			acres				

G. EVIDENCE OF ENVIRONMENTAL RESTORATION PROBLEMS

34. Narrative evidence of Priority 3 problems:

343 tons @ .19% U_3O_8
oper 1956-57
Rcp base
photos 29-35 Roll 14
Rad

CONTACT REPORT

Meeting: ( ) **Telephone:** (X) **Other:** (X)

CONTACT LOCATION: Navajo Superfund Office

ADDRESS: P.O. Box 2946, Window Rock, AZ 86515

PERSON CONTACTED AND TITLE : Annette Polt, Data Manager
Navajo Natural Heritage Program
Fish and Wildlife Dept.

PHONE: 602/871-7060

FROM (Contacting Party) : J.T. Morris, NSP

DATE: 2/10/92

SUBJECT: Threatened and Endangered Species Information on Abandoned Uranium Mine Sites: A&B No. 3, Boyd Tisi No. 2, Charles Huskon No. 26, and Yazzie No. 1.

CONTACT SUMMARY REPORT:

See Attached Memorandum

THE NAVAJO NATION

P.O. BOX 308 • WINDOW ROCK, ARIZONA 86515 • (602) 871-4941

PETERSON ZAH
PRESIDENT

MARSHALL PLUMMER
VICE PRESIDENT

28 February 1992

M E M O R A N D U M

TO: Tom Morris, Environmental Specialist
Superfund Program
Environmental Protection Department

FROM: Annette Polt
Annette Polt, Data Manager
Natural Heritage Program
Fish & Wildlife Department

SUBJECT: SPECIES OF CONCERN FOR FOUR ABANDONED URANIUM MINES NEAR CAMERON, ARIZONA (YAZZIE NO. 1, HUSKON NO. 26, BOYD TISI NO. 2, AND A & B NO. 3)

A search of the Navajo Natural Heritage database has been completed in response to your 10 February 1992 information request concerning the subject projects. This search has identified several species of concern as either occurring or potentially occurring in the project areas. Individual mine sites are addressed separately below.

Tribal and federal status for each species is indicated as follows: Navajo Endangered Species List (NESL), Endangered Species Act (USESA), Migratory Bird Treaty Act (MBTA), and Bald Eagle Act (BEA). Information is not provided on state listing. Species included below which do not occur on any Navajo, federal, or state listing have no legal protection and are included for project planning and information gathering purposes only. Additionally, species with USESA candidate or NESL group 4 status have no legal protection under the USESA and the NESL, respectively.

YAZZIE NO. 1 MINE SITE

Four-mile radius, Yazzie No. 1

Species known to occur within a four-mile radius of the mine site include:

1. Astragalus sophoroides (Painted Desert milk-vetch).

Species with high potential to occur within a four-mile radius of the mine site include:

Species with **potential** to occur within 15 miles downstream of the mine site include:

2. Psorothamnus thompsonae var. whitingii (Whiting indigo bush); NESL group 4; USESA category 2 candidate.

Species with **less likely potential** to occur within 15 miles downstream of the mine site include:

3. Aechmophorus clarkii (Clark's grebe); NESL group 4.
4. Aquila chrysaetos (Golden eagle); NESL group 3; MBTA; BEA.
5. Butorides striatus (Green-backed heron); NESL group 4; MBTA.
6. Circus cyaneus (Northern harrier); NESL group 4; MBTA.
7. Dendroica petechia (Yellow warbler); NESL group 4; MBTA.
8. Empidonax traillii extimus (Southwestern willow flycatcher); NESL group 4; USESA category 2 candidate; MBTA.
9. Euderma maculatum (Spotted bat); NESL group 4; USESA category 2 candidate.
10. Haliaeetus leucocephalus (Bald eagle); NESL group 3; USESA endangered; MBTA; BEA. May migrate along the riparian corridor.
11. Lanius ludovicianus (Loggerhead shrike).
12. Nycticorax nycticorax (Black-crowned night heron); NESL group 4; MBTA.
13. Ovis canadensis nelsoni (Desert bighorn sheep); NESL group 3.
14. Porzana carolina (Sora); NESL group 4; MBTA.
15. Rana pipiens (Leopard frog); NESL group 4.
16. Tyto alba (Barn owl); NESL group 4; MBTA.
17. Xyrauchen texanus (Razorback sucker); NESL group 2; USESA proposed threatened.

HUSKON NO. MINE 26 SITE

Four-mile radius, Huskon No. 26

Species **known** to occur within a four-mile radius of the mine site include:

1. Astragalus sophoroides (Painted Desert milk-vetch).

Species with **high potential** to occur within a four-mile radius of the mine site include:

2. Astragalus beathii (Beath milk-vetch).
3. Cymopteris megacephalus (Bighead water parsnip); NESL group 4; USESA category 2 candidate.
4. Pediocactus peeblesianus var. fickeiseniae (Fickeisen plains cactus); NESL group 3; USESA category 1 candidate.
5. Lampropeltis triangulum (Milk snake); NESL group 4.

Species with **potential** to occur within a four-mile radius of the mine site include:

6. Circus cyaneus (Northern harrier); NESL group 4; MBTA.
7. Dendroica petechia (Yellow warbler); NESL group 4; MBTA.
8. Empidonax traillii extimus (Southwestern willow flycatcher); NESL group 4; USESA category 2 candidate; MBTA.
9. Euderma maculatum (Spotted bat); NESL group 4; USESA category 2 candidate.
10. Lanius ludovicianus (Loggerhead shrike).
11. Nycticorax nycticorax (Black-crowned night heron); NESL group 4; MBTA.
12. Ovis canadensis nelsoni (Desert bighorn sheep); NESL group 3.
13. Porzana carolina (Sora); NESL group 4; MBTA.
14. Rana pipiens (Leopard frog); NESL group 4.
15. Tyto alba (Barn owl); NESL group 4; MBTA.

Species with less likely potential to occur within 15 miles downstream of the mine site include:

16. Haliaeetus leucocephalus (Bald eagle); NESL group 3; USESA endangered; MBTA; BEA. May migrate along the riparian corridor.

BOYD TISI NO. 2 MINE SITE

Four-mile radius, Boyd Tisi No. 2

Species known to occur within a four-mile radius of the mine site include:

1. Amsonia peeblesii (Peebles blue-star); NESL group 4; USESA category 3C.
2. Astragalus beathii (Beath milk-vetch).
3. Phacelia welshii (Welsh phacelia); NESL group 4; USESA category 2 candidate.
4. Rana pipiens (Leopard frog); NESL group 4.

Species with high potential to occur within a four-mile radius of the mine site include:

5. Astragalus sophoroides (Painted Desert milk-vetch).
6. Cymopteris megacephalus (Bighead water parsnip); NESL group 4; USESA category 2 candidate.
7. Pediocactus peeblesianus var. fickeiseniae (Fickeisen plains cactus); NESL group 3; USESA category 1 candidate.

Species with potential to occur within a four-mile radius of the mine site include:

8. Eriogonum heermanii subracemosum (a wild-buckwheat).
9. Psorothamnus thompsonae var. whitingii (Whiting indigo bush); NESL group 4; USESA category 2 candidate.
10. Aquila chrysaetos (Golden eagle); NESL group 3; MBTA; BEA.
11. Charadrius montanus (Mountain plover); NESL group 4; USESA category 2 candidate; MBTA.

13. Haliaeetus leucocephalus (Bald eagle); NESL group 3; USESA endangered; MBTA; BEA. May migrate along the riparian corridor.
14. Lanius ludovicianus (Loggerhead shrike).
15. Nycticorax nycticorax (Black-crowned night heron); NESL group 4; MBTA.
16. Ovis canadensis nelsoni (Desert bighorn sheep); NESL group 3.
17. Porzana carolina (Sora); NESL group 4; MBTA.
18. Rana pipiens (Leopard frog); NESL group 4.
19. Tyto alba (Barn owl); NESL group 4; MBTA.
20. Xyrauchen texanus (Razorback sucker); NESL group 2; USESA proposed threatened.

A & B NO. 3 MINE SITE

Four-mile radius, A & B No. 3

Species known to occur within a four-mile radius of the mine site include:

1. Amsonia peeblesii (Peebles blue-star); NESL group 4; USESA category 3C.
2. Astragalus beathii (Beath milk-vetch).
3. Phacelia welshii (Welsh phacelia); NESL group 4; USESA category 2 candidate.
4. Rana pipiens (Leopard frog); NESL group 4.

Species with high potential to occur within a four-mile radius of the mine site include:

5. Cymopteris megacephalus (Bighead water parsnip); NESL group 4; USESA category 2 candidate.
6. Eriogonum heermanii subracemosum (a wild-buckwheat).
7. Pediocactus peeblesianus var. fickeiseniae (Fickeisen plains cactus); NESL group 3; USESA category 1 candidate.
8. Lampropeltis triangulum (Milk snake); NESL group 4.

Species with potential to occur within a four-mile radius of the mine site include:

9. Agave utahensis var. kaibabensis (Kaibab century plant); NESL group 4.
10. Astragalus sophoroides (Painted Desert milk-vetch).
11. Psorothamnus thompsonae var. whitingii (Whiting indigo bush); NESL group 4; USESA category 2 candidate.
12. Aquila chrysaetos (Golden eagle); NESL group 3; MBTA; BEA.
13. Charadrius montanus (Mountain plover); NESL group 4; USESA category 2 candidate; MBTA.
14. Dendroica petechia (Yellow warbler); NESL group 4; MBTA.
15. Empidonax traillii extimus (Southwestern willow flycatcher); NESL group 4; USESA category 2 candidate; MBTA.

15. Ovis canadensis nelsoni (Desert bighorn sheep); NESL group 3.
16. Porzana carolina (Sora); NESL group 4; MBTA.
17. Rana pipiens (Leopard frog); NESL group 4.
18. Tyto alba (Barn owl); NESL group 4; MBTA.

ALL SITES

Surveys should be conducted during the appropriate season for the species listed above. If you have questions pertaining to surveys, contact John Nystedt, Environmental Assessment Reviewer, Navajo Fish & Wildlife Department, at extension 7060.

Other sensitive species, including the federally listed Humpback chub (Gila cypha, NESL group 2, USESA endangered) and Razorback sucker (Xyrauchen texanus, NESL group 2, USESA proposed threatened) do occur downstream of the 15-mile limit and may be impacted by contaminants from the proposed project areas.

The information in this report is based on existing data known to the Heritage Program at this time. It should not be regarded as the final statement on the occurrence of any species of concern nor should it substitute for on-site surveys for these species. Also, because the Heritage database is continually updated and because information requests are evaluated by type of action, any given information response is only wholly appropriate for its respective request.

If you have any questions I may be reached at extension 7603.

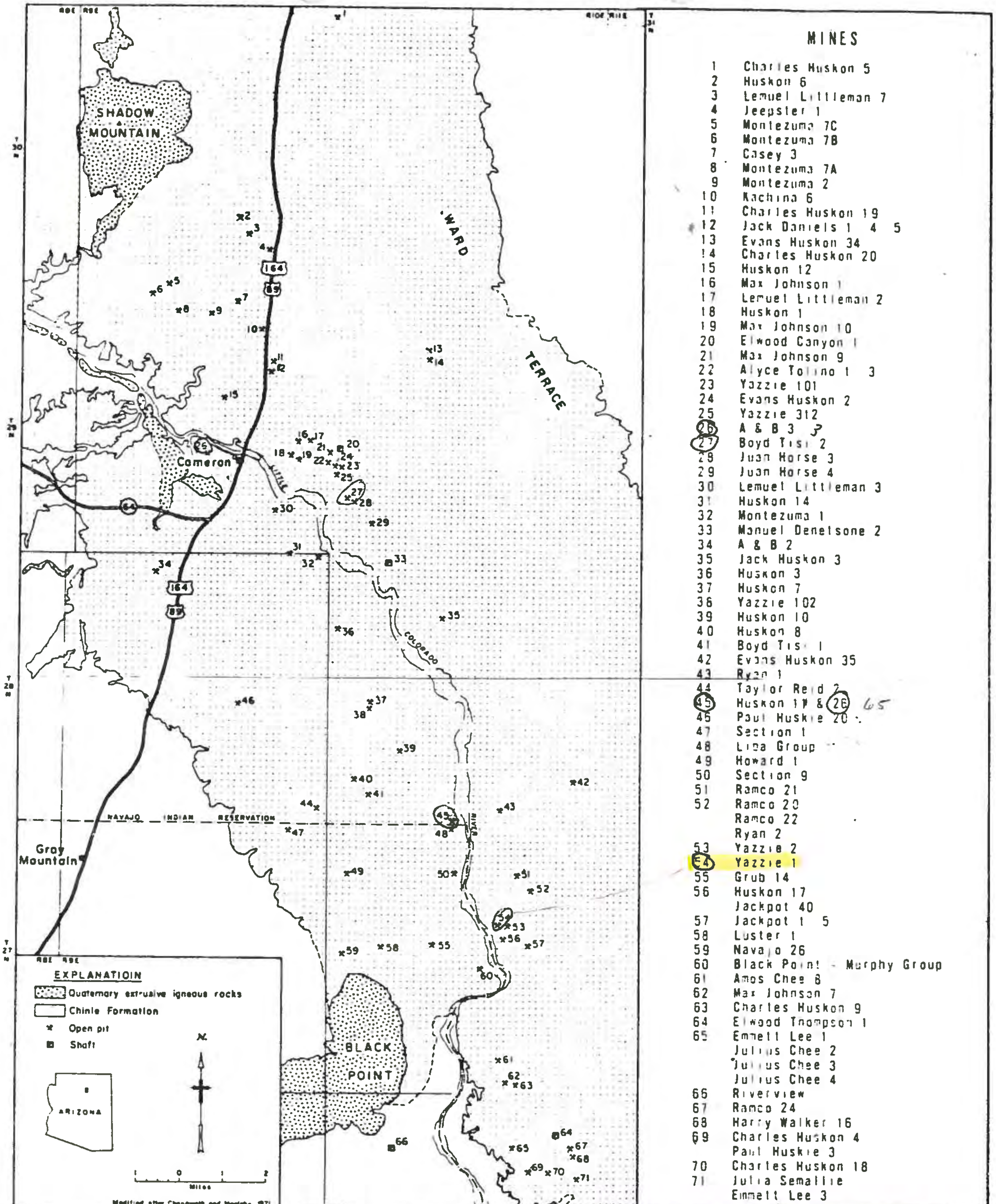


Figure 2.
Mine locations: Cameron area, Coconino County, Arizona.

THE NAVAJO NATION

P. O. DRAWER 308 • WINDOW ROCK, ARIZONA 86515 • (602) 871-6359

PETERSON ZAH
PRESIDENT

MARSHALL PLUMMER
VICE PRESIDENT

01 October 1991

M-E-M-O-R-A-N-D-U-M

TO: Sadie Hoskie, Director
Navajo Environmental Protection

FROM: Martin L. Begaye, Director
Navajo AML Reclamation Department

SUBJECT: REQUEST FOR INFORMATION ON CAMERON URANIUM MINES

In response to the request from Joanne Manygoats, Program Manager, Navajo Superfund Program, attached are the Navajo Reclamation Department's anticipated reclamation/abatement projects in the Cameron, Arizona area for the next four years. The projects are subject to approval by the U.S. Office of Surface Mining, and concurrence by the Hopi tribe.

It ~~has been noted that~~ the Superfund Program ~~and our department~~ have been assessing uranium mines on the reservation, sometimes the same ones but probably for different purposes. Our objective is surface directed: to remove physical hazards and restore the lands as much as possible. Further, by SMCRA mandate, we can only address mines abandoned prior to August 3, 1977 and where there is no responsible party. In order to avoid duplication of effort and ensure a more comprehensive cleanup of uranium mines, I recommend a Cooperative Agreement between our two entities. I suggest a meeting with you and your key staff and my staff to work out a cooperative effort.

Please contact me at extension 6359 to plan for such a meeting.

Martin L. Begaye

xc: Anderson Morgan, Executive Director, Natural Resources (w/attachment)
Joanne Manygoats, Superfund Program (w/o attachment)
Perry H. Charley, Shiprock AML (w/o attachment)
John O'Brien, Tuba City AML (w/o attachment)

Table 1

URANIUM MINES AND OCCURRENCES

YEAR 2: 1993

INDEX	NAME
1	Earl Huskon No. 1
2	Earl Huskon No. 21
3	Earl Huskon No. 3
4	A & B No. 5
5	Charles Huskon No. 7 (MP-357)
6	Lemuel Littleman No. 6
7	A & B No. 13
8	A & B No. 7
9	Charles Huskon No. 5
10	Foley No. 1
11	Charles Huskon No. 6
12	Lemuel Littleman No. 1 & 7
13	Jeepster No. 1
14	Montezuma No. 7C
15a-c	Montezuma No. 7B
16	Montezuma No. 7A
17a,b	Montezuma No. 2
18	Casey No. 3
19	Kachina No. 6
20	Paul Huskie No. 4
21	Evans Huskon No. 34
22	Charles Huskon No. 20
23	Charles Huskon No. 19
24	Jack Daniels No. 1-5
25	Charles Huskon No. 12
26	A & B No. 3
27	Max Johnson No. 1
28a,b	Lemuel Littleman No. 2
29	Charles Huskon No. 1
30	Max Johnson No. 10
31	Max Johnson No. 9
32	Elwood Canyon No. 1
33	Harvey Begay No. 1
34	Alyce Tolino No. 1 & 3
35	Evans Huskon No. 2
36	Yazzie No. 101
37	Yazzie No. 312
38	Boyd Tisi No. 2
39	Juan Horse No. 3
40	Lemuel Littleman No. 3
41	Juan Horse No. 4
42	Pat Lynch
43	Charles Huskon No. 14
44	Montezuma No. 1
45	Manuel Denetsone No. 2
46	Jack Huskon No. 3
47	A & B No. 2
48	Jack Huskon No. 3
49	Charles Huskon No. 3
50	Jack Huskon No. 1
51	Blackhair No. 4
52	Paul Huskie No. 1 & 2, and No. 20
53	Charles Huskon No. 7 (MP-65)
54	Yazzie No. 102
55a,b	Charles Huskon No. 10
56	Yazzie No. 105
57	Lloyd House
58a,b	Charles Huskon No. 8
59	Boyd Tisi No. 1
60	Evans Huskon No. 35
61	Max Johnson No. 4
62	Mel Gardner
63	Ryan No. 1
64	Taylor Reid No. 2
65	Charles Huskon No. 26
66	Charles Huskon No. 11

INDEX	NAME
72a,b	Ramco No. 21
73	Ramco No. 22
74	Ramco No. 20
75	Ryan No. 2
76	Jackpot No. 7
77	Jackpot No. 8
78	Jackpot No. 6
79	Yazzie No. 1
80	Yazzie No. 2
84	Charles Huskon No. 17
85	Jackpot No. 40
86	Jackpot No. 1
87	Jackpot No. 5
89	Amos Chee No. 8
90	Amos Chee No. 7
91	Charles Huskon No. 9
92	Elwood Thompson No. 1
94	Emmett Lee No. 1, and
"	Julius Chee No. 3 & 4
95	Julius Chee No. 2
96a,b	Ramco No. 24, and
"	Harry Walker No. 16
97	Charles Huskon No. 4
98	Paul Huskie No. 3
99	Charles Huskon No. 18
100	Emmett Lee No. 3 and
"	Julia Semallie

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, Ca. 94105-3901

RECEIVED
FEB 03 1992
Navajo Superfund Office

January 30, 1992

Dr. Jonathan P. Deason
Director
Office of Environmental Affairs
U.S. Department of the Interior
1849 C. Street NW PEA (MS2340)
Washington DC 20240

RE: Abandoned Uranium Mine Issues on the Navajo Nation

Dear Dr. Deason:

Thank you for the participation of your staff at the January 22, 1992, meeting in Albuquerque to discuss the Federal Agencies role in the reclamation of abandoned uranium mines on the Navajo Nation. Present at the meeting were representatives of the Department of the Interior's Office of Environmental Affairs (OEA), Bureau of Land Management (BLM), Bureau of Indian Affairs (BIA), Office of Surface Mining (OSM), and Solicitor's Office. EPA was represented by members of my Site Evaluation Section and Emergency Response Section. A representative from Region's 9 ATSDR staff was also present, along with representatives from the Navajo Abandoned Mine Land Program (NAMLP) and Navajo Superfund Program (NSP).

It was concluded that there exist numerous abandoned uranium mine sites on the Navajo Nation that pose significant safety, health and environmental hazards. It was agreed upon in principle, that the OSM, under the authority of the Surface Mine Control Reclamation Act of 1977, will continue to authorize the Navajo Abandoned Mine Land Program to prioritize and reclaim abandoned uranium mine sites on the Navajo Nation. The NSP will assist the NAMLP in developing radiation and reclamation standards.

The NSP through the use of EPA's Preliminary Assessment/Site Investigations (PA/SI) grant will conduct preliminary assessments on sites that are ineligible for SMCRA funding. In addition, the NSP may conduct PA's on sites that the NAMLP has not been able to adequately address in a timely fashion and on sites that have additional hazards that NAMLP can not address. These efforts will be coordinated between the two Navajo agencies in consultation with EPA and OSM.

It was also agreed that EPA, OSM, NAMLP and NSP will work together to review the progress of reclamation actions on the Navajo Nation. The NAMLP and the NSP will coordinate activities in

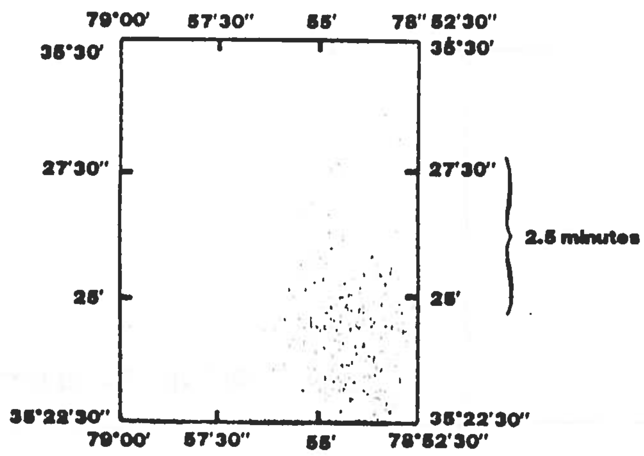
APPENDIX B

LATITUDE AND LONGITUDE CALCULATION

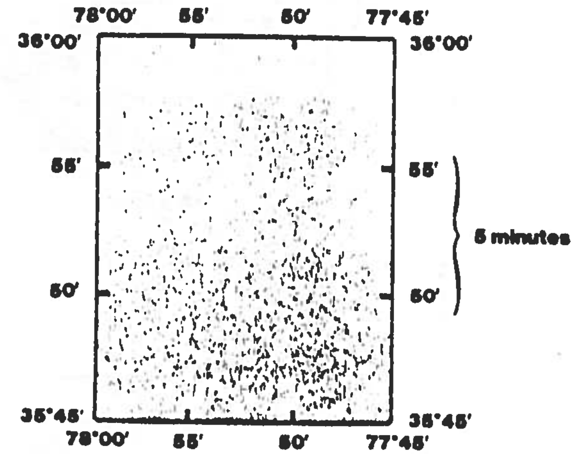
DIRECTIONS FOR USE OF THE TOPO-AID™

The Topo-Aid™ can be used to determine the longitude and latitude of a point on U.S.G.S. 7.5-minute and 15-minute topographic maps, or, to find a point for which the coordinates are known.

U.S.G.S. topographic maps indicate the longitude and latitude at 12 places. At the four corners the entire latitude and longitude is given. Between each corner are two additional grid tics at intervals of 2.5 minutes on 7.5-minute maps and 5 minutes on 15-minute maps:

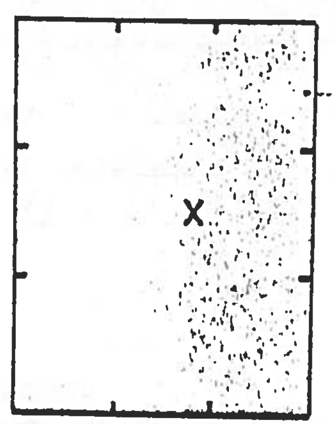


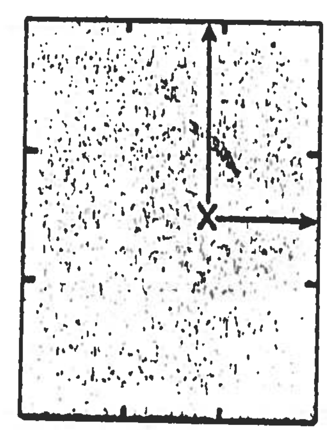
7.5 minute series



15-minute series

Example of use; find the coordinates of the "X"





First, project the point normal to the nearest borders. Next, place the Topo-Aid™ as shown below between the grid tics that the point falls between. The horizontal bars on the Topo-Aid™ should be

NNEPA 1992b

Navajo Superfund Program, Charles Huskon No. 26 Mine, Preliminary Assessment, February, 1992

3809

NAVAJO SUPERFUND PROGRAM

PRELIMINARY ASSESSMENT SUMMARY REPORT

CHARLES HUSKON NO. 26 MINE

February 1992

J.T. Morris

THE NAVAJO NATION

P.O. BOX 308 • WINDOW ROCK, ARIZONA 86515 • (602) 871-4941

PETERSON ZAH
PRESIDENT

MARSHALL PLUMMER
VICE PRESIDENT

March 9, 1992

Paul LaCourreye, Project Officer
Site Assessment, H-8-1
U.S. Environmental Protection Agency
75 Hawthorne Street
San Francisco, California 94105

Dear Mr. LaCourreye:

Please find enclosed the Preliminary Assessment Summary Report package and HRS Scoresheets for the **Charles Huskon No. 26 Mine** near Cameron, Arizona. This report has received NSP internal approval and is now ready for your review and comment.

Please call myself or J.T. Morris, the scientist who prepared the package, with any questions you may have regarding the report. We would appreciate a response in the form of comments or approval at your earliest convenience. You may reach myself or staff at: (602) 871-6859.

Sincerely,

THE NAVAJO NATION

JoAnne A. Manygoats, Manager
Navajo Superfund Program

Enclosure

PURPOSE: CERCLA **Preliminary Assessment Summary** Report

SITE: Charles Huskon No. 26 Mine
Cameron, Navajo Nation
Coconino County, Arizona 86020

Site EPA ID Number: NND983466749

NSP Investigators : J.T. Morris

Date of Inspection: No Site Inspection

Report Prepared By: J.T. Morris, NSP

Through: Joanne Manygoats, Program Mgr.
Navajo Superfund Program

Report Date: February 26, 1992

Submitted To: Paul LaCourreye
Site Assessment Manager
U.S. EPA, Region 9

PA1 COMP / DEFERRED / STATE LEAD
LAT = 35° 45' 31" N
LONG = 111° 19' 50" W

OK - 3/23/92
JMS

NMD98346[illegible]49

CHARLES HUSKON NO. 26 MINE

NAVAJO - CHARLES HUSKON No. 26 ABANDONED URANIUM MINE

PRELIMINARY ASSESSMENT SUMMARY REPORT

1. SITE DESCRIPTION

The Charles Huskon No. 26 abandoned uranium mine site is a minor scraper pit 0.3 acres in size including waste (Appendix A). It is located in Coconino County, Arizona approximately 10 miles southeast of Cameron, Arizona and approximately 0.25 miles west of the Little Colorado River (Fig. 1&2, Appendix A). Eighteen (18) tons of production-grade ore were removed during 1957 (Appendix A). Site location is Township 28N, Range 10E, Section 33 (1, Appendix A). Geographic coordinates for the site are: Latitude 35°45'31" North, Longitude 111°19'50" (1, Appendix B).

2. REGULATORY INVOLVEMENT

Huskon No. 26 has been inventoried by the Navajo Abandoned Mine Lands Department (NAML), and has been classified as a Priority 3 site (Appendix A). Huskon No. 26 will be included in the reclamation of a larger, adjacent site (Huskon No. 11) in 1993 if radiometric monitoring shows that radionuclide migration to the Little Colorado River is occurring (Appendix A).

3. HAZARD RANKING SYSTEM FACTORS

* Low potential for groundwater contamination
* Low potential for surface water contamination of the Little Colorado River
* Moderate potential for soil exposure contamination
* Low potential for airborne particulate contamination

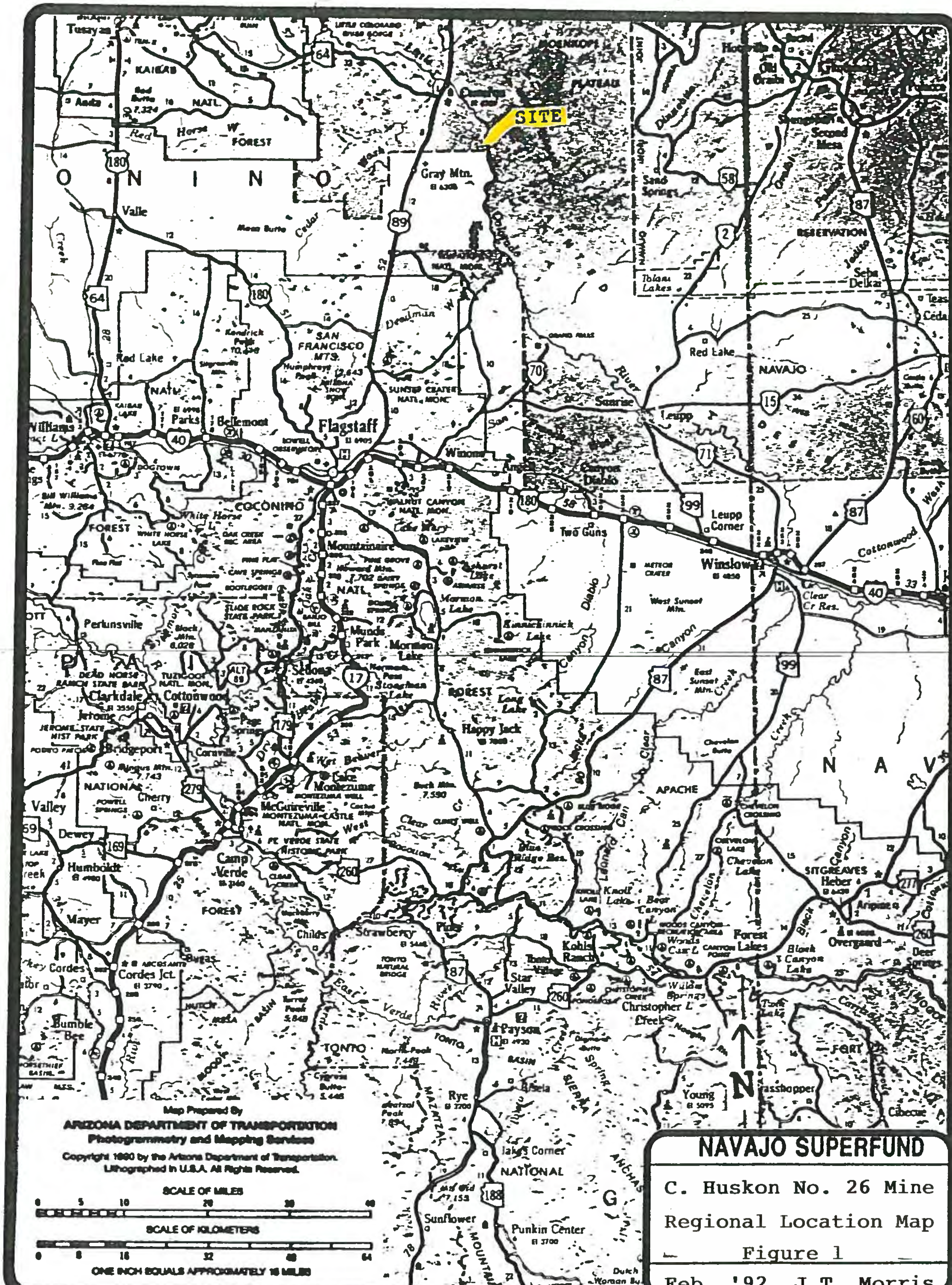
4. EMERGENCY RESPONSE CONSIDERATIONS

None

5. EPA RECOMMENDATIONS

	Initial	Date
No Further Remedial Action Under CERCLA		
Higher Priority <SSI or LSI> Under CERCLA		
Lower Priority <SSI or LSI> Under CERCLA		
Defer To Other Authority	[signature]	3.23.92

NOTES:



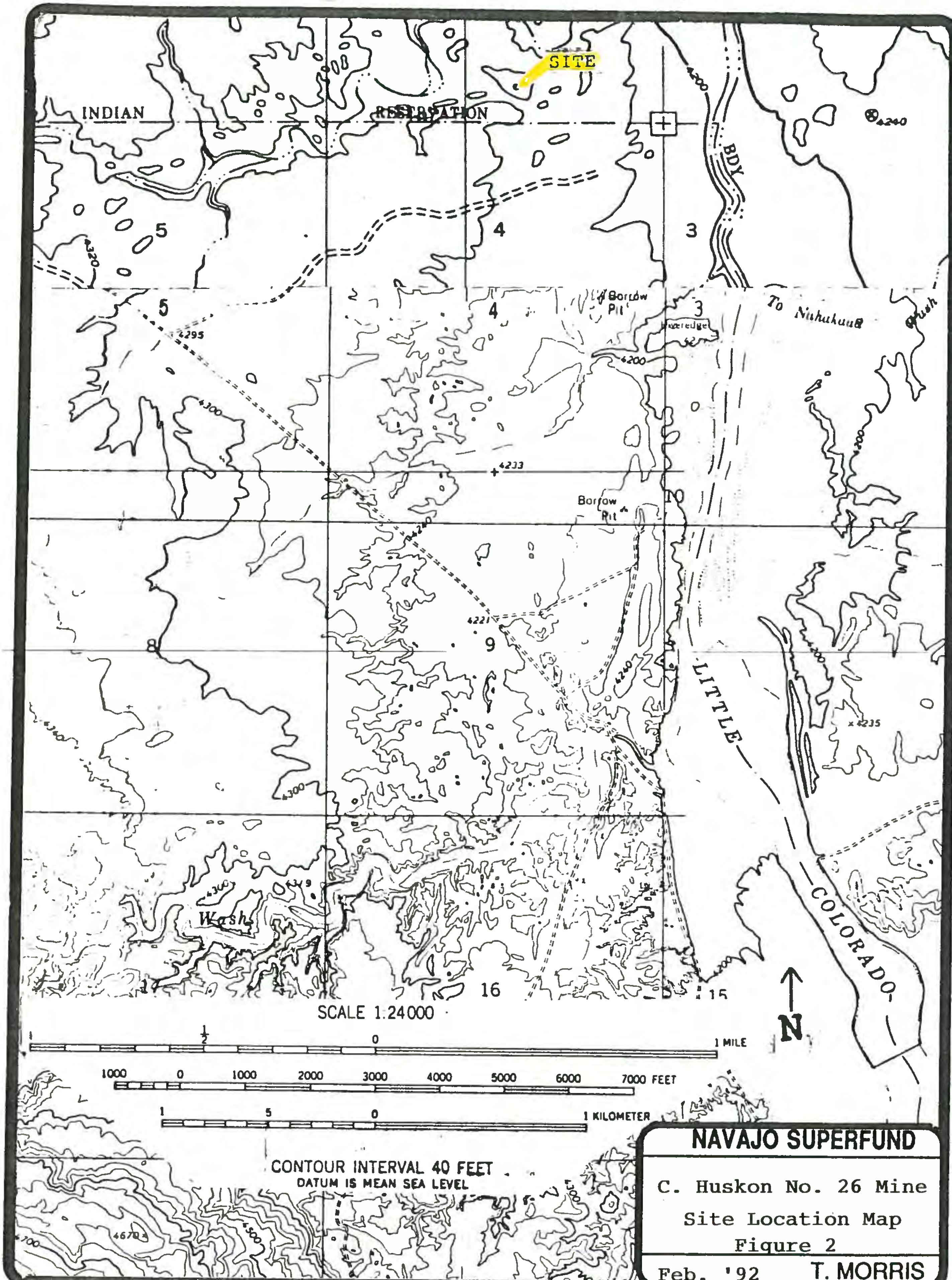
NAVAJO SUPERFUND

C. Huskon No. 26 Mine

Regional Location Map

Figure 1

Feb. '92 J.T. Morris



NAVAJO SUPERFUND

C. Huskon No. 26 Mine
Site Location Map
Figure 2

Feb. '92 T. MORRIS

REFERENCES

1. United States Geological Survey 7.5 minute quadrangle, Cameron SE, Ariz. 1955.

APPENDIX A

CONTACT REPORTS

CONTACT REPORT

Meeting: (   ) **Telephone: (X)** **Other: (   )**

CONTACT LOCATION: Navajo Superfund Office

ADDRESS: P.O. Box 2946, Window Rock, AZ 86515

PERSON CONTACTED AND TITLE : Eunice Tso-dotson, Geologist
Navajo Abandoned Mine Lands Dept.

PHONE: 602/283-4845, 4847

FROM (Contacting Party) : J.T. Morris, NSP

DATE: 1/22/92

SUBJECT: Cameron Abandoned Uranium Mines: A&B No. 3, Boyd Tisi No. 2, Charles Huskon No. 26, and Yazzie No. 1.

CONTACT SUMMARY REPORT:

Boyd Tisi No. 2 mine site is scheduled for reclamation in 1993.

Yazzie No. 1 mine site is scheduled for reclamation in 1994.

CONTACT REPORT

Meeting: ( ) Telephone: (X) Other: ( )

CCONTACT LOCATION: Navajo Superfund Office

ADDRESS: P.O. Box 2946, Window Rock, AZ 86515

PERSON CONTACTED
AND TITLE : John O'Brien, Mining Engineer
Navajo Abandoned Mine Lands Dept.

PHONE: 602/283-4845, 4847

FROM (Contacting
Party) : J.T. Morris, NSP

DATE: 1/24/92, 2/7/92

SUBJECT: Cameron Abandoned Uranium Mines: A&B No. 3, Boyd Tisi No. 2, Charles Huskon No. 26, and Yazzie No. 1

CONTACT SUMMARY REPORT:

Navajo AML is conducting an abandoned uranium mine reclamation program on certain mines in the Cameron area.

John provided NSP with the Problem Area Data Sheets (PADS) for the four mines. See attached.

The A&B No. 3 mine site is an ore outcrop. The waste rock and low grade ore were dumped over the side of the mesa where the outcrop occurred. The other three sites are surface pit mines.

The A&B No. 3 mine site is not to be included in reclamation activities due to cost prohibitive accessibility to site waste and the lack of a pit to deposit the waste. The site has little human visitation and is barren of vegetation that would attract grazing livestock. No fencing or signs are to be erected that might draw attention to the site. Surface runoff from the site would either not make it to the Little Colorado River or would be greatly diluted upon entering the river depending on precipitation.

Area precipitation is 6 inches per year.

The A&B No.3 site has approximately 40 homes within 1 mile. The entire population of Cameron would be within the four mile radius.

There are no permanent populations within 4 mile radii of the Charles Huskon No. 26 and the Yazzie No. 1 sites.

The Huskon No. 26 site will be reclaimed with the adjacent Huskon No. 11 site in 1993 if monitoring shows radionuclide migration to the Little Colorado River.

1-65

DEPARTMENT OF THE INTERIOR
Office of Surface Mining
ABANDONED MINE LANDS INVENTORY UPDATE FORM

A. GENERAL AND LOCATIONAL DATA

1. Date Prepared: 9/14/88
2. Prepared by: C.M. Heaton
3. State/Tribe Name: Navajo AML
4. Telephone Number: 602-729-2294
5. Problem Area (PA) No. ____
6. PA Name: Charles Huskon #26
7. N (Y/N) This PA has been previously submitted and is included in the National AML Inventory (If YES, skip to Part B).
8. Planning Unit (PU) No. ____
9. PU Name: ____
10. County Coconino
11. FIPS CODE (five digit) ____
12. ____ Congressional District Number
13. ____ 8-Digit Water Cataloging Unit (WCU) No. in which PA is located.
14. USGS Quadrangle(s) Cameron (Principal Quad) ____ (Secondary Quad)

____ Other Quad(s)

15. 15' Map Series (Enter 7.5', 15', or other basis)
16. ____ Map Sector (Enter NW, NC, NE, WC, CS, EC, SW, SC, or SE)
17. Principal Quadrangle Coordinates (found on SE map corner)
    N ____ W ____
18. This PA is located ____ (Distance) Miles ____ (Direction)
    SE 1/4 S33 T28N R10E
    From (City, Town, Village, Highway, or other prominent feature on map)
19. S (S/U/B/P) Type of last coal mining?
    (S)Surface (U)Underground (B)Surf/Undgrd (P)Coal Processing

B. REASONS FOR UPDATE

20. B-1 Enter a letter and an applicable number.
    - A. Annual Submission of Projects. New Problem Area.
    - B. Construction Grant Application.
        1. New Problem Area
        2. New cost estimates
        3. Existing Problem Area - new or more serious problems
    - C. Completion Report.
        ____ 1. State Reclamation ____ 2. Emergency
        ____ 3. Federal Reclamation ____ 4. RAMP
    - D. New Problem Area
    - E. New or more serious problem(s) at existing Problem Area.
    - F. Site visit indicates no problem changes.

AML INVENTORY UPDATE FORM (Continued)

C. DESCRIPTION OF HEALTH, SAFETY, AND GENERAL WELFARE PROBLEMS (HS&GW) Priority 1 and 2 Problems (Check the space if the keyword is present)

21.

	Extreme Danger Problems Priority 1	Other HS&GW Problems Priority 2		Extreme Danger Problems Priority 1	Other HS&GW Problems Priority 2
VO	____	____	PWAI	____	____
P	____	____	PWHC	____	____
SB	____	____	S	____	____
GUB	____	____	HEF	____	____
GHE	____	____	IRW	____	____
DPE	____	____	HWB	____	____
DI	____	____	DH	____	____
DS	____	____	CS	____	____
			N (None)	____	____

D. PRIORITY 1 AND 2 CRITERIA

22. N (Y/N) Has there been any occurrences of injury or death to a person, or accident or damage to property due to HS&GW problems?
23. N (Y/N) Have local residents/officials been interviewed regarding HS&GW problems in this PA?
24. N (Y/N) Is there corrorborative evidence concerning the HS&GW problems?
25. Y (Y/N) Is there evidence of site visitation?
26. N (Y/N) Are the HS&GW problems in this PA easily accessible?
27. 4.0 (Mi.) Distance to nearest population from this PA?
28. N (Y/N) Is this PA visible from public use areas?
29. 1 (0-3) How many people are directly impacted by the HS&GW problems?
    (0) None (1) 1-10 (2) 11-100 (3) More than 100
30. S (S,M,O,U) Is there local support for reclamation of the HS&GW problems?
    (S) Support (M) Mixed (O) Opposition (U) Unknown

E. EVIDENCE OF HEALTH, SAFETY, AND GENERAL WELFARE PROBLEMS

31. Narrative evidence of Priority 1 problems: NA

AML INVENTORY UPDATE FORM (Continued)

32. Narrative evidence of Priority 2 problems: NA

F. ENVIRONMENTAL RESTORATION PROBLEMS (Land and Water)

	Problem Keyword		Priority 3 Problems		Problem Keyword		Priority 3 Problems	
33.	Spoil Area	(SA)	.2	acres	Mine Openings	(MO)		number
	Bench	(BE)		acres	Slump	(SP)		acres
	Pits	(PI)	.1	acres	Highwall	(H)		Len. in ft.
	Gob	(GO)		acres	Equip/Facil	(EF)		number
	Slurry	(SL)		acres	Ind/Res Waste	(WA)		acres
	Haul Road	(HR)		acres	Water Problems	(WA)		Gal/min.
					Other	(O)		
					NONE	(N)		
	Total		.3	acres				

G. EVIDENCE OF ENVIRONMENTAL RESTORATION PROBLEMS

34. Narrative evidence of Priority 3 problems: Minor scraper pit on surface outcrop of Shinarump. 2 small gob piles present. No surface impoundments of water, no ground water contamination obvious, no fence needed. TDA, Sec.

Photos. roll #5 shots 1-3

Rad 500 uR / 50 uR

AML INVENTORY UPDATE FORM (Continued)

H. RECLAMATION COST

35. $ _______ Priority 1 (Extreme Danger Problems) estimated reclamation cost.

36. Priority 1 Cost Estimate Justification: NA

37. $ _______ Priority 2 (Other HS&GW Problems) estimated reclamation cost.

38. Priority 2 Cost Estimate Justification: NA

39. $ _______ Priority 3 (Environ. Restor.) estimated reclamation cost.

40. Priority 3 Cost Estimate Justification:

18 tons @ .12% U_3O_8

oper 1957

RCS

CONTACT REPORT

Meeting: ( ) **Telephone: (X)** **Other: (X)**

CONTACT LOCATION: Navajo Superfund Office

ADDRESS: P.O. Box 2946, Window Rock, AZ 86515

PERSON CONTACTED AND TITLE : Annette Polt, Data Manager
Navajo Natural Heritage Program
Fish and Wildlife Dept.

PHONE: 602/871-7060

FROM (Contacting Party) : J.T. Morris, NSP

DATE: 2/10/92

SUBJECT: Threatened and Endangered Species Information on Abandoned Uranium Mine Sites: A&B No. 3, Boyd Tisi No. 2, Charles Huskon No. 26, and Yazzie No. 1.

CONTACT SUMMARY REPORT:

See Attached Memorandum

THE NAVAJO NATION

P.O. BOX 308 • WINDOW ROCK, ARIZONA 86515 • (602) 871-4941

PETERSON ZAH
PRESIDENT

MARSHALL PLUMMER
VICE PRESIDENT

28 February 1992

M E M O R A N D U M

TO: Tom Morris, Environmental Specialist
Superfund Program
Environmental Protection Department

FROM: Annette Polt
Annette Polt, Data Manager
Natural Heritage Program
Fish & Wildlife Department

SUBJECT: SPECIES OF CONCERN FOR FOUR ABANDONED URANIUM MINES NEAR CAMERON, ARIZONA (YAZZIE NO. 1, HUSKON NO. 26, BOYD TISI NO. 2, AND A & B NO. 3)

A search of the Navajo Natural Heritage database has been completed in response to your 10 February 1992 information request concerning the subject projects. This search has identified several species of concern as either occurring or potentially occurring in the project areas. Individual mine sites are addressed separately below.

Tribal and federal status for each species is indicated as follows: Navajo Endangered Species List (NESL), Endangered Species Act (USESA), Migratory Bird Treaty Act (MBTA), and Bald Eagle Act (BEA). Information is not provided on state listing. Species included below which do not occur on any Navajo, federal, or state listing have no legal protection and are included for project planning and information gathering purposes only. Additionally, species with USESA candidate or NESL group 4 status have no legal protection under the USESA and the NESL, respectively.

YAZZIE NO. 1 MINE SITE

Four-mile radius, Yazzie No. 1

Species known to occur within a four-mile radius of the mine site include:

1. *Astragalus sophoroides* (Painted Desert milk-vetch).

Species with high potential to occur within a four-mile radius of the mine site include:

Species with potential to occur within 15 miles downstream of the mine site include:

2. Psorothamnus thompsonae var. whitingii (Whiting indigo bush); NESL group 4; USESA category 2 candidate.

Species with less likely potential to occur within 15 miles downstream of the mine site include:

3. Aechmophorus clarkii (Clark's grebe); NESL group 4.
4. Aquila chrysaetos (Golden eagle); NESL group 3; MBTA; BEA.
5. Butorides striatus (Green-backed heron); NESL group 4; MBTA.
6. Circus cyaneus (Northern harrier); NESL group 4; MBTA.
7. Dendroica petechia (Yellow warbler); NESL group 4; MBTA.
8. Empidonax traillii extimus (Southwestern willow flycatcher); NESL group 4; USESA category 2 candidate; MBTA.
9. Euderma maculatum (Spotted bat); NESL group 4; USESA category 2 candidate.
10. Haliaeetus leucocephalus (Bald eagle); NESL group 3; USESA endangered; MBTA; BEA. May migrate along the riparian corridor.
11. Lanius ludovicianus (Loggerhead shrike).
12. Nycticorax nycticorax (Black-crowned night heron); NESL group 4; MBTA.
13. Ovis canadensis nelsoni (Desert bighorn sheep); NESL group 3.
14. Porzana carolina (Sora); NESL group 4; MBTA.
15. Rana pipiens (Leopard frog); NESL group 4.
16. Tyto alba (Barn owl); NESL group 4; MBTA.
17. Xyrauchen texanus (Razorback sucker); NESL group 2; USESA proposed threatened.

HUSKON NO. MINE 26 SITE

Four-mile radius, Huskon No. 26

Species known to occur within a four-mile radius of the mine site include:

1. Astragalus sophoroides (Painted Desert milk-vetch).

Species with high potential to occur within a four-mile radius of the mine site include:

2. Astragalus beathii (Beath milk-vetch).
3. Cymopteris megacephalus (Bighead water parsnip); NESL group 4; USESA category 2 candidate.
4. Pediocactus peeblesianus var. fickeiseniae (Fickeisen plains cactus); NESL group 3; USESA category 1 candidate.
5. Lampropeltis triangulum (Milk snake); NESL group 4.

Species with potential to occur within a four-mile radius of the mine site include:

6. Circus cyaneus (Northern harrier); NESL group 4; MBTA.
7. Dendroica petechia (Yellow warbler); NESL group 4; MBTA.
8. Empidonax traillii extimus (Southwestern willow flycatcher); NESL group 4; USESA category 2 candidate; MBTA.
9. Euderma maculatum (Spotted bat); NESL group 4; USESA category 2 candidate.
10. Lanius ludovicianus (Loggerhead shrike).
11. Nycticorax nycticorax (Black-crowned night heron); NESL group 4; MBTA.
12. Ovis canadensis nelsoni (Desert bighorn sheep); NESL group 3.
13. Porzana carolina (Sora); NESL group 4; MBTA.
14. Rana pipiens (Leopard frog); NESL group 4.
15. Tyto alba (Barn owl); NESL group 4; MBTA.

Species with less likely potential to occur within 15 miles downstream of the mine site include:

16. Haliaeetus leucocephalus (Bald eagle); NESL group 3; USESA endangered; MBTA; BEA. May migrate along the riparian corridor.

BOYD TISI NO. 2 MINE SITE

Four-mile radius, Boyd Tisi No. 2

Species known to occur within a four-mile radius of the mine site include:

1. Amsonia peeblesii (Peebles blue-star); NESL group 4; USESA category 3C.
2. Astragalus beathii (Beath milk-vetch).
3. Phacelia welshii (Welsh phacelia); NESL group 4; USESA category 2 candidate.
4. Rana pipiens (Leopard frog); NESL group 4.

Species with high potential to occur within a four-mile radius of the mine site include:

5. Astragalus sophoroides (Painted Desert milk-vetch).
6. Cymopteris megacephalus (Bighead water parsnip); NESL group 4; USESA category 2 candidate.
7. Pediocactus peeblesianus var. fickeiseniae (Fickeisen plains cactus); NESL group 3; USESA category 1 candidate.

Species with potential to occur within a four-mile radius of the mine site include:

8. Eriogonum heermanii subracemosum (a wild-buckwheat).
9. Psorothamnus thompsonae var. whitingii (Whiting indigo bush); NESL group 4; USESA category 2 candidate.
10. Aquila chrysaetos (Golden eagle); NESL group 3; MBTA; BEA.
11. Charadrius montanus (Mountain plover); NESL group 4; USESA category 2 candidate; MBTA.

13. Haliaeetus leucocephalus (Bald eagle); NESL group 3; USESA endangered; MBTA; BEA. May migrate along the riparian corridor.
14. Lanius ludovicianus (Loggerhead shrike).
15. Nycticorax nycticorax (Black-crowned night heron); NESL group 4; MBTA.
16. Ovis canadensis nelsoni (Desert bighorn sheep); NESL group 3.
17. Porzana carolina (Sora); NESL group 4; MBTA.
18. Rana pipiens (Leopard frog); NESL group 4.
19. Tyto alba (Barn owl); NESL group 4; MBTA.
20. Xyrauchen texanus (Razorback sucker); NESL group 2; USESA proposed threatened.

A & B NO. 3 MINE SITE

Four-mile radius, A & B No. 3

Species known to occur within a four-mile radius of the mine site include:

1. Amsonia peeblesii (Peebles blue-star); NESL group 4; USESA category 3C.
2. Astragalus beathii (Beath milk-vetch).
3. Phacelia welshii (Welsh phacelia); NESL group 4; USESA category 2 candidate.
4. Rana pipiens (Leopard frog); NESL group 4.

Species with high potential to occur within a four-mile radius of the mine site include:

5. Cymopteris megacephalus (Bighead water parsnip); NESL group 4; USESA category 2 candidate.
6. Eriogonum heermanii subracemosum (a wild-buckwheat).
7. Pediocactus peeblesianus var. fickeiseniae (Fickeisen plains cactus); NESL group 3; USESA category 1 candidate.
8. Lampropeltis triangulum (Milk snake); NESL group 4.

Species with potential to occur within a four-mile radius of the mine site include:

9. Agave utahensis var. kaibabensis (Kaibab century plant); NESL group 4.
10. Astragalus sophoroides (Painted Desert milk-vetch).
11. Psorothamnus thompsonae var. whitingii (Whiting indigo bush); NESL group 4; USESA category 2 candidate.
12. Aquila chrysaetos (Golden eagle); NESL group 3; MBTA; BEA.
13. Charadrius montanus (Mountain plover); NESL group 4; USESA category 2 candidate; MBTA.
14. Dendroica petechia (Yellow warbler); NESL group 4; MBTA.
15. Empidonax traillii extimus (Southwestern willow flycatcher); NESL group 4; USESA category 2 candidate; MBTA.

15. Ovis canadensis nelsoni (Desert bighorn sheep); NESL group 3.
16. Porzana carolina (Sora); NESL group 4; MBTA.
17. Rana pipiens (Leopard frog); NESL group 4.
18. Tyto alba (Barn owl); NESL group 4; MBTA.

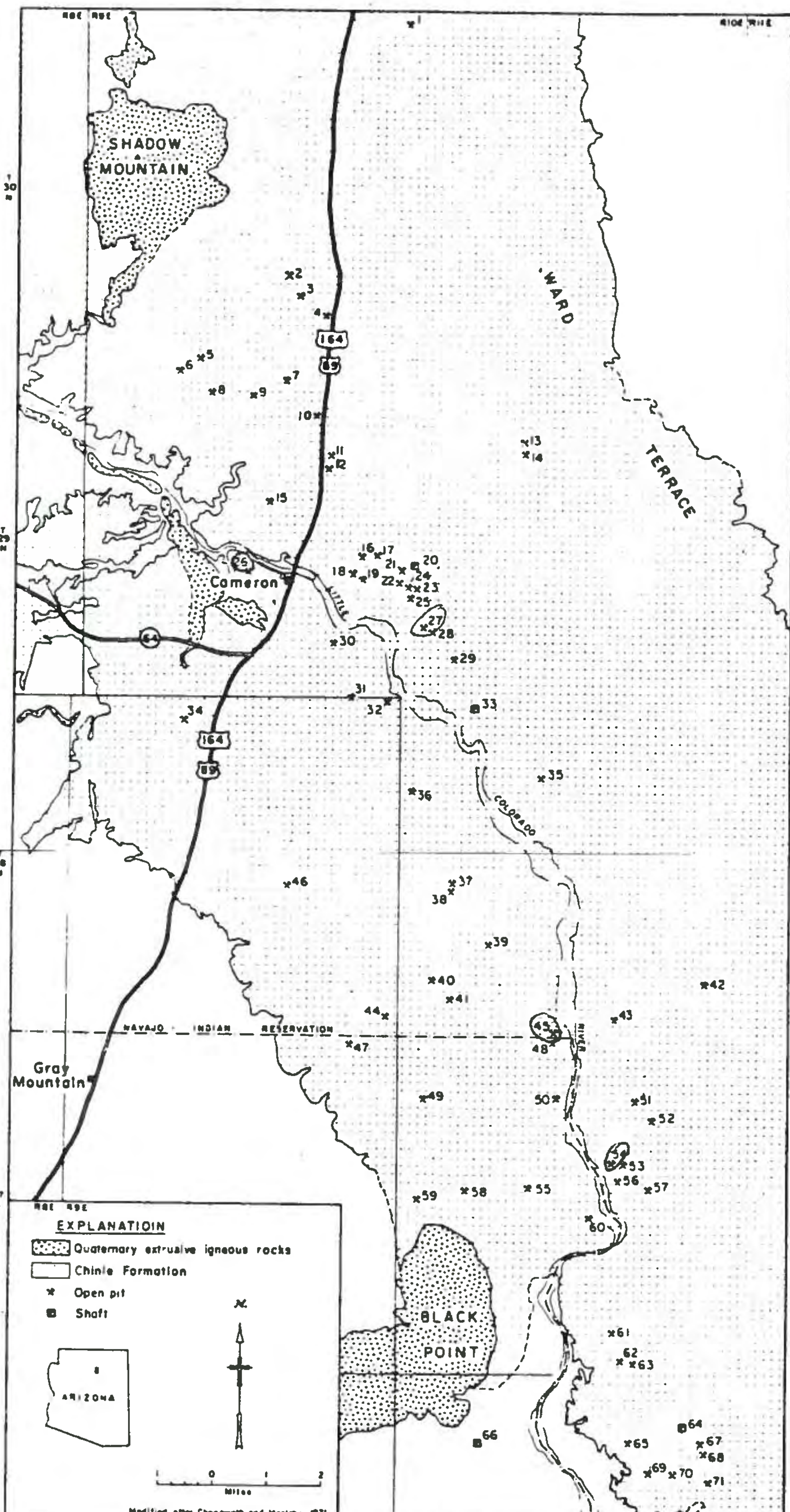
ALL SITES

Surveys should be conducted during the appropriate season for the species listed above. If you have questions pertaining to surveys, contact John Nystedt, Environmental Assessment Reviewer, Navajo Fish & Wildlife Department, at extension 7060.

Other sensitive species, including the federally listed Humpback chub (Gila cypha, NESL group 2, USESA endangered) and Razorback sucker (Xyrauchen texanus, NESL group 2, USESA proposed threatened) do occur downstream of the 15-mile limit and may be impacted by contaminants from the proposed project areas.

The information in this report is based on existing data known to the Heritage Program at this time. It should not be regarded as the final statement on the occurrence of any species of concern nor should it substitute for on-site surveys for these species. Also, because the Heritage database is continually updated and because information requests are evaluated by type of action, any given information response is only wholly appropriate for its respective request.

If you have any questions I may be reached at extension 7603.



MINES

1 Charles Huskon 5
2 Huskon 6
3 Lemuel Littleman 7
4 Jeepster 1
5 Montezuma 7C
6 Montezuma 7B
7 Casey 3
8 Montezuma 7A
9 Montezuma 2
10 Kachina 6
11 Charles Huskon 19
12 Jack Daniels 1 4 5
13 Evans Huskon 34
14 Charles Huskon 20
15 Huskon 12
16 Max Johnson 1
17 Lemuel Littleman 2
18 Huskon 1
19 Max Johnson 10
20 Elwood Canyon 1
21 Max Johnson 9
22 Alyce Tolino 1 3
23 Yazzie 101
24 Evans Huskon 2
25 Yazzie 312
26 A & B 3 3
27 Boyd Tisi 2
28 Juan Horse 3
29 Juan Horse 4
30 Lemuel Littleman 3
31 Huskon 14
32 Montezuma 1
33 Manuel Denetsone 2
34 A & B 2
35 Jack Huskon 3
36 Huskon 3
37 Huskon 7
38 Yazzie 102
39 Huskon 10
40 Huskon 8
41 Boyd Tisi 1
42 Evans Huskon 35
43 Ryan 1
44 Taylor Reid 2
45 Huskon 11 & 26 65
46 Paul Huskie 20
47 Section 1
48 Lisa Group
49 Howard 1
50 Section 9
51 Ramco 21
52 Ramco 20
Ramco 22
Ryan 2
53 Yazzie 2
54 Yazzie 1
55 Grub 14
56 Huskon 17
Jackpot 40
57 Jackpot 1 5
58 Luster 1
59 Navajo 26
60 Black Point - Murphy Group
61 Amos Chee 6
62 Max Johnson 7
63 Charles Huskon 9
64 Elwood Thompson 1
65 Emmett Lee 1
Julius Chee 2
Julius Chee 3
Julius Chee 4
66 Riverview
67 Ramco 24
68 Harry Walker 16
69 Charles Huskon 4
Paul Huskie 3
70 Charles Huskon 18
71 Julia Semallie
Emmett Lee 3

#101

Figure 2.
Mine locations: Cameron area, Coconino County, Arizona.

THE NAVAJO NATION

P. O. DRAWER 308 • WINDOW ROCK, ARIZONA 86515 • (602) 871-6359

PETERSON ZAH
PRESIDENT

MARSHALL PLUMMER
VICE PRESIDENT

01 October 1991

M-E-M-O-R-A-N-D-U-M

TO Sadie Hoskie, Director
Navajo Environmental Protection

FROM Martin L. Begaye, Director
Navajo AML Reclamation Department

SUBJECT REQUEST FOR INFORMATION ON CAMERON URANIUM MINES

In response to the request from Joanne Manygoats, Program Manager, Navajo Superfund Program, attached are the Navajo Reclamation Department's anticipated reclamation/abatement projects in the Cameron, Arizona area for the next four years. The projects are subject to approval by the U.S. Office of Surface Mining, and concurrence by the Hopi tribe.

It has been noted that the Superfund Program and our department have been assessing uranium mines on the reservation, sometimes the same ones but probably for different purposes. Our objective is surface directed: to remove physical hazards and restore the lands as much as possible. Further, by SMCRA mandate, we can only address mines abandoned prior to August 3, 1977 and where there is no responsible party. In order to avoid duplication of effort and ensure a more comprehensive cleanup of uranium mines, I recommend a Cooperative Agreement between our two entities. I suggest a meeting with you and your key staff and my staff to work out a cooperative effort.

Please contact me at extension 6359 to plan for such a meeting.

Martin L. Begaye

xc: Anderson Morgan, Executive Director, Natural Resources (w/attachment)
Joanne Manygoats, Superfund Program (w/o attachment)
Perry H. Charley, Shiprock AML (w/o attachment)
John O'Brien, Tuba City AML (w/o attachment)

Table 1

URANIUM MINES AND OCCURRENCES

YEAR 2: 1993

INDEX	NAME
1	Earl Huskon No. 1
2	Earl Huskon No. 21
3	Earl Huskon No. 3
4	A & B No. 5
5	Charles Huskon No. 7 (MP-357)
6	Lemuel Littleman No. 6
7	A & B No. 13
8	A & B No. 7
9	Charles Huskon No. 5
10	Foley No. 1
11	Charles Huskon No. 6
12	Lemuel Littleman No. 1 & 7
13	Jeepster No. 1
14	Montezuma No. 7C
15a-c	Montezuma No. 7B
16	Montezuma No. 7A
17a,b	Montezuma No. 2
18	Casey No. 3
19	Kachina No. 6
20	Paul Huskie No. 4
21	Evans Huskon No. 34
22	Charles Huskon No. 20
23	Charles Huskon No. 19
24	Jack Daniels No. 1-5
25	Charles Huskon No. 12
26	A & B No. 3
27	Max Johnson No. 1
28a,b	Lemuel Littleman No. 2
29	Charles Huskon No. 1
30	Max Johnson No. 10
31	Max Johnson No. 9
32	Elwood Canyon No. 1
33	Harvey Begay No. 1
34	Alyce Tolino No. 1 & 3
35	Evans Huskon No. 2
36	Yazzie No. 101
37	Yazzie No. 312
38	Boyd Tisi No. 2
39	Juan Horse No. 3
40	Lemuel Littleman No. 3
41	Juan Horse No. 4
42	Pat Lynch
43	Charles Huskon No. 14
44	Montezuma No. 1
45	Manuel Denetsone No. 2
46	Jack Huskon No. 3
47	A & B No. 2
48	Jack Huskon No. 3
49	Charles Huskon No. 3
50	Jack Huskon No. 1
51	Blackhair No. 4
52	Paul Huskie No. 1 & 2, and No. 20
53	Charles Huskon No. 7 (MP-65)
54	Yazzie No. 102
55a,b	Charles Huskon No. 10
56	Yazzie No. 105
57	Lloyd House
58a,b	Charles Huskon No. 8
59	Boyd Tisi No. 1
60	Evans Huskon No. 35
61	Max Johnson No. 4
62	Mel Gardner
63	Ryan No. 1
64	Taylor Reid No. 2
65	Charles Huskon No. 26
66	Charles Huskon No. 11
72a,b	Ramco No. 21
73	Ramco No. 22
74	Ramco No. 20
75	Ryan No. 2
76	Jackpot No. 7
77	Jackpot No. 8
78	Jackpot No. 6
79	Yazzie No. 1
80	Yazzie No. 2
84	Charles Huskon No. 17
85	Jackpot No. 40
86	Jackpot No. 1
87	Jackpot No. 5
89	Amos Chee No. 8
90	Amos Chee No. 7
91	Charles Huskon No. 9
92	Elwood Thompson No. 1
94	Emmett Lee No. 1, and
"	Julius Chee No. 3 & 4
95	Julius Chee No. 2
96a,b	Ramco No. 24, and
"	Harry Walker No. 16
97	Charles Huskon No. 4
98	Paul Huskie No. 3
99	Charles Huskon No. 18
100	Emmett Lee No. 3 and
"	Julia Semallie

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, Ca. 94105-3901

RECEIVED
FEB 03 1992
Navajo Superfund Office

January 30, 1992

Dr. Jonathan P. Deason
Director
Office of Environmental Affairs
U.S. Department of the Interior
1849 C. Street NW PEA (MS2340)
Washington DC 20240

RE: Abandoned Uranium Mine Issues on the Navajo Nation

Dear Dr. Deason:

Thank you for the participation of your staff at the January 22, 1992, meeting in Albuquerque to discuss the Federal Agencies role in the reclamation of abandoned uranium mines on the Navajo Nation. Present at the meeting were representatives of the Department of the Interior's Office of Environmental Affairs (OEA), Bureau of Land Management (BLM), Bureau of Indian Affairs (BIA), Office of Surface Mining (OSM), and Solicitor's Office. EPA was represented by members of my Site Evaluation Section and Emergency Response Section. A representative from Region's 9 ATSDR staff was also present, along with representatives from the Navajo Abandoned Mine Land Program (NAMLP) and Navajo Superfund Program (NSP).

It was concluded that there exist numerous abandoned uranium mine sites on the Navajo Nation that pose significant safety, health and environmental hazards. It was agreed upon in principle, that the OSM, under the authority of the Surface Mine Control Reclamation Act of 1977, will continue to authorize the Navajo Abandoned Mine Land Program to prioritize and reclaim abandoned uranium mine sites on the Navajo Nation. The NSP will assist the NAMLP in developing radiation and reclamation standards.

The NSP through the use of EPA's Preliminary Assessment/Site Investigations (PA/SI) grant will conduct preliminary assessments on sites that are ineligible for SMCRA funding. In addition, the NSP may conduct PA's on sites that the NAMLP has not been able to adequately address in a timely fashion and on sites that have additional hazards that NAMLP can not address. These efforts will be coordinated between the two Navajo agencies in consultation with EPA and OSM.

It was also agreed that EPA, OSM, NAMLP and NSP will work together to review the progress of reclamation actions on the Navajo Nation. The NAMLP and the NSP will coordinate activities in

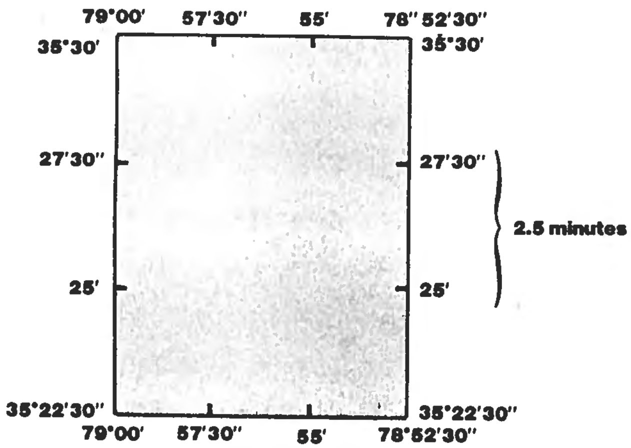
APPENDIX B

LATITUDE AND LONGITUDE CALCULATION

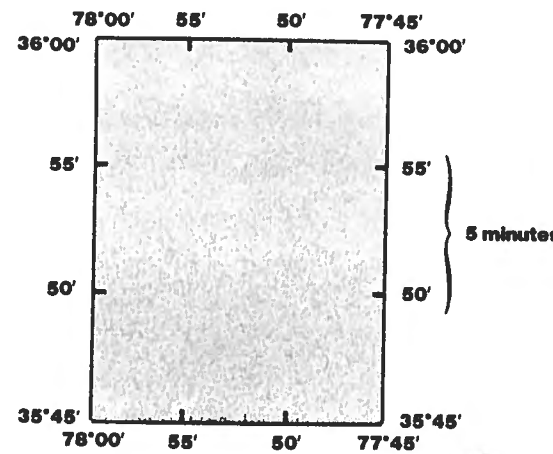
DIRECTIONS FOR USE OF THE TOPO-AID™

The Topo-Aid™ can be used to determine the longitude and latitude of a point on U.S.G.S. 7.5-minute and 15-minute topographic maps, or, to find a point for which the coordinates are known.

U.S.G.S. topographic maps indicate the longitude and latitude at 12 places. At the four corners the entire latitude and longitude is given. Between each corner are two additional grid tics at intervals of 2.5 minutes on 7.5-minute maps and 5 minutes on 15-minute maps:

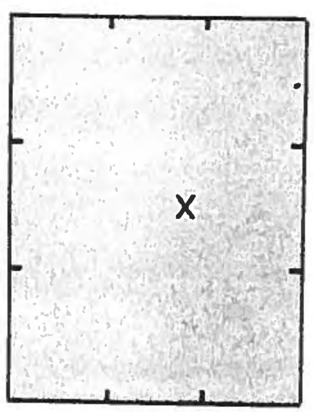


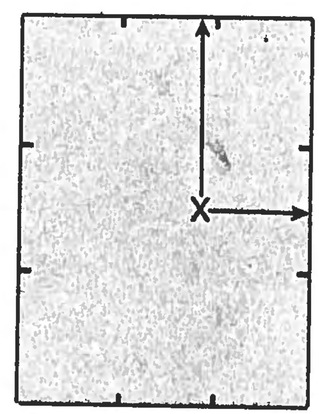
7.5 minute series



15-minute series

Example of use; find the coordinates of the "X"





First, project the point normal to the nearest borders. Next, place the Topo-Aid™ as shown below between the grid tics that the point falls between. The horizontal bars on the Topo-Aid™ should be

SEC 1961

Securities and Exchange Commission, News Digest, Washington D.C., June 6, 1961.

SECURITIES AND EXCHANGE COMMISSION
NEWS DIGEST

A brief summary of financial proposals filed with and actions by the S.E.C.

Washington 25, D.C.

(In ordering full text of Releases from Publications Unit, cite number)

FOR RELEASE June 6, 1961

MID-CONTINENT FILES FOR STOCK OFFERING. Mid-Continent Corporation, 997 Monroe Avenue, Memphis, Tenn., filed a registration statement (File 2-18246) with the SEC on June 5th seeking registration of 140,000 shares of common stock, to be offered for public sale at $7.50 per share. The offering will be made on a best efforts basis through James N. Reddock & Company, which will receive a 75¢ per share selling commission and $12,000 for expenses.

Organized under Tennessee law in April 1960, the company is engaged, directly and through its subsidiaries, in all phases of real estate operations, including the acquisition of land for investment purposes, the construction of homes and other buildings, real estate and insurance brokerage, real estate management, the development and sale of properties owned by it, and other related activities. The estimated $904,845 net proceeds from the stock sale will be used as follows: $150,000 to provide additional working capital for a subsidiary, Mid-Continent Building Corp., which is engaged in building homes; $275,000 for development of two subdivisions; $250,000 for initial capital for purchase, acquisition or organization of a subsidiary real estate mortgage and loan company, Mid-Continent Mortgage Co.; $100,000 to provide additional working capital for the operation of a subsidiary, Mid-Continent Land Investment Corp.; and $75,000 to exercise an option to purchase all of the stock of Raleigh-Bartlett Acres, Inc. a company which owns 487 acres of land near Bartlett, in Shelby County, Tenn.

In addition to certain indebtedness, the company has outstanding 283,386.5 shares of common stock, of which Morris H. Mills, president, and Bill Van Hersh, executive vice president, own 24.08% and 5.22%, respectively, and management officials as a group 48.91%. According to the prospectus, purchasers of the new shares will acquire a 33.07% interest in the company for an aggregate investment of $1,050,000, while holders of the outstanding shares will have a 66.93% interest representing an investment of cash or property aggregating $1,133,546.

ASSOCIATED FUND SEEKS ORDER. Associated Fund, Inc., of St. Louis, sponsor-depositor of the Accumulative Plan for Shares of Associated Fund Trust ("Registrant"), St. Louis unit investment trust, has applied to the SEC for an exemption order under the Investment Company Act with respect to its offering of monthly purchase plans for the accumulation of shares of Associated Fund Trust; and the Commission has issued an order (Release IC-3265) giving interested persons until June 20th to request a hearing thereon. Applicant is sponsor-depositor of Associated Fund Trust ("Fund"), which is currently offering and selling its shares through accumulative plans similar in nature to the type of plan to be issued by Registrant. However, under the accumulative plans offered and sold by the Fund, the Accumulative Payment Plan Certificates represent the interests of the investors in the Fund, and Fund shares are not held in a separate trust for the benefit of the investors. Registrant has been organized as a separate unit investment trust and upon the commencement of the offering of its securities the Fund will discontinue the offering and sale of Fund shares pursuant to its accumulative plan except for the purpose of servicing the presently outstanding Accumulative Payment Plan Certificates. Applicant seeks an exemption from the provisions of the Act requiring that no registered investment company and no principal underwriter for such a company shall make a public offering of securities of which such company is the issuer unless such company has a net worth of at least $100,000.

POTOMAC EDISON SYSTEM FINANCING APPROVED. The SEC has issued an order under the Holding Company Act (Release 35-14458) authorizing two subsidiaries of The Potomac Edison Company, Hagerstown, Md., to issue and sell additional stock to the parent, as follows: Potomac Light and Power Company, 2,000 common shares for $200,000; and Northern Virginia Power Company, 4,000 common shares for $400,000. The sale of the stock will enable the subsidiaries to provide for necessary property additions and improvements.

HAZELTINE INVESTMENT SHARES IN REGISTRATION. Hazeltine Investment Corporation, 660 Grain Exchange, Minneapolis, Minn., filed a registration statement (File 2-18247) with the SEC on June 5th seeking registration of 13,000 5% preferred shares, $100 par, non voting (conditionally cumulative), and 13,000 shares of common stock, to be offered for public sale in units, each consisting of one preferred and one common share. The units are to be offered at $101 each through company officers, and no underwriting discounts or commission will be paid.

The company was organized under Minnesota law in 1960 but took no other steps to organize as such until March 1961 when it was reorganized to engage in the business of acquiring and developing real estate. Subject to sale of a minimum of 9,901 of the units, the company intends to exercise options for the purchase from its promoters of about 1,045 acres of rural lands near Chaska in Carver County, Minnesota, and to develop and resell the same primarily as residential property. The average purchase price to the company is $1,500 per acre which, according to the prospectus, is more than the land is presently worth for any present use. The company believes that such purchase price is not excessive in view of the proposed development of the lands for residential and related shopping center purposes upon completion of a 18-hole golf course which is being constructed on adjacent lands. Of the net proceeds from the sale of the units, $925,000 will be used to make the cash payments to promoters upon exercise of the land options, and to pay 1962 principal and interest

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installments on the purchase money mortgage and purchase contracts applicable to the Partnership property, which concists of 670 acres of the land. The balance will be added to general funds and will be available for use as working capital, for the deferred portion of the land payments and for development of such lands.

The company has outstanding 13,950 shares of common stock, of which Hazeltine Land Co. and F. H. Peavey & Company own 6,700 and 6,530 shares, respectively, and management officials as a group 120 shares. Robert W. Fischer, board chairman, is a general partner of Hazeltine Land Co., and Robert W. Kemerer, president, is vice president of F. H. Peavey. After the sale of the units, the public will own 100% of the preferred and 48.23% of the common stock of the company for which they will have paid $1,313,000 or about 98.95% of the aggregate cash investment in company shares, and the promoters will have paid $13,950 for a 51.77% interest.

FUND CORPORATION FILES FOR OFFERING. Fund Corporation, 523 Marquette Avenue, Minneapolis, Minn., filed a registration statement (File 2-18248) with the SEC on June 5th seeking registration of $10,500,000 of investment plans for the accumulation of shares of Apache Fund, Inc. Such plans include $10,000,000 of Systematic Payment Plans (with and without insurance) and $500,000 of Single Payment Investment Plans.

TRESCO FILES FOR STOCK OFFERING. Tresco, Inc., 3824-28 Terrace Street, Philadelphia, filed a registration statement (File 2-18249) with the SEC on June 5th seeking registration of 100,000 shares of common stock, to be offered for public sale at $5 per share. The offering will be made through underwriters headed by Amos Treat & Co. Inc., which will receive $.625 per share commission and $10,000 for expenses. The registration statement also includes 10,000 additional common shares which the company sold Amos S. Treat at 85¢ per share.

The company is engaged in the manufacture and sale of specially designed and engineered transformers and inductors which are used as components for various types of electronic equipment. Of the net proceeds from the stock sale, $100,000 will be used to reduce existing bank loans, $150,000 for research and development costs necessary to produce new items currently under development, $100,000 to finance initial operations of a subsidiary, and the balance for general corporate purposes.

In addition to certain indebtedness, the company has outstanding (after giving effect to a 480.77 for 1 stock split in April 1961) 210,000 shares of common stock, of which Edward J. Fisher, president, and David Hafler, a director, own 31.6% and 22.7%, respectively, and management officials as a group 76.8%.

WYOMING WOOL PROCESSORS FILES FOR STOCK OFFERING. Wyoming Wool Processors, Inc., Casper Air Terminal, P. O. Box 181, Casper, Wyoming, filed a registration statement (File 2-18250) with the SEC on June 5th seeking registration of 700,000 shares of common stock, to be offered for public sale at $1 per share through management officials and salesmen employed by the company. No commissions will be paid management officials, but salesmen will receive a 15¢ per share commission.

Organized under Wyoming law in May 1960, the company proposes to engage in the operation of a plant for the scouring and combing of wool and the purchase of grease wool produced in the area of Casper, and the sale of the wool tops resulting from the scouring and combing of grease wool in the woolen market. The estimated $595,000 net proceeds from the stock sale will be used to purchase equipment, to rent a plant and warehouse for one year, for supplies and purchase of wool, and as a reserve for contingencies and working capital.

The company has outstanding 109,000 shares of common stock, of which George A. Lee, president, owns 65.1%, and management officials as a group 68.7%.

INDICTMENT NAMES CARL A. AND GERTRUDE M. PRUETT. The SEC Atlanta Regional Office announced June 1st (LR-2034) the return of an indictment (USDC, Atlanta) charging violations of the anti-fraud provisions of the Securities Act and conspiracy by Carl A. Pruett and Gertrude M. Pruett.

COURT ENJOINS ARLEE ASSOCIATES, FIRST DISCOUNT CORP., OTHERS. The SEC New York Regional Office announced June 1st (LR-2035) the entry of a court order (USDC SDNY) permanently enjoining Arlee Associates, Inc., First Discount Corp., Arthur Katz and Leo Sinsheimer from further violating the anti-fraud provisions of the Federal securities laws and engaging in the securities business without being registered with the Commission. The court also named William Esbitt as receiver for the two defendant corporations.

TEXAS ORE LANDS, TIMAN & NELSON ENJOINED. The SEC San Francisco Regional Office and Fort Worth Regional Office announced May 29th (LR-2036) the entry of a court order (USDC, Ariz.) permanently enjoining Texas Ore Lands Corporation, Joseph Timan and Sidney Nelson from violating the Securities Act registration requirement in the sale of oil interests under land in Presidio County, Texas. Action dismissed as to Horizon Land Corporation and Bret Masters.

JOHN MILTON ADDISON, OTHERS ENJOINED. The SEC Fort Worth Regional Office and Denver Regional Office announced June 2d (LR-2037) that the following had been permanently enjoined, after hearing (USDC, Dallas) from further violations of the Securities Act registration and anti-fraud provisions in the offer and sale of various securities: John Milton Addison, Miles A. White, John R. Metz, Dan Nance, White, Green & Addison Associates, Inc., Trans-World Mining Corporation, and Murchison Ventures, Inc., their officers, agents, employees, attorneys, successors and assigns, and all persons acting in concert or participation with them.

SECURITIES ACT REGISTRATIONS. Effective June 6: Fireco Sales Limited (File 2-17894); Lindy Hydrothermal Products, Inc. (File 2-17887); Nat Nast, Inc. (File 2-17978); Panacolor, Inc. (File 2-17643); Virginia Chemicals and Smelting Co. (File 2-17976); Watsco, Inc. (File 2-17958); Morgan Guaranty Trust Co. of New York, ADR's of Sony Kabushiki Kaisha (Sony Corp.) (File 2-18036); Sony Kabushiki Kaisha (Sony Corp.) (File 2-18035); Sony Kabushiki Kaisha (Sony Corp.) (File 2-18067); Ohio Franklin Fund, Inc. (File 2-17566); Public Service Electric and Gas Co. (File 2-18133); Commercial Credit Co. (File 2-18033); Washington Real Estate Investment Trust (File 2-17899). Withdrawn June 6: Burgmaster Corporation (File 2-17776).

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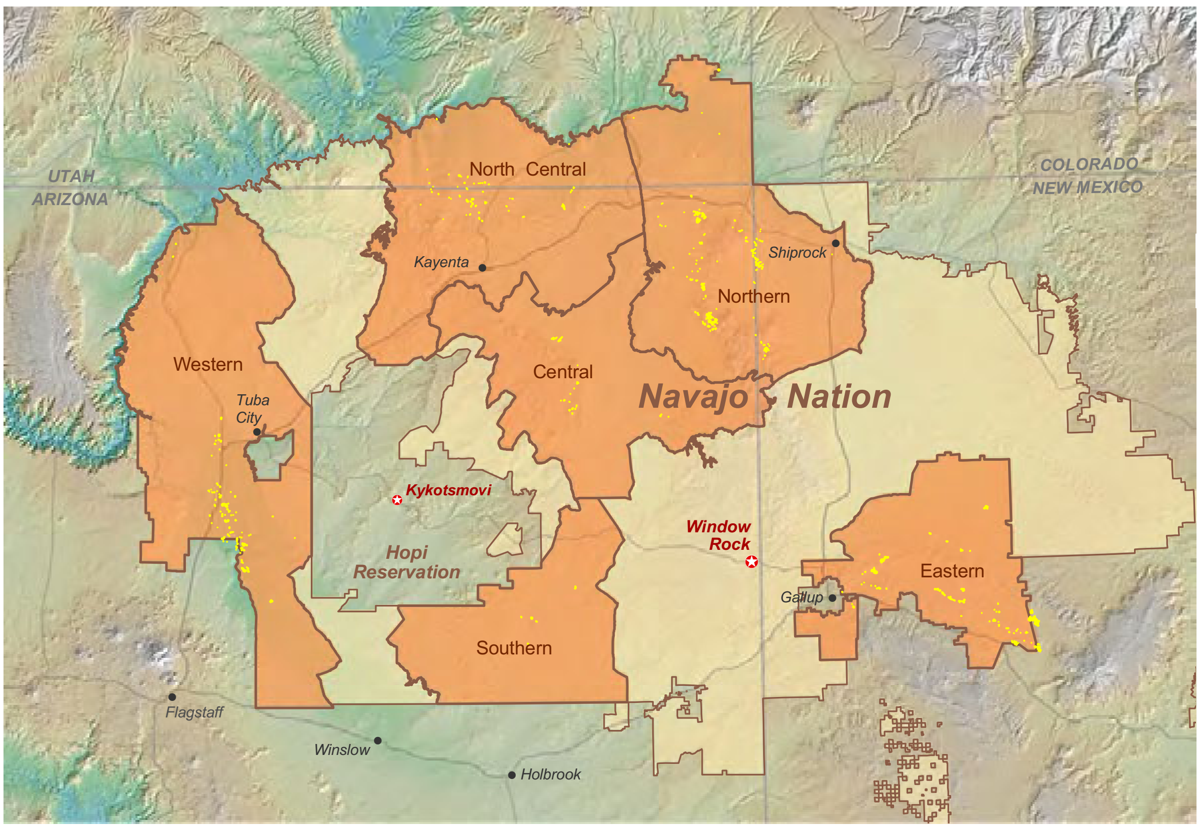
TGS 2007

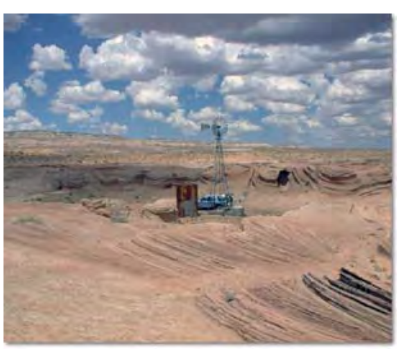
TerraSpectra Geomatics, Abandoned Uranium Mines And The Navajo Nation – Navajo Nation AUM Screening Assessment Report And Atlas With Geospatial Data, August 2007.

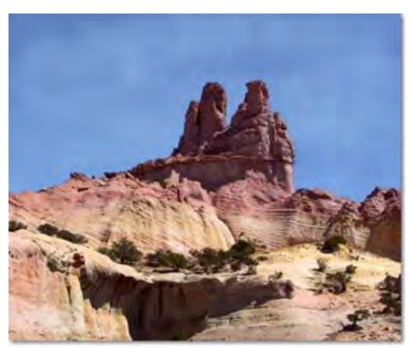
ABANDONED URANIUM MINES AND THE NAVAJO NATION

Navajo Nation AUM Screening Assessment Report And Atlas With Geospatial Data









Screening Assessment Report and Atlas with Geospatial Data prepared by the U.S. Army Corps of Engineers
under an Interagency Agreement for the U.S. Environmental Protection Agency, Region 9
in Cooperation with the
Navajo Nation Environmental Protection Agency and the
Navajo Abandoned Mine Lands Reclamation Program

USACE USEPA NNEPA NAMLRP

August 2007

REPORT COVER AND PHOTO CREDITS

The map on the cover shows the boundaries of the Navajo Nation and Hopi Reservation on a shaded-relief map. The Navajo Nation encompasses approximately 27,000 square miles in portions of three states: Arizona, New Mexico, and Utah. The map also shows the areas where uranium was mined across the Navajo Nation. Abandoned uranium mines (AUM) with mapped locations are shown in yellow on the map. Uranium mines were generally clustered in six regions of the Navajo Nation: North Central, Northern, Central, Eastern, Southern, and Western. The six regions are shown in orange on the map.

Photos from each of the six regions are depicted on the cover (clockwise from top left):

North Central Region: West Mitten Butte located in the Monument Valley Navajo Tribal Park, Oljato Chapter, Utah. Photo courtesy of TerraSpectra Geomatics (November 22, 2002).

Northern Region: Shiprock Peak (Tse' Bit' A'i' - Rock with Wings), a volcanic neck and dike located about 13 miles southwest of Shiprock, New Mexico in the Shiprock Chapter. Photo courtesy of TerraSpectra Geomatics (August 20, 2002).

Central Region: Spider Rock, an 800 foot red sandstone monolith located in Canyon de Chelly National Park, in the Chinle Chapter, Arizona. Photo courtesy of TerraSpectra Geomatics (May 7, 2001).

Eastern Region: Church Rock is a steeple shaped sandstone pillar located in the Red Rock State Park, about 10 miles east of Gallup, New Mexico, in Church Rock Chapter. Photo courtesy the McKinley Soil and Water Conservation District, USDA Service Center, (Accessed on April 6, 2007 at URL *http://mckinleyswcd.com/churchrock.jpg*).

Southern Region: Aerial view of the Hopi Buttes Volcanic Fields looking west. Photo courtesy Louis J. Maher, Dept. of Geology and Geophysics, Univ. of Wisconsin, Madison (Accessed on April 11, 2007 at URL *http://esp.cr.usgs.gov/hopibuttes*).

Western Region: Standing Rock Well in the central area of the Tuba City Chapter, Arizona. Photo courtesy the U.S. Army Corps of Engineers (August 12, 1998).

REPORT GRAPHIC ELEMENTS

Graphic elements used throughout this report are patterned after the Navajo Nation seal and flag. The seal (shown above) was designed by John Claw, Jr. of Many Farms, Arizona and was officially adopted by the Navajo Tribal Council in 1952, by resolution CJ-9-52. The original Navajo Nation seal bears a ring of 48 arrowheads that symbolize the Tribe's protection within the 48 states (as of 1952). Within this ring of arrowheads are three concentric circles that are open at the top. The circles represent a rainbow and symbolize the Navajo Nation. Within these rings are two corn plants, the sustainer of life for the Navajo, their tips yellow with pollen. Between the corn plants are a horse, cow, and sheep, representing livestock. The yellow sun shines from the east (at the top) on the four sacred mountains that are represented by their ceremonial colors: white, turquoise, yellow, and black. In May 1988, the Navajo Nation Council amended the original wording from "the Great Seal of the Navajo Tribe" to "the Great Seal of the Navajo Nation." They also increased the number of arrowheads to 50 to include representation of the states of Hawaii and Alaska (Navajo Nation Hospitality Enterprise, 2005).

In the Navajo Creation Story, it is told that their Creator placed them on a land between the following four mountains, which represent the four cardinal directions:

- Mount Blanca Sacred Mountain of the East — Dawn or White Shell Mountain,
- Mount Taylor Sacred Mountain of the South — Blue Bead or Turquoise Mountain
- San Francisco Peaks Sacred Mountain of the West — Abalone Shell Mountain
- Mount Hesperus Sacred Mountain of the North — Obsidian Mountain

The Navajo Nation flag (shown below), was designed by Jay R. Degroat, a Navajo student from Mariano Lake, New Mexico. It was officially adopted by the Navajo Nation Council in 1968 by Resolution CMY-55-68. On a tan background, the outline of the Navajo Nation is shown in copper, with the outline of the original 1868 Treaty Reservation in dark brown. At the cardinal points in the tan field are the four sacred mountains. A rainbow symbolizing Navajo sovereignty arches over the Navajo Nation and the sacred mountains. In the center of the Nation, a circular symbol depicts the sun above two green stalks of corn, which surrounds three animals representing the Navajo livestock economy, and a traditional hogan and modern home. Between the hogan and the home is an oil derrick symbolizing the resource potential of the Nation, and above this are representations of the wild fauna of the Nation. At the top, near the sun, the modern sawmill symbolizes the progress and industry characteristics of the Navajo Nation's economic development (Navajo Nation Hospitality Enterprise, 2005).

The Navajo consider east to be where everything begins — east signifies dawn and all things good and beautiful. On the Navajo Nation seal, the Navajo convention of east as "up" is used. For this document, the placement of the sacred mountains on the borders follows the cartographic convention of north at the top, as depicted on the Navajo Nation flag.

ABANDONED URANIUM MINES AND THE NAVAJO NATION

Navajo Nation AUM Screening Assessment Report and Atlas with Geospatial Data

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August 2007

ACKNOWLEDGEMENT

Many individuals and organizations assisted in reconstructing the history of uranium mining on the Navajo Nation, and in developing the geospatial datasets presented in this report and Atlas.

The authors would like to extend their appreciation to William Chenoweth, Consulting Geologist, whose personal knowledge of the history of uranium mining on the Navajo Nation proved invaluable.

Special recognition is also extended to Glynn R. Alsup in honor of his tireless efforts on behalf of the United States Army Corps of Engineers and his devotion, commitment, and dedicated service to improving conditions on the Navajo Nation.

Report contributors from TerraSpectra Geomatics included Elaine Ezra, David Brickey, Larry Tinney, Teresa Bell, Ronald Ezra, Katahdin Withnall, Joseph Scepan, and Rick Van Remortel.

The following is a list of the organizations who generously shared knowledge, identified where to seek data, contributed data, and/or provided critical reviews and evaluations. Their contributions are gratefully acknowledged.

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THANK YOU

Diné College Uranium Education Program
Navajo Abandoned Mine Lands Reclamation Program
Navajo Area Indian Health Service
Navajo Department of Data Resources
Navajo Department of Water Resources
Navajo Land Department - GIS Section
Navajo Nation Environmental Protection Agency - Navajo Superfund Program
Navajo Nation Environmental Protection Agency - Surface and Ground Water Protection Department
Navajo Tribal Utility Authority
Southwest Research Information Center (SRIC)
Sustainable Energy Solutions at Northern Arizona University
U.S. Army Corps of Engineers, Los Angeles District
U.S. Army Corps of Engineers, Albuquerque District
U.S. Bureau of Indian Affairs
U.S. Department of Energy
U.S. Environmental Protection Agency, Region 9
U.S. Fish and Wildlife Service
U.S. Geological Survey, USGS Navajo Nation Studies Program
U.S. Geological Survey, Flagstaff
U.S. Geological Survey, Albuquerque

This report is dedicated to Navajo Miners and their families.

Photo of Navajo Miners Working at the King Tutt Point Mine Plot 2, East Reservation Lease taken by Kenneth Hatfield, 1953. Photo courtesy William Chenoweth.

