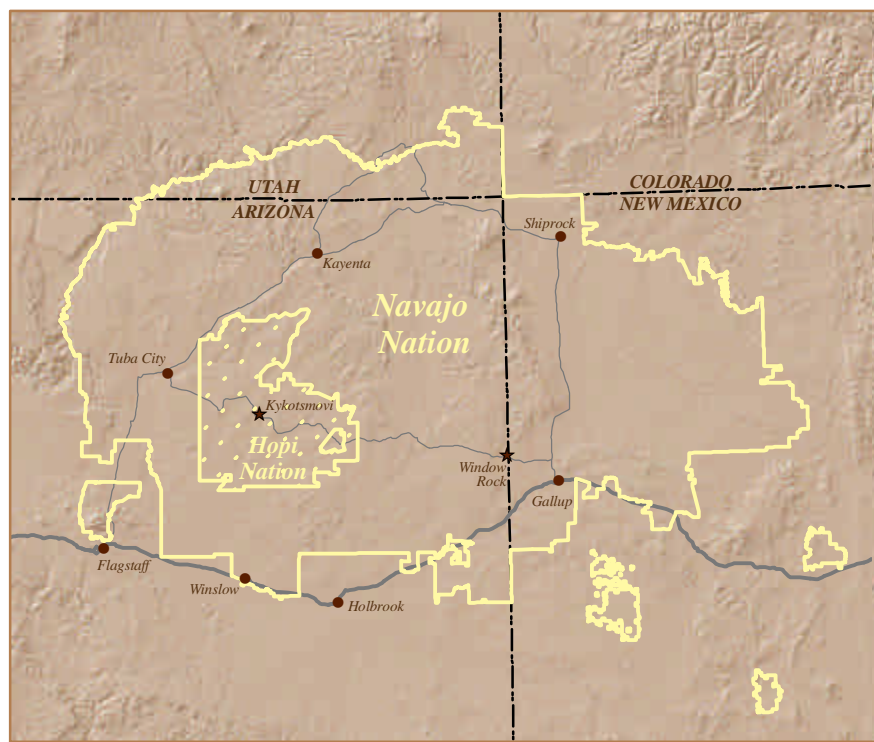


# ABANDONED URANIUM MINES PROJECT ARIZONA, NEW MEXICO, UTAH - NAVAJO LANDS

1994 - 2000

## PROJECT ATLAS



U.S. Environmental Protection Agency  
Region 9 Superfund Records Center

U.S. Army Corps of Engineers  
Los Angeles District





## COVER PHOTOS

*All photos were taken by Glynn Alsup and Brian Jordan of the U.S. Army Corps of Engineers (USACE).*

Cover photos (clockwise from top left).

Cottonwood Chapter at Black Mountain Well. This photo was taken on March 16, 1999 at sample ID CH990316TCS001 (36° 7' 46.1"N, 109° 52' 51.7"W) at an elevation of 6,229.3 feet.

Shonto Chapter at Tank 2K-305. This photo shows Glynn Alsup (USACE) and Frank Laughter (Shonto Grazing Official) collecting a water sample at a water tank in Shonto (sample ID KY980831SHW001). This photo was taken on August 31, 1998 at 36° 46' 41.80"N, 110° 34' 29.80"W at an elevation of 7,269.7 feet.

Cove Chapter series of mines in the Lukachukai Mountains. This photo was taken on May 18, 1999 at 36° 32' 21.06"N, 109° 14' 35.17"W at an elevation of 7,339.8 feet.

Black Mesa Chapter at Windmill Tank 308-1. The end of a long day of sampling. This photo was taken on November 5, 1998 to document sampling sites CH981105BMW005 and CH981105BMW006 (36° 12' 55.23"N, 110° 14' 12.33"W) at an elevation of 6,238.0 feet.

Chinle Chapter at Cottonwood Spring. This photo was taken on November 23, 1998 to document sample ID CH981123CHS001 (36° 10' 58.86"N, 109° 27' 45.92"W) at an elevation of 6,132.7 feet.

