ABANDONED URANIUM MINES PROJECT ATLAS

APPENDIX A.1

SUMMARY OF THE CHARACTERIZATION OF RISK LEADING TO EXPOSURE REDUCTION

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SOURCES OF GREATEST POTENTIAL EXPOSURE

The U.S. Environmental Protection Agency (USEPA) Abandoned Uranium Mines Project acknowledged from the beginning of the field investigations that there were several categories of potential risk due to exposure to radiation, metals, and other hazards related to abandoned uranium mines and their setting. The approach to these sources of potential exposure was to focus first on identifying the sources of greatest potential exposure and thus the greatest risk to human health. Given the regional geology, the types of ore bodies, mining, transport of ore, and local land use, it was determined that the greatest potential exposures would be through internal exposure by consumption of water containing metals, stable and radionuclides, and through external exposure to radiation from stone masonry of mine waste rock, constructed in and around homes as well as to the physical hazards of abandoned mine structures.

Focusing on greatest exposures did not imply that these were the only pathways of exposure, but to apply a consistent method of assigning priority based on greatest potential risk to human health. Additional categories of potential risk were identified, including concerns about long term exposure to lower levels of radiation present in a number of different situations including the general geology of the region, livestock grazing patterns, waste rock piles near old mines, and various mechanisms of erosion. A final concern about the environment around the abandoned mines was not one of direct, potential risk to human health, but a concern for the condition of the land as a cultural resource. This concern was acknowledged, but was beyond the focus of these investigations.

COLLECTING DATA TO EVALUATE THE RISK OF EXPOSURE

The goal of exposure reduction across the greatest area required a balancing of sampling coverage with sampling detail. With limited resources for a project, there were three possible approaches for sampling a large area of mining and mine-related activities. 1) Use all the resources in one area, sampling in detail several times over a period of time. For example an area could have its water sources tested several times over a period of a year, with detailed questionnaires about water usage looking for the number of people using the water and the volume being consumed. This approach was not chosen because it would expend all resources in a single area leaving other areas without any characterization. 2) Use all the resources to conduct a hydro-geological and meteorological study of one or two areas prior to choosing the sampling locations. This approach was not chosen since for the same time and cost, the sampling could be conducted using local information about water usage. 3) Spread the resources across all areas, taking one-time samples of high quality using local information about water usage to choose sample locations. This approach was chosen since it provided the greatest amount of information from which to begin actions to reduce exposures and to focus more detailed investigations if warranted. Involving local officials in the sample location selection proved successful both for water sources used for human consumption and for homes built of mine waste rock. They were familiar with their local situations as well as familiar with the concerns of those living near the old mine.

EXTERNAL EXPOSURE: EXISTING HOMES AND FUTURE CONSTRUCTION

There has been an oral history of homes built of mine waste rock or other mining materials. At the beginning of the field investigations, no written records of these homes were located. The investigation relied on the local officials to identify homes for radiation measurements. Two hogans with stone masonry that included mine waste rock were identified and reported for further action.

In addition the potential for radiation exposure exists in the construction of new homes or schools immediately adjacent or on top of old mines or areas of mining activity where radiation sources remain. The siting of homes, schools, and other structures was reported to be decided by different agencies or individuals depending on the area of the proposed construction and the type of construction. Discussions with various agencies, local officials, and others indicated that one of the most effective ways to avoid creating new problems was to share the information about the radiation sources as shown on the area maps with local agencies, schools and community officials, in order to assist people in making informed decisions about land use.

INTERNAL EXPOSURE: WATER USED FOR HUMAN CONSUMPTION

Many of the families are not served by water systems. Their water comes from springs, hand pumps, wells, or windmills from which water is collected and hauled to where it is needed. It is not uncommon for water to be hauled 20 miles, over unimproved tracts taking one to two hours. The water from any one source is often the sole source for an individual, family, or small community, servicing infants, children, adults, and elders. Some of them may use one source for an entire lifetime.

The water samples were taken at locations identified by local officials as being water used for human consumption. The chapter officials, often the grazing member knew the water sources and users in each area. The samples were collected at the point of use in order to have the laboratory analysis be indicative of the water, as it would be consumed. In this way the results could be evaluated for the risk posed by consuming that water.

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The water was tested for stable and radioactive metals. During the field investigations an additional concern was addressed. People and livestock used many of the same water sources. The presence of the animals increased the likelihood that the water would contain bacteria. Although bacteria was not the focus of the investigation, it was necessary to include bacteria testing so people would not be confused about the water quality results. The water quality might have been good with respect to the metals, but unsafe because of bacteria. The bacteria sampling had only just been included in the field operations when the demobilization occurred. The plan underway at the time of cessation of field operations was to retest the local water sources for bacteria at the same time as discussing and explaining the results to date in each area.

PRESENTATION OF INFORMATION ABOUT THE RISK POSED BY EACH EXPOSURE PATHWAY

External exposure

The levels of radiation from numerous sources were made through aerial and field measurements. In order to evaluate the potential exposure to an external radiation source three factors are considered: the location of the radiation source, the amount of radiation and its specific proximity to people and the land use. From this information the risk of the exposure is determined.[1]

Aerial measurements - The radiation levels measured by the helicopter survey are shown on maps. These radiation data are presented in two forms. The Bismuth^{214} data is indicative of the presence of uranium; thus it is a good indicator of old mines and mine-related activities. The gross count data is indicative of the total radiation in an area.