CONTENTS

Page Number

PART 1 - NAVAJO NATION AUM SCREENING ASSESSMENT

CONTENTS (continued)

Page Number

TABLES

PART 2 - ATLAS WITH GEOSPATIAL DATA

The Table of Contents for the Atlas with Geospatial Data is provided at the beginning of Part 2

EXECUTIVE SUMMARY

The Navajo Nation covers over 27,000 square miles in portions of three states: Arizona, New Mexico, and Utah. There has been widespread uranium mining on the Navajo Nation, beginning in the early 1900's. Peak uranium mining occurred between the 1940's and 1960's in support of the U.S. Government's defense programs. Substantial amounts of land throughout the Navajo Nation were disturbed by surface and underground mining. Over 1,200 mine features (e.g., portals, prospects, rim strips, pits, vertical shafts or waste piles) associated with abandoned uranium mines (AUMs) have been identified. More than 600 AUM sites or related areas have been mapped throughout and within one mile of the Navajo Nation.

In November 1993, U.S. Congressional Subcommittee hearings were conducted in which the Navajo Nation presented testimony about AUMs on the Navajo Nation and requested assistance to determine if the AUMs posed a health risk to Navajo residents. Shortly thereafter, in 1994, the U.S. Environmental Protection Agency (EPA) Region 9 initiated the Navajo Abandoned Uranium Mines (NAUM) Project.

This *Abandoned Uranium Mines and the Navajo Nation* report documents NAUM Project data collection and screening results for all known AUMs on the Navajo Nation. The report has two parts: the *Navajo Nation AUM Screening Assessment Report* and the accompanying *Atlas with Geospatial Data.*

In 2002, the EPA Region 9 Superfund Site Assessment and Technical Support Team developed a custom set of Hazard Ranking System (HRS) screening criteria to assess AUMs on the Navajo Nation for possible remedial actions. The large geographic area covered by the Navajo Nation is beyond the normal scope for the HRS, so a custom model was developed to fit these unique circumstances. The method used to prioritize the AUM sites is based on a limited subset of the locational-distance criteria in the HRS. It does not include the complete set of criteria and factors built into the full HRS model. The scoring is not intended to identify actual risks, but rather to identify and prioritize areas for future investigation and response decisions.

The HRS-derived model used for this study was developed based on the presence of downstream surface water drainages and the numbers of structures and wells proximal to AUM sites. A Geographic Information System (GIS) database was developed for the study and included the following geospatial datasets for the analysis: 1) locations of all known abandoned uranium mines on and within 1 mile of the Navajo Nation, 2) structures within 1 mile of an AUM, 3) drinking water sources within 4 miles of an AUM, and 4) surface drainages 15 miles downstream from an AUM. The GIS was used to compare the individual AUM sites by distance from the human receptors. The *Navajo Nation AUM Screening Assessment Report* presents the analysis results from the model in data tables and maps. Based on the results of this broad-based screening process, EPA will consult with the Navajo Nation about the recommended follow-up investigations or cleanup responses that require attention.

The *Atlas with Geospatial Data* portion of this report describes the geospatial datasets used for the screening analysis. Due to the limited subset of criteria used in the HRS-derived model, the analysis resulted in some cases where AUM sites with little to no waste (e.g., a prospect with no uranium production) scored high due to close proximity to structures and wells. Conversely, some AUM sites with high volumes of waste scored low due to their remote locations with few structures or wells in close proximity. The prioritization process can be enhanced by the addition of more factors, criteria, and data into the model.

The EPA, Navajo Nation Environmental Protection Agency (NNEPA), Navajo Abandoned Mine Lands Reclamation Program (NAMLRP) and U.S. Army Corps of Engineers collectively developed a list of key data needed for the further assessment of AUMs. In order to minimize redundancy and costs, an important aspect of this effort was the systematic collection and review of existing data suitable for use in preliminary assessments and for model refinement. The list focused on data related to contaminant sources and their transport pathways, such as air, soil, ground water and surface water. The NAUM Project Team then carefully examined existing data sources, including those from other federal, state, Navajo agencies, and universities to identify data that could assist with providing answers to questions about the AUMs and the transport of potential contaminants on a Navajo Nationwide level.

The *Atlas and Geospatial Data* includes readily available regional scale data that were compiled for the Navajo Nation. The *Atlas and Geospatial Data* portion of the report is organized into three Sections: Section 1 - *Mining History and Mine Site Information;* Section 2 - *Mine Waste Characteristics; and* Section 3 - *Environmental Setting.* The Sections generally follow an Atlas format, with a text description of the dataset and a facing page with a map example. Referenced documents have been scanned and are provided in digital format on Digital Versatile Disks (DVDs), along with the report, all geospatial datasets used, and associated metadata.

This report can support improved decision-making and provides the following:

- Final documentation and distribution of GIS data, analyses, and maps generated for the screening phase of the NAUM study.
- Compilation of regional GIS data that will support the NNEPA and NAMLRP with further assessment of priority AUM sites.

The target audience of this report is broad, ranging from residents and Chapter Officials, students and teachers, community groups, and technical specialists in various Navajo Nation, State and Federal government agencies, and academic institutions. The content ranges from introductory tutorials to discipline-specific discussions related to environmental assessments.

From Testimony of the Navajo Nation Before the Subcommittee on Oversight and Investigations and the Subcommittee on Native American Affairs Regarding Abandoned Uranium Mines on the Navajo Nation - November 4, 1993:

"From the 1920s to the early 1970s, uranium ore was mined on the Navajo reservation for the U.S. atomic energy program. The primary purchaser and beneficiary of this mining activity was the U.S. government and the development of uranium resources was entrusted to the Atomic Energy Commission.

As a result of this mining, the Navajo Nation has been left with at least 1,104 known abandoned uranium mines and tons of hazardous radioactive uranium mine waste scattered across our lands.

Many Navajo people live and work in close proximity to highly contaminated soil, and breathe and drink contaminated air and water. Some residents live within a few hundred feet of highly radioactive wastes. Sheep and livestock - the basis for our subsistence - graze on contaminated vegetation and drink contaminated water. Often, Navajo homes are built with radioactive mine waste rocks and children play daily in the vicinity of mines and on mill tailing piles."

Based on a review of production records it is estimated that approximately 14% of the uranium used for the United States World War II and Cold War nuclear weapons and energy programs were mined from the Navajo Nation.

COMMUNITY INTRODUCTION

In April 2000, the Navajo Nation Environmental Protection Agency (NNEPA), the Navajo Abandoned Mine Lands Reclamation Program (NAMLRP)[1] and the United States Environmental Protection Agency (EPA) Region 9 made a decision to map and screen all abandoned uranium mines on the Navajo Nation for possible remedial actions. In addition to their own data, the three agencies collected information from tribal, state, and federal agencies, including census, cultural, wildlife, and water resource agencies.

The Navajo Nation screening assessment that follows this introduction provides valuable information and maps of mine locations, the mine type, and how close the mines are to homes and water sources. If you have questions about the information or about our programs or the science involved, please feel free to contact any member of our team listed in the contact information provided (see MISSION STATEMENTS, page 3). Tribal and federal agencies will use the information to determine appropriate assessments, including possible cleanup actions.

For the purposes of this introduction, "abandoned uranium mines" are uranium mines that have been deserted and are no longer being maintained. Based upon several chapter meetings, the following are questions that the agencies have been frequently asked in their outreach work. These questions are important to people who live in areas with abandoned uranium mines. These questions focus on the environment and health.

ENVIRONMENT

1. *What are the impacts of abandoned uranium mines to the water we drink (ground water and surface water)?*

   Uranium is a common, naturally occurring radioactive material that is present in our environment and may be found in water, soil, rock formations, and air. If water is present in the ground next to rocks containing uranium, there will be a certain amount of uranium in the water. Uranium in water comes from different sources. Most of it comes from the water running over uranium bearing rocks and through the soil. Only a small amount comes from airborne dust that settles on water. In some cases, the uranium can be suspended in water, like mixing dirt to make muddy water. Human activities, such as mining, can move the uranium around and change the levels that you are exposed to.

2. *What are the impacts of abandoned uranium mines to soil?*

   Mining practices at abandoned uranium mines often disturbed the soils, thus making them less stable and more susceptible to erosion. Concentrated ore was brought to the surface and indirectly caused the spread of contaminated soils in staging areas. During the digging, the sandstone rock containing the ore was separated by hand, loaded into trucks and transported off-site for milling. Uranium was also spread by erosion and blowing dust and can be found concentrated at the waste piles and ore transfer stations. Soils disturbed by mining are also likely to support less vegetation or they may support a totally new species mix due to the changes in soil composition. Several of these locations on the Navajo Nation have been assessed to identify areas of concern.

3. *What are the impacts of abandoned uranium mines to air?*

   In the air, uranium exists as dust. Very small dust-like particles of uranium in the air fall out of the air onto surface water, plant surfaces, and soil either by themselves or when rain falls. The amount of uranium dust particles in air is usually very small, so it is not considered a significant concern for health impacts.

HEALTH

Uranium is naturally found everywhere in small amounts. We take uranium into our bodies through the food and water we ingest and from the air we breathe. Additionally, we are exposed to radiation from cosmic and natural sources on earth all the time. In a few places, there is more natural uranium in water than in food. People living in these areas take in more uranium from their drinking water than from their foods. When we breathe uranium dust, some of it is exhaled and some stays in our lungs. The size of the uranium dust particles and how easily they dissolve determines where in the body the uranium goes and how it leaves the body. Some of the uranium dust may gradually dissolve and go into the blood. The blood carries the uranium throughout the body and most of it leaves in your urine in a few days, but a little stays in your kidneys and bones.

1. *How far should I live from an abandoned uranium mine, whether it is reclaimed or not?*

   Reclaimed abandoned uranium mines should pose little risk for health hazards because work has been done to make the physical mine area safe and stable. The soils were carefully surveyed with radiation detecting equipment to identify problem areas. The uranium-contaminated soils were buried and many steep areas were stabilized to prevent further movement of the uranium containing soils. Drainage patterns have been diverted away from reclaimed areas to reduce the leaching capability of surface water. Any unreclaimed abandoned uranium mines may pose some risk. The agencies strongly advise people to reduce their exposure to places where there are abandoned uranium mines or mine wastes. People who already live near a mine, or a community considering an area for future development, will want to ask specific questions about a particular mine site or waste pile to better understand the risks. These questions are based on radiation safety principles known as ALARA (As Low as Reasonably Achievable), and follow three basic principles that can be applied to reduce potential exposures to radiation: time, distance, and shielding. Questions could include the following: How long is the person exposed, including residential, farming and recreational activities (time)? How close is the person to the source of exposure while doing these activities (distance)? Is there something between the person and the source of exposure that can absorb some of the radiation (shielding)?

   The agencies looked at how close structures (e.g., homes, churches, businesses) were located to the abandoned uranium mines to assess the potential for people to be exposed. This report serves as a tool for the agencies to discuss where cleanup decisions are needed, as well as how and who can address them.

[1] NAMLRP provided technical and review assistance to the project.

2. *What will happen if I drink water that contains small particles (dissolved) of uranium and heavy metals?*

The Navajo Nation issued a health advisory in 2001 recommending people drink water from regulated safe drinking water sources such as Navajo Tribal Utility Authority (NTUA) and Indian Health Services (IHS) systems. These sources of water are sampled and tested routinely to ensure it is safe to drink. Water containing natural uranium is radioactive, but only to a weak extent. At high concentrations, uranium also has a toxic, chemical effect, and people have developed kidney disease drinking highly contaminated water for long periods. This is why EPA has established standards for uranium in drinking water throughout the United States which are safe for long-term water use. As long as the levels in the drinking water are below these concentrations, the water is safe to drink. The uranium drinking water standard is 30 parts per billion. Please refer to the EPA website for the list of drinking water standards for other elements of concern, including arsenic and lead: *http://www.epa.gov/safewater/mcl.html*. For more information on the health effects of uranium, arsenic and lead, please refer to the Agency for Toxic Substances and Disease Registry website: *http://www.atsdr.cdc.gov/toxfaq-u.html#bookmark05.*

Across the Navajo Nation we looked at how close water sources (for example wells, developed springs, and stock tanks) were located to the abandoned uranium mines to assess the potential for people to be exposed. Please see Figures 12 through 60 for maps showing the locations of water sources and mines on and within 1 mile of the Navajo Nation.

3. *What are the effects of ingesting uranium that has been taken up by livestock?*

There is not enough research in this area, but it is advisable that livestock not graze on areas where abandoned uranium mines are located.

4. *What can people do to reduce the risk of exposure to uranium?*

The most common and easiest things to do are the following:

- Avoid abandoned uranium mines, waste piles, or mill tailings piles.
- Do not collect any rocks from the vicinity of known uranium mines, waste ore piles, or transfer stations.
- Do not use suspect rocks for building homes, foundations, root cellars, corrals, bread ovens, fireplaces, or any other structures.
- If you have yellowish rocks or any rock you know has come from a uranium mine area in your home or yard, call the Navajo Superfund Project Manager at 928-871-6859 for additional information.
- Do not drink from unregulated water sources such as windmills, stock tanks, and springs.

5. *Is it safe to wash dishes or laundry with contaminated water?*

No, the agencies recommend using water from a regulated source such as NTUA and IHS systems.

If you have questions about your drinking water quality, please contact NNEPA Public Water Systems Supervision Program at 928-871-7600. You can reach NTUA at 928-729-5721.

Radiation Exposure Compensation Act (RECA)

Where can I apply for Radiation Exposure Compensation Act (RECA) benefits?

The Uranium Office in Shiprock, New Mexico can provide application packets and pertinent information for miners, transporters, millers, and "downwinders"

Larry Martinez
Uranium Office
Post Office Box 1890
Shiprock, New Mexico 87420
Telephone: 505-368-1261 Fax: 505-368-1266

Radiation Exposure Screening and Education Program (RESEP)

Where can I get screened for compensation requirements under the Radiation Exposure Screening and Education Program?

The following are screening facilities:

Shiprock Northern Indian Health Service
Post Office Box 160
Shiprock, New Mexico 87420
Telephone: 505-368-7032

RESEP Coordinator
Utah Navajo Health System
Montezuma Creek Clinic
Post Office Box 130
Montezuma Creek, Utah 84534
Telephone: 435-651-3291

RESEP Coordinator
Lake Powell Medical Center
647 Vista Avenue
Page, Arizona 86040
Telephone: 928-645-8123, ext. 206

RESEP Coordinator
North Country Community Health Center
2500 North Rose Street
Flagstaff, Arizona 86004
Telephone: 928-213-6100

BACKGROUND

Uranium mining on the Navajo Nation began in the early 1900's. Widespread mining of uranium ore for Cold War weapons and nuclear energy production occurred, with peak activities between the 1940's and 1960's on the Navajo Nation and throughout the Colorado Plateau. The Bureau of Indian Affairs (BIA) and the Navajo Nation negotiated mining leases and mining permits with a number of private mining companies, who in turn processed the ore at their own facilities (mill sites) or sold the raw uranium ore to such facilities. Ultimately, the former United States Atomic Energy Commission (AEC) acted as the sole market for all uranium concentrate (yellowcake) processed from the Navajo Nation during the period from 1947 - 1970. After 1970, milling companies sold their concentrate to electric utilities. All of the vanadium recovered from the ore was sold to the steel industry. Copper recovered from the Monument Valley ores was sold to copper smelters in Arizona (Chenoweth, 2007 - S07110701).

Most uranium mining activities ended in 1968 on the Navajo Nation, but the legacy of abandoned uranium mines (AUM), widely distributed wastes, and collateral environmental, cultural, and economic impacts continue (Sowder, 2001 - S12190201). It is probable that the mining activities led to dispersion of radioactive and heavy metal contaminated dusts, sediments, ground water, and surface water to varying degrees, depending on site conditions, mining practices, and the amount and grade of material extracted. Since uranium is a naturally occurring element, questions about how much dispersion or contamination occurred as a direct result of mining, who is at risk, and to what extent, are difficult to answer without a systematic review and analysis of the AUM sites.

Congressional hearings were held on November 4, 1993, regarding AUMs on the Navajo Nation (U.S. House of Representatives, 1993 - S12120224). The Navajo Nation presented testimony before the Subcommittee on Oversight and Investigations and the Subcommittee on Native American Affairs regarding concerns about the mines and the Navajo Nation requested assistance to determine if the uranium mines posed a health risk to Navajo residents (Hoskie, 1993 - S12120225). The U.S. Environmental Protection Agency (EPA) presented testimony to describe its federal authority under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), also known as Superfund, and how the EPA could assist the tribe.

The risk of human and ecological exposure to uranium on Navajo Lands occurs in the following three ways: 1) Naturally occurring radioactive material (NORM), 2) the AUM sites, and 3) uranium milling activities. CERCLA only addresses wastes resulting from man-made activities, such as mining, which includes waste piles. With respect to naturally occurring ore, EPA has no authority under CERCLA. EPA is also excluded from addressing mill sites; DOE and the Nuclear Regulatory Commission (NRC) have authority under the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA) to investigate and address the former mill sites located near the Navajo communities of Shiprock, New Mexico; Mexican Hat, Utah; Tuba City, Arizona; and Monument Valley, Arizona.

In response to the concerns raised by the Navajo Nation at the Congressional hearings, the EPA initiated the NAUM Project in 1994. Since the beginning of the NAUM Project, several studies have been conducted to determine the scope and impact of uranium mining on the Navajo Nation. The following describes the missions of the primary NAUM Project agencies.

MISSION STATEMENTS

NAVAJO NATION ENVIRONMENTAL PROTECTION AGENCY

On April 21, 1995, the Navajo Nation Council established the Navajo Nation Environmental Protection Agency (NNEPA). NNEPA is an independent regulatory agency within the Executive Branch of the Navajo Nation Government with regulatory, monitoring, and enforcement authority over matters relating to the quality of the environment and over any person or entity doing business within, or otherwise affecting the environment of the Navajo Nation. Funding for NNEPA is provided by Navajo Nation general funds, federal grants from the EPA, the U.S. Department of Justice, and from fees that are collected under existing Tribal environmental laws.

On May 22, 2001, the NNEPA received approval to amend the plans of operations for the Air & Toxics Department, the Surface and Ground Water Protection Department, the Waste Regulatory Compliance Department (WRCD), and the Criminal Enforcement Department. The first three departments are responsible for the civil and administrative enforcement of Tribal environmental laws and regulations. Criminal environmental crimes are investigated by the Criminal Enforcement Department. Each department consists of several programs that are responsible for program development, technical and enforcement development, conducting research, investigating and assessing environmental problems and concerns, monitoring cleanup and/or corrective actions, and providing technical assistance and training.

The Navajo Superfund Program (NSP) is one of several programs within the WRCD and is funded under an EPA CERCLA grant. Under CERCLA, NSP is responsible for conducting site assessments where hazardous substances may have been used by past development activities, such as uranium mining and milling activities that occurred on the Navajo Nation. NSP has conducted assessments at several AUM. Activities related to these assessments included collecting samples of soil sediments and both surface water and ground water. Other activities included conducting surveys using instruments to detect different types of radiation, conducting interviews of chapter officials and local residents, and reviewing U. S. Bureau of Indian Affairs (BIA) lease information to identify the companies that developed the mines. The information was submitted to EPA for use in the federal Hazard Ranking System (HRS) to score each site and to determine the threat associated with actual or potential releases of hazardous substances. EPA uses the HRS to set priorities for further site evaluation and determine possible remedial action if the site is eligible for placement on the National Priorities List (NPL). The NPL identifies sites at which EPA may conduct remedial response actions.

For further information about NNEPA, you may contact the following:

Stephen B. Etsitty, Executive Director
NNEPA
Post Office Box 339
Window Rock, Arizona 86515
Telephone: 928-871-7692

Arlene C. Luther, Department Director
Waste Regulatory Compliance Department
NNEPA
Post Office Box 339
Window Rock, Arizona 86515
Telephone: 928-871-7993

Diana J. Malone, Program Manager
Navajo Superfund Program
NNEPA
Post Office Box 2946
Window Rock, Arizona 86515
Telephone: 928-871-6859

NAVAJO ABANDONED MINE LANDS RECLAMATION PROGRAM (NAMLRP)

The NAMLRP was established in August 1988 as a program under the Navajo Nation's Division of Natural Resources. The purpose of the program is to fulfill the abandoned mine reclamation requirements of Public Law 95-87 "Surface Mining Control and Reclamation Act (SMCRA) of 1977." This legislation was amended and reauthorized in the Amendments Act of 2006.

Through SMCRA, reclamation funds for abandoned mine lands were established to address land and water resources impacted by abandoned mines for which there were no responsible parties. Reclamation could only be addressed to lands that have tribal trust status. Since SMCRA is directed towards the reclamation of coal related mining problems, NAMLRP was required to concentrate first on the reclamation of all known coal mining sites.

A trust fund was established in the U.S. Treasury as the Abandoned Mine Lands (AML) Reclamation Fund to be administered by the Secretary of the Interior. All active coal mining operations deposit 35 cents per ton of coal produced into the fund, while underground mining operations deposit 15 cents per ton of coal produced as of 2007. Fifty percent of the Abandoned Mine Lands Reclamation funds go to eligible tribes and states who can use it for administration, project development, and construction costs.

Since 1988 NAMLRP has been reclaiming abandoned coal and non-coal mine sites within the boundaries of the Navajo Nation. After the establishment of the NAMLRP, the following tasks were completed in order to understand the mining scenario throughout the Navajo Nation. NAMLRP completed an inventory, prioritized the abandoned mine sites according to Office of Surface Mining criteria, and made a determination as to which sites would be reclaimed. Several factors were taken into consideration, such as the need to protect public health, environmental problems, and overall safety for employees.

For further information about NAMLRP, you may contact the following:

Main Office

Madeline Roanhorse, Department Manager
AML Reclamation/UMTRA Department
Post Office Box 1875
Window Rock, Arizona 86515
Telephone: 928-871-6982

Shiprock AML Reclamation Program

Rose Grey, Program Manager
Post Office Box 3605
Shiprock, New Mexico 87420
Telephone: 505-368-1220

Tuba City AML Reclamation Program

Ray Tsingine, Program Manager
Post Office Box 730
Tuba City, Arizona 86045
Telephone: 928-283-3188

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY (EPA)

The mission of the EPA is to protect human health and the environment. Since 1970, EPA has been working for a cleaner, healthier environment for the American people. EPA employs 18,000 people across the country, including the Washington, DC headquarters offices, ten regional offices, and more than a dozen laboratories. EPA conducts environmental science, research, education, and assessment efforts. EPA develops and enforces regulations, provides financial assistance, performs environmental research and cleanup of contaminated sites.

EPA's Region 9 covers the southwestern United States (Arizona, California, Nevada, and Hawaii) and it works with 147 federally recognized tribes. EPA Region 9 has a Memorandum of Understanding with the Navajo Nation to work with the NNEPA in a government to government relationship. In response to concerns raised by the Navajo Nation during a 1993 Congressional hearing, the EPA Region 9 Superfund Program initiated an investigation aimed at assessing human exposure to radiation and heavy metals from abandoned uranium mines. EPA conducted extensive field sampling of abandoned uranium mines, water sources, and homes during the 1990s. In 2002, EPA developed the Abandoned Uranium Mine Project Management Plan in partnership with the NNEPA to create a screening assessment mechanism, with close involvement by the NAMLRP.

The U.S. Army Corps of Engineers has produced a Geographic Information System (GIS) database and this report for EPA in support of AUM screening assessments on the Navajo Nation. The GIS database identifies the locations of all known abandoned uranium mines and uranium mining-related areas on the Navajo Nation and their proximity to structures, water sources, and surface water drainages. This report will allow the project team to recommend Superfund removal actions or assessments to determine a site's eligibility for Superfund removal actions and/or Superfund Site listing to the NNEPA. Based on the results of the mine screening study, EPA will consult with the Navajo Nation about the recommended follow-up investigations or cleanup responses requiring prompt attention.

With respect to future work, EPA and NNEPA will coordinate closely with the NAMLRP to directly address, or to seek additional resources to address sites such as waste piles, unreclaimed mines, and mine contaminated water sources.

For further information about EPA or the Navajo Nation AUM Screening Assessment Report, you may contact the following:

Andrew Bain, Remedial Project Manager (SFD-8-2)
U. S. Environmental Protection Agency
75 Hawthorne Street
San Francisco, California 94105
Telephone: 415-972-3167

GEOGRAPHIC INFORMATION SYSTEM (GIS)

The Navajo Nation AUM Screening Assessment Report and Atlas presents map products that were developed using a Geographic Information System (GIS). A GIS is a system of computer software, hardware, data, and personnel to manipulate, analyze, and present information that is tied to a spatial location.

A geographic or spatial location refers to the location on the earth where an object occurs. This may be in vector (point, line or polygon) or raster (grid or image) form. The location of these basic objects may be expressed in latitude and longitude, Universal Transverse Mercator (UTM) northing and easting coordinates, or some other standard coordinate system. Figure 1 presents an example of mapped features that are represented as points (structures as red squares and wells as blue dots), lines (drainages that are downstream from an AUM and shown as blue lines), polygons (AUM boundary shown as a yellow polygon), and a raster digital orthophotograph as the base image.

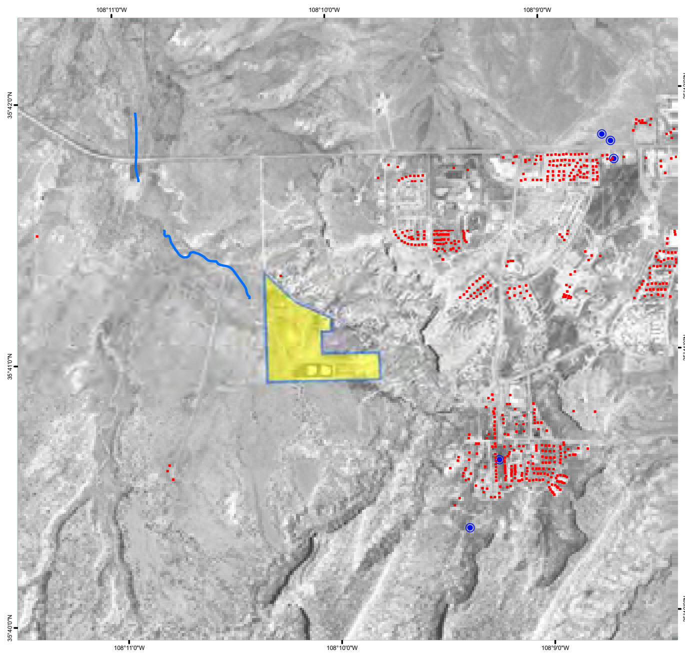


Figure 1. Points, Lines, and Polygons Displayed on Raster Imagery.

As with any database, once it is populated with data, it is possible to search and select on specific parameters. The GIS provides the functionality to select features by attributes or by location. Table 1 lists the results of selecting the wells that are shown in Figure 1. An example of some of the "attributes" that are stored in the wells data layer are shown in Table 1. The database includes information about each well or spring location, which is stored as a point (x,y coordinate) in the GIS. The selected attributes include the well identifier, alias names, the type of well, a code for use of the well, the depth of the well, the source aquifer, the static water level (SWL), and the U.S. Geological Survey identification number.

Table 1. Selected Attributes for the Water Source Dataset.

Well_ID	Alias	Type	Use	Well_Depth	Aquifer	SWL	USGS_ID
15-0579	CROWNPOINT #1	Water Well	MUN	2345.0	221WSRC	423.0	354105108091001
15-0580	15-UNK-0006/17N12W 173333	Observation Well	OTH	2450.0	221WSRC	349.6	354148108083801
15-0581	CONOCO #2 (NTUA)	Water Well	MUN	2377.0	221WSRC	443.2	
15K-303	CROWNPOINT POWERHOUSE WELL	Water Well	DOM	2496.0	221MRSN	225.0	354033108091501
CRWNPT PM5	CROWNPOINT CANYON WELL PM5	Water Well	DOM	2544.0	221MRSN	335.0	354017108092201
CRWNPT PM6	CROWNPOINT BOARD. SCH. PM6	Water Well	DOM	2500.0	221MRSN	350.0	354103108083901
CRWNPT PM7		Water Well	UNK	2345.0	221WSRC	385.0	
SJ 01624		Well	IND				

Using a GIS, it is possible to symbolize the data based on attributes. In Figure 2 wells are symbolize by "Use" which includes the following categories:

- Domestic (DOM)
- Industrial (IND)
- Municipal (MUN)
- Other (OTH)
- Unknown (UNK)

Structures are symbolized by how the location was determined. Green structures were photo interpreted using orthophotography that was flown in 1997. Utility meter locations collected with a Global Positioning System (GPS) were provided by the Navajo Tribal Utility Authority. These meter data were used to add locations for "assumed structures", and are shown as red squares on Figure 2. These structures were not present on the orthophotography, indicating they were constructed after 1997. See DATA, page 13 for more discussion about the structures, wells, and AUM GIS datasets.

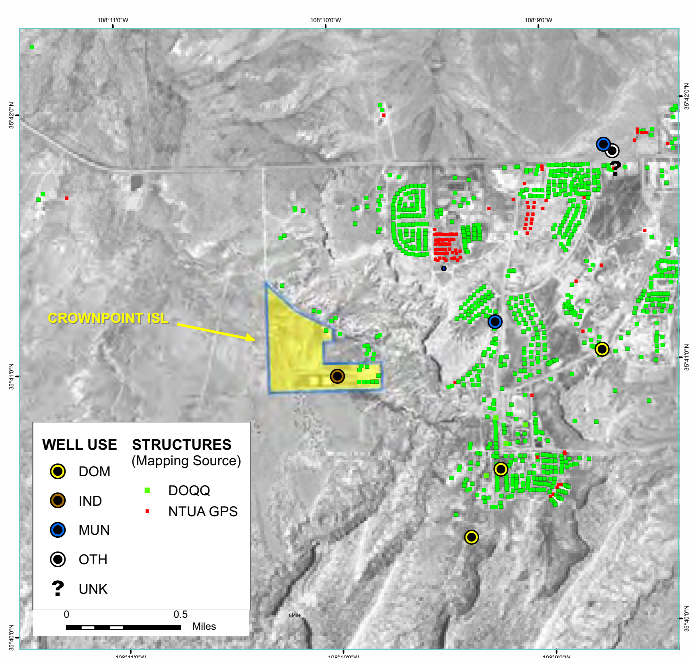


Figure 2. Using Attributes to Symbolize Information.

GEOGRAPHIC INFORMATION SYSTEM (GIS) (continued)

GIS provides analytical tools to allow the user to extract information from the data and the cartographic tools to present the results in a meaningful way. In the example shown in Figure 3, the GIS has been used to generate buffers around the Crownpoint ISL AUM at distances of 200 feet, 1/4 mile, and 1 mile. The GIS overlay functionality was used to tabulate the number of structures and wells that are located within each of these distances from the AUM. The 200 feet buffer is inclusive of the AUM.

The results of the buffer overlays are shown in the table below. Structure counts and well counts for each buffer distance are listed. Figure 3 provides a spatial view of the results, showing the locations of the wells and structure within each buffer.

BUFFER DISTANCE	STRUCTURE COUNT
200 Ft	18
1/4 Mile	10
1 Mile	642
Total	**670**

BUFFER DISTANCE	WELLS COUNT
200 Ft	1
1/4 Mile	0
1 Mile	4
Total	**5**

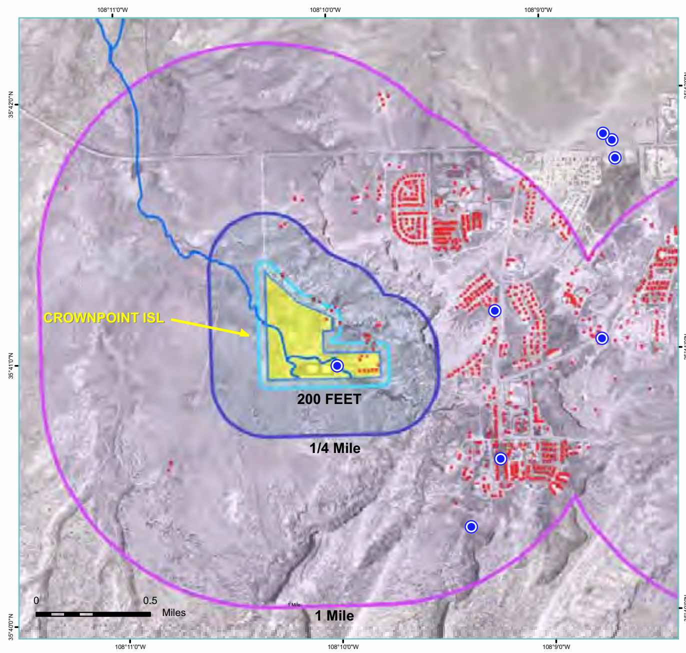


Figure 3. Using Buffer Analyses. Example of Crownpoint In Situ Leaching (ISL) Site.

By integrating spatial information with statistical and analytical processes in a GIS it is possible to develop models that can show spatial patterns that are not otherwise readily apparent. Figure 4 is an example of results of a model that uses broad physical characteristics to describe the potential for contamination of the aquifer from surface and near surface contaminants. These factors included: geology, precipitation, soil properties, slope, and stream courses (Blanchard, 2002 - S01200301).

Numeric scores were developed for each of the datasets listed above based on attributes in the database. For example, slope of the land affects the ability of precipitation to infiltrate soils and geology. Three slope ranges were assigned numerical values as follows: slopes less than 6 degrees increase infiltration of water into the land surface and were give a score of 3. Slopes of 6 to 12 degrees were assigned an intermediate score of 2. Slopes greater than 12 degrees were given a low score (1) because infiltration is minimized due to the runoff of water.

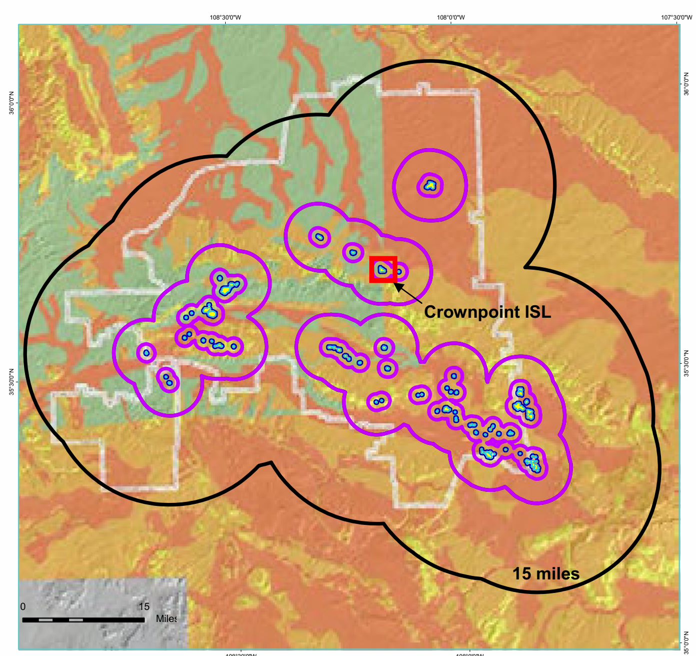


Figure 4. Developing Spatial Models.

= Insignificant potential for contamination of the aquifer
= Least potential for contamination of the aquifer
= Intermediate potential for contamination of the aquifer, and
= Most potential for contamination of the aquifer.

Each of the other factors were scored in a similar manner as slope. The GIS datasets of geology, precipitation, soil properties, and slope were overlain using the GIS resulting in a combined GIS dataset. For each combined GIS polygon, the scores for precipitation, soil properties, and slope were summed and then multiplied by the geologic score to determine the final numeric score. These numeric scores were converted to four (4) categories of "potential for contamination" (shown above).

The area shown in Figure 4 covers the Eastern AUM Region (boundary shown in white), with the locations of the AUMs and buffers out to 15 miles. The modeled results for aquifer sensitivity may prove useful for further assessments of potential contamination from AUMs through ground water pathways.

REPORT ORGANIZATION

PART I - NAVAJO NATION AUM SCREENING ASSESSMENT REPORT

This first part of the report documents the approach and methodology used to develop scores for each of the AUMs on or within one (1) mile of the Navajo Nation. These scores will be used by the NAUM Project Team for screening and prioritization efforts. Results from the initial screening assessment are presented for each of six (6) AUM regions across the Navajo Nation in the form of tables and maps. Some observations about the results and recommendations for improving the scoring process are provided.

PART II - ATLAS AND GEOSPATIAL DATA

The second part of this report describes the geospatial data used to perform the screening assessments in the form of a map Atlas. Each of the GIS datasets are described with an example map on the facing page. This part of the report also presents other geospatial data that have been compiled across the Navajo Nation that could provide useful information for further screening assessment studies and refined prioritization efforts. The data are organized into three (3) Sections:

Section 1: Mining History and Mine Site Information
Section 2: Mine Waste Characteristics
Section 3: Environmental Setting

<u>Mining History and Mine Site Information</u>

Mining History and Mine Site Information presents an overview of the status of our knowledge of the location of abandoned uranium mines on and within 1 mile of the Navajo Nation (e.g., where they are found, what their uranium and vanadium production histories were, what their current reclamation status is, and why they are important as potential risks to human health and the environment). This section provides a description of the history of radium, vanadium, and uranium mining in the United States and the Navajo Nation. The process used to acquire a mining lease or tribal mining permit on the Navajo Nation is discussed. The methods used to evaluate and process different data sources, and the challenges each source presented, are discussed. Ownership and operator histories were researched and compiled for each of the leases and mining permits. The uranium and vanadium ore productions by mine (including tonnages and concentrations of vanadium and uranium ore) were compiled for the Navajo Nation AUMs. Summary tables and associated maps are presented. A key data layer in the NAUM Project GIS is the location and type of AUM site and mine features associated with uranium mining. Determining locations for the AUMs that were suitable for entry into the GIS database was challenging. The data sources and techniques used to develop the AUM sites and mine feature GIS datasets are described in this section.

<u>Mine Waste Characteristics</u>

A thorough site characterization should include an understanding of the different mining processes that occurred throughout mining operations. This type of information can be useful in determining the different types of waste that may be encountered at the site, and where additional sampling should occur, if required. This section provides available sampling data that have been collected on the Navajo Nation that may provide useful insights about the characteristics of the AUM sites (such as size and locations of sites, volumes of potential contaminants, and types of wastes). Information from data sampling and reclamation efforts are presented.

<u>Environmental Setting</u>

The last section of the Atlas provides information that describes the physical and cultural characteristics of the AUM Regions on the Navajo Nation. These types of data can be useful to better understand potential pathways and exposure risks. Data have been compiled from a variety of sources and include the following general categories:

- Administrative Boundaries, Population, and Infrastructure
- Landscape and Environment
- Climate
- Elevation and Topography
- Physiography and Geology
- Ground Water
- Surface Water
- Soils, Vegetation, Land Cover and Land Use
- Basemaps

<u>Geospatial Data</u>

The maps in this Screening Assessment Report and Atlas present the uranium mining history, mine locations and production, and environmental setting data that were compiled for the Navajo Nation. These data were processed into GIS datasets. The data covers the full extent of the Navajo Nation, whereas the earlier Assessment Reports were regionally-based. One of the purposes of the Atlas is to provide a description of these geospatial datasets. The data were developed and the Atlas maps were generated using Environmental Systems Research Institute's (ESRI) GIS software, ArcGIS 9.1.[1]

All of the datasets used in the Navajo Nation Atlas are provided on electronic media (DVD). The vector datasets are in geographic decimal degrees coordinates, using the North American Datum of 1983 (NAD83). The raster datasets have been projected to Universal Transverse Mercator (UTM), Zones 12 or 13 as appropriate, NAD83, meters.

Each thematic dataset has an associated metadata file. ESRI's ArcCatalog can be used to view the xml-based metadata for each dataset, or the .xml metadata file can be viewed in a text editor. Metadata describes the content, quality, condition, data sources, processing history, data usage constraints, and contact information.

A brief description of the data sources that were used to prepare the map are presented for most maps in the Atlas. With ESRI's ArcCatalog, a user can navigate to the file and view its metadata. The metadata includes a source key (Skey) for each data source used to develop a GIS dataset. An Skey number has the format, SMMDDYY###. The S stands for source, MM for the month number, DD for the date, YY for year, and ## for a unique sequential number beginning with 01.

The Skey is also assigned to source documents that were used as references to develop the accompanying text and tables for the report and each Atlas map. Reference documents used in the preparation of this Atlas have been scanned into Adobe Acrobat Portable Document Format or PDF format. These electronic versions of the reference documents are included on the GIS References DVD, with the exception of those that are copyrighted, or are in draft form, considered limited distribution, confidential, or proprietary by the document providers.

[1] Mention of trade names, products, or services does not convey official EPA approval, endorsement, or recommendation.

PURPOSE

The primary purpose of the NAUM Project is to identify AUMs, potential exposures, and to recommend methods to reduce exposure from AUMs on the Navajo Nation. There are more than 1,200 AUM features (e.g., adits, pits, rim strips) located throughout the Navajo Nation. Potential long-term exposure risks can persist even after the surface reclamation of AUM sites is completed. Therefore, an assessment of potential impacts to humans and the environment from the abandoned mines is needed.

A key goal for the NAUM Project is to provide a preliminary screening assessment mechanism to help prioritize Navajo Nation AUM sites using existing, readily available data through a GIS. The focus is to identify the areas with the highest apparent level of risk in order to recommend additional investigations by the appropriate Navajo or lead federal agency. In June 2005, the NAUM Project initiated a series of reports to document preliminary scoring results for AUMs in the six (6) AUM Regions on the Navajo Nation. These six (6) reports were completed and are provided on the GIS References DVD.

Northern AUM Region Screening Assessment Report	March, 2006
Western AUM Region Screening Assessment Report	May, 2006
North Central AUM Region Screening Assessment Report	July, 2006
Central AUM Region Screening Assessment Report	August 2006
Southern AUM Region Screening Assessment Report	October, 2006
Eastern AUM Region Screening Assessment Report	November, 2006

Scoring was accomplished using the methodology described in this report (See METHODOLOGY, page 12). Subsequent to publication of the individual AUM region screening assessment reports, additional information about the AUMs was researched as part of an effort to assign mine names and uranium/vanadium production values to each of the mapped AUMs. The purpose of this Navajo Nation AUM Screening Assessment Report is to provide an updated preliminary scoring for all AUMs mapped on and within one (1) mile of the Navajo Nation in a single document. A brief overview of the CERCLA process and a discussion of potential contaminants and exposure pathways related to AUMs is provided for background.

PROJECT APPROACH

This screening assessment was undertaken by using existing data, selecting indicators from the EPA's Hazard Ranking System (HRS), and applying the analytical capabilities of a GIS to score the AUMs. Key elements of this effort include identifying:

1. The location of the original sources (i.e., AUM)
2. The potential pathways for source exposures
3. The location of population indicators (structures) and water sources at risk for exposure

EPA's Superfund program uses the HRS to evaluate whether a site is serious enough to be listed on the National Priorities List (NPL). Because there are over 1,200 known AUM mine features on the Navajo Nation, EPA needed to screen and prioritize all sites before applying the CERCLA process shown in Figure 5.

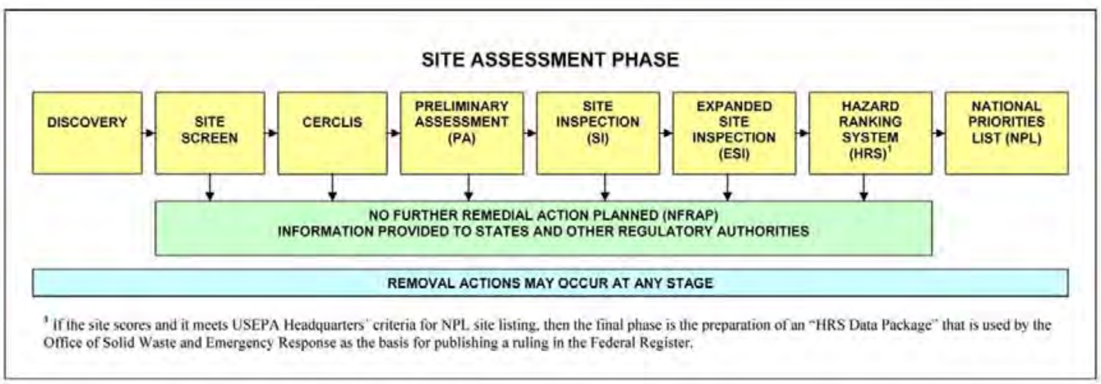


Figure 5. Superfund Process (modified after EPA, 1991– S01230301).

EPA decided to use the geographic measures from the HRS to develop a basic screening model for the AUMs. This screening model includes the location of all known AUM sites as potential sources of exposure. Table 2 provides the possible release mechanisms, pathways, exposure routes, and human and ecological receptors (targets) associated with AUMs.

PRIMARY SOURCES	RELEASE MECHANISM	PATHWAYS	EXPOSURE ROUTE	RECEPTOR		
				Area Resident	Livestock and Terrestrial Wildlife	Aquatic Wildlife
Uranium Mines and Natural Ore Bodies	Infiltration / Percolation	Ground water	Direct Contact	✔	✔	✔
	Storm Water Runoff	Surface Water and Sediments	Direct Contact	✔	✔	✔
	Particles/Dust	Soil Exposure	Inhalation	✔	✔	
			Direct Contact	✔	✔	
	Particles/Dust	Air	Inhalation	✔	✔	
			Direct Contact	✔	✔	

Table 2. Possible Pathways, Exposure Routes, and Human and Ecological Receptors (after EPA, 1991 - S01230301).

EPA's project team created an HRS-derived model to compare the individual AUM sites by distance from the human receptors. Radiation and toxic metals released from an AUM site can travel through the air, through the soils, and through surface- and ground water. The HRS-derived model includes those pathways of potential contamination, and then evaluates the presence of structures and drinking water sources as indicators of population at potential risk to exposure. This report presents the results from the model in maps and data tables that were designed to identify and prioritize the AUM sites that might pose the highest threat to their surrounding communities.

The results in this report were not generated using a complete HRS model, nor does the screening assessment specify NPL site candidates. Based on results from this broad-based screening process, the EPA, NNEPA and NAMLRP will discuss next steps. One of the possible results of the analysis in this report might be to conduct a Preliminary Assessment (PA) or Site Inspection (SI) at any specific sites identified as a priority via the scoring criteria and Navajo knowledge about the setting. Other decisions might entail referrals for EPA removal actions, referrals to other agencies, or a determination that no further action is necessary.

CONTAMINANTS AND EXPOSURE PATHWAYS

EPA identifies the most serious hazardous waste sites in the nation using the HRS. These sites make up the National Priorities List (NPL) and are the sites targeted for long-term federal cleanup activities. Elevated uranium levels have been found in at least 54 of the 1,517 current or former NPL sites. However, the total number of NPL sites evaluated for uranium is not known. As more sites are evaluated, the sites at which uranium is found may increase (ATSDR, 1999[1] - S05160701. Uranium is a natural and commonly occurring radioactive element. It is found in very small amounts in nature in the form of minerals, but may be processed into a metal. Rocks, soil, surface and underground water, air, and plants and animals all contain varying amounts of uranium. Typical concentrations in most materials are a few parts per million (ppm). Some parts of the Navajo Nation exhibit higher than average uranium levels due to natural geological formations. Most uranium ores contain between 0.05 and 0.2% uranium, up to 1,000 times the levels normally found in soil. After the uranium is extracted, it is converted into uranium dioxide or other chemical forms by a series of chemical milling processes. The residue remaining after the uranium has been extracted is called mill tailings. Mill tailings contain a small amount of uranium, as well as other naturally radioactive waste products such as radium and thorium.

Natural uranium is a mixture of three isotopes of uranium, U-234, U-235, and U-238. Radioactive isotopes are constantly changing into different isotopes by giving off radiation. The half-life is the time it takes for half of that uranium isotope to give off its radiation and change into a different element. The half-lives of uranium isotopes are very long (244 thousand years for U-234, 710 million years for U-235, and 4½ billion years for U-238). The shorter half-life makes U-234 the most radioactive, and the longer half-life makes U-238 the least radioactive. U-234 will be about 20,000 times more radioactive and the U-235 will be 6 times more radioactive than the U-238. Radioactive decay of the parent U-238 material produces a series of new elements and radiation, including radium and radon, alpha and beta particles, and gamma radiation that individually interact and contaminate the air, water and soil media. Ultimately, uranium decays into a stable form of lead.

Because of the slow rate of decay, the total amount of natural uranium in the earth stays almost the same, but it can be moved from place to place through natural processes or by human activities. When rocks are eroded by water or wind, uranium minerals become a part of the soil. When it rains, the soil containing uranium minerals can be transported via leached material and deposited into rivers and lakes. Although exposure to uranium in natural settings may be limited, mining activities often result in increased exposure risks. Mining, milling, and other human activities, such as construction of structures using radioactive waste ore materials, can also move uranium around natural environments as an additional long-term exposure pathway. Mining activities disturb mineralization that can affect exposures. Traditionally, uranium has been extracted from open-pits and underground mines. In the past decade, alternative techniques such as in-situ leach mining, in which solutions are injected into underground deposits to dissolve uranium, have become more widely used. Activities such as removing overburden, tunneling, and transporting ore can expose previously protected mineral deposits to accelerated oxidation and increase their mobility through the environment. (EPA, 2000 - S02200302). These activities can also lead to the release of hazardous materials into the environment through air, water, and soil.

Air - Natural weathering processes of crustal rock and soil can change the crustal ratio of uranium isotopes. In some cases, human activities have also altered the normal crustal distribution of naturally occurring radioactive materials, resulting in what has been termed Technologically Enhanced Naturally-Occurring Radioactive Material (TNORM). No new radioactivity is produced, but uranium and its progeny are redistributed in such a way that real exposure or the potential for human exposure may increase. A major localized source of enhanced natural uranium can result from mining and milling operations. Uranium ore is removed from its natural location during open-pit, in-situ leach, or underground mining operations. The primary sources of airborne releases are from the actual mining, from ore crushing and grinding, from ore debris piles, and from ore stockpiles. Currently, mining and milling operations represent a minimal source of uranium release. Another method by which uranium may be introduced into the atmosphere is the natural process of erosion and wind activity. Wind erosion of tailings at uranium mining and milling activities can also result in the resuspension of uranium.

Water - The redistribution of uranium and uranium progeny to both surface water and ground water occurs primarily from the natural erosion of rock and soil; some redistribution also comes from the mining and milling. Uranium is discharged to surface water and/or ground water during mining operations. If an open-pit or underground mine extends below the water table, ground water must be removed to permit mining operations to continue. This is usually accomplished by pumping and discharging excess water into the ground or nearby bodies of water. Since mine water is generally concentrated with uranium, its introduction into surface water bodies may produce measurable increases in uranium levels. Waste waters from open-pit mines are typically one to two orders of magnitude greater in volume and radioactivity content than waters from shaft or underground mines. Contamination of ground water and surface water can also occur by water erosion of tailings piles.

Soil - Uranium is a naturally occurring radionuclide that is present in nearly all rocks and soils (soils being derived from erosion of the rocks). The average concentration in U.S. soils is about 2 pCi/g (3 ppm); however, much higher levels are found in areas such as the Colorado Plateau. The uranium present in the rocks and soil as a natural constituent represents natural background levels. Contamination of the soil can occur either from deposition of uranium originally discharged into the atmosphere, or from waste products discharged directly into or on the ground (e.g., water containing uranium from either underground or open-pit mines).

Uranium ore concentrations and associated radioactivity varies widely at mining areas and geological formations across the Navajo Nation. Other potential contaminants of concern include arsenic and lead. EPA is evaluating the likelihood for offsite migration of contaminants due to historic mining activities, but is not assessing natural occurrences (EPA, 2004 - S01130602).

[1] Unless otherwise cited, the information contained in this section is from "Toxicological Profile for Uranium," (ATSDR, 1999 - S051607001).

NAVAJO NATION AUM REGIONS

The Navajo Nation is located on the Colorado Plateau and covers over 27,000 square miles in northeast Arizona, northwest New Mexico, and southeast Utah and occupies portions of twelve (12) counties within those states. The tribal government structure consists of 110 Chapters. Section 3 "Environmental Setting" of the Atlas provides more detailed information about the administrative boundaries.

Significant amounts of uranium were produced from deposits in the Chinle and Morrison formations, and minor deposits occurred in the Bidahochi, Dakota Sandstone, Todilto Limestone, Navajo Sandstone, Kayenta, Moenkopi and Toreva formations. Uranium ores were mined from deposits located across the Navajo Nation. For the purposes of this report, six (6) AUM Regions are identified: North Central, Northern, Western, Central, Southern, and Eastern (Figure 6). The following provides brief descriptions of the six (6) AUM Regions and presents statistics about the number of AUMs that were mapped, how many AUMs had records of uranium/vanadium production, and how many AUMs were not productive or for which no records of uranium production were found.[1]

NORTH CENTRAL AUM REGION

The North Central AUM Region lies in northeastern Arizona and southeastern Utah. It spans four (4) counties: Apache, Coconino, and Navajo Counties in Arizona, and San Juan County, Utah. The region is comprised of five (5) Navajo Nation Chapters: Dennehotso, Kayenta, Mexican Water, Oljato, and Shonto. The region covers approximately 2,829 square miles in the Monument Valley and Navajo Uplands area of the Navajo Nation.

Uranium was mined in the North Central AUM Region in 1944 and between 1947 and 1969. A total of 68 AUM-related polygons were identified in the region. The Harvey Lee Sampson No.s 1 and 9 mine was the only AUM in the region that had reported production, but could not be located and, therefore, was not entered into the GIS dataset. Forty (40) productive AUMs were located in the region. Twenty-three (23) AUMs were mapped that had no records of uranium production, but did have evidence of surface disturbance (e.g., NAMLRP reclamation sites) and were located within a mining claim. The Mexican Hat Stockpile was also located in the North Central AUM Region. The Gothe Mine in Oljato Chapter was added to the GIS database after publication of the preliminary North Central AUM Region screening assessment report.

NORTHERN AUM REGION

The Northern AUM Region is located in the northeastern portion of the Navajo Nation, straddling three (3) counties and three (3) states: Apache County, Arizona; San Juan County, New Mexico; and San Juan County, Utah. The region is comprised of eleven (11) Chapters: Aneth, Beclabito, Cove, Lukachukai, Red Mesa, Red Valley, Round Rock, Sanostee, Shiprock, Sweetwater, and Teec Nos Pos. The region covers approximately 3,009 square miles in the hilly, high-altitude mountains and plains of the Navajo Nation.

Uranium was mined in the Northern AUM Region from 1948 to 1967 in the Carrizo Mountains and in the Sanostee area from 1952 to 1982. A small amount of radium was mined in 1920. A total of 271 AUM-related polygons were identified in the Northern AUM Region, which is 14 fewer than the preliminary Northern AUM Region screening assessment report. This is due to aggregation of several AUM polygons that were originally entered as separate NAMLRP reclamation projects. As part of the effort to assign mine names and production values to AUMs, it was determined that many of the reclamation projects covered a single AUM (e.g., reclamation projects NA-0303, NA-0304, NA-0305, NA-0307, NA-0309 and NA-0340 were all part of the Cove Mesa Mines AEC Lease Plot 7). A total of 174 productive uranium mines were located, and 55 AUMs were mapped with no production or records of production. Two (2) of the non-productive AUMs were transfer stations (Cove and Climax Transfer Stations).

WESTERN AUM REGION

The Western AUM Region is located on the western edge of the Navajo Nation, and is contained within Coconino County, Arizona. The region is comprised of seven (7) Chapters: Bodaway/Gap, Cameron, Coalmine Canyon, Coppermine, LeChee, Leupp, and Tuba City, covering approximately 4,028 square miles in the Painted Desert area of the Navajo Nation.

Uranium was mined in the Western AUM Region between 1951 and 1963. A total of 126 AUM-related polygons were identified in the region, which is two (2) more than reported in the preliminary Western AUM Region screening assessment report. The Julius Chee #4 was split into two (2) AUMs and the Hosteen Nez AUM was added. There were 98 productive uranium/vanadium AUMs located on or within one (1) mile of the Navajo Nation. Thirteen (13) AUMs were mapped with no production history, but which exhibited evidence of surface disturbance (e.g., trenches) and they were located within a mining claim.

CENTRAL AUM REGION

The Central AUM Region is located predominantly in northeastern Arizona, with a small portion of the Tsaile/Wheatfields Chapter extending into northwestern New Mexico. The region spans three (3) counties: Apache and Navajo Counties in Arizona, and San Juan County in New Mexico. The Central AUM Region is comprised of nine (9) Navajo Nation Chapters: Black Mesa, Chilchinbeto, Chinle, Many Farms, Rock Point, Rough Rock, Tachee/Blue Gap, Tsaile/Wheatfields, and Tselani/Conttonwood. The region covers approximately 2,196 square miles in the Black Mesa, Chinle Valley, and Defiance Plateau areas of the Navajo Nation.

Uranium was mined in the Central AUM Region between 1954 and 1968. There were a total of 34 AUM related polygons mapped in the Central AUM Region. Fifteen (15) AUMs with documented production were located in the region and thirteen (13) AUMs were mapped for which no records of uranium production were located.

[1] It should noted that in some cases there are multiple surface disturbances (AUM polygons) associated with a single AUM site. In these cases, each AUM polygon that was associated with a productive AUM site was assigned the same mine name. For example, uranium was mined from eleven (11) pits/rim strips on the Tom Wilson AUM in the Central AUM Region. Four (4) surface AUM polygons were mapped around these pits/rim strips, but uranium production was reported as a single value for the Tom Wilson mine. All four of these polygons were assigned the mine name "Tom Wilson." For this reason, the number of AUM-related polygons that were mapped may be higher than the total number of AUM site reported in this section and throughout the report.

SOUTHERN AUM REGION

The Southern AUM Region is located on the south central border of the Navajo Nation. The region spans two (2) counties: Apache and Navajo Counties in Arizona. The region is comprised of six (6) Chapters: Dilkon, Greasewood Springs, Indian Wells, Steamboat, Teesto, and White Cone. The Southern AUM Region covers approximately 1,726 square miles in the Navajo Section of the Colorado Plateaus Province. A large part of the Southern AUM Region is located in the Hopi Buttes volcanic field.

Uranium was mined in the Southern AUM Region between 1954 and 1959. There was only one (1) productive AUM located in the region, the Morale mine. Five (5) AUMs were mapped that had no records of uranium production, but did had evidence of surface disturbance and they were located within a mining permit. A total of six (6) AUMs were mapped in the region.

EASTERN AUM REGION

The Eastern AUM Region is located in northwestern New Mexico and crosses into portions of three (3) counties: Cibola, McKinley, and San Juan. The region is comprised of seventeen (17) Navajo Nation Chapters: Haystack, Becenti, Bread Springs, Casamero Lake, Church Rock, Coyote Canyon, Crownpoint, Iyanbito, Littlewater, Mariano Lake, Nahodishgish, Pinedale, Red Rock, Rock Springs, Smith Lake, Standing Rock, and Thoreau. The Eastern AUM Region covers approximately 1,784 square miles in the "Checkerboard Area" of the Navajo Nation, which includes Tribal Trust Lands, fee lands, allotment lands, privately owned, and federal lands. See Section 3 - Land Status, page 3-4 in the Atlas. The Eastern AUM Region is located within the highly productive Grants Uranium District in northwestern New Mexico.

During a period spanning nearly three decades (1951 to at least 1989), the Grants Uranium District produced more uranium than any other district in the United States (McLemore and Chenoweth, 2003 - S08020606). There were 97 AUM-related areas mapped in the region. Sixty-five (65) AUMs with documented production were located in the region and 18 AUMs were mapped for which no records of uranium production were located. Changes from the preliminary Eastern AUM Region screening assessment report include: removal of six (6) AUM polygons associated with the Crownpoint Monument In-Situ Leach (ISL) and Crownpoint South Trend ISL plant sites, which were proposed but never constructed. The Section 25 Shaft AUM polygon was merged with the Section 25 mine AUM. The Section 32/33 AUM polygon was split into two (2) AUMs and individual production values were assigned. Finally, two (2) AUM polygons were added for the productive Haystack mine.

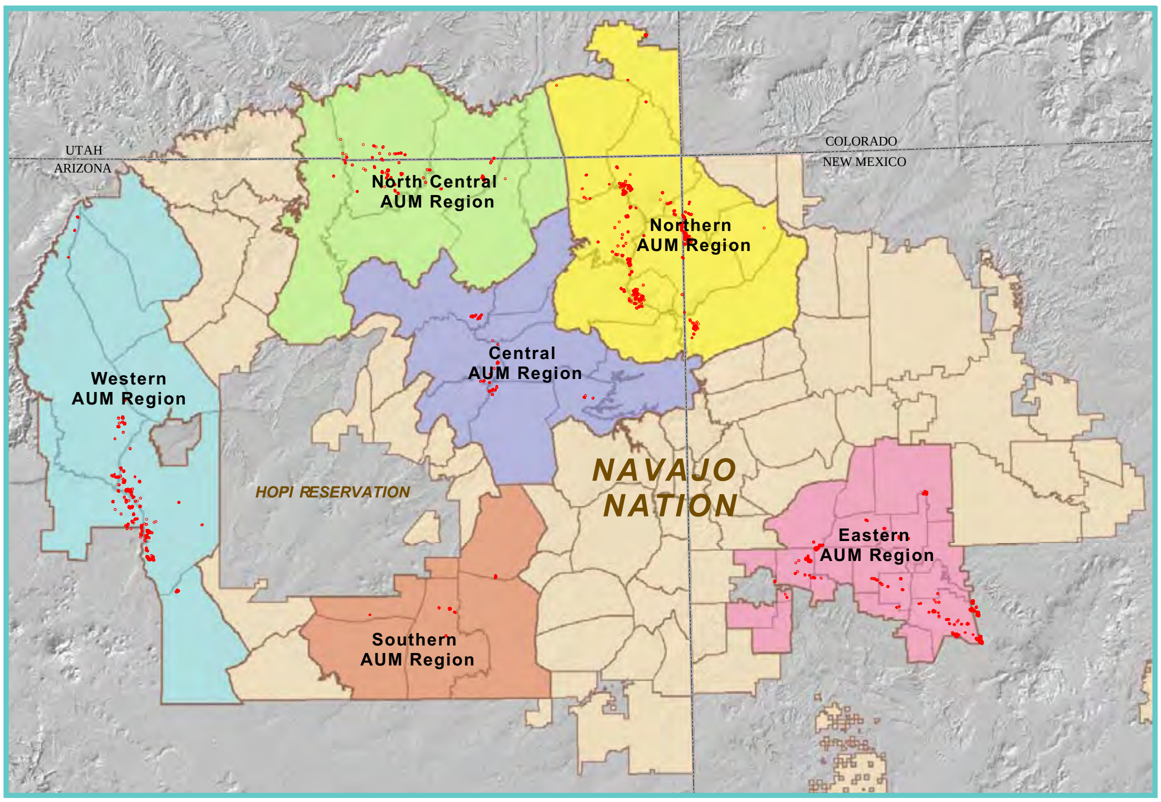


Figure 6. Locations of AUM Regions on the Navajo Nation.

METHODOLOGY

The methodology used to develop this Navajo Nation AUM Screening Assessment Report applied the following steps:

- Develop a Hazard Ranking System (HRS) derived model to assess and compare AUM priorities on the Navajo Nation
- Acquire data inputs for the HRS model and automate into a GIS database
- Apply the screening criteria using GIS analysis tools
- Generate a scoring list for each pathway and compile a composite scoring list for each AUM

HAZARD RANKING SYSTEM (HRS) DERIVED MODEL

EPA's Region 9 Superfund Site Assessment and Technical Support Team selected a subset of HRS criteria to develop preliminary screening scores for the AUMs. The purpose of this analytical model is to prioritize Navajo AUM sites using readily available data. The level of detail in this study is not as robust as required for remedy decision making, since the purpose of the screening model is not to determine actual risks, but rather to identify priority areas for future investigation. The EPA team considered probable Navajo exposure pathways as the basis for the model. The large area involved in the assessment falls beyond the normal scope for HRS, so a custom model was developed to best fit these unique circumstances.

Due to the unique nature of the task, the EPA team considered the probable Navajo exposure pathways and used 40 CFR 300, Federal Register Notice, HRS Final Rule, December 1990 (EPA, 1990 - S01130601) as the basis for the HRS-derived model. Given the EPA's experience collecting available and pertinent Navajo Nation environmental data and the large land area under consideration, the EPA decided to conservatively address all known release points (i.e., AUMs, mine related features, and waste piles), drainages downstream from AUMs, all known water wells (domestic, agricultural, and municipal), and all structures. However, sensitive environments, such as endangered species, and cultural data, were not readily available with enough locational specificity (compatible with GIS format) to input into the model. The inclusion of HRS criteria for sensitive environments would be recommended during future site-specific characterization activities, where the Navajo Nation would also be able to protect sensitive information with appropriate controls.

Consideration was given to the general fate and transport of radionuclides, as well as probable Navajo Nation exposure assessment scenarios. For example, the scenario of a rural homestead adjacent to an unfenced AUM site where the residents spend considerable hours outdoors with access to a nearby surface water source was considered. As a conservative assumption, it was presumed that all water sources may be used for human consumption and that uranium ore is mobile in dissolved media. For the two water pathways, a simple numeric progression was chosen. A high bias was used in weighting the soil and air pathway for close proximity (within 200 feet) due to the rural, agrarian lifestyle of the residents. A low bias was used in weighting the soil and air pathway for more distant proximity (>200 feet) due to the difficulty in attributing sources.

The AUM Project HRS-derived model for each of the pathways is listed below.

Air Pathway – 200 feet, 1,320 feet (1/4 mile), and 1 mile

- For structures within 200 feet of an AUM site, assign 100 points per structure
- For structures that exist between 200 feet and 1,320 feet, assign 25 points per structure
- For structures that exist between 1,320 feet and 1 mile, assign 10 points per structure
- For structures beyond 1 mile, assign 0 points

Soil Exposure - 200 feet, 1,320 feet, and 1 mile

- For structures within 200 feet of an AUM site, assign 100 points per structure
- For structures that exist between 200 feet and 1,320 feet, assign 25 points per structure
- For structures that exist between 1,320 feet and 1 mile, assign 10 points per structure
- For structures beyond 1 mile, assign 0 points

Ground water Pathway - 1,320 feet, 1 mile, and 4 miles

- For wells within 1,320 feet of an AUM site, assign 100 points per well
- For wells that exist between 1,320 feet and 1 mile, assign 50 points per well
- For wells that exist between 1 mile and 4 miles, assign 10 points per well
- For wells beyond 4 miles, assign 0 points

Surface Water Pathway - 1 mile, 4 miles, and 15 miles

- For perennial or intermittent surface water within one mile of an AUM site, assign 100 points
- For perennial or intermittent surface water that exist between 1 mile and 4 miles, assign 50 points
- For perennial or intermittent surface water that exists between 4 miles and within 15 miles, assign 10 points
- For perennial or intermittent surface water beyond 15 miles, assign 0 points

DATA

The following data were required to apply the HRS-derived scoring algorithm. GIS datasets were generated and the primary sources used to develop these GIS datasets are listed below:

AUM Sites - Locations for AUMs on and within 1 mile of the Navajo Nation were derived from several sources. Primary sources included: NAMLRP Reclamation Project boundaries; unpublished NAMLRP field inventory locations; numerous uranium mine history reports and written communications from William L. Chenoweth; Navajo Tribal Mining Department Claim Maps, a database of uranium mines, prospects, occurrences, and mills in New Mexico (McLemore et al., 2005 - S09290601); a Monument Valley District property map (Malan, 1964 - S03010603), a report on radioactive occurrences and uranium production in Arizona (Scarborough, 1981 - S09240202), maps showing uranium-bearing diatremes of the Hopi Buttes, Arizona (Wenrich and Mascarenas, 1982 - S06280601 and 1989 - S07270601); U.S. Atomic Energy Commission Certification Reports; U.S. Department of Energy aerial radiation surveys funded by EPA, Region 9, U.S. Geological Survey (USGS) Digital Orthophoto Quarter Quadrangles (DOQQ); and USGS 7.5' topographic maps scanned as Digital Raster Graphic (DRG) files.

AUM boundary polygons were generated for each AUM. These polygons were used to represent the surface extents and locations of AUMs. Polygon boundaries for AUMs with underground workings were also generated when maps or drawings were available. In addition, the location of three (3) stockpiles used as a transfer station for uranium ore were identified and mapped: Cove, Climax, and Mexican Hat.

Structures - Structures include residences or other types of buildings where people may live, work, or gather. Locations of structures within 1 mile of AUMs were interpreted from DOQQs, DRGs, and utility meter locations. Structures are the target for the air and soil pathways.

Wells - A wells database was acquired from the Navajo Department of Water Resources and augmented using data from the Arizona Department of Water Resources, New Mexico Office of the State Engineer, Utah Department of Water Resources, U. S. Army Corps of Engineers water sample locations, USGS/EPA National Hydrography Dataset (NHD), Geographic Names Information System, USGS Ground Water Site Investigations Database, DRGs, DOQQs, and the Church Rock Uranium Monitoring Project (CRUMP, 2003 - S01140501). Wells were used as a target for the ground-water pathway.

Drainages - The high resolution NHD, DOQQs and DRGS were used to identify perennial and intermittent drainages downstream from AUMs.

Part II "*Atlas and Geospatial Data*" provides additional descriptions of the GIS datasets and their sources and provides examples of map products that were developed from the GIS datasets

Abandoned Uranium Mine
Spoil from the Haystack mine in the Haystack Chapter.
Photo courtesy of TerraSpectra Geomatics (photo taken August 2006).

Structures
Structure within 200 feet of the Harvey Blackwater No. 3 Mine (NAMLRP reclamation project site NA-0226 in the Kayenta Chapter).
Photo courtes y of T erraSpectra Geomatics (photo taken April 2005).

Wells
Windmill and water tank 8K-402 in the southeast portion of Oljato Chapter. Photo courtesy of U.S. Army Corps of Engineers (photo taken September 1998

Surface Water
Little Colorado River looking west from Cameron Trading Post
Photo courtesy of TerraSpectra Geomatics (photo taken April 2005).

Figure 7. Example Ph otographs of Modified HRS Scoring Factors.

RESULTS

This section presents results from the HRS-derived screening model for AUM sites located on and within one (1) mile of the Navajo Nation. As previously stated, these scores are not intended to indicate actual risk, but will be used to assist with establishing priorities for future investigations. Previous screening assessment reports presented tables for each of the component pathway scores. The "Ground Water Pathway Score" tables presented the counts of wells that are located within the 1/4 mile, 1 mile, and 4 mile buffers and the total number of wells within 4 miles of each AUM. The scores for each buffer zone were tabulated and presented in a table for each AUM. The "Soil Pathway and Air Pathway Score" tables presented the counts of structures that are within the 200 foot, 1/4 mile, and 1 mile buffers as well as the total number of structures within 1 mile of each AUM. The scores for each buffer zone were tabulated and presented for each AUM. Since the air and soil pathway criteria are the same, the total score results for the soil pathway and air pathway were shown in the same table. These component pathway score tables have been generated for all AUMs mapped on the Navajo Nation, but due to the volume of information, they are not presented as individual tables in this report. They can be found on the GIS Data DVD as an MS Excel spreadsheet (DB/AUM/NN_Scoring.xls). Notable results for the ground water, soil, air, and surface water pathways are discussed in following sections.

Tables for the "Combined Pathway Score" for each AUM Region are presented in this report. The combined pathway score is the sum of the scores for each pathway for each AUM. There are six (6) Combined Pathway Score Tables and several associated maps showing the locations of the scored AUMs. The score tables are sorted by MAP-ID, which is an arbitrary number to facilitate map labeling. The MAP-ID is generally assigned so that MAP-ID increases from west to east and north to south within each AUM Region.

C = Central
E = Eastern
N = Northern
NC = North Central
S = Southern
W = Western

The MAP-ID numbers have a prefix that is associated with the AUM Region in which it occurs (shown at left). The region prefix has been added to the MAP-ID to allow correspondence with the previous six (6) screening assessment reports for comparison purposes. There are some changes to the AUMs from the previous reports, including:

- Added AUM - new MAP-ID
- Deleted AUM - gap in MAP-ID sequence
- Merged AUM - gap in MAP-ID sequence
- Split AUM - new information was obtained that allowed refinement to the boundary of an AUM. In these cases the MAP-ID are the same as the previous report, but the split polygons will share the same MAP-ID with the addition of a suffix (e.g., W112a and W112b).

SOIL PATHWAY AND AIR PATHWAY

The soil exposure pathway involves direct exposure to hazardous substances and areas of suspected contamination. This pathway differs from the three migration pathways in that it accounts for contact with in-place hazardous substances at the site rather than migration of substances from the site. Evaluation of the soil pathway using the modified HRS required knowing the location of the AUM sites and distance to structures. The HRS criteria used to evaluate the soil pathway were:

- For structures within 200 feet of an AUM site, assign 100 points per structure
- For structures between 200 feet and 1,320 feet, assign 25 points per structure
- For structures between 1,320 feet and 1 mile, assign 10 points per structure
- If no structures exist within 1 mile, assign 0 points

Figure 8. Potential Air Pathway. Example of wind-blown dust during a storm in Monument Valley, Utah. Photo courtesy TerraSpectra Geomatics (taken 9/4/2004).

The air pathway involves wind that can entrain particulates from mine waste piles, roads, and other disturbed areas. Waste rock at AUM sites contains radionuclides and metals that may be released as fugitive dust, where they can be inhaled or ingested. This material can contaminate areas downwind as particles settle out of suspension in the air (EPA, 2000 - S02200302). Evaluation of the air pathway using the modified HRS also required knowing the location of AUM sites and distance to structures. Figure 8 (right) shows an example photograph depicting wind blown dust preceding a storm. These dust events can increase the potential for inhalation, ingestion, and transport of radionuclide particles associated with uranium mining.

The buffer distances around the AUM sites and the factors associated with each distance are the same for both the soil and air pathways. A single table was generated for both pathways. Results for the soil and air pathway assessment can be found on the GIS Data DVD and are presented in the spreadsheet "DB/AUM/NN_scoring.xls" in the "Air_Soil_Scores" tab. The spreadsheet shows the number of structures that occur within 200 feet, 1/4 mile, and 1 mile of AUM sites. The number of structures within each buffer are multiplied by the scoring factor for each buffer. The scores for each buffer are summed to obtain the total score for each AUM site.

The highest scored AUM for the soil and the air pathways is the Crownpoint ISL AUM in the Crownpoint Chapter (MAP-ID #E35 - Figure 57). The soil pathway score for Crownpoint ISL is 8,470 and air pathway score is 8,470 for a total soil and air pathway score of 16,940. The soil and air pathway scores calculated for this site are based on eighteen (18) structures within 200 feet of the AUM, ten (10) structures in the 200 foot to 1/4 mile buffer, and 642 structures in the 1/4 mile to 1 mile buffer, for a total of 670 structures within one (1) mile of the AUM.

GROUND WATER PATHWAY

Mining operations can affect ground water quality in several ways. For example, underground workings can provide a direct conduit to aquifers. Ground water quality is also affected when waters infiltrate through surface materials (e.g., mine debris piles) into ground water. Contamination can also occur when there is a hydraulic connection between surface water and ground water. Any of these situations can cause elevated contaminant levels in ground water. In addition, contaminated ground water may discharge to surface water down gradient of the AUM site as contributions to base flow in a stream channel or spring (EPA, 2000 - S02200302).

Evaluation of the ground water pathway using the HRS-derived criteria required the location of the AUM sites and distance to wells (including developed springs). For the ground water pathway, when available, underground workings of the AUMs were mapped and the total area of the surface and underground extent of the AUM was used to generate the buffers. The HRS criteria used to evaluate the ground water pathway were:

- For wells within 1,320 feet of an AUM site, assign 100 points per well
- For wells between 1,320 feet and 1 mile, assign 50 points per well
- For wells between 1 mile and 4 miles, assign 10 points per well
- If no well exists within 4 miles, assign 0 points

Results for the ground water pathway assessment can be found on the GIS Data DVD and are presented in the spreadsheet “DB/AUM/NN_scoring.xls” in the “Groundwater_Scores” tab. The highest ground water pathway score is 1,290 and is located at the unproductive NAMLRP reclamation site NA-0238 in the Red Mesa Chapter (MAP-ID #N2 - Figure 23). The total ground water pathway score for this site is comprised of 0 wells within 1/4 mile of the AUM, 0 wells in the 1/4 mile to 1 mile buffer, and 129 wells in the 1 mile to 4 mile buffer.

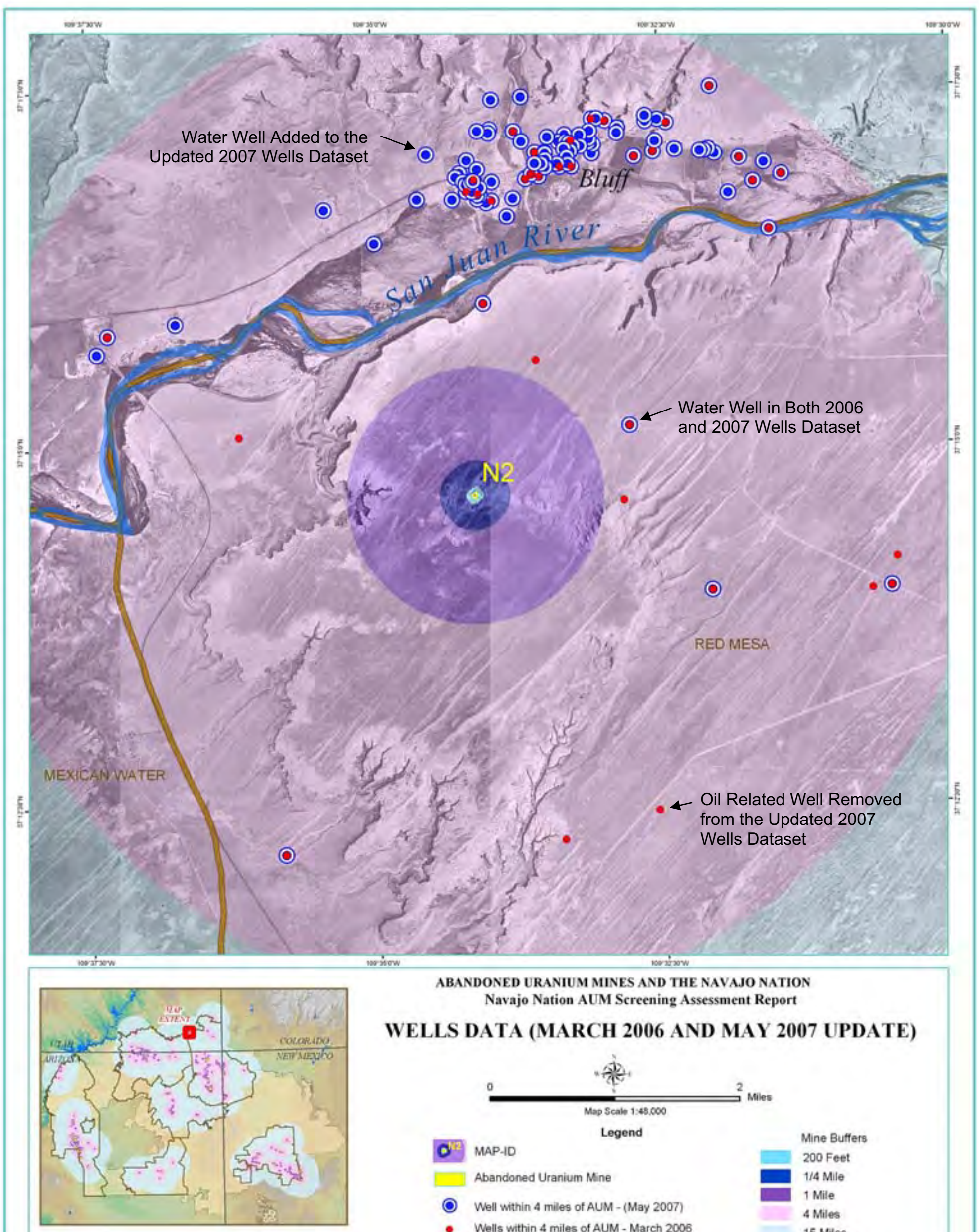


Figure 9. Example Comparison of Wells Data Used in March 2006 and Updated May 2007.

It should be noted that the wells dataset used for this report was updated from the version used for the previous AUM Region screening assessment reports. Figure 9 shows site NA-0238 (MAP-ID #N2) with the 1/4 mile, 1 mile, and 4 mile buffer around the AUM. Wells used in the Northern AUM Region screening assessment report (March, 2006) are shown as red dots. The updated wells dataset used for this report are shown as larger blue dots. This figure illustrates that several wells have been added, particularly near the community of Bluff, Utah. These new wells were made available from the Utah Division of Water Rights Database (dated 2/19/2007). A few wells were removed after determining they were oil or gas related wells and not likely used as drinking water sources. The updates to the wells data have resulted in some substantial changes in scores for some AUMs (e.g., the NA-0238 ground water score was 360 in the Northern AUM Region screening assessment report).

SURFACE WATER PATHWAY

Water erosion is the process by which soil particles are detached and transported from their original location. Sedimentation is the by-product of erosion, whereby eroded particles are deposited at a location different from their origin. Erosion is a concern for AUMs primarily because of the mine wastes. Major sources of erosion and sediment loadings at mining sites include waste rock and overburden piles, haul and access roads, exploration areas, and reclamation areas. Hazardous constituents (e.g., radionuclides and metals) associated with discharges from mining operations may be found at elevated levels in sediments (EPA, 2000 - S02200302).

Evaluation of the surface water pathway using the modified HRS required knowing the location of the AUM sites and distance to perennial and intermittent streams or drainages. The HRS criteria used to evaluate the surface water pathway were:

- For perennial or intermittent surface water within one mile of an AUM site, assign 100 points
- For perennial or intermittent surface water between 1 mile and 4 miles, assign 50 points
- For perennial or intermittent surface water between 4 miles and 15 miles, assign 10 points
- If no perennial or intermittent surface water exists within 15 miles, assign 0 points

All but two (2) of the AUM sites on or within one (1) mile of the Navajo Nation were located within one (1) mile of a downstream intermittent stream or drainage (see Figure 10) and scored 160 (score = 100+50+10). The two AUMs that do not have downstream drainages are both located in the Western AUM Region in the Coalmine Canyon Chapter. The Evans Huskon No. 35 mine (MAP-ID #W79 - Figure 37, page 54) was a rim strip/pit that produced about 170 pounds of uranium. There is no record that the AUM has been reclaimed. The Cam061 prospect (MAP-ID #W80 - Figure 37, page 54) is located within a quarter mile to the north-east of the Evan Huskon No. 35 mine. No records of production were located for this AUM. This AUM is a mine feature that was mapped by NAMLRP, but did not require reclamation.

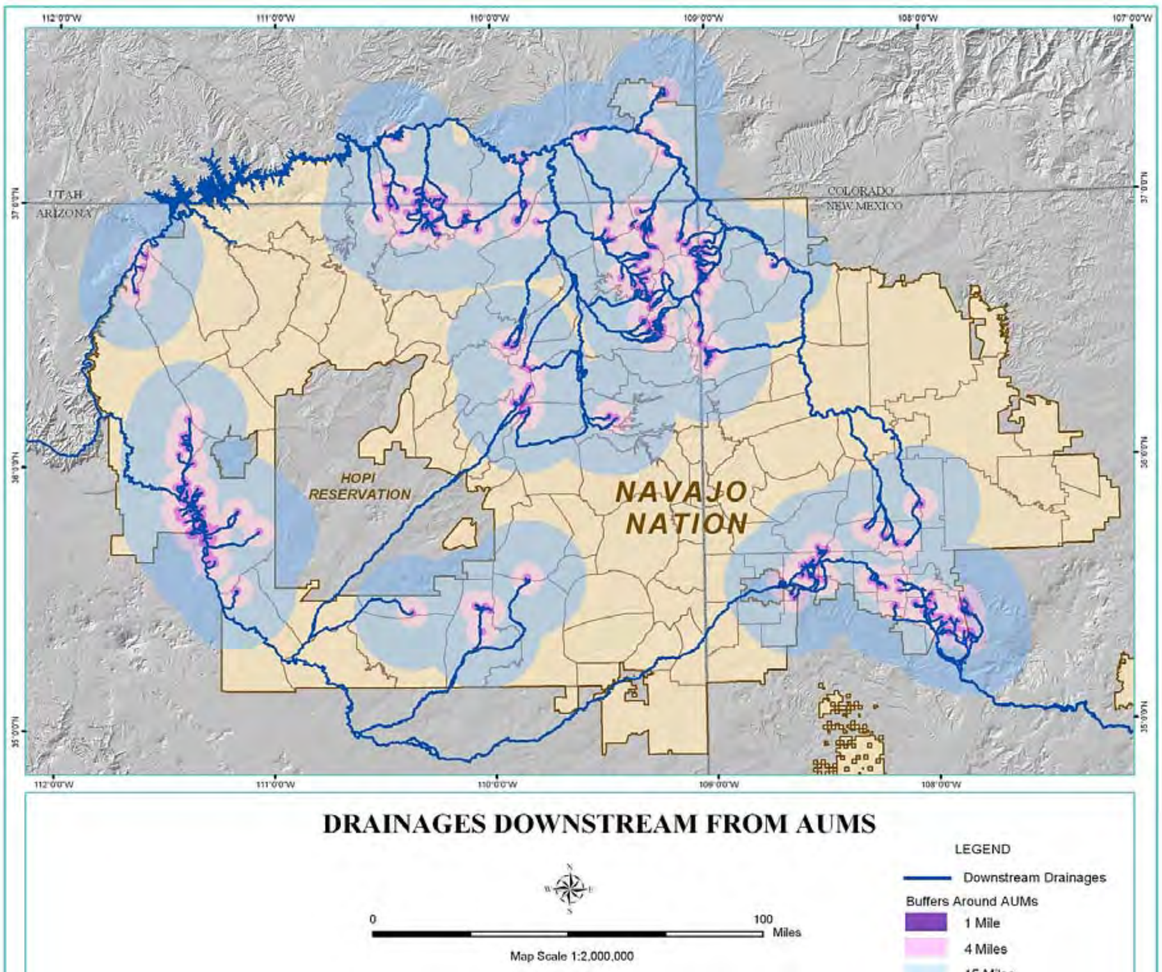


Figure 10. Surface Water Drainages Downstream from AUM Sites.

COMBINED PATHWAYS

After total scores were developed for each of the four pathways it was possible to tabulate a combined pathways score for each of the AUM sites. Scores for air, soil, surface water, and ground water were summed to obtain combined scores, which are presented in the following tables by AUM Region. The tables are sorted by MAP-ID number.

- Table 4. North Central Combined Pathway Scores Table
- Table 5. Northern Combined Pathway Scores Table
- Table 6. Western Combined Pathway Scores Table
- Table 7. Central Combined Pathway Scores Table
- Table 8. Southern Combined Pathway Scores Table
- Table 9. Eastern Combined Pathway Scores Table

The GIS database was used to generate several maps depicting the combined pathways results. A map index was developed for each of the AUM Regions to show the locations of the AUM sites and the extents of the aggregated buffers that were generated around the AUM sites. Also shown on AUM Region Index figures are the extents of the map figures (enlargement) for the combined pathways. AUM sites are labeled with their corresponding MAP-ID on the map enlargements. Also shown are structures, wells, and drainages. Table 3 below lists the map figure number, title, and the range of MAP-IDs on each map. As previously discussed, there are some changes to the AUMs from the previous six (6) screening assessment reports, including: added AUMs have a new MAP-ID; deleted and merged AUM polygons do not appear in the score tables or maps; split AUMs polygons share the same MAP-ID with an alpha suffix (e.g., W112a).

Table 3. MAP-ID Correspondence to Figure Number.

FIGURE NUMBER	FIGURE TITLE	RANGE OF MAP-IDS
Figure 12	North Central AUM Region Combined Pathways - Map Figure Index	NC1 - NC68
Figure 13	Combined Pathways in the Monitor Mesa Area Map	NC1
Figure 14	Combined Pathways in the Mexican Hat Area Map	NC2
Figure 15	Combined Pathways in the North Nokai Mesa Area Map	NC3 - NC9 and N68*
Figure 16	Combined Pathways in the Oljato Area Map	NC10 - NC45
Figure 17	Combined Pathways in the South Nokai Mesa Area Map	NC46
Figure 18	Combined Pathways in the South El Capitan Flat Area Map	NC47 - NC53
Figure 19	Combined Pathways in the Monument Valley Area Map	NC54 - NC60
Figure 20	Combined Pathways in the Cane Valley Area Map	NC61 - NC67
Figure 21	Northern Region Combined Pathways - Map Index Map	N1 - N285
Figure 22	Combined Pathways in the North Central Aneth Area Map	N1
Figure 23	Combined Pathways in the Northwest Red Mesa Area Map	N2
Figure 24	Combined Pathways in the North Teec Nos Pos Area Map	N3 - N4
Figure 25	Combined Pathways in the South Red Mesa Area Map	N5 - N10
Figure 26	Combined Pathways in the Tse Tah Area Map	N11 - N58
Figure 27	Combined Pathways in the Northeast Carrizo Area Map	N59 - N85
Figure 28	Combined Pathways in the Southwest Sweet-water Area Map	N86
Figure 29	Combined Pathways in the West Carrizo Area Map	N87 - N124*
Figure 30	Combined Pathways in the East Carrizo Area Map	N129 - N190
Figure 31	Combined Pathways in the Shiprock Area Map	N191
Figure 32	Combined Pathways in the Lukachukai Area Map	N192 - 263
Figure 33	Combined Pathways in the Chuska Area Map	N264 - N285
Figure 34	Western Combined Pathways - Map Figure Index	W1 - W125
Figure 35	Combined Pathways in the Echo Cliffs Region	W1 - W4
Figure 36	Combined Pathways in the Southeastern Bodaway/Gap Region	W5 - W17
Figure 37	Combined Pathways in the Cameron Region	W18 - W70 * W72 - W91
Figure 38	Combined Pathways in the Adeii Eechii Cliffs Region	W71 and W125*
Figure 39	Combined Pathways in the Southern Little Colorado Region	W92 - W122*
Figure 40	Combined Pathways in the East Black Falls Region	W123 - W124
Figure 41	Central Region Combined Pathways - Map Figure Index	C1 - C34
Figure 42	Combined Pathways in the Rough Rock Area Map	C1 - C10
Figure 43	Combined Pathways in the Tachee Area Map	C11 - C30
Figure 44	Combined Pathways in the Chinle Area Map	C31 - C34
Figure 45	Southern Region Combined Pathways - Map Figure Index	S1 - S6
Figure 46	Combined Pathways in the Cedar Springs Area Map	S1
Figure 47	Combined Pathways in the Bidahochi Area Map	S2 - S5
Figure 48	Combined Pathways in the Greasewood Area Map	S6
Figure 49	Eastern Region Combined Pathways - Map Figure Index	E1 - E103
Figure 50	Combined Pathways in the Northwest Church Rock Area Map	E1 - E2
Figure 51	Combined Pathways in the Northeast Church Rock Area Map	E3 - E9
Figure 52	Combined Pathways in the Nahodishgish Area Map	E10 - E11*
Figure 53	Combined Pathways in the Becenti Area Map	E16
Figure 54	Combined Pathways in the Church Rock Area Map	E17 - E21
Figure 55	Combined Pathways in the Iyanbito Area Map	E22 - E28
Figure 56	Combined Pathways in the Mariano Lake Area Map	E29 - E34
Figure 57	Combined Pathways in the Crownpoint Area Map	E35 - E36*
Figure 58	Combined Pathways in the Western Hay-stack Area Map	E40 - E56
Figure 59	Combined Pathways in the Ambrosia Lake Area Map	E57 - E76
Figure 60	Combined Pathways in the Haystack Area Map	E77 - E103*

* Indicates MAP-ID ranges where AUM polygons were added, deleted, or merged, resulting in gaps in the MAP-ID numbers.

COMBINED PATHWAYS (continued)

Based on the modified HRS model used for this assessment, scores for AUM sites on and within one (1) mile of the Navajo Nation range from 10 to 17,640. The highest composite pathway score on the Navajo Nation is the Crownpoint ISL (In-Situ Leach) AUM. This AUM is located in the Eastern AUM Region in the Crownpoint Chapter (MAP-ID #E35 - Figure 57, page 74). The Composite Score of 17,640 is comprised of the following contributions from the individual pathways:

Air Pathway	
18 structures within the 200 foot buffer	18 x 100 = 1,800
10 structures between 200 feet and 1/4 mile, and	10 x 25 = 250
642 structures between 1/4 mile and 1 mile	642 x 10 = 6,420
	8,470
Soil Pathway	
18 structures within the 200 foot buffer	18 x 100 = 1,800
10 structures between 200 feet and 1/4 mile, and	10 x 25 = 250
642 structures between 1/4 mile and 1 mile	642 x 10 = 6,420
	8,470
Groundwater Pathway	
1 wells within 1/4 mile	1 x 100 = 100
4 wells between 1/4 mile and 1 mile, and	4 x 50 = 200
24 wells between 1 mile and 4 miles of the AUM site	24 x 10 = 240
	540
Surface Water Pathway	
Presence of downstream drainage from the AUM site through each of the buffers.	**160**
Composite Pathway Score for Crownpoint ISL	8,470 + 8,470 + 540 + 160 = **17,640**

Figure 11 below shows an enlargement of the one (1) mile buffer area around the Crownpoint ISL and the Section 29-Conoco (the fourth highest scoring AUM on the Navajo Nation) to illustrate the significance that proximity to the community of Crownpoint has on the scoring. The Crownpoint ISL AUM was shutdown when the price of uranium collapsed and there was no production from this AUM. However, a shaft was sunk to the ore horizon and surface facilities were constructed. Section 29 Conoco was also unproductive, although a shaft was sunk to the ore horizon just before the uranium market collapsed.