Tuba City Chapter at Standing Rock Well. This photo was taken on August 12, 1998 at sample ID CT980812TCW005 (36° 14' 18.07"N, 111° 13' 39.57"W) at an elevation of 5,205.8 feet.

Blue Gap Chapter at White Clay Spring. This photo was taken on November 24, 1998 and shows Brian Jordan (USACE) preparing to collect a location measurement using a Global Positioning System (GPS) instrument. The photo was taken at sample ID CH981124BGS002 (36° 13' 1.40"N, 109° 52' 55.03"W) at an elevation of 6,899.0 feet.

The map shows the boundaries of the Navajo and Hopi Nations on a shaded relief image base. The Navajo Nation encompasses approximately 25,000 square miles in portions of three states: Arizona, New Mexico, and Utah. The Hopi Nation is located in northeast Arizona. The Navajo Nation provided the boundaries used in this Atlas for the Navajo Nation and Hopi Nation. Also shown are primary highways and population centers.

For information about the Hopi Nation, visit the website at <http://www.hopi.nsn.us>. The Navajo Nation website is at: <http://www.navajo.org>.

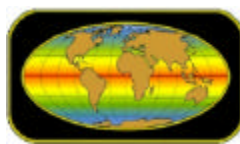


# ABANDONED URANIUM MINES PROJECT ARIZONA, NEW MEXICO, UTAH - NAVAJO LANDS

1994 - 2000

## PROJECT ATLAS

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December 2000

# ABANDONED URANIUM MINES PROJECT ATLAS

## ACKNOWLEDGEMENT

The assistance and support of the Navajo Nation communities in the areas of this project are respectfully acknowledged for their contribution to the investigations of the abandoned uranium mines. Community representatives--elected officials, teachers, and other leaders--shared their knowledge with a sincere welcome and hope for the future. Their expressions of interest and support provided a constant source of enthusiasm and commitment to the objectives of the project. It would not have been possible to collect the necessary data without their unique knowledge of the terrain, water sources and land use of the areas around the old mines. The long drives for the fieldwork that began at dawn and ended by moonlight could not have been possible without this enthusiasm enriched by their Navajo sense of humor. Thank you to the Chapter Officials who provided translation into Navajo for community members interested in the purpose of the work. Thank you to the numerous officials who generously donated their time in identifying old mines, homes made of mine waste rock and water sources used by the people of their communities. Thank you to the teachers who brought the science of field investigations into their classrooms where students learned about the abandoned uranium mines. Community leaders contributed hundreds of hours of their time toward the success of thousands of hours of surveying, sampling and educating. Their dedication to serving their communities remains an inspiration for all.

Áhéhee'  
THANK YOU



# ABANDONED URANIUM MINES PROJECT ATLAS

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# ABANDONED URANIUM MINES PROJECT ATLAS

## EXECUTIVE SUMMARY

### BACKGROUND

The U.S. Environmental Protection Agency (USEPA) Region 9 Abandoned Uranium Mines Project began following a U.S. Congressional Committee study and hearings held in 1993<sup>1</sup>. The Navajo Nation presented testimony concerning abandoned uranium mines and requested assistance in determining if the old mines posed a health risk to residents. The USEPA presented testimony to describe its federal authority under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and how the USEPA could assist the tribe. The U.S. Department of Energy (USDOE) and the U.S. Department of Interior (USDOI), the Navajo Nation Environmental Protection Agency (NNEPA) and the Navajo Nation Abandoned Mine Lands Reclamation Department (NNAMLRD) also participated in the hearings.

In 1994, USEPA Region 9 investigated the abandoned uranium mines in the King Tutt Mesa study area located in the Red Valley Chapter of the Navajo Nation. The investigations were conducted with the assistance of the NNEPA Superfund Program, Bechtel Environmental, and the USDOE Remote Sensing Laboratory. In June 1997, the USEPA Region 9 and Bechtel Environmental issued a draft document<sup>2</sup> for comment. From the King Tutt Mesa study, a three-step process was developed for investigating other areas with abandoned uranium mines.