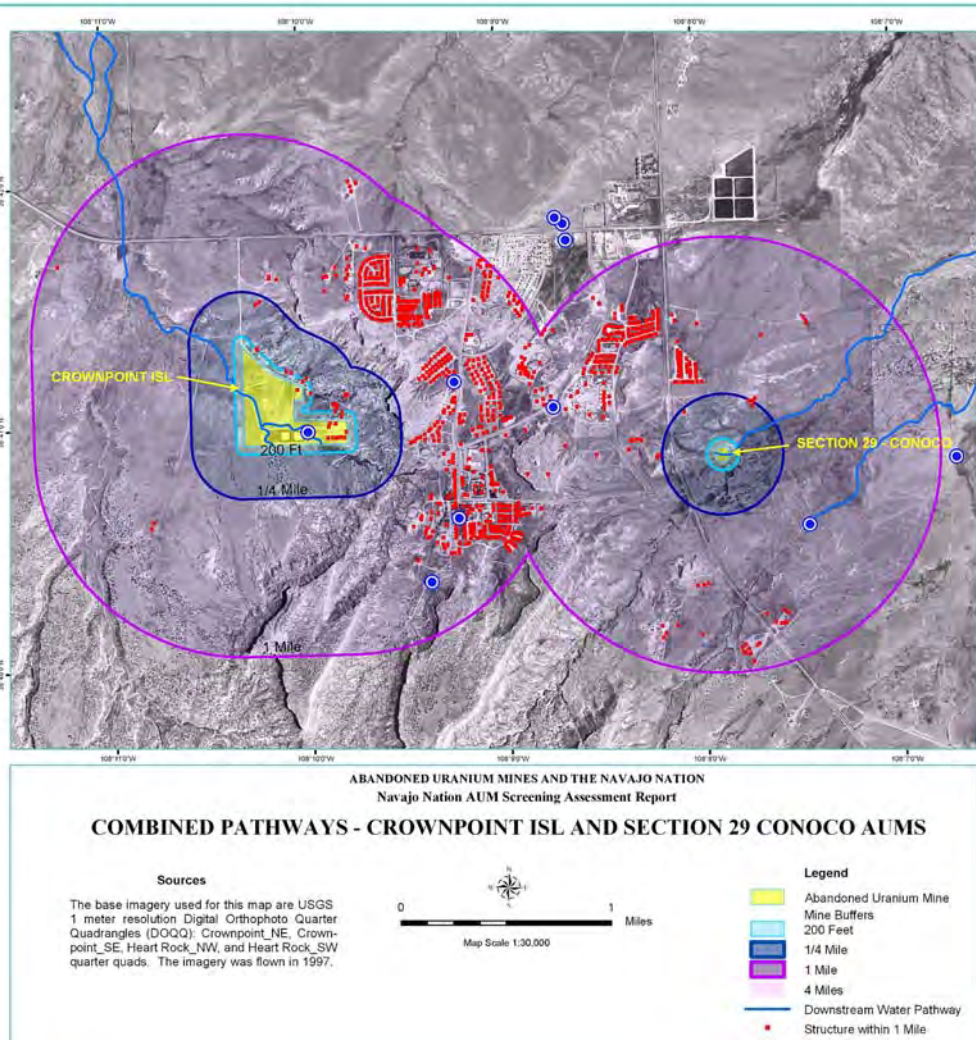


Figure 11. Crownpoint ISL and Section 29-Conoco AUMs Combined Pathways Factors.

Table 4. North Central AUM Region Combined Pathway Scores.

Map-ID	Chapter	Mine Name / Identifier Name	Total Ground Water Score	Total Soil Score	Total Air Score	Total Surface Water Score	Combined Score
NC1	Oljato	Whirlwind	0	0	0	160	160
NC2	Off Navajo Nation	Mexican Hat Stockpile	910	775	775	160	2620
NC3	Oljato	Horsetrail	10	10	10	160	190
NC4	Oljato	Tract 15	10	0	0	160	170
NC5	Oljato	Alfred Mills	10	0	0	160	170
NC6	Oljato	Tract 12	10	0	0	160	170
NC7	Oljato	Tract 14	0	0	0	160	160
NC8	Oljato	Mon060	0	0	0	160	160
NC9	Shonto	Tract 17	0	0	0	160	160
NC10	Oljato	Tract 7	50	0	0	160	210
NC11	Oljato	Taylor Reid No. 1	390	0	0	160	550
NC12	Oljato	Taylor Reid No. 1	330	10	10	160	510
NC13	Oljato	C-3	340	20	20	160	540
NC14	Oljato	Mitten No. 3	390	70	70	160	690
NC15	Oljato	Charles Keith	710	1105	1105	160	3080
NC16	Oljato	Copper Point	570	230	230	160	1190
NC17	Oljato	Norcross	460	450	450	160	1520
NC18	Oljato	Skyline Road	460	30	30	160	680
NC19	Oljato	Tom Holliday	440	30	30	160	660
NC20	Oljato	Mitten No. 1	410	40	40	160	650
NC21	Oljato	Mitten No. 1	400	70	70	160	700
NC22	Oljato	Utah No. 1 Lease	370	200	200	160	930
NC23	Oljato	Skyline	380	240	240	160	1020
NC24	Oljato	Rock Door No. 1	490	1145	1145	160	2940
NC25	Oljato	Monument No. 3	240	70	70	160	540
NC26	Oljato	Utah No. 1	460	20	20	160	660
NC27	Oljato	Radium Hill No. 1	520	20	20	160	720
NC28	Oljato	Fern No. 1	470	0	0	160	630
NC29	Oljato	Harve Black No. 2	730	240	240	160	1370
NC30	Oljato	Tract 11	30	10	10	160	210
NC31	Oljato	Tract 11E	60	10	10	160	240
NC32	Oljato	Tract 24 Mine - B	270	90	90	160	610
NC33	Oljato	Tract 24 Mine - A	280	80	80	160	600
NC34	Oljato	Starlight	480	10	10	160	660
NC35	Oljato	Starlight East	540	10	10	160	720
NC36	Oljato	Moonlight	530	150	150	160	990
NC37	Oljato	Daylight	420	30	30	160	640
NC38	Oljato	Mitten No. 2	410	200	200	160	970
NC39	Oljato	Monument No. 1 North	390	220	220	160	990
NC40	Oljato	Golden Crown	450	305	305	160	1220
NC41	Oljato	Monument No. 1	360	190	190	160	900
NC42	Oljato	Sunlight	500	35	35	160	730
NC43	Oljato	South Sunlight	520	35	35	160	750
NC44	Oljato	Big Four No. 2	470	40	40	160	710
NC45	Oljato	Big Chief	330	0	0	160	490
NC46	Oljato	Tract 2B	40	20	20	160	240
NC47	Oljato	Joe Rock #7-9	110	20	20	160	310
NC48	Oljato	Bootjack	130	20	20	160	330
NC49	Oljato	Firelight No. 6	120	115	115	160	510
NC50	Oljato	Alma-Seegan	80	210	210	160	660
NC51	Oljato	Black Rock Trench	40	185	185	160	570
NC52	Oljato	Black Rock	40	150	150	160	500
NC53	Oljato	Sally	40	180	180	160	560
NC54	Oljato	Binale 2	70	0	0	160	230
NC55	Oljato	Mitchell Mesa	30	0	0	160	190
NC56	Oljato	Binale 1	30	0	0	160	190
NC57	Oljato	Lone Mesa 2 Claim	120	0	0	160	280
NC58	Kayenta	Round Mesa Claim	50	0	0	160	210
NC59	Kayenta	AEC Sample 13756 & USGS Sample MV-8	20	0	0	160	180
NC60	Kayenta	Sam Charlie No. 1	20	0	0	160	180
NC61	Kayenta	Harvey Blackwater No. 3	40	305	305	160	810
NC62	Kayenta	Harvey Blackwater No. 1	90	50	50	160	350
NC63	Kayenta	Harvey Blackwater Claim (South)	150	80	80	160	470
NC64	Kayenta	Harvey Blackwater No. 4	160	70	70	160	460
NC65	Kayenta	Monument No. 2	130	0	0	160	290
NC66	Kayenta	Monument No. 2	500	160	160	160	980
NC67	Dennehotso	Bluestone No. 1	120	60	60	160	400
NC68	Oljato	Gothe Mine	0	0	0	160	160

Table 5. Northern AUM Region Combined Pathway Scores.

Map-ID	Chapter	Mine Name / Identifier Name	Total Ground Water Score	Total Soil Score	Total Air Score	Total Surface Water Score	Combined Score
N1	Off Navajo Nation	Pete	420	10	10	160	600
N2	Red Mesa	NA-0238	1290	0	0	160	1450
N3	Aneth	Montezuma Creek Mine	620	60	60	160	900
N4	Teec Nos Pos	Aneth 1	210	70	70	160	510
N5	Red Mesa	Tom Morgan 1	40	80	80	160	360
N6	Red Mesa	Barton 3	50	140	140	160	490
N7	Red Mesa	John Lee Benally	120	80	80	160	440
N8	Red Mesa	Phillip Dee 1	180	150	150	160	640
N9	Red Mesa	NA-0509A	230	240	240	160	870
N10	Sweetwater	Johnny McCoy 1	470	440	440	160	1510
N11	Teec Nos Pos	John Kee 4	190	305	305	160	960
N12	Teec Nos Pos	Capitan Benally No. 4A	70	80	80	160	390
N13	Red Mesa	Brodie 1	130	260	260	160	810
N14	Teec Nos Pos	Block K	200	215	215	160	790
N15	Teec Nos Pos	NA-0928	230	100	100	160	590
N16	Teec Nos Pos	Silentman 1	190	125	125	160	600
N17	Teec Nos Pos	McKenzie 3	270	145	145	160	720
N18	Teec Nos Pos	Plot 2	270	185	185	160	800
N19	Teec Nos Pos	NA-0904	290	160	160	160	770
N20	Teec Nos Pos	Plot 1	310	150	150	160	770
N21	Teec Nos Pos	Plot 4	220	170	170	160	720
N22	Teec Nos Pos	Plot 3	220	185	185	160	750
N23	Teec Nos Pos	Plot 5	220	295	295	160	970
N24	Sweetwater	NA-0926	230	130	130	160	650
N25	Sweetwater	NA-0924	220	160	160	160	700
N26	Teec Nos Pos	Hoskie Henry	160	560	560	160	1440
N27	Teec Nos Pos	Pope 1	160	420	420	160	1160
N28	Teec Nos Pos	Plot 6	170	575	575	160	1480
N29	Teec Nos Pos	Hoskie Henry	170	525	525	160	1380
N30	Teec Nos Pos	NA-0919B	160	270	270	160	860
N31	Teec Nos Pos	NA-0919A	160	300	300	160	920
N32	Teec Nos Pos	Plot 7	170	390	390	160	1110
N33	Teec Nos Pos	Tse079	170	410	410	160	1150
N34	Teec Nos Pos	Plot 8	170	400	400	160	1130
N35	Teec Nos Pos	Black Rock Point Mines	170	430	430	160	1190
N36	Teec Nos Pos	NA-0917A	170	460	460	160	1250
N37	Teec Nos Pos	Plot 9	170	200	200	160	730
N38	Teec Nos Pos	Jimmie Bileen 1	170	170	170	160	670
N39	Teec Nos Pos	Sandy K	170	200	200	160	730
N40	Teec Nos Pos	Plot 10	170	200	200	160	730
N41	Teec Nos Pos	Plot 11	170	170	170	160	670
N42	Sweetwater	North Martin	450	255	255	160	1120
N43	Sweetwater	Grover Cleveland 1	490	110	110	160	870
N44	Sweetwater	Martin Mine & George Simpson No. 1	590	250	250	160	1250
N45	Sweetwater	Rattlesnake No. 8	690	150	150	160	1150
N46	Sweetwater	Tsosie 1	490	110	110	160	870
N47	Sweetwater	George Simpson 1 Incline	680	280	280	160	1400
N48	Sweetwater	Saytah	640	300	300	160	1400
N49	Sweetwater	Carson	840	170	170	160	1340
N50	Sweetwater	AEC Plot 3	690	90	90	160	1030
N51	Sweetwater	Plot 13	890	270	270	160	1590
N52	Sweetwater	Last Chance	670	270	270	160	1370
N53	Sweetwater	Melvin Benally No. 1	120	130	130	160	540
N54	Sweetwater	Saytah Canyon	120	130	130	160	540
N55	Sweetwater	CBW-MC Mine	140	140	140	160	580
N56	Sweetwater	Saytah Canyon	140	120	120	160	540
N57	Sweetwater	Melvin Benally No. 3	110	185	185	160	640
N58	Sweetwater	School Boy	90	0	0	160	250
N59	Teec Nos Pos	Rattlesnake No. 1	190	10	10	160	370
N60	Teec Nos Pos	Bettie No. 1	50	0	0	160	210
N61	Beclabito	Zona No. 1	80	0	0	160	240
N62	Beclabito	Ruben No. 1	80	0	0	160	240
N63	Beclabito	Jim Lee No. 1, Richard King No. 1	140	0	0	160	300
N64	Beclabito	Todakonzie No. 1	90	0	0	160	250
N65	Beclabito	NA-0424	310	1985	1985	160	4440
N66	Beclabito	NA-0420	210	2815	2815	160	6000
N67	Beclabito	Harvey Begay 3	140	0	0	160	300
N68	Red Valley	Tony Tuc	100	0	0	160	260

Table 5. Northern AUM Region Combined Pathway Scores (continued)

Map-ID	Chapter	Mine Name / Identifier Name	Total Ground Water Score	Total Soil Score	Total Air Score	Total Surface Water Score	Combined Score
N69	Beclabito	Upper Red Canyon	100	0	0	160	260
N70	Beclabito	Kings 6	110	100	100	160	470
N71	Beclabito	Barton & Begay	100	100	100	160	460
N72	Beclabito	Barton & Begay	180	20	20	160	380
N73	Beclabito	Rocky Flats No. 2	140	20	20	160	340
N74	Beclabito	Bec064	110	0	0	160	270
N75	Beclabito	Canyon No. 1	110	0	0	160	270
N76	Beclabito	Bec068	110	0	0	160	270
N77	Beclabito	John John 1	140	20	20	160	340
N78	Beclabito	John John 1	130	20	20	160	330
N79	Beclabito	John John 1	130	20	20	160	330
N80	Beclabito	King No. 2	130	20	20	160	330
N81	Beclabito	Rocky Flats No. 1	130	0	0	160	290
N82	Beclabito	Rocky Flats No. 1	130	0	0	160	290
N83	Beclabito	Rocky Flats No. 1	180	0	0	160	340
N84	Beclabito	Rocky Flats No. 1	180	30	30	160	400
N85	Beclabito	Rocky Flats No. 1	170	30	30	160	390
N86	Sweetwater	Chester Mud No. 1	10	90	90	160	350
N87	Sweetwater	Eurida Mine	20	50	50	160	280
N88	Sweetwater	Plot 14	20	20	20	160	220
N89	Sweetwater	East Workings	10	50	50	160	270
N90	Sweetwater	NA-0505B	10	50	50	160	270
N91	Sweetwater	Plot 16	10	50	50	160	270
N92	Sweetwater	Plot 15	10	0	0	160	170
N93	Sweetwater	NA-0504	20	80	80	160	340
N94	Sweetwater	Chimney No. 1	10	0	0	160	170
N95	Sweetwater	Sunnyside	0	10	10	160	180
N96	Sweetwater	Sunnyside	0	10	10	160	180
N97	Sweetwater	Swt018	0	120	120	160	400
N98	Red Valley	Tohe Thlany Begay Mine	0	0	0	160	160
N99	Red Valley	Cov192	0	0	0	160	160
N100	Sweetwater	AEC Plot B	0	40	40	160	240
N101	Sweetwater	Mildred 1	0	0	0	160	160
N102	Sweetwater	NA-0512	0	10	10	160	180
N103	Sweetwater	AEC Plot D	0	20	20	160	200
N104	Sweetwater	Sheepskin Mesa	0	10	10	160	180
N105	Sweetwater	Tree Mesa	0	10	10	160	180
N106	Sweetwater	Swt003	0	10	10	160	180
N107	Sweetwater	NA-0510	0	0	0	160	160
N108	Sweetwater	Kinusta Mesa	0	20	20	160	200
N109	Sweetwater	NA-0511	0	20	20	160	200
N110	Sweetwater	Cove Mesa Mines (Cato Sells)	0	0	0	160	160
N111	Red Valley	Cove Mesa Mines (Cato Sells)	0	10	10	160	180
N112	Red Valley	Cove Mesa Mines (Cato Sells)	0	10	10	160	180
N113	Sweetwater	Cove Mesa Mines (AEC Lease Plot 7)	0	0	0	160	160
N114	Sweetwater	Cove Mesa Mines (AEC Lease Plot 7)	0	0	0	160	160
N116	Red Valley	Cove Mesa Mines (AEC Lease Plot 7)	0	0	0	160	160
N118	Sweetwater	Cove Mesa Mines (AEC Lease Plot 7)	0	0	0	160	160
N119	Red Valley	Cove Mesa Mines (AEC Lease Plot 7)	0	0	0	160	160
N120	Sweetwater	Cove Mesa Mines (AEC Lease Plot 7)	10	0	0	160	170
N122	Red Valley	Cove Mesa Mines (AEC Lease Plot 7)	10	0	0	160	170
N123	Sweetwater	Cove Mesa Mines (AEC Lease Plot 7)	10	0	0	160	170
N124	Sweetwater	Cove Mesa Mines (AEC Lease Plot 7)	10	0	0	160	170
N129	Red Valley	Cottonwood Butte	190	30	30	160	410
N130	Red Valley	Syracuse Mine	160	0	0	160	320
N131	Red Valley	Hazel	170	30	30	160	390
N132	Red Valley	NA-0410	200	30	30	160	420
N133	Red Valley	North Star	210	30	30	160	430
N134	Red Valley	Lone Star	200	30	30	160	420
N135	Red Valley	Valley View	150	50	50	160	410
N136	Red Valley	White Cap	160	0	0	160	320
N137	Red Valley	Upper Canyon	250	160	160	160	730
N138	Red Valley	Leroy	250	130	130	160	670
N139	Red Valley	Lower Canyon	240	130	130	160	660
N140	Red Valley	NA-0405	240	200	200	160	800
N141	Red Valley	Oak Springs Mine (Gravel Cap)	400	540	540	160	1640
N142	Red Valley	Oak Springs Mine	400	475	475	160	1510
N143	Red Valley	Oak238	260	235	235	160	890

Table 5. Northern AUM Region Combined Pathway Scores (continued)

Map-ID	Chapter	Mine Name / Identifier Name	Total Ground Water Score	Total Soil Score	Total Air Score	Total Surface Water Score	Combined Score
N144	Red Valley	VCA Plot 7 Mines	260	195	195	160	810
N145	Red Valley	VCA Plot 7 Mines	260	135	135	160	690
N146	Red Valley	Franks Point	230	90	90	160	570
N147	Red Valley	Upper Salt Rock	190	30	30	160	410
N148	Red Valley	VCA Plot 7 Mines	180	30	30	160	400
N149	Red Valley	Lower Salt Rock	180	30	30	160	400
N150	Red Valley	Williams Point	270	40	40	160	510
N151	Red Valley	Salt Canyon	220	0	0	160	380
N152	Red Valley	Salt Canyon	220	10	10	160	400
N153	Red Valley	VCA Plot 3	310	170	170	160	810
N154	Red Valley	Lookout Point	270	90	90	160	610
N155	Red Valley	Lookout Point Incline	310	190	190	160	850
N157	Red Valley	VCA Plot 3	170	20	20	160	370
N158	Red Valley	Shadyside No. 2	170	30	30	160	390
N159	Red Valley	Shadyside No. 1	180	50	50	160	440
N160	Red Valley	VCA Plot 3	180	40	40	160	420
N161	Red Valley	Begay No. 2	180	40	40	160	420
N162	Red Valley	Begay Incline	180	90	90	160	520
N164	Red Valley	Shadyside Incline	260	90	90	160	600
N166	Red Valley	VCA Plot 3	400	460	460	160	1480
N167	Red Valley	Nelson Point	360	360	360	160	1240
N168	Red Valley	Tent No. 1	360	200	200	160	920
N169	Red Valley	Oak143, Oak146	310	350	350	160	1170
N174	Red Valley	NA-0824	270	60	60	160	550
N175	Red Valley	Junction	220	80	80	160	540
N176	Red Valley	King Tutt Point	250	210	210	160	830
N177	Red Valley	Carrizo No. 1	170	90	90	160	510
N178	Red Valley	Begay No. 1	170	120	120	160	570
N179	Red Valley	King Tutt 1	210	120	120	160	610
N180	Red Valley	Red Wash Point	210	135	135	160	640
N181	Red Valley	Oak124, Oak125	170	120	120	160	570
N182	Red Valley	Begay No. 1	210	120	120	160	610
N183	Red Valley	Alongo Mines	220	145	145	160	670
N184	Red Valley	Red Rock	290	395	395	160	1240
N185	Red Valley	NA-0828	250	305	305	160	1020
N186	Red Valley	Oak230	250	290	290	160	990
N187	Red Valley	Red Wash (Leroy Pettigrew)	250	290	290	160	990
N188	Red Valley	Red Wash (Hosteen S. Begay)	160	80	80	160	480
N189	Red Valley	Upper Red Wash	140	120	120	160	540
N190	Red Valley	Upper Red Wash	140	35	35	160	370
N191	Shiprock	Climax Transfer Station	70	1705	1705	160	3640
N192	Red Valley	East Mesa Mines	70	0	0	160	230
N193	Red Valley	West Mesa Mine	80	0	0	160	240
N194	Cove	Cove Transfer Station	330	2030	2030	160	4550
N195	Round Rock	Mexican Cry Mine	30	0	0	160	190
N196	Round Rock	Mexican Cry Mine	30	0	0	160	190
N197	Round Rock	Hall Mine	30	0	0	160	190
N198	Round Rock	Tom Joe No. 6	30	0	0	160	190
N199	Round Rock	Nakai Chee Begay Mine	30	0	0	160	190
N200	Cove	Cato No. 2	120	10	10	160	300
N201	Cove	Cato No. 1 Pit	120	340	340	160	960
N202	Cove	Frank Jr. Mine	120	60	60	160	400
N203	Cove	NA-0319	120	20	20	160	320
N204	Cove	Mesa VI Mine	160	20	20	160	360
N205	Cove	NA-0319	160	20	20	160	360
N206	Cove	Mesa V Adit	120	0	0	160	280
N207	Cove	Mesa V Incline	120	0	0	160	280
N208	Cove	Mesa V Mine	160	0	0	160	320
N209	Cove	Mesa V Mine	160	20	20	160	360
N210	Cove	NA-0318	120	0	0	160	280
N211	Cove	Cov087	160	20	20	160	360
N212	Cove	Mesa IV 1/2 Mine and Simpson 181	160	20	20	160	360
N213	Cove	North Portal, Frank No. 1 Mine	160	20	20	160	360
N214	Cove	East Portal, Frank No. 1 Mine	160	20	20	160	360
N215	Cove	Frank No. 2	150	20	20	160	350
N216	Cove	South Portal, Frank No. 1 Mine	130	20	20	160	330
N217	Cove	NA-0316	130	20	20	160	330
N218	Cove	Cov068	120	0	0	160	280

Table 5. Northern AUM Region Combined Pathway Scores (continued)

Map-ID	Chapter	Mine Name / Identifier Name	Total Ground Water Score	Total Soil Score	Total Air Score	Total Surface Water Score	Combined Score
N219	Cove	Mesa IV, Mine No. 2	120	0	0	160	280
N220	Cove	Mesa IV, Mine No. 3	120	0	0	160	280
N221	Cove	Mesa IV, Mine No. 1	120	10	10	160	300
N222	Cove	Mesa II Pit	120	0	0	160	280
N223	Cove	Mesa IV 1/4 Mine	130	20	20	160	330
N224	Cove	Mesa IV, West Mine	120	30	30	160	340
N225	Cove	Mesa I Mine 11	100	0	0	160	260
N226	Cove	Mesa I Mine 15	110	0	0	160	270
N227	Cove	Mesa I Mine 10	140	0	0	160	300
N228	Cove	Mesa I Mine 13	140	0	0	160	300
N229	Cove	Mesa I Mine 12	100	0	0	160	260
N230	Cove	Mesa I Mine 14	70	0	0	160	230
N231	Round Rock	Jimmie King No. 9 Mine	30	0	0	160	190
N232	Cove	Mesa IV, East Side	70	10	10	160	250
N233	Cove	Mesa III, Northwest Mine	70	25	25	160	280
N234	Cove	Cov000	70	10	10	160	250
N235	Cove	Mesa III, West Mine	80	25	25	160	290
N236	Cove	Mesa III Mine	70	25	25	160	280
N237	Cove	Mesa II 1/2, Mine 4	70	25	25	160	280
N238	Cove	Mesa II 1/2 Mine	70	10	10	160	250
N239	Cove	NA-0313	70	10	10	160	250
N240	Cove	Mesa II 1/4 Mine	70	10	10	160	250
N241	Cove	Mesa II, Mine 4	70	0	0	160	230
N242	Cove	Henry Phillips Mine	70	0	0	160	230
N243	Cove	Mesa I 1/2 Mine	60	0	0	160	220
N244	Cove	Mesa II, Mine No. 1, P-150	70	10	10	160	250
N245	Cove	Mesa II, Mine No. 1 & 2, P-21	70	10	10	160	250
N246	Cove	Mesa I 3/4, Mine No. 2, P150	70	10	10	160	250
N247	Cove	Mesa I 1/2, West Mine	60	0	0	160	220
N248	Cove	Mesa I 1/4 Mine	100	30	30	160	320
N249	Round Rock	NA-0333	40	0	0	160	200
N250	Round Rock	NA-0332	40	0	0	160	200
N251	Round Rock	Tommy James Mine	50	0	0	160	210
N252	Round Rock	Step Mesa Mine	60	0	0	160	220
N253	Cove	Mesa I 3/4 Incline	80	0	0	160	240
N254	Round Rock	Flag No. 1 Mine	70	0	0	160	230
N255	Round Rock	Black No. 1 Mine	60	0	0	160	220
N256	Round Rock	Black No. 2 Mine (West)	50	0	0	160	210
N257	Round Rock	Black No. 2 Mine	50	0	0	160	210
N258	Cove	Billy Topaha Mine	50	0	0	160	210
N259	Round Rock	Joleo Mine	50	0	0	160	210
N260	Round Rock	Cisco Mine	50	0	0	160	210
N261	Round Rock	Camp Mine	40	0	0	160	200
N262	Round Rock	Knife Edge Mesa Mine	60	0	0	160	220
N263	Round Rock	NA-0343	60	0	0	160	220
N264	Red Valley	Rocky Spring	150	380	380	160	1070
N265	Red Valley	H. B. Roy No. 1	30	0	0	160	190
N266	Sanostee	Key and Tohe	20	20	20	160	220
N267	Sanostee	Castle Tsosie	10	0	0	160	170
N268	Sanostee	Joe Ben 1	10	0	0	160	170
N269	Sanostee	Joe Ben 2	10	0	0	160	170
N270	Sanostee	Deneh Nezz 3	10	0	0	160	170
N271	Sanostee	Deneh Nezz 1, 2	10	0	0	160	170
N272	Sanostee	Enos Johnson Claim?	10	0	0	160	170
N273	Sanostee	John Joe 1	10	0	0	160	170
N274	Sanostee	Enos Johnson	10	0	0	160	170
N275	Sanostee	Enos Johnson	10	0	0	160	170
N276	Sanostee	Joe Ben 3	10	0	0	160	170
N277	Sanostee	NA-0603	10	0	0	160	170
N278	Sanostee	Enos Johnson 3	10	0	0	160	170
N279	Sanostee	Enos Johnson 1, Enos Johnson 2	10	0	0	160	170
N280	Sanostee	Enos Johnson	10	0	0	160	170
N281	Sanostee	Enos Johnson	10	0	0	160	170
N282	Sanostee	Horace Ben	10	0	0	160	170
N283	Sanostee	Carl Yazzie 1	10	0	0	160	170
N284	Sanostee	H. B. Roy No. 2	10	10	10	160	190
N285	Sanostee	Reed Henderson	0	0	0	160	160

Table 6. Western AUM Region Combined Pathway Scores

Map-ID	Chapter	Mine Name / Identifier Name	Total Ground Water Score	Total Soil Score	Total Air Score	Total Surface Water Score	Combined Score
W1	Bodaway/Gap	Jimmie Boone	40	0	0	160	200
W2	Bodaway/Gap	Tommy	50	120	120	160	450
W3	Bodaway/Gap	June	50	40	40	160	290
W4	Bodaway/Gap	Thomas No. 1	190	10	10	160	370
W5	Bodaway/Gap	Martin Johnson No. 4	110	490	490	160	1250
W6	Bodaway/Gap	Earl Huskon No. 1	20	10	10	160	200
W7	Bodaway/Gap	Max Huskon No. 5	30	0	0	160	190
W8	Bodaway/Gap	Paul Huskie No. 21	30	0	0	160	190
W9	Bodaway/Gap	Earl Huskon No. 3	30	0	0	160	190
W10	Bodaway/Gap	A & B No. 5	20	0	0	160	180
W11	Bodaway/Gap	Max Huskon No. 1	20	40	40	160	260
W12	Bodaway/Gap	Henry Sloan No. 1	30	110	110	160	410
W13	Bodaway/Gap	Henry Sloan No. 1	20	95	95	160	370
W14	Bodaway/Gap	Charles Huskon No. 7 (MP-357)	20	25	25	160	230
W15	Bodaway/Gap	A & B No. 13	70	80	80	160	390
W16	Bodaway/Gap	A & B No. 7	40	50	50	160	300
W17	Coalmine Canyon	Charles Huskon No. 5	40	20	20	160	240
W18	Coalmine Canyon	Charles Huskon No. 6	40	45	45	160	290
W19	Coalmine Canyon	Lemuel Littleman No. 7	80	40	40	160	320
W20	Coalmine Canyon	Jeepster No. 1	80	60	60	160	360
W21	Bodaway/Gap	Montezuma No. 7C	40	0	0	160	200
W22	Bodaway/Gap	Montezuma No. 7B	40	0	0	160	200
W23	Bodaway/Gap	Montezuma No. 7B	100	0	0	160	260
W24	Bodaway/Gap	Montezuma No. 7A	130	0	0	160	290
W25	Bodaway/Gap	Montezuma No. 2	130	0	0	160	290
W26	Bodaway/Gap	Montezuma No. 2	130	0	0	160	290
W27	Bodaway/Gap	Montezuma No. 2	130	150	150	160	590
W28	Coalmine Canyon	Casey No. 3	130	190	190	160	670
W29	Coalmine Canyon	Jack Daniels No. 3	50	0	0	160	210
W30	Coalmine Canyon	Kachina No. 6	190	205	205	160	760
W31	Coalmine Canyon	Charles Huskon No. 19	190	160	160	160	670
W32	Coalmine Canyon	Charles Huskon No. 19	240	265	265	160	930
W33	Coalmine Canyon	Jack Daniels No. 5	300	555	555	160	1570
W34	Coalmine Canyon	Jack Daniels No. 1	250	555	555	160	1520
W35	Coalmine Canyon	Jack Daniels No. 4	320	520	520	160	1520
W36	Coalmine Canyon	Evans Huskon No. 34	60	20	20	160	260
W37	Coalmine Canyon	Charles Huskon No. 20	60	20	20	160	260
W38	Coalmine Canyon	Charles Huskon No. 12	230	560	560	160	1510
W39	Cameron	A & B No. 3	650	2535	2535	160	5880
W40	Coalmine Canyon	Max Johnson No. 1	340	430	430	160	1360
W41	Coalmine Canyon	Charles Huskon No. 1	380	590	590	160	1720
W42	Coalmine Canyon	Max Johnson No. 10	340	360	360	160	1220
W43	Coalmine Canyon	Lemuel Littleman No. 2	200	260	260	160	880
W44	Coalmine Canyon	Harvey Begay No. 1	180	0	0	160	340
W45	Coalmine Canyon	Max Johnson No. 9	280	0	0	160	440
W46	Coalmine Canyon	Elwood Canyon No. 1	230	0	0	160	390
W47	Coalmine Canyon	Alyce Tolino No. 1 & 3	280	110	110	160	660
W48	Coalmine Canyon	Evans Huskon No. 2	280	40	40	160	520
W49	Coalmine Canyon	Yazzie No. 101	270	40	40	160	510
W50	Coalmine Canyon	Yazzie No. 312	280	70	70	160	580
W51	Coalmine Canyon	Boyd Tisi No. 2	360	130	130	160	780
W52	Coalmine Canyon	Juan Horse No. 3	360	130	130	160	780
W53	Cameron	Lemuel Littleman No. 3	260	170	170	160	760
W54	Coalmine Canyon	Juan Horse No. 4	270	70	70	160	570
W55	Coalmine Canyon	Pat Lynch	60	0	0	160	220
W56	Cameron	A & B No. 2	440	915	915	160	2430
W57	Cameron	Charles Huskon No. 14	270	25	25	160	480
W58	Cameron	Harry Walker No. 19	210	20	20	160	410
W59	Cameron	Montezuma No. 1	250	10	10	160	430
W60	Coalmine Canyon	Manuel Denetsone No. 2	220	0	0	160	380
W61	Coalmine Canyon	Jefferson Canyon No. 1	140	0	0	160	300
W62	Cameron	Charles Huskon No. 3	120	0	0	160	280
W63	Cameron	Charles Huskon No. 3	80	0	0	160	240
W64	Cameron	Charles Huskon No. 3	90	0	0	160	250
W65	Cameron	Charles Huskon No. 3	110	10	10	160	290
W66	Coalmine Canyon	Jack Huskon No. 3	60	0	0	160	220
W67	Cameron	Black Hair No.4	180	190	190	160	720
W68	Cameron	Paul Huskie No. 20	80	110	110	160	460

Table 6. Western AUM Region Combined Pathway Scores (continued)

Map-ID	Chapter	Mine Name / Identifier Name	Total Ground Water Score	Total Soil Score	Total Air Score	Total Surface Water Score	Combined Score
W69	Cameron	Huskon No. 7	80	0	0	160	240
W70	Cameron	Yazzie No. 102	80	0	0	160	240
W71	Coalmine Canyon	Yellow Jeep No. 7A and 7B	10	0	0	160	170
W72	Cameron	Yazzie No. 105	50	0	0	160	210
W73	Cameron	Charles Huskon No. 10	70	0	0	160	230
W74	Cameron	Charles Huskon No. 10	70	10	10	160	250
W75	Coalmine Canyon	Lloyd House	20	0	0	160	180
W76	Cameron	Charles Huskon No. 8	60	0	0	160	220
W77	Cameron	Charles Huskon No. 8	100	0	0	160	260
W78	Cameron	Boyd Tisi No. 1	140	0	0	160	300
W79	Coalmine Canyon	Evans Huskon No. 35	10	0	0	0	10
W80	Coalmine Canyon	Cam061	10	0	0	0	10
W81	Coalmine Canyon	Mel Gardner	30	10	10	160	210
W82	Coalmine Canyon	Ryan No. 1	30	0	0	160	190
W83	Cameron	Taylor Reid No. 2	200	10	10	160	380
W84	Cameron	Taylor Reid No. 3	140	10	10	160	320
W85	Off Navajo Nation	Section 1 Lease	130	10	10	160	310
W86	Off Navajo Nation	Section 1 Lease	140	10	10	160	320
W87	Off Navajo Nation	Ada and Nordell	200	10	10	160	380
W88	Cameron	Charles Huskon No. 26	30	10	10	160	210
W89	Cameron	Charles Huskon No. 11	30	10	10	160	210
W90	Off Navajo Nation	New Liba Group	30	0	0	160	190
W91	Off Navajo Nation	New Liba Group	30	0	0	160	190
W92	Off Navajo Nation	Section 9 Lease	30	0	0	160	190
W93	Coalmine Canyon	Ramco No. 21	30	25	25	160	240
W94	Coalmine Canyon	Ramco No. 20	40	35	35	160	270
W95	Coalmine Canyon	Ramco No. 22	30	35	35	160	260
W96	Coalmine Canyon	Ryan No. 2	20	20	20	160	220
W97	Coalmine Canyon	Ryan No. 3	20	20	20	160	220
W98	Off Navajo Nation	Section 9 Lease	40	0	0	160	200
W99	Off Navajo Nation	Section 9 Lease	40	0	0	160	200
W100	Coalmine Canyon	Yazzie No. 1	40	10	10	160	220
W101	Coalmine Canyon	Yazzie No. 2	40	20	20	160	240
W102	Coalmine Canyon	Charles Huskon No. 17	30	20	20	160	230
W103	Coalmine Canyon	Jackpot No. 40	30	10	10	160	210
W104	Coalmine Canyon	Jackpot No. 1	30	20	20	160	230
W105	Coalmine Canyon	Jackpot No. 5	30	10	10	160	210
W106	Off Navajo Nation	Grub No. 14	50	0	0	160	210
W107	Off Navajo Nation	Black Point-Murphy Group	30	45	45	160	280
W108	Coalmine Canyon	Amos Chee No. 8	70	10	10	160	250
W109	Coalmine Canyon	Max Johnson No. 7	110	0	0	160	270
W110	Coalmine Canyon	Charles Huskon No. 9	110	30	30	160	330
W111	Coalmine Canyon	Emmett Lee No. 1	120	30	30	160	340
W112a	Coalmine Canyon	Julius Chee No. 4	120	30	30	160	340
W112b	Coalmine Canyon	Julius Chee No. 2	120	30	30	160	340
W113	Coalmine Canyon	Julius Chee No. 3	120	30	30	160	340
W114	Coalmine Canyon	Elwood Thompson No. 1	120	30	30	160	340
W115	Coalmine Canyon	Ramco No. 24	90	40	40	160	330
W116	Coalmine Canyon	Harry Walker No. 16	90	30	30	160	310
W117	Coalmine Canyon	Julius Chee No. 2	80	30	30	160	300
W118	Coalmine Canyon	Charles Huskon No. 4	80	40	40	160	320
W119	Coalmine Canyon	Paul Huskie No. 3	80	40	40	160	320
W120	Coalmine Canyon	Charles Huskon No. 18	80	30	30	160	300
W121	Coalmine Canyon	Julia Semallie	80	10	10	160	260
W122	Coalmine Canyon	Emmett Lee No. 3	80	10	10	160	260
W123	Leupp	Adolf Maloney No. 2	30	40	40	160	270
W124	Leupp	Amos Chee No. 2 and No. 3	30	0	0	160	190
W125	Coalmine Canyon	Hosteen Nez	110	0	0	160	270

Table 7. Central AUM Region Combined Pathway Scores

Map-ID	Chapter	Mine Name / Identifier Name	Total Ground Water Score	Total Soil Score	Total Air Score	Total Surface Water Score	Combined Score
C1	Chilchinbeto	Tom Wilson	110	135	135	160	540
C2	Chilchinbeto	Tom Wilson	110	135	135	160	540
C3	Chilchinbeto	Tom Wilson	100	180	180	160	620
C4	Chilchinbeto	Tom Wilson	100	180	180	160	620
C5	Chilchinbeto	Jim Hatattly	120	140	140	160	560
C6	Chilchinbeto	Jim Hatattly	210	120	120	160	610
C7	Chilchinbeto	Tom Klee	270	290	290	160	1010
C8	Chilchinbeto	Tom Klee	130	110	110	160	510
C9	Rough Rock	Rough Rock Slope No. 9	190	40	40	160	430
C10	Many Farms	Dan Taylor No. 1	210	10	10	160	390
C11	Black Mesa	Frank Todecheenie No. 1	100	0	0	160	260
C12	Black Mesa	Sam Charley No. 1	100	0	0	160	260
C13	Black Mesa	Kasewood Bahe No. 1	100	0	0	160	260
C14	Black Mesa	Thomas Begay No. 1	100	0	0	160	260
C15	Black Mesa	Etsitty No. 1	30	90	90	160	370
C16	Black Mesa	Blk029	50	140	140	160	490
C17	Tachee/Blue Gap	Claim 35	40	535	535	160	1270
C18	Black Mesa	Claim 28	80	395	395	160	1030
C19	Black Mesa	Claim 28	80	395	395	160	1030
C20	Tselani/Cottonwood	Claim 16	20	0	0	160	180
C21	Tselani/Cottonwood	EdwardSteve No. 1	20	40	40	160	260
C22	Tselani/Cottonwood	Blk022	20	40	40	160	260
C23	Tselani/Cottonwood	Claim 7	80	10	10	160	260
C24	Tselani/Cottonwood	Claim 10	80	10	10	160	260
C25	Tselani/Cottonwood	Claim 6	80	0	0	160	240
C26	Tselani/Cottonwood	Claim 3	40	0	0	160	200
C27	Tselani/Cottonwood	Claim 3 / Claim 4	40	0	0	160	200
C28	Tselani/Cottonwood	Arrowhead No. 2	40	0	0	160	200
C29	Tselani/Cottonwood	Arrowhead No. 1	40	0	0	160	200
C30	Tselani/Cottonwood	Black Mountain Vase	40	0	0	160	200
C31	Chinle	Zhealy Tso, North Prospect	80	80	80	160	400
C32	Chinle	Zhealy Tso, Pits	80	30	30	160	300
C33	Chinle	Zhealy Tso, South Prospect	80	60	60	160	360
C34	Chinle	Occurrence B	50	1980	1980	160	4170

Table 8. Southern AUM Region Combined Pathway Scores

Map-ID	Chapter	Mine Name / Identifier Name	Total Ground Water Score	Total Soil Score	Total Air Score	Total Surface Water Score	Combined Score
S1	Teesto	NA-0750	320	150	150	160	780
S2	Indian Wells	Mail Box claim	210	380	380	160	1130
S3	Indian Wells	Morale Mine	190	50	50	160	450
S4	Indian Wells	Gwen claim	220	90	90	160	560
S5	Indian Wells	Hoskie Tso No. 1	230	165	165	160	720
S6	Steamboat	Sjodin claim	270	100	100	160	630

Photo showing the reclaimed Morale Mine with a water tank and livestock corral in close proximity. Photo courtesy TerraSpectra Geomatics (photo taken May 2006).

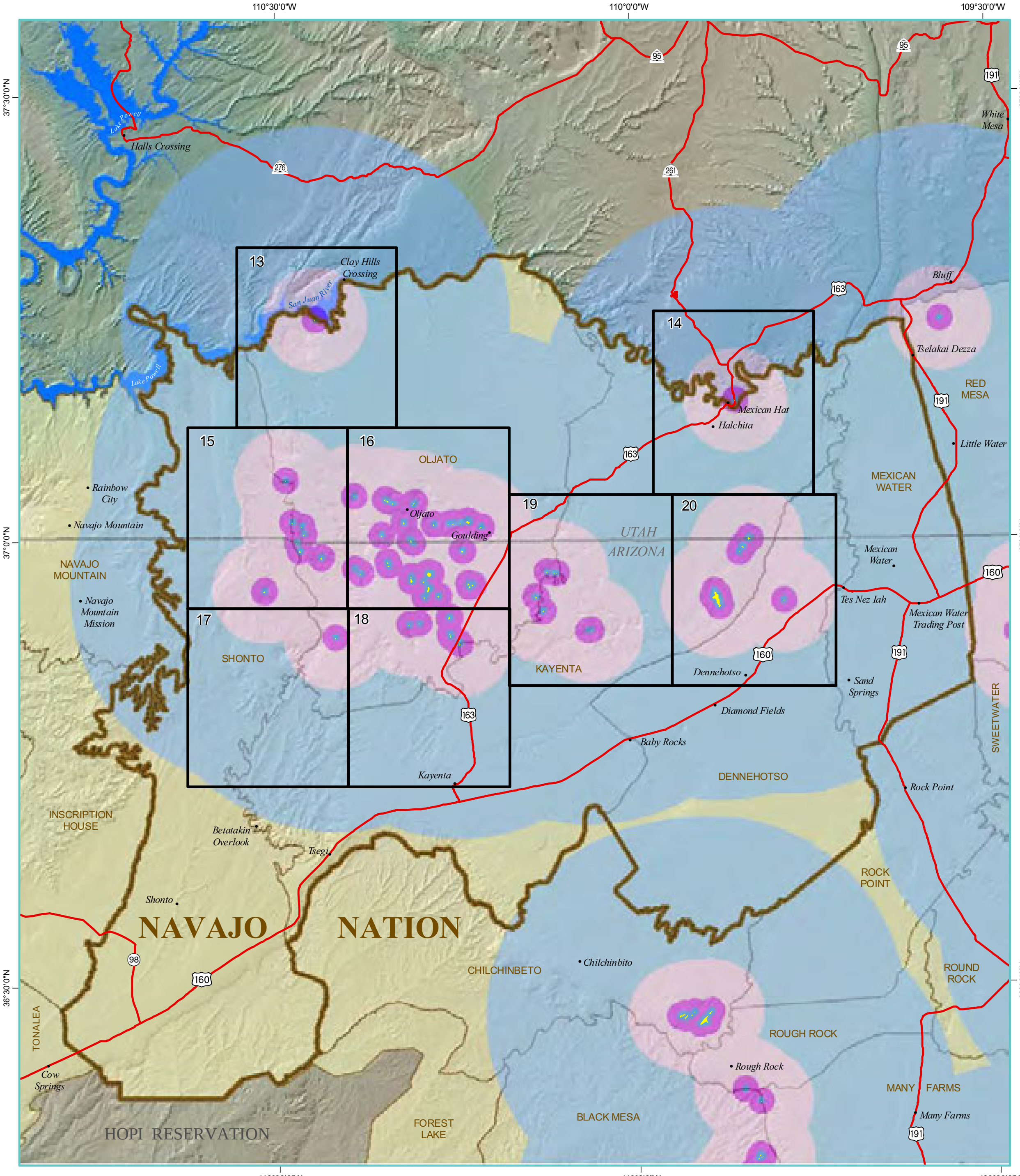
Table 9. Eastern AUM Region Combined Pathway Scores (continued)

Map-ID	Chapter	Mine Name / Identifier Name	Total Ground Water Score	Total Soil Score	Total Air Score	Total Surface Water Score	Combined Score
E1	Church Rock	Grace Insitu Leach	110	255	255	160	780
E2	Church Rock	Section 13	120	270	270	160	820
E3	Coyote Canyon	NE Church Rock No. 2	510	140	140	160	950
E4	Coyote Canyon	NE Church Rock No. 1	320	770	770	160	2020
E5	Nahodishgish	NE Church Rock No. 1-East	350	520	520	160	1550
E6	Pinedale	NE Church Rock	540	1025	1025	160	2750
E7	Church Rock	Church Rock ISL	300	90	90	160	640
E8	Church Rock	Church Rock	470	640	640	160	1910
E9	Church Rock	Section 16 deposit	390	1430	1430	160	3410
E10	Nahodishgish	Standing Rock	200	635	635	160	1630
E11	Nahodishgish	Crownpoint, Section 9	650	380	380	160	1570
E16	Becenti	Nose Rock No. 1	100	300	300	160	860
E17	Church Rock	Hogback No. 4	500	140	140	160	940
E18	Church Rock	C D and S	300	620	620	160	1700
E19	Church Rock	Delter	240	520	520	160	1440
E20	Church Rock	Eunice Becenti	420	395	395	160	1370
E21	Church Rock	Diamond No. 2	400	115	115	160	790
E22	Church Rock	Foutz No. 3	210	615	615	160	1600
E23	Church Rock	Foutz No. 2	140	300	300	160	900
E24	Iyanbito	Foutz No. 1	140	300	300	160	900
E25	Iyanbito	Williams and Reynolds	100	10	10	160	280
E26	Iyanbito	Christensen Mine	130	0	0	160	290
E27	Iyanbito	Rats Nest Mine	140	0	0	160	300
E28	Iyanbito	Westwater #1	130	0	0	160	290
E29	Mariano Lake	Mariano Lake	130	465	465	160	1220
E30	Mariano Lake	Mariano Lake	200	785	785	160	1930
E31	Mariano Lake	Mac No. 1	230	790	790	160	1970
E32	Smith Lake	Black Jack No. 2	250	370	370	160	1150
E33	Smith Lake	Mac No. 2	170	80	80	160	490
E34	Smith Lake	Ruby No. 1	690	320	320	160	1490
E35	Crownpoint	Crownpoint ISL	540	8470	8470	160	17640
E36	Crownpoint	Section 29-Conoco	240	2725	2725	160	5850
E39	Smith Lake	Black Jack No. 1	530	540	540	160	1770
E40	Smith Lake	Ruby No. 3	700	295	295	160	1450
E41a	Casamero Lake	Section 32	230	115	115	160	620
E41b	Casamero Lake	Section 33	230	115	115	160	620
E42	Thoreau	Largo	780	60	60	160	1060
E43	Smith Lake	Reynolds	670	0	0	160	830
E44	Baca/Prewitt	Silver Bit No. 15	350	20	20	160	550
E45	Baca/Prewitt	Silver Bit No. 18	350	70	70	160	650
E46	Baca/Prewitt	Alta	360	0	0	160	520
E47	Baca/Prewitt	Francis	300	0	0	160	460
E48	Baca/Prewitt	Evelyn	320	0	0	160	480
E49	Baca/Prewitt	Elkins	780	190	190	160	1320
E50	Baca/Prewitt	Elkins	780	200	200	160	1340
E51	Baca/Prewitt	Billy the Kid	1210	1795	1795	160	4960
E52	Baca/Prewitt	Glover	1100	705	705	160	2670
E53	Baca/Prewitt	Red Top	950	465	465	160	2040
E54	Baca/Prewitt	Haven	690	240	240	160	1330
E55	Baca/Prewitt	Yucca	720	70	70	160	1020
E56	Baca/Prewitt	Red Cap	680	10	10	160	860
E57	Off Navajo Nation	Mary No. 1	210	130	130	160	630
E58	Off Navajo Nation	Kermac Mine No. 10	220	40	40	160	460
E59	Off Navajo Nation	Dysart No. 1	260	60	60	160	540
E60	Off Navajo Nation	Buckey	330	180	180	160	850
E61	Off Navajo Nation	Homestake Sapin Mine No. 15	370	50	50	160	630
E62	Baca/Prewitt	Kermac Mine No. 22	410	50	50	160	670
E63	Off Navajo Nation	Homestake Sapin Mine No. 23	430	60	60	160	710
E64	Off Navajo Nation	Kermac Mine No. 24	300	130	130	160	720
E65	Off Navajo Nation	Homestake Sapin Mine No. 25	300	315	315	160	1090
E66	Baca/Prewitt	Section 34	530	0	0	160	690
E67	Baca/Prewitt	Lost Mine	290	0	0	160	450
E68	Baca/Prewitt	Section 2	390	160	160	160	870
E69	Baca/Prewitt	Section 1	80	280	280	160	800
E70	Baca/Prewitt	Febco	70	230	230	160	690
E71	Baca/Prewitt	Silver Spur	90	150	150	160	550
E72	Baca/Prewitt	Section 5	140	250	250	160	800
E73	Baca/Prewitt	Junior	110	40	40	160	350

Table 9. Eastern AUM Region Combined Pathway Scores (continued)

Map-ID	Chapter	Mine Name / Identifier Name	Total Ground Water Score	Total Soil Score	Total Air Score	Total Surface Water Score	Combined Score
E74	Baca/Prewitt	Section 4	150	60	60	160	430
E75	Baca/Prewitt	Dakota	110	50	50	160	370
E76	Baca/Prewitt	Pat	110	80	80	160	430
E77	Baca/Prewitt	Haystack	350	320	320	160	1150
E78	Baca/Prewitt	Haystack No. 2	410	420	420	160	1410
E79	Baca/Prewitt	Haystack	290	465	465	160	1380
E80	Baca/Prewitt	Bibo Trespass	270	610	610	160	1650
E81	Baca/Prewitt	Section 24	300	575	575	160	1610
E82	Baca/Prewitt	Haystack No. 1	280	815	815	160	2070
E83	Baca/Prewitt	Section 18	250	685	685	160	1780
E84	Baca/Prewitt	Section 18	240	820	820	160	2040
E85	Baca/Prewitt	Section 18 SEQ	260	590	590	160	1600
E86	Baca/Prewitt	Red Point Lode	100	0	0	160	260
E87	Baca/Prewitt	Section 22	220	110	110	160	600
E88	Off Navajo Nation	Bobcat	330	40	40	160	570
E89	Off Navajo Nation	Blue Peak	360	10	10	160	540
E90	Baca/Prewitt	Section 23	380	355	355	160	1250
E91	Baca/Prewitt	Section 26	260	655	655	160	1730
E92	Baca/Prewitt	Section 26	370	250	250	160	1030
E93	Off Navajo Nation	Section 25	580	140	140	160	1020
E95	Off Navajo Nation	Divide	440	10	10	160	620
E96	Off Navajo Nation	Section 25 Decline	610	10	10	160	790
E97	Baca/Prewitt	Section 26	290	250	250	160	950
E98	Off Navajo Nation	Section 25	590	90	90	160	930
E99	Off Navajo Nation	Section 25	690	10	10	160	870
E100	Off Navajo Nation	Section 30	550	10	10	160	730
E101	Off Navajo Nation	Section 36	570	10	10	160	750
E102	Baca/Prewitt	Haystack	290	510	510	160	1470
E103	Baca/Prewitt	Haystack	220	545	545	160	1470

Occupied home within 500 feet of the NE Churchrock AUM tailings pile. Photo courtesy of Southwest Research and Information Center.



ABANDONED URANIUM MINES AND THE NAVAJO NATION
Navajo Nation AUM Screening Assessment Report

NORTH CENTRAL AUM REGION COMBINED PATHWAYS - MAP FIGURE INDEX

Sources

Abandoned uranium mine areas are primarily from the Navajo Abandoned Mine Lands Reclamation Program (NAMLRP) and augmented by several other sources. The Navajo Nation and Chapter boundaries are from the Navajo Land Department. Hydrographic data for streams are from the U.S. Geological Survey (USGS) National Hydrographic Dataset. Selected Populated Places are from the USGS Geographic Names Information System (GNIS). Buffers were generated by TerraSpectra Geomatics. Map index figure outlines are approximate.

Map Area Designations

Figure

13 - Monitor Mesa
14 - Mexican Hat
15 - North Nokai Mesa
16 - Oljato
17 - South Nokai Mesa
18 - South El Capitan Flat
19 - Monument Valley
20 - Cane Valley

0 10 Miles

Map Scale 1:500,000

Legend

North Central AUM Region
Chapter
Abandoned Uranium Mine
Mine Buffers
1/4 Mile
1 Mile
4 Miles
15 Miles
Populated Places
Highways

Figure 12. North Central AUM Region Combined Pathways Map Figure Index.

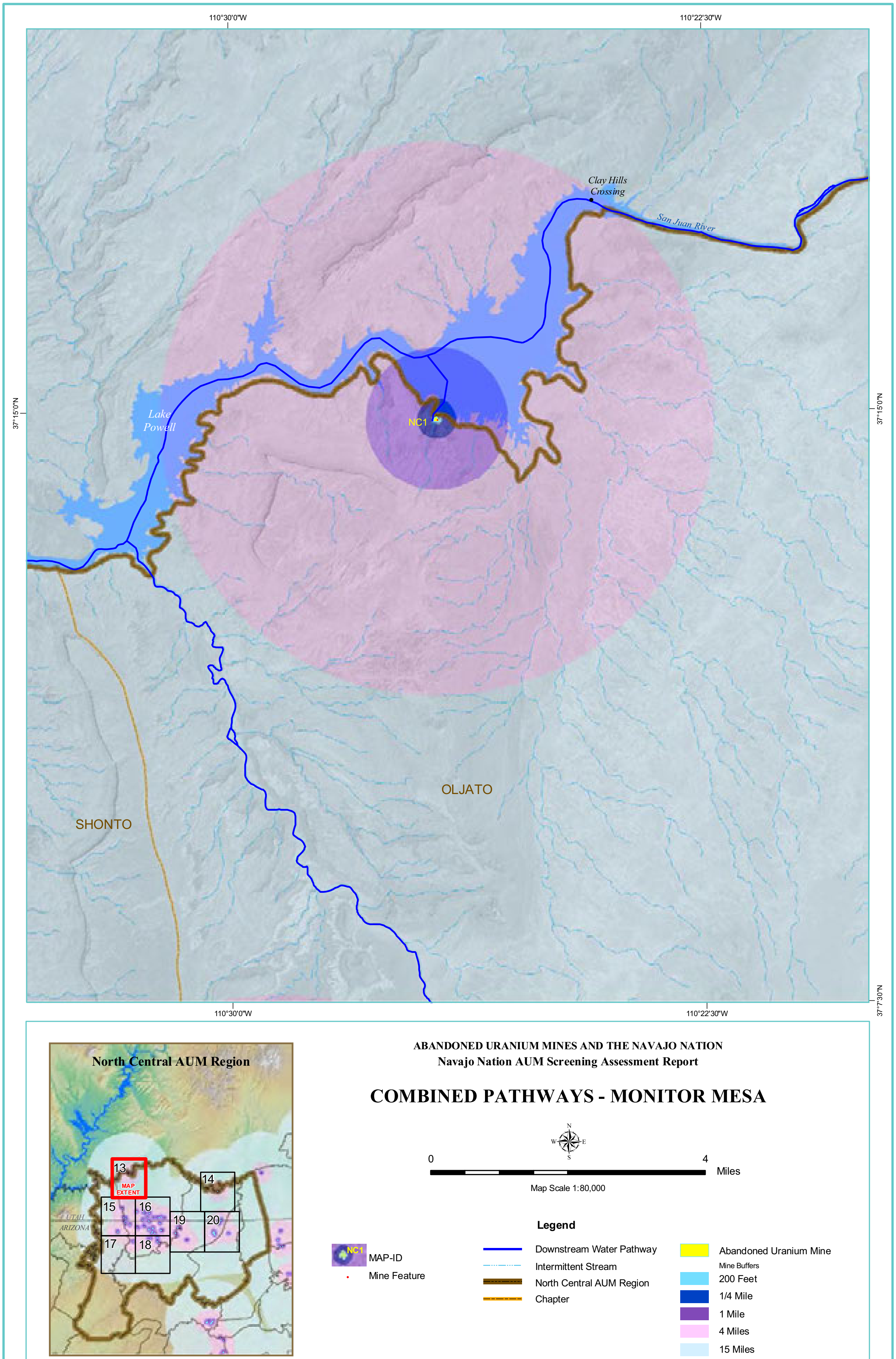
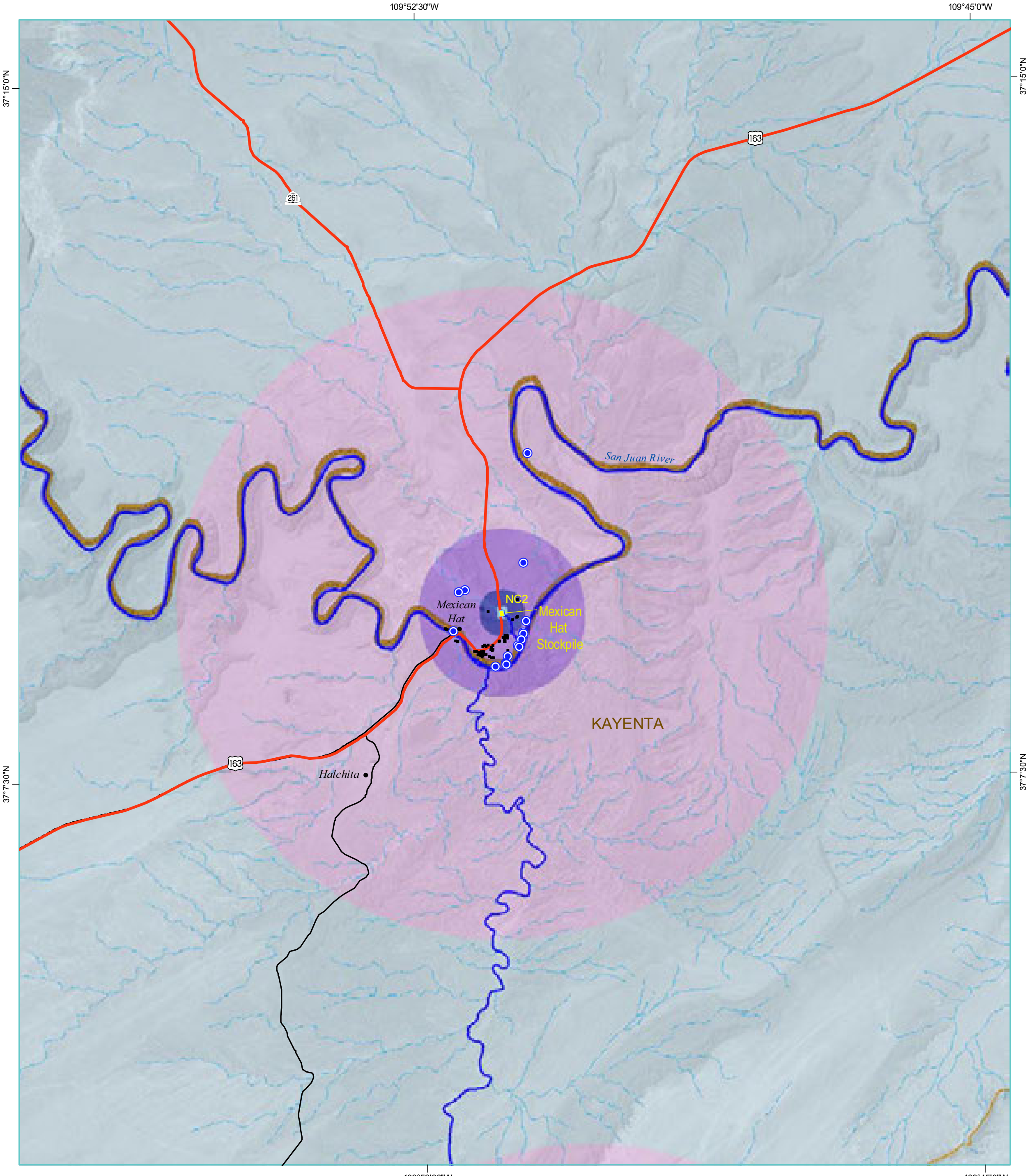
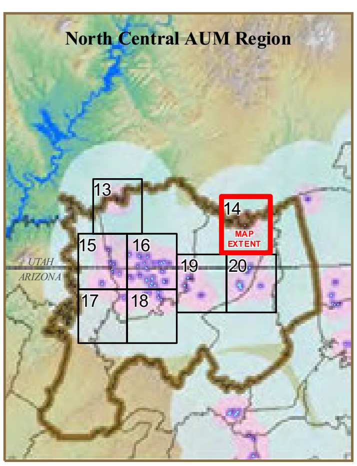


Figure 13. Combined Pathways in the Monitor Mesa Area.





ABANDONED URANIUM MINES AND THE NAVAJO NATION
Navajo Nation AUM Screening Assessment Report

COMBINED PATHWAYS - MEXICAN HAT

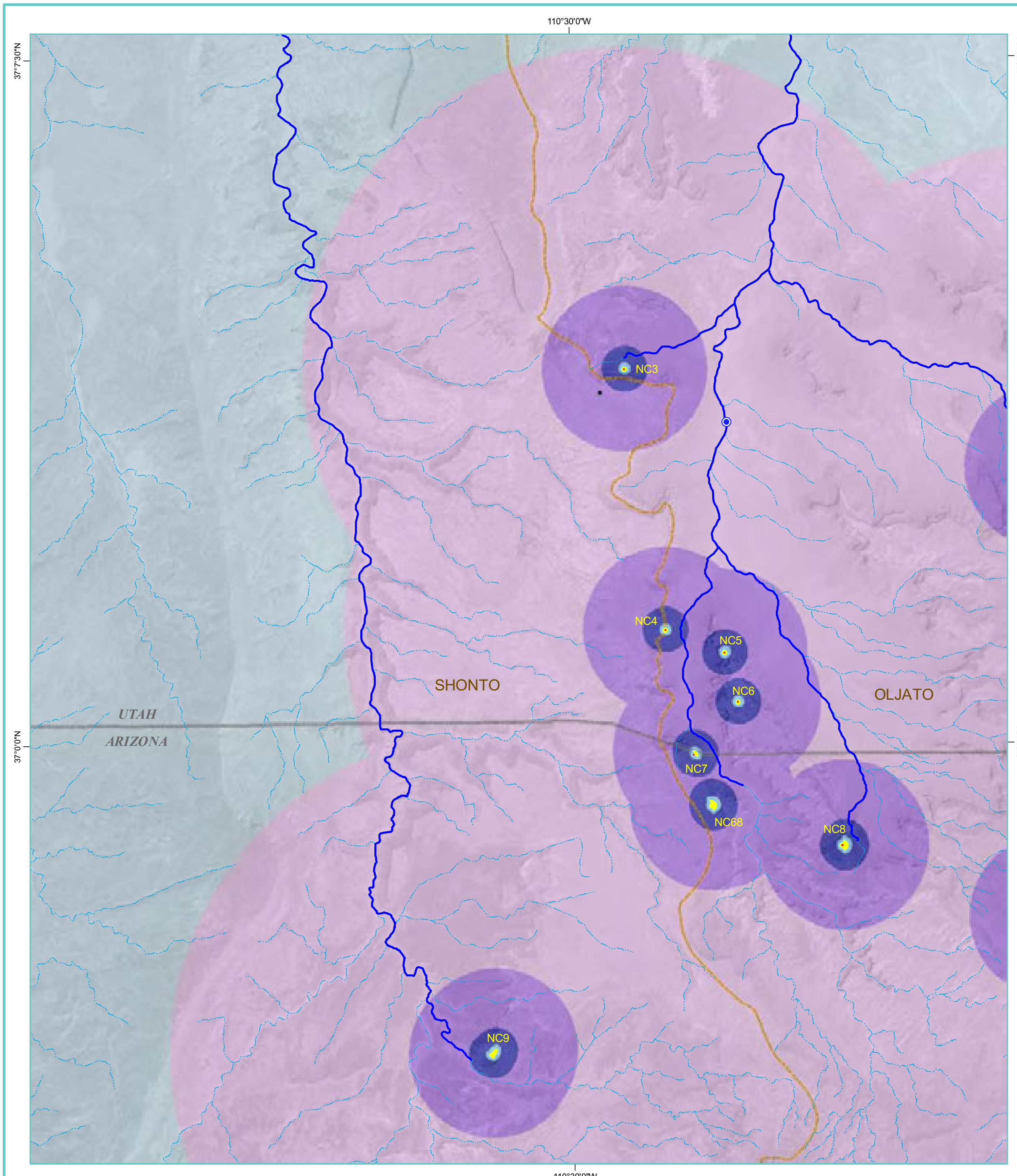
0 4 Miles

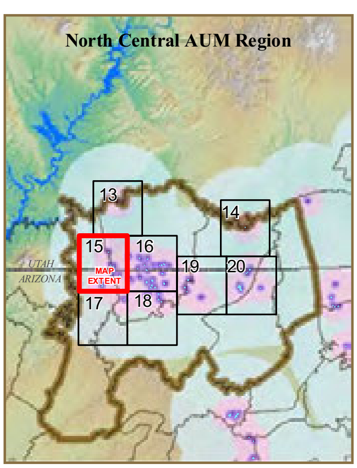
Map Scale 1:80,000

Legend

- MAP-ID
- Structure within 1 mile
- Well within 4 milles
- Downstream Water Pathway
- Intermittent Stream
- North Central AUM Region
- Chapter
- Highway
- Paved Road
- Abandoned Uranium Mine
- Mine Buffers
- 200 Feet
- 1/4 Mile
- 1 Mile
- 4 Miles
- 15 Miles

Figure 14. Combined Pathways in the Mexican Hat Area.





ABANDONED URANIUM MINES AND THE NAVAJO NATION
Navajo Nation AUM Screening Assessment Report

COMBINED PATHWAYS - NORTH NOKAI MESA

N W E S

0 4 Miles

Map Scale 1:80,000

Legend

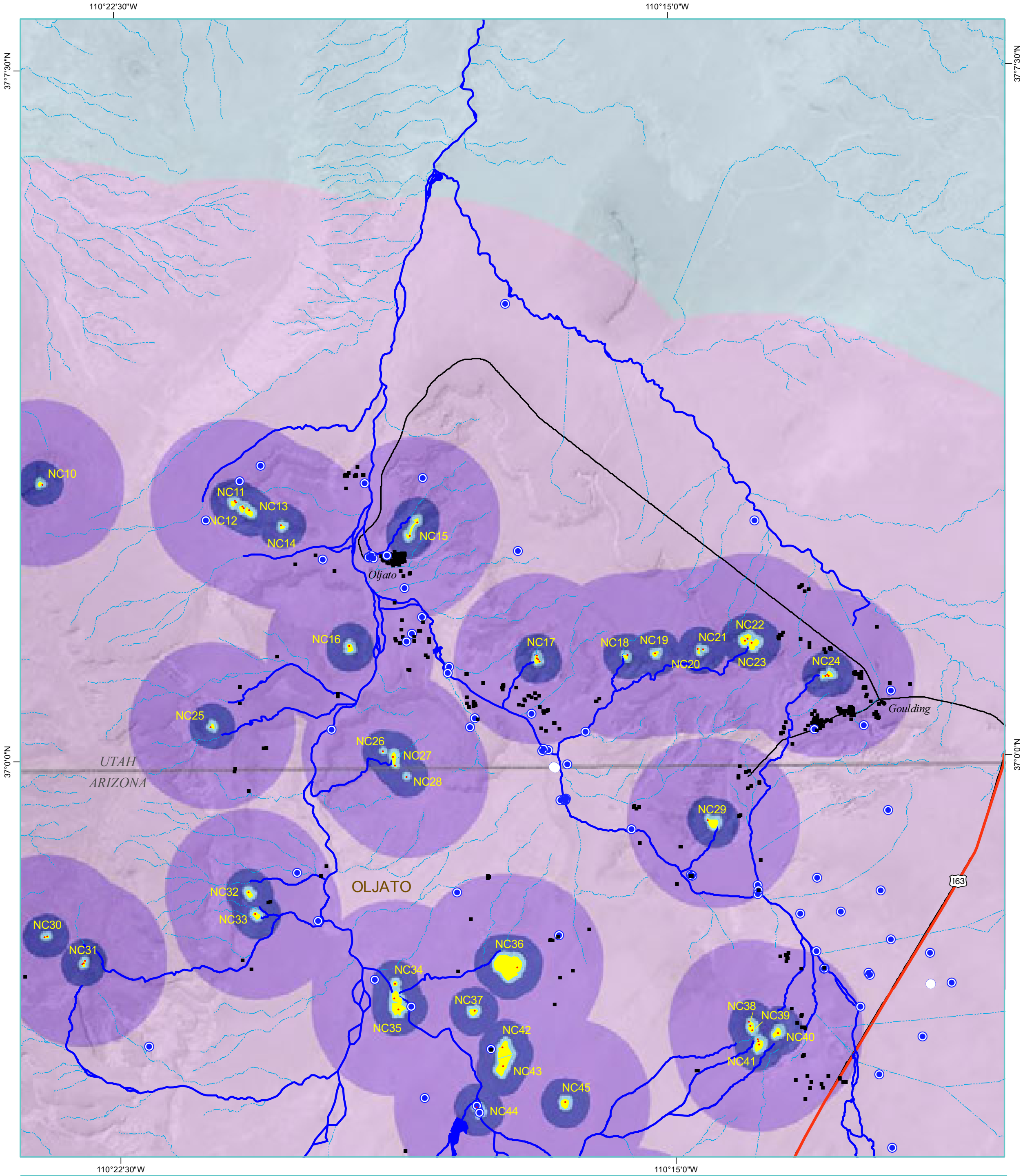
NC3 MAP-ID*
Mine Feature
Structure within 1 mile

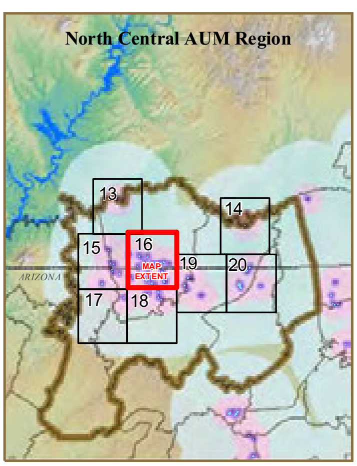
Downstream Water Pathway
Intermittent Stream
Chapter

Abandoned Uranium Mine
Mine Buffers
200 Feet
1/4 Mile
1 Mile
4 Miles
15 Miles

* MAP-ID NC68 added

Figure 15. Combined Pathways in the North Nokai Mesa Area.





ABANDONED URANIUM MINES AND THE NAVAJO NATION
Navajo Nation AUM Screening Assessment Report

COMBINED PATHWAYS - OLJATO

N
W E
S

0 4 Miles

Map Scale 1:80,000

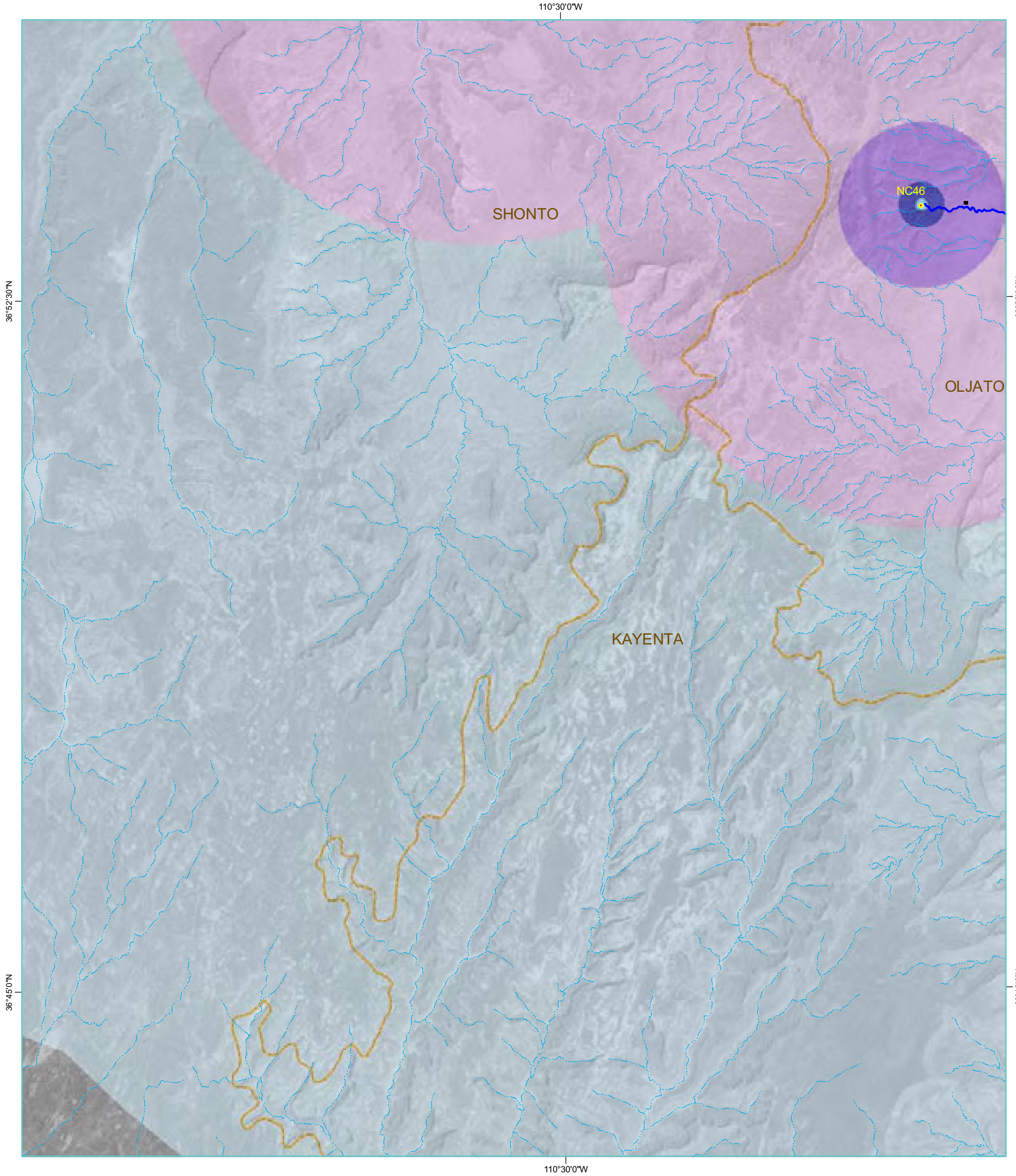
Legend

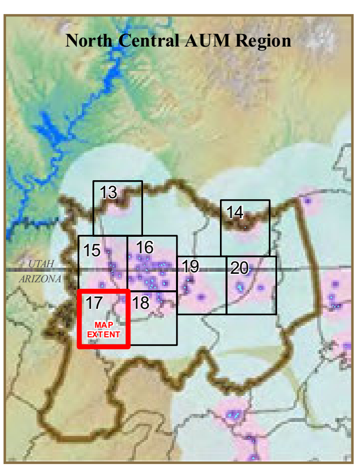
NC10 MAP-ID
Mine Feature
Structure within 1 mile
Well within 4 milles

Downstream Water Pathway
Intermittent Stream
Highway
Paved Road

Abandoned Uranium Mine
Mine Buffers
200 Feet
1/4 Mile
1 Mile
4 Miles
15 Miles

Figure 16. Combined Pathways in the Oljato Area.





ABANDONED URANIUM MINES AND THE NAVAJO NATION
Navajo Nation AUM Region Screening Assessment Report

COMBINED PATHWAYS - SOUTH NOKAI MESA

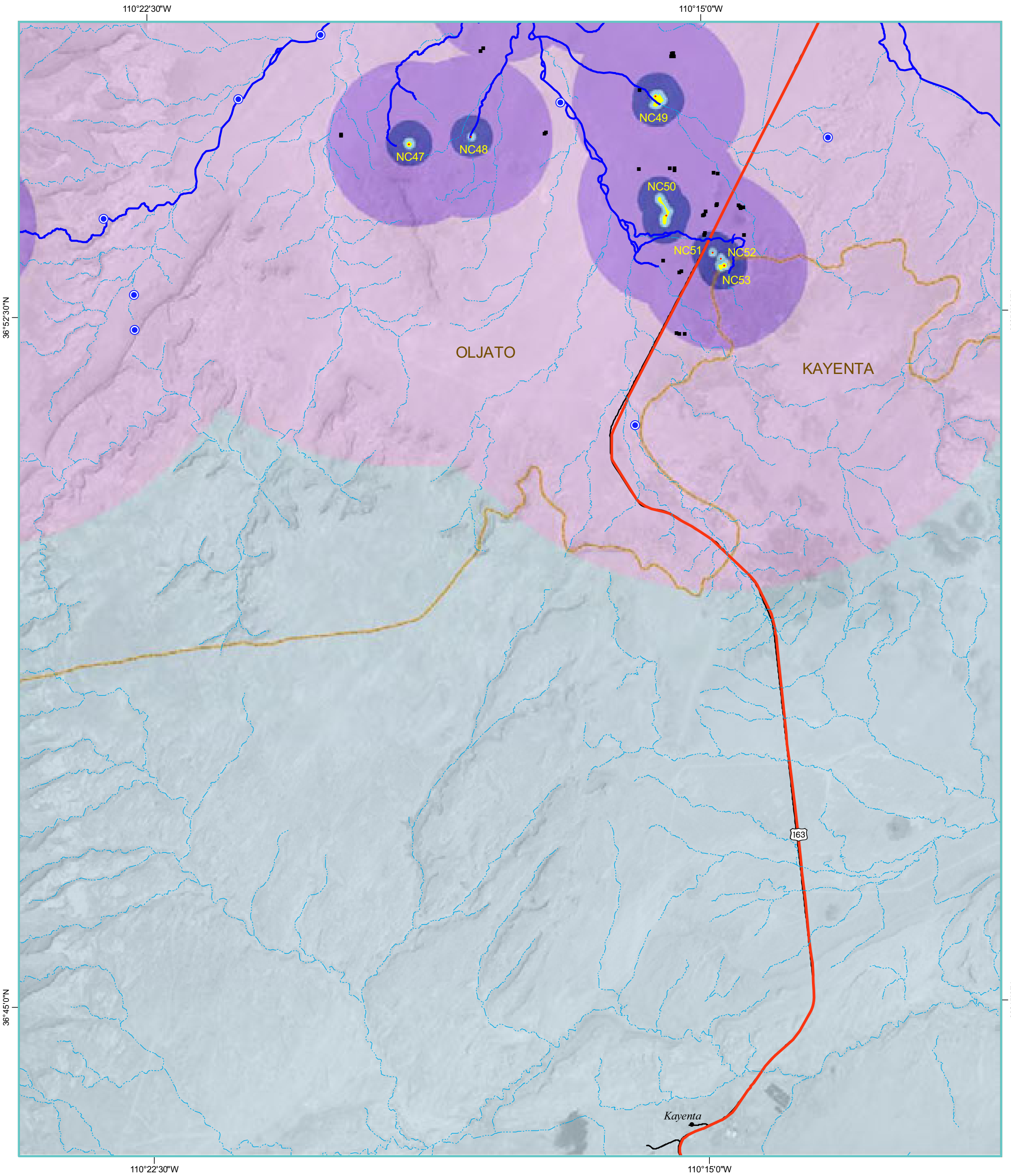
0 — 4 Miles

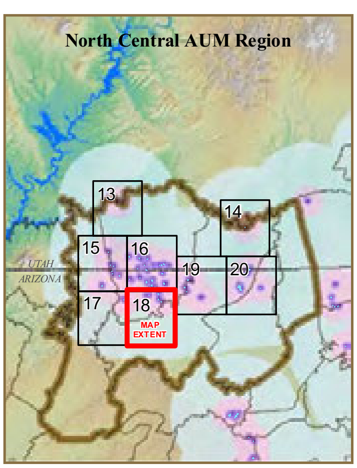
Map Scale 1:80,000

Legend

NC46 MAP-ID
Mine Feature
Structure within 1 mile
Downstream Water Pathway
Intermittent Stream
Chapter
Abandoned Uranium Mine
Mine Buffers
200 Feet
1/4 Mile
1 Mile
4 Miles
15 Miles

Figure 17. Combined Pathways in the South Nokai Mesa Area.





ABANDONED URANIUM MINES AND THE NAVAJO NATION
Navajo Nation AUM Screening Assessment Report

COMBINED PATHWAYS - SOUTH EL CAPITAN FLAT

N
W E
S

0 4 Miles

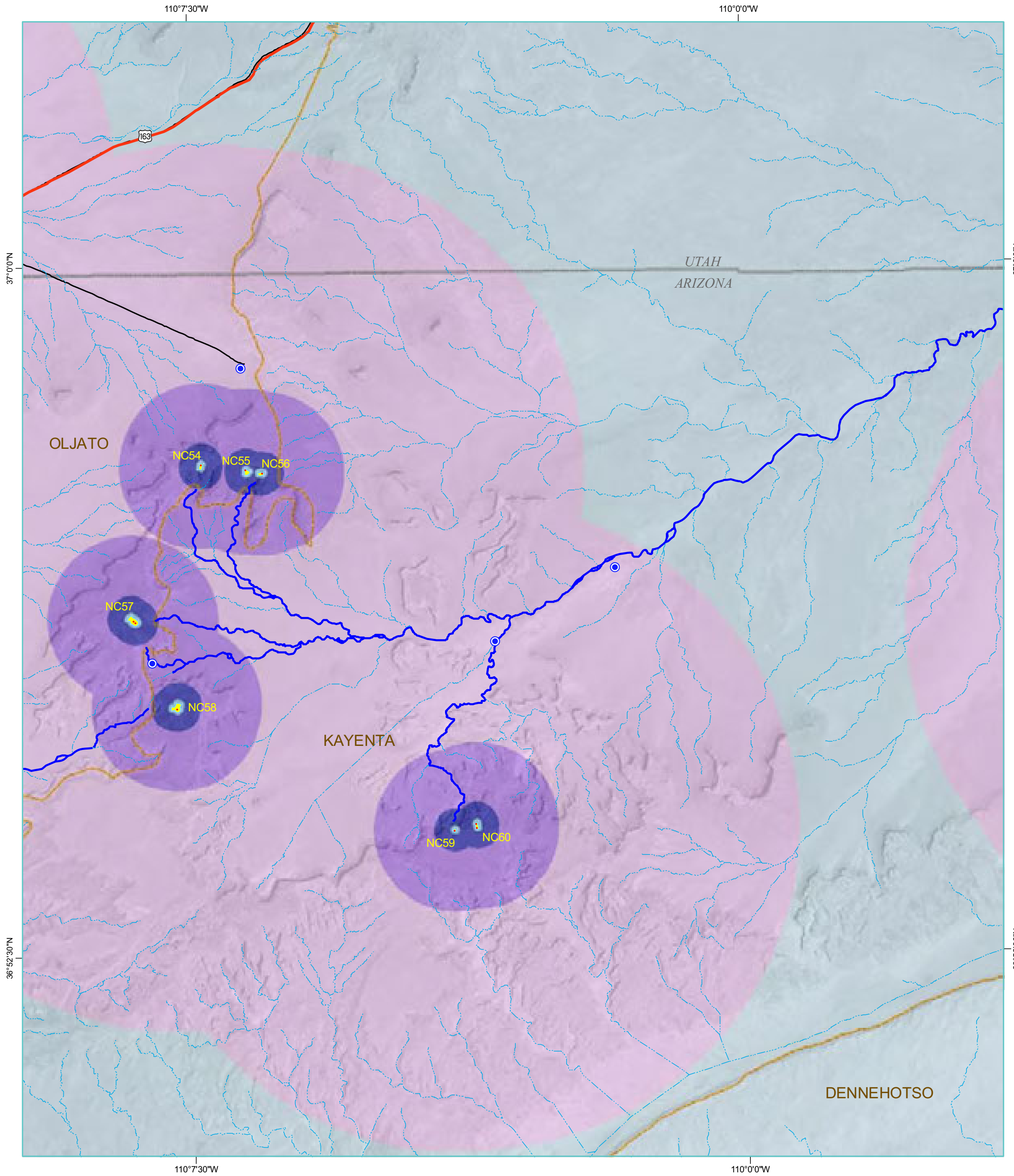
Map Scale 1:80,000

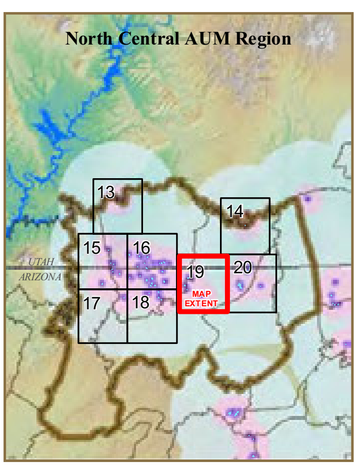
Legend

- NC47 MAP-ID
- Mine Feature
- Structure within 1 mile
- Well within 4 milles
- Downstream Water Pathway
- Intermittent Stream
- Chapter
- Highway
- Paved Road
- Abandoned Uranium Mine

Mine Buffers
- 200 Feet
- 1/4 Mile
- 1 Mile
- 4 Miles
- 15 Miles

Figure 18. Combined Pathways in the South El Capitan Flat Area.





ABANDONED URANIUM MINES AND THE NAVAJO NATION
Navajo Nation AUM Screening Assessment Report

COMBINED PATHWAYS - MONUMENT VALLEY

N S W E

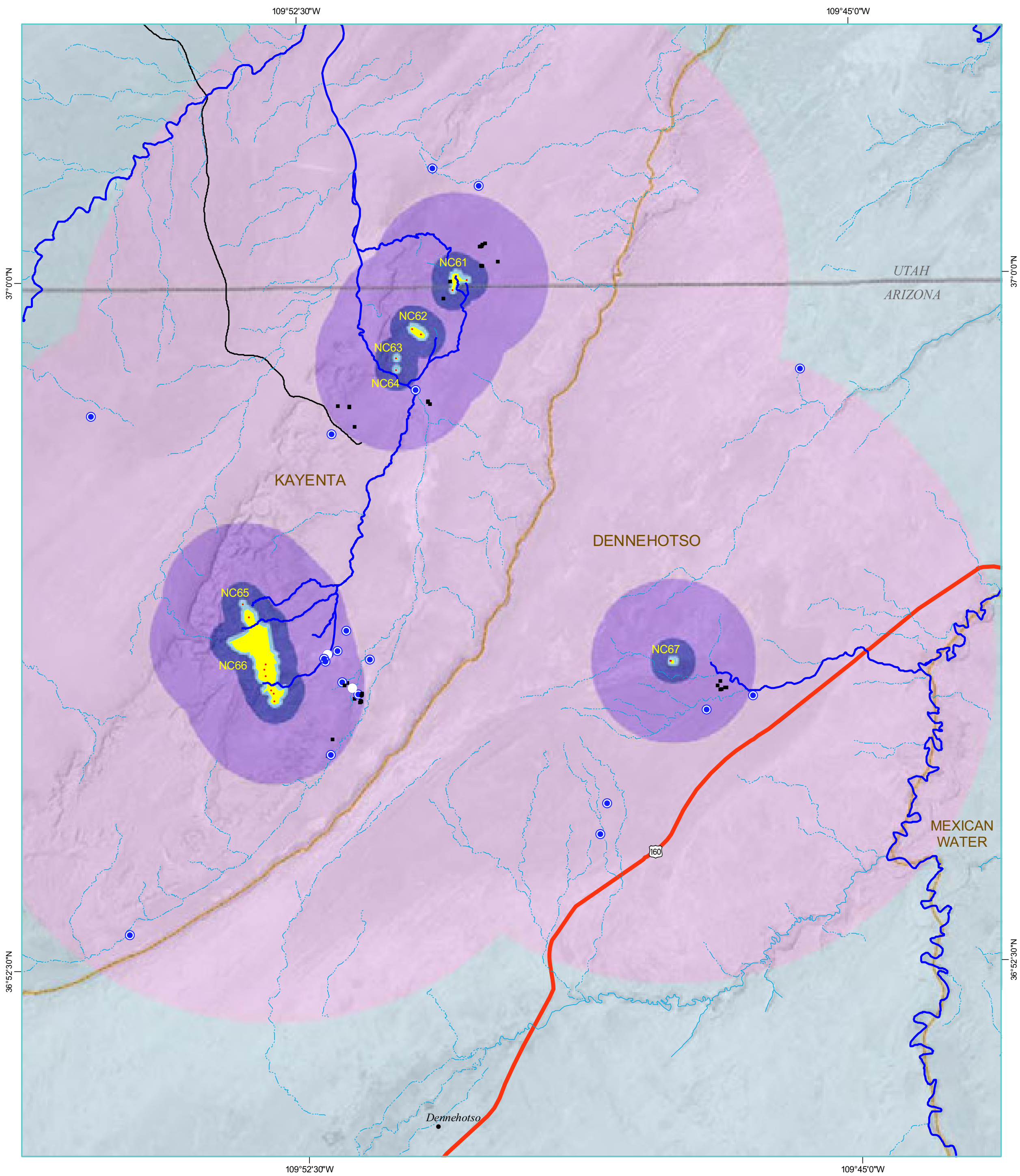
0 4 Miles

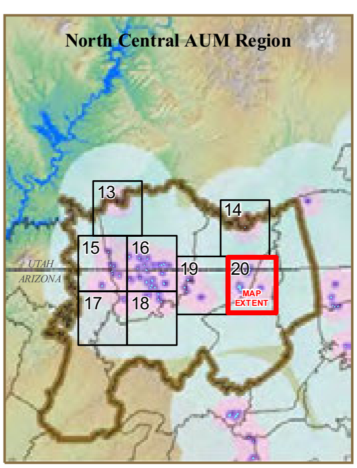
Map Scale 1:80,000

Legend

- NC54 MAP-ID
- Mine Feature
- Well within 4 milles
- Downstream Water Pathway
- Intermittent Stream
- Chapters
- Highway
- Paved Road
- Abandoned Uranium Mine
- Mine Buffers
  - 200 Feet
  - 1/4 Mile
  - 1 Mile
  - 4 Miles
  - 15 Miles

Figure 19. Combined Pathways in the Monument Valley Area.