1. Conduct aerial (helicopter) radiation surveys to locate the sources of radiation in the areas of old mines.
2. Test the water used for human consumption in the areas of old mines.
3. Survey homes to determine if they were constructed with radioactive materials from the mines.

Various planning materials were collected and reviewed prior to extending the project. Numerous historical records and reports of mining activity in the Navajo Nation were assembled. The results of studies of similar environmental situations in other mining areas were reviewed. These were combined with the lessons learned from the King Tutt Mesa study to expand the project to other mining areas across the Navajo Nation. Through Interagency Agreements with USDOE and the USACE, senior scientists and field personnel brought expert technologies for surveys and sampling to six mining districts known to be areas of historical mining and exploration for uranium:

Four Corners  
Monument Valley  
Cameron-Tuba City  
Bidahochi  
Central Area  
Chinle

The USDOE Aerial Measuring System (AMS) survey capability was used to measure and map radiation sources within known uranium mining areas. The same type of helicopter surveys that were used in 1994 in the Four Corners Area were conducted in 1997, 1998 and 1999 in the other areas. A project total of 1,144 square miles were surveyed. In March 1998 the USACE joined the project to investigate water used for human consumption and home construction using mine waste rock in the areas of the old uranium mining activities.

The lead agency was the USEPA Region 9, with Patti Collins as the Project Manager-Senior Scientist and Vicki Rosen as the Community Involvement Coordinator. Working with the USEPA were agencies including NNEPA, NNAMLRD, USDOE, and USACE, as well as academic and scientific institutions.

### ABANDONED URANIUM MINES PROJECT - DATA COLLECTION

#### Purpose

The purpose of the Abandoned Uranium Mines Project was to identify the radiation sources, characterize the exposure, and recommend methods to reduce radiation exposure from abandoned uranium mines on the Navajo Nation.

Providing education and outreach about radiation, and working with individual communities living in proximity to the abandoned mines, was also an important component of the project. In order for the Abandoned Uranium Mines Project to succeed, it was necessary to involve the affected communities and to engage them as active community partners. An important objective of the project was to develop an outreach strategy that would result in a two-way sharing of information. This involved educational efforts to increase understanding and awareness of the mines and their possible effects, as well as engaging the participation of Chapter Officials to assist in identifying water sources used for human consumption and homes that should be surveyed.

A preliminary technical objective of the project was to determine where the old uranium mines were located. Historical maps and records were researched to identify possible mine locations. Aerial helicopter radiation surveys were flown to measure radiation over suspected mining areas in order to locate the current sources of radiation.

<sup>1</sup> The July 1993 Congressional Committee report was titled "Deep Pockets: Taxpayer Liability for Environmental Contamination". Subsequent Congressional hearings were held on November 4, 1993.

<sup>2</sup> USEPA Region 9 Superfund Division, 1997. Integrated Assessment, Draft for Comment, Navajo Uranium Mines-King Tutt Mesa Study Area, Red Valley Chapter, Navajo Nation, Oak Spring, New Mexico 87420, Site EPA ID Number: NND 986667434

# ABANDONED URANIUM MINES PROJECT ATLAS

## EXECUTIVE SUMMARY (continued)

To evaluate risks to human health by ingestion of stable and radioactive metals in water, a sampling program was designed to measure analyte concentrations in water sources used for human consumption. The sampling program consisted of collecting one water sample at each well, tap, spring, or tank identified by local Chapter Officials as a source used for human consumption. All samples were collected as a point-of-use sample designed to duplicate the most likely method in which a person would obtain water for human consumption. If there was a common source for multiple users, such as a community well or tap, only the common source location was sampled.

### The Data

From 1994 to 2000, USEPA Region 9 brought the project to approximately 30 chapters on the Navajo Nation. Outreach materials in the form of simple flyers and photographs were distributed to the chapter houses and trading posts. Maps were developed from the aerial surveys to show radiation contours, water-sampling results and risk analysis. These maps were provided to, and reviewed with, Chapter Officials. Several presentations on uranium, the mines and the environment were given at schools throughout the Navajo Nation. Presentations with more technical content were given to several science classes to teach about the project and how the water sampling was performed. A coloring book titled "Gamma Goat - The Dangers of Uranium" was created to teach the younger children about uranium mines and radiation.