ABANDONED URANIUM MINES AND THE NAVAJO NATION

Navajo Nation AUM Screening Assessment Report

COMBINED PATHWAYS - CANE VALLEY

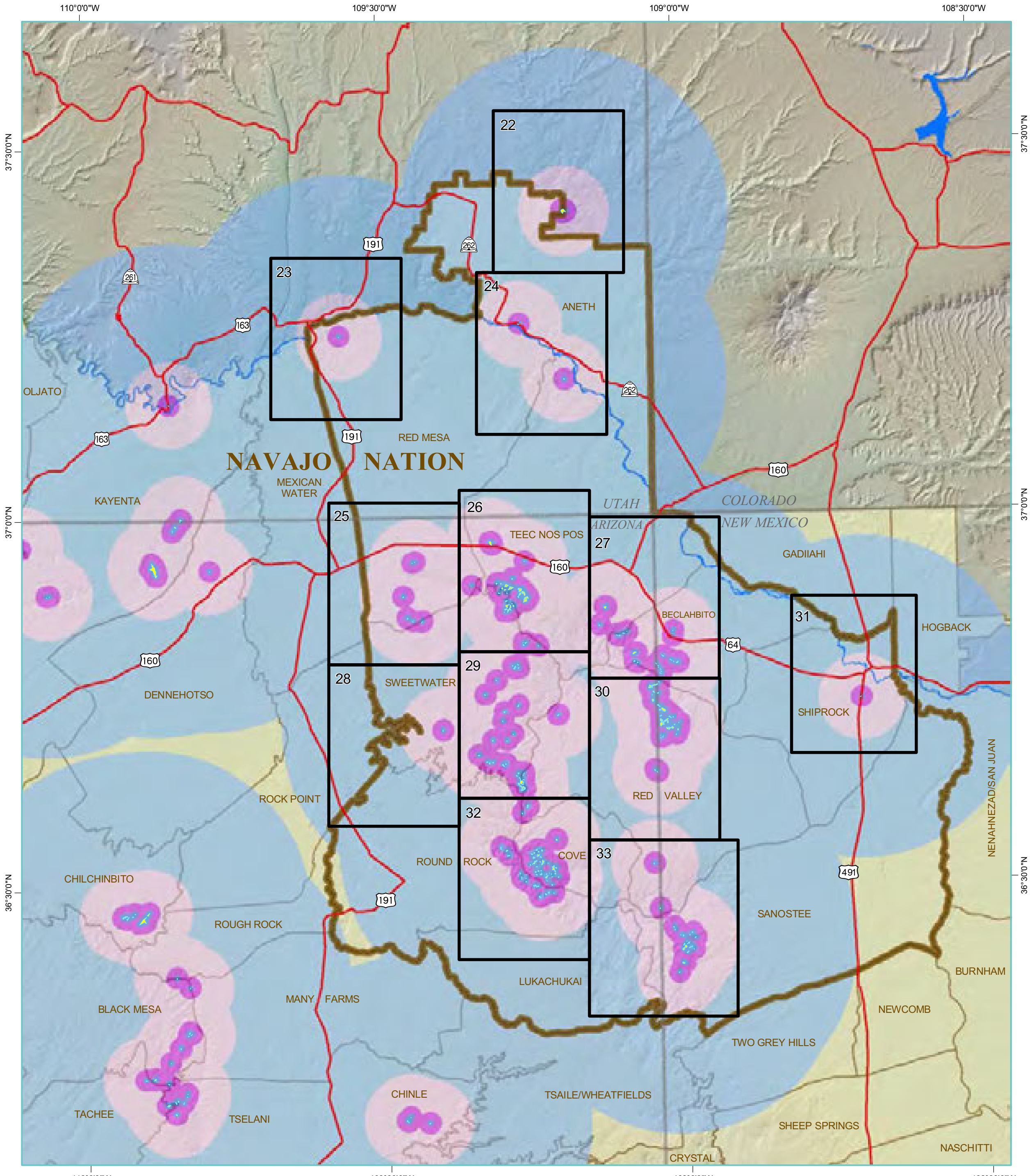
0 — 4 Miles

Map Scale 1:80,000

Legend

- NC61 MAP-ID
- Mine Feature
- Structure within 1 mile
- Well within 4 miles
- Downstream Water Pathway
- Perennial Stream
- Intermittent Stream
- Chapter
- Highway
- Paved Road
- Abandoned Uranium Mine
- Mine Buffers
  - 200 Feet
  - 1/4 Mile
  - 1 Mile
  - 4 Miles
  - 15 Miles

Figure 20. Combined Pathways in the Cane Valley Area.



ABANDONED URANIUM MINES AND THE NAVAJO NATION

Navajo Nation AUM Screening Assessment Report

NORTHERN AUM REGION COMBINED PATHWAYS - MAP INDEX

Sources

Abandoned uranium mine areas are primarily from the Navajo Abandoned Mine Lands Reclamation Program (NAMLRP) and augmented by several other sources. The Navajo Nation and Chapter boundaries are from the Navajo Land Department. Hydrographic data for streams are from the U.S. Geological Survey (USGS) National Hydrographic Dataset. Buffers were generated by TerraSpectra Geomatics. Map index figure outlines are approximate.

Map Index Area Designations

Figure

22 - North Central Aneth
23 - Northwest Red Mesa
24 - North Teec Nos Pos
25 - South Red Mesa
26 - Tse Tah
27 - Northeast Carrizo
28 - Southwest Sweetwater
29 - West Carrizo
30 - East Carrizo
31 - Shiprock
32 - Lukachukai
33 - Chuska

N W E S

0 20 Miles

Map Scale 1:600,000

Legend

Northern AUM Region

Abandoned Uranium Mine

Mine Buffers

1/4 Mile

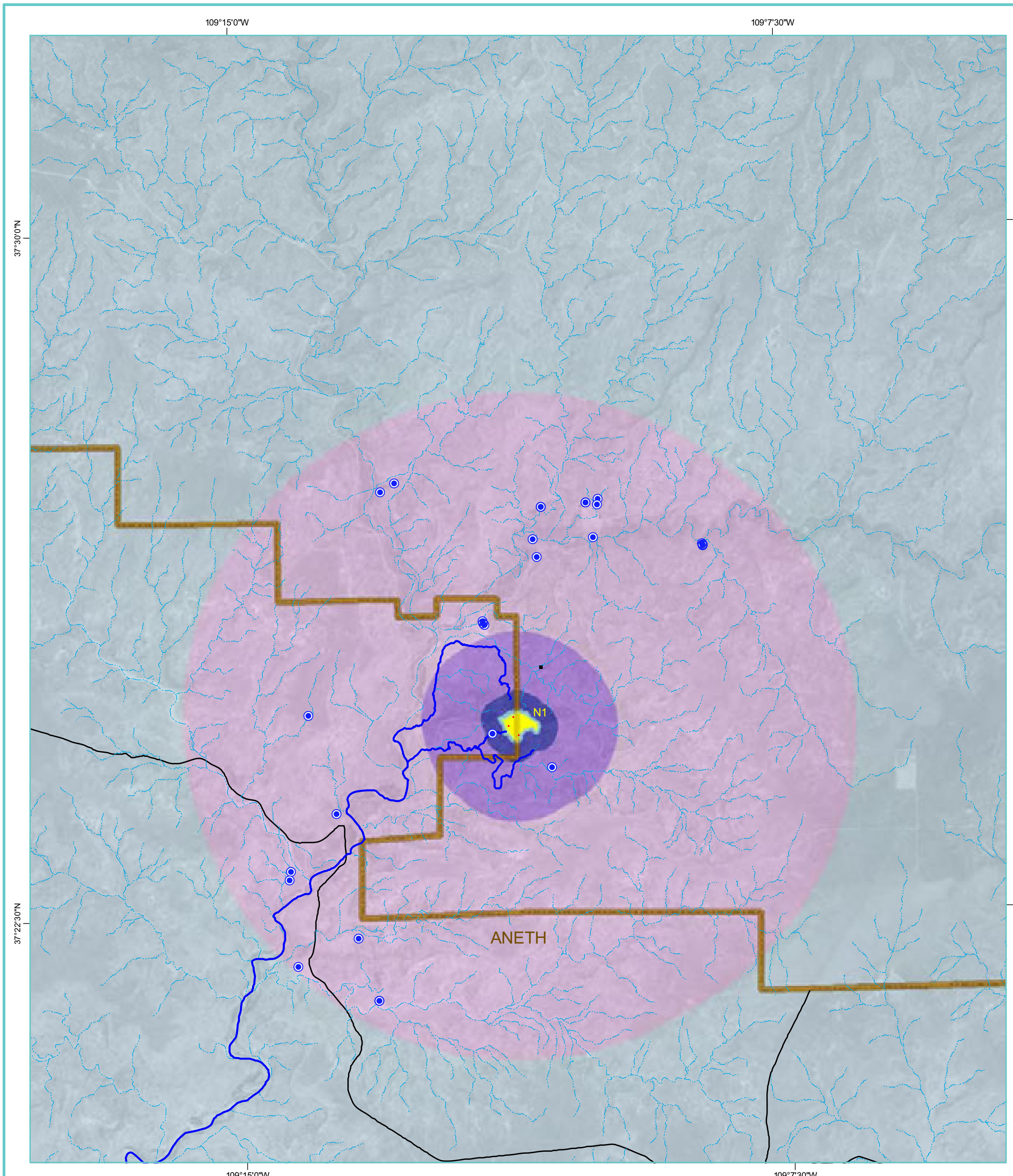
1 Mile

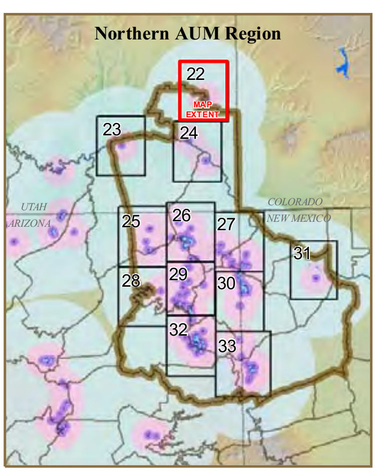
4 Miles

15 Miles

Highways

Figure 21. Northern AUM Region Combined Pathways Map Figure Index.





ABANDONED URANIUM MINES AND THE NAVAJO NATION
Navajo Nation AUM Screening Assessment Report

COMBINED PATHWAYS - NORTH CENTRAL ANETH

N
W E
S

0 4 Miles

Map Scale 1:80,000

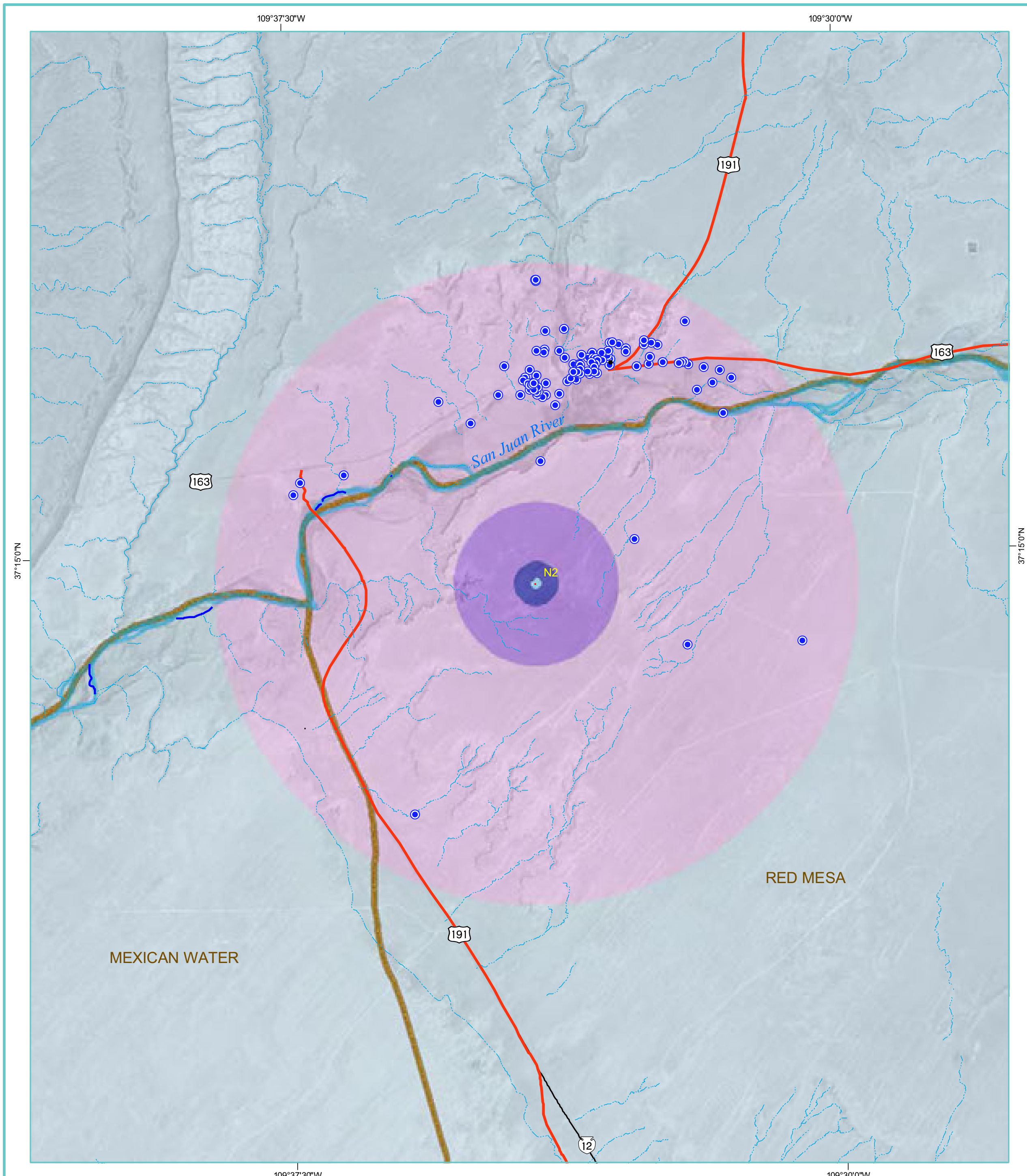
Legend

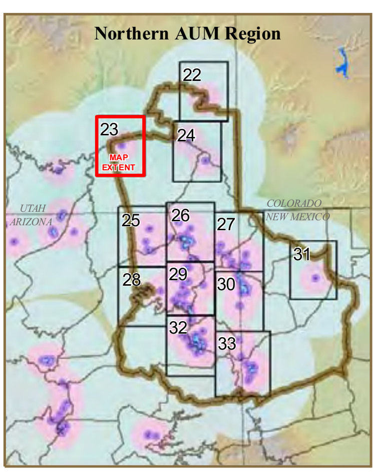
N1 MAP-ID
Mine Feature
Structure within 1 Mile
Well within 4 Miles

Downstream Water Pathway
Intermittent Stream
Northern AUM Region
Chapter
Paved Road

Abandoned Uranium Mine
Mine Buffers
200 Feet
1/4 Mile
1 Mile
4 Miles
15 Miles

Figure 22. Combined Pathways in the North Central Aneth Area.





ABANDONED URANIUM MINES AND THE NAVAJO NATION

Navajo Nation AUM Screening Assessment Report

COMBINED PATHWAYS - NORTHWEST RED MESA

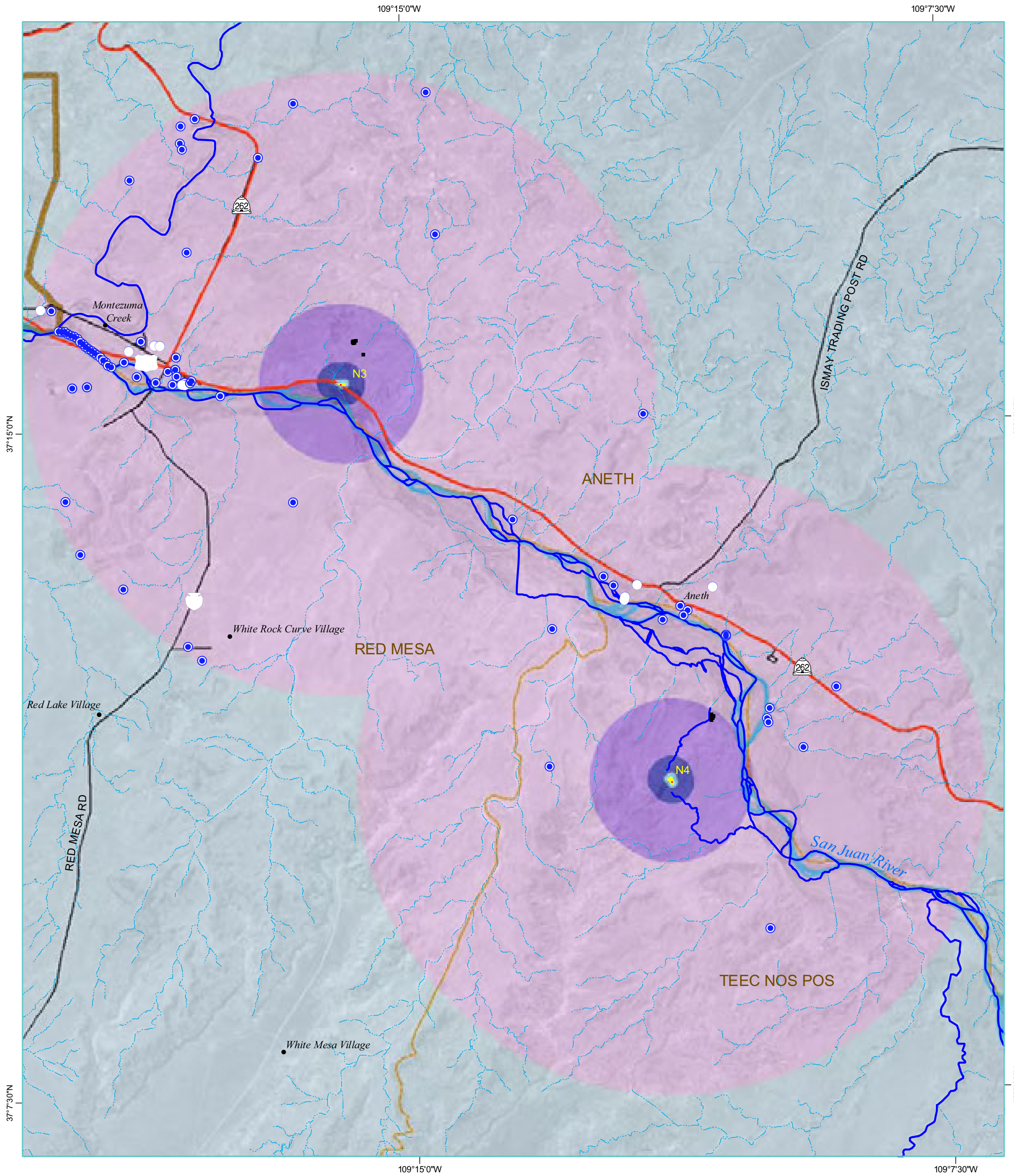
0 4 Miles

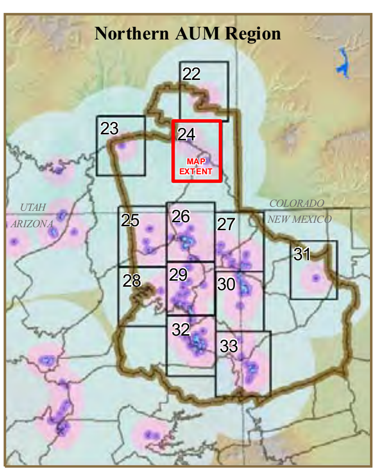
Map Scale 1:80,000

Legend

Symbol		Line		Fill	
N2	MAP-ID		Downstream Water Pathway		Abandoned Uranium Mine
	Mine Feature		Perennial Stream		Mine Buffers
	Structure within 1 Mile		Intermittent Stream		200 Feet
	Well within 4 Miles		Northern AUM Region		1/4 Mile
			Chapter		1 Mile
			Highway		4 Miles
			Paved Road		15 Miles

Figure 23. Combined Pathways in the Northwest Red Mesa Area.





ABANDONED URANIUM MINES AND THE NAVAJO NATION

Navajo Nation AUM Screening Assessment Report

COMBINED PATHWAYS - NORTH TEEC NOS POS

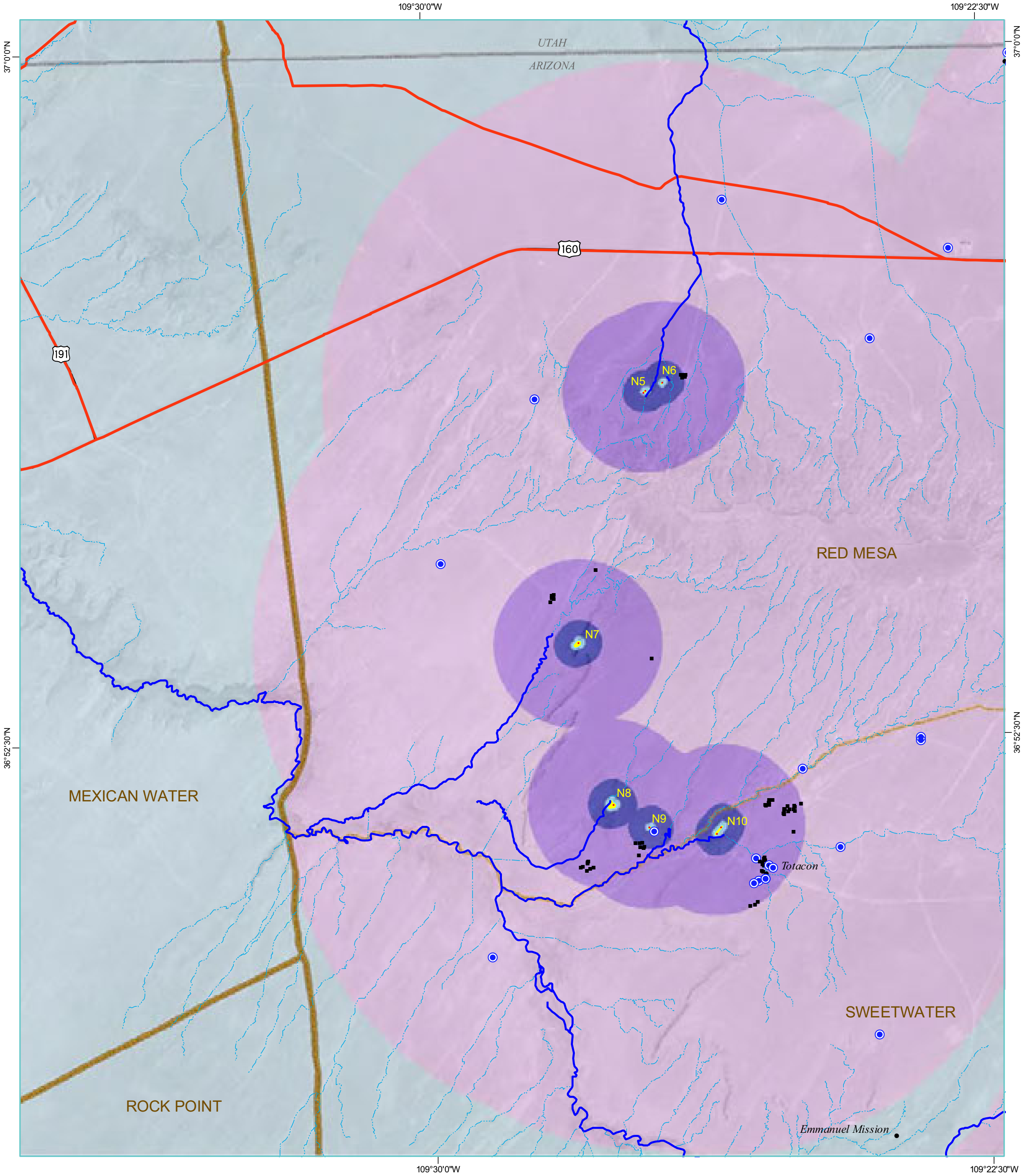
0 4 Miles

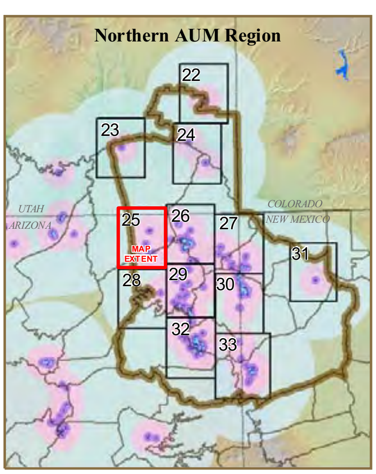
Map Scale 1:82,500

Legend

N3 MAP-ID	Downstream Water Pathway	Abandoned Uranium Mine
Mine Feature	Perennial Stream	Mine Buffers
Structure within 1 Mile	Intermittent Stream	200 Feet
Well within 4 Miles	Northern AUM Region	1/4 Mile
	Chapter	1 Mile
	Highway	4 Miles
	Paved Road	15 Miles

Figure 24. Combined Pathways in the North Teec Nos Pos Area.





ABANDONED URANIUM MINES AND THE NAVAJO NATION
Navajo Nation AUM Screening Assessment Report

COMBINED PATHWAYS - SOUTH RED MESA

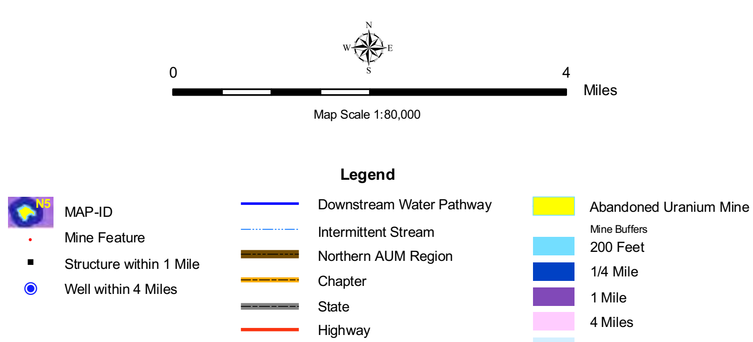
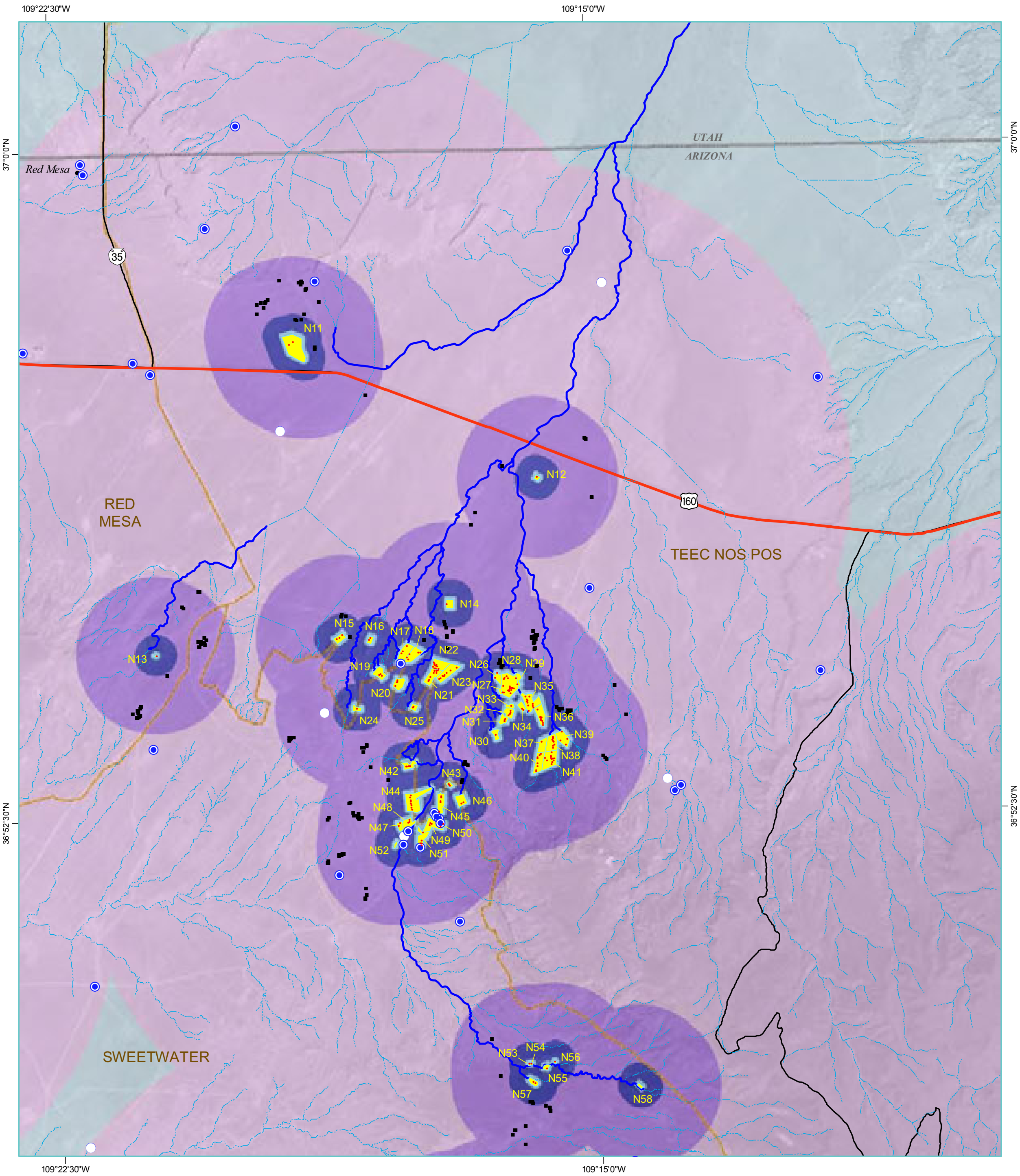
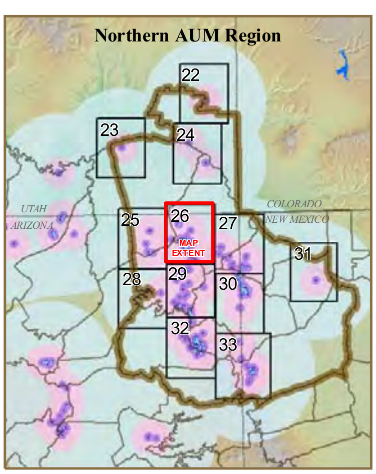


Figure 25. Combined Pathways in the South Red Mesa Area.





ABANDONED URANIUM MINES AND THE NAVAJO NATION
Navajo Nation AUM Screening Assessment Report

COMBINED PATHWAYS - TSE TAH

0 4 Miles

Map Scale 1:82,500

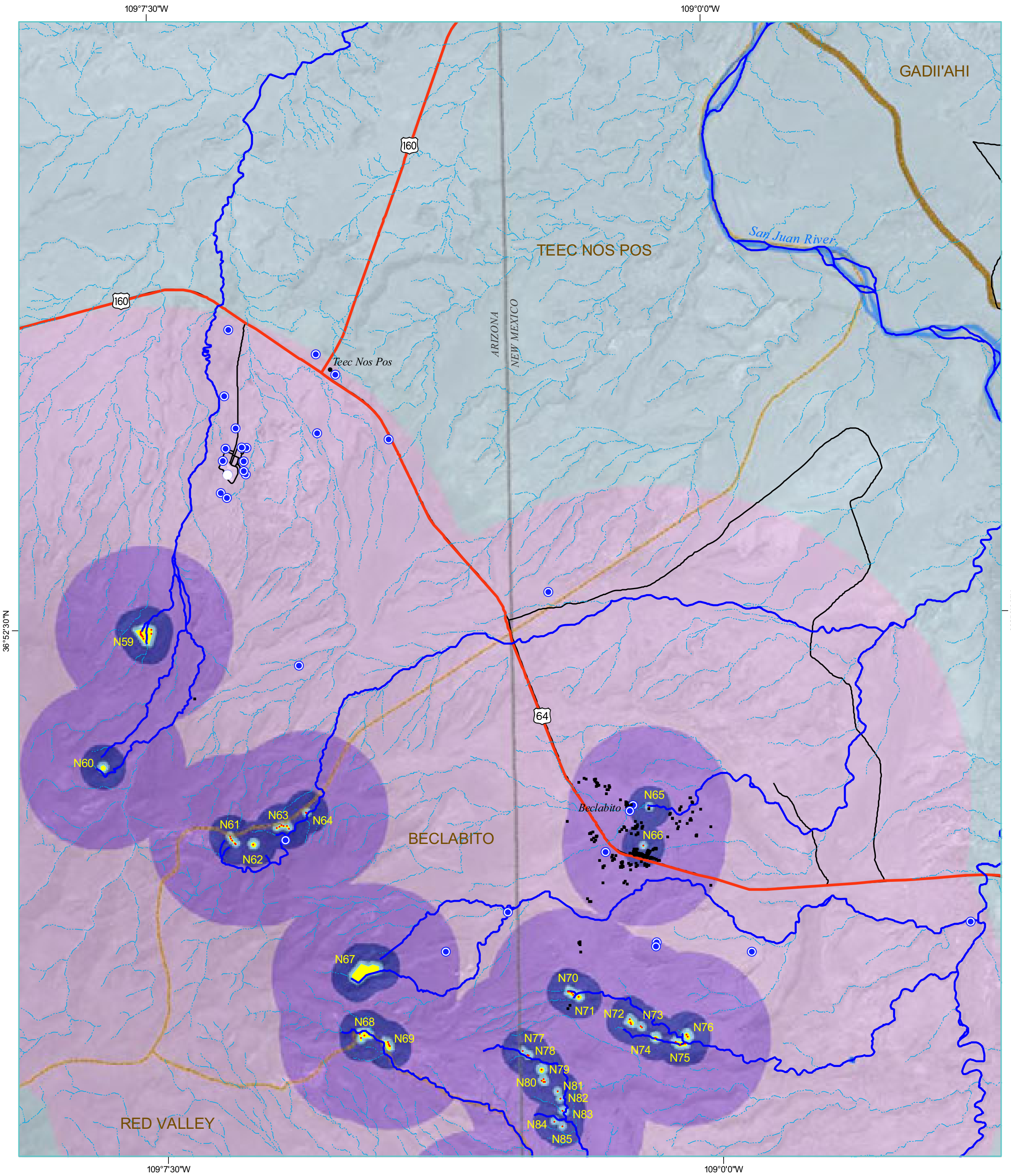
Legend

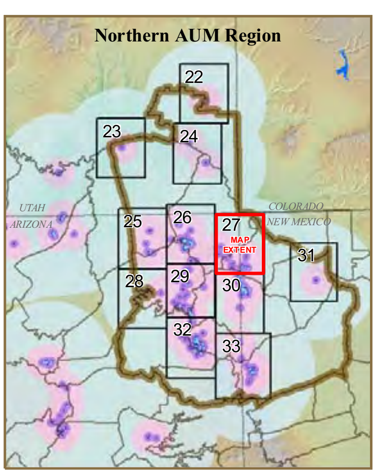
N11 MAP-ID
Mine Feature
Structure within 1 Mile
Well within 4 Miles

Downstream Water Pathway
Intermittent Stream
Northern AUM Region
Chapter
State
Highway
Paved Road

Abandoned Uranium Mine
Mine Buffers
200 Feet
1/4 Mile
1 Mile
4 Miles
15 Miles

Figure 26. Combined Pathways in the Tse Tah Area.





ABANDONED URANIUM MINES AND THE NAVAJO NATION

Navajo Nation AUM Screening Assessment Report

COMBINED PATHWAYS - NORTHEAST CARRIZO

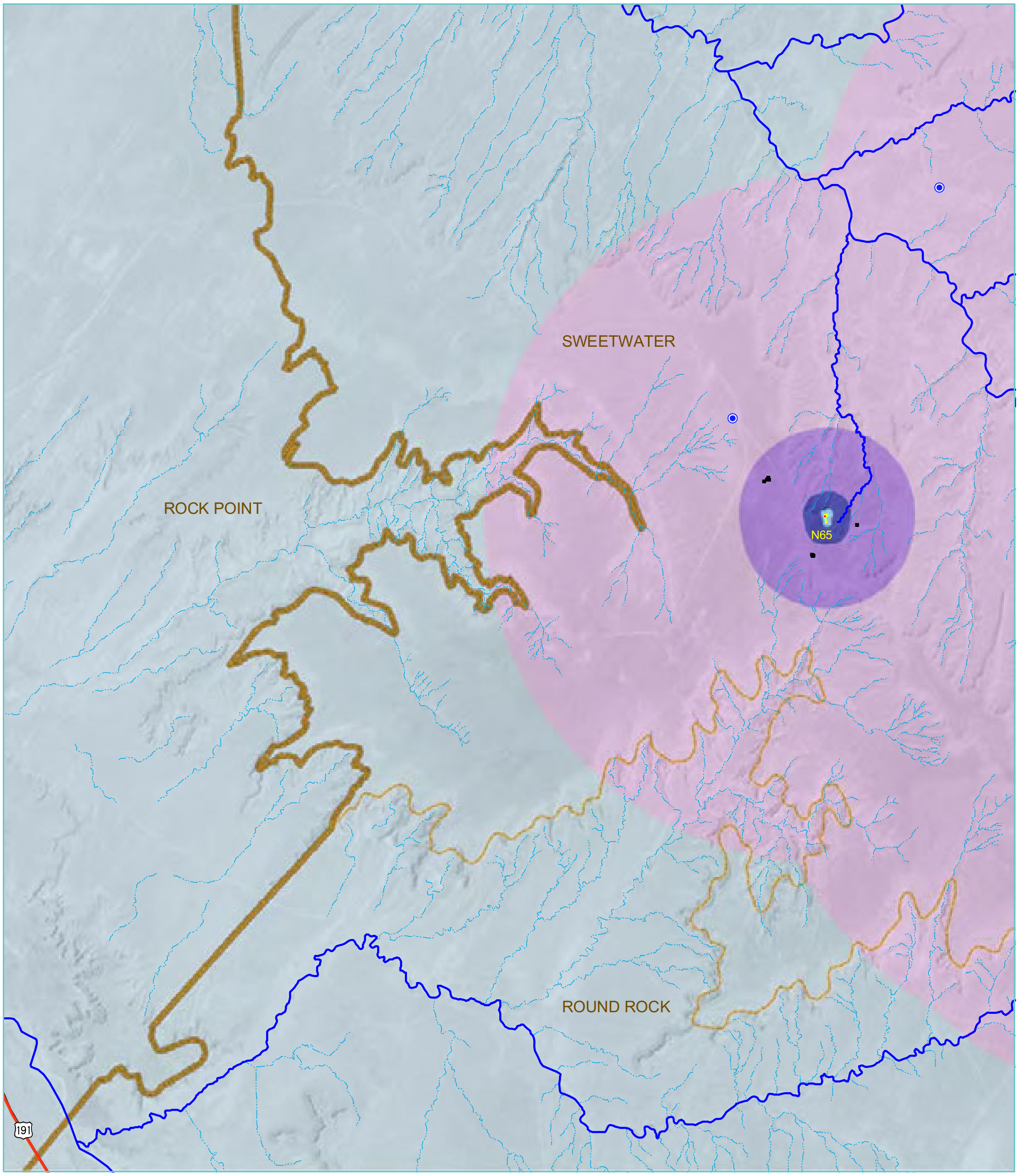
0 4 Miles

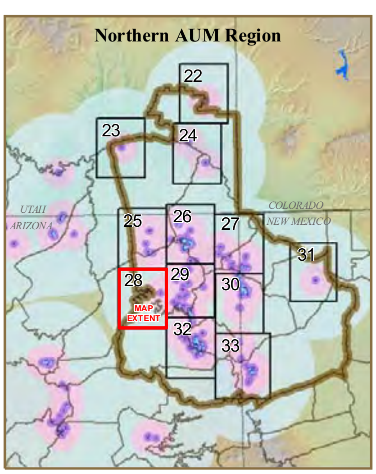
Map Scale 1:80,000

Legend

- MAP-ID
- Mine Feature
- Structure within 1 Mile
- Well within 4 Miles
- Downstream Water Pathway
- Perennial Stream
- Intermittent Stream
- Northern AUM Region
- Chapter
- State
- Highway
- Paved Road
- Abandoned Uranium Mine
- Mine Buffers
  - 200 Feet
  - 1/4 Mile
  - 1 Mile
  - 4 Miles
  - 15 Miles

Figure 27. Combined Pathways in the Northeast Carrizo Area.





ABANDONED URANIUM MINES AND THE NAVAJO NATION
Navajo Nation AUM Screening Assessment Report

COMBINED PATHWAYS - SOUTHWEST SWEETWATER

N
W E
S

0 4 Miles

Map Scale 1:77,500

Legend

N86 MAP-ID
Mine Feature
Structure within 1 Mile
Well within 4 Miles

Downstream Water Pathway
Intermittent Stream
Northern AUM Region
Chapter
Highway

Abandoned Uranium Mine
Mine Buffers
200 Feet
1/4 Mile
1 Mile
4 Miles
15 Miles

Figure 28. Combined Pathways in the Southwest Sweetwater Area.

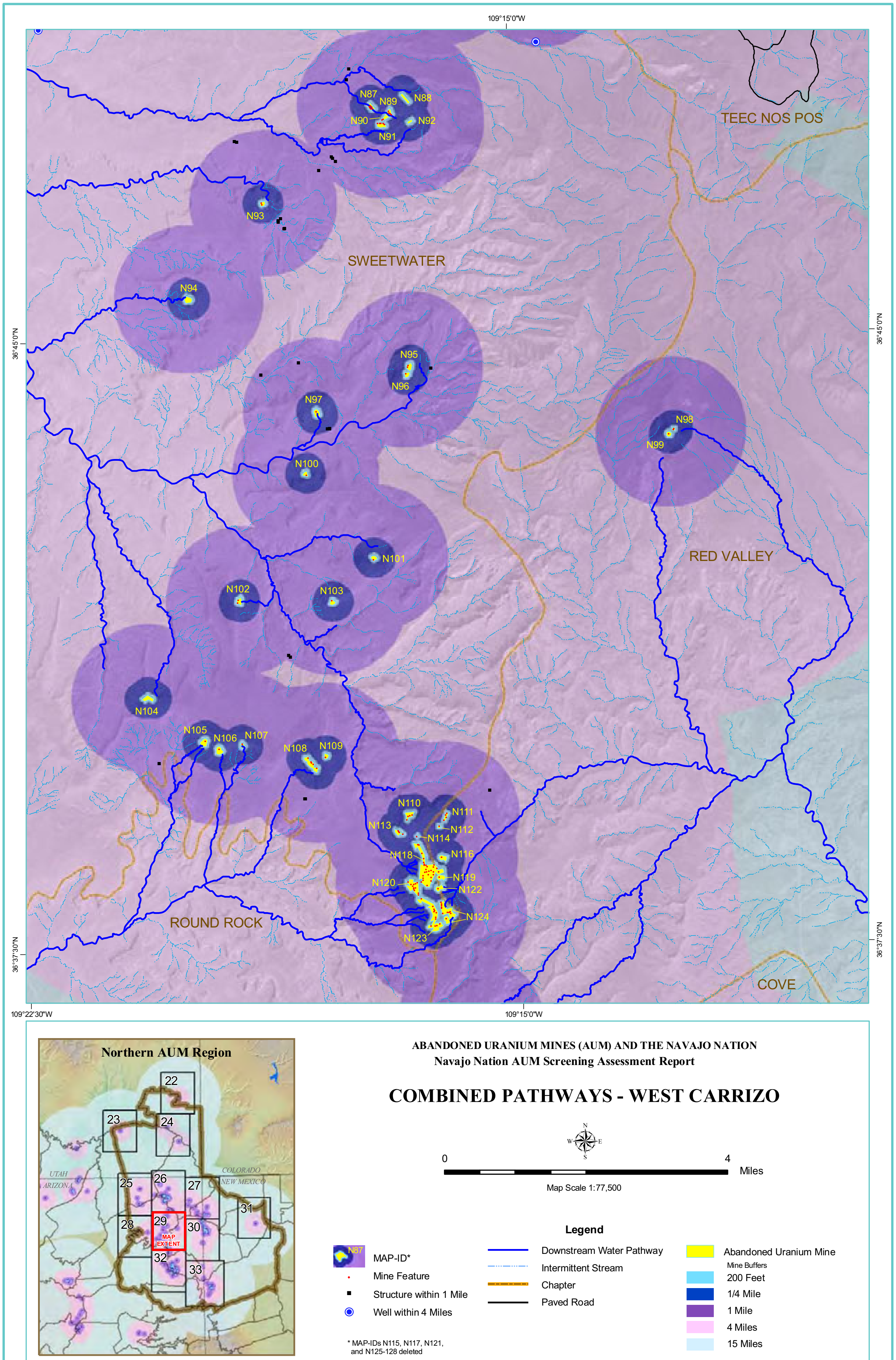
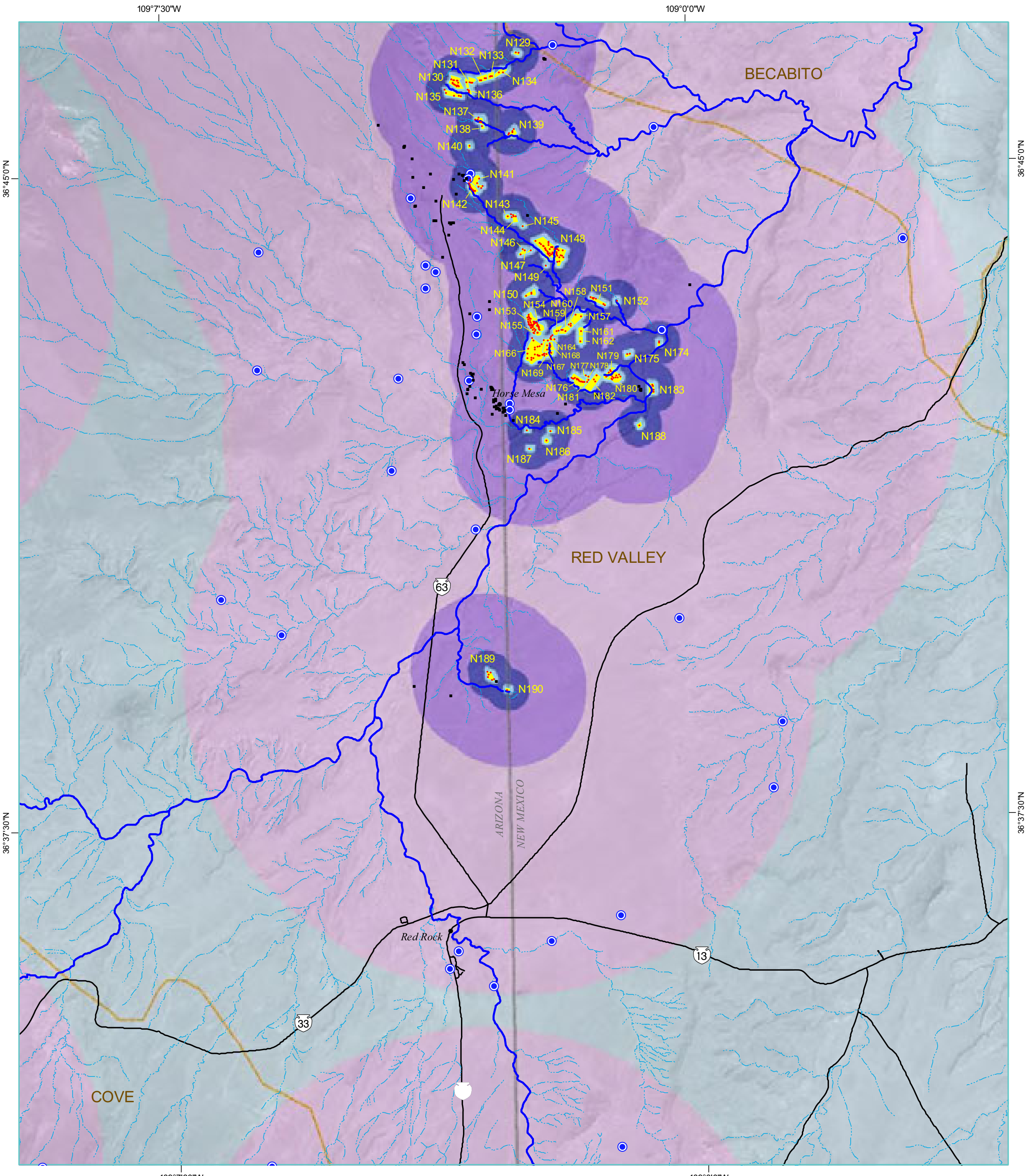
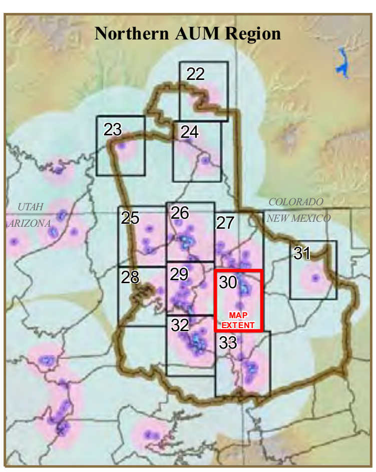


Figure 29. Combined Pathways in the West Carrizo Area.





ABANDONED URANIUM MINES AND THE NAVAJO NATION

Navajo Nation AUM Screening Assessment Report

COMBINED PATHWAYS - EAST CARRIZO

N W E S

0 4 Miles

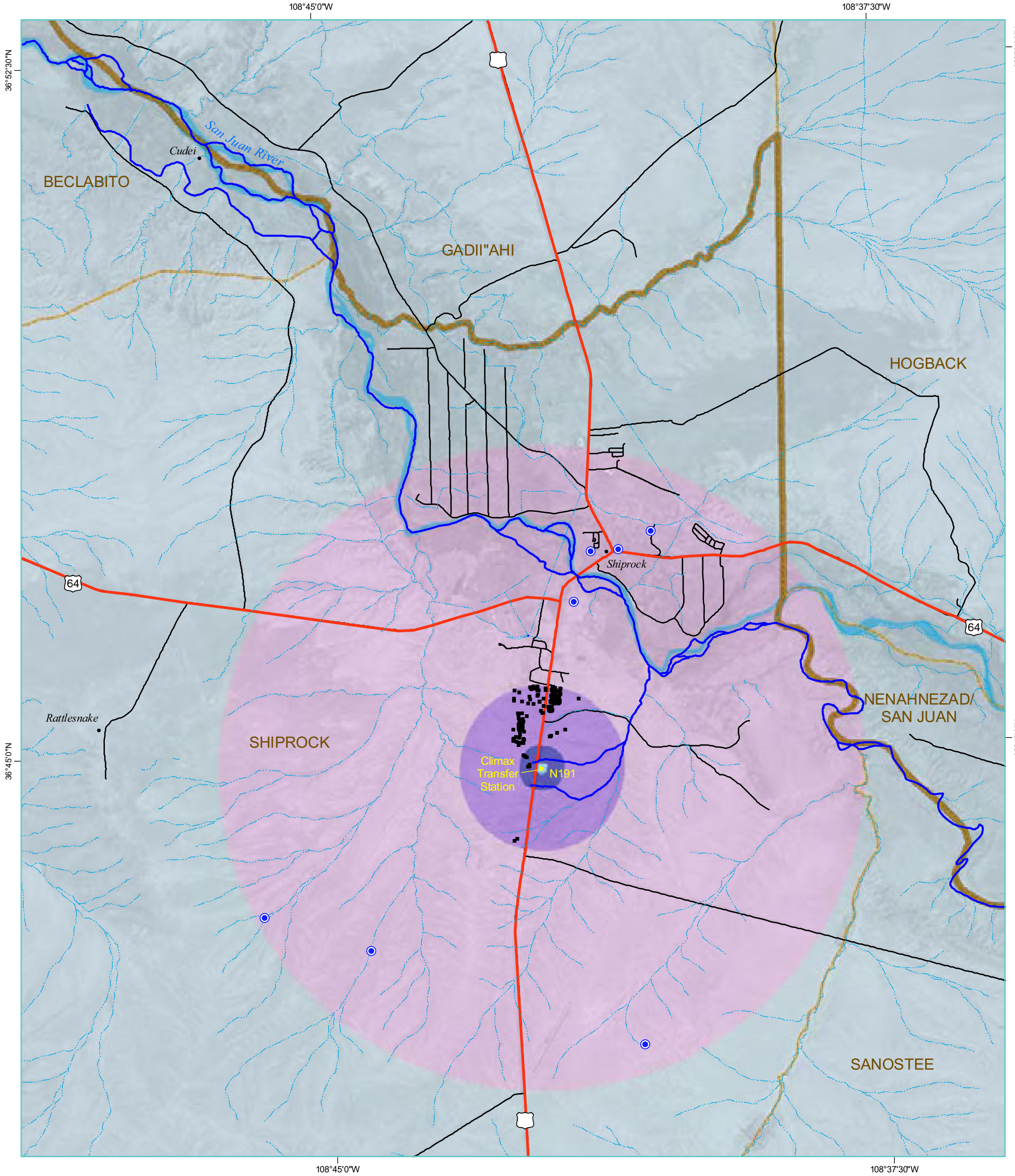
Map Scale 1:85,000

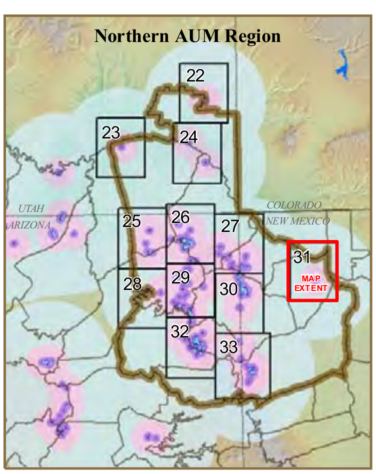
Legend

- N129 MAP-ID*
- Mine Feature
- Structure within 1 Mile
- Well within 4 Miles
- Downstream Water Pathway
- Intermittent Stream
- Chapter
- Paved Road
- Abandoned Uranium Mine
- Mine Buffers
- 200 Feet
- 1/4 Mile
- 1 Mile
- 4 Miles
- 15 Miles

* MAP-IDs N156, N163, N165, and N170-173 deleted

Figure 30. Combined Pathways in the East Carrizo Area.





ABANDONED URANIUM MINES AND THE NAVAJO NATION
Navajo Nation AUM Screening Assessment Report

COMBINED PATHWAYS - SHIPROCK

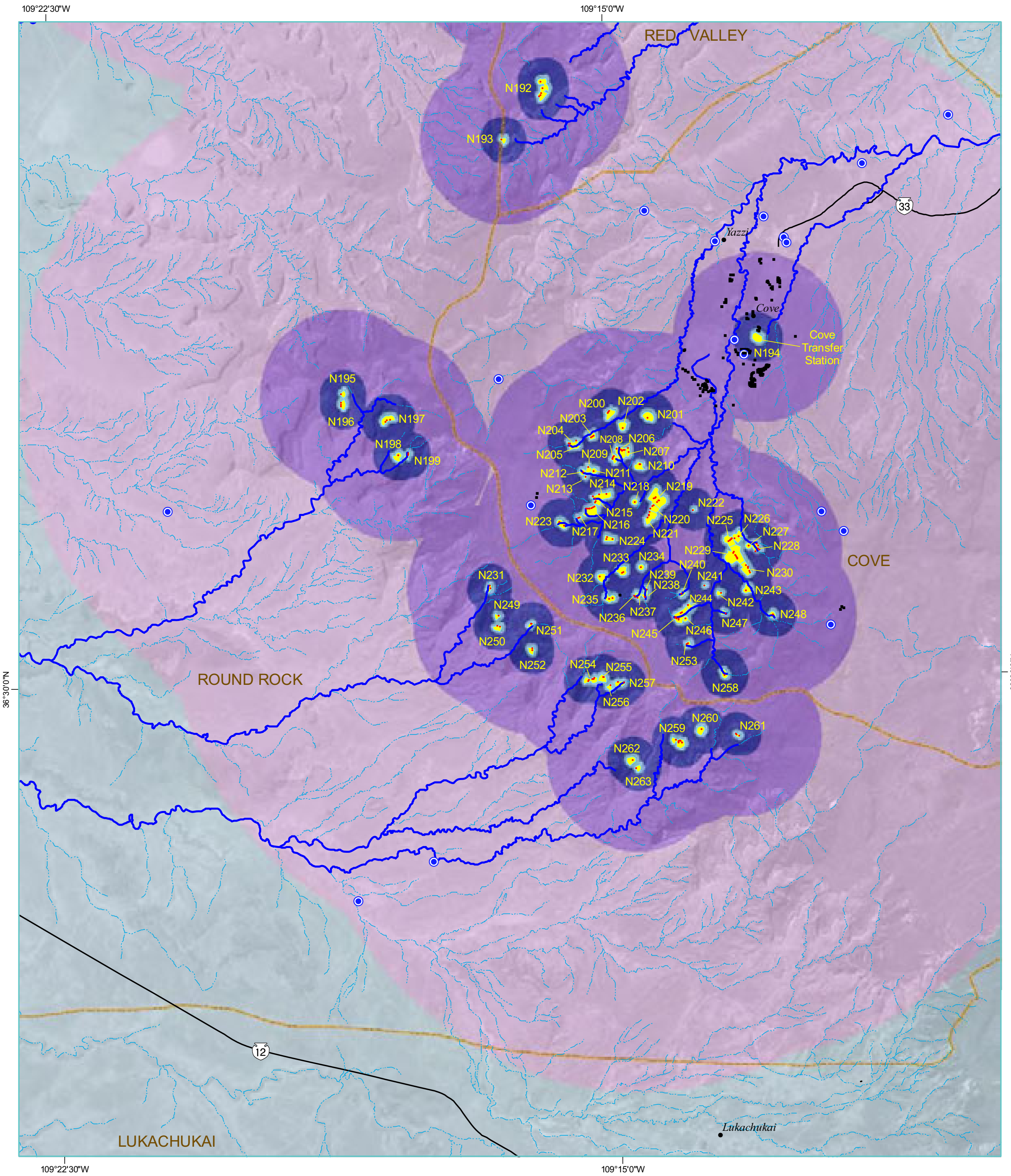
0 — 4 Miles

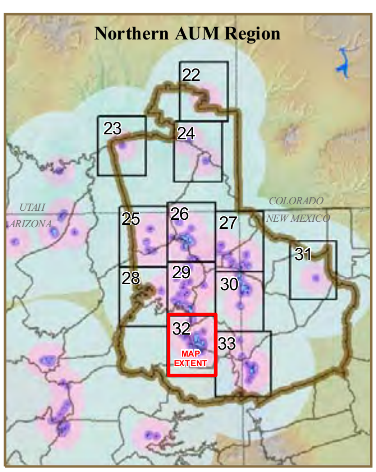
Map Scale 1:80,000

Legend

- N191 MAP-ID
- Mine Feature
- Structure within 1 Mile
- Well within 4 Miles
- Downstream Water Pathway
- Intermittent Stream
- Northern AUM Region
- Chapter
- Highway
- Paved Road
- Abandoned Uranium Mine
- Mine Buffers
  - 200 Feet
  - 1/4 Mile
  - 1 Mile
  - 4 Miles
  - 15 Miles

Figure 31. Combined Pathways in the Shiprock Area.





ABANDONED URANIUM MINES AND THE NAVAJO NATION

Navajo Nation AUM Screening Assessment Report

COMBINED PATHWAYS - LUKACHUKAI

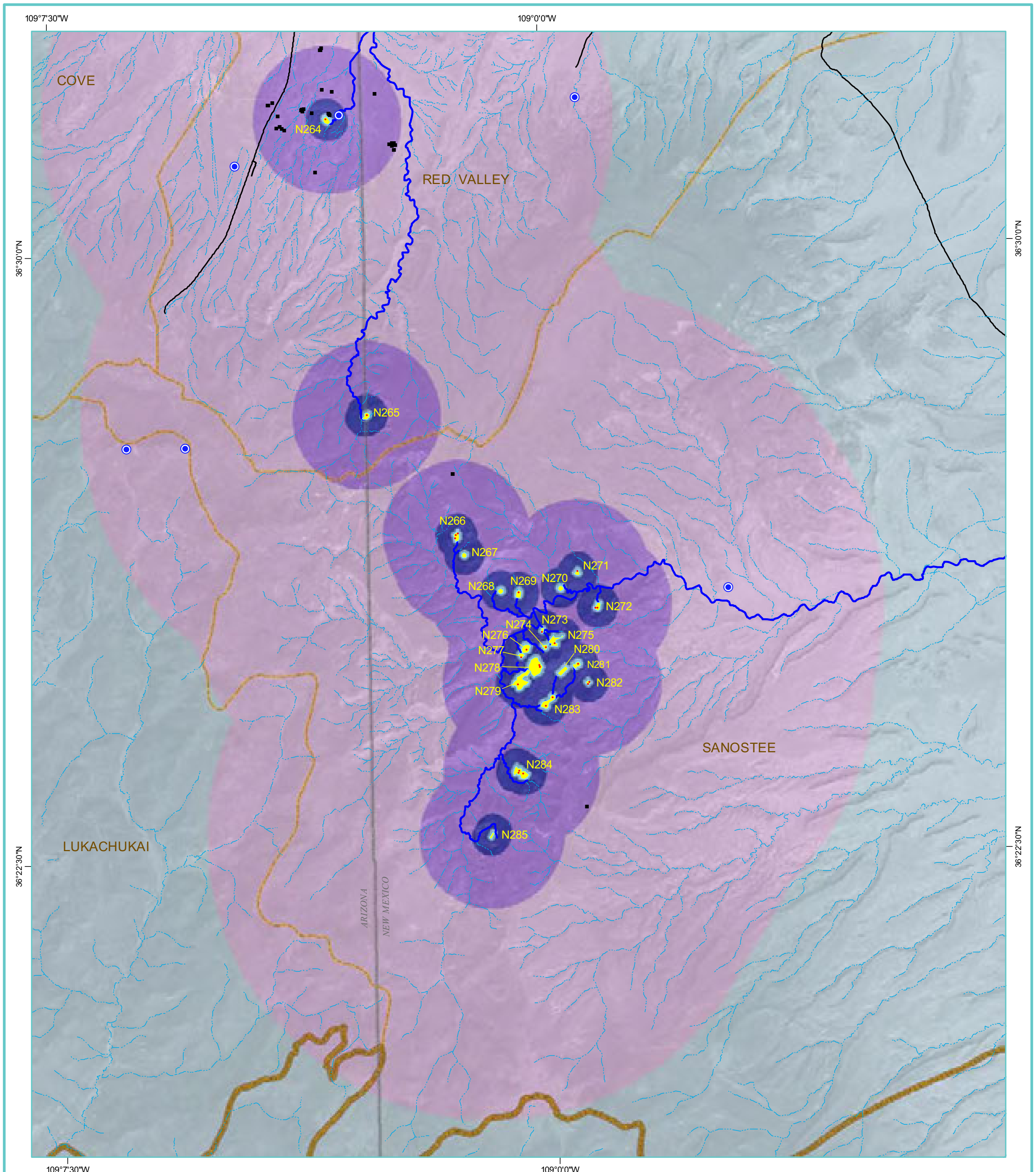
0 4 Miles

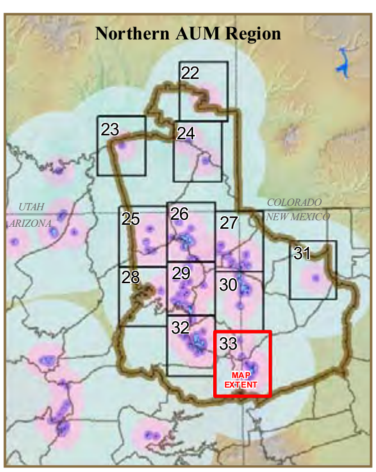
Map Scale 1:80,000

Legend

- MAP-ID
- Mine Feature
- Structure within 1 Mile
- Well within 4 Miles
- Downstream Water Pathway
- Intermittent Stream
- Chapter
- Paved Road
- Abandoned Uranium Mine
- Mine Buffers
  - 200 Feet
  - 1/4 Mile
  - 1 Mile
  - 4 Miles
  - 15 Miles

Figure 32. Combined Pathways in the Lukachukai Area.





ABANDONED URANIUM MINES AND THE NAVAJO NATION
Navajo Nation AUM Screening Assessment Report

COMBINED PATHWAYS - CHUSKA

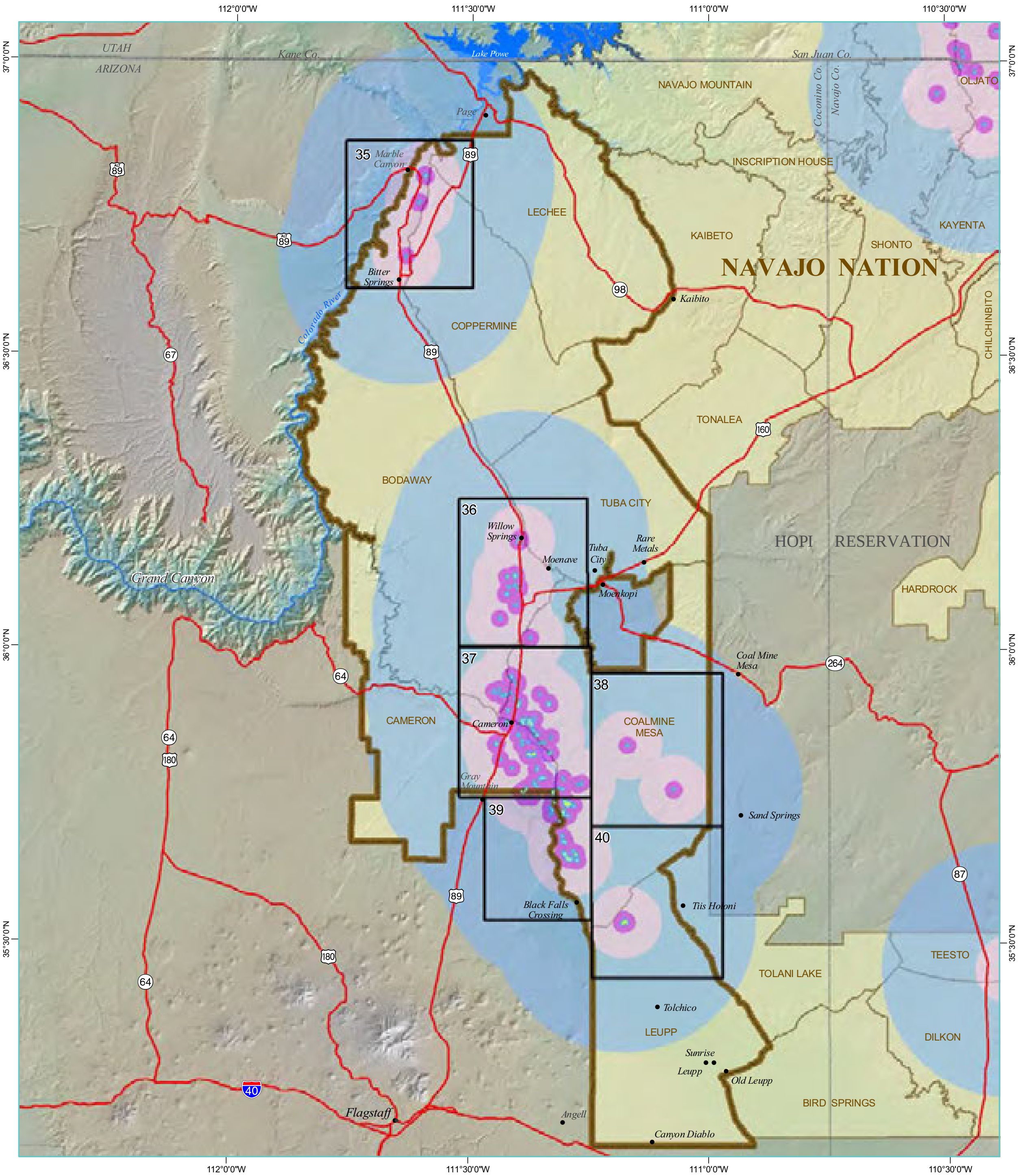
0 4 Miles

Map Scale 1:90,000

Legend

- N264 MAP-ID
- Mine Feature
- Structure within 1 Mile
- Well within 4 Miles
- Downstream Water Pathway
- Intermittent Stream
- Northern AUM Region
- Chapter
- State
- Paved Road
- Abandoned Uranium Mine
- Mine Buffers
  - 200 Feet
  - 1/4 Mile
  - 1 Mile
  - 4 Miles
  - 15 Miles

Figure 33. Combined Pathways in the Chuska Area.



ABANDONED URANIUM MINES AND THE NAVAJO NATION

Navajo Nation AUM Screening Assessment Report

WESTERN AUM REGION COMBINED PATHWAYS - MAP FIGURE INDEX

Sources

Abandoned uranium mine areas are primarily from the Navajo Abandoned Mine Lands Reclamation Program (NAMLRP) and augmented by several other sources. The Navajo Nation and Chapter boundaries are from the Navajo Land Department. Hydrographic data for streams are from the U.S. Geological Survey (USGS) National Hydrographic Dataset. Selected Populated Places are from the USGS Geographic Names Information System (GNIS). Buffers were generated by TerraSpectra Geomatics. Map index figure outlines are approximate.

Map Index Area Designations

Figure

35 - Echo Cliffs
36 - Southeastern Bodaway/Gap
37 - Cameron
38 - Adeii Eechii Cliffs
39 - Southern Little Colorado
40 - East Black Falls

N
W E
S

0 20 Miles

Map Scale 1:750,000

Legend

Western AUM Region

Abandoned Uranium Mine

Mine Buffers

1/4 Mile

1 Mile

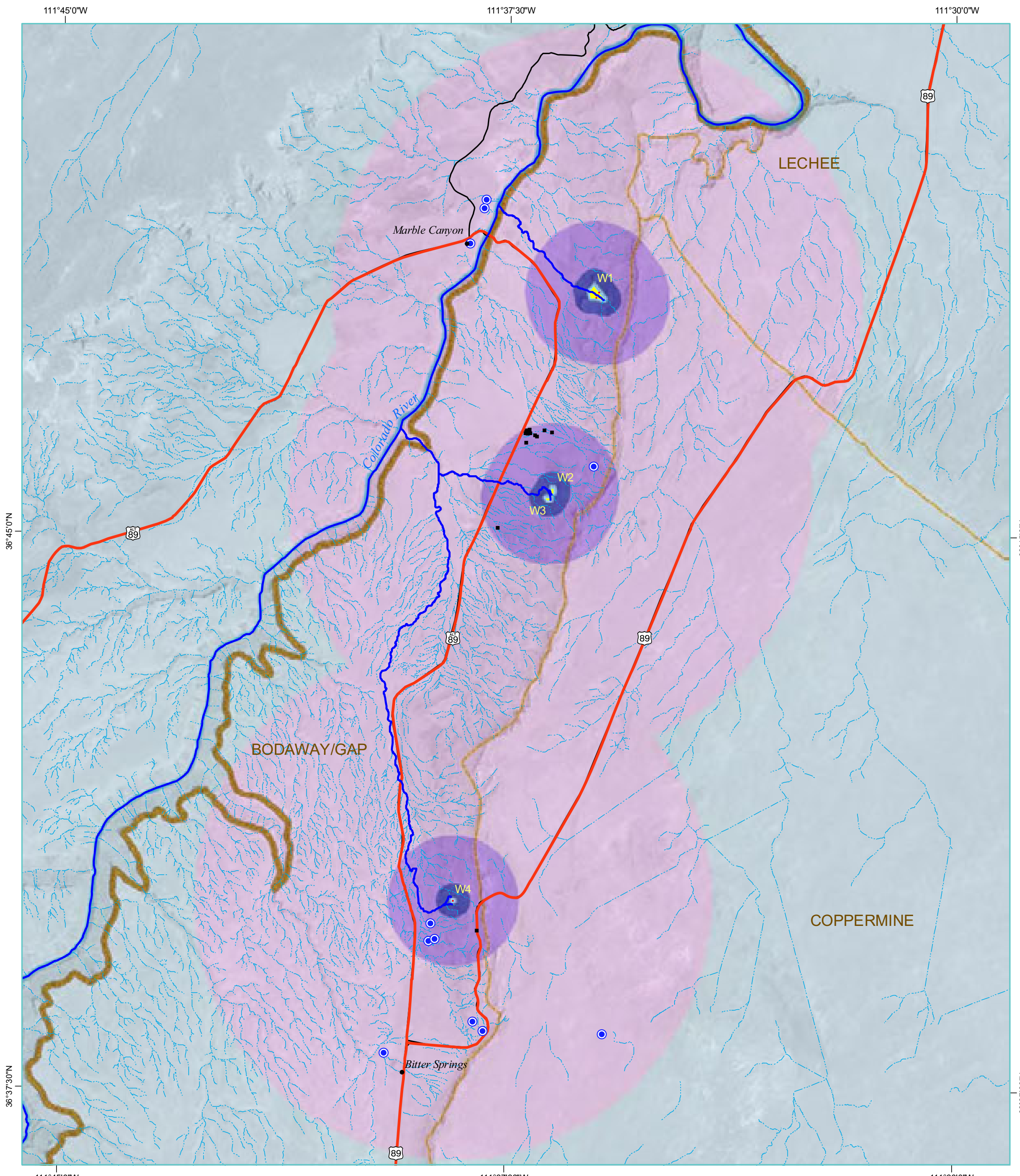
4 Miles

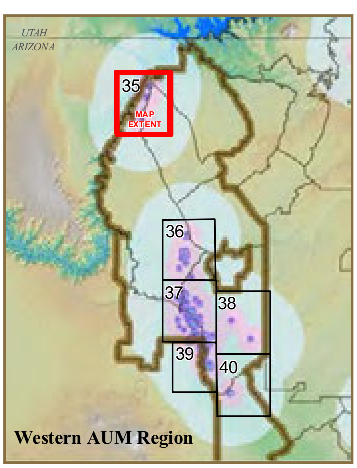
15 Miles

Populated Places

Highways

Figure 34. Western AUM Region Combined Pathways Map Figure Index.





ABANDONED URANIUM MINES AND THE NAVAJO NATION
Navajo Nation AUM Screening Assessment Report

COMBINED PATHWAYS - ECHO CLIFFS

N W E S

0 4 Miles

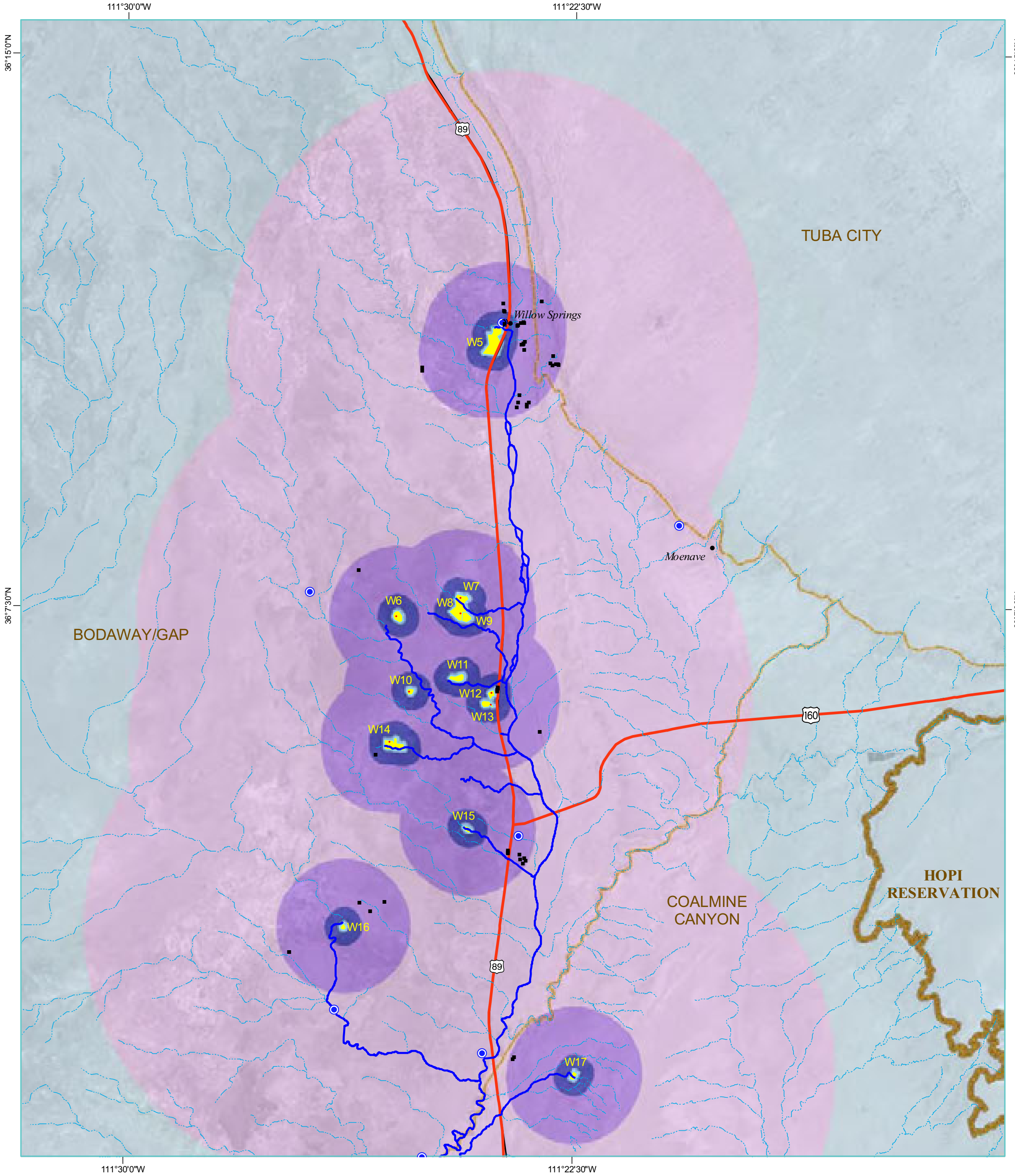
Map Scale 1:100,000

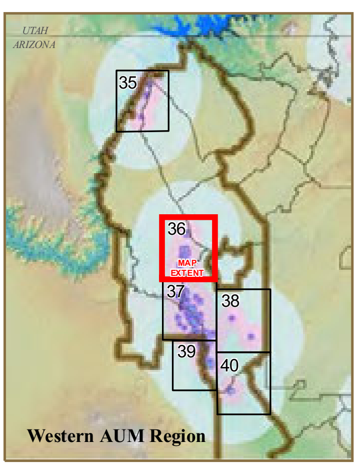
Legend

- MAP-ID
- Mine Feature
- Structure within 1 mile
- Well within 4 miles
- Downstream Water Pathway
- Perennial Stream
- Intermittent Stream
- Western AUM Region
- Chapter
- Highway
- Paved Road
- Abandoned Uranium Mine

Mine Buffers
- 200 Feet
- 1/4 Mile
- 1 Mile
- 4 Miles
- 15 Miles

Figure 35. Combined Pathways in the Echo Cliffs Area.





ABANDONED URANIUM MINES AND THE NAVAJO NATION

Navajo Nation AUM Screening Assessment Report

COMBINED PATHWAYS - SOUTHEASTERN BODAWAY/GAP

0 4 Miles

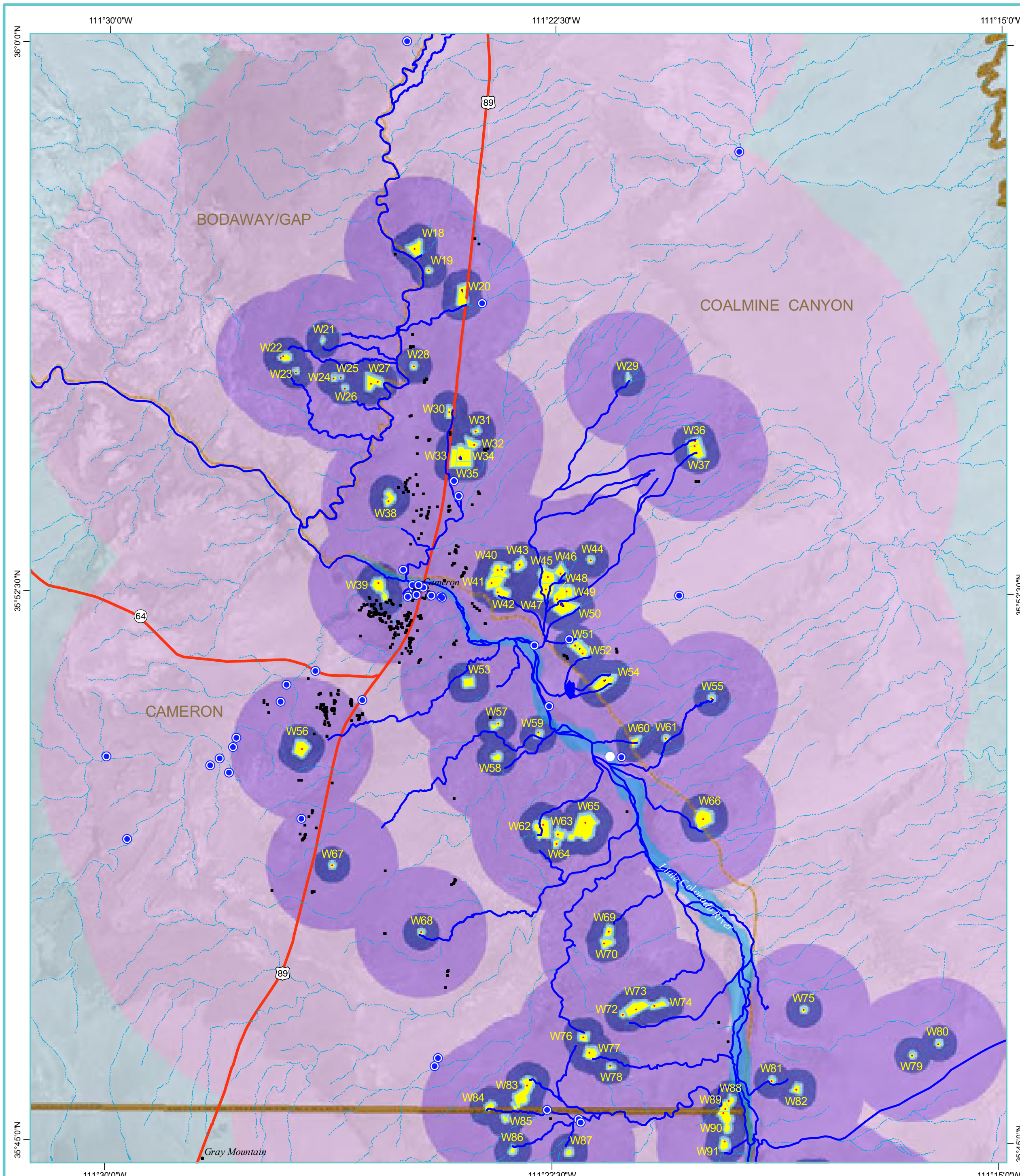
Map Scale 1:100,000

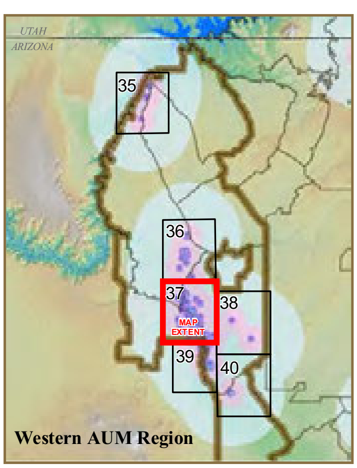
Legend

- W5 MAP-ID
- Mine Feature
- Structure within 1 mile
- Well within 4 miles
- Downstream Water Pathway
- Intermittent Stream
- Western AUM Region
- Chapter
- Highway
- Abandoned Uranium Mine

Mine Buffers
- 200 Feet
- 1/4 Mile
- 1 Mile
- 4 Miles
- 15 Miles

Figure 36. Combined Pathways in the Southeastern Bodaway/Gap Area.





ABANDONED URANIUM MINES AND THE NAVAJO NATION

Navajo Nation AUM Screening Assessment Report

COMBINED PATHWAYS - CAMERON

N W E S

0 4 Miles

Map Scale 1:100,000

Legend

- W18 MAP-ID*
- Mine Feature
- Structure within 1 mile
- Well within 4 miles
- Downstream Water Pathway
- Perennial Stream
- Intermittent Stream
- Western AUM Region
- Chapter
- Highway
- Abandoned Uranium Mine
- Mine Buffers
  - 200 Feet
  - 1/4 Mile
  - 1 Mile
  - 4 Miles
  - 15 Miles

*MAP-ID W71 shown in Figure 38

Figure 37. Combined Pathways in the Cameron Area.

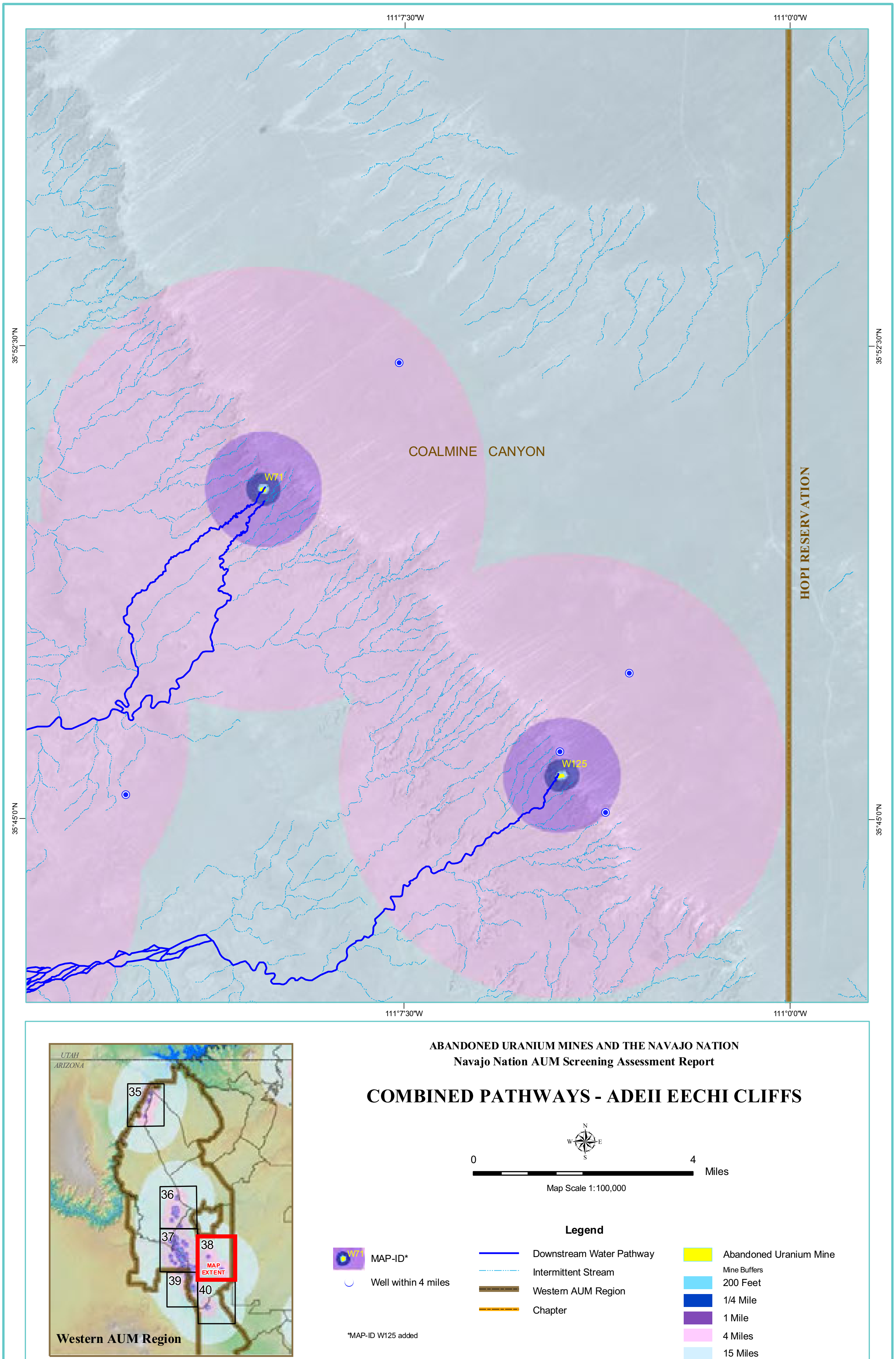
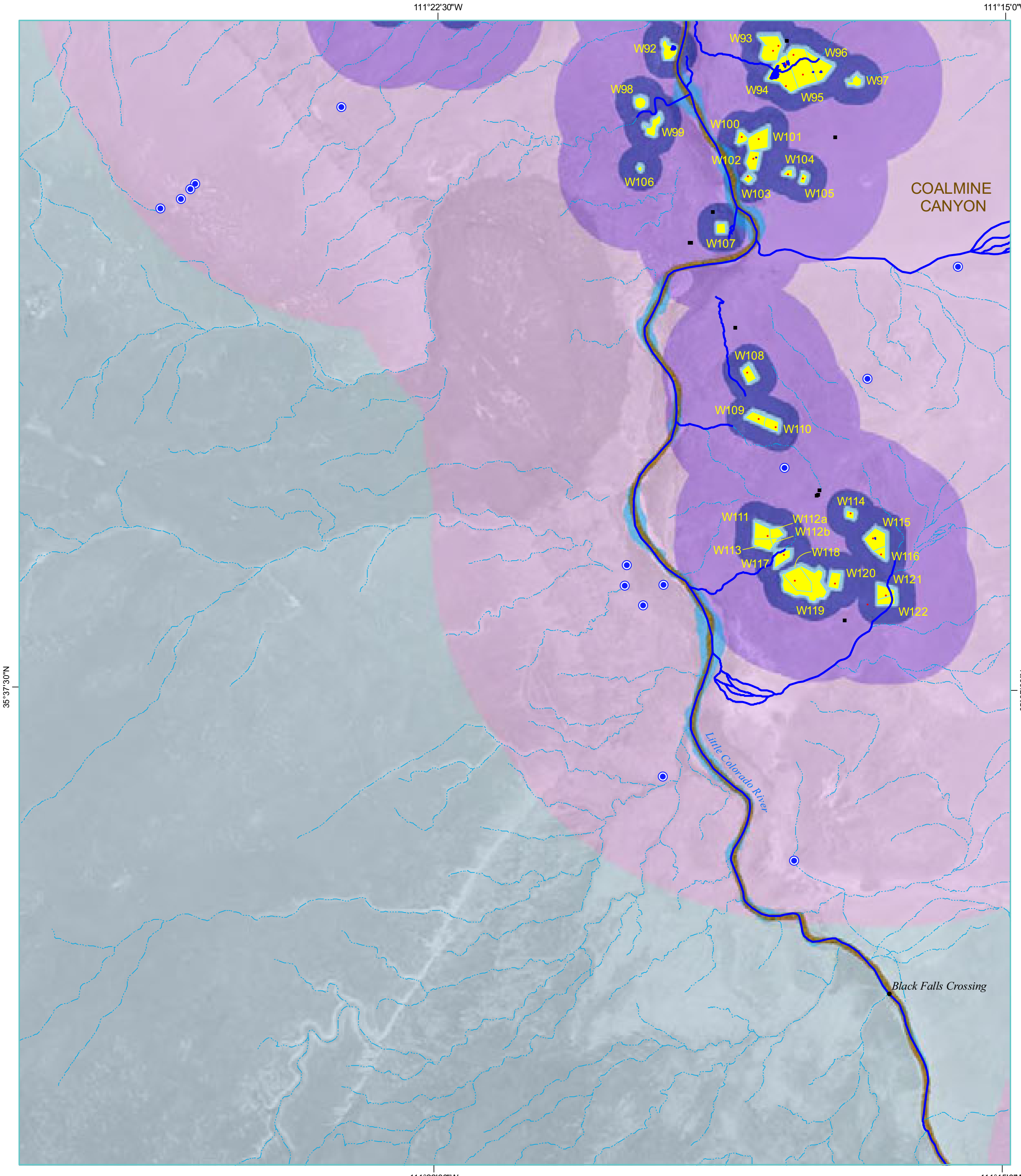
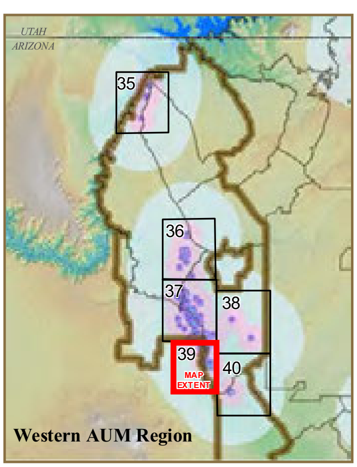


Figure 38. Combined Pathways in the Adeii Eechi Cliffs Area.





ABANDONED URANIUM MINES AND THE NAVAJO NATION

Navajo Nation AUM Screening Assessment Report

COMBINED PATHWAYS - SOUTHERN LITTLE COLORADO

0 — 4 Miles

Map Scale 1:80,000

Legend

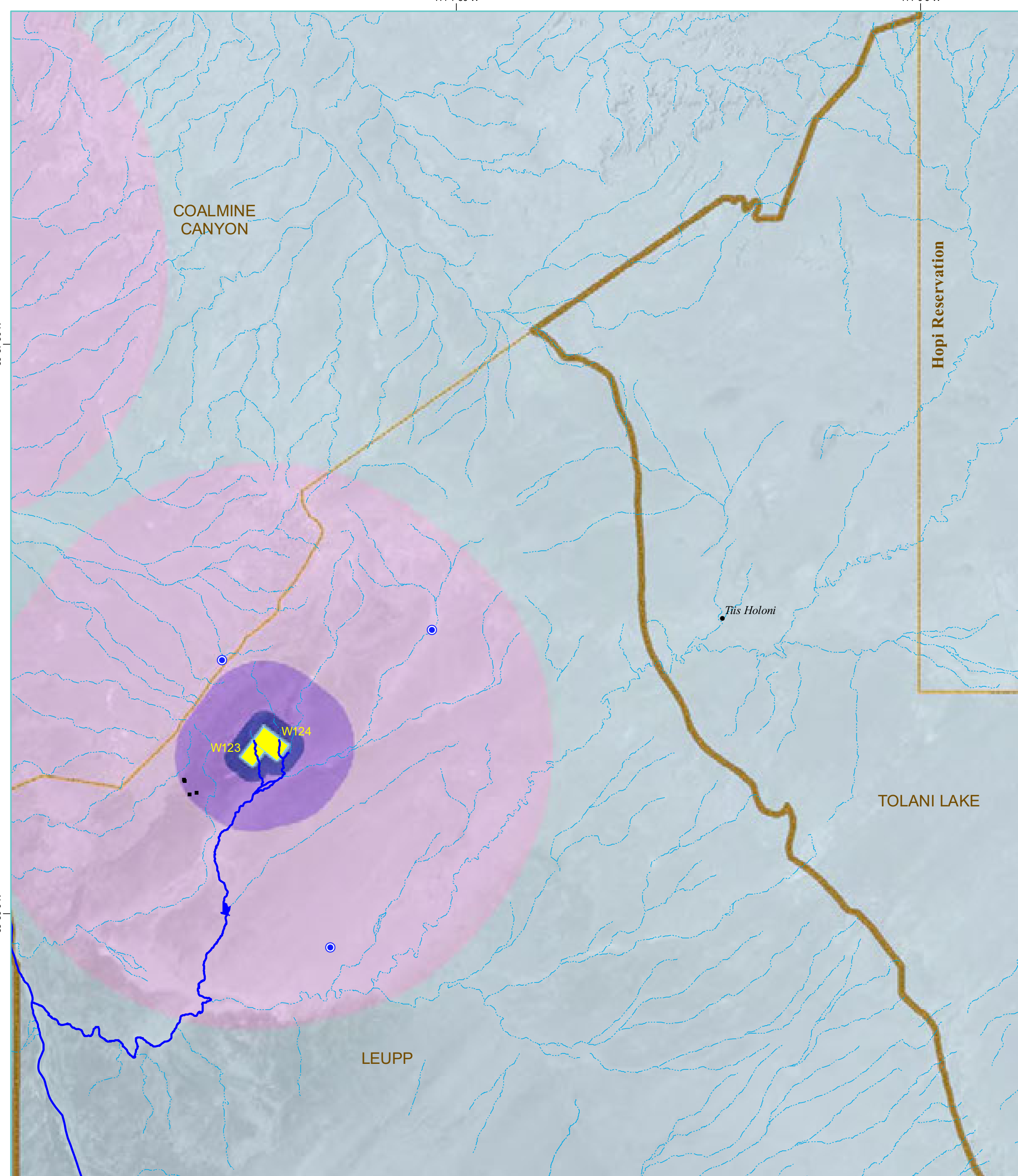
- MAP-ID*
- Mine Feature
- Structure within 1 mile
- Well within 4 miles
- Downstream Water Pathway
- Perennial Stream
- Intermittent Stream
- Western AUM Region
- Chapter
- Abandoned Uranium Mine

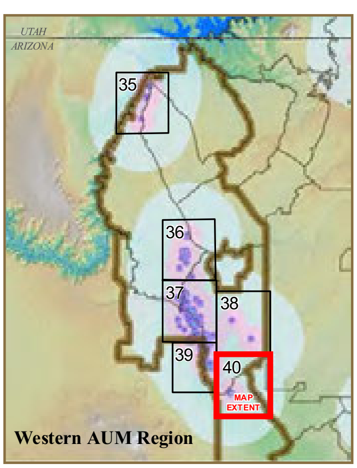
Mine Buffers

- 200 Feet
- 1/4 Mile
- 1 Mile
- 4 Miles
- 15 Miles

*MAP-ID W112 split into W112a and W112b

Figure 39. Combined Pathways in the Southern Little Colorado Area.





ABANDONED URANIUM MINES AND THE NAVAJO NATION
Navajo Nation AUM Screening Assessment Report

COMBINED PATHWAYS - EAST BLACK FALLS

N W E S

0 4 Miles

Map Scale 1:100,000

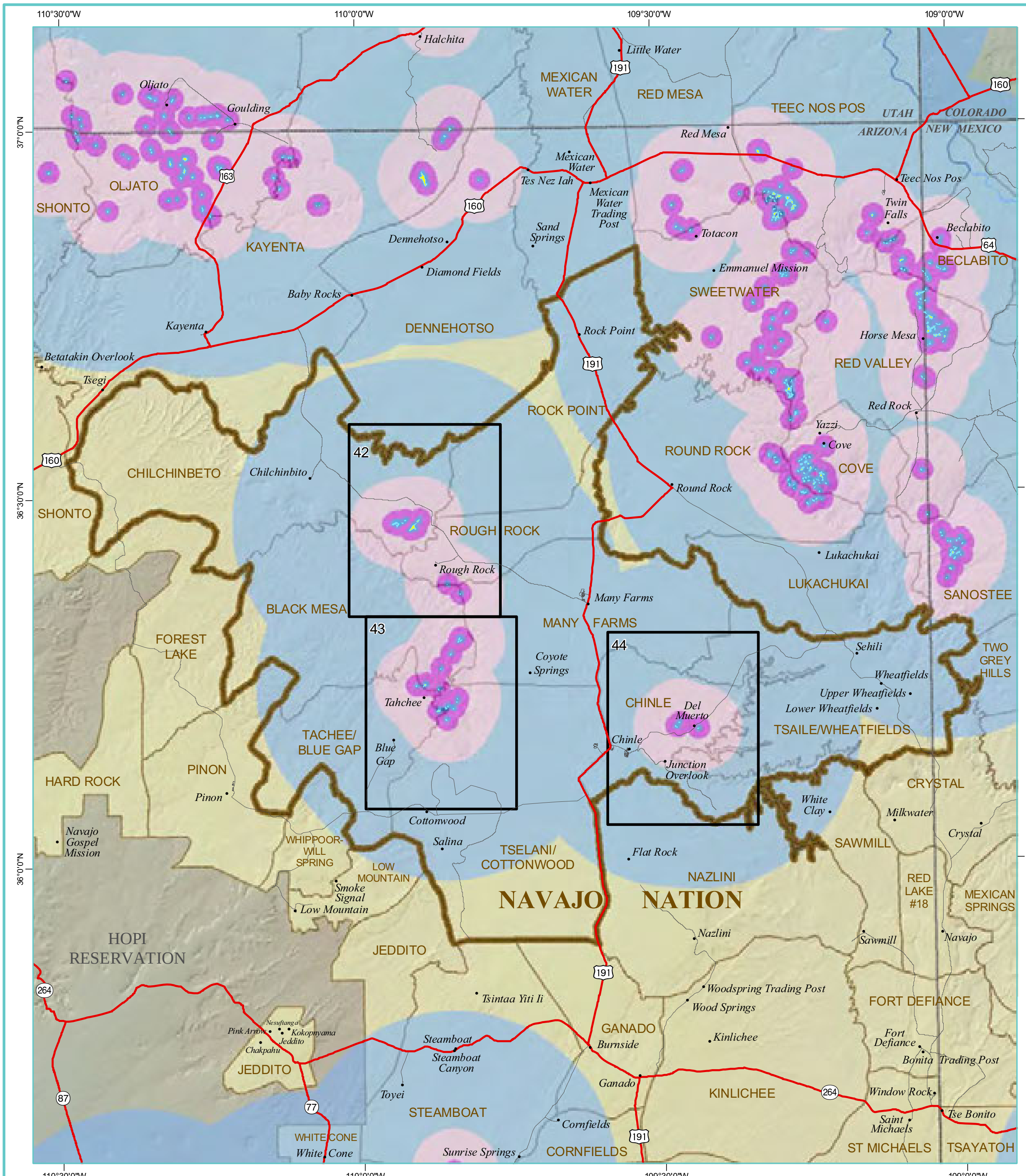
Legend

W123 MAP-ID
Structure within 1 mile
Well within 4 miles

Downstream Water Pathway
Intermittent Stream
Western AUM Region
Chapter

Abandoned Uranium Mine
Mine Buffers
200 Feet
1/4 Mile
1 Mile
4 Miles
15 Miles

Figure 40. Combined Pathways in the East Black Falls Area.



ABANDONED URANIUM MINES AND THE NAVAJO NATION

Navajo Nation AUM Screening Assessment Report

CENTRAL AUM REGION COMBINED PATHWAYS - MAP FIGURE INDEX

Sources

Abandoned Uranium Mine (AUM) locations are primarily from the Navajo Abandoned Mine Lands Reclamation Program (NAMLRP) and augmented by other sources. The Navajo Nation and Chapter boundaries are from the Navajo Land Department. Hydrographic data for streams are from the U.S. Geological Survey (USGS) National Hydrographic Dataset. Buffers were generated by TerraSpectra Geomatics. Map index figure boundaries are approximate.

Map Area Designations

Figure

42 - Rough Rock
43 - Tachee
44 - Chinle

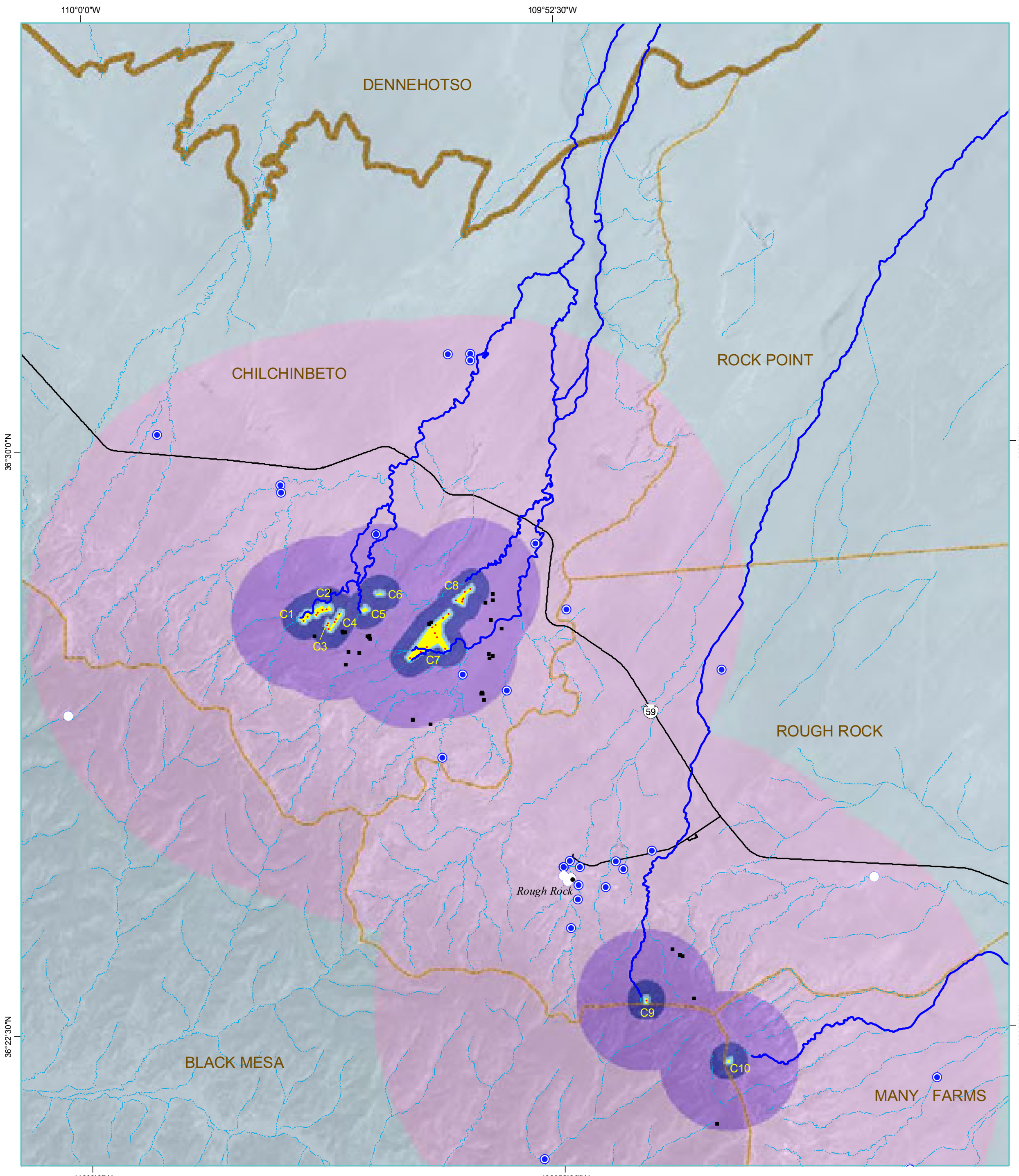
0 20 Miles

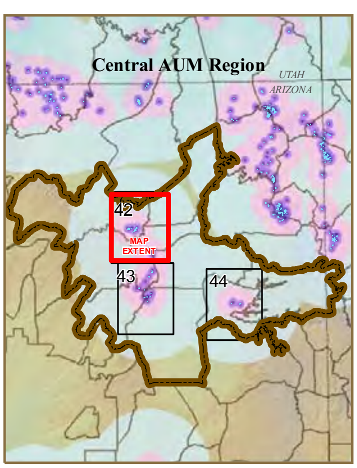
Map Scale 1:600,000

Legend

- Central AUM Region
- Abandoned Uranium Mine
- Mine Buffers
- 1/4 Mile
- 1 Mile
- 4 Miles
- 15 Miles
- Populated Places
- Highways

Figure 41. Central AUM Region Combined Pathways Map Figure Index.





ABANDONED URANIUM MINES (AUM) AND THE NAVAJO NATION
Navajo Nation AUM Screening Assessment Report

COMBINED PATHWAYS - ROUGH ROCK

0 4 Miles

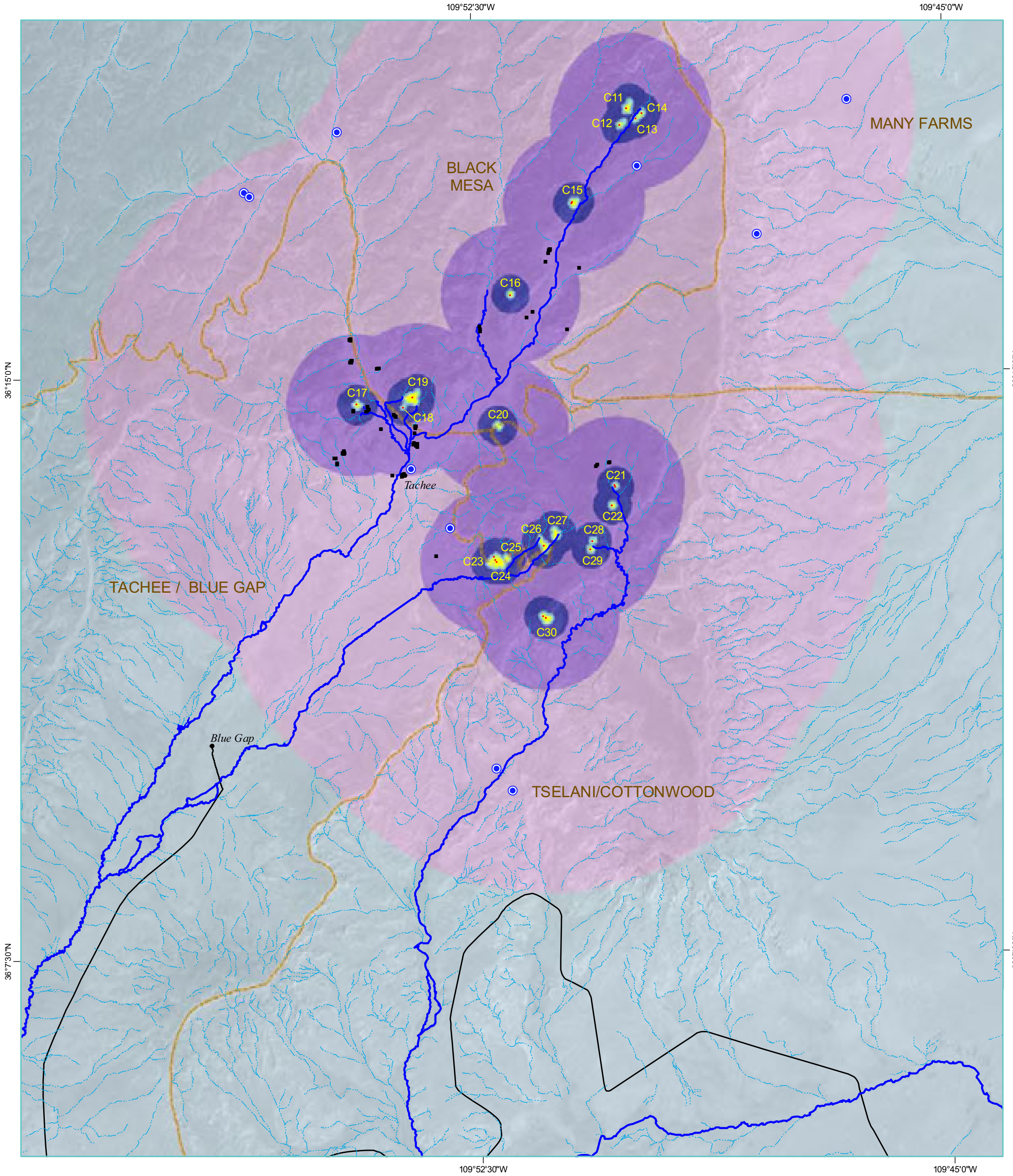
Map Scale 1:95,000

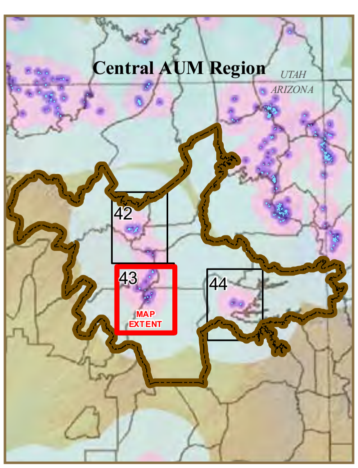
Legend

- C1 MAP-ID
- Mine Feature
- Structure within 1 mile
- Well within 4 milles
- Downstream Water Pathway
- Intermittent Stream
- Central AUM Region
- Chapter
- Paved Road
- Abandoned Uranium Mine

Mine Buffers
- 200 Feet
- 1/4 Mile
- 1 Mile
- 4 Miles
- 15 Miles

Figure 42. Combined Pathways in the Rough Rock Area.





ABANDONED URANIUM MINES AND THE NAVAJO NATION
Navajo Nation AUM Screening Assessment Report

COMBINED PATHWAYS - TACHEE

N
W E
S

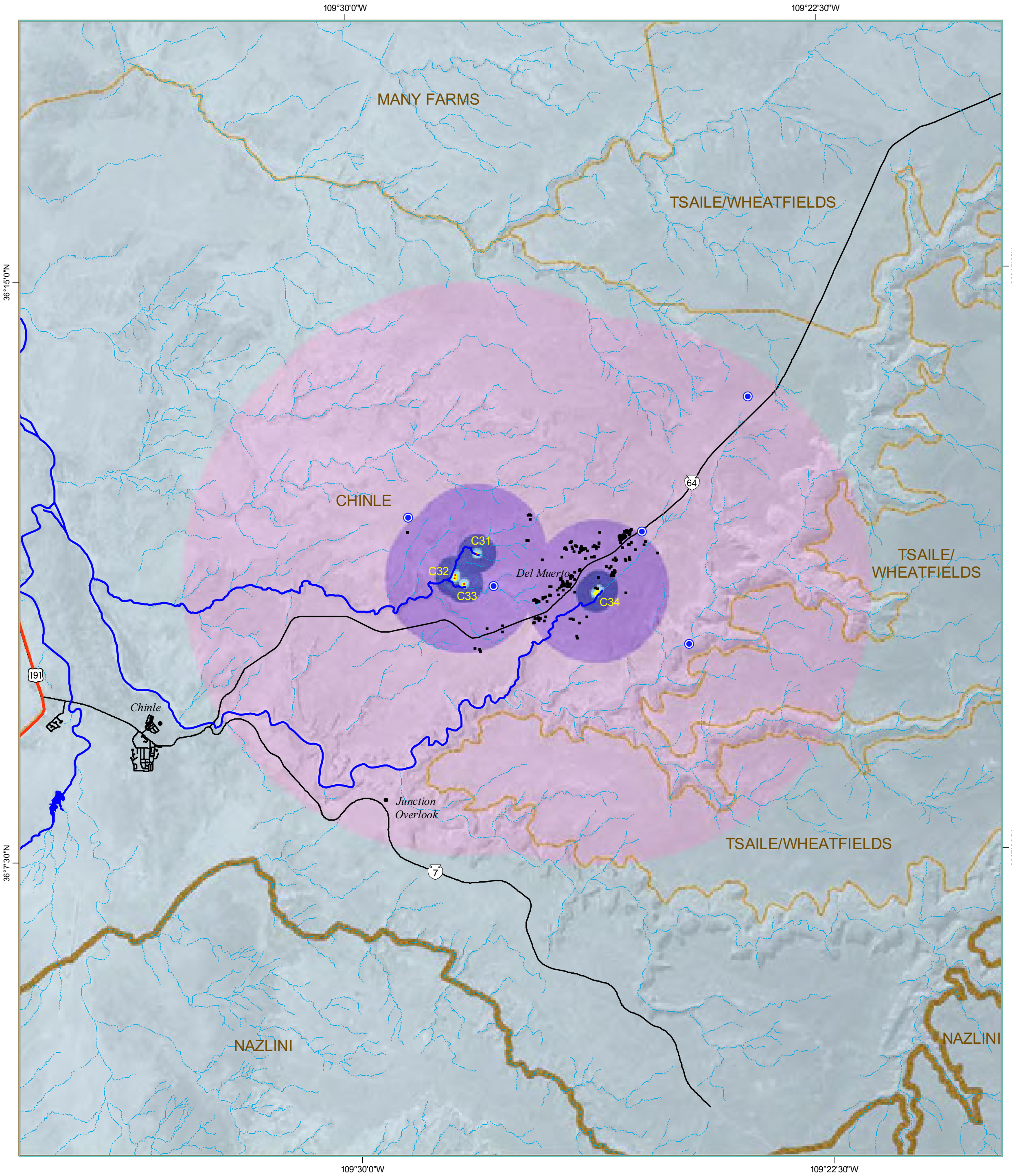
0 4 Miles

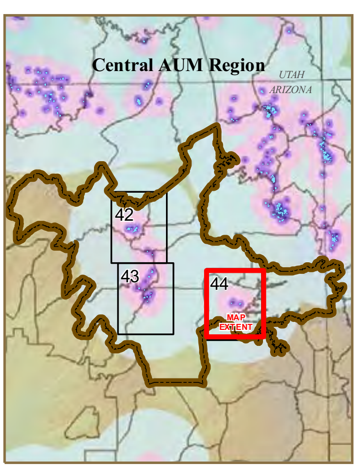
Map Scale 1:95,000

Legend

C11 MAP-ID	Downstream Water Pathway	Abandoned Uranium Mine
Mine Feature	Intermittent Stream	Mine Buffers
Structure within 1 mile	Chapter	200 Feet
Well within 4 milles	Paved Road	1/4 Mile
		1 Mile
		4 Miles
		15 Miles

Figure 43. Combined Pathways in the Tachee Area.





ABANDONED URANIUM MINES AND THE NAVAJO NATION
Navajo Nation AUM Screening Assessment Report

COMBINED PATHWAYS - CHINLE

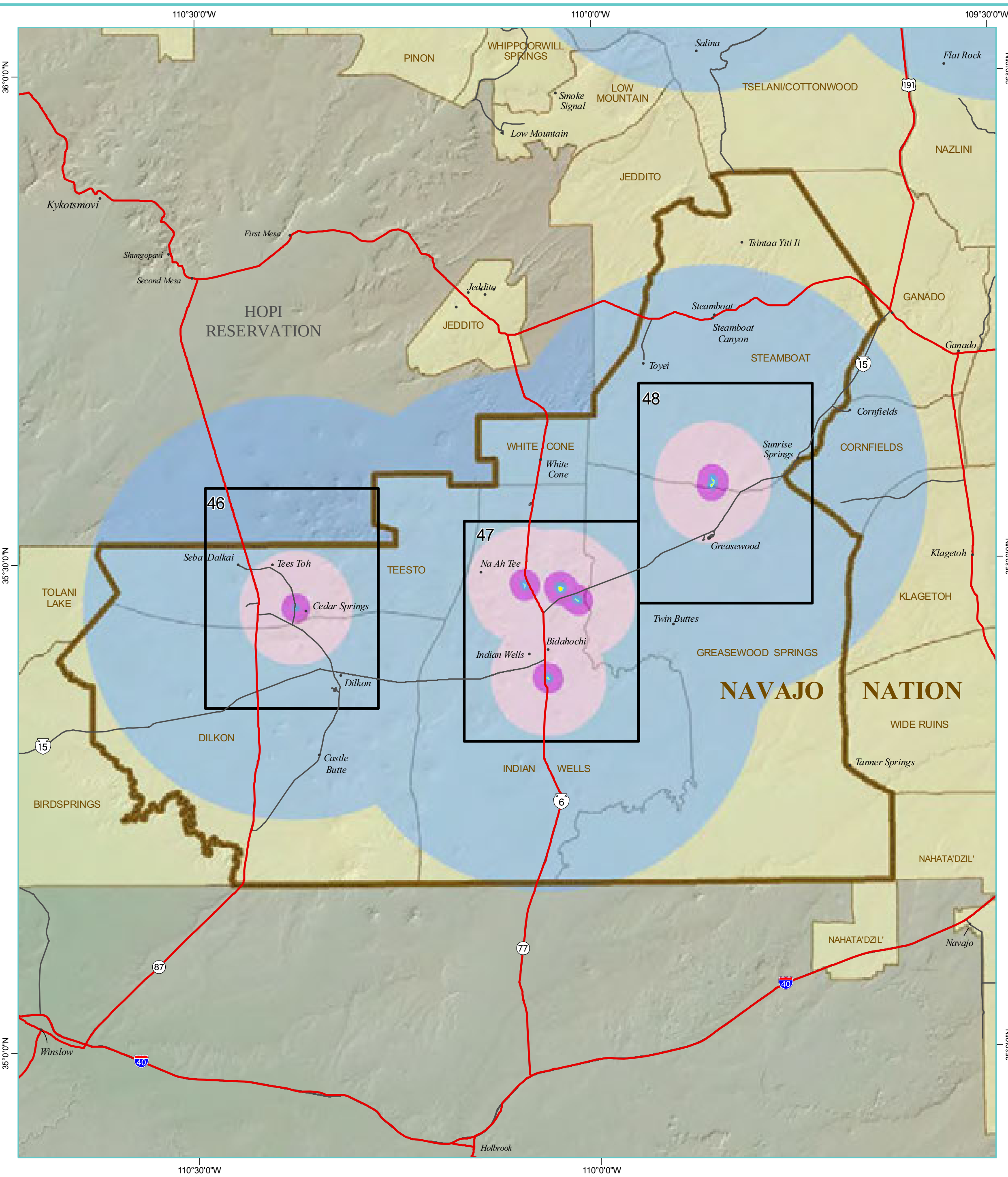
0 4 Miles

Map Scale 1:95,000

Legend

- C31 MAP-ID
- Mine Feature
- Structure within 1 mile
- Well within 4 milles
- Downstream Water Pathway
- Intermittent Stream
- Central AUM Region
- Chapter
- Paved Road
- Abandoned Uranium Mine
- Mine Buffers
  - 200 Feet
  - 1/4 Mile
  - 1 Mile
  - 4 Miles
  - 15 Miles

Figure 44. Combined Pathways in the Chinle Area.



ABANDONED URANIUM MINES AND THE NAVAJO NATION

Navajo Nation AUM Screening Assessment Report

SOUTHERN AUM REGION COMBINED PATHWAYS - MAP FIGURE INDEX

Sources

Abandoned uranium mine areas are primarily from the Navajo Abandoned Mine Lands Reclamation Program (NAMLRP) and augmented by other sources. The Navajo Nation and Chapter boundaries are from the Navajo Land Department. Hydrographic data for streams are from the U.S. Geological Survey (USGS) National Hydrographic Dataset. Buffers were generated by TerraSpectra Geomatics. Map index figure boundaries are approximate.

Map Index Region Designations

Figure
- 46 - Cedar Springs
- 47 - Bidahochi
- 48 - Greasewood

N W E S

0 10 Miles

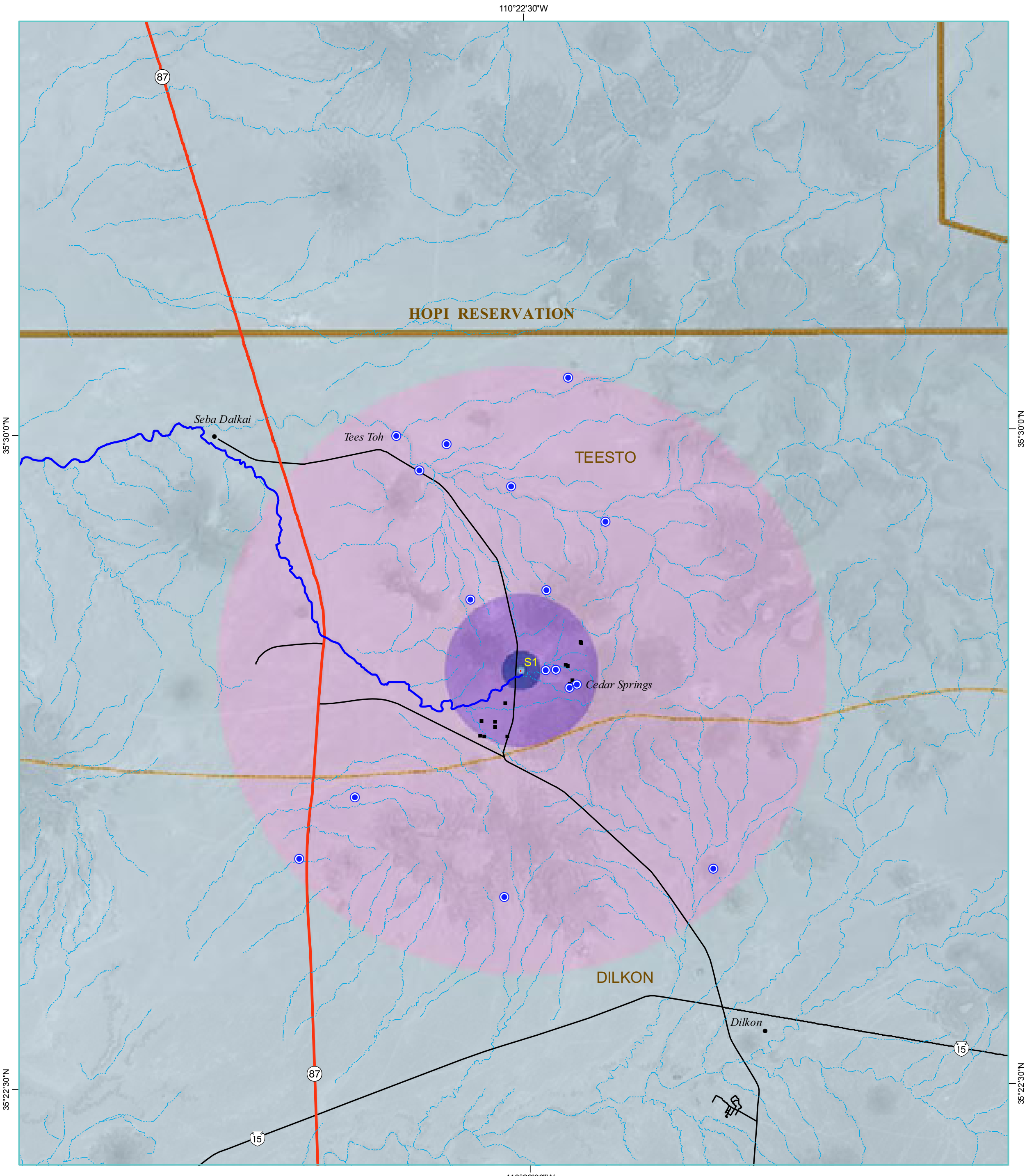
Map Scale 1:450,000

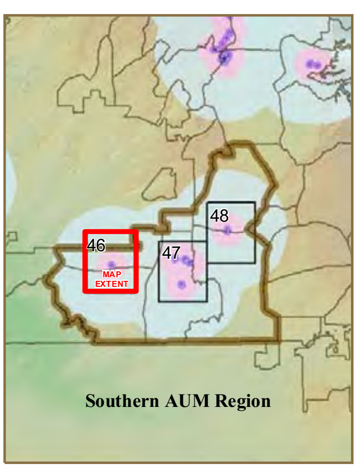
Legend

- Southern AUM Region
- Abandoned Uranium Mine
- Chapter
- Highways
- Paved Roads
- Populated Places

Mine Buffers
- 1/4 Mile
- 1 Mile
- 4 Miles
- 15 Miles

Figure 45. Southern AUM Region Combined Pathways Map Figure Index.





ABANDONED URANIUM MINES AND THE NAVAJO NATION
Navajo Nation AUM Screening Assessment Report

COMBINED PATHWAYS - CEDAR SPRINGS

N
W E
S

0 4 Miles

Map Scale 1:85,000

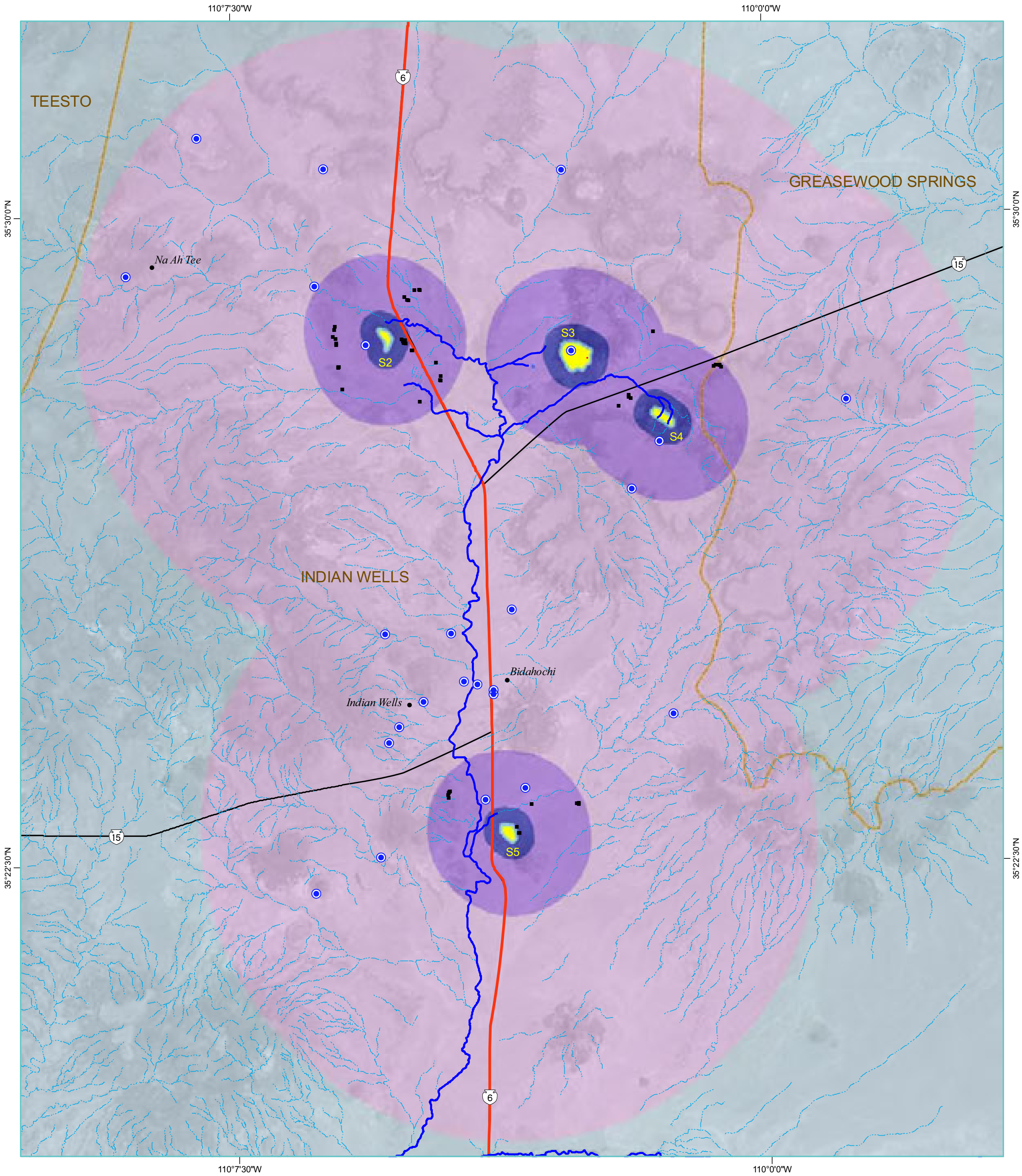
Legend

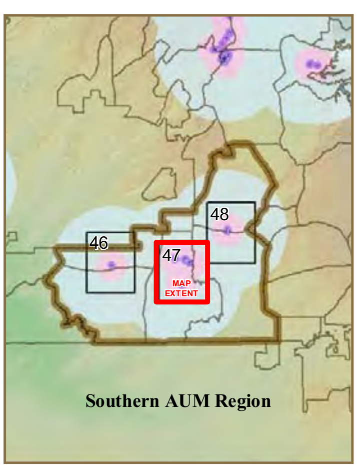
S1 MAP-ID
Mine Feature
Structure within 1 mile
Well within 4 milles

Downstream Water Pathway
Intermittent Stream
Southern AUM Region
Chapter
Highway
Paved Road

Abandoned Uranium Mine
Mine Buffers
200 Feet
1/4 Mile
1 Mile
4 Miles
15 Miles

Figure 46. Combined Pathways in the Cedar Springs Area.





ABANDONED URANIUM MINES AND THE NAVAJO NATION
Navajo Nation AUM Screening Assessment Report

COMBINED PATHWAYS - BIDAHOCHI

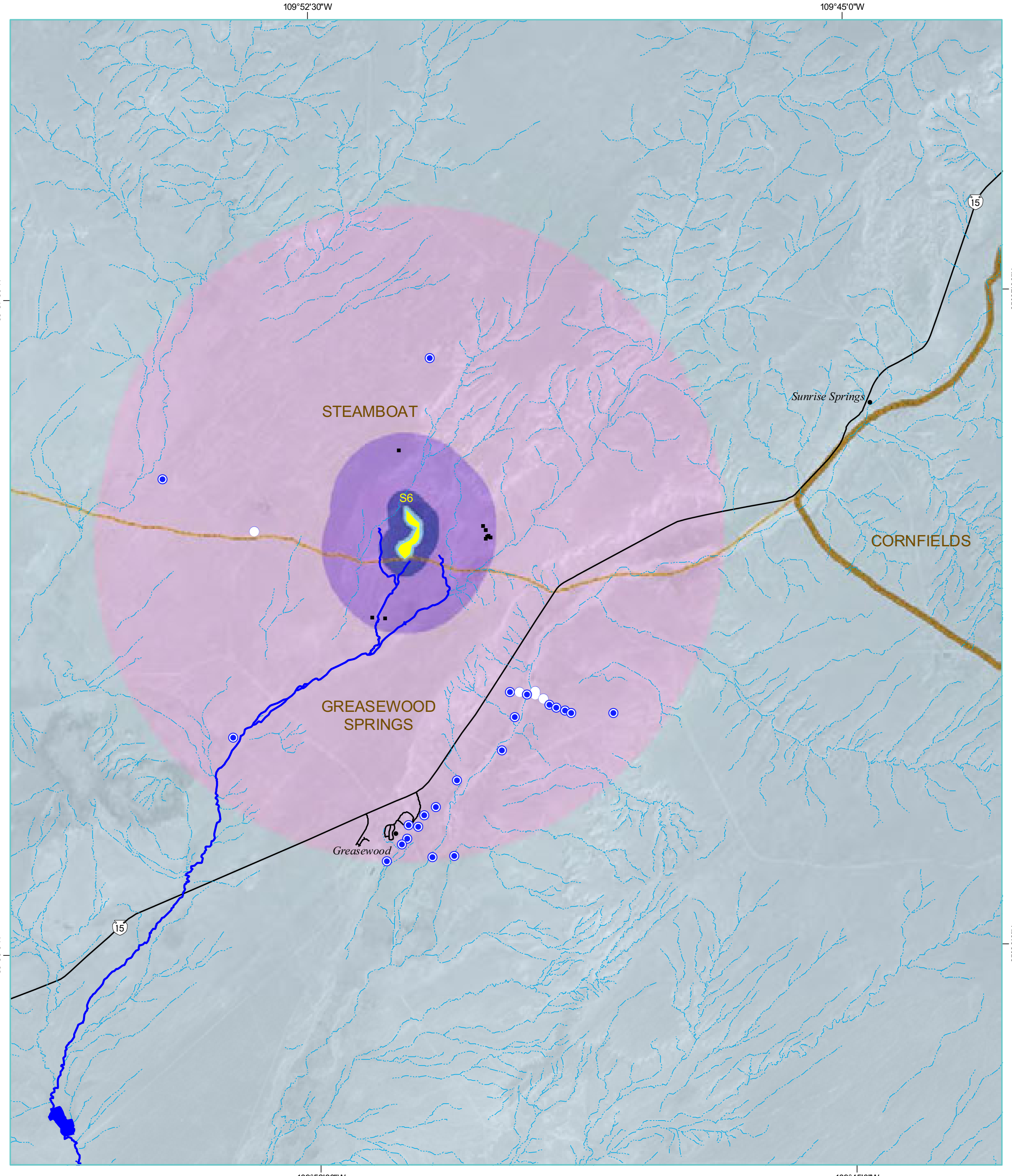
0 — 4 Miles

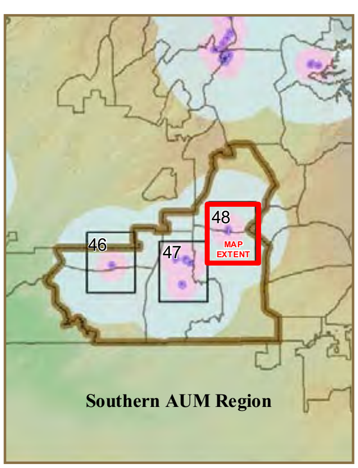
Map Scale 1:85,000

Legend

- S2 MAP-ID
- Mine Feature
- Structure within 1 mile
- Well within 4 milles
- Downstream Water Pathway
- Intermittent Stream
- Chapter
- Highway
- Paved Road
- Abandoned Uranium Mine
- Mine Buffers
  - 200 Feet
  - 1/4 Mile
  - 1 Mile
  - 4 Miles
  - 15 Miles

Figure 47. Combined Pathways in the Bidahochi Area.





ABANDONED URANIUM MINES AND THE NAVAJO NATION
Navajo Nation AUM Screening Assessment Report

COMBINED PATHWAYS - GREASEWOOD

0 4 Miles

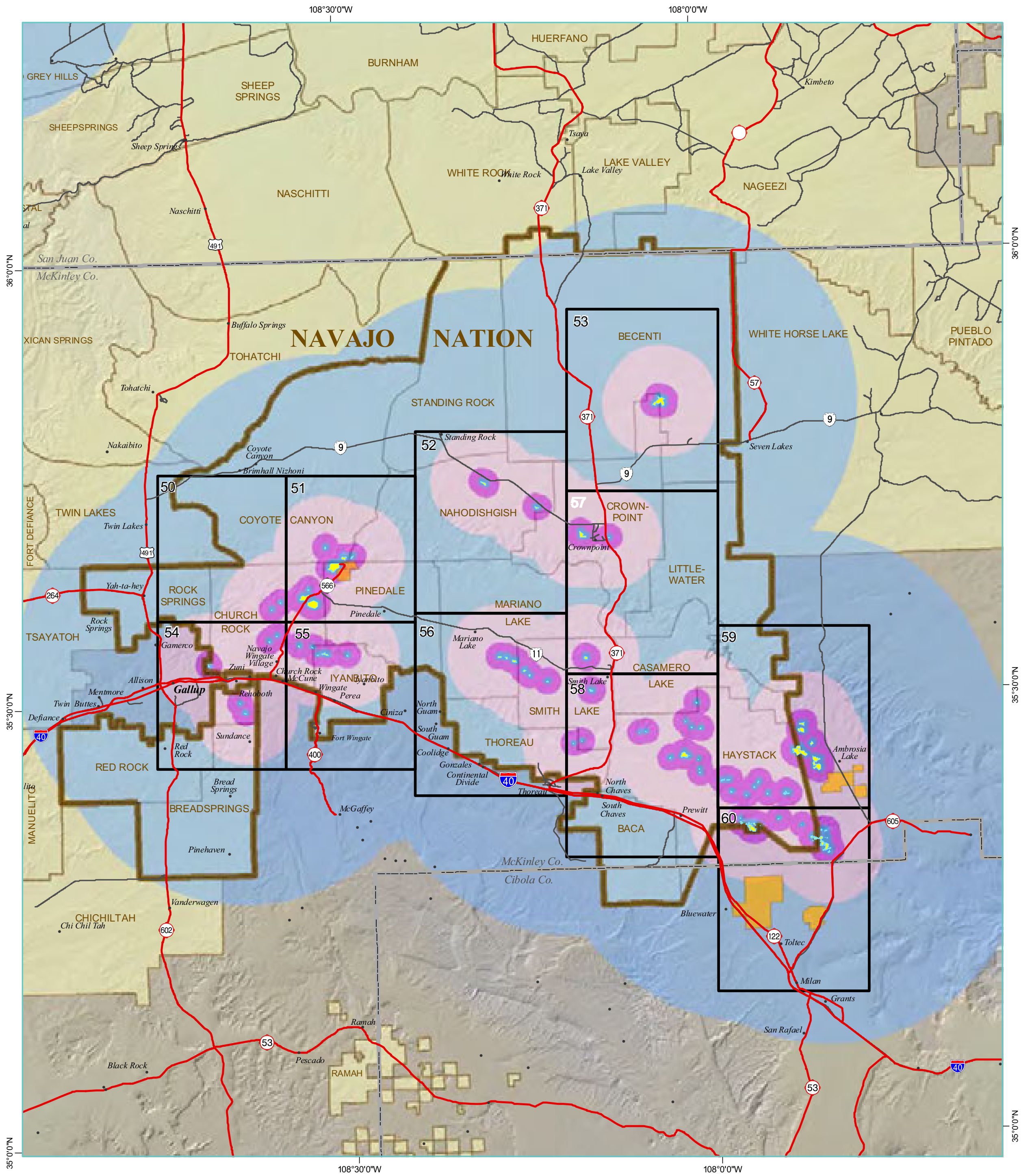
Map Scale 1:85,000

Legend

- S6 MAP-ID
- Mine Feature
- Structure within 1 mile
- Well within 4 milles
- Downstream Water Pathway
- Intermittent Stream
- Southern AUM Region
- Chapter
- Paved Road
- Abandoned Uranium Mine

Mine Buffers
- 200 Feet
- 1/4 Mile
- 1 Mile
- 4 Miles
- 15 Miles

Figure 48. Combined Pathways in the Greasewood Area.



ABANDONED URANIUM MINES AND THE NAVAJO NATION

Navajo Nation AUM Screening Assessment Report

EASTERN AUM REGION COMBINED PATHWAYS - MAP FIGURE INDEX

Sources

Abandoned uranium mine areas are from a variety of sources. The Navajo Nation and Chapter boundaries are from the Navajo Land Department. Hydrographic data for streams are from the U.S. Geological Survey (USGS) National Hydrographic Dataset. Buffers were generated by TerraSpectra Geomatics. Map index area boundaries are approximate.

Map Index Area Designations

Figure

- 50 - NW Church Rock
- 51 - NE Church Rock
- 52 - Nahodishgish
- 53 - Becenti
- 54 - Church Rock
- 55 - Iyanbito
- 56 - Mariano Lake
- 57 - Crownpoint
- 58 - Baca/Prewitt
- 59 - Ambrosia Lake
- 60 - Haystack

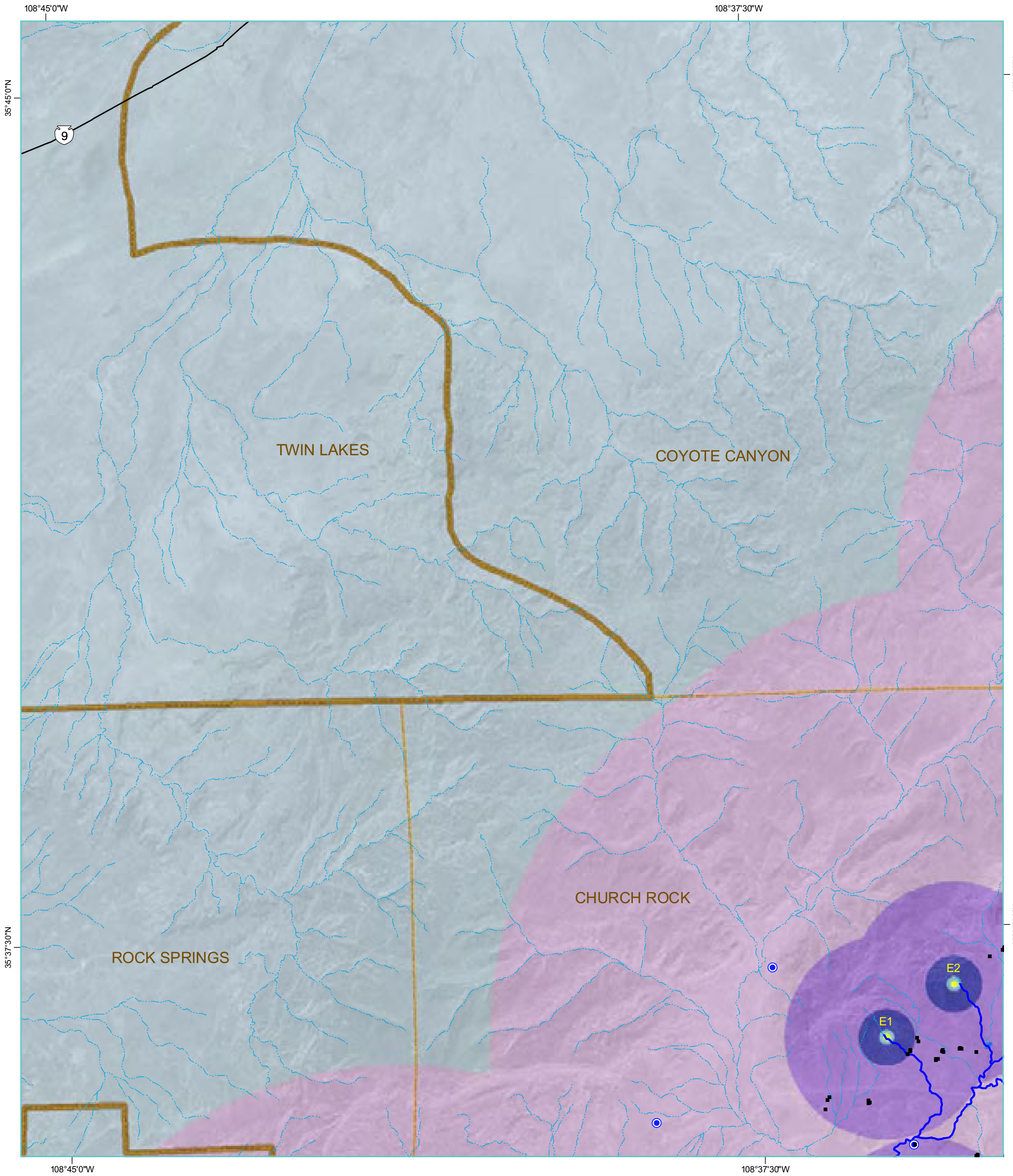
0 15 Miles

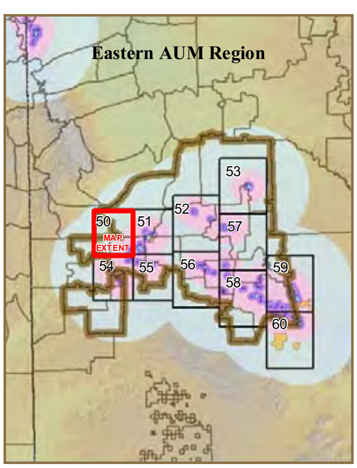
Map Scale 1:500,000

Legend

- Eastern AUM Region
- Chapter
- Highway
- Paved Road
- Populated Places
- Abandoned Uranium Mine
- Mine Buffers
  - 1/4 Mile
  - 1 Mile
  - 4 Miles
  - 15 Miles
- Uranium Mill/ Reclamation Site

Figure 49. Eastern AUM Region Combined Pathways Map Figure Index.





ABANDONED URANIUM MINES AND THE NAVAJO NATION

Navajo Nation AUM Screening Assessment Report

COMBINED PATHWAYS - NORTHWEST CHURCH ROCK

N W E S

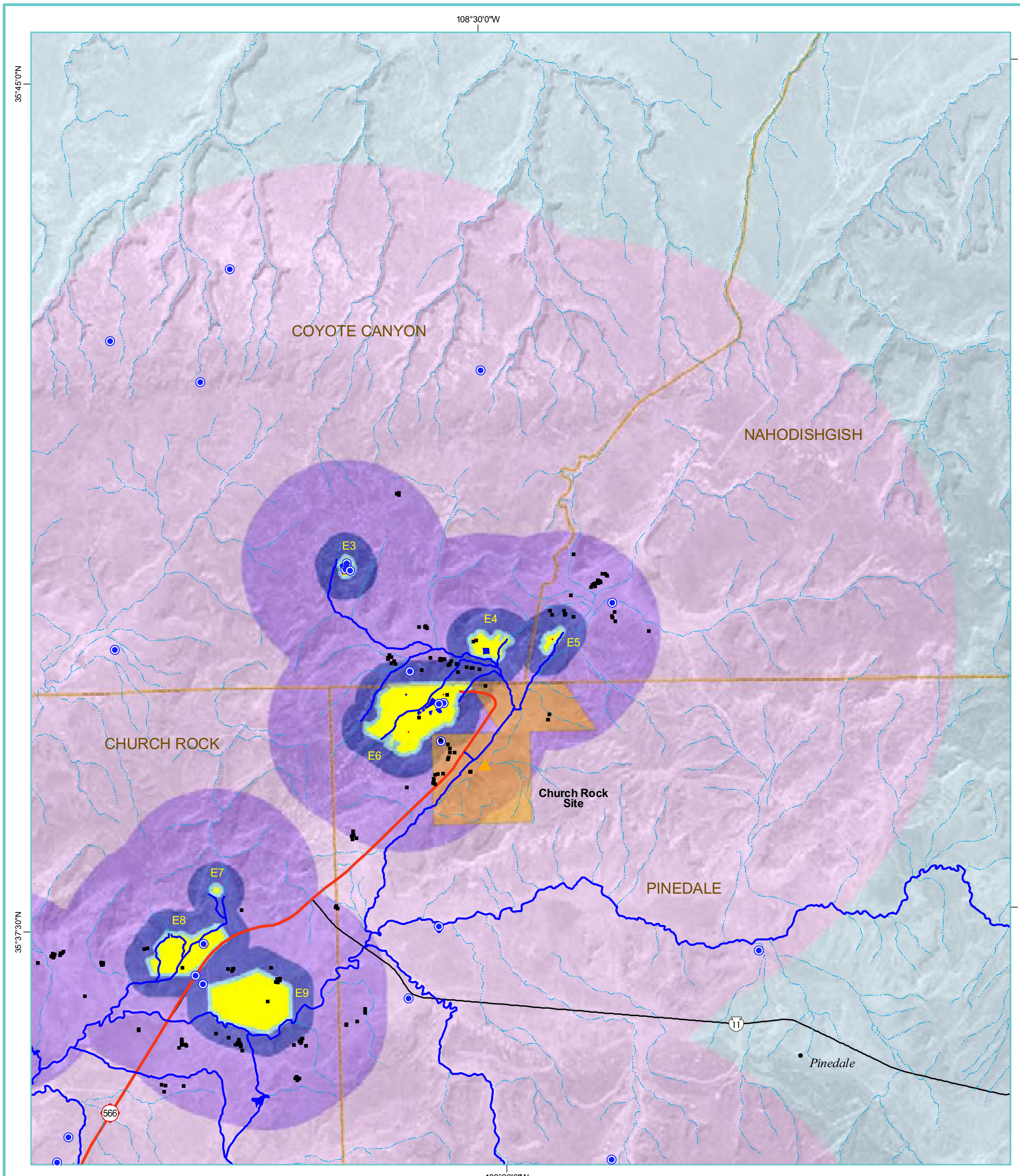
0 4 Miles

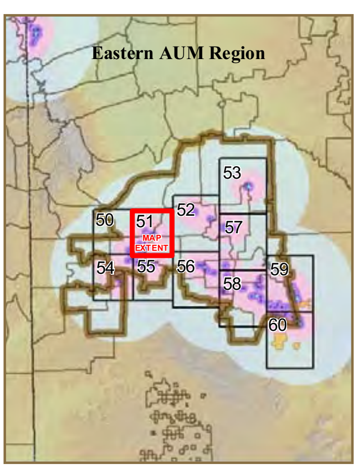
Map Scale 1:65,000

Legend

- MAP-ID
- Structure within 1 mile
- Well within 4 miles
- Downstream Water Pathway
- Intermittent Stream
- Eastern AUM Region
- Chapter
- Paved Road
- Abandoned Uranium Mine
- Mine Buffers
- 200 Feet
- 1/4 Mile
- 1 Mile
- 4 Miles
- 15 Miles

Figure 50. Combined Pathways in the Northwest Church Rock Area.





ABANDONED URANIUM MINES AND THE NAVAJO NATION

Navajo Nation AUM Screening Assessment Report

COMBINED PATHWAYS - NORTHEAST CHURCH ROCK

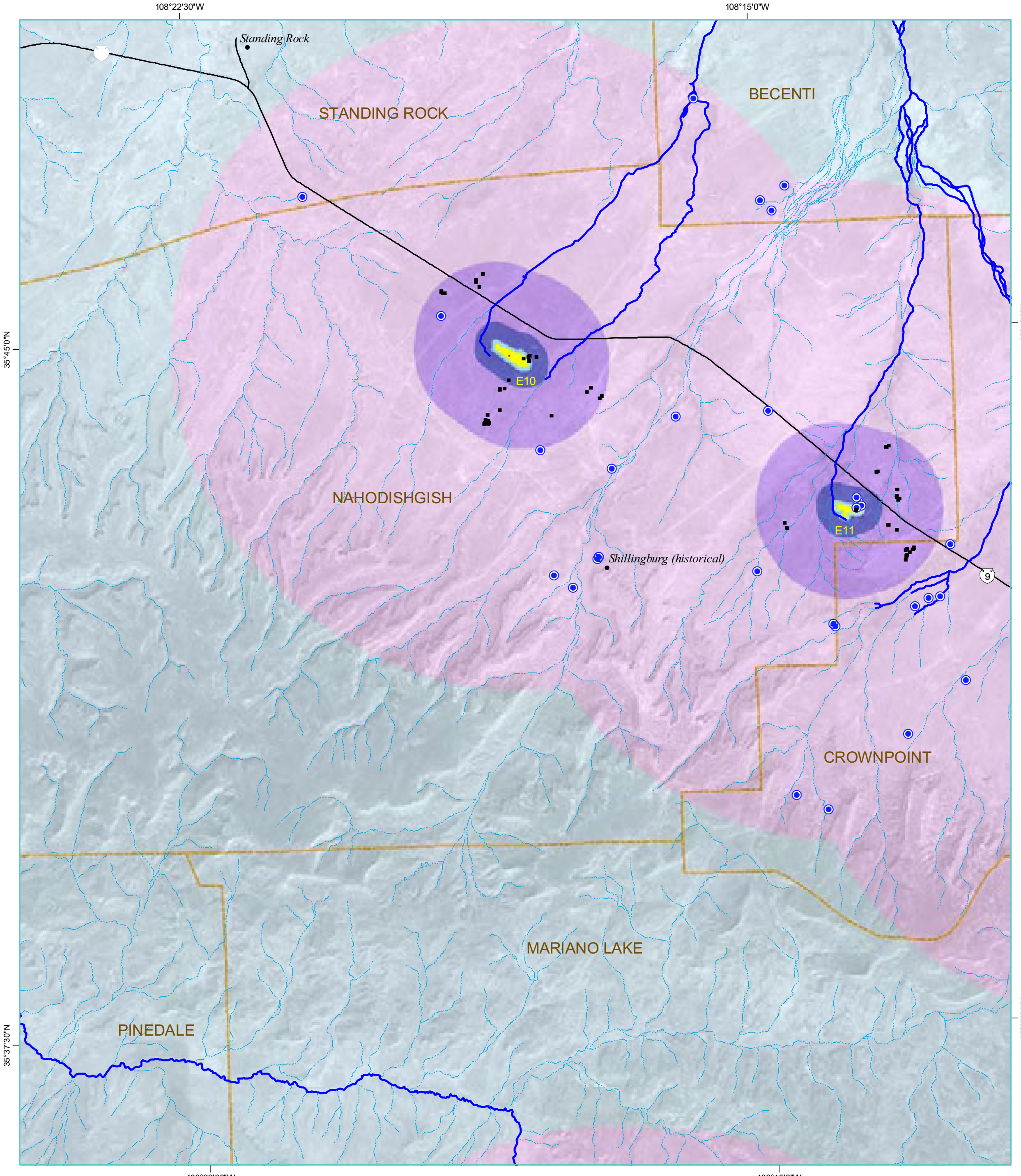
0 4 Miles

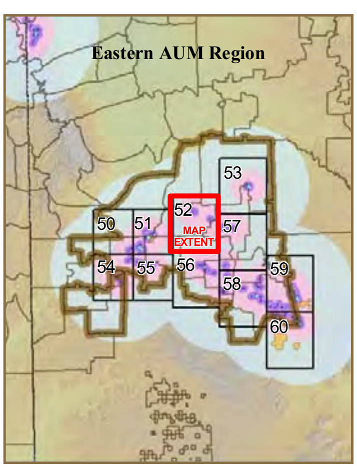
Map Scale 1:65,000

Legend

- MAP-ID
- Mine Feature
- Structure within 1 mile
- Well within 4 miles
- Downstream Water Pathway
- Intermittent Stream
- Chapter
- Highway
- Paved Road
- Abandoned Uranium Mine
- Mine Buffers
- 200 Feet
- 1/4 Mile
- 1 Mile
- 4 Miles
- 15 Miles
- Uranium Mill/ Reclamation Site

Figure 51. Combined Pathways in the Northeast Church Rock Area.





ABANDONED URANIUM MINES AND THE NAVAJO NATION
Navajo Nation AUM Screening Assessment Report

COMBINED PATHWAYS - NAHODISHGISH

N W E S

0 4 Miles

Map Scale 1:80,000

Legend

E10 MAP-ID*
Mine Feature
Structure within 1 mile
Well within 4 miles

* MAP-IDs E12-E15 deleted

Downstream Water Pathway
Intermittent Stream
Chapter
Paved Road

Abandoned Uranium Mine
Mine Buffers
200 Feet
1/4 Mile
1 Mile
4 Miles
15 Miles

Figure 52. Combined Pathways in the Nahodishgish Area.

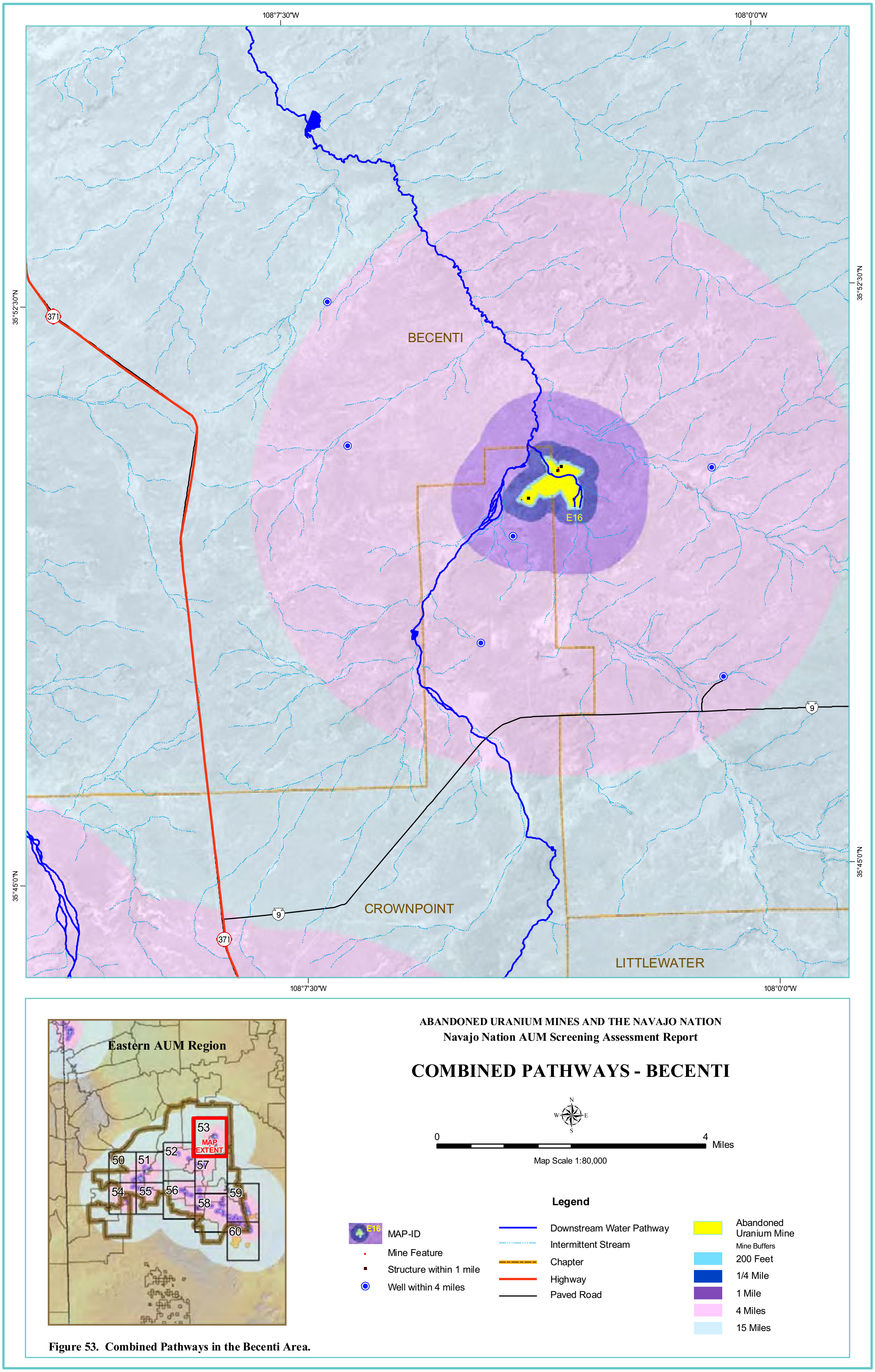
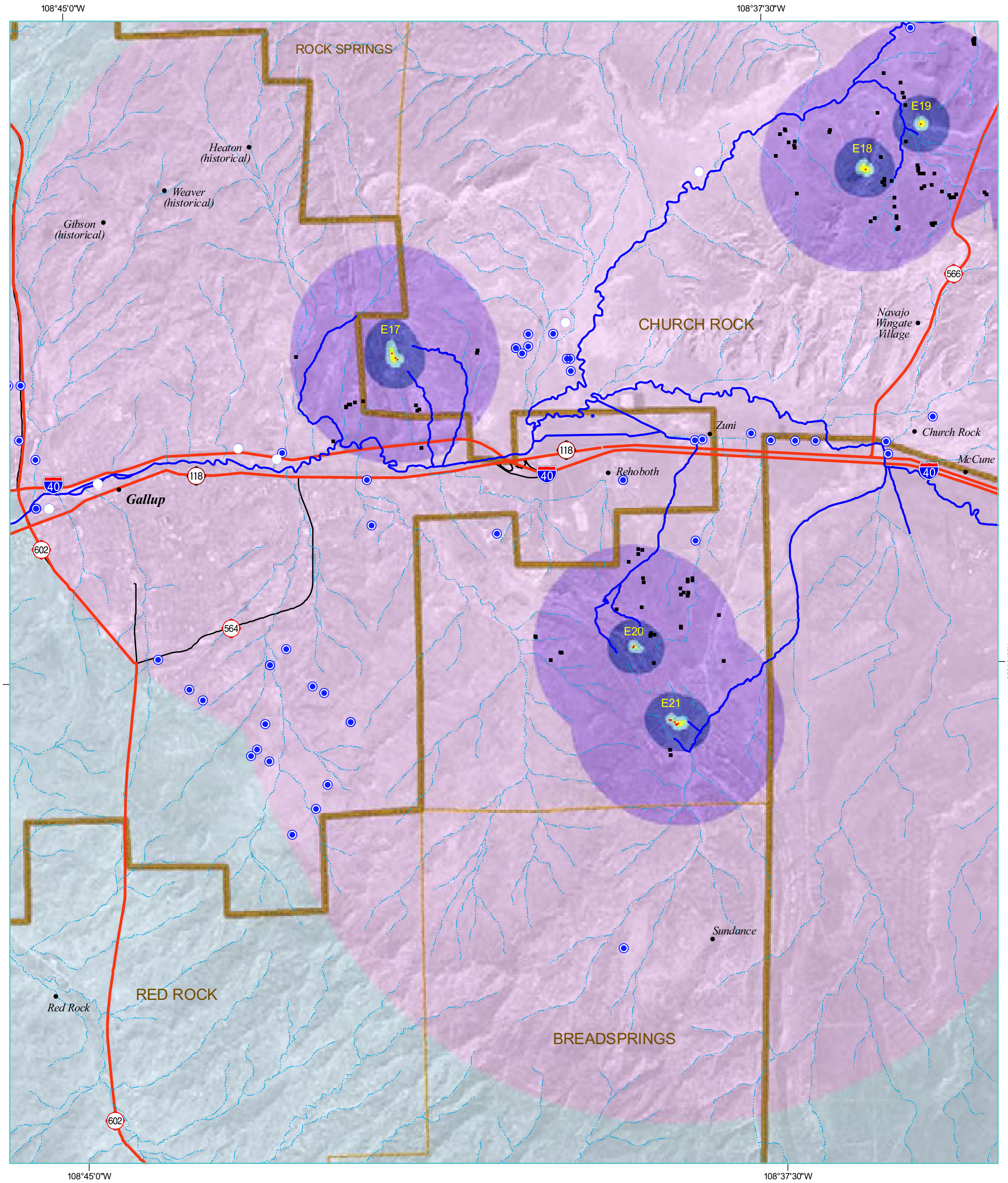
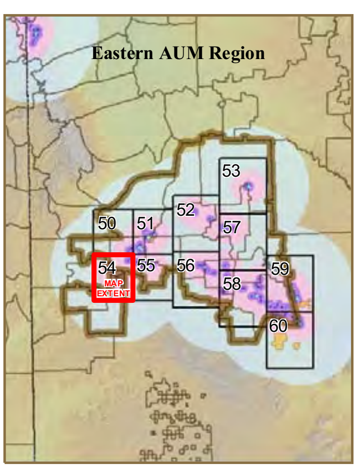


Figure 53. Combined Pathways in the Becenti Area.





ABANDONED URANIUM MINES AND THE NAVAJO NATION

Navajo Nation AUM Screening Assessment Report

COMBINED PATHWAYS - CHURCH ROCK

0 — 4 Miles

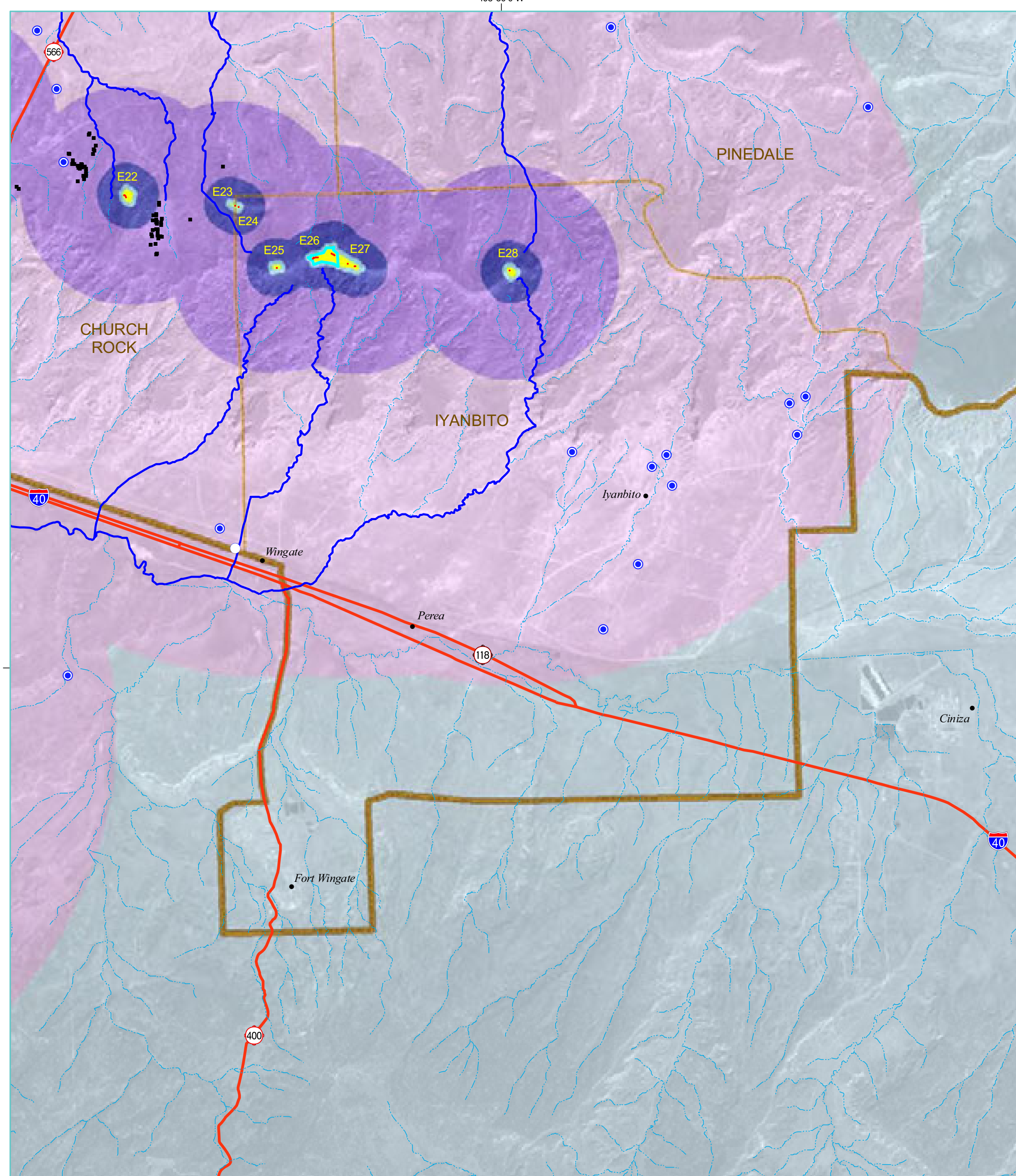
Map Scale 1:65,000

Legend

MAP-ID	Downstream Water Pathway	Abandoned Uranium Mine
Mine Feature	Intermittent Stream	Mine Buffers
Structure within 1 mile	Eastern AUM Region	200 Feet
Well within 4 miles	Chapter	1/4 Mile
	Highway	1 Mile
	Paved Road	4 Miles
		15 Miles

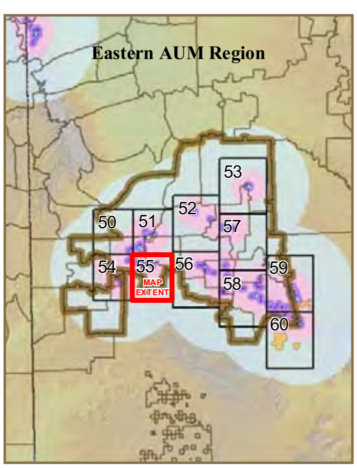
Figure 54. Combined Pathways in the Church Rock Area.

108°30'0"W



35°30'0"N

108°30'0"W



ABANDONED URANIUM MINES AND THE NAVAJO NATION

Navajo Nation AUM Screening Assessment Report

COMBINED PATHWAYS - IYANBITO

N W E S

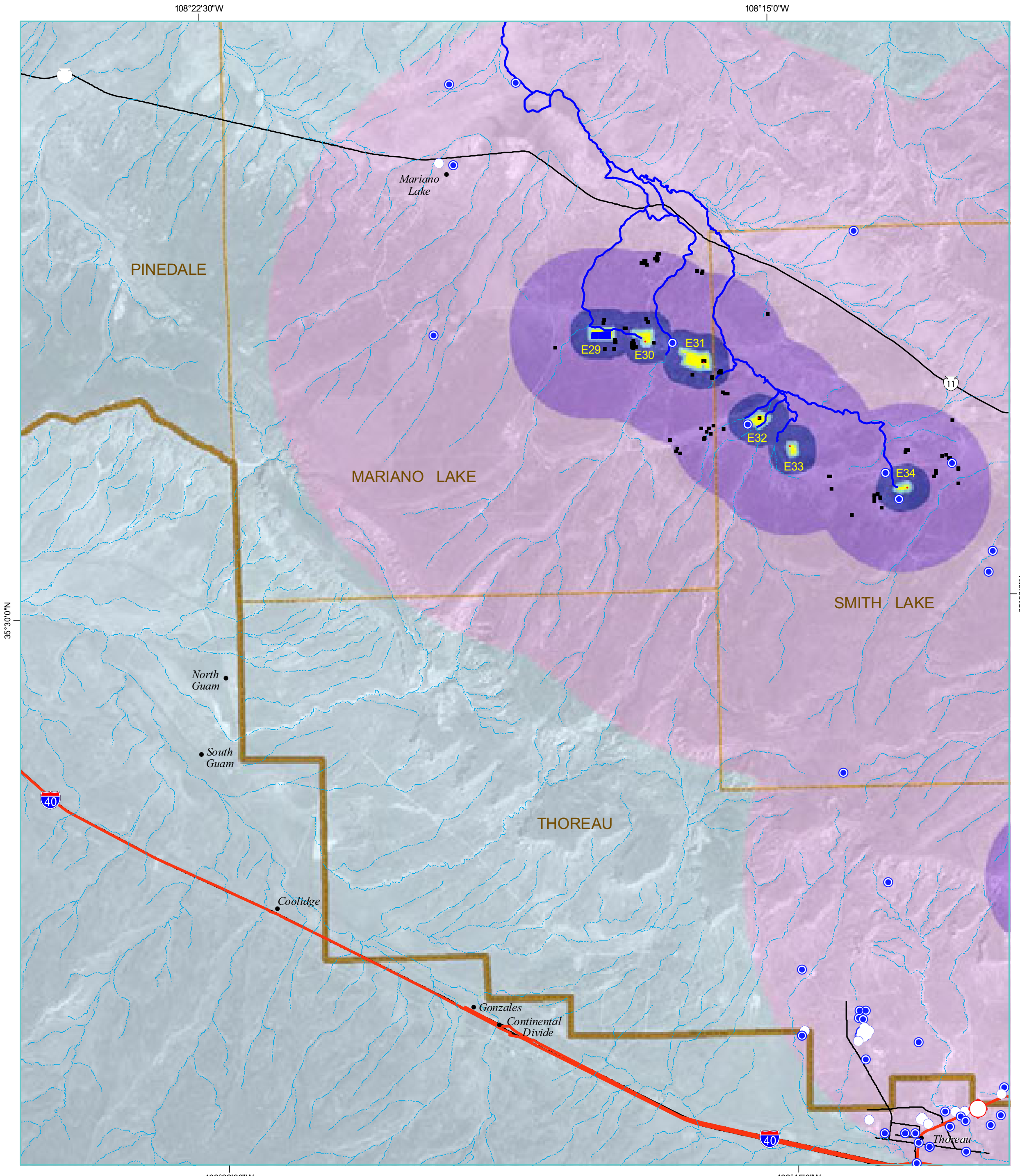
0 4 Miles

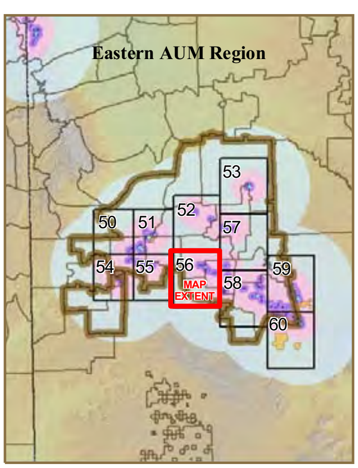
Map Scale 1:65,000

Legend

Symbol	Description
E22	MAP-ID
	Mine Feature
	Structure within 1 mile
	Well within 4 miles
	Downstream Water Pathway
	Intermittent Stream
	Eastern AUM Region
	Chapter
	Highway
	Abandoned Uranium Mine
	Mine Buffers
	200 Feet
	1/4 Mile
	1 Mile
	4 Miles
	15 Miles

Figure 55. Combined Pathways in the Iyanbito Area.





ABANDONED URANIUM MINES AND THE NAVAJO NATION
Navajo Nation AUM Screening Assessment Report

COMBINED PATHWAYS - MARIANO LAKE

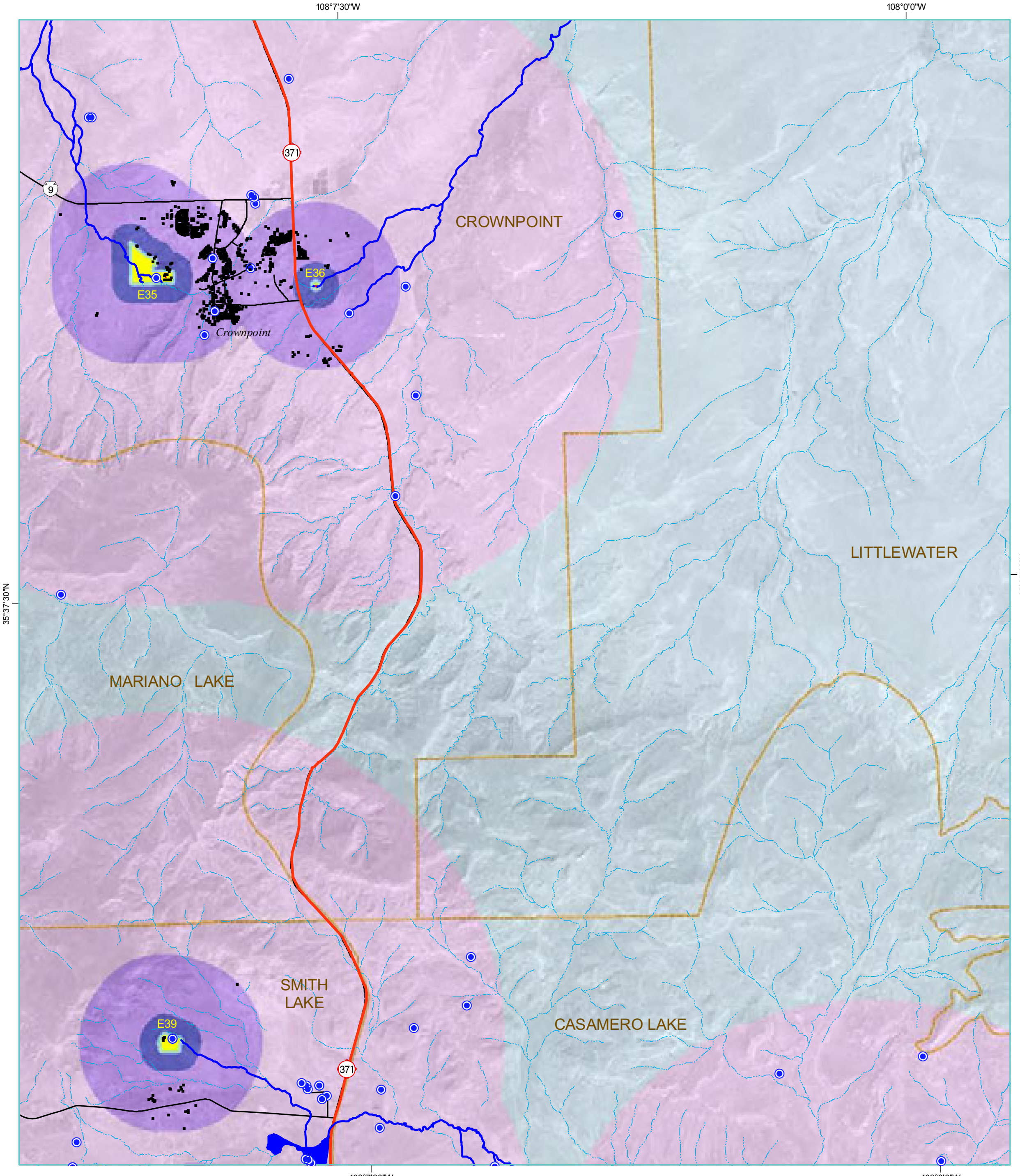
0 — 4 Miles

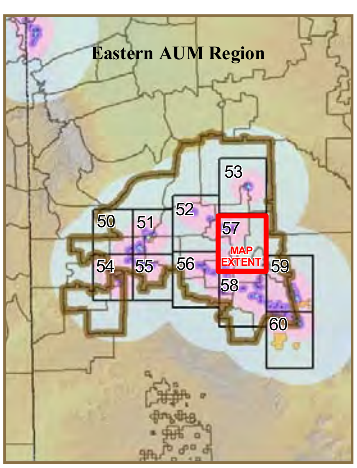
Map Scale 1:80,000

Legend

- MAP-ID
- Mine Feature
- Structure within 1 mile
- Well within 4 miles
- Downstream Water Pathway
- Intermittent Stream
- Eastern AUM Region
- Chapter
- Highway
- Paved Road
- Abandoned Uranium Mine
- Mine Buffers
  - 200 Feet
  - 1/4 Mile
  - 1 Mile
  - 4 Miles
  - 15 Miles

Figure 56. Combined Pathways in the Mariano Lake Area.





ABANDONED URANIUM MINES AND THE NAVAJO NATION

Navajo Nation AUM Screening Assessment Report

COMBINED PATHWAYS - CROWNPOINT

0 4 Miles

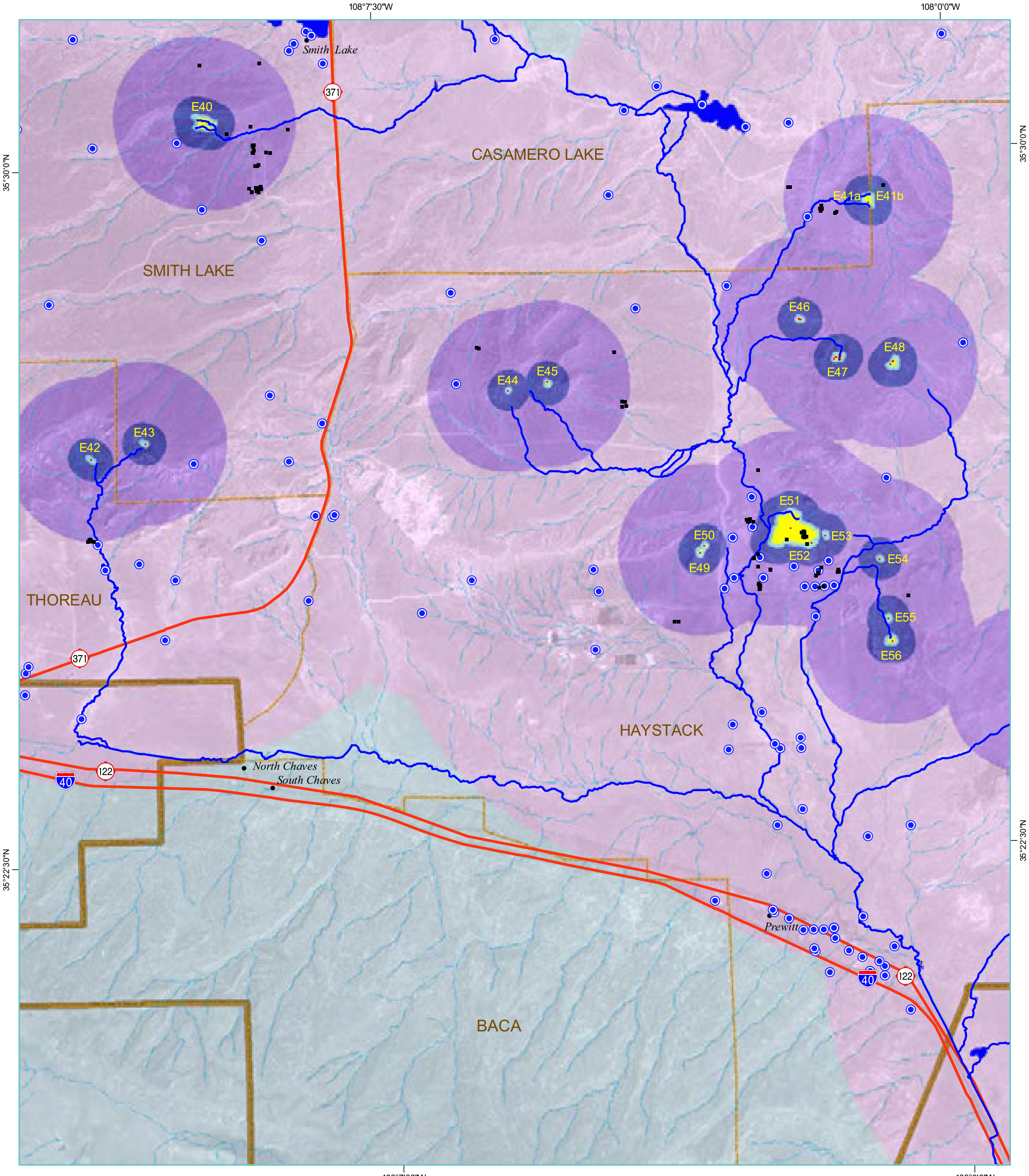
Map Scale 1:80,000

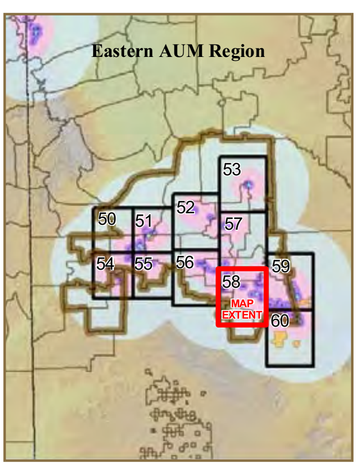
Legend

- E35 MAP-ID*
- Mine Feature
- Structure within 1 mile
- Well within 4 miles
- Downstream Water Pathway
- Intermittent Stream
- Chapter
- Highway
- Paved Road
- Abandoned Uranium Mine
- Mine Buffers
  - 200 Feet
  - 1/4 Mile
  - 1 Mile
  - 4 Miles
  - 15 Miles

*MAP-IDs E37-E38 deleted

Figure 57. Combined Pathways in the Crownpoint Area.





ABANDONED URANIUM MINES AND THE NAVAJO NATION
Navajo Nation AUM Screening Assessment Report

COMBINED PATHWAYS - WESTERN HAYSTACK

N W E S

0 4 Miles

Map Scale 1:80,000

Legend

E40 MAP-ID*

Mine Feature

Structure within 1 mile

Well within 4 miles

Downstream Water Pathway

Intermittent Stream

Eastern AUM Region

Chapter

Highway

Abandoned Uranium Mine

Mine Buffers

200 Feet

1/4 Mile

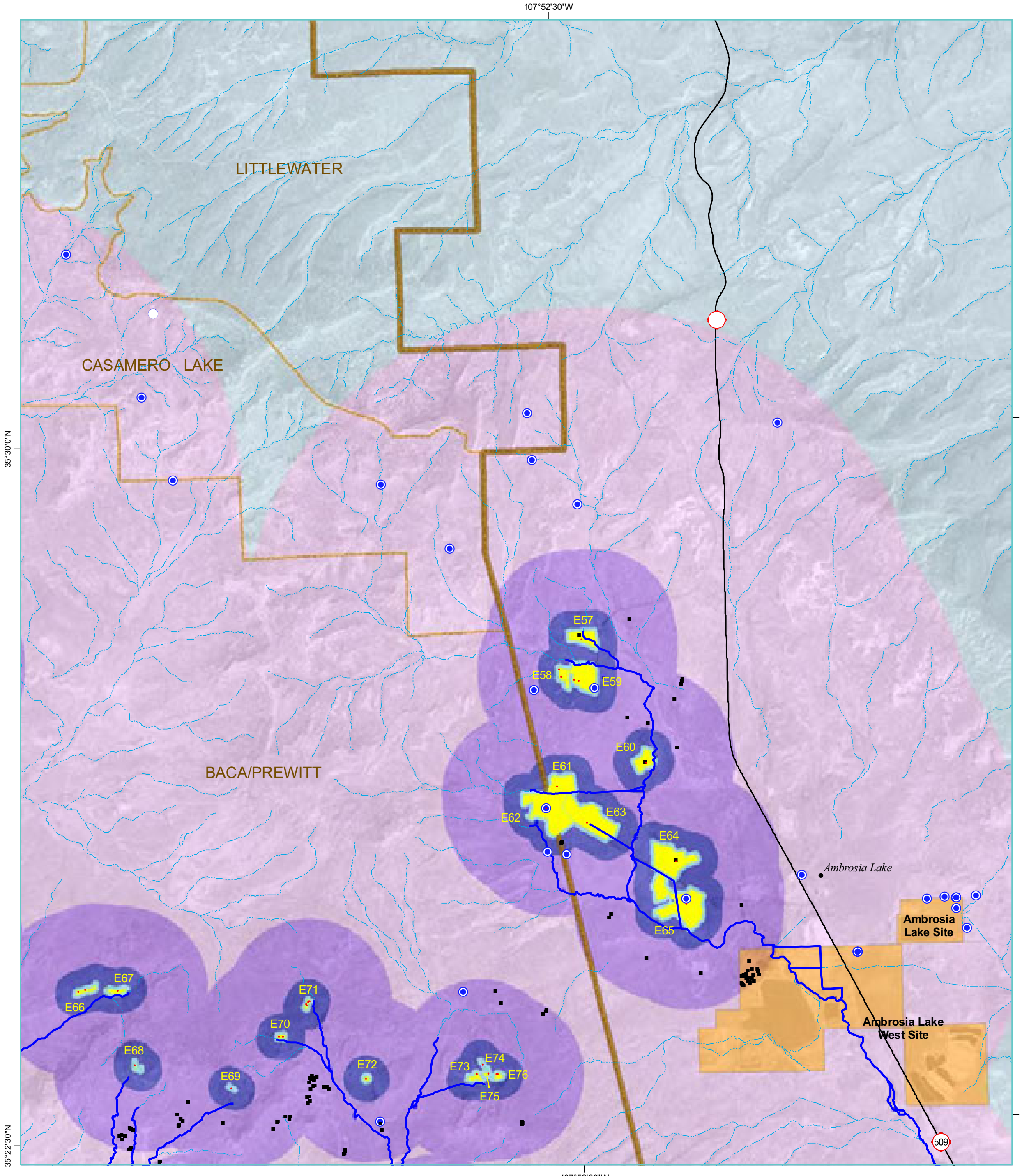
1 Mile

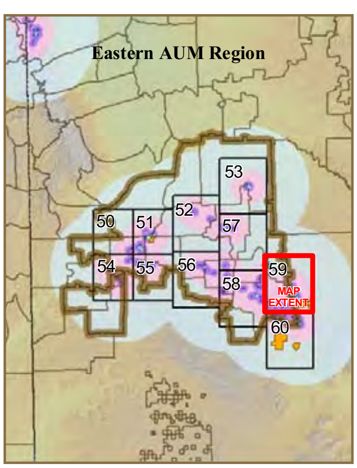
4 Miles

15 Miles

*MAP-ID E41 divided into E41a and E41b

Figure 58. Combined Pathways in the Western Haystack Area.