Aerial radiological surveys of 41 uranium mining areas (1,144 square miles) within the Navajo Nation were conducted during the period from October 1994 through October 1999. The USEPA Region 9 funded the surveys and the USDOE Remote Sensing Laboratory in Las Vegas, Nevada conducted the aerial surveys. The aerial survey data were used to characterize the overall radioactivity and excess Bismuth<sup>214</sup> levels within the surveyed areas. Bismuth<sup>214</sup> is an indicator of uranium ore deposits and/or uranium mines. Identifying current radiation source areas was useful for designing field sampling plans for water and home surveys.

The USACE identified many radiation sources, sampled water used for human consumption, and conducted home surveys. Between June 1998 and January 2000 the USACE field investigations included 227 water samples, 27 Quality Control Samples (of which 14 were field blanks and 13 were duplicates), 28 home surveys, and 34 radiation surveys. The home surveys are not presented in this Atlas.

In January 2000, Michael Feeley (Deputy Director of the USEPA Region 9 Superfund Program) initiated demobilization of the field team. The demobilization was based on a request from Derrith Watchman-Moore, Executive Director of the NNEPA to cease all visits to tribal chapters. The project team began demobilization of all field activities including sampling and communications. The demobilization was completed January 31, 2000. Subsequently all aspects of the project began close-out activities leading to the summarization and distribution of the data collected between 1994 and 2000. These close-out activities included archiving all of the scientific information collected for the project and development of this Project Atlas.

## PROJECT ATLAS

The Abandoned Uranium Mines Project Atlas was designed to provide the user with an overview of the project and the water and aerial radiation data that were collected for the project. The maps in the overview section of the Atlas provide a regional view of the Navajo Nation. For each survey area, the Atlas provides contour maps that depict where gross count and Bismuth<sup>214</sup> radiation were measured from the aerial radiation surveys conducted during the period October 1994 through October 1999. The Atlas is also a compilation of data tables and reference maps that reflect field information, laboratory analytical results (stable and radioactive metals), and basic risk information associated with water samples collected between June 1998 and January 2000 from water sources within the Navajo Nation. Finally, the Atlas appendices provide the user with summary descriptions of the history, data collection, data management and community involvement activities associated with the project. A list of references is included in Appendix F for users who are interested in additional information about this and related projects. These references are available through the USEPA Region 9 Superfund Records Center.



*Monument Valley*

# ABANDONED URANIUM MINES PROJECT ATLAS

## ATLAS ORGANIZATION AND STRUCTURE

The following provides a brief description of the Project Atlas organization and structure. The Atlas presents results from the aerial radiation surveys and water sample data collection efforts conducted for the Abandoned Uranium Mines Project. The Atlas is organized into the following seven sections:

Section 1:	Regional Overview
Section 2:	Four Corners Area
Section 3:	Cameron/Tuba City Area
Section 4:	Central Area
Section 5:	Chinle Area
Section 6:	Bidahochi Area
Section 7:	Monument Valley Area

### REGIONAL OVERVIEW

The Regional Overview Section provides a description of the project. Regional maps for the entire project area were prepared to provide the user with an overview of the project data collection activities and the regional environment. Data used in the planning process for selecting sample locations have been shown on regional maps: mines, aerial radiation survey areas, and springs. The locations of the water samples are provided on a regional map. Land ownership, geology, annual precipitation, and physiography maps, and a Landsat satellite image of the region are also presented.

### SURVEY AREA MAPS AND DATA

Sections 2 through 7 provide maps and data for the survey areas listed above. Each section contains the following maps and data tables or legends:

Overview Map
Aerial Radiation Contours - Gross Count
Aerial Radiation Contours - Bismuth <sup>214</sup>
Water Sample Information
Water Sample Analysis for Stable Metals
Water Sample Analysis for Radioactive Metals
Summary of Water Quality Analysis with Respect to Stable and Radioactive Metals
Water Quality Analysis and Bismuth <sup>214</sup> Contours

Atlas users should refer to the Table of Contents for a complete listing of the maps and data tables, and the associated page numbers.

#### Overview Maps

Each section begins with an area description and an overview map. The overview map shows the boundaries of the aerial radiation surveys on a Landsat Multispectral Scanner (MSS) satellite image base. The facing page has a map showing the location of the survey area within the Navajo Nation and photographs that are representative of the ground conditions present in the survey area.

#### Aerial Radiation Contour Maps

The USDOE Remote Sensing Laboratory flew aerial radiation surveys over each of the survey areas. A contour map showing terrestrial exposure rates (gross count) is presented for each survey area. The gross count contours include contributions from all natural terrestrial contributors (potassium, uranium, thorium) and possible man-made contributors. The map shows the gross count contours and the extents of the aerial radiation surveys on a single band Landsat MSS satellite image base (shown in grayscale). Facing the gross count radiation contour map is a figure showing a legend and source statement for the radiation contours. A map showing geologic map units draped on a shaded-relief image with historical uranium mine locations and the extents of the survey areas is also shown.

A contour map showing excess bismuth activity (bismuth is an indicator of uranium) is presented for each survey area. Aerial radiation contours are indicative of uranium concentrations that are higher than the regional levels. The map shows the Bismuth <sup>214</sup> contours and the extents of the aerial radiation surveys on a single band Landsat MSS satellite image base (shown in grayscale). Facing the Bismuth <sup>214</sup> contour map is a figure showing a legend and source statement for the radiation contours, and enlargements of the survey areas where Bismuth <sup>214</sup> contours are present.

#### Water Sample Maps

Water samples were collected at each of the six survey areas. For the water sample data, the format of the Atlas shows a map with a facing page of data. The map shows the water sample locations and the extents of the aerial radiation surveys on a single band Landsat MSS satellite image base (shown in grayscale). Also presented on the map are locations of springs, populated places, hospitals, schools, and churches. A facing data page presents for each water sample location the map identifier, sample name, the type of water source (e.g., spring, wind mill, or home), sample identifier (ID), geographic coordinates (latitude and longitude in degrees, minutes, and seconds), elevation in feet, and the date and time the sample was collected.

# ABANDONED URANIUM MINES PROJECT ATLAS

## ATLAS ORGANIZATION AND STRUCTURE (continued)

Unique map identification numbers (Map IDs) were assigned to each sample. The following format for the sample ID was used:

AAymmddBBCxxx

AA General Area Identifier (e.g., CT = Cameron/Tuba City Area)  
BB Chapter Identifier (e.g., TC = Tuba City)\*  
C Sample Type Identifier (e.g., W = Well)  
yy Year (e.g., 98 = 1998)  
mm Month (e.g., 01 = January)  
dd Day (e.g., 01=1st day of the month)  
xxx Sequential Number of Sample for the Chapter (e.g., 001)

For example, the sample identification number CT980101TCW001 would correspond to the first well sampled in the Tuba City Chapter of the Cameron/Tuba City Area on January 1, 1998.

\* *The Navajo Nation GIS group supplied the chapter boundaries for the area maps. It is recognized that for various reasons, the residents and/or Chapter Officials may have differing ideas of their areas of jurisdiction. Each water sample ID is coded with the chapter from the official who identified the water source.*

The following letter combinations were used as the General Area Identifiers:

BI Bidahochi Area  
CT Cameron/Tuba City Area  
CH Chinle Area\*  
RV Red Valley Area\*\*  
MV Monument Valley Area

\* *When summary maps and tables were produced, the original Chinle Area was divided into the Central Area and the Chinle Area. The sample IDs retained the original unique identifier numbers.*

\*\* *When developing summary tables and maps, the Red Valley Area was renamed the Four Corners Area. The Sample ID retained the original unique identifier numbers.*

The following letter combinations were used as the Chapter Area Identifiers:

BM	Black Mesa Chapter	NZ	Nazlini Chapter
BG	Bodaway/Gap Chapter	OL	Oljato Chapter
CA	Cameron Chapter	RV	Red Valley Chapter
CH	Chilchinbito Chapter*	RR	Rough Rock Chapter
CH	Chinle Chapter*	SH	Shonto Chapter
CM	Coalmine Chapter	SW	Sweetwater Chapter
CV	Cove Chapter	BG	Tachee/Blue Gap Chapter
DE	Dennehotso Chapter	TN	Teec Nos Pos Chapter
DI	Dilkon Chapter	TE	Teesto Chapter
IW	Indian Wells Chapter	TC	Tselani/Cottonwood Chapter**
KY	Kayenta Chapter	TC	Tuba City Chapter**
LG	Lower Greasewood Chapter	WC	White Cone Chapter

\* *Chilchinbito Chapter and Chinle Chapters have the same unique identifier letters, CH. They can be distinguished from one another by the survey area in which they are located. Chilchinbito is in the Kayenta Survey area (KY) and Chinle is in the Chinle Area (CH).*

\*\* *Tselani/Cottonwood Chapter and Tuba City Chapter have the same unique identifier letters, TC. They can be distinguished from one another by the survey area in which they are located. Tselani/Cottonwood Chapter was originally in the Chinle Survey Area (CH). Tuba City is in the Cameron/Tuba City Survey Area (CT).*

The sample identifiers were designated as follows:

W Well  
S Spring  
M Mine  
H Home

### Water Sample Analysis for Stable Metals

Results from the Water Sample Analysis for Stable Metals are presented for each survey area on a map and facing data page. The map shows the water sample locations and the extents of the aerial radiation surveys on a single band Landsat MSS satellite image base (shown in grayscale). Also presented on the map are locations of populated places, hospitals, schools, and churches. A facing data page presents for each water sample the map identifier, sample ID, sample name, and results for aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, copper, iron, lead, mercury, nickel, selenium, silver, thallium, vanadium, and zinc. Also presented are calculated values of the Incremental Lifetime Cancer Risk with respect to radioactive metals.

### Water Sample Analysis for Radioactive Metals

Results from the Water Sample Analysis for Radioactive Metals are presented for each survey area on a map and facing data page. The map shows the water sample locations and the extents of the aerial radiation surveys on a single band Landsat MSS satellite image base (shown in grayscale). Also presented on the map are locations of populated places, hospitals, schools, and churches. A facing data page presents for each water sample the map

## ABANDONED URANIUM MINES PROJECT ATLAS

### ATLAS ORGANIZATION AND STRUCTURE (continued)

identifier, sample ID, sample name, and results for alpha, beta, lead<sup>210</sup>, radium<sup>226</sup>, thorium<sup>228</sup>, thorium<sup>232</sup>, uranium<sup>235</sup>, and uranium<sup>238</sup>. Also presented are calculated values of the Incremental Lifetime Cancer Risk with respect to radioactive metals.

#### Summary of Water Quality Analysis with Respect to Stable and Radioactive Metals

Results from the Summary of Water Quality Analysis with Respect to Stable and Radioactive Metals are presented for each survey area on a map and facing data page. The map shows the water sample locations and the extents of the aerial radiation surveys on a single band Landsat MSS satellite image base (shown in grayscale). Also presented on the map are locations of populated places, hospitals, schools, and churches. A facing data page presents for each water sample the map identifier, sample ID, sample name, total cancer risk, Hazard Index (HI), arsenic, lead, and total uranium. Also presented are the risk categories and risk ranking for each sample.

#### Water Quality Analysis and Bismuth Contours

The last two maps of each section show the water sample sites by risk ranking and the aerial radiation contours for Bismuth<sup>214</sup>. One map is presented on a single band Landsat MSS satellite image base (shown in grayscale), and the second map shows the same information on a scanned topographic map base.

### BASEMAPS

There are three primary basemaps presented in the Atlas, ranging from regional to local scale. The regional maps shown in Section 1 cover the surveyed area of the Navajo Nation and are presented at a scale of 1:1,400,000 (one inch represents approximately 22 miles). Each regional map covers an area approximately 345 miles (550 km) wide by approximately 185 miles (300 km) high.