ABANDONED URANIUM MINES AND THE NAVAJO NATION
Navajo Nation AUM Screening Assessment Report

COMBINED PATHWAYS - AMBROSIA LAKE

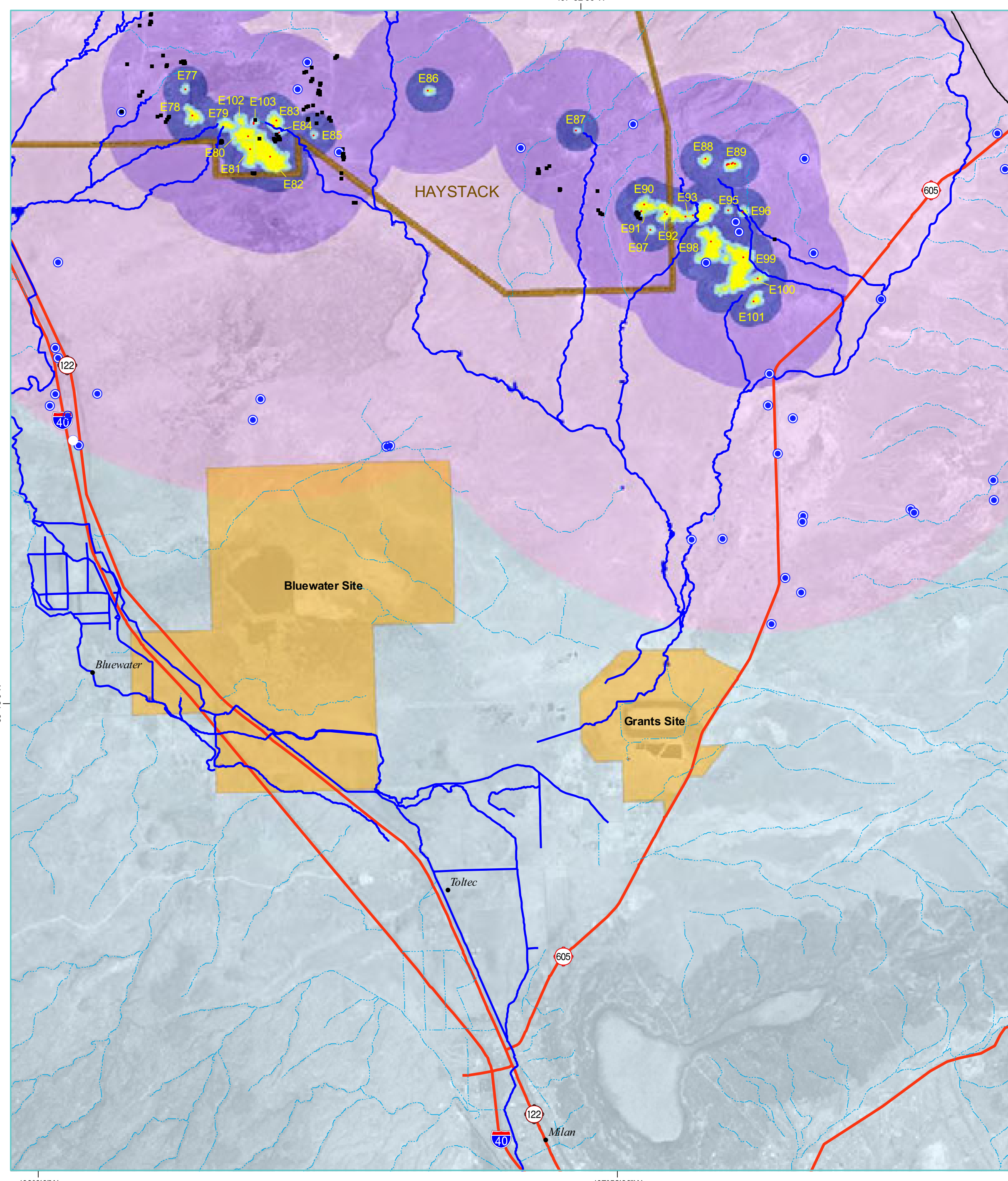
0 4 Miles

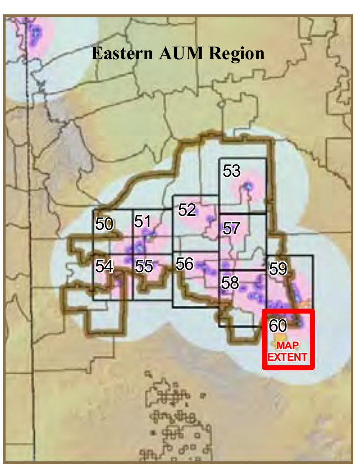
Map Scale 1:80,000

Legend

MAP-ID	Downstream Water Pathway	Abandoned Uranium Mine
Mine Feature	Intermittent Stream	Mine Buffers
Structure within 1 mile	Eastern AUM Region	200 Feet
Well within 4 miles	Chapter	1/4 Mile
	Paved Road	1 Mile
		4 Miles
		15 Miles
		Uranium Mill/ Reclamation Site

Figure 59. Combined Pathways in the Ambrosia Lake Area.





ABANDONED URANIUM MINES AND THE NAVAJO NATION
Navajo Nation AUM Screening Assessment Report

COMBINED PATHWAYS - HAYSTACK

0 — 4 Miles

Map Scale 1:80,000

Legend

- MAP-ID (E77)
- Mine Feature
- Structure within 1 mile
- Well within 4 miles
- Downstream Water Pathway
- Intermittent Stream
- Eastern AUM Region
- Chapter
- Highway
- Paved Road
- Abandoned Uranium Mine
- Mine Buffers
  - 200 Feet
  - 1/4 Mile
  - 1 Mile
  - 4 Miles
  - 15 Miles
- Uranium Mill/ Reclamation Site

*MAP-ID E94 deleted
MAP-IDs E102 and E103 added

Figure 60. Combined Pathways in the Haystack Area.

DISCUSSION

This DISCUSSION section is organized by the six (6) AUM Regions. As noted earlier, the results from the scoring are not intended to identify actual risks, but are meant to provide a coarse screening of priority AUM sites for further investigation. The GIS approach facilitated a consistent and documented scoring process. The GIS cartographic tools also allowed flexible visualization of the data and analysis results.

NORTH CENTRAL AUM REGION SCREENING ASSESSMENT SCORE RESULTS

Review of the North Central AUM Region Combined Pathway Scores (Table 4) and Figure 61 “North Central AUM Region Combined Pathways - Three Score Ranges” show that three of the four highest scoring AUM sites in the region occur in the Monument Valley mining area on Oljato Mesa in the Oljato Chapter (Charles Keith, Rock Door No. 1, and Norcross). These three (3) AUMs have been reclaimed by NAMLRP. The fourth highest scoring site is located about one (1) mile north of the Mexican Hat bridge on Highway 163 and is off the Navajo Nation. This AUM-related site was a uranium ore transfer location.

Since the primary HRS criteria are counts of structures and wells at specified distances from the AUMs, areas with high occurrences of homes and wells proximal to the AUM sites scored high. The two highest scoring mines in the North Central AUM Region, Charles Keith mine (MAP-ID #NC15) and Rock Door No. 1 mine (MAP-ID #NC24) in the Oljato Chapter are examples of AUM sites that scored high (3,080 and 2,940 respectively) due to proximity of homes and wells. Conversely, remote AUM sites with sparse population and few wells score low. This can be seen in the generally low scores for the AUM sites in the western and southern Oljato, and west central Kayenta Chapters (shown in green on Figure 61).

High scoring AUMs were not necessarily high ore producers. The Rock Door No. 1 mine only had 25 tons of ore mined and produced 331 pounds of uranium and 937 pounds of vanadium (Chenoweth, 1991 - S03100502). Only 59 tons of ore were mined from the Charles Keith mine, which produced 237 pounds of uranium and 179 pounds of vanadium (Chenoweth, 1991 - S03100502). These are significantly smaller production numbers compared to the Bootjack AUM in Oljato Chapter (MAP-ID #NC48) that scored 330 but had 36,236 tons of ore mined with 331,010 pounds of uranium extracted (Chenoweth, 1993 - S10100222). The Monument No. 2 AUM (MAP-ID #NC66) in the Kayenta Chapter scored 980, but produced more uranium than any other mine in Arizona with 773,132 tons of ore mined and 5,276,093 pounds of uranium and 21,915,125 pounds of vanadium extracted (Gregg et al., 1989 - S10020208), and has an associated UMTRA cleanup site.

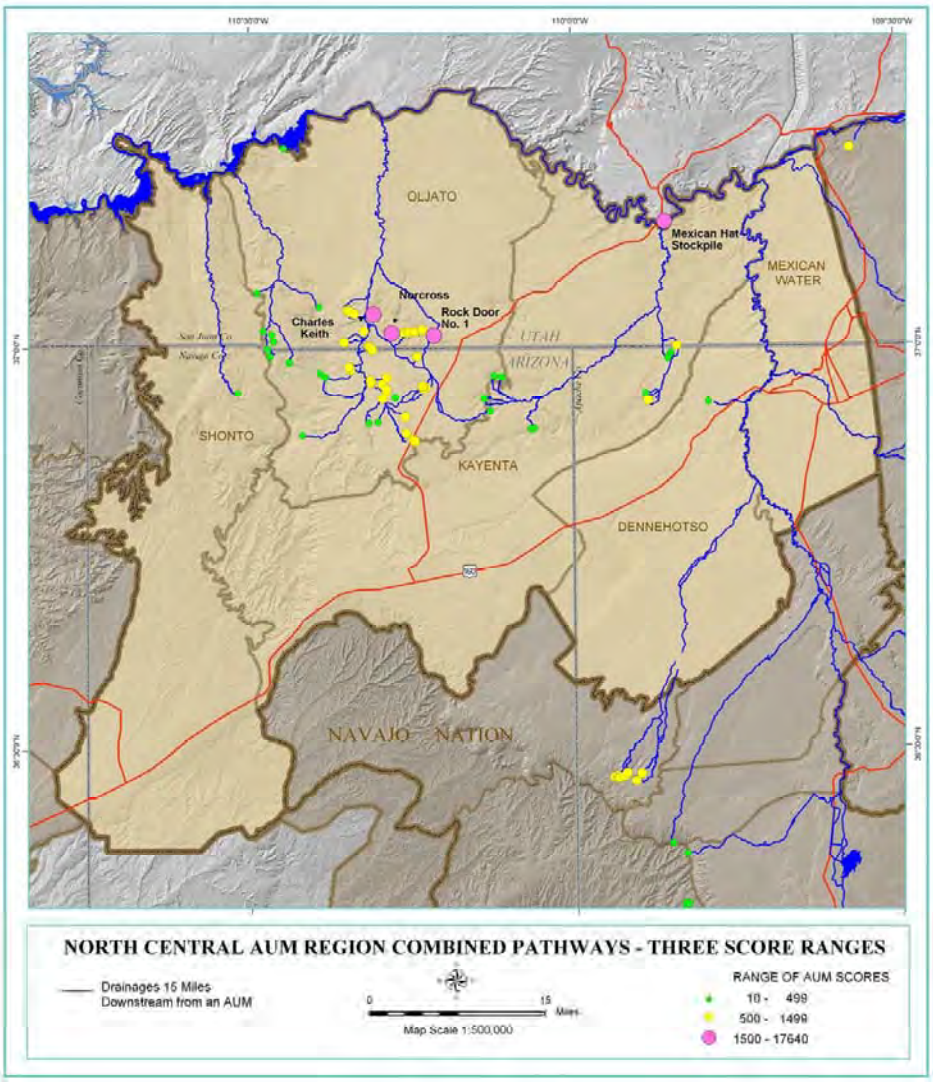


Figure 61. North Central AUM Region Combined Pathways Map with Three Score Ranges.

NORTHERN AUM REGION SCREENING ASSESSMENT SCORE RESULTS

Review of the Northern AUM Region Combined Pathway Scores (Table 5) and Figure 62 "Northern AUM Region Combined Pathway - Three Score Ranges" show that the highest scoring AUM sites occur in the Northeast Carrizo mining area of the Beclabito Chapter (NA-0420 and NA-0424), the Lukachukai mining area of Cove Chapter (Cove Transfer Station), the Climax Transfer Station south of the Shiprock community, the Oak Springs Mine (Gravel Cap) and Oak Springs Mine in the Red Valley Chapter, and the Plot 13 and Johnny McCoy 1 AUMs in the in Sweetwater Chapter. NA-0420 and NA-0424 are AUM sites that were reclaimed by the NAMLRP. NA-0420 is identified as a rim strip/pit feature, and NA-0424 is identified as a prospect. Uranium/vanadium production records could not be located for either of these sites. The Cove Transfer Station was not an AUM, but was used as a stockpile site. Uranium ore was trucked from the Kerr-McKee mines in the Lukachukai Mountains and dumped at the stockpile, then loaded onto larger trucks and transported to the Shiprock mill (Dare, 1961 - S10280202). Historical records could not be found for the Climax Transfer Station (MAP-ID #N191). William Chenoweth (2006 - S03010601) identified the site as a stockpile for ore mined at the Frank No. 1 Mine that was then transferred to the Climax Uranium Mill in Grand Junction. The Navajo Nation Environmental Protection Agency Superfund Program has recently conducted field assessments of the site (NNEPA, 2006 - S03030601). The Oak Springs Mine (Gravel Cap), Oak Springs Mine, Plot 13, and Johnny McCoy 1 were all productive mines that have been reclaimed by the NAMLRP.

Remote AUM sites with sparse population and wells scored low. This can be seen in the generally low scores for the AUM sites in the Chuska, Lukachukai, southwest Sweetwater, west Carrizo and portions of the northeast Carrizo mining areas (shown in green on Figure 62).

Rocky Spring Mine in the Chuska mining area (MAP-ID #N264) is an example of an AUM site that scored moderately high (1,070) due to proximity of homes and wells. However, this is an unreclaimed rim strip/pit site with limited production (a total of 11 tons of ore mined), and only 3 pounds of uranium and 62 pounds of vanadium extracted (Chenoweth, 1984 - S03130303). This is an insignificant production number compared to the Mesa II, Mine #1&2, P-21 AUM (MAP-ID #N245) that scored 250 but had 274,128 tons of ore mined with 1,284,853 pounds of uranium and 5,475,210 pounds of vanadium extracted (Chenoweth, 1988 - S10280203).

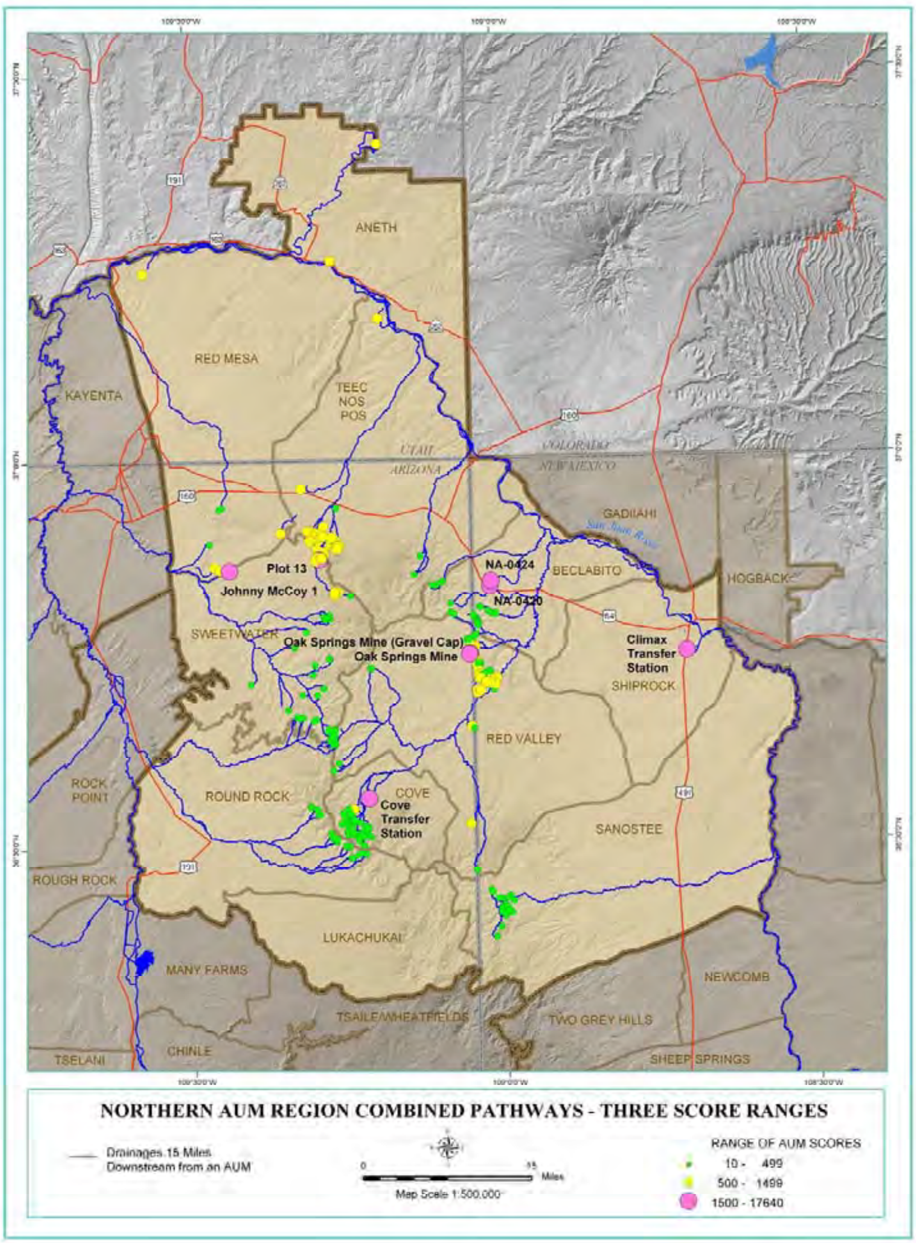


Figure 62. Northern AUM Region Combined Pathways Map with Three Score Ranges.

WESTERN AUM REGION SCREENING ASSESSMENT SCORE RESULTS

Review of the Western AUM Region Combined Pathway Scores (Table 6) and Figure 63 "Western AUM Region Combined Pathway - Three Score Ranges" show that the highest scoring AUM sites occur in the Little Colorado River mining area of the Cameron Chapter (A&B No. 2 and A&B No. 3) and Coalmine Canyon Chapter (Charles Huskon No. 1 and No. 12, and Jack Daniels Nos. 1, 4, and 5). All of these sites have been reclaimed by the NAMLRP.

AUM sites in the southwestern Coalmine Canyon, and southeastern and northern Bodaway/Gap Chapters generally scored low (shown in green on Figure 63). This is due to the remoteness of the AUMs with sparse populations and few wells.

Martin Johnson No. 4 mine in the Bodaway/Gap Chapter (MAP-ID #W5) is an example of an AUM site that scored moderately high (1,250) due to proximity of homes and wells. However, this AUM only had 38 tons of ore mined and produced 120 pounds of uranium and 23 pounds of vanadium. The A & B No. 3 mine (MAP-ID #W39) has the highest score (5,880) in the Western AUM Region. This was a producing mine, with 586 tons of ore mined and 1,458 pounds of uranium and 515 pounds of vanadium extracted. This is a significantly smaller production number compared to the Ramco No. 20 AUM (MAP-ID #W94) that scored 270 but had 22,642 tons of ore mined with 99,226 pounds of uranium and 19,259 pounds of vanadium extracted. Production numbers are from Chenoweth (1993 - S10100239).

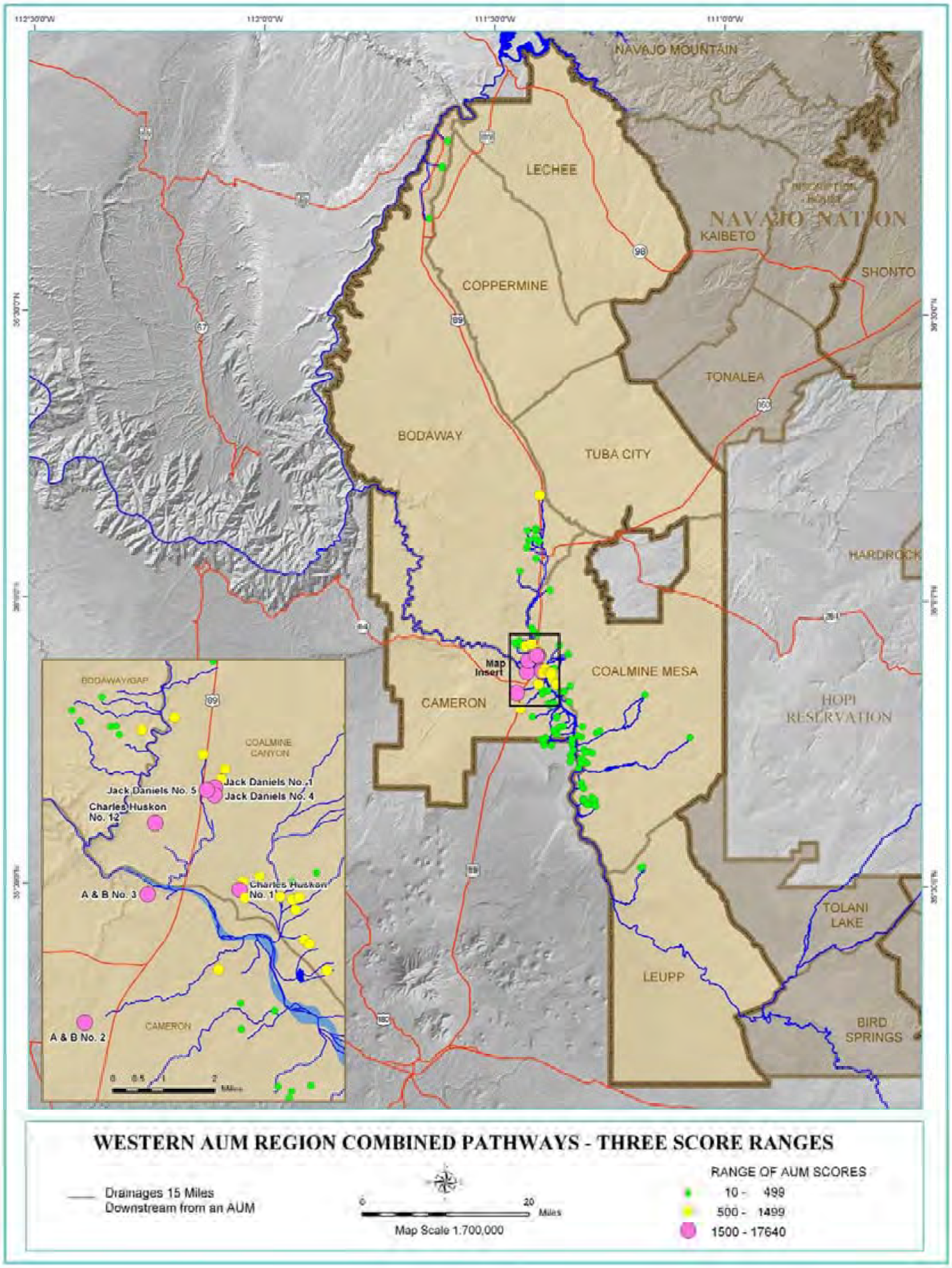


Figure 63. Western AUM Region Combined Pathways Map with Three Score Ranges.

CENTRAL AUM REGION SCREENING ASSESSMENT SCORE RESULTS

Review of the Central AUM Region Combined Pathway Scores (Table 7) and Figure 64 "Central AUM Region Combined Pathways - Three Score Ranges" shows that the Occurrence B AUM in the Chinle Chapter is the highest scoring AUM site. This AUM is an example of an AUM site that scored high (4,170) due to proximity of homes and wells. This AUM site is also proximal to the Canyon de Chelly National Monument, shown in orange in Figure 64.

Remote AUM sites with sparse population and few wells score low. This can be seen in the generally low scores for the AUM sites in the eastern Black Mesa, northeastern Tachee/Blue Gap, and northwestern Tselani/Cottonwood Chapters (shown in green on Figure 64).

High scoring AUMs did not necessarily produce large amounts of uranium. The Occurrence B AUM (MAP-ID #C34) did not have any reported production of uranium or vanadium. This occurrence was described as a stripped area (borrow pit) 500 feet by 700 feet across and 10 feet deep with radioactive rocks (up to 4 times background) (Chenoweth, 1990 - S10020207).

Conversely, one of the more significant uranium producing mines in the Central AUM Region was Claim 7 in Tselani/Cottonwood Chapter (MAP-ID #C24). The combined score for Claim 7 was 260, but it was one of the largest uranium producers in the region with 5,614 tons of ore mined and 14,594 pounds of uranium extracted (Chenoweth, 1990 - S10100236).

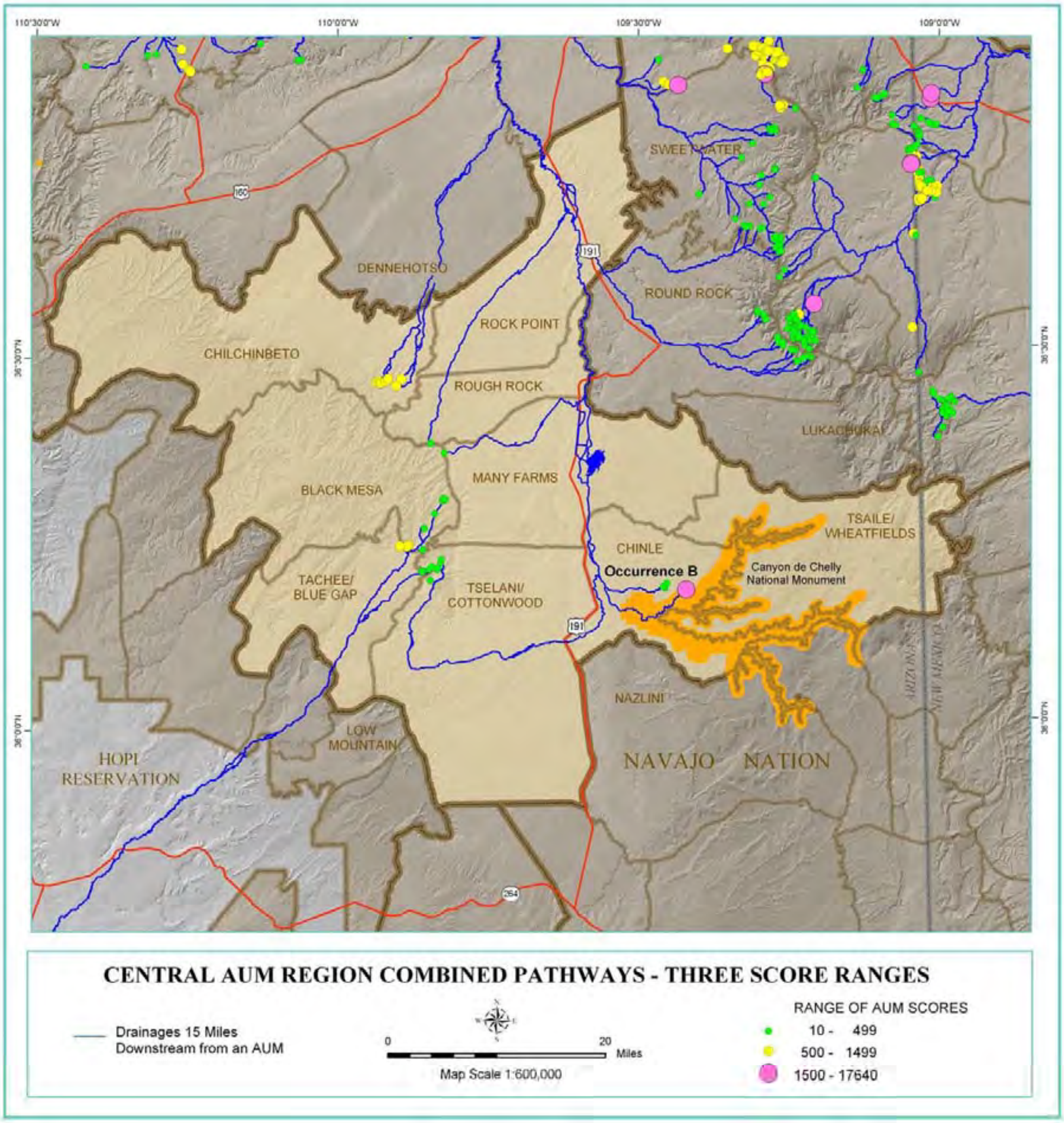


Figure 64. Central AUM Region Combined Pathways Map with Three Score Ranges.

SOUTHERN AUM REGION SCREENING ASSESSMENT SCORE RESULTS

Review of the Southern AUM Region Combined Pathway Scores (Table 8) and Figure 65 "Southern AUM Region Combined Pathways - Three Score Ranges" show the highest scoring AUM site occurs in the Indian Wells Chapter at the Mail Box Claim (MAP-ID #S2) with a score of 1,130.

There were no AUMs in the Southern AUM Region that scored above 1,500. The Mail Box Claim did not have any reported production of uranium or vanadium. The Morale Mine (shown in green) has the lowest combined pathway score at 450 (MAP-ID #S3). It was the only producing uranium mine in the Southern AUM Region, with 192 tons of ore mined, and 580 pounds of uranium and 162 pounds of vanadium produced (Chenoweth, 1990 - S10020205).

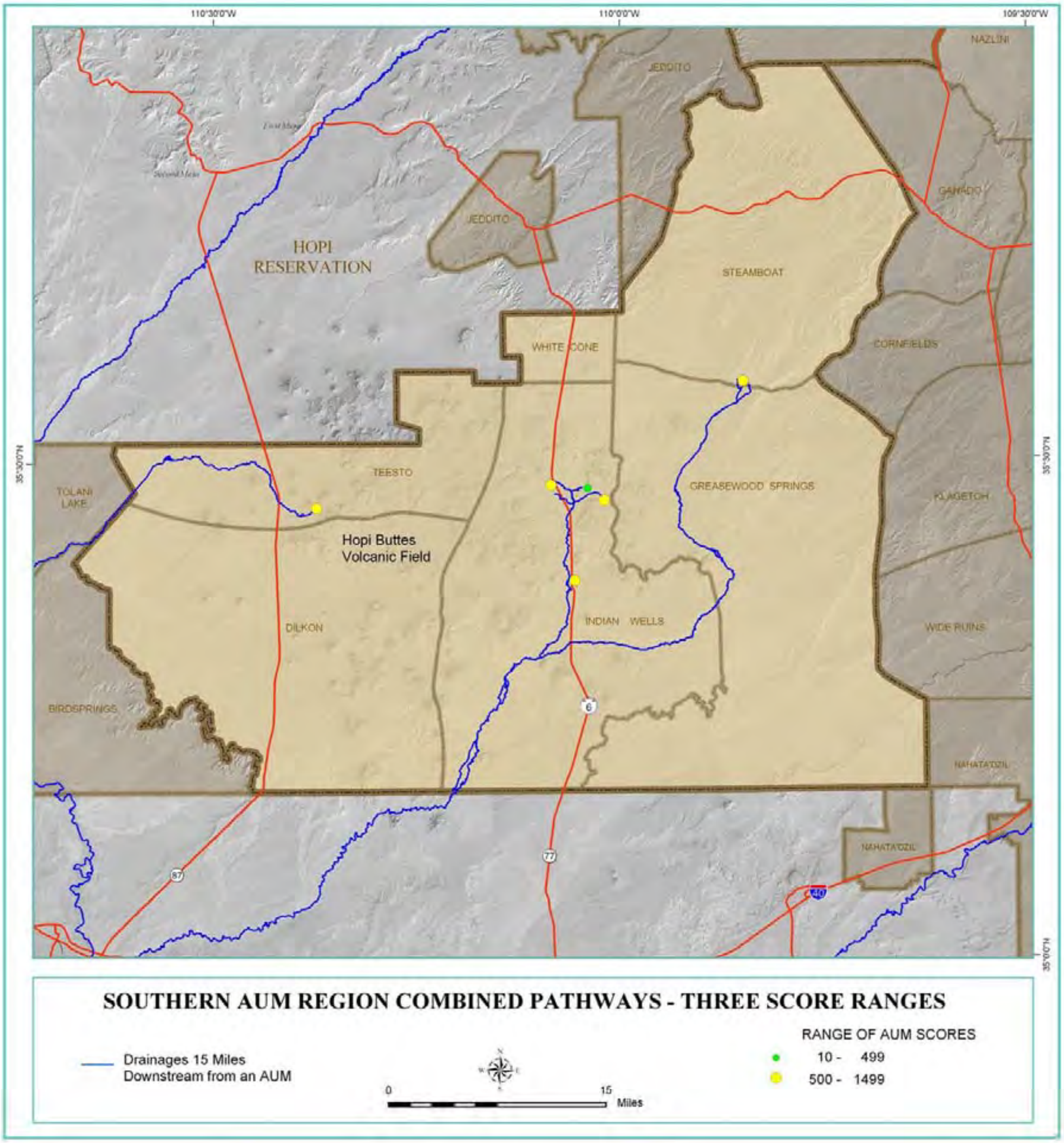


Figure 65. Southern AUM Region Combined Pathways Map with Three Score Ranges.

EASTERN AUM REGION SCREENING ASSESSMENT SCORE RESULTS

Much of the Eastern AUM Region is contained within the Grants Uranium District, the largest uranium producing area in the United States. Review of the Eastern AUM Region Combined Pathway Scores (Table 9) and Figure 66 “Eastern AUM Region Combined Pathways - Three Score Ranges” shows that there are twenty-four (24) AUM sites with scores that fall within the 1500 - 17,640 range. The highest scoring AUM site on the Navajo Nation is located in the Eastern AUM Region in the Crownpoint Chapter at the Crownpoint ISL (MAP-ID #E35). Since the primary HRS criteria are counts of structures and wells at specified distances from the AUMs, areas with high occurrences of homes and wells proximal to the AUM sites scored high. The highest scoring AUM in the Eastern AUM Region is an example of an AUM site that scored high (17,640) due to proximity of homes and wells (shown in pink on Figure 66). Conversely, remote AUM sites with sparse population and few wells score low. This can be seen in the generally low scores for the AUM sites in the Iyanbito and Smith Lake Chapters (shown in green on Figure 66).

The NE Church Rock mine (MAP-ID #E6) was the fifth highest scored AUM in the Eastern AUM Region (2,750). It was also the fifth highest producing mine on the Navajo Nation, with 3,398,648 tons of ore and 9,773,362 pounds of uranium. High scoring AUMs did not necessarily produce large amounts of uranium. An example is the highest scored Crownpoint ISL AUM (17,490), and the second highest scored Section 29-Conoco (5,850) with no uranium or vanadium production (McLemore et al., 2005 - S09290601). A mine site was developed at the Crownpoint ISL (see Figure 11 on page 18) and several warehouses and office buildings were constructed by Conoco in the 1970’s. Conoco completed at least 157 drill holes in the 1970’s, totaling about 316,750 drilled linear feet. Conoco began development of the uranium resource and constructed a plant facility, leach ponds, and three shafts were sunk to the mineralized horizons. Falling uranium prices in the early 1980’s resulted in the termination of the mine development. The mine plan called for underground extraction with surface processing (Myers, 2006 - S09300601).

Conversely, one of the more significant uranium producing mines in the Eastern AUM Region was the Dysart No. 1 AUM adjacent to the Haystack Chapter (MAP-ID #E59). The combined score for Dysart No. 1 was 540, but 891,922 tons of ore were mined, with 3,795,495 pounds of uranium and 47,438 pounds of vanadium produced (McLemore et al., 2005 - S09290601).

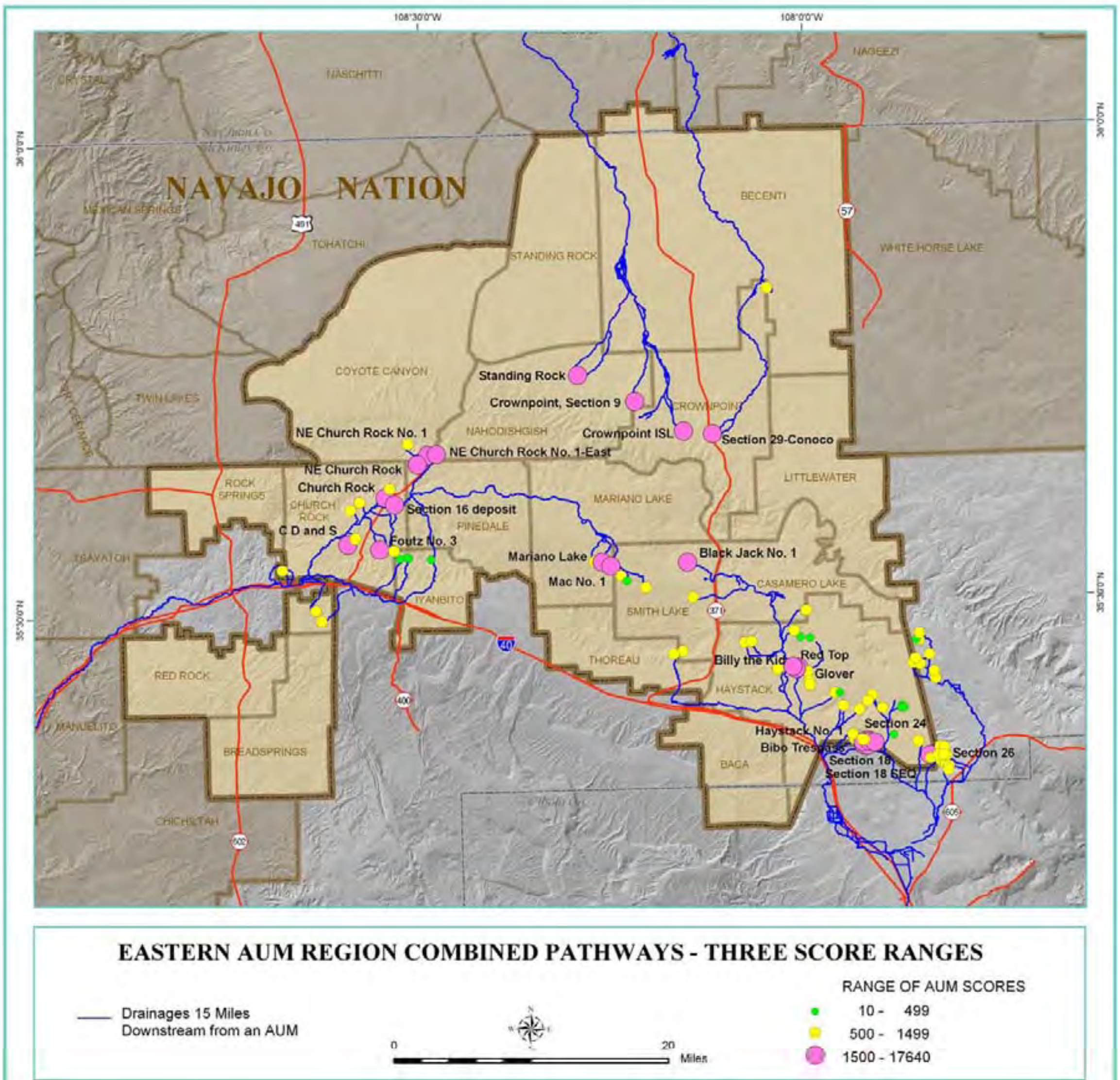


Figure 66. Eastern AUM Region Combined Pathways Map with Three Score Ranges.

RECOMMENDATIONS

Results from this modified screening process will be used to assist with identifying AUM sites for possible further investigation. There are several courses of action that may be used to remediate a site, including Removal Actions and Brownfields redevelopment. If the site is eligible for CERCLA assessments, then the site proceeds through the Preliminary Assessment stage and onward. If the site is not CERCLA eligible, the Site Screen recommendation is for No Further Remedial Action, in which the site may be referred to another party. The Site Screen may also recommend a Removal Action, though not necessarily detailed characterization, of the site contamination. Site specific characterization priorities should be established based on Navajo Nation priorities, AUM screening scores, resources, and site specific factors.

ADDITIONAL POSSIBLE SCORING FACTORS

Screening assessments at mine sites commonly require evaluation of exposures from multiple sources and exposures via multiple pathways (EPA, 2000 - S02200302). The modified HRS model used for this study was developed for the purpose of performing a coarse screening based on the presence of surface water drainages and the numbers of structures and wells proximal to AUM sites. Using existing GIS datasets, or by automating readily available data for the entire Navajo Nation, it may be possible to improve the analysis to better assess priority areas for further investigation. The following provides a list of existing or available datasets that could be used to develop additional factors that consider waste characteristics, likely transport pathways, and ecological targets.

- HRS factors related to uranium mine waste characteristics:
  - AUM reclamation sites with associated unreclaimed mine debris piles
  - AUM reclamation status (reclaimed versus unreclaimed)
  - AUM production (productive versus non-productive prospects)
  - Total uranium and/or vanadium production for each mine
  - The presence of host geologic formations for uranium ore
  - Water or stream sediment samples
  - Historic uranium haul routes, buying stations, and transfer stations
- HRS factors related to pathways and likelihood of release:
  - Surface or underground AUM extraction method (e.g., open pit or underground working)
  - Extent (size) of surface and/or underground workings
  - Perched water tables or documentation of infiltrated water in AUMs
  - Precipitation
  - Aquifer sensitivity
  - Slope proximal to AUM
  - Intersections of surface water pathway buffers with downstream targets (i.e., wetlands or structures)
- HRS factors related to targets:
  - Natural springs (undeveloped)
  - Sensitive habitats
  - Agricultural fields
  - Corrals and animal pens
  - Identification of schools, hospitals, Chapter houses, and community centers
  - Cumulative effects from multiple AUMs on targets (e.g.,several AUMs within 4 miles of a single well)

Inputs for many of these parameters have been processed and are presented in Part 2 of this document “Atlas with Geospatial Data.” In order to provide spatial datasets that cover the entire Navajo Nation, many of the datasets are at regional scales (1:250,000 and smaller). While the spatial accuracies and detail of these regional datasets are not appropriate for detailed site investigations, they may provide useful information for regional assessments and site prioritizations for further study or remediation activities.

The following discussion provides several examples of how the data that has been collected could be used to augment and improve the AUM screening assessment.

NON-POTABLE WATER SAMPLES WITH URANIUM EXCEEDING MAXIMUM CONTAMINANT LEVELS

Water samples have been collected on the Navajo Nation for various programs and studies, and have in some cases included samples for for radionuclides, including uranium. Sites listed below in Tables 10, 11, and 12 have come to EPA's attention due to elevated radionuclide activity in water samples (EPA, 2000 - S02260102). As of December 8, 2003, the EPA Maximum Contaminant Level (MCL) for uranium is 30 micrograms per liter (µg/L)[1] or 20 pico-curies per liter (pCi/L)[2]. MCL is the maximum permissible level of a contaminant in water delivered to users of a public water system. Water samples from the following locations were sampled for Uranium-234, Uranium-235 and Uranium-238 and the summed total values were greater than 20 pCi/L (EPA, 2000 - S02260102). The locations of these water samples with elevated uranium levels are displayed on Figure 67 "Non-Potable Water Sample Locations with Elevated Uranium." The water sources cited were not sampled from Public Water Supply Systems (PWSS). The MCL's were used for comparison purposes only. The results for both studies were from one-time sampling events by EPA and the USGS and are not definitive with respect to attribution from mining related versus naturally occurring sources. Water sampling was conducted prior to NAMLRP reclamation activity and current conditions may differ. The Eastern AUM Region was not included in this sampling program.

Table 10. USACE Water Samples with Elevated Uranium.

REGION	USACE SAMPLE NAME	SAMPLE ID	SAMPLE DATE	SITE TYPE	TOTAL URANIUM (pCi/L)
Central	Benally Spring	KY981008CHS001	10/8/1998	Spring	47.1
Central	Burro Spring	KY981008CHS002	10/8/1998	Spring	60.1
Central	Cottonwood Spring	CH981123CHS001	11/23/1998	Spring	22.4
Central	Tank 10R-51	CH990316TCW004	3/16/1999	Wind Mill	22.3
Central	Tank 10T-533	CH981119TCW003	11/19/1998	Wind Mill	73.0
Central	Tinyehtoh Spring	KY981008CHS003	10/8/1998	Spring	39.9
Central	Waterfall Spring	CH981104BGS001	11/4/1998	Spring	61.7
Central	White Clay Spring	CH981124BGS002	11/24/1998	Spring	45.9
North Central	Baby Rock Spring 8-44	KY980901DES001	9/1/1998	Spring	36.3
North Central	Monument Pass Well	KY000112OLW014	1/12/2000	Well	40.0
North Central	Tank 8A-299	KY980902OLW001	9/2/1998	Wind Mill	171.9
Northern	9K216	RV990907SWW005	9/7/1999	Well	27.2
Northern	9T550	RV990907SWW004	9/7/1999	Well	32.3
Northern	9T586	RV990907SWW006	9/7/1999	Well	20.3
Northern	Alcove Canyon Springs	RV990330CVS010	3/30/1999	Spring	125.3
Northern	Area 1	RV990518CVS015	5/18/1999	Stream	51.3
Northern	Area 2	RV990518CVS017	5/18/1999	Stream	116.1
Northern	Area 4	RV990518CVS016	5/18/1999	Stream	148.8
Northern	Camp Mine	RV991026CVM013	10/26/1999	Mine	419.7
Northern	Cove Mesa 2	RV991020CVM012	10/20/1999	Mine	879.0
Northern	Ellison Wells	RV990517CVW004	5/17/1999	Well	34.7
Northern	P.H.S. 4-28-59	RV990329CVS005	3/29/1999	Spring	23.4
Northern	Pipe Mine	RV991019CVM010	10/19/1999	Mine	67.5
Northern	Sah Tah Spring	RV990317TNS001	3/17/1999	Spring	45.8
Northern	Slimwagon Well	RV990907SWW003	9/7/1999	Well	76.0
Northern	Thumb Rock Well	RV990519RVW005	5/19/1999	Well	30.4
Northern	Water Well 309	RV990519CVW005	5/19/1999	Well	83.7
Northern	West Thumb Rock Well	RV991201RVW013	12/1/1999	Well	32.8
Southern	Sheep Dip Spring	BI980702LGS002	7/2/1998	Spring	190.7
Southern	Tank 17T-517	BI980701LGW001	7/1/1998	Wind Mill	33.7
Western	Badger Spring	CT980729CMS004	7/29/1998	Spring	22.1
Western	Fivemile Wash Spring	CT000120CMS009	1/20/2000	Spring	28.4
Western	Lechee Spring	CT980811TCS001	8/11/1998	Spring	20.8
Western	Open Pit Mine	CT980722CAM003	7/22/1999	Mine	57.1
Western	Open Pit Mine	CT980722CAM002	7/22/1998	Mine	50.9
Western	Paddock Well	CT991130CAW007	11/30/1999	Well	46.4
Western	Tohachi Spring	CT980729CMS003	7/29/1998	Spring	84.2
Western	Tse To Baah Naali Spring	CT980729CMS005	7/29/1998	Spring	23.3

While this study is focused on elevated levels of uranium, it should also be noted that arsenic levels above the MCL were also detected in several of the water samples collected by the EPA from unregulated water sources in the Southern AUM Region, particularly in the Greasewood and Steamboat Chapters (EPA, 2000 - S02260102).

[1] EPA, 2006 (S05190701). "List of Drinking Water Contaminants and MCL's" accessed on 2/28/06 at URL http://www.epa.gov/safewater/mcl.html#mcls.

[2] EPA, 2002 (S05030601). "EPA Implementation Guidance for Radionuclides." The total uranium mass measurements for the USACE water samples were converted to activity using a conversion factor of 0.67 pCi/µg.

In 2004 the Navajo Nation Surface and Ground Water Protection Department of the NNEPA conducted a study that was titled "Sanitary Assessment of Drinking Water used by Navajo Residents not Connected to Public Water Systems (Ecosystem Management, Inc., 2004 - S05050701)." Thirteen (13) unregulated water sources were sampled for radionuclides, arsenic, pesticides, and coliform after being identified as potential sources of drinking water in the selected Chapters. Three of the samples had gross alpha results that were larger than the MCL of 15 pCi/L. The locations of these NNEPA water samples are listed below (Table 11).

Table 11. NNEPA Water Samples with Elevated Uranium.

REGION	CHAPTER	WELL NAME	GROSS ALPHA (pCi/L)
North Central	Kayenta	08T-522	25.7
Western	Coalmine Mesa	Box Spring	25.5
Western	Coalmine Mesa	Badger Tank Well	70.5

In 1991 the USGS, in cooperation with the NAMLRP, began a study to assess the chemical characteristics and hydraulic interaction of shallow ground water and mine water in AUMs in the Monument Valley and Cameron mining districts that had partially filled with water (Longsworth, 1994 - S02250302). Two AUMs in the Monument Valley mining district and six (6) AUMs in the Cameron mining district were studied. The AUMs in Monument Valley were the Moonlight and Radium Hill No. 1 mines. The Moonlight mine was an open pit that included two spoil piles and an oval shaped pit about 750 feet long by 525 feet wide and 134 feet deep. During this study about 5,000 square feet of the pit bottom was covered with as much as four feet of water. The Radium Hill No. 1 mine consisted of a drill hole approximately 2 feet in diameter and 96 feet deep, five spoil piles, and an inclined shaft. Water from these two mines contained large radionuclide activities.

Data in the Cameron area were collected from the 1) Jeepster No. 1 mine, an elliptical pit about 700 feet long by 200 feet at the widest point and ore was extracted from as deep as 60 feet below land surface; 2) Jack Daniels mine, consisted of one main pit approximately 450 feet by 250 feet and about 26 feet deep; 3) Manuel Denetsone No. 2 mine was sampled at a drill hole approximately 2 feet in diameter and 33 feet deep, and; 4) Ramco No. 20 mine at one of the smaller pits (200 feet by 400 feet and about 4 feet deep). Data were also collected from existing wells and springs. The locations of these USGS water samples with elevated uranium levels are listed below (Table 12) and are plotted on Figure 67 "Non-Potable Water Sample Locations with Elevated Uranium."

Table 12. USGS Water Samples with Elevated Uranium.

REGION	USGS SAMPLE NAME	SITE TYPE	SAMPLE DATE	DEPTH TO GROUND WATER (ft below land surface)	TOTAL URANIUM (Dissolved U^{238}, U^{234}, and U^{235} pCi/L)
Northern	Moonlight Mine (MVD-1)	Shallow well	10/15/1991	0.4	22,440
Northern	Moonlight Mine (MVD-2)	Shallow well	10/16/1991	0.2	28,530
Northern	Radium Hill No. 1 Mine	Mine drill hole	12/19/1991	86.8	450
Western	Jeepster No. 1 mine (JSW –1)	Open Pit	10/29/1991	4,225	52.8
Western	Jack Daniels Mine (JDD-1)	Shallow Well	11/01/1991	4,190	365.7
Western	Jack Daniels Mine (JDSW-1)	Open Pit	10/31/1991	4,190	25.4
Western	Manuel Denetsone No. 2 Mine	Mine drill hole	11/02/1991	4,159	418.9
Western	Ramco No. 20 NW	Open pit	11/06/1991	4,211	35.6
Western	Clay Well Spring	Spring box	11/05/1991	4,220	65.1
Western	Arizona Inspection Station Well	Well	12/19/1991	4,185	44.9

As part of the National Uranium Resources Evaluation (NURE) program (Smith, 2001 - S07250302), water samples were collected from springs, streams, and water wells by the Los Alamos Scientific Laboratory (LASL) between August and October, 1978 across the central and eastern portion of the Navajo Nation. The samples were analyzed by the LASL for elemental concentrations of uranium in water, in parts per billion, using fluorometry and delayed-neutron counting analysis techniques. Figure 67 shows the sample locations where results for concentration of uranium in water was greater than 30 parts per billion (ppb).

Review of these water sample results suggest that uranium mining may have affected the down-gradient watersheds. An area of interest is the Lukachukai mining area in the southwest portion of Cove Chapter. While the AUM scores are low, there are a series of 8 water samples that indicate elevated levels of uranium downstream from the Lukachukai AUMs, which were highly productive uranium and vanadium mines. Two of the AUMs in the Lukachukai mining area have highly elevated total uranium levels: Camp Mine (419.66 pCi/L) and Cove Mesa 2 (879.00 pCi/L). Based on notes and photos taken during water sampling field visits by the U.S. Army Corps of Engineers, both of these mines had wetland areas proximal to them.

Another area of interest is the Cove Mesa mines in the West Carrizo mining area. This is a highly productive uranium mining area with mines that score low due to their remote locations. The water sample at Alcove Canyon Spring resulted in a total uranium value of 125.34 pCi/L.

Two water sample sites have elevated radionuclide activity, but appear outside CERCLA authority:

- Thumb Rock Well - no apparent AUM nearby
- West Thumb Rock Well - no apparent AUM nearby

Water samples with elevated uranium levels should be evaluated for post-reclamation water sampling.

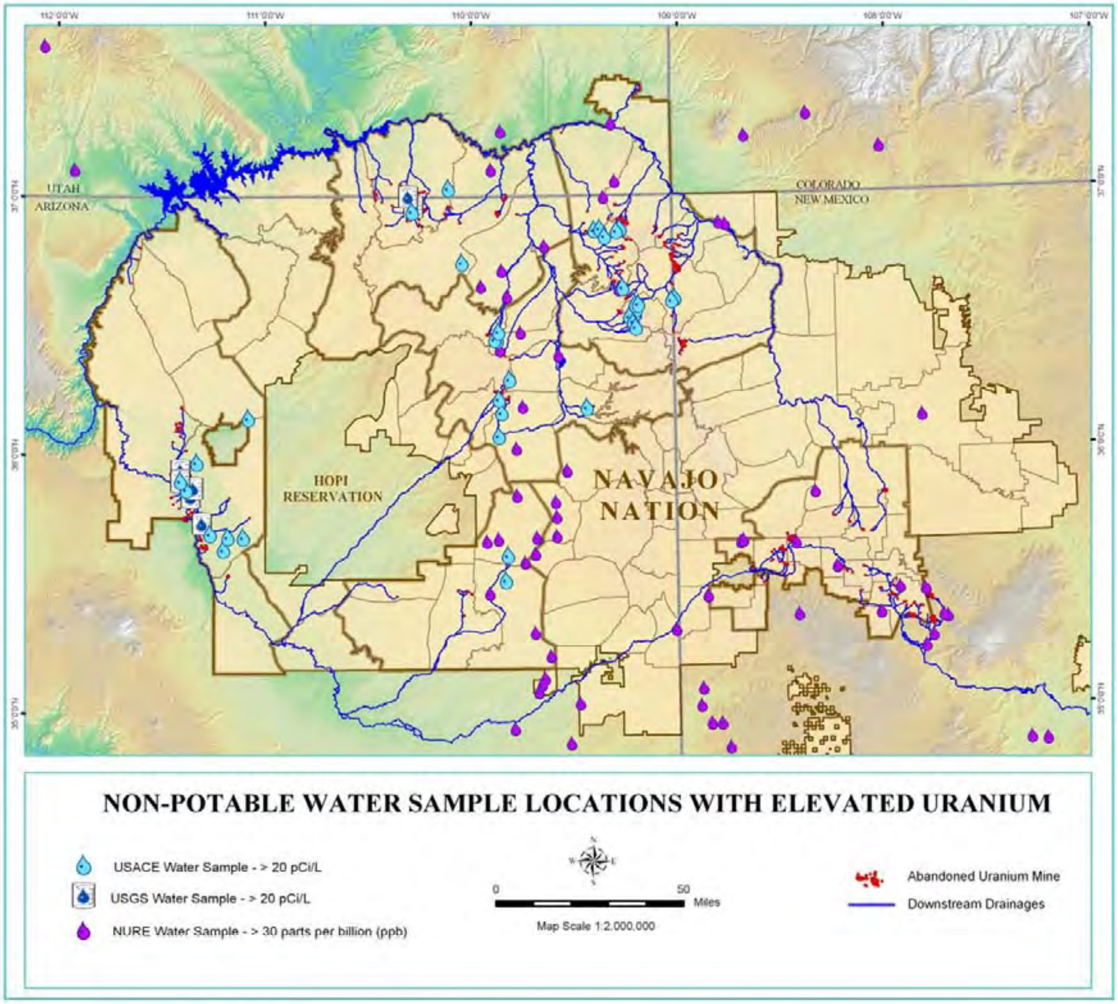


Figure 67. Water Sample Locations on the Navajo Nation with Elevated Uranium.

PERCHED OR SHALLOW WATER TABLES

Most of the mines in the North Central AUM region were extracting uranium from channel deposits in the basal Shinarump Member of the Chinle Formation. Perched water tables were present in the basal Shinarump conglomerate at many of the AUM sites. Bootjack Mine, the deepest uranium-ore deposit mined in the region was extremely wet. In 1959, ground water flowed into the workings at an average of 200 gallons per minute. This water was collected in the shaft sump and pumped to an evaporation pond on the surface (Chenoweth, 1993 - S10100222). Ground water, at the rate of 50 gallons per minute, seeped into the mine workings at the Alma-Seegan Mine (Chenoweth, 1994 - S10100230), Big Four No. 2 Mine (Chenoweth, 1994 - S10100228), Fern No. 1 Mine (Chenoweth, 1994 - S10100227) Firelight No. 6 Mine (Chenoweth, 1992 - S10100224) and Starlight Mine (Chenoweth, 1997 - S10100233). Water flowed into the mine workings at the Big Chief Mine at approximately 80 gallons per hour (Chenoweth, 1992 - S10100223). A sump and pump was required at the Moonlight Mine due to water seepage (Chenoweth, 2003 - S08250503). Perched water was encountered during mining at the Utah No. 1 Mine (School Section 36) (Chenoweth, 1991 - S03100502). Mining at the C-3 mine was in wet ground because a perched water table was encountered in the basal Shinarump (Chenoweth, 1991 - S03100502). Results from the water samples taken at the Moonlight and Radium Hill mines suggests that AUMs that partially fill with water may concentrate radionuclide activities and other dissolved constituents. Collection and analysis of additional hydrologic data would be necessary to determine shallow ground water flow characteristics and thus the implications of radionuclide mobilization near mines in the Monument Valley mining district (Longsworth, 1994 - S02250302).

MINE WATER EXTRACTION

In the Eastern AUM Region uranium was recovered from mine water. Mine water recovery is also referred to as Old Stope-Leach Projects and are described by Holen and Hatchell (1986 - S08200601) as another form of In Situ Leach (ISL) mining. Surface or recirculated mine waters, along with air to facilitate oxidation, were pumped through injection drill holes into old uranium mine stopes (an underground excavation from which ore is extracted). These water solutions were then pregnant with leached uranium, and were collected in sumps within the mine workings and pumped to the surface into open settling and holding ponds. After settling, these waters were passed to an Ion Exchange facility to remove the uranium. The extracted waters were either used for recirculation, discharged to surface waters, or were used in nearby uranium mills as process water. In some cases natural mine water flow, where underground mines were flooded below the water table, was pumped to the surface and its dissolved uranium was extracted in an Ion Exchange facility. This method of mining was used extensively at the large mines in the Ambrosia Lake area. It was also used at the Church Rock and the Mariano Lake mines where the settling and holding ponds and fences are readily visible on orthophotos. However, these pregnant solutions ponds were not mapped everywhere and have not been characterized for exposure risk. McLemore and Chenoweth (1991 - S03030608) reported that 893,787 pounds of uranium oxide were recovered from mine waters of Kerr McGee, Homestake Sapin Partners, and United Nuclear mines throughout the entire Grants Uranium District.

Table 13 lists productive AUMs that were determined to have workings below the water table or were considered wet mines that required pumping. It also shows AUMs that were not mined, but the ore deposits occur below the water table, and would likely require pumping if mined.

Table 13. AUMs With Uranium Ore Deposits Below the Water Table.

MINE NAME	PRODUCER	TONS	U3O8_LBS	START_YEAR	END_YEAR	WATER TABLE * If Mined	REGION
Crownpoint, Section 9	No					Below*	Eastern
NE Church Rock No. 2	No					Below*	Eastern
Nose Rock No. 1	No					Below*	Eastern
Section 13	No					Below*	Eastern
Section 29-Conoco	No					Below*	Eastern
Black Jack No. 2	Yes	247,613	1,129,004	1959	1970	Below	Eastern
Church Rock	Yes	292,604	883,580	1960	1982	Below	Eastern
Church Rock ISL	No					Below	Eastern
Crownpoint ISL	No					Below	Eastern
Grace Insitu Leach	Yes	9	201	1975	1975	Below	Eastern
Homestake Sapin Mine No. 23	Yes	4,811,351	17,520,976	1959	1989	Below	Eastern
Homestake Sapin Mine No. 25	Yes	3,145,969	9,960,150	1959	1983	Below	Eastern
Kermac Mine No. 22	Yes	3,851,523	13,471,257	1958	1985	Below	Eastern
Kermac Mine No. 24 and 26	Yes	2,894,860	15,365,512	1959	1983	Below	Eastern
Mariano Lake	Yes	505,489	2,265,405	1977	1982	Below	Eastern
NE Church Rock	Yes	3,498,648	9,773,362	1972	1982	Below	Eastern
NE Church Rock No. 1	Yes	836,570	2,953,673	1976	1985	Below	Eastern
NE Church Rock No. 1-East	Yes	322,602	1,234,784	1978	1983	Below	Eastern
Section 16 deposit						Below	Eastern
Alma-Seegan	Yes	6,769	25,541	1965	1966	Below	North Central
Big Chief	Yes	32,834	151,221	1959	1961	Below	North Central
Big Four No. 2	Yes	3,930	20,444	1963	1963	Below	North Central
Bootjack	Yes	36,236	331,010	1957	1966	Below	North Central
Fern No. 1	Yes	9,582	126,703	1956	1961	Below	North Central
Firelight No. 6	Yes	2,141	7,611	1959	1960	Below	North Central
Moonlight	Yes	223,237	1,177,501	1956	1966	Below	North Central
Radium Hill No. 1 and Utah No. 1	Yes	12,776	87,737	1955	1962	Below	North Central
South Sunlight	Yes	28,645	171,460	1962	1965	Below	North Central
Starlight	Yes	40,378	231,731	1958	1961	Below	North Central
Starlight East	Yes	45,990	289,378	1961	1964	Below	North Central
Sunlight	Yes	55,024	291,462	1958	1964	Below	North Central

Figure 68 shows two areas near the Bootjack Mine with above-background levels of excess Bismuth-214 (see page 91). The radiation contour area to the northeast corresponds to the location of the evaporation ponds (shown in Figure 69) where water in the mine was pumped to the surface. AUMs with underground workings that had histories of water infiltration and pumping may warrant additional examination for possible radionuclides or concentrations of other dissolved constituents.

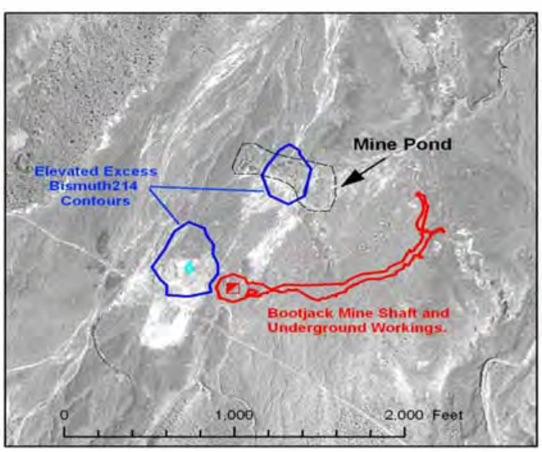


Figure 68. Bootjack Mine Surface and Underground Workings and Proximal Areas with Excess Bismuth-214.

Figure 69. Plan Map of the Underground Workings and Surface Features of the Bootjack Uranium Mine (Chenoweth, 1993 - S10100222).

AUMS WITH SURFACE WATER PATHWAYS TO WATER SOURCES

Two of the AUMs in the North Central AUM region are located upstream and adjacent to major water sources - San Juan River and Lake Powell. The Whirlwind Mine is on the south bank of the San Juan River (Glen Canyon National Recreation Area) approximately 16 miles northwest of Oljato Trading Post (Chenoweth, 1991 - S03100502). The Whirlwind Mine operated from 1950 to 1966 and extracted 15,777.8 tons of ore with 69,403.5 pounds of uranium and 277,779.1 pounds of vanadium recorded. Figure 70 shows the location of the Whirlwind Mine on a natural color orthophotograph (left) generated from 2004 imagery during drought conditions. The outline of the Whirlwind Mine is shown in red and from this image it can be seen that the Whirlwind Mine is directly upstream from the San Juan River (approximately 2000 feet upstream). The USGS topographic map on the right was developed in 1987 during non-drought conditions, and shows that the Whirlwind Mine drained directly into a drainage within 400 feet of Lake Powell's shore.

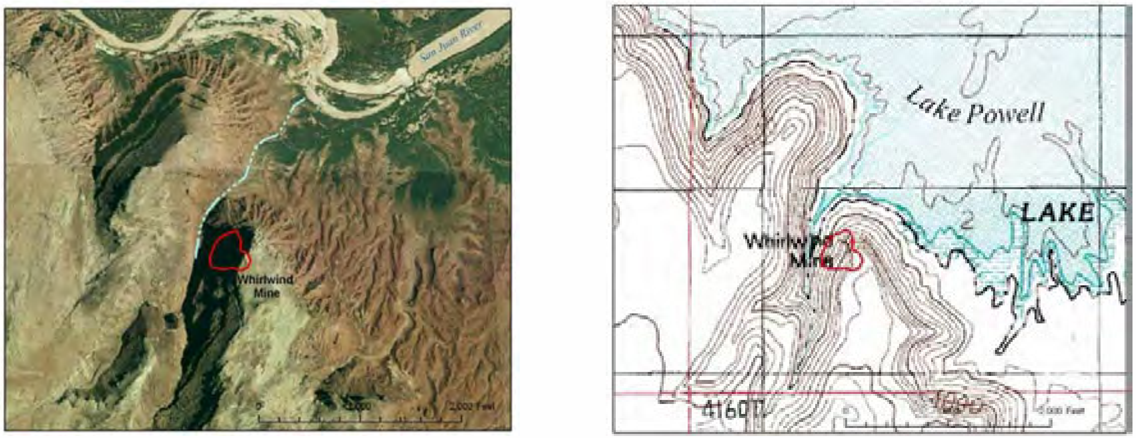


Figure 70. Whirlwind Mine on the South Bank of Lake Powell. Natural color image (left) acquired in 2004 and USGS topographic map (right) dated 1987.

Mexican Hat Stockpile (Figure 71) is an AUM-related site located in a drainage that flows directly into the San Juan River, which is located less than 1/2 mile downstream. During the late 1940's and 1950's, the Vanadium Corporation of America (VCA) and individual Navajo's mining in the vicinity of VCA's Monument No. 2 mine stockpiled their ore at this location in ore bins along the wash on both sides of the highway (Chenoweth, 2006 - S04200601). Companies mining on Oljato Mesa and on Monitor Butte also stockpiled their ores here. This was done because the small, narrow, suspension bridge across the San Juan River at Mexican Hat at that time could not support large trucks. Ores were hauled from the mines in five-ton trucks to the stockpile area and then 21-ton semi-trailer trucks were used to haul the ore to the AEC ore-buying station at Monticello, Utah or the VCA mill at Durango, Colorado (Chenoweth, 1994 - S10100221). The wagon road from Cane Valley over Comb Ridge connecting Kayenta to Shiprock road (now US Highway 160) was not improved by the Atomic Energy Commission until 1952 (Chenoweth, 1989 - S10100213). When completed, this route greatly reduced the mileage to Durango, Colorado and eliminated the Mexican Hat stockpiling.

Figure 71. Mexican Hat Stockpile.

There may be other sites like the Mexican Hat Stockpile. Donald Bayles, a uranium ore hauler living in Blanding, Utah, stated in an oral history interview:

"I hauled ore from Mexican Hat which is Monument Valley One [sic] Mine. They hauled the ore up and would put the ore in a bin on the other side of the bridge. Then from there they'd have a little truck to take it across the bridge. They'd take it up on this side of Mexican Hat to a little creek. Then they'd take it on top. They had some little chutes they'd dump it in. When we'd come down and load it, we'd just open the chutes. They'd keep trucking it across the bridge there because the bridge wasn't made for too much weight."

This statement suggests there may have been another uranium ore transfer point on the south side of the bridge. Ore was loaded into a bin where it was stockpiled to load into smaller trucks to cross the bridge and dump at the Mexican Hat Stockpile (Tate, 2001 - S05310703). AUMs located upstream from water sources and/or associated riparian/wetland areas such as these sites may warrant additional study.

MINE SUBSIDENCE IN THE EASTERN AUM REGION

The Eastern AUM Region has also experienced mine subsidence, which was likely an unintended result of retreat mining underground. This can happen when a mine collapses as pillars separating stopes are extracted. Holmquist (1970 - S01140711) describes surface subsidence of 2-3 feet over thicker stopes at the Dysart No. 1 mine. The ore was 320-370 feet below the surface. At the Homestake Sapin Mine No. 15, caving above mine stopes collapsed to the surface. At the Kermac Mine No. 22 two large stopes caved to the surface creating holes 60 feet deep. The ore was at a level of 360 feet below the surface. At this mine, uranium mill tailings were run underground to prevent further caving to the surface. At the Homestake Sapin Mine No. 23, surface sand was injected via a drillhole to prevent collapse. In this area some mines were below the water table and flowed up to 1,600 gallons per minute. The environmental impact of these various mining occurrences has not been characterized.

EXPLORATION DRILLING

Navajo prospectors were the first to discover uranium mineralization in the Lukachukai Mountains (Chenoweth, 1988 - S10280203), on Black Mesa (Chenoweth, 1990 - S10100236), and in the Cameron area (Chenoweth, 1993 - S10100239). It was a Navajo sheepherder whose discovery in the Todilto Limestone triggered the boom in the Grants uranium district (Chenoweth, 1985 - S08020601). The earlier discoveries in the Carrizo Mountains and these successful prospecting efforts were followed by extensive drilling and stripping programs across the Navajo Nation by the Atomic Energy Commission (AEC) and private companies. These activities would penetrate uranium mineralization at depth or at the surface, opening additional pathways to uranium ore deposits.

Chenoweth (1990 - S10100236) describes how bulldozers were used by the AEC in the Black Mesa area of the Central AUM Region to expose uranium mineralized outcrops after ground and aerial reconnaissance revealed promising outcrops. Later these exposed outcrops and nearby areas were typically drilled to search for and define uranium ore bodies. Some were eventually mined and others left exposed. An inspection of the DOE aerial radiation surveys in this area shows strong correlation with these unexploited but radioactive outcrops.

In the Cameron area of the Western AUM Region Chenoweth (1993 - S10100239) provides an extensive description of drilling activities. He reports that from 1953 through 1962 approximately 1,005,000 feet of surface drilling occurred at about 20,000 holes that rarely exceeded 100 feet in depth. They were drilled around known mines and typically in a 500 foot grid pattern decreasing to a 50 foot grid in promising areas. Drilling was also performed at the locations of aerial radiometric anomalies.

Extensive drilling programs were conducted by the AEC in the Northern AUM Region. Exploration occurred in the eastern Carrizo Mountains (Chenoweth, 1984 - S03130303), the northern and western Carrizo Mountains (Chenoweth, 1985 - S10020203), and the Lukachukai Mountains (Chenoweth, 1988 - S10280203). It was noted that mining companies also ran some drilling programs.

In numerous locations within the North Central AUM Region there is evidence of previous uranium exploration activities. An example is the Tract 10 and Tract 11 area where there is significant surface expression of exploration drilling evident on the photos. Figure 72 shows a grid of roads used to access and lay out exploration drilling sites. Phillips Petroleum Company conducted an extensive exploration program on Tracts 10 and 11, known as the Strategic Minerals Project 68 (Chenoweth, 1991 - S03100502). This drilling included 245 holes with 40,000 feet of total linear drilling. The exploration resulted in locating an ore body at a depth of 200 feet with an average thickness of 5 feet that was reported to contain 8,300 tons of uranium. The potential impacts of these exploration activities as a migration pathway may warrant further investigation.

Malan (1964 - S04290701) prepared a map locating exploratory drilling projects of Monument Valley for Arizona and Utah. Figure 73 below shows the greater extent of exploratory drilling areas (shown in yellow) that were mapped by Malan in comparison to the extent of AUMs (shown in red).

Figure 72. Exploration Drilling in the Tracts 10 and 11 Area of the North Central AUM Region.

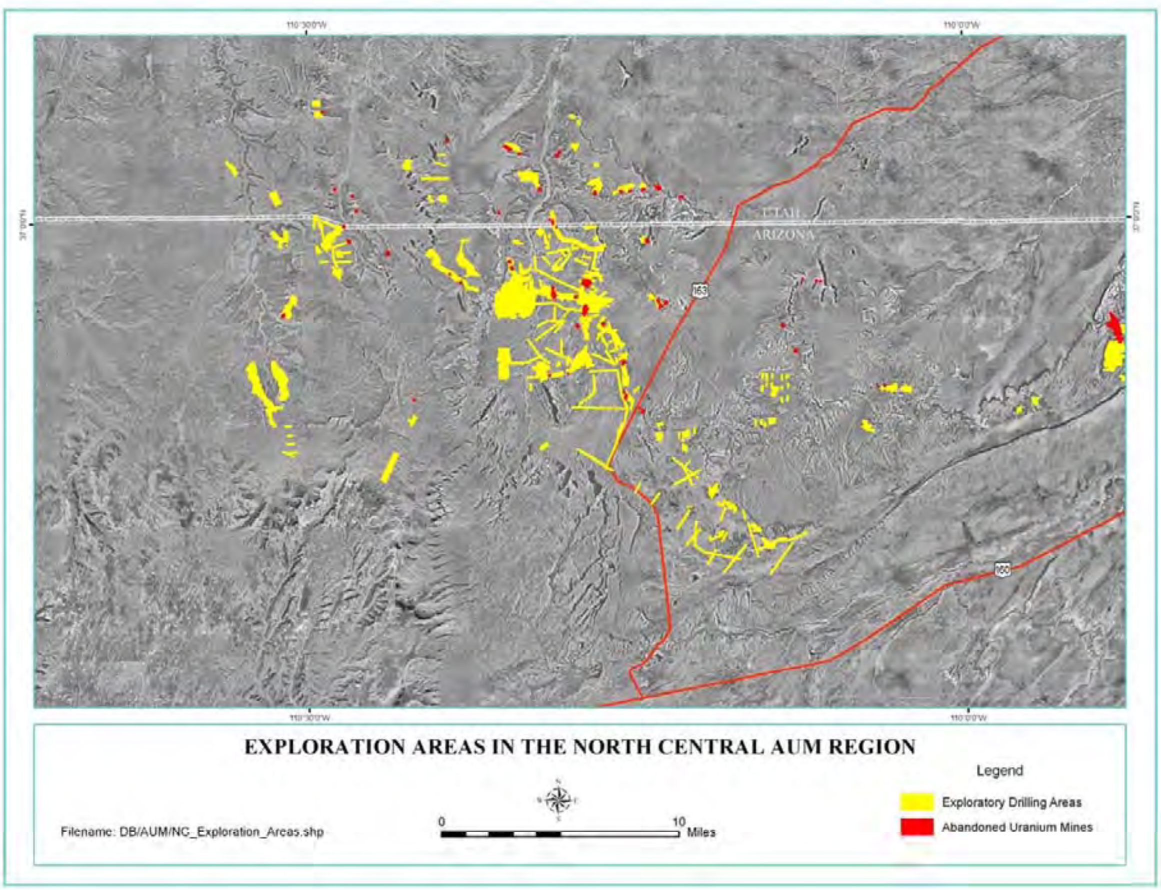


Figure 73. Exploration Areas in the North Central AUM Region.

AERIAL RADIATION SURVEY—EXCESS BISMUTH-214 AREAS

The aerial radiological surveys that were flown over portions of the Navajo Nation proved to be a useful tool for locating AUMs and AUM-related areas, like the Cove Transfer Station shown in Figure 74. See Part II, Section 2, "Aerial Radiation Survey" for more information. These types of surveys allow characterization of large areas to identify where higher spatial resolution ground-based measurements may be required. The acquisition of new high resolution aerial radiation surveys may help locate ore transfer stations, ore haulage routes, or AUMs in areas that were not flown during the 1994 - 1999 surveys, such as the Eastern AUM Region.

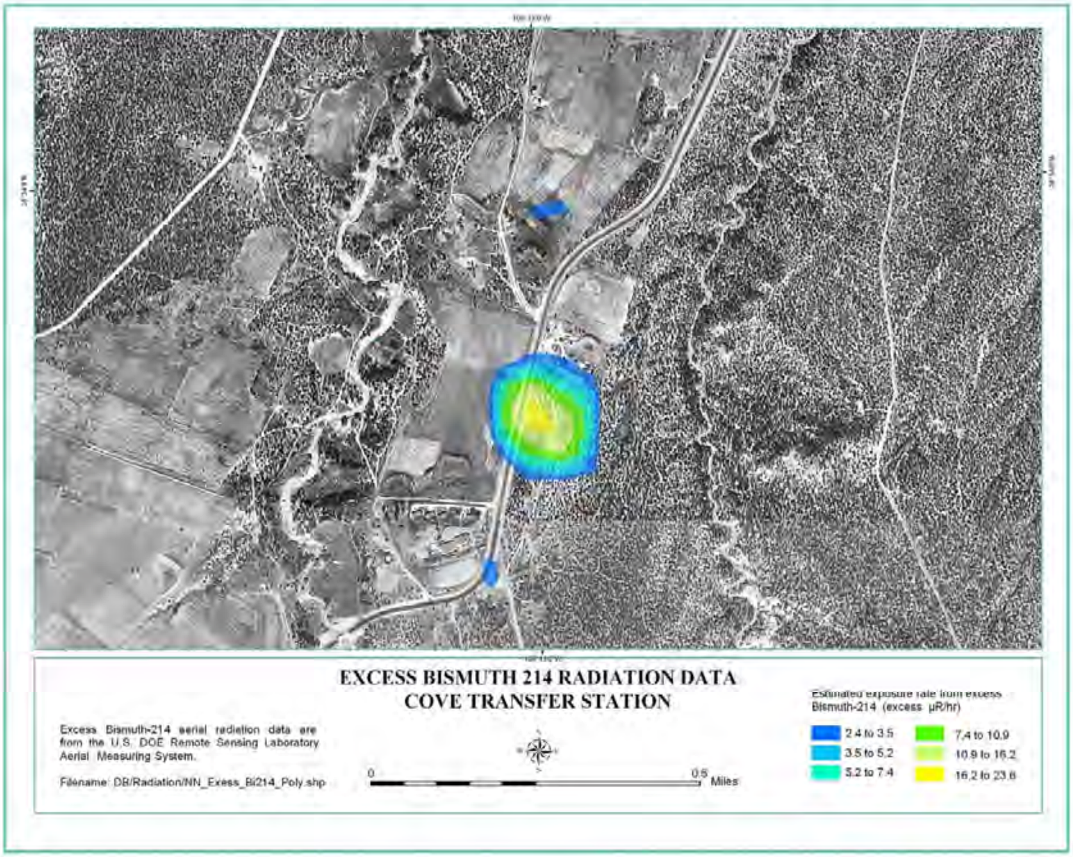


Figure 74. Cove Transfer Station. Location of this site was established by the DOE aerial gamma radiation survey.

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Geohydrology and Water Chemistry of Abandoned Uranium Mines and Radiochemistry of Spoil-Material Leachate, Monument Valley and Cameron Areas, Arizona and Utah

By STEVE A. LONGSWORTH

U.S. GEOLOGICAL SURVEY
Water-Resources Investigations Report 93—4226

Prepared in cooperation with
THE NAVAJO NATION

Tucson, Arizona
1994

U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY
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TABLES

CONVERSION FACTORS AND VERTICAL DATUM

Multiply	*By*	*To obtain*
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
square foot (ft^2)	0.0929	square meter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer
ounce	28.3495	gram
pound (lb)	0.45359	kilogram
ton	1.102	megagram
gallon per minute (gal/min)	0.06308	liter per second

In this report, degrees are reported in Celsius (°C), which can be converted to degrees Fahrenheit (°F) by the following equation:

$$°F = 1.8(°C)+32$$

Chemical concentration and water temperature are given only in metric units. Chemical concentration in water is given in milligrams per liter (mg/L) or micrograms per liter (µg/L). Milligrams per liter is a unit expressing the solute per unit volume (liter) of water. One thousand micrograms per liter is equivalent to 1 milligram per liter. For concentrations less than 7,000 milligrams per liter, the numerical value is about the same as for concentrations in parts per million. Specific conductance is given in microsiemens per centimeter (µS/cm) at 25 degrees Celsius. Radioactivity is expressed in picocuries per liter (pCi/L), which is the amount of radioactive decay producing 2.2 disintegrations per second in a unit volume (liter) of water.

Sea Level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929—A geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called *Sea Level Datum of 1929*.

Geohydrology and Water Chemistry of Abandoned Uranium Mines and Radiochemistry of Spoil-Material Leachate, Monument Valley and Cameron Areas, Arizona and Utah

By Steve A. Longsworth

ABSTRACT

Abandoned uranium mines in the Monument Valley and Cameron mining districts that have partially filled with water were studied to define hydrologic and chemical characteristics of mine water and shallow ground water and to evaluate possible chemical interactions of shallow ground water and the mine-spoil material that will be used in mine reclamation. Uranium mines in the Monument Valley area were established predominantly in channel-fill deposits within the Shinarump Member of the Chinle Formation. The Shinarump Member yields ground water to wells and may yield water to the Moonlight and Radium Hill mines. Depth-to-water measurements in the area of the Moonlight and Radium Hill mines indicate that local ground-water flow is from the southeast to the northwest along the trend of Oljeto Wash. In the study area near Cameron, uranium was mined from channel-fill deposits within the Petrified Forest Member of the Chinle Formation. Units of the Petrified Forest Member do not yield ground water to wells in the area, but fractures in the lower part of the Petrified Forest Member are probable pathways for upward flow of ground water from the Shinarump Member. Depth-to-water measurements were not sufficient to determine local ground-water flow directions, although previous investigations determined that regional flow in the area is toward the Little Colorado River. In the Cameron area, water in mines can originate from several sources. Most of the mines receive water from surface inflow of rainfall runoff, but ground water also may be transmitted to open pits and drill holes in the subsurface through fractures or along faults in the Petrified Forest Member.

Uranium-238 activities in shallow ground water from mines ranged from 150 to 14,000 picocuries per liter and radium-226 activities ranged from 0.10 to 110 picocuries per liter. Uranium-238 activities in pit water from mines ranged from 11 to 22 picocuries per liter. Radon-222 activities from three ground-water samples ranged from 590 to 250,000 picocuries per liter. Radionuclide activities in well and spring water generally were less than in shallow ground water and pit water. Water from Clay Well spring, which is about 1.9 miles from the nearest mine, contained a uranium-238 activity of 27 picocuries per liter. Radionuclide activities in well and spring water may result from naturally occurring mineralization in water-bearing rock units. The effects of mining activity could not be determined from chemical analyses of well and spring water.

Laboratory-batch tests indicate that radionuclide activities varied in leachate and generally correlated with field gamma measurements. Uranium concentrations in leachate samples ranged from 20 to 7,700 micrograms per liter and radium-226 activities ranged from 0.95 to 34 picocuries per liter. Batch tests were done with material that was 2.00 millimeters and smaller. Particle-size data indicate that spoil material near sampling locations is predominantly gravel and coarser sediments at three of the mines and sand-size sediments at the fourth. The radiochemistry of leachate from coarser sediments was not determined, and the specific rate and magnitude of radionuclide leaching are dependent on site-specific conditions that include the amounts of oxygen and organic material present, temperature, spoil mineralogy, and local ground-water composition.

INTRODUCTION

Uranium was mined on the Navajo Indian Reservation in the Monument Valley area, Arizona and Utah, during 1948-69 and near Cameron, Arizona, during 1950-63. The Monument Valley mining district contains 73 abandoned mines and the Cameron mining district contains 98 abandoned mines, generally along the Little Colorado River. Many of the mines present potential radiation hazards where the mines have partially filled with water. During 1984-87, water near the abandoned uranium mines in the Cameron area was sampled and analyzed to assess the extent of radionuclides and other potential contaminants (Donald Payne, Navajo Nation Division of Water Resources, written commun., 1987). Samples were collected from 49 locations that included springs, wells, mine pits, surface impoundments, and the Little Colorado River. Unfiltered samples were collected at most sites and additional filtered samples were collected from mine pits. Analyses of filtered and unfiltered samples indicated significant radionuclide activity that in several instances exceeded standards of the U.S. Environmental Protection Agency (1985). Reconnaissance sampling and laboratory analyses by the U.S. Geological Survey (USGS) in 1988 were done to define ranges of general radionuclide activities in water from springs, wells, and mine pits.

The Navajo Nation Abandoned Mine Lands Reclamation Department (NAMLRD) has developed reclamation plans that include burial of mine-spoil material within the mines on the basis of naturally occurring radioactivity. Mine spoils consist of non-ore-bearing material that was excavated above ore deposits and lower-grade ore that was set aside for possible future processing. Mobilization of uranium and radium may be of concern if shallow ground water associated with many of the mines is hydrologically interconnected with water that supplies wells or springs used by local Navajo inhabitants. The USGS, in cooperation with the NAMLRD, began a study in August 1991 to assess the chemical characteristics and hydraulic interaction of shallow ground water and mine water and the possible chemical interactions between shallow ground water and spoil material.

PURPOSE AND SCOPE

This report describes the geohydrology of the abandoned mines; the chemistry of mine, well, and spring waters; and the radiochemistry of spoil-material leachate from laboratory-batch tests. A total of 11 mines in the two mining districts were proposed for study on the basis of hazard prioritization and assumptions of hydrologic variability between mines. Field conditions, however, limited data collection to eight mines. Water-level and chemistry data also were collected from one unnamed drill hole, seven wells, and three springs. Data collected by the USGS before the study also are included.

Location and Well-Classification System

The Navajo Indian Reservation is in parts of Apache, Navajo, and Coconino Counties in northeastern Arizona; San Juan County in southeastern Utah; and San Juan and McKinley Counties in northwestern New Mexico. This study encompasses the Monument Valley and Cameron mining districts in northeastern Arizona and southeastern Utah (fig. 1). Local well numbering is based on Bureau of Indian Affairs administrative districts and numbered 15-minute quadrangles within each district (fig. 2). Well numbers consist of two main parts. The first part is a numeral that designates the Bureau of Indian Affairs' district and either

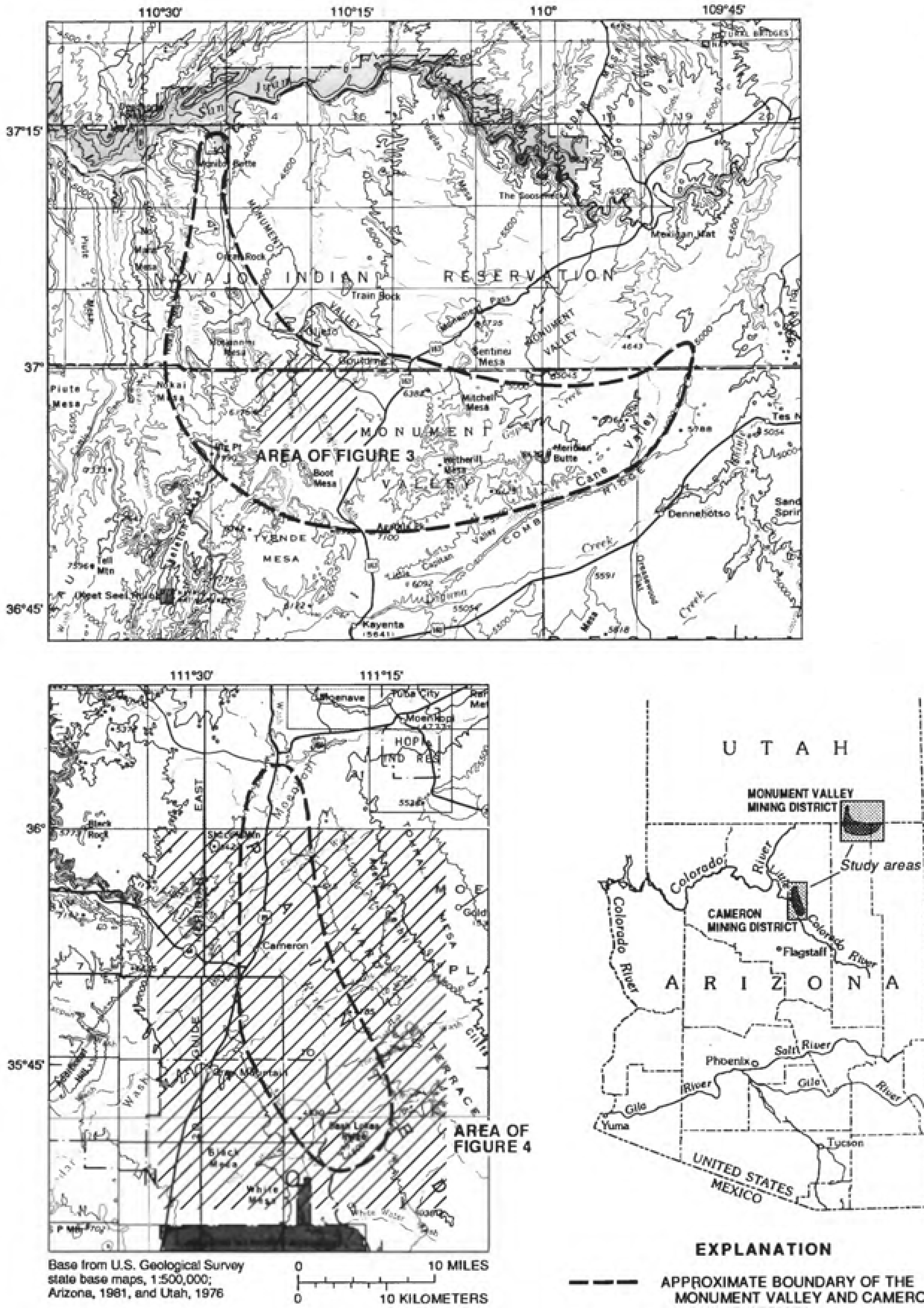


Figure 1. Location of study areas and Monument Valley and Cameron mining districts.