Overview maps shown at the beginning of Sections 2 through 7 cover the area surrounding the survey area and are presented at a scale of 1:600,000 (one inch represents approximately 9.5 miles). Each overview map covers an area approximately 150 miles (240 km) wide by approximately 80 miles (130 km) high.

Survey area maps in Sections 2 through 7 cover the immediate survey area and are presented at a scale of 1:350,000 (one inch represents approximately 5.5 miles). Each survey area map covers an area approximately 85 miles (135 km) wide by approximately 45 miles (70 km) high.

The projection used for all of the basemaps is Universal Transverse Mercator, Zone 12, meters, NAD27.

Each basemap shows political, administrative, and project boundaries, transportation, and cultural features. A legend showing the symbology used throughout the Atlas is presented on the next page. Appendix B provides map source information.

### DESCRIPTION OF APPENDICES

#### Appendix A Project Summaries

The following project summaries are presented from the USACE "Data Quality Assurance Summary Report" dated November 2000, and other documents produced during the investigations and at the close-out of the project. These summaries provide an overview of the data collection and data management processes and procedures used for this project.

- A.1 Summary of the Characterization of Risk Leading to Exposure Reduction
- A.2 Community Information and Education Summary
- A.3 USDOE Aerial Measuring System Summary
- A.4 USACE Water Sampling and Other Field Sampling
  - A.4a USACE Project History Summary
  - A.4b USACE Field Operations Summary
  - A.4c USACE Data Management Summary

#### Appendix B Data References

Appendix B provides bibliographic citations for the spatial datasets used to generate the maps presented in the Project Atlas.

#### Appendix C Gazetteer

Appendix C provides the names of geographic features within the Abandoned Uranium Mines Project area. Also provided are the type of feature and location in latitude and longitude. The Gazetteer is derived from data available from the U.S. Geological Survey's Geographic Names Information System (GNIS) digital files and Environmental Systems Research Institute (ESRI).

#### Appendix D Glossary

A list of terms and definitions used on the Abandoned Uranium Mines Project.

#### Appendix E Acronyms

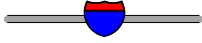


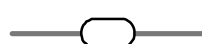



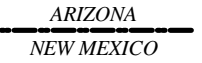

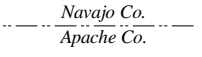




A list of acronyms and abbreviations used on the Abandoned Uranium Mines Project.

#### Appendix F References

A bibliography of publications and references used on the Abandoned Uranium Mines Project.

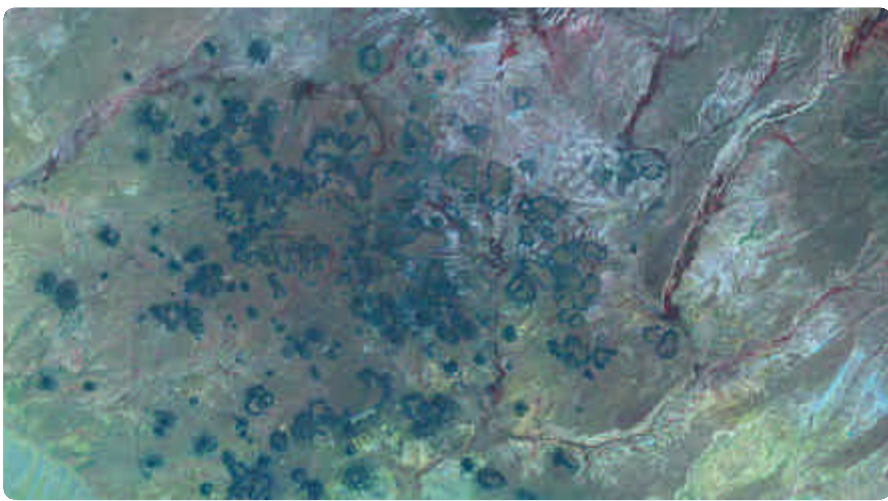
# ABANDONED URANIUM MINES PROJECT

## BASEMAP LEGEND

	U.S. Interstate Route		Populated Place
	U.S. Route	<i>Shiprock</i>	Town or City Name
	State Route		Chapter House
	Street or Road		Hospitals
	State Boundary		Schools
	County or Municipal Boundary		Churches
	Navajo Nation Boundary		
	Chapter Boundary		
	Aerial Radiation Survey Boundary		

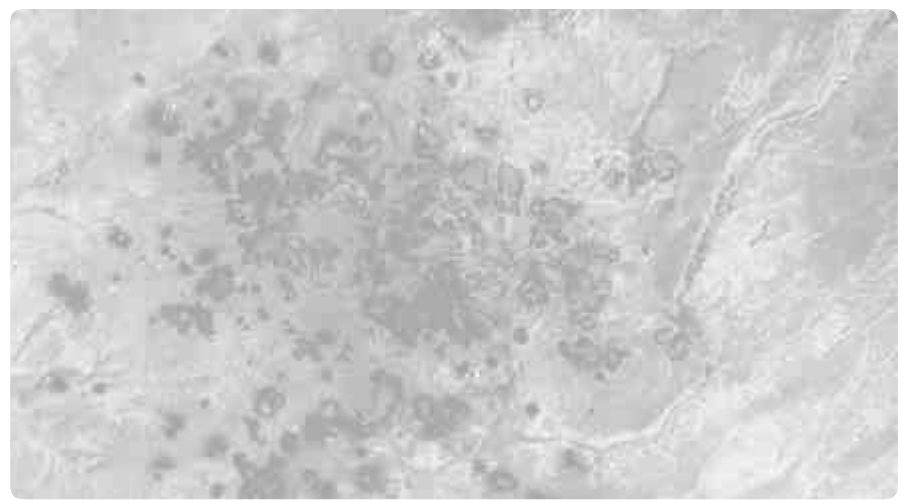
Highways, roads, state and county boundaries, populated places, hospitals, schools, and churches are from Environmental Systems Research Institute, Redlands, CA. Navajo and Hopi Nation boundaries are from the Navajo Nation GIS. Aerial radiation survey boundaries are from the Department of Energy, Remote Sensing Laboratory, Las Vegas.

## IMAGE BASEMAPS



A Landsat multispectral scanner (MSS) satellite image was used as the image base for the Atlas overview maps. The image base was a mosaic of several satellite images and was generated using MSS band 4 (near-infrared), MSS band 2 (red), and MSS band 1 (green). The MSS satellite data were acquired between June 2, 1992 and September 7, 1992. The MSS data were produced by the North American Landscape Characterization (NALC) project, a cooperative effort between the USEPA, the U.S. Geological Survey (USGS), and the National Aeronautics and Space Administration (NASA). TerraSpectra Geomatics enhanced and mosaiced the satellite image basemaps.

A single band of the Landsat multispectral scanner (MSS) satellite image is used as the image base for the Atlas Survey Area maps. The image base is from the same mosaic of several satellite images and was generated using the single MSS band 4 (near-infrared).



1:100,000 scale Digital Raster Graphics (DRG) images were used as the base for the enlarged Bismuth aerial radiation contour maps. 1:500,000 scale DRG images were used as the base for the Summary of Water Quality Analysis and Bismuth-214 Contour maps. DRGs are scanned U.S. Geological Survey (USGS) topographic maps. The DRGs used for the Atlas were acquired from VisiCom.

## MY LAND

I am sitting outside my hogan.  
I am thinking,  
Looking at the red rocks,  
the ridges, the sheep,  
the plants,  
and all in my world,  
I look at my parents,  
They are getting old,  
weak and limping.  
There aren't any of my  
sisters and brothers  
around.  
I am thinking  
What it will be like here  
in the Future.

Thomas Littleben  
Grandson of Hashk'aan'Ts'dsi  
10th grade, Rock Point School

Thank you to Thomas Littleben for permission to use his poem.