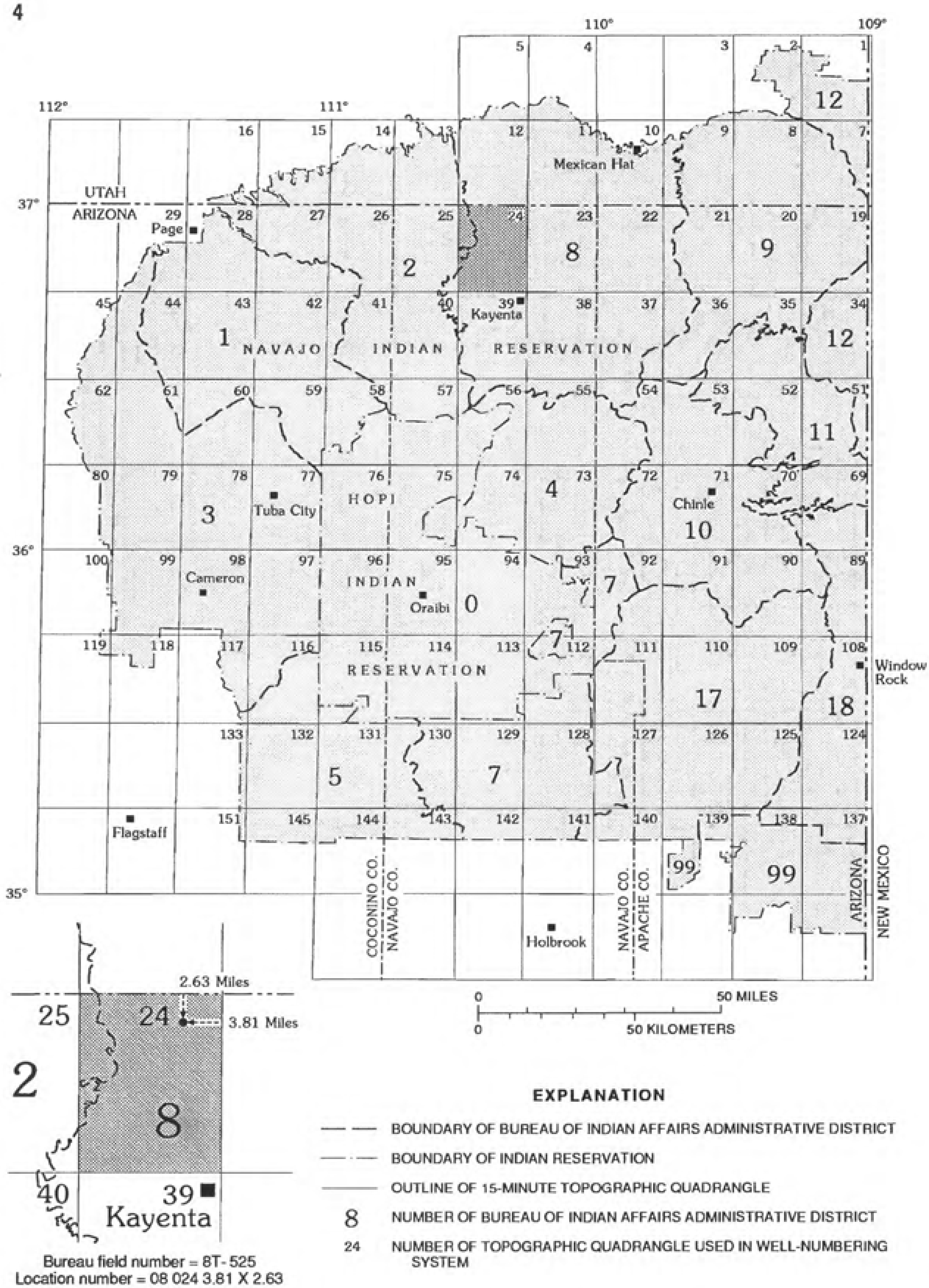


Figure 2. Bureau of Indian Affairs administrative districts, 15-minute quadrangles, and well-numbering system.

a "K," "T," or another letter identifying the source of funds used in the drilling of the well; for new wells and inventories made before 1950, the first letter of the last name of the person who first inventoried the well or spring for the Bureau. The letter "K" is used for wells drilled under the Bureau's drilling program, and the letter "T" is used for wells drilled under the Navajo Tribal Well-Development Program. The second part of the Bureau field number represents the order in which the drilled wells, dug wells, and springs were inventoried in each district. Additional letters used at the end of some designations are obtained from the number of a nearby development that was inventoried previously. These letters are arranged consecutively, beginning with "A."

The location number for wells and springs indicates the position within a 15-minute quadrangle (fig. 2). The three-part number consists of the number of the quadrangle, the distance in miles west of the northeast corner, and the distance in miles south of the northeast corner.

Physiographic Setting

Monument Valley lies along the Arizona-Utah border within the Colorado Plateau but lacks distinct geographical boundaries. The Monument Valley mining district generally extends from near Cane Valley in Arizona on the east to Nokai Mesa on the west and from the San Juan River in southeastern Utah on the north to near Agathla Peak on the south (fig. 1). Differential erosion of nearly horizontal rock layers has formed many canyons, mesas, and monuments. Ephemeral streams drain the valley and are tributary to the San Juan River, which flows from north of the study area to the southwest. Land-surface altitudes in the district range from about 4,700 ft above sea level in Cane Valley to about 6,700 ft on Hoskinnini Mesa in the western part of the district. Annual rainfall was found to be related to altitude and orographic effects (Cooley and others, 1969). Within the mining district, rainfall probably ranges from less than 6 in./yr at the lower altitudes of canyon bottoms to more than 10 in./yr at altitudes of more than 6,000 ft. Long-term weather stations have not been established within the district. Land in Monument Valley is used by the inhabitants for sheep grazing and tourism. Vegetation consists of sparse grasses and desert shrubs at lower altitudes and pinyon-juniper forests at higher altitudes.

The Cameron mining district extends from about 19 mi southeast of Cameron along the Little Colorado River to about 14 mi north along U.S. Highways 89 and 164 (fig. 1). The district is about 8 mi wide along the Little Colorado River and about 4 mi wide north of Cameron. Ward Terrace is a broad sloping ridge along the northeast and east edge of the district and was formed from erosion of sandstone and limestone. Between Ward Terrace and the Little Colorado River are small hummocky hills and gently sloping topography formed from erosion of less resistant rocks. This area is part of the Painted Desert, known for its multicolored bands of rock outcrops. The Moenkopi Wash drains the northern part of the district and is the largest tributary of the Little Colorado River within the district, flowing into the Little Colorado River approximately 3 mi northwest of Cameron. The Little Colorado River channel is broad and shallow in the southeastern part of the district but forms a more narrow, steep canyon downstream near Cameron. The river flows intermittently northwestward across the district and joins the Colorado River in the Grand Canyon. Land-surface altitudes in the district range from less than 4,100 ft at the Little Colorado River northwest of Cameron to about 5,400 ft on Shadow Mountain north of Cameron. Rainfall probably ranges from 6 to 9 in./yr on the basis of differences in land-surface altitudes within the district (Cooley and others, 1969). Long-term weather stations have not been established within the district.

Geologic Setting

Consolidated rocks exposed in the Monument Valley and Cameron areas of the Colorado Plateau are primarily flat-lying sedimentary units ranging in age from Permian to Jurassic. The units are underlain by basement rocks of Precambrian to Permian age that are 2,000 to 7,000 ft below land surface and that crop out outside the study area on the Defiance Plateau, in the Zuni Mountains, and in the Grand Canyon (Cooley and others, 1969, p. 10) about 80 mi southwest of Monument Valley. The sedimentary rocks consist of mudstone, siltstone, sandstone, limestone, conglomerate, coal, and gypsum. Mudstone and siltstone are the most abundant rock types and occur throughout the stratigraphic column. Cooley and others (1969, p. 11) stated that small amounts of gypsum may be present in much of the stratigraphic column. The Shinarump and Petrified Forest Members of the Chinle Formation of Triassic age are important sources of uranium in the Monument Valley and Cameron areas. Tertiary igneous rocks occur as dikes, volcanic plugs, and breccia pipes in the central and eastern parts of the Monument Valley area. Quaternary deposits in the Monument Valley and Cameron areas include dune sand, terrace deposits, and alluvium that overlie the consolidated sedimentary rocks. Lava flows and cinder cones of Quaternary age are present as surface features in the northwestern and western parts of the Cameron area. Large-scale folding, uplifts, and normal faulting have tilted the strata in some areas.

The Monument Valley section of the Colorado Plateau was uplifted during the Late Cretaceous and early Tertiary periods, forming the Monument upwarp, a broad flattened anticline that trends north and south and extends from north of the study area in the Cataract Canyon region of southern Utah to the southern part of Monument Valley in Arizona (Witkind and Thaden, 1963, p. 62). The east flank of the upwarp in this area is marked by Comb Ridge. Subordinate structural elements near the crest of the upwarp are the Organ Rock Anticline, Oljeto Syncline, Agathla Anticline, Tse Biyi Syncline, and Gypsum Creek Dome (Baker, 1936, p. 66-68; Witkind and Thaden, 1963, p. 62-64). Rock units in the west-central part of Monument Valley near the Moonlight and Radium Hill mines are part of the east flank of the Oljeto Syncline. The axis of the syncline approximately follows Oljeto Wash in the Utah and Arizona parts of Monument Valley and follows the west edge of Tynde Mesa beyond the southern extent of Oljeto Wash in Arizona (fig. 1). Rock units on the west flank of the syncline dip eastward at a maximum of 35° and form the east flank of the Organ Rock Anticline. Rock units dip only about 3° to the west on the east flank of the syncline (Witkind and Thaden, 1963, p. 63).

Rocks in the Cameron area generally dip from about 1° to 11° to the northeast. The area lies northeast of the East Kaibab Monocline and southwest of the Black Mesa basin in Arizona. Strata near Shadow Mountain in the northwestern part of the study area are tilted by three small structures—a syncline, anticline, and monocline. The syncline and anticline trend northeastward, and the monocline trends north-northwestward. The faults within the mining district are oriented in directions parallel to the folds.

Mining History

Uranium was discovered in Monument Valley in 1942 and in the Cameron area in 1950. In 1942, the Vanadium Corporation of America began leasing two parcels of land in the Monument Valley area for extracting vanadium ore (Witkind and Thaden, 1963,

p. 68). The parcels contained paleochannels filled with Shinarump deposits and would later be the sites of the Monument No. 1 and Monument No. 2 mines. In 1948, a rich vanadium-uranium deposit was discovered at the Monument No. 2 mine, and production increased as uranium became important (Witkind and Thaden, 1963, p. 69; Chenoweth and Malan, 1973, p. 139). Other deposits were discovered in the late 1940's and early 1950's in Shinarump channels exposed at rim outcrops (Chenoweth and Malan, 1973, p. 139). Between 1955, which was the largest production year, and 1969 when mining ceased, 1,362,000 tons of vanadium-uranium ore was produced from 53 sites in Monument Valley (Chenoweth and Malan, 1973, p. 140). The ore at these sites averaged 0.32 percent U_3O_8, a stable uranium-oxide, and contained 8,730,000 lbs of U_3O_8. Adits and open pits were used for mining shallow deposits, and shafts and inclines were used to reach deeper ore. The ore bodies ranged from a few feet to a few hundred feet long and from less than 1 foot to 12 feet thick. Uranium ore at the Moonlight Mine and other important uranium deposits were discovered in buried channels in the central part of Monument Valley in 1955 and 1956.

In 1950, in the Cameron area, uranium was found in the Kayenta Formation of Jurassic age, which led to further prospecting of the entire area. A Navajo prospector discovered the first commercially significant ore deposit in 1952 within the Petrified Forest Member of the Chinle Formation. Continued surface prospecting supplemented by airborne radiometric surveying identified additional deposits in 1953. As mining developed, shallow exploratory drilling encountered deposits that had no surface expression (Chenoweth and Malan, 1973, p. 141). Shallow deposits were mined by open pits or underground methods. Shafts were used at four sites. Production from these mines reached a peak in 1957 and gradually declined until mining ceased in 1963. During this period, 289,300 tons of ore containing 1,211,800 lbs of U_3O_8 were produced from 98 separate sites. Most of the uranium production came from the 67 ore deposits in the lower part of the Petrified Forest Member. Additional production came from 27 deposits in the sandstone and siltstone member of the Chinle Formation, 3 deposits in the Kayenta Formation, and 1 deposit within a breccia pipe in the Moenkopi Formation. Ore bodies ranged in size from a single fossilized log to a nearly continuous body 450 ft by 300 ft (Chenoweth and Malan, 1973, p. 141).

DESCRIPTION OF STUDY SITES

Two mines in the Monument Valley mining district and six mines in the Cameron mining district were studied during 1991 and 1992. Mines were selected for study on the basis of environmental factors. Initial investigations were at open pits that presented the highest potential health hazard, contained water, and were accessible to personnel and equipment. Some of the selected pits in the Cameron area, however, were dry during field visits. Additional sites were planned for study in the Cameron area, but shallow ground-water samples could not be collected at most sites with available equipment. Water samples also were collected at three existing wells and three spring boxes (springs improved with concrete cisterns and hand pumps; table 1). Site data for shallow wells, mine drill holes, wells, and auger holes and depths to ground water are presented in table 2. Data collected by the USGS before this study in the Cameron area also were used in the study.

Monument Valley Area

Data were collected in the Monument Valley mining district from the Moonlight and Radium Hill mines. The Moonlight mine is in the west-central part of Monument Valley,

Table 1. Site information and water and spoil-material sample types, Monument Valley and Cameron mining districts

[Laboratory analysis codes: C, chemical; B, batch leachate; P, particle size; M, mineralogical. Dashes indicate no data]

Site name and sample identification (figs. 3 and 4, tables 3-8)	Latitude-longitude	Source	Land surface altitude (feet above sea level)	Sample type and laboratory analysis: Mine sites: Pit water	Mine sites: Shallow ground water	Mine sites: Spoil material	Ground water from wells and springs
Monument Valley mining district							
Moonlight mine							
(MVD-1)	36°57′44″ 110°17′05″	Shallow well	[1]5,070		C		
(MVD-2)		Shallow well	[1]5,070		C		
(MVSW-1)		Open pit	[1]5,070	C			
(MVS-1 to MVS-4)		Spoil pile	--------			B	
(MVS-P1 to MVS-P4)		Spoil pile	--------			P	
Radium Hill mine			--------				
(Radium Hill)	37°00′08″ 110°18′37″	Mine drill hole	[2]5,245		C		
(RHS-1)		Spoil pile	--------			B	
(RHS-P1)		Spoil pile	--------			P	
(RHM-1)		Spoil pile	--------			M	
08 024-03.81X02.63 (8T-525)	36°57′41″ 110°19′07″	Well	[1]5,026				C,B
08 024-02.27X03.65 (8K-433)	36°56′50″ 110°17′29″	Well	[1]5,100	Depth-to-water measurement only			
Unnamed 6-inch well near El Capitan Wash	36°57′20″ 110°18′33″	Well	[2]5,040	Depth-to-water measurement only			
Unnamed 4-inch well near El Capitan Wash	36°56′15″ 110°17′37″	Well	[2]5,090	Depth-to-water measurement only			
Unnamed mine drill hole near well 8K-433	36°56′52″ 110°17′17″	Mine drill hole	[2]5,140	Depth-to-water measurement only			

See footnotes at end of table.

Table 1. Site information and water and spoil-material sample types, Monument Valley and Cameron mining districts—Continued

Site name and sample identification (figs. 3 and 4, tables 3-8)	Latitude-longitude	Source	Land surface altitude (feet above sea level)	Sample type and laboratory analysis			
				Mine sites			Ground water from wells and springs
				Pit water	Shallow ground water	Spoil material	
Cameron mining district							
Jeepster No. 1 mine							
(JSW-1)		Open pit	[3]4,225	C			
(JS-1 to JS-4)	35°56′38″ 111°24′02″	Spoil pile	--------			B	
(JS-P1 to JS-P4)		Spoil pile	--------			P	
(JSM-1)		Spoil pile	--------			M	
(Auger hole)		Auger hole	[3]4,225		Depth-to-water measurement only		
Jack Daniels mine							
(JDD-1)		Shallow well	[3]4,190		C		
(JDSW-1)	35°54′21″ 111°24′01″	Open pit	[3]4,190	C			
(JDS-1 to JDS-4)		Spoil pile	--------			B	
(JDS-P1 to JDS-P4)		Spoil pile	--------			P	
(JDM-1)		Spoil pile	--------			M	
Manuel Denetsone No. 2 mine (M.D.-45)	35°50′27″ 111°21′06″	Mine drill hole	[3]4,159		C		
Ramco No. 20 mine (Ramco No. 20 NW)	35°44′16″ 111°17′54″	Open pit	[3]4,211	C			
03 098-05.03X08.25 (Clay Well spring)	35°52′28″ 111°20′21″	Spring box	[2]4,220				C
03 117-02.67X05.77 (Yellow Spring)	35°39′53″ 111°17′51″	Spring box	[2]4,465				C
03 098-07.70X09.60 (Little Colorado Spring)	35°51′42″ 111°23′43″	Spring box	[2]4,160				C

See footnotes at end of table.

Table 1. Site information and water and spoil-material sample types, Monument Valley and Cameron mining districts—Continued

Site name and sample identification (figs. 3 and 4, tables 3-8)	Latitude-longitude	Source	Land surface altitude (feet above sea level)	Sample type and laboratory analysis: Mine sites: Pit water	Mine sites: Shallow ground water	Mine sites: Spoil material	Ground water from wells and springs
Cameron mining district—Continued							
03 098-06.07X11.16 (3T-539)	35°50′15″ 111°21′18″	Well	[1]4,161				C
03 098-08.46X07.21 (Arizona Inspection Station well)	35°54′01″ 111°24′09″	Well	[2]4,185				C,B
Juan Horse No. 3 mine (Auger hole)	35°51′44″ 111°21′57″	Auger hole	[3]4,108	Depth-to-water measurement only			
Juan Horse No. 4 mine (Auger hole)	35°51′16″ 111°21′38″	Auger hole	[3]4,108	Depth-to-water measurement only			
Farm Project "A" well 03 098-07.40X10.40 (FPA)	35°50′57″ 111°22′32″	Well	[2]4,138	Depth-to-water measurement only			
03 117-01.65X04.76 (Balokai Spring)	35°40′51″ 111°16′46″	Spring box	[2]4,458				C
Yazzie No. 312 mine (Yazzie No. 312)	35°52′20″ 111°22′20″	Open pit	[2]4,150	C			

[1] Surveyed.
[2] Determined from U.S. Geological Survey topographic map.
[3] Determined from Navajo Nation Abandoned Mine Lands Reclamation Department topographic map.

Arizona, about 1.8 mi east of the junction of El Capitan and Oljeto Washes (fig. 3 and table 1). The site includes two spoil piles and an oval-shaped pit approximately 750 ft long by 525 ft wide and 134 ft deep. The land-surface altitude is approximately 5,200 ft at the pit rim and 5,066 ft at the pit bottom. Uranium ore was mined from a paleochannel in the Shinarump Member that was cut into the underlying Moenkopi Formation and from the upper 15 ft of the Moenkopi Formation (Malan, 1968, p. 799). Ground water was seeping into the pit during mine inspections made between 1957 and 1967 (C.M. McConnell and L.G. Anderson, engineers, U.S. Geological Survey, written communs., 1957, 1958, 1967). During field investigation for this study, about 5,000 ft^2 of the pit bottom was covered with as much as 4 ft of water.

The Radium Hill mine in Utah is about 3 mi northeast of the Moonlight mine (fig. 3) and consists of a drill hole approximately 2 ft in

Table 2. Site data for shallow wells, mine drill holes, wells, and auger holes and depths to ground water, Monument Valley and Cameron mining districts

[X, open hole; ?, unknown]

Site name (field identification; figs. 3 and 4, tables 3-8)	Site type	Depth of hole (feet below land surface)	Open interval [screen or perforations (feet below land surface)]	Date depth to ground water measured	Depth to ground water (feet below land surface)
Monument Valley mining district					
Moonlight mine					
(MVD-1)	Shallow well	1.7	0.7-1.7	10-15-91	0.4
(MVD-2)	Shallow well	1.9	.9-1.9	10-16-91	.2
Radium Hill mine					
(Radium Hill)	Mine drill hole	96	X	10-17-91	86.8
08 024-03.81X02.63 (8T-525)	Well	383	17-81 248-383	10-17-91	Flowing
08 024-02.27X03.65 (8K-433)	Well	46	32-38	10-17-91	15.8
Unnamed 6-inch well near El Capitan Wash	Well	151	?	10-17-91	9.8
Unnamed 4-inch well near El Capitan Wash	Well	145	?	10-17-91	5.8
Unnamed drill hole near well 8K-433	Mine drill hole	156	X	10-17-91	56.2
Cameron mining district					
Jeepster No. 1 mine (auger hole)	Auger hole	7.0	X	10-31-91	3.5
Jack Daniels mine (JDD-1)	Auger hole	7.8	X	11-01-91	6.5
Manuel Denetsone No. 2 mine (M.D.-45)	Mine drill hole	33	X	11-02-91	16.3
03 098-06.07X11.16 (3T-539)	Well	188	81-188	11-02-91	24.1

Table 2. Site data for shallow wells, mine drill holes, wells, and auger holes and depths to ground water, Monument Valley and Cameron mining districts—Continued

Site name (field identification) (figs. 3 and 4, tables 3-8)	Site type	Depth of hole (feet below land surface)	Open interval [screen or perforations (feet below land surface)]	Date depth to ground water measured	Depth to ground water (feet below land surface)
Cameron mining district—Continued					
03 098-08.46X07.21 (Arizona Inspection Station well)	Well	50	?	11-02-91	23.8
Juan Horse No. 3 mine (auger hole)	Auger hole	9.1	X	11-05-91	7.3
Juan Horse No. 4 mine (auger hole)	Auger hole	12.4	X	11-04-91	9.2
Farm Project "A" well 03 098-07.04X10.40 (FPA)	Well	54	?	11-06-91	12.6

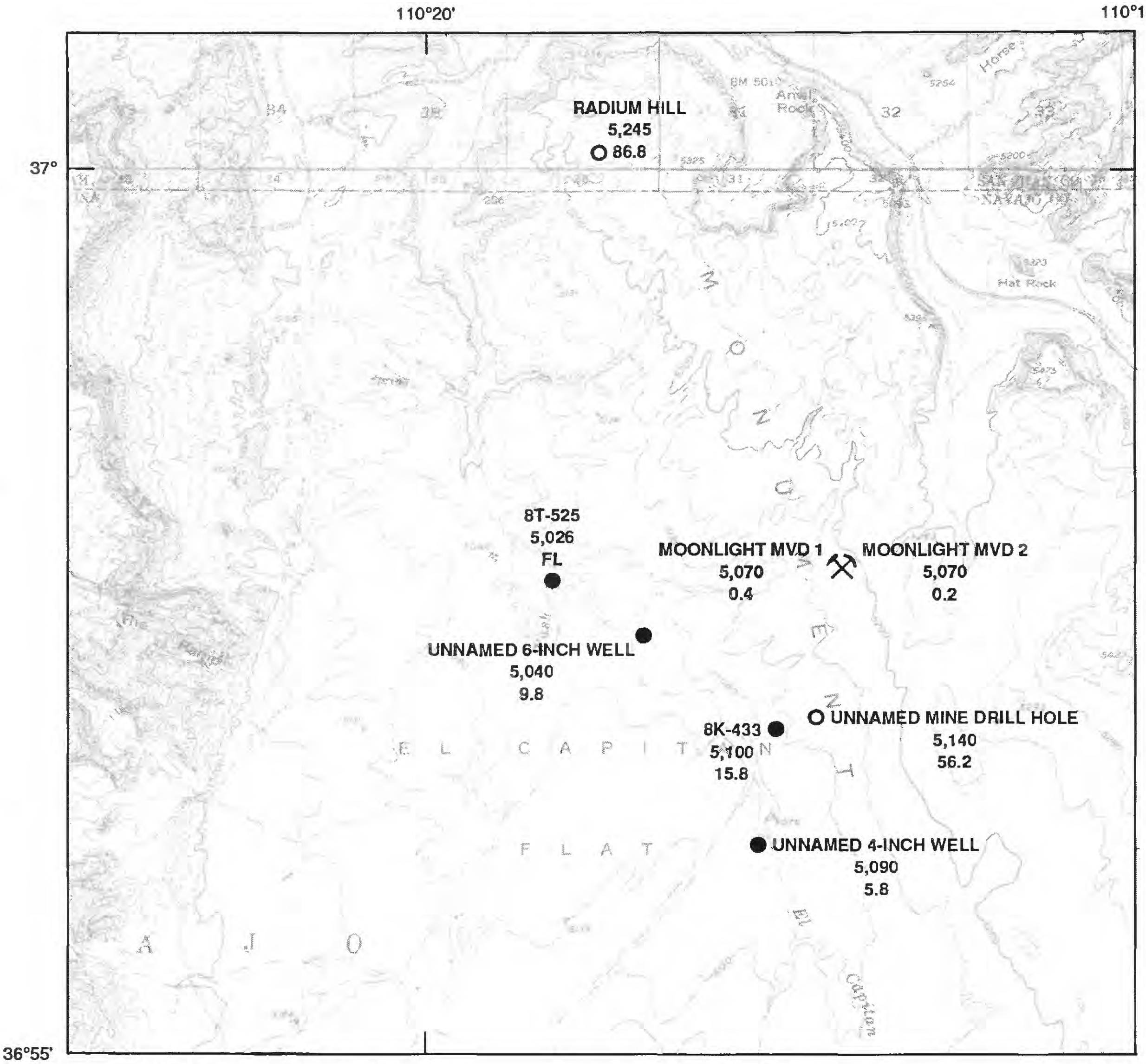
diameter and 96 ft deep, five spoil piles, and an inclined shaft. Uranium ore was extracted at the mine from one or more paleochannels in the Shinarump Member. The depth and lateral extent of the channel or channels were not determined.

Ground-water samples were collected from well 8T-525 (08 024-03.81X02.63), approximately 1.8 mi west of the Moonlight Mine near the junction of El Capitan and Oljeto Washes (fig. 3), for laboratory chemical analysis and for use in laboratory-batch tests. The well was drilled to a depth of 383 ft; however, measurements during this study indicated an obstruction or casing collapse at 82 ft. Ground water near the well is under artesian conditions and flows out of the casing at land surface. Depth to water was measured in well 8K-433 (08 024-02.10X3.00), in two abandoned wells along El Capitan Wash, and in an unnamed mine drill hole (fig. 3 and table 2). Well 8K-433 is about 1.1 mi south of the Moonlight Mine and supplies water to a stock tank.

Cameron Area

Data were collected from the Jeepster No. 1 mine about 4.7 mi north of Cameron and approximately 300 ft west of U.S. Highway 89 (fig. 4 and table 1). The mine consists of an elliptical pit approximately 200 ft wide at the north end, 80 ft wide at the south end, and 700 ft long. Spoil materials are in two piles on the ground near the south end of the pit. During mining operations, uranium ore was extracted from as deep as 60 ft below land surface in a carbonaceous sandstone lens within the Petrified Forest Member of the Chinle Formation (Scarborough, 1981, p. 153). About 15 ft of sediment has accumulated in the northern part of the pit since the cessation of mining in 1957. Loose surface material has been transported into the pit by wind and by rainfall runoff entering the south end of the pit along the access ramp.

The Jack Daniels mine is about 2.2 mi north of Cameron and about 850 ft east of U.S. Highway 89. The site consists of one main pit



Base from U.S. Geological Survey 1:62,500
Boot Mesa, 1952, and Oljeto, 1952

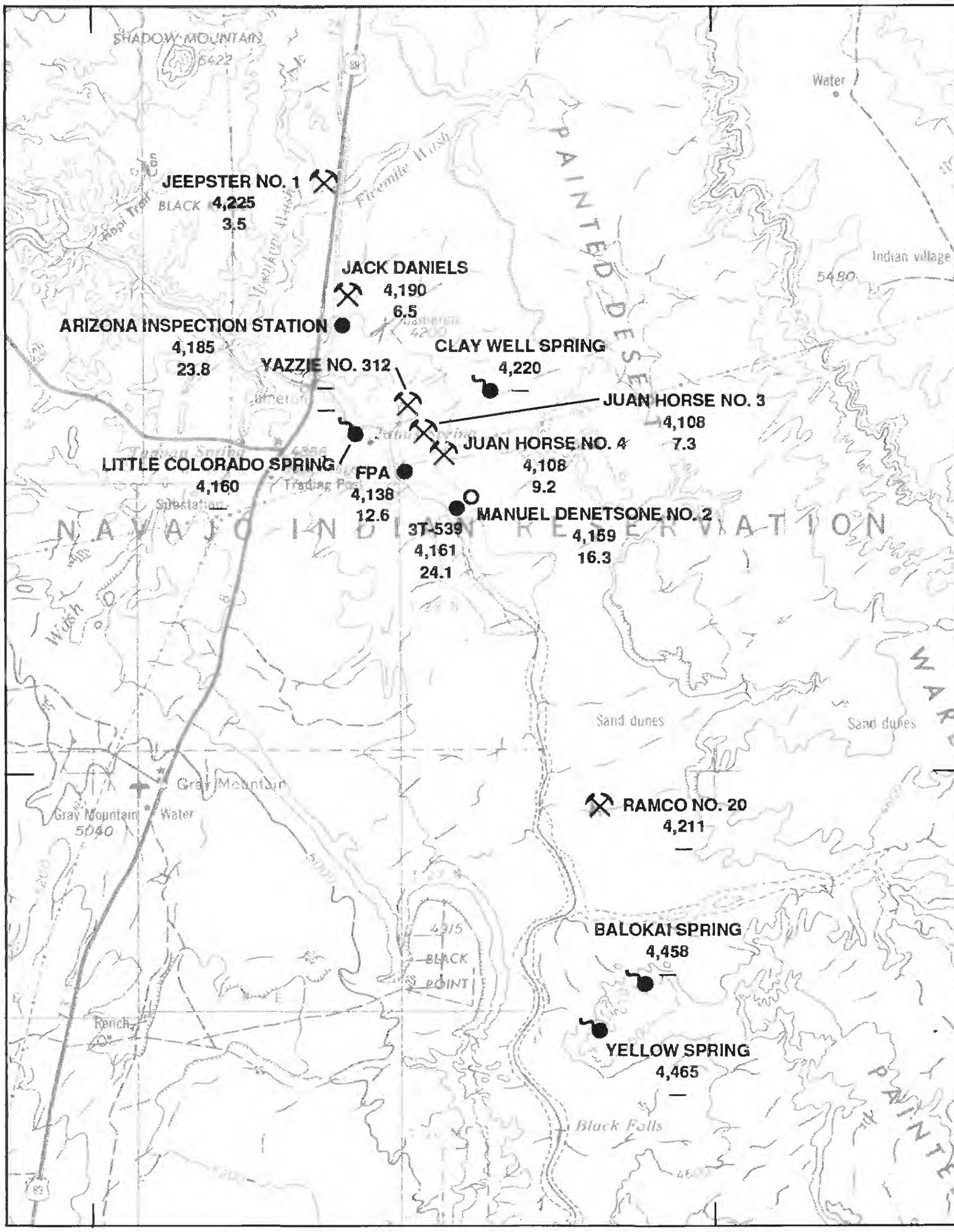
0 1 2 3 MILES

0 1 2 3 KILOMETERS

EXPLANATION

8K-433 5,100 15.8	MEASUREMENT SITE—First entry is site name; second entry is altitude of land surface, in feet above sea level; third entry, is depth to water, in feet below land surface; **FL**, flowing
●	WELL
○	MINE DRILL HOLE
⚒	OPEN-PIT MINE—Depth to water measured through shallow well

Figure 3. Depth to water and altitude of land surface for selected wells and mines in the Monument Valley mining district.



Base from U.S. Geological Survey 1:250,000
Flagstaff, 1954-70

0 — 10 MILES
0 — 10 KILOMETERS

EXPLANATION

3T-539
4,161
24.1 MEASUREMENT SITE—First entry is site name; second entry is altitude of land surface, in feet above sea level; third entry is depth to water, in feet below land surface; dash indicates no data

● WELL

SPRING

O MINE DRILL HOLE

OPEN-PIT MINE—Depth to water measured through auger hole

Figure 4. Depth to water and altitude of land surface for selected wells, springs, and mines in the Cameron mining district.

and several smaller bulldozer cuts and scrapings that produced ore from five mining claims (Scarborough, 1981, p. 151). The main pit is approximately 450 ft by 250 ft and was about 26 ft deep during mining operations. Uranium ore was mined from a sandstone and siltstone channel near the base of the Petrified Forest Member (Scarborough, 1981, p. 151). During field investigation in 1991, the pit was only 10 to 15 ft deep as a result of an influx of surface sediments since mining ceased in 1962 or 1963. Sediment transported by rainfall runoff may enter the pit through present channels eroded into the west, south, and east sides. Spoil material was placed in at least eight piles on the north, east, and south sides of the pit.

The Manuel Denetsone No. 2 mine is about 4.2 mi southeast of Cameron and 0.5 mi east of the Little Colorado River. The site consists of a main shaft filled with sediment and three open drill holes approximately 2 ft in diameter. Measured depth of the drill hole sampled for this study was 33 ft; however, the hole may have been obstructed or partially caved. Uranium ore was mined at this site from discontinuous, mineralized lenses in carbonaceous sandstone of the Petrified Forest Member (Scarborough, 1981, p. 154).

The Ramco No. 20 mine is about 12 mi southeast of Cameron and about 1.3 mi east of the Little Colorado River. The main pit at this site is part of three mining claims and is about 200 ft by 2,200 ft and about 70 ft deep. The Ramco No. 20 site contains several spoil piles and two smaller pits that are about 200 ft by 400 ft and about 3 to 4 ft deep. Uranium ore was mined in the larger pit from an east- to northeast-trending channel-fill deposit in the Petrified Forest Member (Scarborough, 1981, p. 159). The smaller pits may have resulted from surface scrapings of scour and fill channels also in the Petrified Forest Member and probably were deeper during active mining operations. Water from the small pit on the west edge of the mining property was collected and analyzed for this study. The larger pit did not contain surface water during the field investigation.

The Juan Horse No. 3 and Juan Horse No. 4 mine pits (fig. 4) did not contain surface water during the study period. Uranium ore was mined at these sites from carbonaceous sandstone in the basal part of the Petrified Forest Member of the Chinle Formation (Scarborough, 1981, p. 153).

Data also were collected from existing wells and springs in the Cameron area (fig. 4). Samples were obtained from the Arizona Inspection Station well (03 098-08.46X07.21), well 3T-539 (03 098-06.07X11.16), Yellow Spring (03 117-02.67X05.77), Little Colorado Spring (03 098-07.70X09.60), and Clay Well spring (03 098-05.03X08.25). The Arizona Inspection Station well is about 1.8 mi north of Cameron and 0.35 mi southwest of the Jack Daniels mine. The well is 50 ft deep and supplies water to the Arizona Inspection Station on U.S. Highway 89. The length of the steel well casing is not known. Well 3T-539 is approximately 4.1 mi southeast of Cameron and 0.22 mi east of the Little Colorado River. The well is 188 ft deep, and the steel casing is perforated from 81 to 188 ft. A wind-powered piston pump in the well supplies water to a stock tank. Little Colorado Spring is near the south bank of the Little Colorado River about 1.7 mi southeast of Cameron, Yellow Spring is near the Baah Lokaa Ridge about 16 mi southeast of Cameron, and Clay Well spring is about 4 mi east of Cameron along a wash tributary to the Little Colorado River. The springs were improved by construction of concrete cisterns and hand pumps and are used to supply water to local residents. Depth to water was measured in well 3T-539, the Arizona Inspection Station well, and the unused Farm Project "A" well (03 098-07.04X10.40; fig. 4 and table 2).

Data were collected before this study in 1988 from the Clay Well spring, Yellow Spring, Little Colorado Spring, well 3T-539, Balokai Spring (03 117-1.65X04.76), and the open pit at the Yazzie No. 312 mine (table 1). Balokai Spring, also known as Lee Well, is about 15.5 mi southeast of Cameron and also is an improved spring used by local people. The Yazzie No. 312 mine is about 2.2 mi east of Cameron and about 0.7 mi north of the Juan Horse No. 3 mine.

METHODS OF INVESTIGATION

Sample collection and laboratory analyses were designed to characterize the chemical composition of the shallow ground water and mine water and to approximate the degree of post-reclamation leaching of radionuclides from spoil materials into the shallow ground water. Samples of shallow ground water and mine water were collected and analyzed, and spoil materials were collected and combined in laboratory-batch tests with ground-water samples from two wells that were assumed to be unaffected by mining activity (table 1 and figs. 3 and 4). Additional spoil material was collected for particle-size and mineralogical analyses. Depth to water was measured in hand-augered holes, shallow wells, mine drill holes, and existing wells. Land-surface altitudes were determined from survey and level data, from NAMLRD 1-foot contour-interval topographic maps, or from USGS 7.5-minute topographic maps. Surface gamma activity was monitored at all mines using a hand-held gamma meter.

Water-chemistry data were used to define the areal variability in radionuclide activities and concentrations of other constituents. Laboratory-batch tests provided data on chemical interactions of spoil material and shallow ground water that may occur following mine reclamation. Mineralogical analyses of spoil materials were used to characterize lithology and identify possible mineralogic constraints on radionuclide leaching. Depth to water was measured to characterize hydraulic connections between shallow ground water and abandoned mines and to define ground-water flow directions.

Field Methods

Field data and water samples were collected from shallow wells, pits and drill holes at mines, and existing wells and springs. Ground-water samples were collected at mines through 1.38-inch-diameter stainless-steel shallow wells. The shallow wells were hand-driven from the ground surface or from the bottom of a 3-inch-diameter hand-augered hole to the desired depth. Samples of shallow ground water could not be collected at the Jeepster No. 1, Juan Horse No. 3, or Juan Horse No. 4 mines because the shallow-well screens became clogged by silt and clay in the pit sediments. Ground-water samples were collected from mine drill holes using a polyvinyl chloride (PVC) bailer or a peristaltic pump. Pit-water samples were collected using a peristaltic pump. Water samples were collected from two existing wells using wind- or electric-powered in-well pumps, and water samples from the flowing well and from spring boxes were collected using a peristaltic pump. Depths to water in hand-augered holes, shallow wells, and existing wells were measured using a calibrated steel tape.

Water samples generally were collected after field measurements of temperature, pH, specific conductance, and dissolved-oxygen concentration had stabilized. Raw samples were collected for laboratory pH, specific conductance, and radon analyses; additional samples were filtered on site for alkalinity determinations and dissolved-constituent analyses. Samples for radon analyses were collected at three sites. Pit-water samples from the Jack Daniels and Ramco No. 20 mines had to be centrifuged and filtered at the USGS office in Flagstaff, Arizona, because of large suspended-sediment concentrations. Field alkalinities were not determined for these samples because the samples were not filtered on site.

Water for laboratory-batch tests was collected from well 8T-525 in the Monument Valley area and from the Arizona Inspection Station well in the Cameron area. Sample containers were kept from prolonged exposure to light and excessive temperature variations during transport in order to reduce possible physical and chemical alterations.

Spoil material was collected from the Moonlight, Radium Hill, Jeepster No. 1, and Jack Daniels mines for laboratory-batch tests and particle-size analyses. At each site, gamma measurements were made on several parts of spoil piles to identify the range of natural radiation levels. Approximately 1.0 kg of spoil material was collected from each of three or four subareas and was used to represent the general lithologic composition of a pile or a range of radioactivity within the pile. Material was collected from about 6 to 12 in. below the surface of the piles to limit possible effects of weathering in batch tests. Gamma measurements were made on the surface of the pile and at sample depth. A portion of each of the representative spoil-material samples was split out and collected for particle-size analyses. The remaining material was passed through a No. 10 mesh-size (2.00-mm opening) brass sieve and collected in each of two preweighed, acid-rinsed bottles for use in batch tests. At three of the mines, a portion of spoil material was collected from each representative sample before sieving for mineralogical analyses.

Laboratory Methods

Laboratory work included mixing of water and spoil materials and preparation of leachate samples (batch tests), physical and chemical analyses of water, and particle-size and mineralogical analyses of spoil materials. The batch tests for this study were modified from method D 4319 of the American Society for Testing and Materials (ASTM, 1990). The ASTM test is used to determine the rate at which chemical species in an aquifer travel with respect to the advancing front of ground water. The test can be used to determine distribution ratios of specific chemical species, which then can be used to estimate distribution coefficients for given geochemical conditions. Only ion exchange and adsorption processes within granular porous media, however, are considered in application of the ASTM test. Other important processes that may retard the flow of chemical species relative to ground-water flow include complex formation, precipitation or coprecipitation, oxidation-reduction reactions, and precipitate filtration. Also, because it is a short-term test, the attainment of equilibrium is not presumed. In this study, the test was modified and used to provide an approximation of radionuclide leaching from spoil material after contact with shallow ground water. All requirements of the ASTM test were not met in the modified version because of substantial costs inherent in obtaining advanced equipment and analytical expertise and because the chemical species of concern were components of the solid material rather than the fluid. Only the fraction of spoil material 2.00 mm (millimeter) in diameter and smaller was used in the batch tests because this material presents a large surface area per volume and should provide the greatest potential for radionuclide leaching. Distribution ratios and distribution coefficients were not calculated from the test results.

Laboratory-batch tests and particle-size analyses of spoil material were done at the Chemistry Laboratory of the New Mexico Bureau of Mines and Mineral Resources (NMBMMR) in Socorro, New Mexico. Batch-test procedures consisted of measuring physical and chemical characteristics of the water, combining spoil material with water, agitating the water and spoil mixtures for a predetermined period, measuring physical and chemical characteristics of the material mixtures, and collecting leachate for chemical analyses. Temperature, specific conductance, pH, and carbonate and bicarbonate alkalinity were measured in the water before it was mixed with the spoil material and in the water and spoil-material mixture after the agitation period. Water was combined with the spoil material at a 4-to-1 ratio by weight. For each sample, 2.5 L (liter) of water and 0.625 kg of spoil material were placed into each of two 3-liter Nalgene bottles and the contents stirred thoroughly. The bottles were placed on a rolling device for 12 hours of agitation, then removed to allow the contents to settle for 60 hours. The leachate was centrifuged and passed through a 0.45-micrometer pore-size polycarbonate filter, collected in bottles, and preserved with acid.

Water samples were analyzed at the USGS National Water Quality Laboratory (NWQL) in Arvada, Colorado, and at the International Technology Corporation Laboratory (ITCL) in Richland, Washington. Radiochemical analyses were done at the ITCL, and the remaining analyses were done at the NWQL. Analytical methods used by the NWQL are discussed by Fishman and Friedman (1989). Analytical methods used by the ITCL have been approved by the U.S. Environmental Protection Agency (USEPA).

The NMBMMR also analyzed spoil material for particle-size distribution. Weight percentages were determined of material smaller than 62 μm (micrometers) in diameter, material from 62 μm to 2.00 mm in diameter, and material larger than 2.00 mm in diameter. The range of particle sizes for each sample site provides a general character of the material that will be used in mine reclamation.

Mineralogical analyses of spoil material were done at the USGS office in Sacramento, California. Analyses by X-ray diffractometry were done on spoil samples from three mines to determine major, minor, and trace minerals that made up at least 5 to 10 percent of the sample volume. A sample weighing less than 10 grams was used to compare diffractograms of the minerals present to prepared standards from known minerals. The diffractograms were then used to determine minerals present in each sample.

GEOHYDROLOGY

Monument Valley Area

The Monument Valley mining district lies within the Monument Valley hydrogeologic subdivision of the Navajo Indian Reservation, which is part of the Henry hydrologic basin (Cooley and others, 1969, p. 25 and 40). The Monument Valley subdivision is one of the driest and least favorable areas for development of ground-water supplies in the Navajo country because of the relative impermeability of the sedimentary rocks and because dissection has drained some of the former water-bearing units.

Geohydrologic Units

The consolidated sedimentary rocks in the Monument Valley area generally consist of eolian and fluvial deposits that, in some instances, alternate one with another, are light buff to deep reddish brown, and are about 5,000 ft thick (Witkind and Thaden, 1963, p. 6). The sedimentary rocks range in age from Permian to Jurassic and consist of the Cutler Formation, Moenkopi Formation, Chinle Formation, Glen Canyon Group, San Rafael Group, and Morrison Formation. The Shinarump Member of the Chinle Formation, the Moenkopi Formation, and the De Chelly Sandstone Member and Organ Rock Tongue of the Cutler Formation are part of the C aquifer system in the Monument Valley area (Levings and Farrar, 1977).

The Organ Rock Tongue is predominantly a reddish-brown poorly sorted siltstone with a few thin, very fine grained silty sandstone lenses near the base of the unit. In the upper 25 to 50 ft of the unit, the grain size changes and the unit becomes gradually coarser toward the contact. At the contact with the De Chelly Sandstone Member, the unit is a fine-grained sandstone. The Organ Rock Tongue is from about 670 to 700 ft thick in the Monument Valley area (Witkind and Thaden, 1963, p. 11).

The De Chelly Sandstone Member overlies the Organ Rock Tongue and is a crossbedded grayish-yellow to tan fine-grained sandstone that forms the main part of the monuments and larger mesas in the area. The De Chelly is poorly sorted and is weakly cemented by chalcedony, calcium carbonate, and iron oxide. The unit ranges in thickness from 300 to 550 ft and pinches out near Monitor Butte about 15 mi north of the Arizona-Utah border. In the western part of the Monument Valley area, the De Chelly is about 300 ft thick and decreases in thickness northward (Witkind and Thaden, 1963, p. 13).

The Hoskinnini Member forms the basal unit of the Moenkopi Formation and unconformably overlies the De Chelly Sandstone Member of the Cutler Formation. The unit consists of dark red very fine grained to fine-grained silty sandstone with varying amounts of medium- and coarse-grained sandstone in some beds. Overlying the Hoskinnini Member are the lower siltstone, middle sandstone, and upper siltstone members. The Moenkopi Formation is about 278 ft thick at one location near the San Juan River, about 150 ft thick in the central part of Monument Valley, and about 50 ft thick near Comb Ridge (Repenning and others, 1969, p. 9 and 12).

The Chinle Formation overlies the Moenkopi Formation and is the primary source of uranium ore in the Monument Valley area. The Chinle Formation in this area consists of, in ascending order, the Shinarump, Monitor Butte, Petrified Forest, Owl Rock, and Church Rock Members. Thickness of the Chinle Formation varies because of local thinning and wedging out of members and because of an uneven basal contact with the Moenkopi Formation (Repenning and others, 1969, p. 15; Witkind and Thaden, 1963, p. 21). The Shinarump Member in most areas is light tan to light gray and is composed of a basal conglomerate and an upper part that consists of varying amounts of sandstone, siltstone, and mudstone. The Shinarump probably averages about 75 ft in thickness in the Monument Valley area although it attains a maximum thickness of about 250 ft (Levings and Farrar, 1977). Basal deposits fill channels cut into the underlying Moenkopi Formation (Chenoweth and Malan, 1973, p. 139). These scour-and-fill sediments contain abundant amounts of silicified wood and fossilized plant matter (Chenoweth and Malan, 1973, p. 139; Witkind and Thaden, 1963, p. 23). The contact is marked by a zone of bleaching developed in the underlying Moenkopi Formation. The unit is resistant to weathering and forms a cap rock over older formations on many mesas and buttes.

Deposits of dune sand, alluvium, talus, and landslide blocks of Quaternary age cover large areas of bedrock in the Monument Valley area. Alluvium fills most of the stream washes and in some areas is covered by dune sand. The combined dune sand and alluvium thickness is between about 80 and 100 ft along Oljeto Wash (Witkind and Thaden, 1963, p. 50). Well 8P-331 (08 24-01.47X02.32), about 0.5 mi northwest of the Moonlight mine, penetrates 110 ft of alluvium (Levings and Farrar, 1977); however, this well could not be located during the study.

Occurrence of Ground Water

Although ground water may be found in the alluvium and in all the consolidated sedimentary rocks, it generally is available to wells only in the alluvium and in the relatively more permeable units of the C aquifer (Cooley and others, 1969, p. 7). The alluvium may yield more than 10 gal/min of water to wells. Within the C aquifer, the Shinarump Member may yield 5 to 10 gal/min, the De Chelly Sandstone Member may yield 5 gal/min, and the Organ Rock Tongue may yield 1 to 2 gal/min. The Moenkopi Formation generally does not yield water to wells (Levings and Farrar, 1977). Well 8K-433 is perforated in the Shinarump Member of the Chinle Formation and well 8T-525 is perforated both in the Shinarump and in the De Chelly Sandstone. The perforated or screened intervals in the two unnamed wells near El Capitan Wash are not known; however, the depths of the wells indicate they probably were drilled into the Shinarump. The unnamed mine drill hole near well 8K-433 probably terminates in the Shinarump.

Recharge to the alluvium and the C aquifer is directly from rainfall, from ephemeral streams, or from leakage from underlying water-bearing units (Cooley and others, 1969, p. 40). Alluvium and other surficial deposits are recharged by rainfall, by influent streams, and by discharge from the consolidated aquifers. Recharge to the C aquifer in outcrop areas occurs mostly through fractures and along bedding planes. High rates of evaporation and low permeabilities limit the amount of recharge in the nonfractured parts of the aquifer (Cooley and others, 1969, p. 41). In the area near the Moonlight and Radium Hill mines, ground water generally moves from the recharge areas toward the Oljeto and El Capitan Washes and then eventually flows north and discharges to the San Juan River (fig. 3). Water is withdrawn from domestic and stock wells.

Hydrology of Mines

Channel deposits of the Shinarump Member in the area of the Moonlight and Radium Hill mines generally are more permeable than the overlying Chinle Formation and underlying Moenkopi Formation and yield water to nearby wells. Reports from mine inspections indicate ground-water seepage into the Moonlight mine as early as 1957 (C.M. McConnell, engineer, U.S. Geological Survey, written commun., 1957). Ground-water seepage along the pit walls above the pit floor was not present during field investigation but may occur below the present water surface. Ground water may flow into the pit through permeable sediments, through fractures, or along bedding planes in the Moenkopi Formation, or through coarse sediments in the Shinarump Member (fig. 5). The contact between the Shinarump Member and the Moenkopi Formation was not mapped at the site during this study. Malan (1968) stated that ore extended downward as much as 15 ft into the Moenkopi.

The bottom of the pit at the Moonlight mine contains an unknown thickness of dark-gray to dark-brown unconsolidated sand, silt, and clay that probably is a mixture of material weathered from the pit walls and material transported from areas near the pit rim by wind and rainfall runoff. An access ramp leads into the pit from the west side of the rim but terminates about 60 ft from the pit floor along the west pit wall. The ramp is within an area that generally slopes westward from the pit; however, the ramp drains a small area between the two spoil piles that lie north of the ramp. Small drainage features have been incised into the ramp sediments at the upper part but do not extend along the entire ramp length. Records indicate that the pit was about 145 ft deep when the mine was in operation (Scarborough, 1981, p. 222). During field investigation, the floor of the pit at the south end was about 134 ft from the pit rim and about 3 to 4 ft lower than the floor at the north end. The maximum depth of water in the south end of the pit was about 4 ft in October 1991.

Depth to water and land-surface altitude at the Moonlight mine, at existing wells, and at

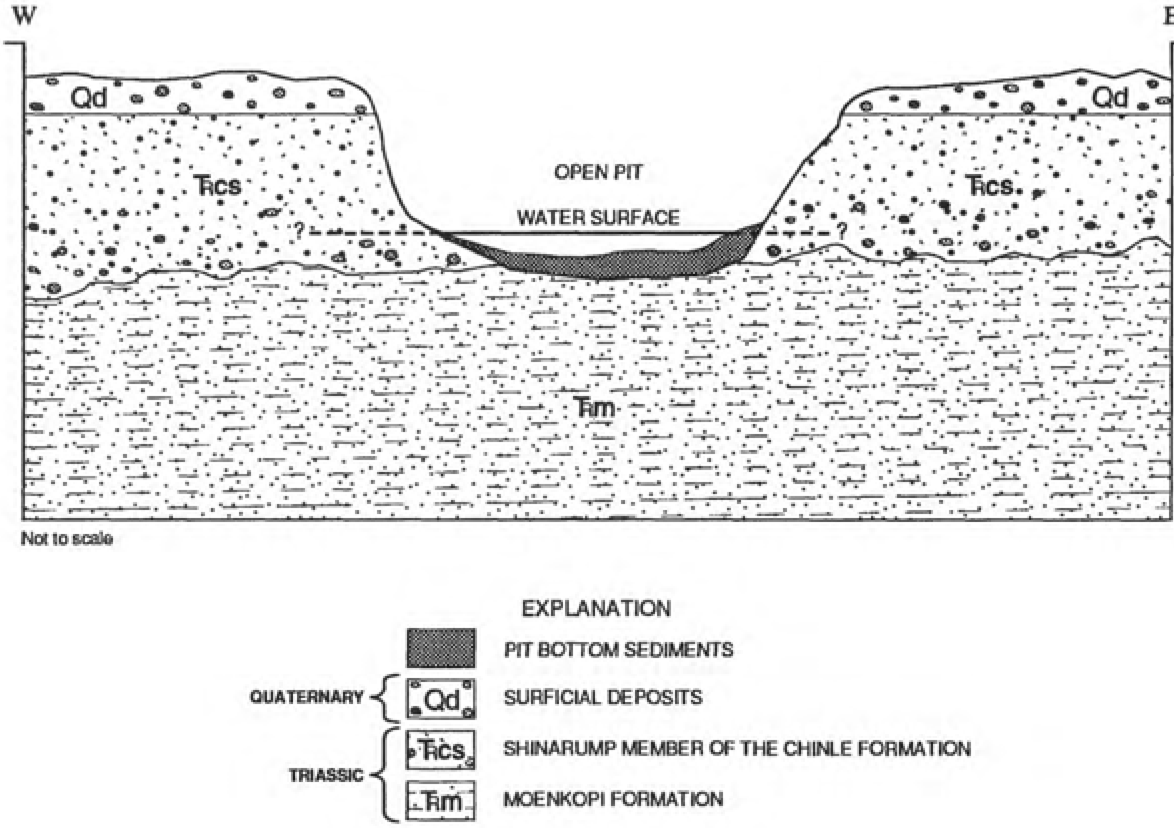


Figure 5. Lithologic units in the Moonlight mine pit, Monument Valley.

the unnamed mine drill hole indicate that local ground-water flow is from the southeast toward the northwest along the trend of Oljeto Wash (fig. 3 and table 2). The depth to water in the Radium Hill drill hole was 86.8 ft from the land-surface altitude of 5,245 ft, indicating a ground-water altitude of approximately 5,158 ft. Ground-water conditions between the Moonlight and Radium Hill mines cannot be established because depth to water in the area between the sites is not known. The thickness of the Shinarump varies significantly within short lateral differences, and the unit may not be water bearing in areas where the basal contact occurs at higher subsurface altitudes. Water in well 8T-525 rises above the top of the casing, indicating local confined ground-water conditions in the Shinarump Member, the De Chelly Sandstone Member, or in both units.

Cameron Area

The Cameron mining district lies within the Painted Desert hydrogeologic subdivision of the Navajo Indian Reservation, which is part of the Black Mesa hydrologic basin (Cooley and others, 1969, p. 23 and 41). The mining district is drained by the Moenkopi Wash and the Little Colorado River. Most rocks of Triassic age that underlie the area do not yield water to wells, and ground-water supplies generally are insufficient or of poor chemical quality for stock and domestic use. Quaternary alluvial deposits and the Shinarump Member of the Chinle Formation transmit water to the existing wells and springs included in this study.

Geohydrologic Units

Consolidated sedimentary rocks exposed in the Cameron mining district are units of the Moenkopi and Chinle Formations of Triassic age. The rocks are mudstones, siltstones, sandstones, conglomerates, and limestones in shades of brown, red, yellow, gray, and purple that generally are easily weathered into badland topography. The combined thickness of these formations ranges from about 1,500 to 1,650 ft within the area (Repenning and others, 1969, figs. 4 and 6). Uranium ore was mined from the Petrified Forest Member of the Chinle Formation at mines included in this study.

The Chinle Formation in the Cameron area is similar in structure and lithology to the Chinle Formation in Monument Valley. In the Cameron area, the basal Shinarump Member overlies the Moenkopi Formation and is about 30 to 60 ft thick. The Shinarump is overlain by the sandstone and siltstone member, the Petrified Forest Member, and, in the northeastern part of the area, the Owl Rock Member. The sandstone and siltstone member is about 100 to 160 ft thick and primarily a sandstone at Cameron (Repenning and others, 1969, p. 18). The sandstone beds are predominantly fine- to coarse-grained quartz and feldspar that contain accessory mica and commonly display crossbedding and banding of light gray, light purple, and yellowish brown. Parts of the beds are conglomeratic and include pebbles that average about 0.5 in. in diameter. The sandstone beds, however, are not as crossbedded or as conglomeratic as the underlying Shinarump Member. The Petrified Forest Member overlies the sandstone and siltstone member and consists of blue, gray, and white mudstone and tuffaceous siltstone that locally includes lenses of sandstone with varying amounts of carbonaceous matter. The sandstone lenses probably are ancient fluvial channel fills and were sources of most uranium ore mined in the area (Chenoweth and Malan, 1973). Bollin and Kerr (1958) stated that fractures in the Petrified Forest Member mudstones and the many faults in the area were pathways for movement of uranium solutions under hydrostatic pressure in the underlying Shinarump Member. The fractures and faults are probable current pathways for ground-water movement from the Shinarump Member into overlying units and open-mine pits. The Petrified Forest Member is about 850 ft thick in parts of the Cameron area but thins southwestward to its updip limit near the Little Colorado River (Repenning and others, 1969, p. 23; Ulrich and others, 1984).

Quaternary alluvium covers older rocks in parts of the Cameron area. Younger alluvium fills the Little Colorado River channel upstream from Cameron, where the channel is broad and shallow. Younger alluvium also fills most of the Moenkopi Wash north of Cameron. The younger alluvium is unconsolidated sand, silt, clay, and minor interbedded gravel. Older alluvial deposits near the Little Colorado River are Pleistocene in age, consist of consolidated gravelly sand with interbedded sand and silt, and are as much as 120 ft thick (Ulrich and others, 1984).

Occurrence of Ground Water

Alluvial deposits yield small quantities of water to springs and to at least one well in the study area. Cooley and others (1969, p. 44 and 46) indicated that within the Navajo Indian Reservation, wells in the alluvium yield from 5 to 275 gal/min and springs generally yield less than 10 gal/min. Springs included in this study occur at contacts between alluvial deposits and impermeable consolidated rock units or possibly where bedding planes or joints in consolidated sediments intersect the land surface.

The blue mudstone unit of the Petrified Forest Member and the sandstone and siltstone member contained ground water in some areas when the mines were in operation. Repenning and others (1969, p. 24) stated that standing water observed in uranium-ore exploration pits near Cameron resulted from ground water in the Shinarump Member flowing through fractures in the overlying blue mudstone unit. The blue mudstone unit does not presently yield water to wells. Ground water also was observed in the sandstone and siltstone member of the Chinle Formation in uranium-test holes. A few wells in the area yield small quantities of water from both the sandstone and siltstone member and the Shinarump Member. Some of the mine pits are underlain by permeable sediments of the Petrified Forest Member, which may be hydraulically connected to the underlying sandstone and siltstone member or Shinarump Member.

The Shinarump Member of the Chinle Formation yields water to at least two wells in the area of the mines studied—well 3T-539 west of the Manuel Denetsone No. 2 mine and the Arizona Inspection Station well south of the Jack Daniels mine. Artesian conditions exist locally in the Shinarump Member where ground water is transmitted through fractures in the lower part of the Petrified Forest Member and into the open pits. According to Cooley and others (1969, p. 41), the regional ground-water flow direction is toward the Little Colorado River, which is the primary area of natural ground-water discharge. Depth-to-water measurements collected for this study from the two existing wells in the Shinarump were not sufficient to determine directions of local ground-water flow. Cooley and others (1969, p. 46) indicated that wells in the Shinarump Member yield from 1 to 60 gal/min.

The alluvium receives ground-water recharge from rainfall, from ephemeral streams, and in some areas, possibly from leakage from deeper water-bearing units. The sandstone and siltstone member and the Shinarump Member probably receive ground-water recharge from deeper water-bearing units because of their limited surface exposure in the area. Depth-to-water measurements are shown in figure 4.

Hydrology of Mines

Water presently contained in the Jeepster No. 1, Jack Daniels, and Ramco No. 20 mine pits may originate from several sources. The three pits receive water from rainfall and surface inflow of rainfall runoff from surrounding areas. Ground water also may move from permeable sediments of the sandstone and siltstone member or the Shinarump Member through fractures or along faults into the lower part of the Petrified Forest Member and into the open pits (fig. 6). Although these pits receive some rainfall runoff, they also retain water through extensive dry periods, which indicates a subsurface water source.

The Juan Horse No. 3 and No. 4 mine pits may receive ground-water flow in a similar manner as the three pits mentioned above. Although the two pits did not contain surface water during field investigation, sediments in the pit bottoms were wet and ground-water levels were less than 10 ft below the pit bottom (table 2).

The Manuel Denetsone No. 2 drill hole terminates in a unit of the Petrified Forest Member and may receive ground-water inflow directly from the underlying sandstone and siltstone member or Shinarump Member or indirectly from fractures or along faults in the mudstone unit of the Petrified Forest Member. Additional water may be contributed by infiltration of rainfall into sediments along the nearby wash, which may be hydraulically connected to the sandstone sediments in the drill hole, or by direct inflow of rainfall runoff into the drill hole at land surface.

Ground-water altitudes in the Cameron area vary significantly in short lateral distances (table 2 and fig. 4). Because of the sparsity and

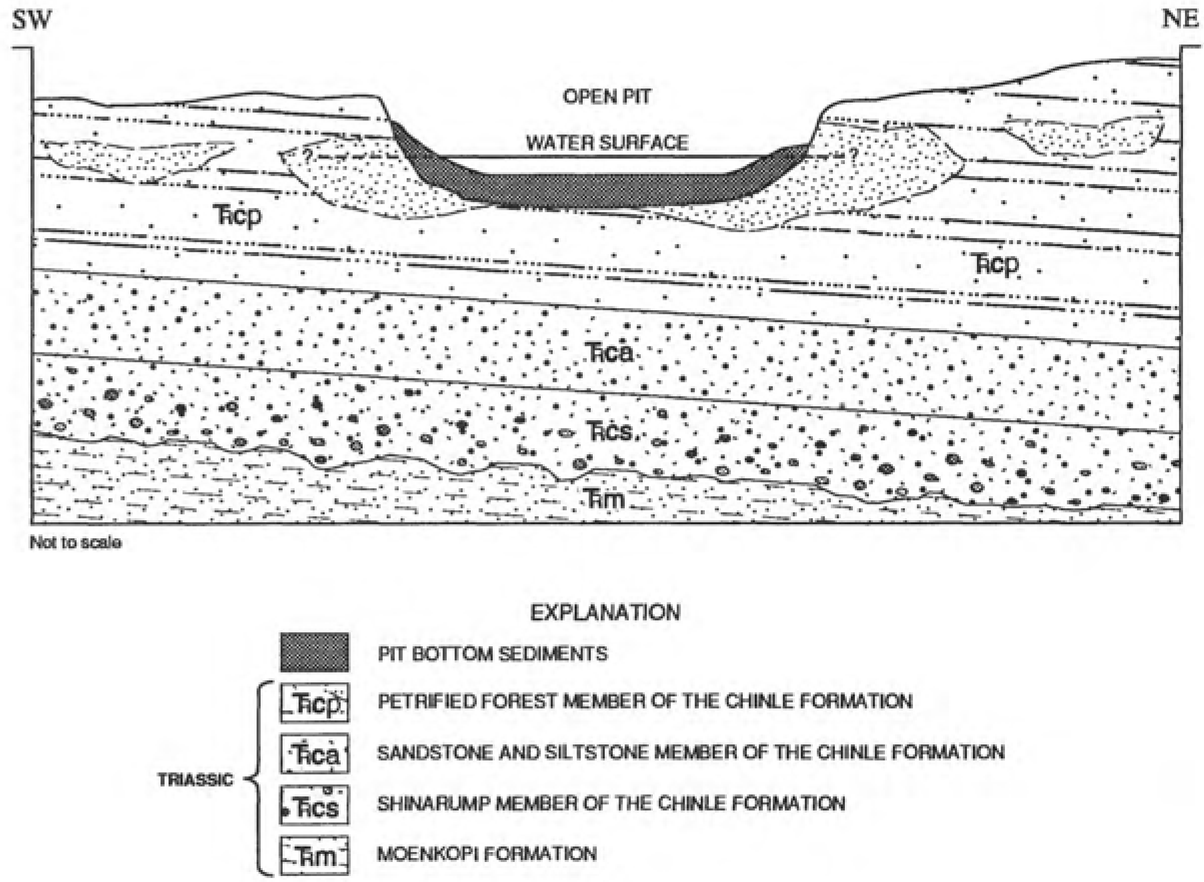


Figure 6. Lithologic units near mine pits studied in the Cameron mining district.

remoteness of wells, relations of local ground-water occurrences cannot be defined with present data. Channel-fill deposits that encompass individual mines and are water bearing probably are not laterally continuous and, consequently, produce local variability in depths to water.

WATER CHEMISTRY

Monument Valley Area

Water-chemistry data from the Monument Valley area include analyses of samples from two mines and one existing well (table 3). Water chemistry at the two mines is influenced by uranium mineralization. Radionuclide activities and concentrations of most dissolved constituents were larger in water from the mines than in water from well 8T-525. Although the fate of the shallow ground water and pit water at the mines is unknown and the quality of water on the Navajo Indian Reservation is not regulated by the State of Arizona, the water-chemistry data from this study are referenced to USEPA drinking-water regulations and State of Arizona aquifer water-quality and surface-water-quality standards for purposes of comparison (U.S. Environmental Protection Agency, 1992; State of Arizona, 1992).

Shallow ground water at the Moonlight mine is characterized by high specific conductance and large radionuclide activities.

Table 3. Field measurements and laboratory analyses of water, Monument Valley and Cameron mining districts

[°C, degrees Celsius; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; dashes indicate no data; <, value is known to be less than the value shown; µg/L, micrograms per liter; pCi/L, picocuries per liter]

Sample identification	Date	Time	Temperature water (°C)	Specific conductance (µS/cm)	pH (standard units)	Carbonate, dissolved (mg/L as CO_3)	Bicarbonate, dissolved (mg/L as HCO_3)	Alkalinity, dissolved (mg/L as $CaCO_3$)	Oxygen, dissolved (mg/L)
Field measurements—Monument Valley mining district									
MVD-1	10-15-91	1745	14.0	5,950	7.0	----	410	336	0.4
MVD-2	10-16-91	1145	15.0	7,200	7.1	----	495	406	.4
MVSW-1	10-16-91	1500	15.0	5,440	8.0	----	395	324	6.2
Radium Hill	12-17-91	1100	10.0	1,680	7.2	----	293	240	----
8T-525	12-17-91	1445	13.5	642	7.5	----	328	269	----
Field measurements—Cameron mining district									
JSW-1	10-29-91	1645	10.5	20,300	9.5	14	48	63	11.2
JDD-1	11-01-91	1600	18.5	2,430	7.4	----	1,070	873	1.6
JDSW-1	[1]10-31-91	1715	4.5	1,090	8.2	----	------	-----	10.4
M.D.-45	11-02-91	1630	19.0	2,240	7.6	----	571	468	.8
Ramco No. 20 NW	11-06-91	1345	15.0	1,420	8.7	----	------	-----	9.9
Clay Well spring	11-05-91	1600	14.5	1,930	8.4	38	620	572	6.2
Yellow Spring	11-07-91	1200	15.0	1,090	7.9	----	277	227	3.3
Little Colorado Spring	12-19-91	1015	5.0	537	8.0	----	234	192	8.2
3T-539	12-20-91	1030	16.0	4,200	7.5	----	322	264	----
Arizona Inspection Station well	12-19-91	1350	19.0	1,040	8.8	9.6	284	233	----

[1]Field measurements made prior to sample collection date.

Table 3. Field measurements and laboratory analyses of water—Continued

Sample identification	Date	Time	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Chloride, dissolved (mg/L as Cl)	Sulfate, dissolved (mg/L as SO_4)	Fluoride, dissolved (mg/L as F)	Nitrogen, nitrite dissolved (mg/L as N)
Laboratory analyses—Monument Valley mining district									
MVD-1	10-15-91	1745	440	540	460	65	3,700	1.8	<0.010
MVD-2	10-16-91	1145	430	640	720	15	4,500	.50	<.010
MVSW-1	10-16-91	1500	430	430	500	51	3,300	2.6	<.010
Radium Hill	12-17-91	1100	300	72	23	23	820	.50	<.010
8T-525	12-17-91	1445	26	18	85	13	66	.50	<.010
Laboratory analyses—Cameron mining district									
JSW-1	10-29-91	1645	620	130	6,000	310	12,000	3.8	<.010
JDD-1	11-01-91	1600	14	2.6	510	76	180	1.1	<.010
JDSW-1	11-07-91	1545	15	.85	240	42	120	.90	<.010
M.D.-45	11-02-91	1630	9.9	2.3	450	260	280	1.6	.010
Ramco No. 20 NW	11-06-91	1345	11	1.3	330	54	63	1.0	<.010
Clay Well spring	11-05-91	1600	5.4	1.8	420	190	130	2.3	<.010
Yellow Spring	11-07-91	1200	28	3.8	200	47	240	2.2	<.010
Little Colorado Spring	12-19-91	1015	31	23	46	26	46	.50	<.010
3T-539	12-20-91	1030	82	31	710	1,000	280	1.3	<.010
Arizona Inspection Station well	12-19-91	1350	2.5	.40	210	110	89	2.7	<.010

Table 3. Field measurements and laboratory analyses of water—Continued

Sample identification	Date	Time	Nitrogen, NO_2+NO_3 dissolved (mg/L as N)	Silica, dissolved (mg/L as SiO_2)	Barium, dissolved (µg/L as Ba)	Beryllium, dissolved (µg/L as Be)	Cadmium, dissolved (µg/L as Cd)	Chromium, dissolved (µg/L as Cr)	Cobalt, dissolved (µg/L as Co)
Laboratory analyses—Monument Valley mining district—Continued									
MVD-1	10-15-91	1745	<0.050	7.7	13	<2	4.0	2	1,700
MVD-2	10-16-91	1145	<.050	8.0	10	<2	4.0	1	1,100
MVSW-1	10-16-91	1500	<.050	.06	43	<2	<3.0	20	9
Radium Hill	12-17-91	1100	.097	13	33	<.5	<1.0	<5	8
8T-525	12-17-91	1445	<.050	8.2	36	<.5	<1.0	<5	<3
Laboratory analyses—Cameron mining district—Continued									
JSW-1	10-29-91	1645	<.050	1.5	<10	<5	2.0	<3	<4
JDD-1	11-01-91	1600	<.050	11	30	<15	<3.0	<20	<9
JDSW-1	11-07-91	1545	<.050	18	100	<.5	<1.0	<5	<3
M.D.-45	11-02-91	1630	<.050	14	110	<2	<3.0	<20	<9
Ramco No. 20 NW	11-06-91	1345	<.050	26	130	<.5	<1.0	<5	<3
Clay Well spring	11-05-91	1600	1.00	16	71	1	<1.0	<5	<3
Yellow Spring	11-07-91	1200	.590	20	37	<.5	<1.0	<5	<3
Little Colorado Spring	12-19-91	1015	2.40	9.3	63	<.5	<1.0	<5	<3
3T-539	12-20-91	1030	<.050	8.2	35	<2	<3.0	<20	<9
Arizona Inspection Station well	12-19-91	1350	8.20	11	26	<.5	<1.0	<5	<3

Table 3. Field measurements and laboratory analyses of water—Continued

Sample identification	Date	Time	Copper, dissolved (µg/L as Cu)	Iron, dissolved (µg/L as Fe)	Lead, dissolved (µg/L as Pb)	Lithium, dissolved (µg/L as Li)	Manganese, dissolved (µg/L as Mn)	Molybdenum, dissolved (µg/L as Mo)	Nickel, dissolved (µg/L as Ni)
Laboratory analyses—Monument Valley mining district—Continued									
MVD-1	10-15-91	1745	40	1,900	<1	640	2,700	3,000	850
MVD-2	10-16-91	1145	200	240	<1	990	1,700	3,600	540
MVSW-1	10-16-91	1500	<30	28	<30	770	65	760	30
Radium Hill	12-17-91	1100	<10	190	<10	65	420	10	10
8T-525	12-17-91	1445	<10	180	<10	78	8	<10	<10
Laboratory analyses—Cameron mining district—Continued									
JSW-1	10-29-91	1645	<10	43	<1	1,200	<10	210	<1
JDD-1	11-01-91	1600	<30	36	<30	190	54	30	<30
JDSW-1	11-07-91	1545	20	26	<10	28	2	10	<10
M.D.-45	11-02-91	1630	<30	95	<30	190	35	70	<30
Ramco No. 20 NW	11-06-91	1345	20	71	<10	32	4	10	<10
Clay Well spring	11-05-91	1600	<10	95	<10	59	<1	10	<10
Yellow Spring	11-07-91	1200	<10	8	10	52	1	<10	<10
Little Colorado Spring	12-19-91	1015	<10	<3	<10	45	<1	<10	<10
3T-539	12-20-91	1030	<30	730	40	320	250	<30	<30
Arizona Inspection Station well	12-19-91	1350	<10	18	<10	150	<1	<10	<10

Table 3. Field measurements and laboratory analyses of water—Continued

Sample identification	Date	Time	Silver, dissolved (µg/L as Ag)	Strontium, dissolved (µg/L as Sr)	Vanadium, dissolved (µg/L as V)	Zinc, dissolved (µg/L as Zn)	Uranium -238, dissolved (pCi/L)	Uranium -234, dissolved (pCi/L)	Uranium -235, dissolved (pCi/L)
Laboratory analyses—Monument Valley mining district—Continued									
MVD-1	10-15-91	1745	<1.0	5,200	<18	770	11,000	11,000	440
MVD-2	10-16-91	1145	<1.0	6,000	<24	690	14,000	14,000	530
MVSW-1	10-16-91	1500	<3.0	7,300	<18	34	-----------	-----------	-------
Radium Hill	12-17-91	1100	1.0	1,300	<6	28	210	230	12
8T-525	12-17-91	1445	<1.0	980	<6	3	.50	.90	<.1
Laboratory analyses—Cameron mining district—Continued									
JSW-1	10-29-91	1645	<1.0	20,000	16	44	22	30	.8
JDD-1	11-01-91	1600	<3.0	490	<18	<9	150	210	5.7
JDSW-1	11-07-91	1545	<1.0	450	48	<3	11	14	.4
M.D.-45	11-02-91	1630	<3.0	410	<18	<9	180	230	8.9
Ramco No. 20 NW	11-06-91	1345	<1.0	350	63	<3	15	20	.6
Clay Well spring	11-05-91	1600	2.0	270	210	4	27	38	1.1
Yellow Spring	11-07-91	1200	<1.0	400	24	8	4.3	5.7	.2
Little Colorado Spring	12-19-91	1015	1.0	970	<6	29	-----------	-----------	-------
3T-539	12-20-91	1030	3.0	5,300	<18	110	-----------	-----------	-------
Arizona Inspection Station well	12-19-91	1350	<1.0	130	46	5	20	24	.9

Table 3. Field measurements and laboratory analyses of water—Continued

Sample identification	Date	Time	Gross alpha, dissolved (µg/L as U-nat)	Gross beta, dissolved (pCi/L as Cs-137)	Gross beta, dissolved (pCi/L as Sr/Yt-90)	Radium 226, dissolved, radon method (pCi/L)	Radon 222, total (pCi/L)
Laboratory analyses—Monument Valley mining district—Continued							
MVD-1	10-15-91	1745	18,000	20,000	15,000	44	53,000
MVD-2	10-16-91	1145	19,000	21,000	16,000	110	250,000
MVSW-1	10-16-91	1500	8,500	11,000	8,100	8.6	----------
Radium Hill	12-17-91	1100	690	300	220	19	----------
8T-525	12-17-91	1445	3.0	6.6	4.9	.16	590
Laboratory analyses—Cameron mining district—Continued							
JSW-1	10-29-91	1645	72	100	76	.25	----------
JDD-1	11-01-91	1600	480	260	200	.10	----------
JDSW-1	11-07-91	1545	23	21	16	.07	----------
M.D.-45	11-02-91	1630	680	360	270	.52	----------
Ramco No. 20 NW	11-06-91	1345	27	35	26	.09	----------
Clay Well spring	11-05-91	1600	95	50	38	.08	----------
Yellow Spring	11-07-91	1200	11	10	7.5	.03	----------
Little Colorado Spring	12-19-91	1015	16	14	10	.30	----------
3T-539	12-20-91	1030	19	24	18	.44	----------
Arizona Inspection Station well	12-19-91	1350	60	37	28	.07	----------

In water samples from shallow wells MVD-1 and MVD-2, concentrations of sulfate, cobalt, iron, manganese, molybdenum, nickel, and zinc were larger than concentrations of these constituents in the pit-water sample (MVSW-1) and concentrations in water from the Radium Hill drill hole and were significantly larger than concentrations in water from well 8T-525. Concentrations of cobalt (1,100 to 1,700 µg/L), iron (240 to 1,900 µg/L), manganese (1,700 to 2,700 µg/L), molybdenum (3,000 to 3,600 µg/L), nickel (540 to 850 µg/L), and zinc (690 to 770 µg/L) in the shallow ground water probably result from secondary mineralization associated with the uranium ore body. Activities of three uranium isotopes, radium-226, and radon-222 were determined in water from the two shallow wells. Uranium-238 activity was 11,000 and 14,000 pCi/L, uranium-234 activity was 11,000 and 14,000 pCi/L, and uranium-235 activity was 440 and 530 pCi/L. Radium-226 activity was 44 and 110 pCi/L, and radon-222 activity was 53,000 and 250,000 pCi/L in water from the two shallow wells. Nickel and radium were the only constituents that exceeded the USEPA primary maximum contaminant levels (MCL's) and State of Arizona aquifer water-quality standards; however, uranium and radon greatly exceeded USEPA proposed MCL's. The MCL for nickel is 100 µg/L and the MCL and State of Arizona aquifer water-quality standards for the combined radium-226 and radium-228 activity are 5 pCi/L. Although there are no present (1992) primary MCL's for total uranium or radon, proposed MCL's of 20 µg/L for uranium and 300 pCi/L for radon are being considered for implementation (U.S. Environmental Protection Agency, 1992). A uranium concentration of 20 µg/L is equivalent to 30 pCi/L of uranium-238.

The pit-water chemistry at the Moonlight mine (MVSW-1) was similar to the chemistry of the shallow ground water, with respect to concentrations of calcium, magnesium, sodium, and sulfate. Concentrations of fluoride, barium, chromium, and strontium, however, were significantly larger, and concentrations of cadmium, cobalt, copper, iron, manganese, molybdenum, nickel, and zinc were smaller in the pit water. Uranium activities could not be determined because of problems during laboratory analysis. Gross alpha activities, however, indicate that uranium activities may be smaller in the pit water than in the shallow ground water. Radium-226 activity in the pit water also was smaller than in the shallow ground water. Dissolved-constituent concentrations and radionuclide activities were below USEPA primary MCL's. Radium-226 (8.6 pCi/L) was the only constituent that exceeded the State of Arizona surface-water-quality standard.

Ground water at the Radium Hill mine generally had lower specific conductance and smaller radionuclide activities than did shallow ground water or pit water at the Moonlight mine. Water at the Radium Hill mine contained a larger silica concentration than shallow ground water or pit water at the Moonlight mine and a larger barium concentration than shallow ground water at the Moonlight mine. Uranium activity in water at the Radium Hill mine was less than in shallow ground water at the Moonlight mine but exceeded the USEPA proposed MCL. Radium-226 activity was less than in shallow ground water at the Moonlight mine but larger than in pit water and exceeded the USEPA primary MCL and State of Arizona aquifer water-quality standard.

Well 8T-525 yields water from the Shinarump Member of the Chinle Formation and the underlying De Chelly Sandstone Member of the Cutler Formation. The quantity of water transmitted to the well by each formation is not known. Dissolved-constituent concentrations generally were less, and radionuclide activities were significantly less in water from well 8T-525 than in water from the mines. The radon activity of 590 pCi/L, however, exceeded the USEPA proposed MCL. Smaller dissolved-constituent concentrations and smaller radionuclide activities in water from the well may result from less extensive uranium mineralization in the Shinarump Member near the well and from dilution by ground water from the De Chelly Sandstone.

Cameron Area

Water-chemistry data for the Cameron area include analyses of samples collected for this study from four mines, two existing wells, and three springs (table 3) and before this study from one mine, one existing well, and four springs (table 4). Dissolved-constituent concentrations and radionuclide activities in water from sites in the Cameron area generally were less than in water from the Monument Valley area. Analyses of ground water from the Jack Daniels and Manuel Denetsone No. 2 mines show significant radionuclide activities resulting from interaction with uranium minerals near the pits. The radionuclide activity of water from the remaining sites was significantly less than in water from the Jack Daniels and Manuel Denetsone No. 2 mines.

Analyses of water from the Jeepster No. 1, Jack Daniels, Manuel Denetsone No. 2, and Ramco No. 20 mines show significant variation in dissolved-constituent concentrations and radionuclide activities. Pit water from the Jeepster No. 1 mine (JSW-1) contained the greatest amount of dissolved constituents and contained significantly larger concentrations of calcium, sodium, chloride, sulfate, fluoride, strontium, and lithium than water from the remaining sites and water from the Monument Valley area. These large concentrations may indicate that the ore deposits were more mineralized at the Jeepster No. 1 mine or that the pit received little rainfall runoff and lost a significant quantity of water to evaporation before sampling. None of the constituent concentrations exceeded USEPA MCL's or State of Arizona water-quality standards. Uranium-238 activities in pit water from the Cameron sites ranged from 11 to 22 pCi/L.

The largest uranium-238 and gross alpha activities were in ground water from the Jack Daniels mine (JDD-1) and the Manuel Denetsone No. 2 drill hole (M.D.-45). Uranium-238 activity was 150 and 180 pCi/L, and gross alpha activity was 480 and 680 pCi/L, respectively, for the JDD-1 and M.D.-45 samples. Ground water from the Manuel Denetsone No. 2 drill hole also had the largest radium-226 activity (0.52 pCi/L); however, the radium-226 activity in the JDD-1 sample (0.10 pCi/L) was exceeded by activities in pit water from the Jeepster No. 1 mine (0.25 pCi/L) and in water from well 3T-539 (0.44 pCi/L). Because radium-228 activities were not determined on field-collected water samples, comparisons with the USEPA MCL and State of Arizona water-quality standards of a combined radium-226 and radium-228 activity of less than 5 pCi/L could not be made conclusively on samples with radium-226 activities of less than 5 pCi/L. Chemical analyses of water from the laboratory-batch tests, however, indicate that spoil material adjacent to the mines contains radium-228 activities equal to or less than radium-226 activities. Because all the radium-226 activities in water from the Cameron mines were below 1.0 pCi/L, it is probable that the combined radium activities would be below 5 pCi/L. Samples JSW-1, JDD-1, M.D.-45, and Ramco No. 20 NW each contained total uranium activities greater than 30 pCi/L, which is equivalent to the USEPA proposed MCL of 20 μg/L. Uranium activities were not determined in pit water from the Yazzie No. 312 mine collected in 1988, but gross alpha activity was less than in water from the four mines included in this study. The Yazzie No. 312 pit did not contain water during field investigation for this study.

Dissolved-constituent concentrations in water from wells and springs in the Cameron

Table 4. Additional field measurements and laboratory analyses of water from sites in the Cameron mining district

[°C, degrees Celsius; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; dashes indicate no data; pCi/L, picocuries per liter; µg/L, micrograms per liter]

Field measurements

Sample identification	Date	Time	Temperature water (°C)	Specific conductance (µS/cm)	pH (standard units)	Carbonate, total (mg/L as CO_3)	Bicarbonate, total (mg/L as HCO_3)	Alkalinity, total (mg/L as $CaCO_3$)
Clay Well spring	12-06-88	1215	8.0	-------	8.7		-----	572
Yellow Spring	12-05-88	1530	-----	865	8.0	-----	212	174
Little Colorado Spring	12-06-88	------	-----	-------	------	-----	-----	-----
3T-539	12-05-88	1650	-----	2,200	8.1	-----	253	207
Balokai Spring (Lee Well)	12-05-88	------	-----	1,390	8.0	-----	-----	283
Yazzie No. 312 (mine pit)	12-06-88	1320	8.0	-------	8.7	120	454	572

Laboratory analyses

Sample identification	Date	Time	Uranium -238, dissolved (pCi/L)	Uranium -234, dissolved (pCi/L)	Gross alpha, dissolved (µg/L as U-nat)	Gross beta, dissolved (pCi/L as Cs-137)	Gross beta, dissolved (pCi/L as Sr/Yt-90)	Radon 222, total (pCi/L)
Clay Well spring	12-06-88	1215	20	29	110	46	30	-------
Yellow Spring	12-05-88	1530	---	---	22	8.2	5.8	-------
Little Colorado Spring	12-06-88	------	---	---	19	9.4	7.1	1,700
3T-539	12-05-88	1650	---	---	6.3	6.4	4.1	-------
Balokai Spring (Lee Well)	12-05-88	------	---	---	23	9.9	6.6	-------
Yazzie No. 312 (mine pit)	12-06-88	1320	---	---	21	6.5	4.9	-------

area generally were similar to concentrations in water from the mines with a few exceptions. Concentrations of sodium, chloride, and sulfate were significantly less in water from the Little Colorado River Spring than in water from the mines or other wells and springs. Concentrations of iron, lead, and manganese were significantly greater in water from well 3T-539 than in water from the mines or other wells and springs.

Radionuclide activities in water from wells and springs generally were less than in shallow ground water and pit-water samples. Uranium-238 (27 pCi/L), gross alpha (95 pCi/L), and gross beta (50 pCi/L) activities in water from the Clay Well spring were larger than in pit water from mines. Radionuclide activities were greater in water from the Arizona Inspection Station well than in two of the three pit-water samples. Uranium activities could not be determined in water from the Little Colorado Spring or well 3T-539 because of problems during laboratory analysis and were determined only in water from Clay Well spring as part of the 1988 analyses (table 4). A water sample collected from the Little Colorado Spring in 1988 contained 1,700 pCi/L of radon-222, and water collected from the spring in 1991 contained 0.30 pCi/L of radium-226. Water from well 3T-539 contained the second largest radium-226 activity (0.44 pCi/L). Radon activity in the Little Colorado Spring exceeded the USEPA proposed MCL. The chemistry of water from wells and springs included in this study probably is influenced by the abundance of mineralized sediments in the water-bearing units. The smaller radionuclide activities in pit water and well and spring water, relative to activities in shallow ground water, may represent the background levels of these constituents for the area. Data from this study, however, were not sufficient to determine representative background levels.

RADIOCHEMISTRY OF SPOIL-MATERIAL LEACHATE

Spoil-material samples were selected for laboratory-batch tests on the basis of field gamma measurements (table 5). Additional samples were collected for particle-size and mineralogical analyses to identify physical characteristics.

Particle-size data from spoil materials used in laboratory-batch tests indicate that spoil piles are gravel and coarser sediments near sample sites at the Moonlight, Radium Hill, and Jack Daniels mines and are predominantly sand at the Jeepster No. 1 mine (table 6). Sediment size may be important in the rate and magnitude of radionuclide leaching from spoil materials after mine reclamation. Smaller sediment sizes have correspondingly larger surface areas per unit volume and thus would allow for a greater degree of chemical interaction between spoil materials and shallow ground water. Laboratory-batch tests were done using sediments 2.00 mm in diameter and smaller; therefore, the amount of radionuclides that would leach from coarser spoil material is unknown. Although smaller-sized material presents greater surface area for chemical interactions, the inclusion of larger materials during reclamation may allow for increased water velocities because of increased pore size and entrain additional oxygen that would increase mobilization of uranium. For the pH conditions in this study, uranium minerals generally are more soluble under oxidizing conditions and less soluble under reducing conditions (Drever, 1988, p. 337). Langmuir (1978, p. 555), however, stated that uranium in natural waters generally is complexed with carbonate, phosphate, and other compounds that significantly increase solubility of uranium minerals at intermediate oxidation potentials. Actual leaching rates and movement of radionuclides would depend on site-specific conditions that include the amount of oxygen and organic material present,

Table 5. Sample locations and field gamma measurements of spoil material, Monument Valley and Cameron mining districts

[μR/hr, microroentgens per hour; dashes indicate no data]

Sample identification	Date	Sample area (sub part)	Sub-sample	Gamma measurements (μR/hr) At surface	Gamma measurements (μR/hr) At sample depth
Monument Valley mining district					
Moonlight mine					
MVS-1	10-15-91	North pile	1	22	----
			2	22	21
			3	19	18
			4	19	19
MVS-2	10-15-91	Northwest pile (SW)	1	470	330
			2	205	90
			3	345	270
MVS-3	10-15-91	Northwest pile (NW)	1	95	50
			2	630	360
			3	65	50
MVS-4	10-15-91	Northwest pile (N)	1	60	43
			2	65	55
			3	115	----
Radium Hill mine					
RHS-1	12-17-91	Southwest pile	1	205	295
			2	185	285
			3	190	320
Cameron mining district					
Jeepster No. 1 mine					
JS-1	10-29-91	Southeast pile	1	18	20
			2	18	23
			3	19	23

Table 5. Sample locations and field gamma measurements of spoil material, Monument Valley and Cameron mining districts—Continued

Sample identification	Date	Sample area (sub part)	Sub-sample	Gamma measurements (µR/hr) At surface	Gamma measurements (µR/hr) At sample depth
Cameron mining district—Continued					
Jeepster No. 1 mine—Continued					
JS-2	10-29-91	South pile	1	19	23
			2	100	200
			3	29	27
JS-3	10-29-92	West pile	1	18	21
			2	21	5
			3	14	19
JS-4	10-29-92	North pile	1	47	70
			2	60	95
			3	105	150
Jack Daniels mine					
JDS-1	10-31-91	Southeast pile	1	140	190
			2	70	110
			3	39	50
JDS-2	10-31-91	South pile	1	35	39
			2	115	220
			3	130	195
JDS-3	10-31-91	Northeast pile	1	65	85
			2	27	39
			3	60	75
JDS-4	10-31-91	North pile	1	49	60
			2	48	75
			3	33	34

Table 6. Particle-size data from spoil material, Monument Valley and Cameron mining districts

[>, greater than; mm, millimeter; µm, micrometer; <, less than]

Sample identification (corresponding batch test sample)	Percentage of total weight		
	Gravel and larger (> 2.00 mm)	Sand (62 µm to 2.00 mm)	Silt and clay (< 62 µm)
Moonlight mine			
MVS-P1 (MVS-1)	68	27	5
MVS-P2 (MVS-2)	67	29	4
MVS-P3 (MVS-3)	80	17	3
MVS-P4 (MVS-4)	35	57	8
Radium Hill mine			
RHS-P1 (RHS-1)	63	25	12
Jeepster No. 1 mine			
JS-P1 (JS-1)	17	68	15
JS-P2 (JS-2)	20	63	17
JS-P3 (JS-3)	17	66	17
JS-P4 (JS-4)	13	63	24
Jack Daniels mine			
JDS-P1 (JDS-1)	58	25	17
JDS-P2 (JDS-2)	60	29	11
JDS-P3 (JDS-3)	61	31	8
JDS-P4 (JDS-4)	55	35	10

temperature, spoil mineralogy, and local ground-water composition (Langmuir, 1978, p. 558).

Data from X-ray diffractometry analyses of spoil samples from the Radium Hill, Jeepster No. 1, and Jack Daniels mines were used to identify minerals that composed at least 5 to 10 percent by volume of each sample (John Neil, U.S. Geological Survey, written commun., 1992). All the samples contained quartz as a major or minor constituent. Although gypsum appeared to be the most abundant mineral in the Radium Hill sample, it may have appeared exceptionally high because of the increased intensity of X-ray diffraction from aligned cleavage fragments. The Radium Hill sample probably contained the most gypsum; however, quartz probably would have appeared predominant in the analyses if a larger sample volume had been used. Quartz was most likely the most abundant mineral in all the samples. In addition to gypsum and quartz, the Radium Hill sample contained kaolinite, a trace amount of muscovite, and possibly calcite. The Jeepster No. 1 sample, in addition to quartz, also contained kaolinite, gypsum, one or two unidentified 10- to 14-angstrom clays, a trace amount of orthoclase, and possibly muscovite and calcite. The Jack Daniels sample, in addition to quartz, also contained kaolinite, orthoclase, one or two unidentified 10- to 14-angstrom clays, intermediate plagioclase, and trace amounts of calcite and gypsum. Spoil material from the Moonlight mine was not collected for mineralogical analysis. No attempts were made at correlating the general spoil-material mineralogy with the leachate radiochemistry.

Chemical data from the leachate analyses indicate significant radionuclide dissolution from spoil material during laboratory-batch tests. Radionuclide activities in the leachate samples generally correlate with the field gamma measurements made for locating spoil-sample sites (tables 5, 7, and 8). Physical and chemical characteristics of the water were determined before mixing with spoil materials, and physical and chemical characteristics of the water-spoil material mixtures were determined after completion of batch tests (table 7). Leachate from spoil sample MVS-3 contained the largest uranium concentration (7,700 μg/L), and leachate from MVS-2 contained the largest radium-226 and radium-228 activities (34 and 2.7 pCi/L, respectively; table 8).

Radionuclide activities in leachate samples showed significant variation between mines and between spoil piles sampled at each mine. Smaller activities were found in samples from spoil piles known to consist primarily of overburden sediments from the mine pits. Leachate from spoil sample MVS-1 contained the smallest uranium concentration (20 μg/L) but contained the second largest radium-228 activity (2.1 pCi/L). Radionuclide activities in leachate from the JS-1 and JS-3 spoil samples also were significantly lower than in leachate from other samples. Leachate from sample JS-1 contained 38 μg/L of uranium and had a radium-226 activity of 0.95 pCi/L. Leachate from spoil samples collected at the Jack Daniels mine contained large uranium concentrations and radium-226 activities, although gamma measurements at sample sites JDS-3 and JDS-4 indicated material of lower radionuclide activity than samples JDS-1 and JDS-2.

CONSIDERATIONS FOR FURTHER STUDY

Collection and analysis of additional hydrologic data would be necessary to determine shallow ground-water flow characteristics and thus the implications of radionuclide mobilization near mines in the Monument Valley and Cameron mining districts. Information from additional wells installed at the mines would provide data on the lateral and vertical extent of the shallow ground-water system and its relation to units that supply water to nearby existing wells and springs. Background levels of radionuclides also could be determined from water-chemistry data collected from the additional wells. Dissolved-oxygen concentration and redox measurements in water from the wells could be used to relate radionuclide concentrations to chemical reactions in the shallow ground water. Stable-isotope data from pit water and shallow ground water could indicate whether water at mine sites is from rainfall, ground water, or a mixture of both. Further monitoring of water levels could provide information on the hydraulic relations between mines and the few existing wells and the response of the ground-water system to seasonal variations in rainfall. Geophysical methods could provide information on the thickness and configuration

Table 7. Laboratory measurements from batch tests of spoil material, Monument Valley and Cameron mining districts

[°C, degrees Celsius; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; dashes indicate no data]

Sample identification	Temperature water (°C)	Specific conductance (µS/cm)	pH (standard units)	Carbonate, total (mg/L)	Bicarbonate, total (mg/L)
Water from study area wells before batch tests					
8T-525[1]	23.0	600	7.9	-----	315
Arizona Inspection Station well[2]	23.0	1,000	9.0	10	216
Water and spoil-material mixtures after batch tests					
Monument Valley mining district					
MVS-1	20.0	600	8.3	6.9	275
MVS-2	20.0	600	8.0	-----	152
MVS-3	20.0	600	7.8	-----	275
MVS-4	20.0	600	8.2	6.9	313
RHS-1	20.0	2,850	6.5	-----	311
Cameron mining district					
JS-1	23.0	2,900	8.5	6.9	214
JS-2	23.0	3,000	7.7	-----	280
JS-3	23.0	3,600	8.0	-----	250
JS-4	23.0	2,000	8.5	7.5	245
JDS-1	22.0	2,600	8.5	8.8	214
JDS-2	22.0	2,400	8.3	6.3	216
JDS-3	22.0	3,500	8.0	-----	237
JDS-4	22.0	5,000	7.9	-----	229

[1]Used in tests with spoil material from the Monument Valley mining district.
[2]Used in tests with spoil material from the Cameron mining district.

Table 8. Leachate radiochemistry from batch test of spoil material, Monument Valley and Cameron mining districts

[µg/L, micrograms per liter; pCi/L, picocuries per liter; <, value is known to be less than the value shown]

Sample identification	Uranium natural, dis-solved (µg/L as U)	Gross alpha, dis-solved (µg/L as U-nat)	Gross beta, dis-solved (pCi/L as Cs-137)	Gross beta, dis-solved (pCi/L as Sr/Yt-90)	Radium 226, dis-solved, radon method (pCi/L)	Radium 228, dis-solved (pCi/L as Ra-228)
Monument Valley mining district						
MVS-1	20	32	20	15	1.0	2.1
MVS-2	3,500	3,400	1,600	1,200	34	2.7
MVS-3	7,700	8,200	3,200	2,400	17	1.6
MVS-4	1,600	1,700	960	720	4.0	1.6
RHS-1	2,500	2,700	1,100	820	6.5	<1.0
Cameron mining district						
JS-1	38	76	50	37	.95	<1.0
JS-2	2,700	3,600	1,700	1,300	8.2	<1.0
JS-3	94	140	83	62	1.3	1.3
JS-4	1,100	1,300	800	600	21	1.2
JDS-1	2,200	2,500	1,400	1,100	9.7	<1.0
JDS-2	3,800	4,700	2,300	1,800	10	<1.0
JDS-3	2,400	3,400	1,600	1,200	3.9	<1.0
JDS-4	2,700	3,700	1,800	1,400	4.3	<1.0

of water-bearing alluvial units associated with springs.

SUMMARY

Hydrologic data were collected from abandoned uranium mines and from wells and springs in the Monument Valley and Cameron mining districts to provide information for reclamation plans developed by the NAMLRD. Several open pits, shafts, and drill holes have partially filled with water, presenting potential pathways of radiation exposure to animals and humans that come into contact with the water. This report describes the chemical characteristics and hydraulic interaction of shallow ground water and pit water and the

possible chemical interactions between the shallow ground water and the spoil material that will be used in reclamation.

The mining districts lie in the Colorado Plateau region of northeastern Arizona and part of southeastern Utah. Seventy-three mined sites existed in the Monument Valley area after mining ceased in 1969, and ninety-eight mined sites existed in the Cameron area after mining ceased in 1963. Most of the uranium was mined from mineralized deposits in sandstones, siltstones, mudstones, and conglomerates of the Chinle and Moenkopi Formations of Triassic age. Uranium mines in the Monument Valley area were established mainly in channel-fill deposits within the Shinarump Member of the Chinle Formation. In the study area near Cameron, uranium was mined from channel-fill deposits within the Petrified Forest Member of the Chinle Formation. Field investigation involved two mines, one drill hole, and four wells in the Monument Valley area and six mines, three wells, and three springs in the Cameron area. Data collected from one mine, one well, and four springs before the study also were used.

In the Monument Valley mining district, water in the open pit at the Moonlight mine and in the drill hole at the Radium Hill mine may occur from ground-water flow from the Shinarump Member of the Chinle Formation. Ground water in the Shinarump Member also flows to several wells near the two mines. Ground water was 86.8 ft below land surface in a drill hole at one of the mines and flowed at land surface from a well completed in the De Chelly Sandstone. Local ground-water flow near the Moonlight and Radium Hill mines is from the southeast to the northwest along the trend of Oljeto Wash. Regional ground-water flow in the Cameron area is toward the Little Colorado River. The definition of ground-water relations in the area of the mines is restricted by the sparsity of existing wells. Depth to ground water measured in the Cameron area ranged from 3.5 ft below the pit bottom at the Jeepster No. 1 mine to 24.1 ft below land surface at well 3T-539. In the Cameron mining district, rainfall runoff contributes water to several of the pits and drill holes. Ground water in the Shinarump Member and sandstone and siltstone member may flow into open pits and mine drill holes through fractures or along faults in the lower part of the overlying Petrified Forest Member.

Significant differences in ground-water and pit-water chemistry were determined between the two mining districts and between sample sites within each district. Although the fate of pit water and shallow ground water near the mines is unknown, chemical analyses of water were compared to USEPA and State of Arizona water-quality standards. In the Monument Valley area, water from the two mines contained larger radionuclide activities and generally larger concentrations of other dissolved constituents than ground water from well 8T-525, which is about 1.8 mi west of the Moonlight mine. Shallow ground water from the Moonlight mine contained the largest uranium-238 and radium-226 activities, 14,000 and 110 pCi/L, respectively, and the largest radon-222 activity, 250,000 pCi/L. Water from well 8T-525 also contained significant radon-222 activity (590 pCi/L). Radionuclide activities generally were smaller in water from the Cameron area than in water from the Monument Valley area. Shallow ground water from the Jack Daniels and Manuel Denetsone No. 2 mines contained 150 and 180 pCi/L of uranium-238 and 0.10 and 0.52 pCi/L of radium-226, respectively. Pit water and water from wells and springs in the Cameron area, however, contained radionuclide activities that may reflect background levels for the area. Uranium-238 activities in pit water from the Cameron area ranged from 11 to 22 pCi/L; water from Clay Well spring, about 1.9 mi from the nearest mine, contained 27 pCi/L, which was the third largest uranium-238 activity among the samples.

Significant amounts of radionuclides were leached from spoil materials during laboratory-batch tests. Spoil materials from each of the two mining districts were combined with water from a well that was assumed to have limited chemical influences from mining disturbances. Uranium concentrations and radium activities generally correlate with field gamma measurements made on spoil piles at each site. Smaller radionuclide activities were found in overburden material from the Moonlight and Jeepster No. 1 mines. Uranium concentrations in leachate samples ranged from 20 to 7,700 μg/L, and radium-226 activities ranged from 0.95 to 34 pCi/L. The batch tests were completed using the portion of spoil material that was 2.00 mm in diameter and smaller to maximize surface areas and increase chemical interactions. Particle-size data indicate that the spoil material is predominantly gravel and coarser sediments (larger than 2.00 mm in diameter) at three of the four mines and is predominantly sand at the remaining mine. The character of radionuclide leachate and mobilization of radionuclides from the larger material cannot be determined from the batch-test data, and actual leaching rates and movement of radionuclides would depend on site-specific conditions that include the amount of oxygen and organic material present, temperature, spoil mineralogy, and local ground-water composition.

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WESTON 2011

Weston Solutions, Inc., Navajo Abandoned Uranium Mines Site Screen Report, Section 9 Lease AUM Site, January, 2011.

Navajo Abandoned Uranium Mine

Site Screen Report

This form is for use at the site of abandoned uranium mines (AUM) located on Navajo Nation lands. Applicable sites include all mine and mine features that have or have not undergone reclamation by the Navajo Abandoned Mine Lands Reclamation Program, including features, adits, pits and waste piles. Applicable sites also include all AUM sites listed in the USEPA CERCLIS database, all sites listed in the 2008 AUM GIS Report issued by USACOE and USEPA, all AUM sites on allotment lands associated with the Navajo Nation, and any and all AUM sites not listed in any database located on Navajo lands. Reconnaissance of any sites located on lands adjacent to Navajo lands that may be impacting Navajo lands will need to be coordinated with the authorities appropriate to those lands.

The purpose of the form is to ascertain the status and location of the identified AUM site, and record all immediate site information associated with the mine site. Decisions and recommendations on what additional steps are needed will be provided on a separate document.

Section 9 Lease AUM Site

*This screening report has been revised to remove the indication that Site ID# 457 contained structures associated with a former processing mill. The structures at the site appeared similar to mill structures during the initial site screening. After further examination, the structures at the site may have likely been associated with mining activities and operations other than that of a processing mill. Please Contact USEPA for further explanation.

Navajo AUM Western Region

Prepared by:

Weston Solutions, Inc.

Contract: W91238-06-F-0083

12767.063.599.1111

January 2011

Part I Site Identification, Location and Status

Site Names and ID numbers as applicable

Mine ID: 457; 458; 459

Map ID: ***457***: W92; ***458***: W98; ***459***: W99

CERCLIS: NNN000909110

Navajo Abandoned Mine Land Reclamation Program: None

Local name / Aliases: Section 9; Upgrader Property; C. O. Bar Livestock Company; mitone 1; mitone No. 1

Chapter and local area: State of Arizona

County: Coconino **State:** Arizona

Lat/Long: ***457***: 35.7397361971 N / -111.324146661 W
458: 35.7304249432 N / -111.330390516 W
459: 35.7261848105 N / -111.327493692 W

Nearby road and highway: Highway 89 **Local Post Office:** Cameron, AZ

Surface Land Status: check one or more and provide ownership and contact information below

Tribal Trust Land	☐	**Public lands**	☐
Private	☐	**Tribal Fee Land**	☐
Bureau of Land Mgmt	☐	**Allotment**	☐
State	☒	**Fee land**	☐

Subsurface Mineral Rights:

No information on subsurface mineral rights ownership was found in the EPA/AUM Database.

Claim and operator information:

The Section 9 Lease mine claim consists of 3 separate mine sites (#'s 457, 458, 459). The mine claim surface land status is classified as State of Arizona land. Historical documents showed the operator of the mine as the Rare Metals Corporation in 1957, C.L. Rankin from 1958 to 1959, and Murchison Ventures from 1959 to 1960. No additional ownership / lease information was identified in the EPA/AUM database.

Number of residential structures within 200 feet of mine: None

Estimated volume of mine waste onsite: ***457***: 46,296 yd^3; ***458***: 8,333 yd^3; ***459***: 249 yd^3

Part II Summary of radiological readings

Mine ID: 457

Highest gamma radiation measurement:

999,960 counts per minute (cpm)

Describe any other radiological measurements:

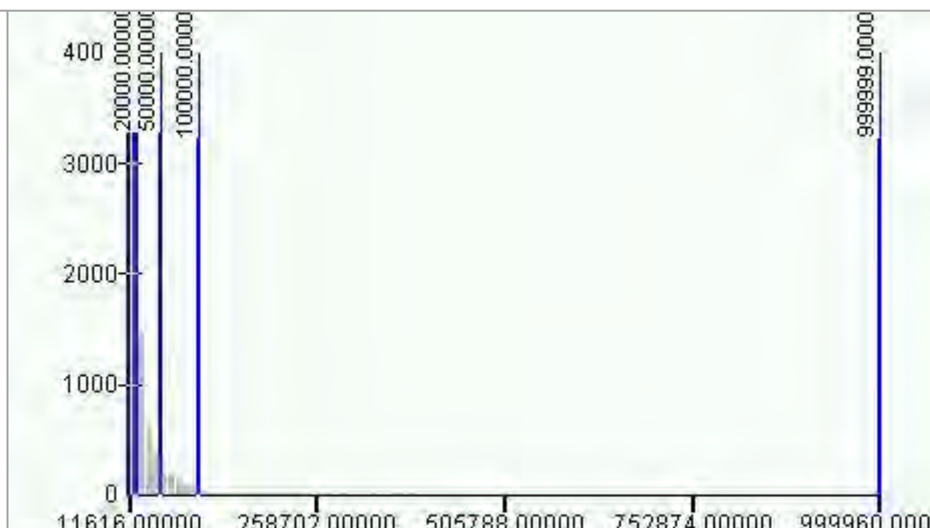
A total of 6,717 gamma radiation measurements were collected from the mine site, ranging from 11,616 cpm to 999,960 cpm. The measurements collected throughout the concrete structure foundation area were found at levels ranging from approximately 50,000 cpm (bare cement foundation) to 1,000,000 cpm (small dirt piles atop foundation), at the waste piles throughout the site at levels ranging from approximately 40,000 cpm to 1,000,000 cpm, and at the former pond area and downstream drainage at maximum levels of approximately 100,000 cpm. The measurements are represented in Figures 1, 2, 3, and 4.

Background Readings: 15,843 cpm; 15,455 cpm

Background Average: 15,649 cpm (mine claim background average was 15,626 cpm)

Distribution Chart and Statistics:

The following chart and statistics were generated by ESRI ArcGIS 9.3.1, and show the general distribution of the site gamma radiation measurements. The horizontal X axis represents the gamma radiation reading levels in cpm (lowest levels to the left). The vertical Y axis represents the frequency of each gamma radiation level.



Count:	6717
Minimum:	11616.00000
Maximum:	999960.00000
Sum:	332315799.00000
Mean:	49473.84234
Median:	22558.00000
Standard Deviation:	92138.62204

Mine ID: 458

Highest gamma radiation measurement:

968,863 counts per minute (cpm)

Describe any other radiological measurements:

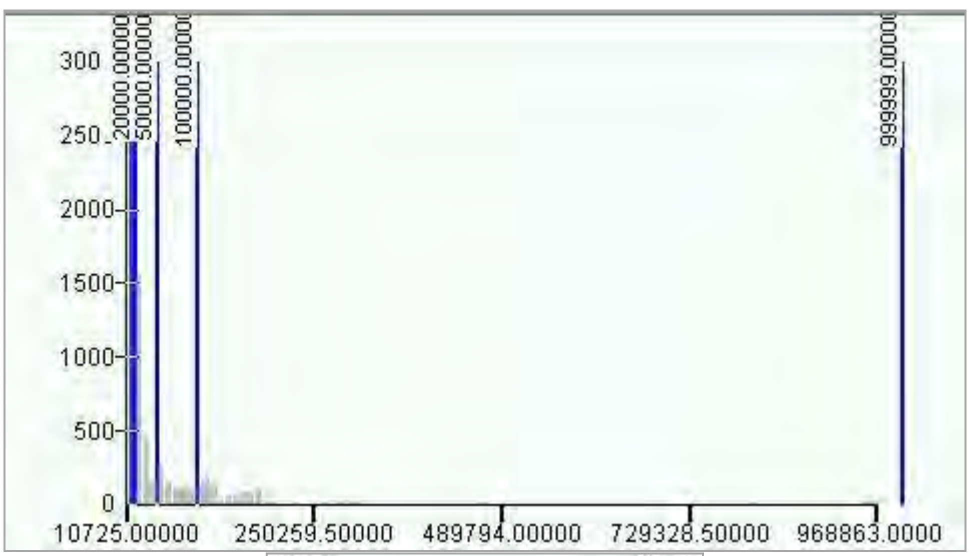
A total of 7,037 gamma radiation measurements were collected from the mine site, ranging from 10,725 cpm to 968,863 cpm. The measurements collected along the edge of the waste rock area were found at a maximum level of approximately 150,000 cpm, in the center of the waste rock area at a maximum level of approximately 1,000,000 cpm, and at possible pit area at a maximum level of approximately 300,000 cpm. The measurements are represented in Figures 1, 2, 5, and 6.

Background Readings: 15,455 cpm

Background Average: 15,455 cpm (mine claim background average was 15,626 cpm)

Distribution Chart and Statistics:

The following chart and statistics were generated by ESRI ArcGIS 9.3.1, and show the general distribution of the site gamma radiation measurements. The horizontal X axis represents the gamma radiation reading levels in cpm (lowest levels to the left). The vertical Y axis represents the frequency of each gamma radiation level.



Count:	7037
Minimum:	10725.00000
Maximum:	968863.00000
Sum:	414257471.00000
Mean:	58868.47677
Median:	22469.00000
Standard Deviation:	105611.70106

Mine ID: 459

Highest gamma radiation measurement:

879,666 counts per minute (cpm)

Describe any other radiological measurements:

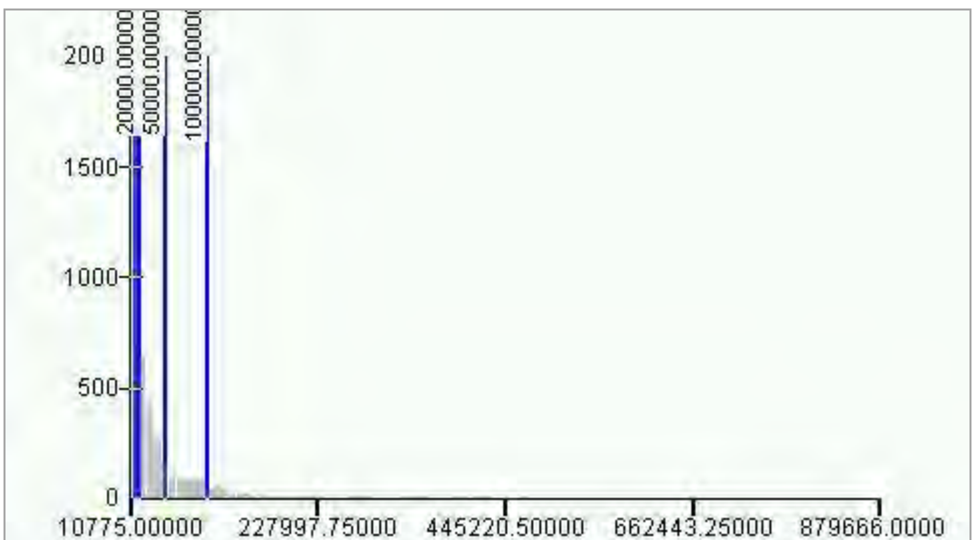
A total of 4,040 gamma radiation measurements were collected from the mine site, ranging from 10,775 cpm to 879,666 cpm. The measurements collected from the waste rock area were found at maximum levels ranging from approximately 60,000 cpm to 875,000 cpm, in the pit area ranging from approximately 30,000 cpm and the top to approximately 100,000 cpm at the bottom. The measurements are represented in Figures 1, 2, 7, and 8.

Background Readings: 15,775 cpm

Background Average: 15,775 cpm (mine claim background average was 15,626 cpm)

Distribution Chart and Statistics:

The following chart and statistics were generated by ESRI ArcGIS 9.3.1, and show the general distribution of the site gamma radiation measurements. The horizontal X axis represents the gamma radiation reading levels in cpm (lowest levels to the left). The vertical Y axis represents the frequency of each gamma radiation level.



Count:	4040
Minimum:	10775.00000
Maximum:	879666.00000
Sum:	207376058.00000
Mean:	51330.70743
Median:	22562.00000
Standard Deviation:	80056.99470

Part III Status of Reclamation and Mine Waste

Mine ID: 457

The following information was obtained from the Navajo Abandoned Mine Land Reclamation Program (NAMLRP) Point Features Database:

NAMLRP Status of the mine site: Reclaimed : Unknown **Waste Pile onsite :** No

NAMLRP Project Number: None

NAMLRP Mine features: None

The following information was obtained from field observations collected during the 2010 site screening:

Provide description and status of all mine sites and features at site. Include all waste piles, adits, pits and other features, and indicate whether they are open, closed, covered, capped, buried or unreclaimed. Indicate approximate size, shape and extent, including description of any reclamation caps. Note condition of all caps.

Observed reclamation work and status:

Adits
None

Waste Piles
Waste piles spread throughout entire central part of site, primarily surrounding the concrete structure foundation, total estimated size of 1,000' x 250' x 5'

Pits
None

Shafts
None

Other Debris and Mine Features
A concrete foundation and 2 walls from a former structure were found in the center of the site, the foundation was spread out between 2 levels, covering an estimated area of 100' x 50'. Two of the walls were still partially intact. The lower wall is approximately 30' high. Two chutes are still visible leading between the levels. A smaller 20' x 20' foundation was found approximately 300' south of large foundation. Other various metal and wood debris was found throughout site.

Mine ID: 458

The following information was obtained from the Navajo Abandoned Mine Land Reclamation Program (NAMLRP) Point Features Database:

NAMLRP Status of the mine site: Reclaimed : Unknown **Waste Pile onsite :** No

NAMLRP Project Number: None

NAMLRP Mine features: None

The following information was obtained from field observations collected during the 2010 site screening:

Provide description and status of all mine sites and features at site. Include all waste piles, adits, pits and other features, and indicate whether they are open, closed, covered, capped, buried or unreclaimed. Indicate approximate size, shape and extent, including description of any reclamation caps. Note condition of all caps.

Observed reclamation work and status:

Adits
None

Waste Piles
Majority of site is a large waste pile, extends S past the site boundaries, estimated size of 750' x 300' x 5'

Pits
None

Shafts
None

Other Debris and Mine Features
Mining debris spread out (drill rods); possible pit area in center of waste area

Mine ID: 459

The following information was obtained from the Navajo Abandoned Mine Land Reclamation Program (NAMLRP) Point Features Database:

NAMLRP Status of the mine site: Reclaimed : Yes **Waste Pile onsite :** No

NAMLRP Project Number: NA-0155A

NAMLRP Mine features: 1 Rim Strip / Pit

The following information was obtained from field observations collected during the 2010 site screening:

Provide description and status of all mine sites and features at site. Include all waste piles, adits, pits and other features, and indicate whether they are open, closed, covered, capped, buried or unreclaimed. Indicate approximate size, shape and extent, including description of any reclamation caps. Note condition of all caps.

Observed reclamation work and status:

Adits
None

Waste Piles
7 Waste piles: 2 small piles 6' x 4' x 2.5', yellow-brown upstream of N gully; 1 medium pile, 10' x 8' x 4', yellow brown upstream of N gully; 4 large piles, 20' diameter x 15' h, yellow brown, near open pit

Pits
Open Pit 60' x 80' x 15' depth, sandy bottom with vegetation

Shafts
None

Other Debris and Mine Features
None

Part IV

Site observations and Environs

Observed Structures: list number of and describe human habitation status of structures at the following distances from mine:

0 to 200 feet: None

200 feet to 0.25 mile: None

Observed Public or commercial structure: list and describe all schools, clinics, Chapter Houses, places of business and any other structure used by members of the community at the following distances:

0 to 200 feet: A large concrete foundation and 2 intact walls from a large structure were found in the center of site 457

200 feet to 0.25 mile: None

Levels measured around the perimeter(s) of the identified structure(s):

Waste piles atop the foundation area were found at levels up to 1,000,000 cpm

Observed water sources: list the number and type of wells and surface water sources that are potentially used for human consumption at the following distances from the mine:

0 to 0.25 miles: Little Colorado River Basin runs through the eastern edge of site 457

0.25 miles to 4 miles: None

Sensitive environments: note and describe all sensitive environments located within visible range of the mine site, including: wetlands, endangered species, habitats and approximate locations of sites that may be under protection of the government of the Navajo Nation.

Little Colorado River Basin adjacent to site 457, possible wetlands

Known Site History: include information from interviews with Chapter officials and residents. Note information on mine ownership, type of mining operation, period of operation, known amount of production, and any other information as provided.

Section 9 Lease mine claim consists of 3 separate mine sites (#'s 457, 458, 459) with a total combined area of 158,706.71 m^2. The mine claim was identified as being operational from 1957 to 1960. Historical documents showed the operator of the mine as the Rare Metals Corporation in 1957, C.L. Rankin from 1958 to 1959, and Murchison Ventures from 1959 to 1960. While operational, the mine had a total production volume of 362 tons. No other historical information or any additional ownership / lease information was identified in the EPA/AUM database.

Part V Response Action Summary

Summary of Evaluation Factors:

Accessibility:

Was the mine easily accessible to potential human activity?
Yes

Radiological Measurements:

Were any gamma radiation measurements collected at the mine greater than two times the site-specific background levels?
Yes

Waste Piles:

Were any unreclaimed waste piles observed at the mine with gamma radiation measurements greater than two times the site-specific background levels?
Yes

Structures:

Were any structures observed within 200 feet of the mine?
Yes

Potential Drinking Water Sources:

Were any potential drinking water sources observed within 4 miles of the mine?
Yes

Reclamation:

Was the mine reported to be previously reclaimed, or did the mine appear to be reclaimed?
No

Part VI Photos

Photo 1. Section 9 Lease, Site #457, western boundary

Photo 2. Section 9 Lease, Site #457, waste pile

Photo 3. Section 9 Lease, Site #457, waste piles

Photo 4. Section 9 Lease, Site #457, concrete structure area

Photo 5. Section 9 Lease, Site #457, concrete structure area

Photo 6. Section 9 Lease, Site #457, concrete structure area

Photo 7. Section 9 Lease, Site #457, concrete structure area

Photo 8. Section 9 Lease, Site #457, concrete structure area waste pile

Photo 9. Section 9 Lease, Site #457, concrete structure area

Photo 10. Section 9 Lease, Site #457, concrete structure area

Photo 11. Section 9 Lease, Site #457, concrete structure area

Photo 12. Section 9 Lease, Site #457, concrete structure area waste pile, gamma readings approximately 1,000,000 cpm

Photo 13. Section 9 Lease, Site #457, concrete structure area

Photo 14. Section 9 Lease, Site #457, concrete structure area

Photo 15. Section 9 Lease, Site #457, concrete structure area

Photo 16. Section 9 Lease, Site #457, former pond area

Photo 17. Section 9 Lease, Site #457, former pond area

Photo 18. Section 9 Lease, Site #457, Little Colorado River basin, eastern boundary


Photo 19. Section 9 Lease, Site #457, Little Colorado River basin, eastern boundary


Photo 20. Section 9 Lease, Site #457, foundation south of concrete structure area

Photo 21. Section 9 Lease, Site #457, debris

Photo 22. Section 9 Lease, Site #457, debris

Photo 23. Section 9 Lease, Site #457, debris

Photo 24. Section 9 Lease, Site #457, road leading to western boundary

Photo 25. Section 9 Lease, Site #458

Photo 26. Section 9 Lease, Site #458, waste pile


Photo 27. Section 9 Lease, Site #458, waste piles


Photo 28. Section 9 Lease, Site #458, waste piles

Photo 29. Section 9 Lease, Site #458, waste piles

Photo 30. Section 9 Lease, Site #458, waste pile, gamma readings approximately 1,000,000 cpm

Photo 31. Section 9 Lease, Site #458, center of waste area and possible pit

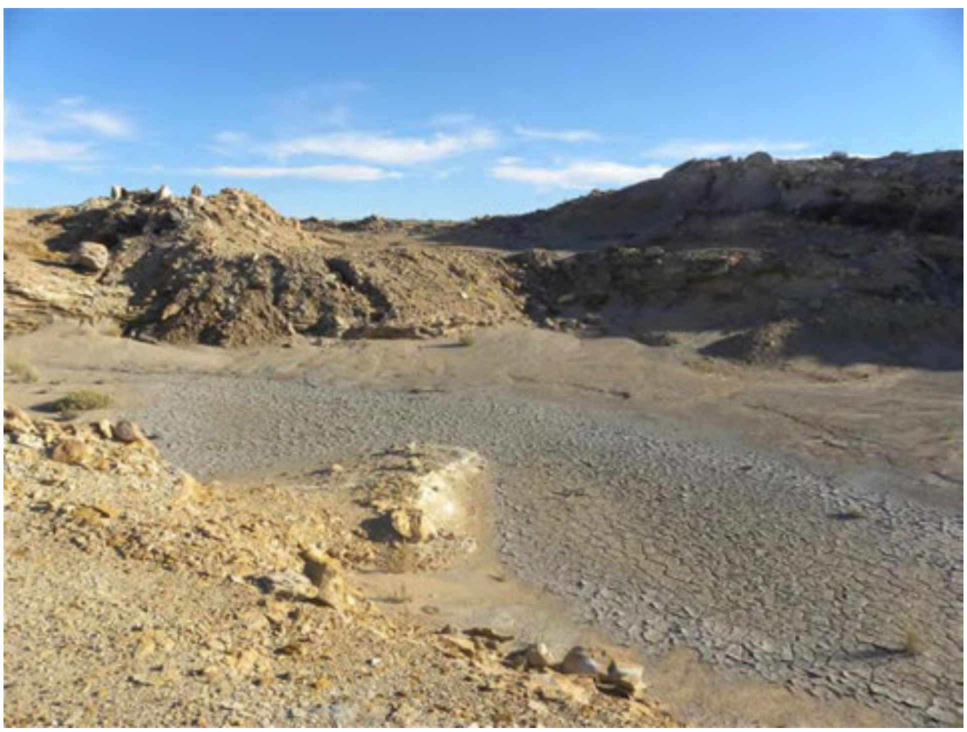


Photo 32. Section 9 Lease, Site #458, center of waste area and possible pit

Photo 33. Section 9 Lease, Site #458, mining evidence

Photo 34. Section 9 Lease, Site #459, waste piles

Photo 35. Section 9 Lease, Site #459, waste piles

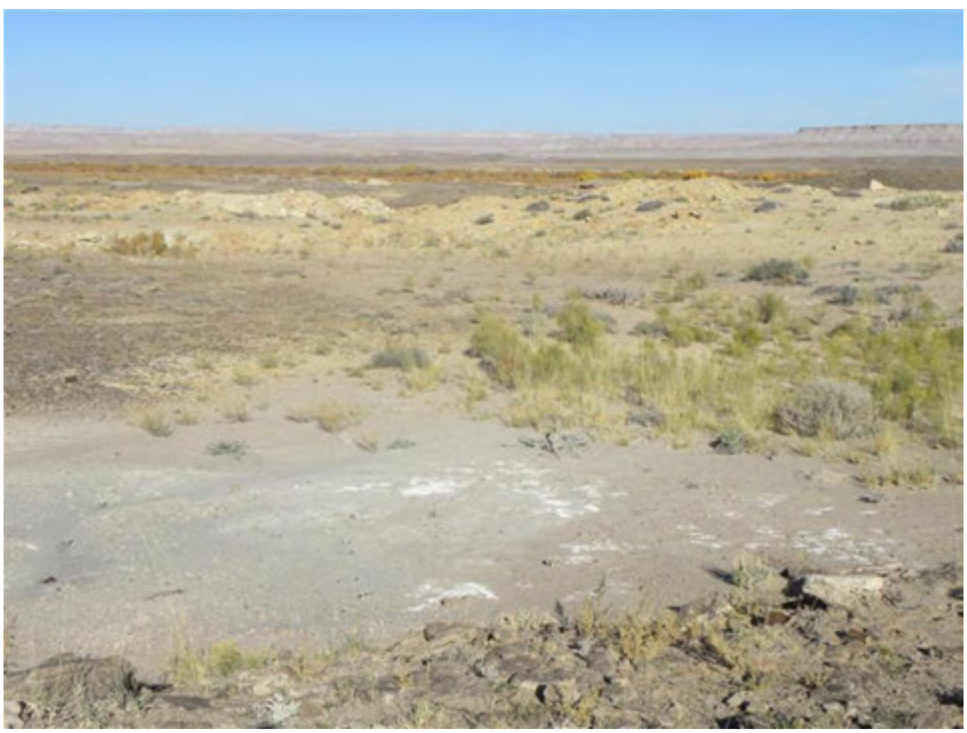


Photo 36. Section 9 Lease, Site #459

Photo 37. Section 9 Lease, Site #459, waste piles

Photo 38. Section 9 Lease, Site #459, possible pit area with waste piles

Photo 39. Section 9 Lease, Site #459

Part VII Contacts Reports and Information

Name: Stanley Edison (928) 871-6861

Eugene Esplain (928) 871-7331

Title or official role (if any) Navajo EPA Superfund Program

Address ___PO Box 2946, Window Rock, AZ 86515

Information provided Lead Regulatory Agency

Name____

Title or official role (if any) ________________________________

Address____

Telephone number____

Information provided______________________________________

Name____

Title or official role (if any) ________________________________

Telephone number____

Information provided______________________________________

Name____

Title or official role (if any) ________________________________

Telephone number____

Information provided______________________________________

Figure 1 - Gamma Radiation Measurements, Above Two Times Background
Section 9 Lease (457, 458, 459)
Coconino County, Arizona

Legend

Gamma Radiation Measurements

- < 2X Backgound
- > 2X Background

General Slope Direction

Observed Waste Pile

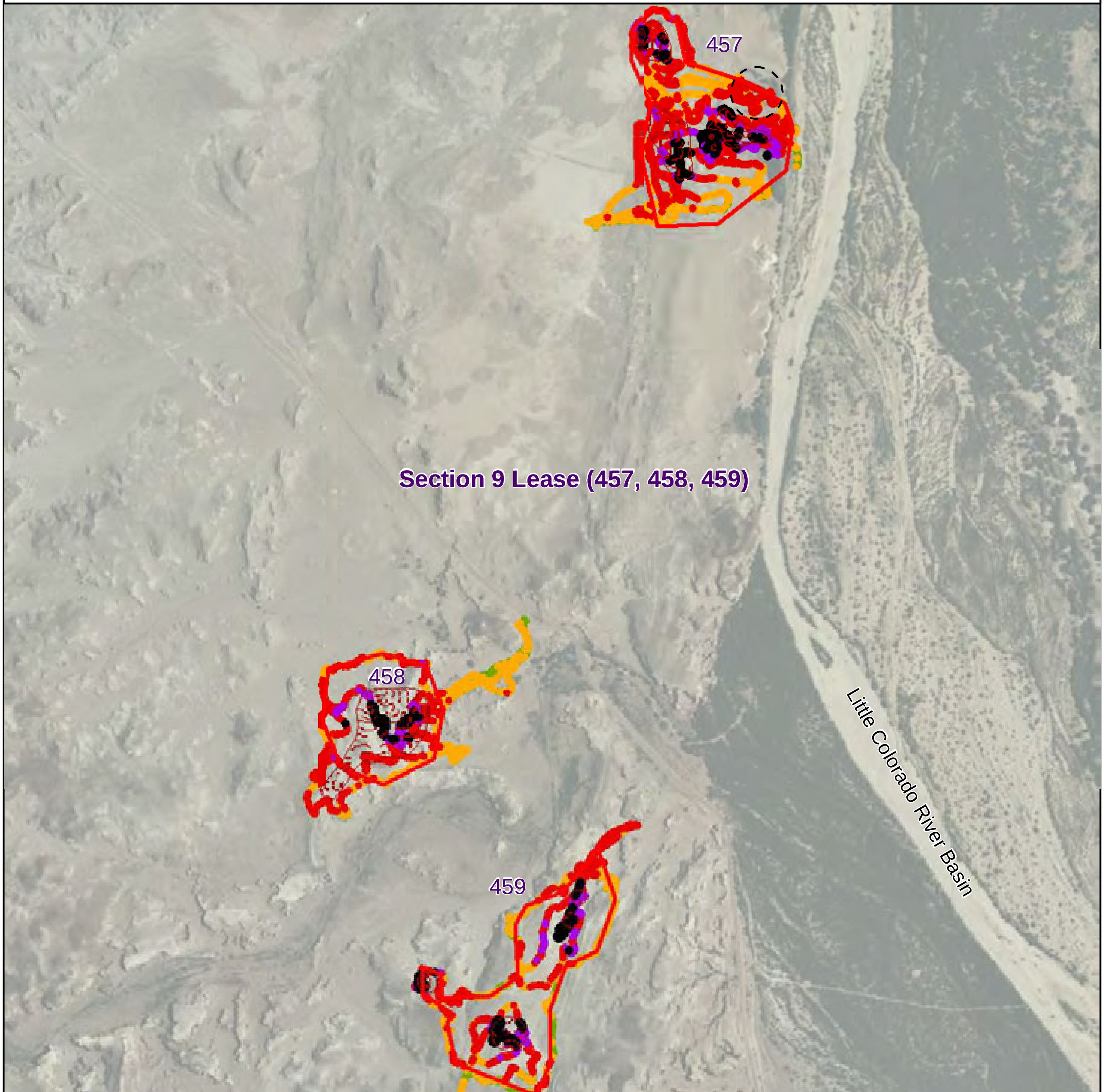
Mine Site Boundary

Feet
0 1,000

Gamma survey conducted 11/2010
Measured as counts per minute (cpm)

Average background 15,626 cpm

Figure 2 - Gamma Radiation Measurements
Section 9 Lease (457, 458, 459)
Coconino County, Arizona



Legend

Gamma Radiation Measurements

- 0 - 10,000
- 10,000 - 15,000
- 15,000 - 20,000
- 20,000 - 50,000
- 50,000 - 100,000
- > 100,000

Average background 15,626 cpm

General Slope Direction

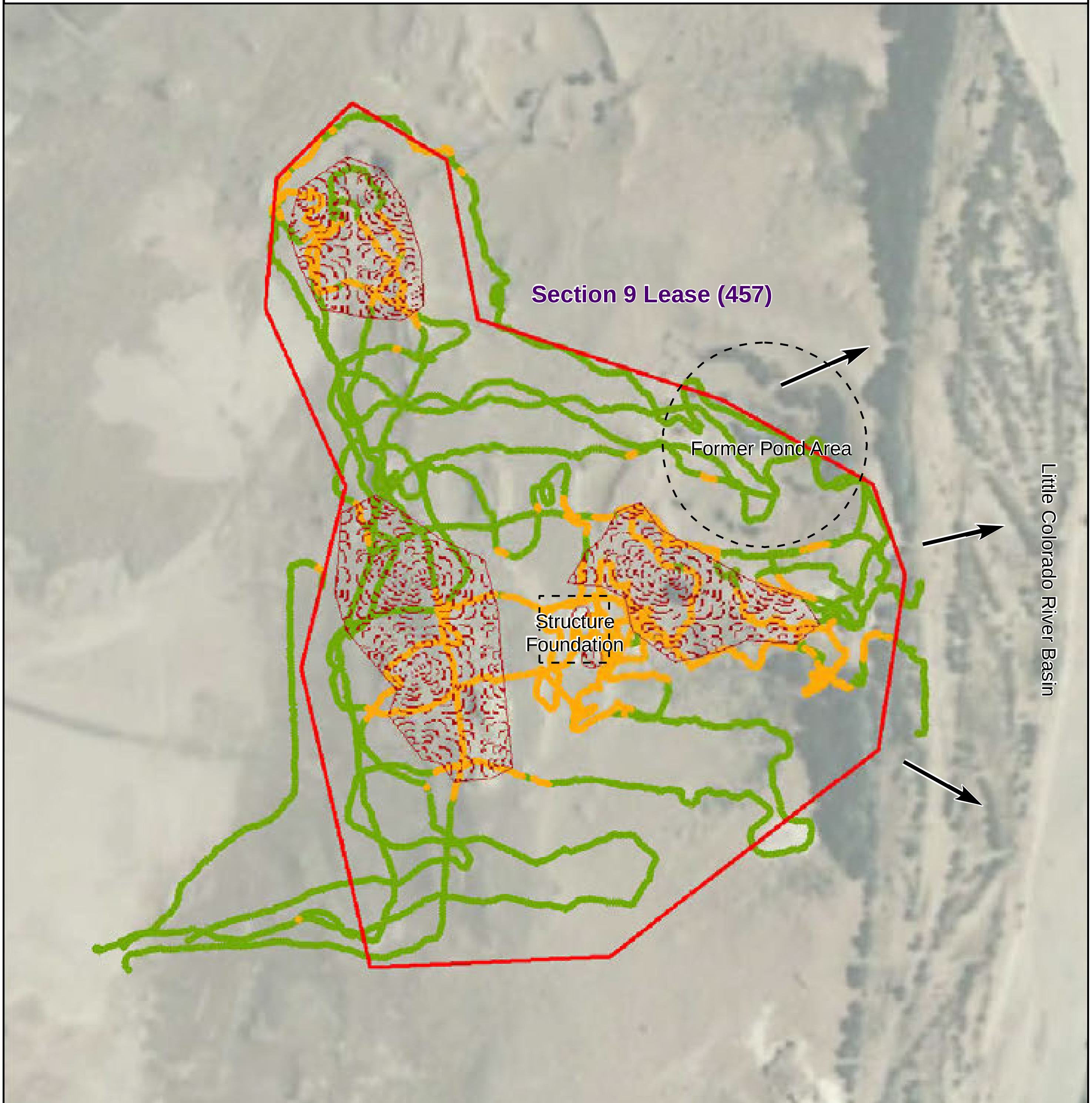
Observed Waste Pile

Mine Site Boundary

Feet
0 1,000

Gamma survey conducted 11/2010
Measured as counts per minute (cpm)

Figure 3 - Gamma Radiation Measurements, Above Two Times Background
Section 9 Lease (457)
Coconino County, Arizona



Legend

Gamma Radiation Measurements

- < 2X Backgound
- > 2X Background

General Slope Direction

Observed Waste Pile

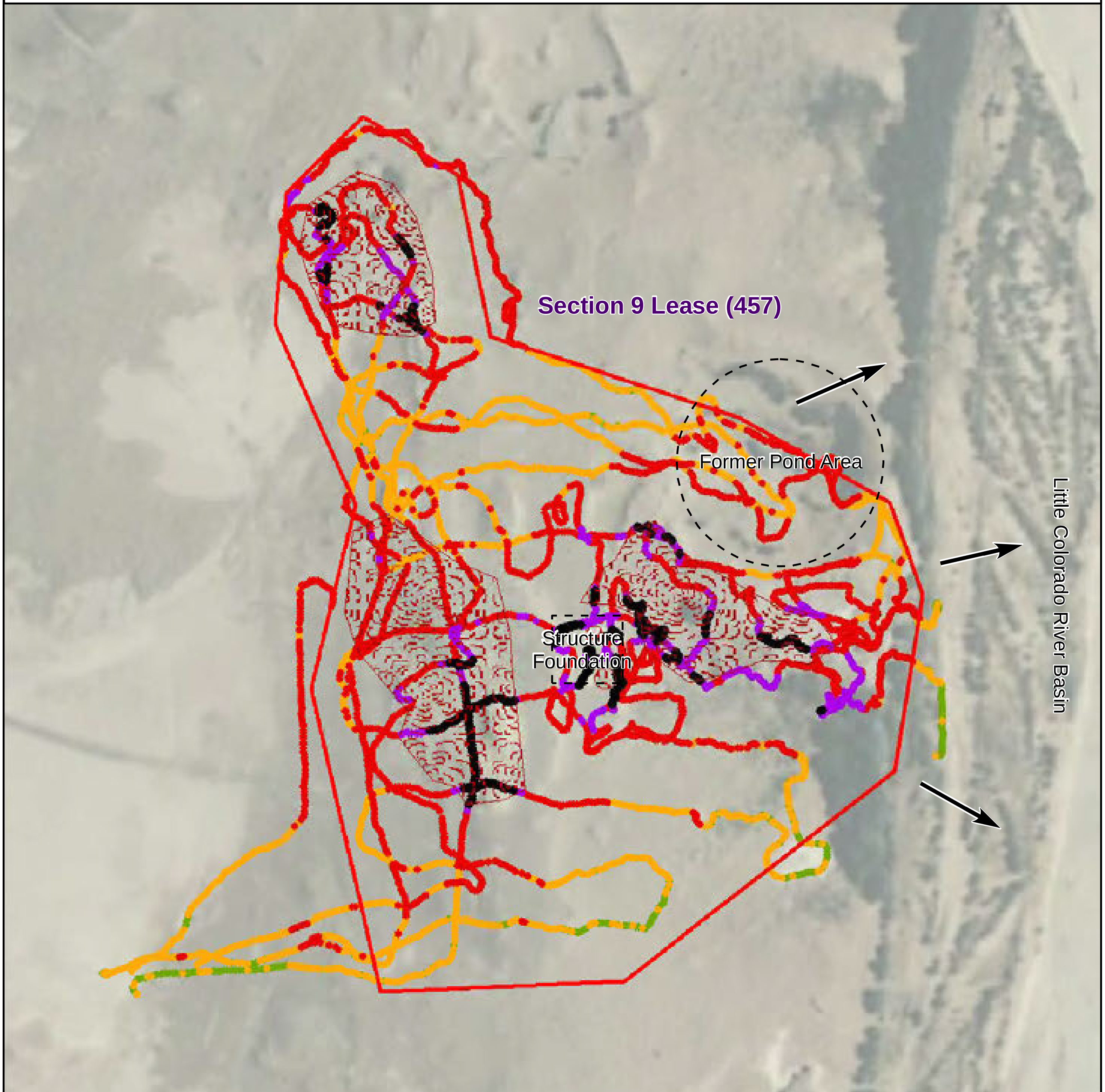
Mine Site Boundary

Feet
0 250

Gamma survey conducted 11/2010
Measured as counts per minute (cpm)

Average background 15,626 cpm

Figure 4 - Gamma Radiation Measurements
Section 9 Lease (457)
Coconino County, Arizona



Legend

Gamma Radiation Measurements

- 0 - 10,000
- 10,000 - 15,000
- 15,000 - 20,000
- 20,000 - 50,000
- 50,000 - 100,000
- > 100,000

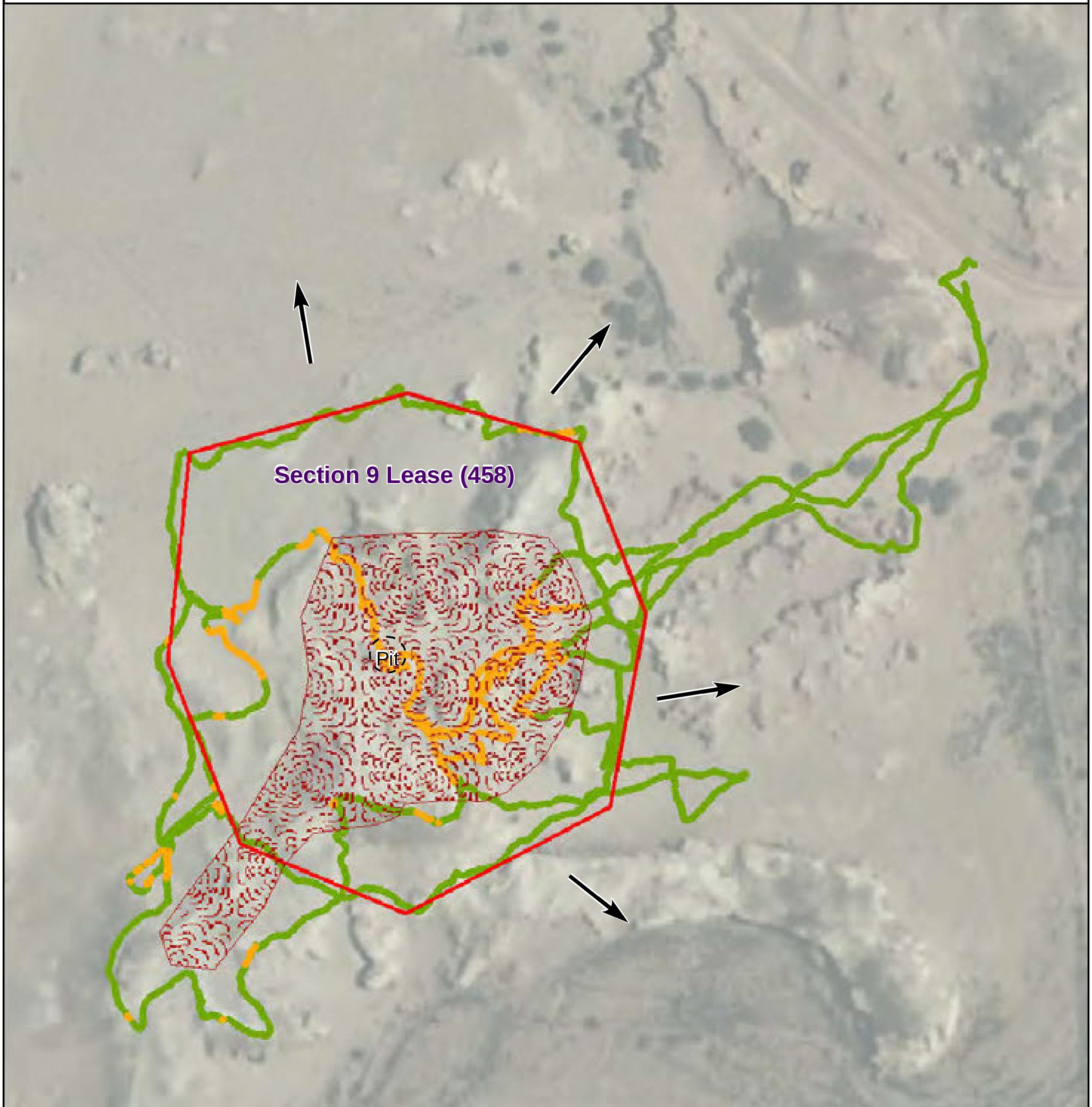
Average background 15,626 cpm

- General Slope Direction
- Observed Waste Pile
- Mine Site Boundary

Gamma survey conducted 11/2010
Measured as counts per minute (cpm)

Feet
0 250

Figure 5 - Gamma Radiation Measurements, Above Two Times Background
Section 9 Lease (458)
Coconino County, Arizona



Legend

Gamma Radiation Measurements

- < 2X Backgound
- > 2X Background

Gamma survey conducted 11/2010
Measured as counts per minute (cpm)

Average background 15,626 cpm

General Slope Direction

Observed Waste Pile

Mine Site Boundary

N

Feet
0 250

Figure 6 - Gamma Radiation Measurements
Section 9 Lease (458)
Coconino County, Arizona

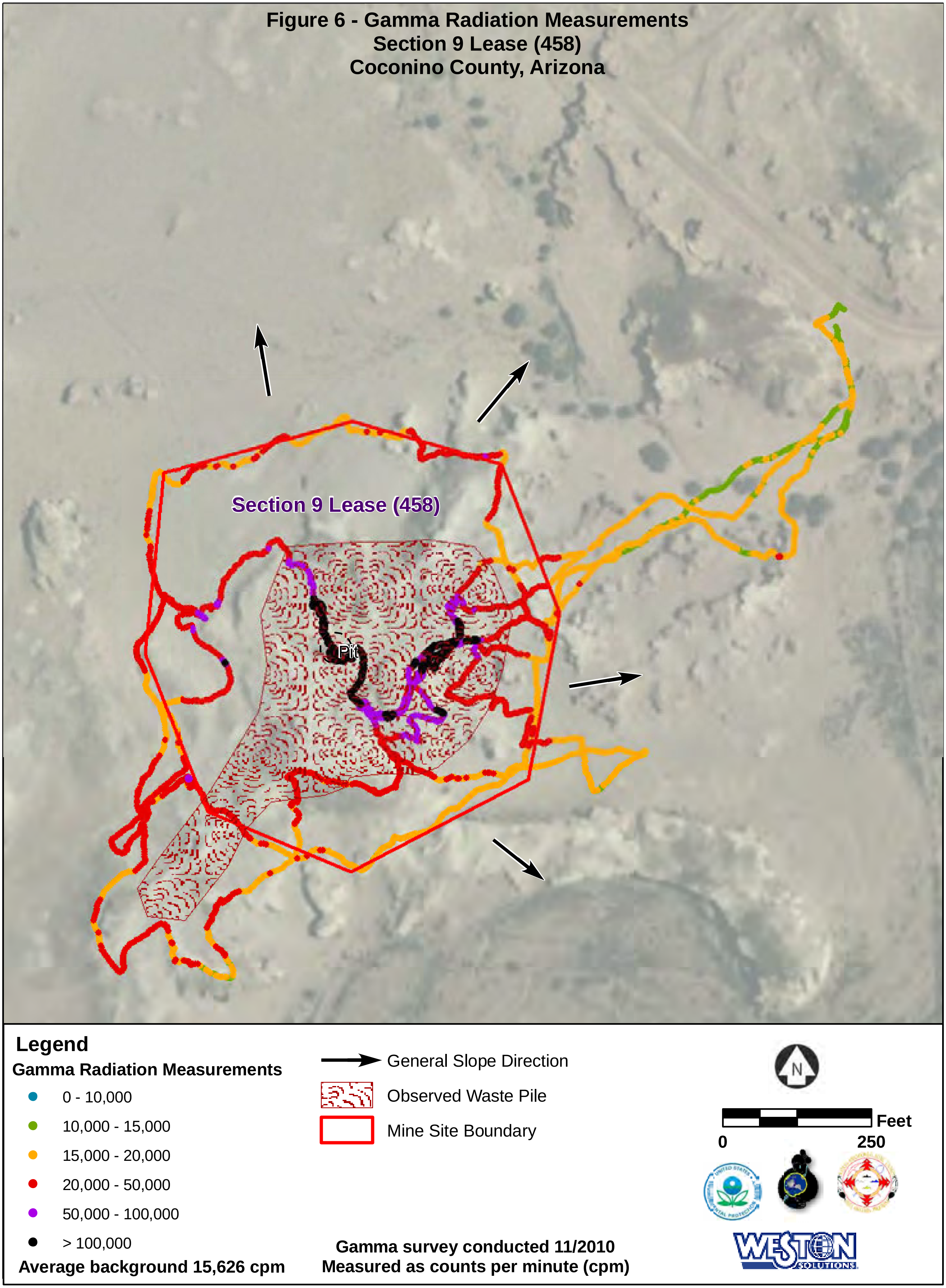
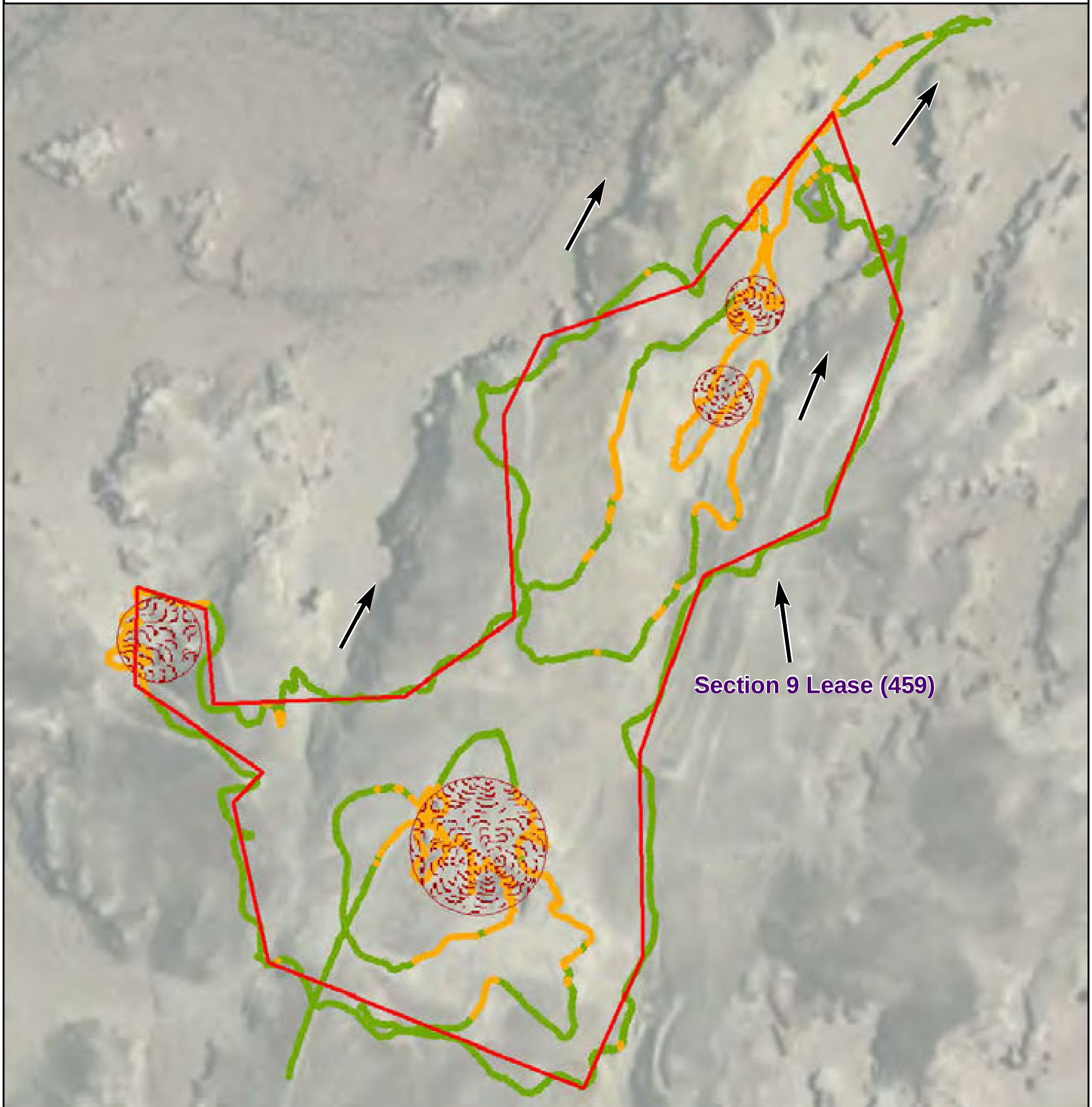


Figure 7 - Gamma Radiation Measurements, Above Two Times Background
Section 9 Lease (459)
Coconino County, Arizona



Legend

Gamma Radiation Measurements

- < 2X Backgound
- > 2X Background

General Slope Direction

Observed Waste Pile

Mine Site Boundary

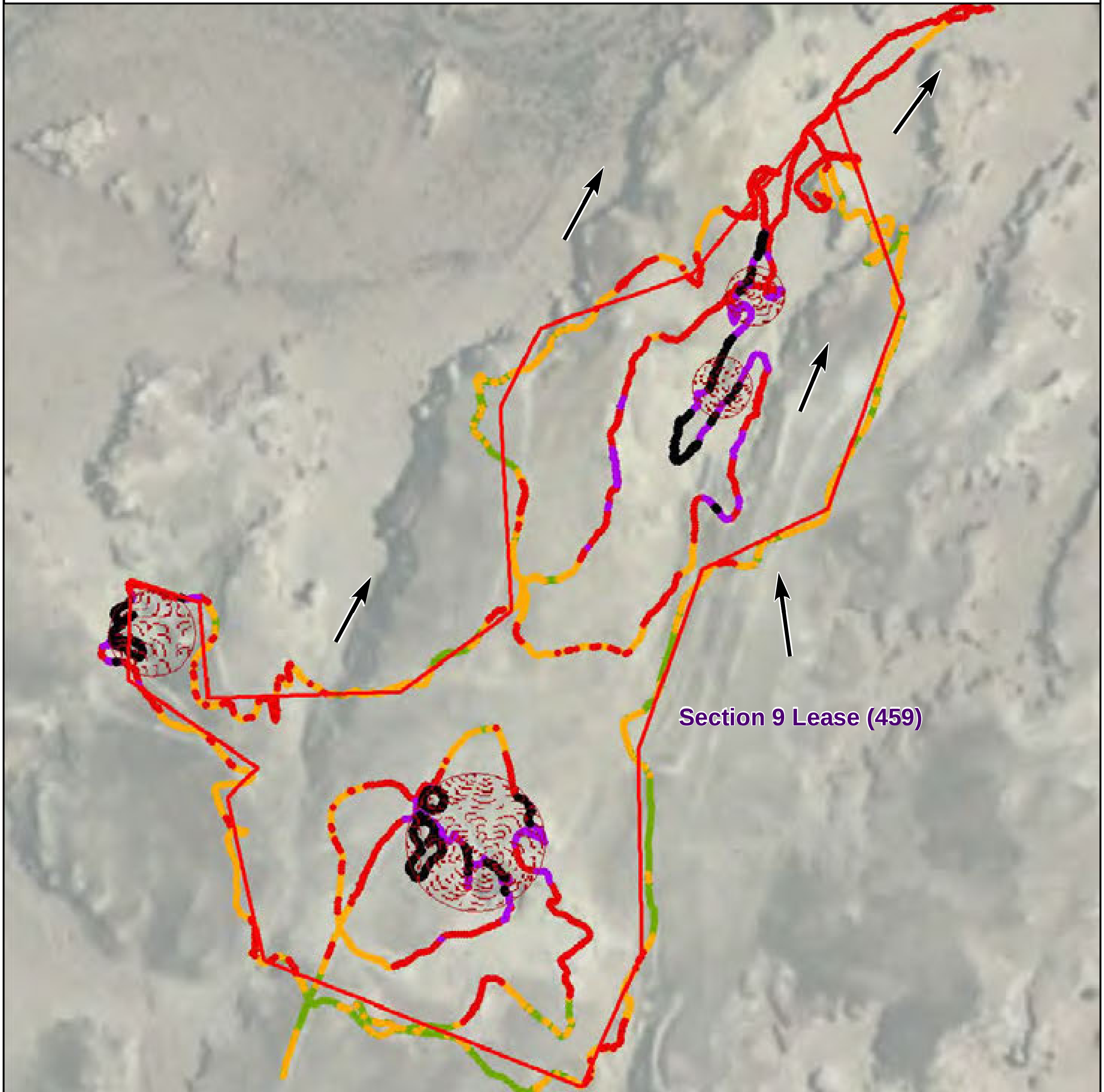
Feet

0 250

Gamma survey conducted 11/2010
Measured as counts per minute (cpm)

Average background 15,626 cpm

Figure 8 - Gamma Radiation Measurements
Section 9 Lease (459)
Coconino County, Arizona



Legend

Gamma Radiation Measurements

- 0 - 10,000
- 10,000 - 15,000
- 15,000 - 20,000
- 20,000 - 50,000
- 50,000 - 100,000
- > 100,000

Average background 15,626 cpm

General Slope Direction

Observed Waste Pile

Mine Site Boundary

N

Feet

0 250

Gamma survey conducted 11/2010

Measured as counts per minute (cpm)

WLC 2012

William L. Chenoweth, Section 9 Lease Analysis, Documents, and Field Notes,
September 1, 2012

Section 9 Document

Questions

(1) I get 361.55 tons for DOE (1979) document

1957	17.95	Rare Metals
1958	87.21	C.L. Rankin
1959	243.32	C.L. Rankin
1959	10.76	Murchison
1960	11.51	Murchison
	361.55	number used in CR-93-13

The 23.93 tons of material shipped in 1962 came from processing waste material left on Section 9 and from an old pit on Section 16, an AZ State Lease. Blakeman told me much of the material came from Section 16. That is why it was labeled Milestone #1.
In my report CR-93-13 that is why I kept it as separate property (See footnote 3 on page 24)

(2) That refers to the East Half of Section 9

(3) There was really no mining done in 1962 only the crushing of material previously mined on Sections 9 & 16

Comments On Operational History

1) After April 1, 1962, the AEC would only buy concentrate (yellowcake) from ores discovered prior to 11/24/58. The AEC office in Flagstaff had to work with every operator in AZ (except Monument Valley) to determine their reserves. It took about 4 years.

2) Mining Permits were issued by the Navajo Tribal Council (at the request of the Tribal Mining Department) and approved by the BIA

The term ore is material that can be sold for a profit. In uranium that would be material that assayed 0.10% U_3O_8 or greater. Material less than 0.10% U_3O_8 is uranium bearing waste rock.

bearing waste

Looking over my old field notes, I found the following items of interest

2-11-60 Contacted Paul Babbitt of C O Bar (attorney) in Flagstaff.

11-3-61 Contacted Leon Sterling (Milestone) at upgrader
Fired Blakemore as a consultant
Will get upgrader feed from Section 9 and Section 16 where he has a AZ State lease

3-8-62 Visited site. Plant was running a small stockpile of material left by Marcheson

4-5-62 Visited Tuba City mill. Mr. Rumke (manager) showed me their assays from Milestone's material,

Plant feed	0.02% U_3O_8
Product	0.06% U_3O_8
Tails	0.009% U_3O_8

Conclusion - Plant did not do what the investors was promised

William L. Chenoweth
9-1-12

2-11-60

CO Bar Livestock Co

Paul Babbitt Vice president

Lease and agreement dated August 10, 1959 with Marchion-Venture clue

sec 1	27	9
sec 5	27	10
7		
9		
17		
19		
21		
29		
15 portion west of ℄ Little Colo		
33 portion west of ℄ Little Colo		

For period of five years

C L Rankin gets $400/month beginning 100 days from date in lieu of royalties

C O Bar gets 1½% royalty and 200 per month beginning 100 days from date

If Marchion cancels ground reverts back to C L Rankin on terms of lease dated 9-30-58

C O Bar received $3.25 royalty check from Rare Metals for shipment. Only $100 total money received to date

— o —

Lands date relinquished lease on 7 & 17 May 31, 1958

Bonner leased 1, 9, 17 & 19 on Sept 15, 1958 (didn't include sec 7)

Lease assigned to C L Rankin on Sept 30, 1958

Rankin relinquished sec 17 on March 17, 1959

Rankin planned to add 17 in May 1959 but never signed papers.

— o —

From Chenoweth's Field Notes

(5)

E-mail Source

Sender: Kim Merin <kmerin@toeroek.com>

Subject: FW: Section 9 Lease PA: Please review operational history

Date: Thu, 30 Aug 2012 16:40:08 +0000

To: "'wl CHENOWETH (cheno@bresnan.net)'" <cheno@bresnan.net>

Cc: 'Steve Arbaugh' <Arbaugh.Steve@epamail.epa.gov>

ENFORCEMENT CONFIDENTIAL

Hi Bill,

Would you have time to review the following information for any errors/clarifications, and to address the following three questions from Steve? Ideally we'd love to get your response by early next week, but please let me know whether that is realistic given your schedule.

Thanks,

Kim

Includes Milestone #1

Specific Questions Regarding the Section 9 Operational History Below:

1. Section 9 total ore produced - I [Steve] get 374.4 tons of ore as opposed to 386 tons estimated by AEC. This is not a big deal but still a question.
2. Does the designation for the Section 9 property as Section 9 E H refer to eastern half?
3. The last shipment of ore from Milestone Hawaii, Inc. was in 1962. So the statement that mining operations ceased in 1961 misleading?

Operational History

Uranium ore was first reported in the Cameron area in 1950. Following the discovery, the United States Atomic Energy Commission (AEC) began to employ local Navajo residents to prospect the area. Land rights within the Navajo Nation were handled by the Bureau of Indian Affairs (BIA), who assigned mining permits to the Navajo residents. #2 The main mining production in the area began in 1951. In 1955, the Rare Metals Corporation (Rare Metals) was contracted by the AEC to open a mill near Tuba City, in order to produce highly concentrated "yellowcake" from the mined uranium ore. By 1956, the production was reaching its peak, and in 1958 the AEC announced that after April 1, 1962 it would no long accept any ore that had been discovered before November #1 24, 1958. Uranium mining in the Cameron area ceased by 1963 (ABGMT 1981; AEC; AGS 1993; NMGS 1958).

build & operate

The Section 9 Lease site is an abandoned uranium mine claim consisting of three separate mined areas (AUMs 457, 458, and 459) within a single leased property, and was operational from 1957 to 1962. The Site is located immediately south and west of the Navajo Nation border. While the nearby land rights within the Navajo Nation were handled by the BIA, the Site, along with many of the odd-numbered sections in the

(6)

vicinity, was owned by the C. O. Bar Livestock Company (CO Bar) from Flagstaff, Arizona. The Site area has reportedly been used for livestock cattle production by CO Bar and its parent company, Babbitt Ranches LLC (Babbitt), since 1886. The Site has also been identified under the following names: Upgrader Property, C.O. Bar Livestock Company, and Milestone No. 1 (ABGMT 1981; AEC; AGS 1993; TGS 2007; Appendix C-4).

In 1957 Rare Metals leased the rights to Township 27 North, Range 10 East, Section 9 from CO Bar, and began an open pit mining operation at three separate locations within the section. In the first year, Rare Metals shipped 17.95 tons of low grade ore from the Site to the Tuba City mill (AGS 1993).

By 1958 Rare Metals ceased mining operations at the Site, and C.L. Rankin acquired the lease from CO Bar. In the fall of 1958 C.L. Rankin shipped 87.21 tons of low grade ore (AGS 1993). Also shipped ore in 1959

In 1959 Murchison Ventures, Inc. from Denver, Colorado, acquired the lease of the Site. Murchison Ventures built a small processing plant known as a "Benson Upgrader" in the northeast part of the section (AUM 457), near one of the former pits. The upgrader plant separated the ore into a higher-grade slime fraction and a lower-grade sand fraction. The leftover sand tailings were left on the banks of the Little Colorado River, immediately east of the plant. The plant was reportedly used to take low-grade uranium ore from waste rock generated during earlier mining activities, and produce a higher "sellable" grade ore. Murchison Ventures sent a shipment of 10.76 tons of upgraded ore to the Tuba City Mill in 1959, under the name CO Bar Livestock Company Lease. In 1960, the plant was modified, and another shipment of 11.31 tons of ore was made. The company was reorganized in 1960 and renamed Milestone Hawaii, Inc. In 1961, the promoter of the operation, John Milton Addison, along with six associates, was convicted of fraud, conspiracy, and federal security violations as a result of the upgrading operation. In 1962, Milestone Hawaii made a shipment of 23.93 tons from the updated plant, and labeled the shipment origin as Milestone 1 (ABGMT 1981; AEC; AGS 1993; SEC 1961). Mining operations ceased at the Site in 1961; no known mining activities have been performed at the Site since. While operational, the AEC estimated the uranium ore production volume at the Section 9 Lease Mine, which included all three AUMs, as 386 tons. The Site is currently used by Babbitt for livestock grazing (ABGMT 1981; AEC; AGS 1993).

material

Very little of the ore came from Sec 9.

recorded

?

Kimberly Merin

Toeroek Associates, Inc

Office: (510) 899-4603

Mobile: (720) 626-7149

I doubled checked the numbers in document DOE - 1979 which was compiled from the big computer sheets Steve borrowed from me.
I found I had miscopied two numbers.
Correct numbers are below

1957	17.95
1958	87.21
1959	234.32
1959	10.76
1960	11.31
	361.55

The following sheet is from DOE document - GJBX-220(82) dated October 1982
Steve borrowed my copy and had it copied when he was out here

See first full paragraph

The material shipped as Milestone #1 was waste rock from Section 16 and Section 9 that was run through the "Benson Upgrader".
I was told that the majority of the rock came from Section 16

of $8 per pound. Thus, in 1956, the stage was set for a continuing AEC concentrate procurement program after March 31, 1962, with an established price for concentrates rather than for ores.

By late 1957, dramatic increases in reported ore reserves and in milling capacity prompted an AEC announcement that "it no longer is in the interest of the Government to expand production of uranium concentrate."* Then, in November 1958, in order to prevent further expansion of production under its essentially unlimited purchase commitment, the AEC redefined its 1962-1966 procurement program by withdrawing portions of the program announced in May 1956. The Government stated it would buy, in the 1962-1966 period, only "appropriate quantities of concentrate derived from ore reserves developed prior to November 24, 1958, in reliance upon the May 24, 1956, announcement."† Other aspects of the program announced in 1956 were retained: The AEC would buy only concentrates; the U_3O_8 price would remain at $8 per pound; and ores would not be purchased nor ore prices guaranteed.

With the objective of fostering the development and utilization of atomic energy for peaceful purposes, the AEC announced in May 1958 that "domestic producers of uranium ores and concentrate may now make private sales of these materials to domestic and foreign buyers for peaceful uses of atomic energy."‡ All such sales would be subject to licensing by the AEC, and the release of uranium under contract to the AEC would be considered, subject to appropriate contract modifications. While this announcement removed the legal impediment to private sales of uranium concentrate, no such sales were actually made until 1966.

In 1962, it was apparent to the AEC that the private market for uranium concentrates would not be sufficient to sustain a viable domestic uranium industry by the end of 1966 when the AEC procurement program was scheduled to end. Thus, in November 1962, the AEC announced its "stretch-out" program for 1967 through 1970.§ Under the program, the milling companies could voluntarily defer delivery of a portion of their 1963-1966 contract commitments until 1967 and 1968 in return for an AEC commitment to purchase, in 1969 and 1970, an additional amount of U_3O_8 equal to the quantity so deferred. The "stretch-out" program was the last of the major policy changes made in the AEC procurement program, although in January 1969, the AEC requested and accepted proposals for some further reductions in deliveries of concentrates in 1969 and 1970. The procurement program ended December 31, 1970.

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*Remarks prepared by Jesse C. Johnson, Director, Division of Raw Materials, U.S. Atomic Energy Commission, for delivery before the 4th Annual Conference of the Atomic Industrial Forum, New York, New York, October 28, 1957.

†Announcement dated November 21, 1958, and released November 24, 1958.

‡Public statement issued by the U.S. Atomic Energy Commission in Washington, D.C., May 8, 1958.

§Announcement dated November 17, 1962, and published in the Federal Register, November 20, 1962, 27FR11435.

APPENDIX F:

EPA Quick Reference Fact Sheet

United States
Environmental Protection
Agency

Office of
Solid Waste and
Emergency Response

Publication 9345.4-03FS

September 1993

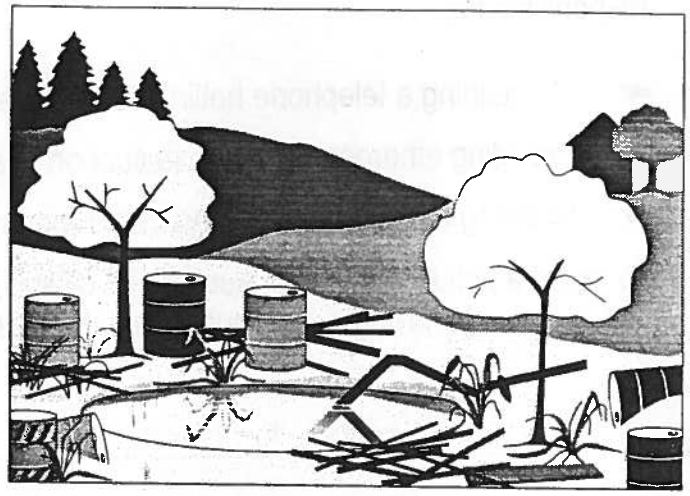
EPA

SITE ASSESSMENT:
Evaluating Risks at Superfund Sites

Office of Emergency and Remedial Response
Hazardous Site Evaluation Division 5204G

Quick Reference Fact Sheet

The Challenge of the Superfund Program



A series of headline-grabbing stories in the late 1970s, such as Love Canal, gave Americans a crash course in the perils of ignoring hazardous waste. At that time, there were no Federal regulations to protect the country against the dangers posed by hazardous substances (mainly industrial chemicals, accumulated pesticides, cleaning solvents, and other chemical products) abandoned at sites throughout the nation. And so, in 1980 Congress passed the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), commonly known as Superfund, to address these problems.

The major goal of the Superfund program is to protect human health and the environment by cleaning up areas, known as "sites," where hazardous waste contamination exists. The U.S. Environmental Protection Agency (EPA) is responsible for implementing the Superfund program.

At the time it passed the Superfund law, Congress believed that the problems associated with uncontrolled releases of hazardous waste could be handled in five years with $1.6 billion dollars. However, as more and more sites were identified, it became apparent that the problems were larger than anyone had originally believed. Thus, Congress passed the Superfund Amendments and Reauthorization Act (SARA) in 1986. SARA expanded and strengthened the authorities given to EPA in the original legislation and provided a budget of $8.5 billion over five years. Superfund was extended for another three years in 1991.

What is EPA's Job at Superfund Sites?

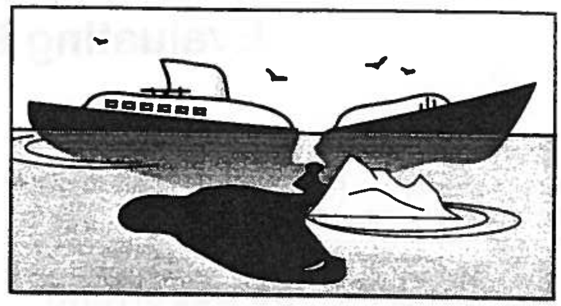
For more than 10 years, EPA has been implementing the Superfund law by:

- Evaluating potential hazardous waste sites to determine if a problem exists;
- Finding the parties who caused the hazardous waste problems and directing them to address these problems under EPA oversight or requiring them to repay EPA for addressing these problems; and
- Reducing immediate risks and tackling complex hazardous waste problems.

The Superfund site assessment process generally begins with the discovery of contamination at a site and ends with the completion of remediation (i.e., cleaning up the waste at a site) activities. This fact sheet explains the early part of the process, called the *site assessment* phase.

The National Response Center

The National Response Center (NRC), staffed by Coast Guard personnel, is the primary agency to contact for reporting all oil, chemical, and biological discharges into the environment anywhere in the U.S. and its territories. It is responsible for:



- Maintaining a telephone hotline 365 days a year, 24 hours a day;
- Providing emergency response support in specific incidents; and
- Notifying other Federal agencies of reports of pollution incidents.

To report a pollution incident, such as an oil spill, a pipeline system failure, or a transportation accident involving hazardous material, call the NRC hotline at **800-424-8802.**

1 Site Discovery

Hazardous waste sites are discovered in various ways. Sometimes concerned residents find drums filled with unknown substances surrounded by dead vegetation and call the NRC, EPA, or the State environmental agency; or an anonymous caller to the NRC or EPA reports suspicious dumping activities. Many sites come to EPA's attention through routine inspections conducted by other Federal, State, or local government officials. Other sites have resulted from a hazardous waste spill or an explosion. EPA enters these sites into a computer system that tracks any future Superfund activities.

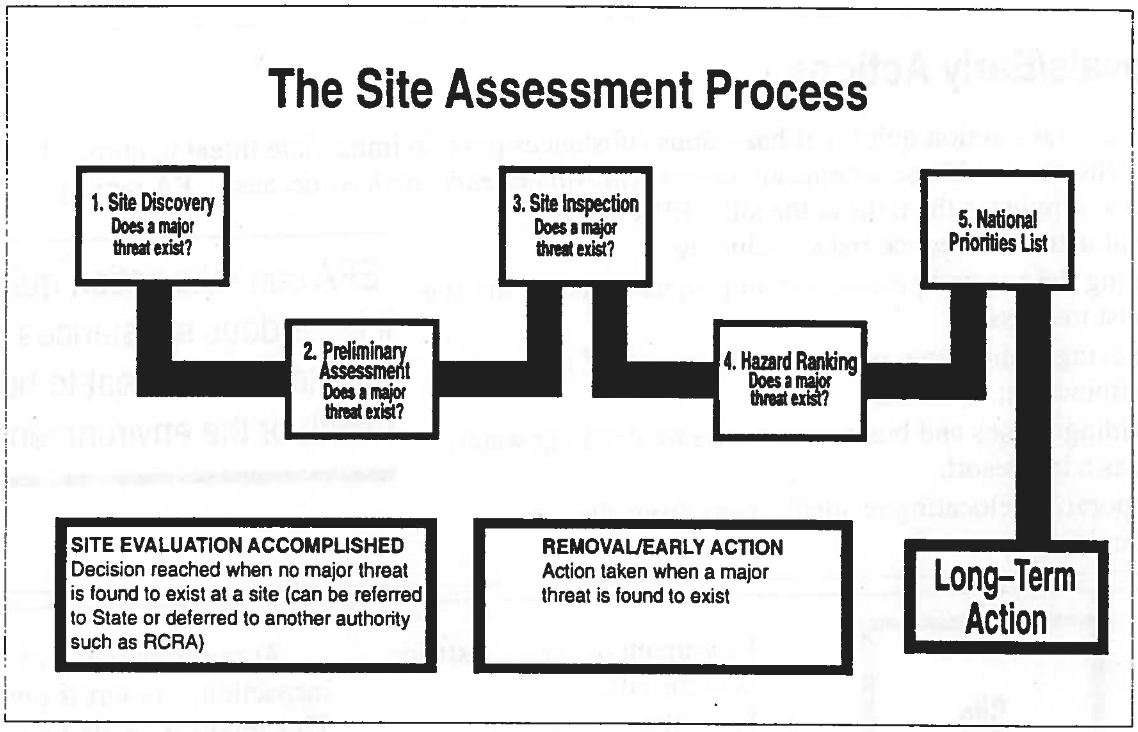
2 Preliminary Assessment

After learning about a site, the next step in the site assessment process is to gather existing information about the site. EPA calls this the *preliminary assessment.* Anyone can request that a preliminary assessment be performed at a site by petitioning EPA, the State environmental agency, local representatives, or health officials.

During the preliminary assessment, EPA or the State environmental agency:

- Reviews available background records;
- Determines the size of the site and the area around it;
- Tries to determine whether hazardous substances are involved;
- Identifies actual or potential pollution victims, such as the nearby population and sensitive environments;
- Makes phone calls or interviews people who may be familiar with the site; and
- Evaluates the need for early action using EPA's removal authority.

By gathering information and possibly visiting the site, EPA or the State environmental agency is able to determine if major threats exist and if cleanup is needed. Many times, the preliminary assessment indicates that no major threats exist.



However, if hazardous substances do pose an immediate threat, EPA quickly acts to address the threat. When a site presents an immediate danger to human health or the environment—for example, there is the potential for a fire or an explosion or the drinking water is contaminated as a result of hazardous substances leaking out of drums—EPA can move quickly to address site contamination. This action is called a *removal* or an *early action.* Additional information on early actions can be found on page 4.

EPA or the State environmental agency then decides if further Federal actions are required. Of the more than 35,000 sites discovered since 1980, only a small percentage have needed further remedial action under the Federal program.

A report is prepared at the completion of the preliminary assessment. The report includes a description of any hazardous substance release, the possible source of the release, whether the contamination could endanger people or the environment, and the pathways of the release. The information outlined in this report is formed into hypotheses that are tested if further investigation takes place. You can request a copy of this report once it becomes final— just send your name and address to your EPA regional Superfund office. See page 8 for further information on these contacts.

Sometimes it is difficult to tell if there is contamination at the site based on the initial information gathering. When this happens, EPA moves on to the next step of the site assessment, called the *site inspection.*

Making Polluters Pay

One of the major goals of the Superfund program is to have the responsible parties pay for or conduct remedial activities at hazardous waste sites. To accomplish this goal, EPA:

- Researches and determines who is responsible for contaminating the site;
- Issues an order requiring the private parties to perform cleanup actions with EPA oversight; and
- Recovers costs that EPA spends on site activities from the private parties.

Removals/Early Actions

EPA can take action quickly if hazardous substances pose an immediate threat to human health or the environment. These actions are called *removals* or *early actions* because EPA rapidly eliminates or reduces the risks at the site. EPA can take a number of actions to reduce risks, including:

- Fencing the site and posting warning signs to secure the site against trespassers;
- Removing, containing, or treating the source of the contamination;
- Providing homes and businesses with safe drinking water; and, as a last resort,
- Temporarily relocating residents away from site contamination.

"EPA can take action quickly if hazardous substances pose an immediate threat to human health or the environment."

3 Site Inspection

If the preliminary assessment shows that hazardous substances at the site may threaten residents or the environment, EPA performs a site inspection. During the site inspection, EPA or the State collects samples of the suspected hazardous substances in nearby soil and water. EPA may initiate a concurrent SI/remedial investigation at those sites that are most serious and determined early as requiring long-term action. Sometimes, wells have to be drilled to sample the ground water. Site inspectors may wear protective gear, including coveralls and respirators, to protect themselves against any hazardous substances present at the site. Samples collected during the site inspection are sent to a laboratory for analysis to help EPA answer many questions, such as:

- Are hazardous substances present at the site? If so, what are they, and approximately how much of each substance is at the site?
- Have these hazardous substances been released into the environment? If so, when did the releases occur, and where did they originate?
- Have people been exposed to the hazardous substances? If so, how many people?
- Do these hazardous substances occur naturally in the immediate area of the site? At what concentrations?
- Have conditions at the site gotten worse since the preliminary assessment? If so, is an early action or removal needed? (See box above.)

Often, the site inspection indicates that there is no release of major contamination at the site, or that the hazardous substances are safely contained and have no possibility of being released into the environment. In these situations, EPA decides that no further Federal inspections or remedial actions are needed. This decision is referred to as *site evaluation accomplished.* (See page 5 for more details on the *site evaluation accomplished* decision.)

At the completion of the site inspection, a report is prepared. This report is available to the public–call your EPA regional Superfund office for a copy. See page 8 for the phone numbers of these offices.

"During the site inspection, EPA or the State collects samples of the suspected hazardous substances in nearby soil and water."

At sites with particularly complex conditions, EPA may need to perform a second SI to obtain legally defensible documentation of the releases.

Because EPA has limited resources, a method has been developed to rank the sites and set priorities throughout the nation. That method, known as the *Hazard Ranking System*, is the next step in the site assessment process.

4 Hazard Ranking System

EPA uses the information collected during the preliminary assessment and site inspection to evaluate the conditions at the site and determine the need for long-term remedial actions. When evaluating the seriousness of contamination at a site, EPA asks the following questions:

- Are people or sensitive environments, such as wetlands or endangered species, on or near the site?
- What is the toxic nature and volume of waste at the site?
- What is the possibility that a hazardous substance is in or will escape into ground water, surface water, air, or soil?

Based on answers to these questions, each site is given a score between zero and 100. Sites that score 28.5 or above move to the next step in the process: listing on the *National Priorities List*. Sites that score below 28.5 are referred to the State for further action.

Site Evaluation Accomplished

In many instances, site investigators find that potential sites do not warrant Federal action under the Superfund program. This conclusion can be attributed to one of two reasons:

- The contaminants present at the site do not pose a major threat to the local population or environment; or
- The site should be addressed by another Federal authority, such as EPA's Resource Conservation and Recovery Act (RCRA) hazardous waste management program.

When investigators reach this conclusion, the site evaluation is considered accomplished. A site can reach this point at several places during the site assessment process, namely at the conclusion of the preliminary assessment or the site inspection, or once the site is scored under the Hazard Ranking System.

5 National Priorities List

Sites that are listed on the *National Priorities List* present a potential threat to human health and the environment, and require further study to determine what, if any, remediation is necessary. EPA can pay for and conduct remedial actions at NPL sites if the responsible parties are unable or unwilling to take action themselves. There are three ways a site can be listed on the National Priorities List:

- It scores 28.5 or above on the Hazard Ranking System;
- If the State where the site is located gives it top priority, the site is listed on the National Priorities List regardless of the HRS score; or
- EPA lists the site, regardless of its score, because all of the following are true about the site:
  - The Agency for Toxic Substances and Disease Registry (ATSDR), a group within the U.S. Public Health Service, issues a health advisory recommending that the local population be *dissociated* from the site (i.e., that the people be temporarily relocated or the immediate public health threat be removed);
  - EPA determines that the site poses a significant threat to human health; and
  - Conducting long-term remediation activities will be more effective than addressing site contamination through early actions.

The list of proposed sites is published in the *Federal Register*, a publication of legal notices issued by Federal agencies. The community typically has 60 days to comment on the list. After considering all comments, EPA publishes a list of those sites that are officially on the National Priorities List. When a site is added to the National Priorities List, the site assessment is completed. Long-term actions take place during the next phase. See page 6 for more details on long-term actions.

As a Concerned Citizen, How Can I Help ?

- Read this fact sheet.
- Call EPA with any potential sites in your area.
- Provide EPA with site information.
- Comment on proposed listing of sites on the National Priorities List.
- If the site is listed on the NPL, work with your citizens' group to apply for a technical assistance grant.

Addressing Sites in the Long Term

Once a site is placed on the National Priorities List, it enters the long-term or remedial phase. The stages of this phase include:

- ✓ Investigating to fully determine the nature and extent of contamination at the site, which can include a public health assessment done by the ATSDR;
- ✓ Exploring possible technologies to address site contamination;
- ✓ Selecting the appropriate technologies—also called remedies;
- ✓ Documenting the selected remedies in a record of decision (ROD);
- ✓ Designing and constructing the technologies associated with the selected remedies;
- ✓ If necessary, operating and maintaining the technologies for several years (e.g., long-term treatment of ground water) to ensure safety levels are reached; and
- ✓ Deleting the site from the National Priorities List, completing Superfund's process and mission.

Some Commonly Asked Questions

Q: **What exactly is a site?**

A: EPA designates the area in which contamination exists as the "site." Samples are taken to define the area of contamination. At any time during the cleanup process the site may be expanded if contamination is discovered to have spread further.

Q: **How long will it take to find out if a threat exists?**

A: Within one year of discovering the site, EPA must perform a preliminary assessment. The preliminary assessment allows EPA to determine if there is an immediate danger at the site; if so, EPA takes the proper precautions. You will be notified if you are in danger. EPA may also contact you to determine what you know about the site.

Q: **What is the State's role in all these investigations?**

A: The State can take the lead in investigating and addressing contamination. It also provides EPA with background information on (1) immediate threats to the population or environment, and (2) any parties that might be responsible for site contamination. The State shares in the cost of any long-term actions conducted by the Superfund program, comments on the proposal of sites to the National Priorities List, and concurs on the selected remedies and final deletion of sites from the National Priorities List.

Q: **Why are private contractors used to assess sites?**

A: EPA has a limited workforce. By using private contractors, EPA is able to investigate more sites. Also, EPA is able to draw on the expertise of private contracting companies.

Q: **Why are there so many steps in the evaluation process? Why can't you just take away all the contaminated materials right now, just to be safe?**

A: When EPA assesses a site, it first determines if contamination poses any threats to the health of the local population and the integrity of the environment. Dealing with worst sites first is one of Superfund's national goals. By evaluating contamination in a phased approach, EPA can quickly identify sites that pose the greatest threats and move them through the site assessment process. Once EPA understands the conditions present at a site, it searches for the remedy that will best protect public health and the environment. Cost is only one factor in weighing equally protective remedies. Many sites do not warrant actions because no major threat exists. However, if a significant threat does exist, EPA will take action.

about Superfund Sites

Q: If a site is added to the National Priorities List, how will we know when EPA has completed the cleanup efforts?

A: EPA notifies the public and requests their comments on the actions proposed to treat site contaminants. In addition, the community is notified when a site will be deleted from the National Priorities List. The entire process can take as long as 7 years; at sites where ground water is contaminated, it can take even longer.

Q: I live next door to a site and I see EPA and contractor personnel wearing "moon suits." Am I safe?

A: EPA and contractor personnel wear protective gear because they might actually be handling hazardous materials. Also, these people are regularly exposed to contaminants at different sites and do not always know what contaminants they are handling. EPA takes steps to protect the public from coming in contact with the site contamination. If a dangerous situation arises, you will be notified immediately.

Q: If a site is added to the National Priorities List, who pays for the activities?

A: EPA issues legal orders requiring the responsible parties to conduct site cleanup activities under EPA oversight. If the parties do not cooperate, Superfund pays and files suit for reimbursement from responsible parties. The sources of this fund are taxes on the chemical and oil industries; only a small fraction of the fund is generated by income tax dollars.

Q: How can I get more information on any health-related concerns?

A: Contact your EPA regional Superfund office for more information. The ATSDR also provides information to the public on the health effects of hazardous substances. Ask your EPA regional Superfund office for the phone number of the ATSDR office in your region.

Q: How can I verify your findings? What if I disagree with your conclusions?

A: You can request copies of the results of the site assessment by writing to your EPA regional Superfund office. The public is given the opportunity to comment on the proposal of a site to the National Priorities List and the actions EPA recommends be taken at the site. If a site in your community is listed on the National Priorities List, a local community group may receive grant funds from EPA to hire a technical advisor. Call your EPA regional Superfund office (see page 8) for the location of an information repository and for information on applying for a **technical assistance grant.**

Q: How can I get further information? How can I get a list of the sites EPA has investigated?

A: Contact your EPA regional Superfund office (see page 8) for more information and a list of sites in your area.

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Important Phone Numbers

For information on the Superfund program or to report a hazardous waste emergency, call the national numbers below.

U.S. EPA Headquarters Hazardous Site Evaluation Division
☎ Site Assessment Branch
703-603-8860

Federal Superfund Program Information
☎ EPA Superfund Hotline
800-424-9346

Emergency Numbers:

Hazardous Waste Emergencies
☎ National Response Center
800-424-8802

ATSDR Emergency Response Assistance
☎ Emergency Response Line
404-639-0615

For answers to site-specific questions and information on opportunities for public involvement, contact your region's Superfund community relations office.

EPA Region 1: *Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont*
☎ Superfund Community Relations Section
617-565-2713

EPA Region 2: *New Jersey, New York, Puerto Rico, Virgin Islands*
☎ Superfund Community Relations Branch
212-264-1407

EPA Region 3: *Delaware, District of Columbia, Maryland, Pennsylvania, Virginia, West Virginia*
☎ Superfund Community Relations Branch
800-438-2474

EPA Region 4: *Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee*
☎ Superfund Site Assessment Section
404-347-5065

EPA Region 5: *Illinois, Indiana, Michigan, Minnesota, Ohio, Wisconsin*
☎ Office of Superfund
312-353-9773

EPA Region 6: *Arkansas, Louisiana, New Mexico, Oklahoma, Texas*
☎ Superfund Management Branch, Information Management Section
214-655-6718

EPA Region 7: *Iowa, Kansas, Missouri, Nebraska*
☎ Public Affairs Office
913-551-7003

EPA Region 8: *Colorado, Montana, North Dakota, South Dakota, Utah, Wyoming*
☎ Superfund Community Involvement Branch
303-294-1124

EPA Region 9: *Arizona, California, Hawaii, Nevada, American Samoa, Guam*
☎ Superfund Office of Community Relations
800-231-3075

EPA Region 10: *Alaska, Idaho, Oregon, Washington*
☎ Superfund Community Relations
206-553-2711