The radiation source areas, identified on the maps of the findings of the investigations, were not characterized as to the risk posed by each source since the specific proximity to people and the land use had not been determined at the time of the close out.

Field measurements - The measurements of radiation made by the field team include a gamma radiation reading at each water sample location, various areas of old mining activity such as pits, mine openings and waste piles, and stone masonry used in home construction. The risk posed by these specific external sources of radiation exposure had not been calculated or presented on maps at the time of the close out.[2]

Internal exposure

Given the setting and land use of the area, the greatest potential internal exposure to radiation and related metals was determined to be through consumption of water. Over 200 water sources used for human consumption were identified and tested. The analytical results for the analysis of radioactive and stable metals were presented in data summary tables and on maps. The calculation of the risk posed by consuming water from each of the sources was performed using the standard method.

Using standard assumptions provided the best initial look at the information for the project purposes of locating the greatest exposures in order to take action to reduce or eliminate exposure. By standard assumptions is meant someone drinking two liters of water a day from that source for 30 years. If the consumption of the water from a particular source differs, then the actual exposure would differ from the calculations. For example, if the person consumed one liter instead of two liters a day, the exposure would be half. If the person consumed the water for 60 years rather than 30 years, the risk of exposure would be double, or twice as high.

Once the results of the laboratory analyses were tabulated, the levels detected were compared to levels of concern for human consumption. The presentation of the data was designed to show the risk posed by consuming the water, rather than whether or not the water was being regulated under a regulatory scheme for water quality. The emphasis on evaluating the risk posed – supported the project objective of determining and communicating the risk for the purpose of eliminating or reducing exposures.

For consistency of approach, the risk of exposure to the metals found in each water source was presented in terms of toxicity and cancer risk. The toxicity is represented by a term called the Hazard Index (HI). The cancer risk is represented by a term called the Incremental Lifetime Cancer Risk (ILCR). For the water tested at each sample location, the risk numbers were found by summing the HI for each chemical to determine the total HI, and summing the ILCR for each chemical to determine the total ILCR.

For each sample location the risk numbers, the HI and the ILCR, are presented for comparison against two commonly used references, the Preliminary Remediation Goal (PRG) and the Maximum Contaminant Level (MCL). Each of these two systems of quantifying water quality provides a level or quantity for an individual chemical. In other words there is a PRG for arsenic and an MCL for arsenic; each level or quantity of which has an associated HI and ILCR. Each water sample was presented on tables with an associated number representing the quantity of each of the chemicals found in that sample. These numbers can be compared to the PRG and ILCR for each chemical.

The PRGs are useful since they represent the same cancer risk across all chemicals. In other words the PRG for arsenic represents the same cancer risk as the PRG for uranium, noted as 1x10-6. The PRG levels are not the absolute concentrations above which harmful effects would be expected but rather as the concentrations go higher than the PRGs there is an increased probability of adverse effects.

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The second reference for comparison was the MCL. These are chemical specific concentrations used for regulatory purposes for water sources that are monitored under the Safe Drinking Water Act (SDWA). The MCLs are set based on the risk posed by the chemical with additional consideration to the cost of removing the chemical and the availability of water treatment technologies. The MCLs are used in the presentation of the data for a general reference even though most of the water sources tested in this project are not regulated under the SDWA. In any case the MCLs could not be the sole means of reference since not all the chemicals have an associated MCL.

There were three chemicals that were found at levels of concern no matter which reference was used. The three chemicals were arsenic, lead and uranium. In order to present a comparison of risk posed by the water sources - one source compared to another, and to present a broad picture of the sources, a three-category system was used.

The presentation in three categories (using three color codes) of the analytical data from the water sampling was designed to show the range of quality of the water sampled. Although the data form a continuous range from least to most risk, it was useful and instructive to present the data in another way by grouping into categories. The color-codes for the three categories were yellow for "less risk", orange for "some risk", and red for "more risk". The three categories provided a frame of reference to view the worst situations as well as the overall picture of quality with respect to the metals tested. There were 26 sources in the yellow "less risk" category, 154 in the orange "some risk" category and 46 in the red "more risk" category. Such a presentation provided a context for discussion as well as a clearer picture of those situations warranting rapid action to reduce exposure to sources posing the greatest risk from the metals found in the water.[3]

The relative risk for the purpose of comparing one water source to another was also presented in the form of a table. For each of the six areas the water sources were listed in order of risk from least to most risk.[4] This table of risk ranking was shown on the area maps and on the risk pages of the water summary tables

Cumulative effects due to multiple exposures

The risks associated with each area as described above were meant to be generally descriptive of the risk. The cumulative risks posed by the situations in each area were not fully determined at the time of the close out of the project. In other words, a water source may have had both stable and radioactive metals and fecal coliform bacteria. If there were also mine waste rock used in stone masonry in the home, there was additional exposure. The assessment of cumulative effects was not done as of the close out of the project.

RISK AND EXPOSURE REDUCTION

This approach to characterizing the sources of exposure with one-time high quality samples was successful in locating and documenting current exposures as well as providing a big picture across six mining areas. If the actions necessary to reduce exposure required costly treatment plants with long term operations and maintenance, then a complete picture of the hydro-geology and meteorology might be necessary in order to design the appropriate engineering of a remedy. In this situation the actions to reduce the exposures through consumption of water or through home construction materials made of mine waste rock are simple and inexpensive in the context of Superfund actions. The exposures could be reduced or eliminated with less money and in shorter time than it would take to do additional studies. This is particularly important since many people do not have a choice or do not know of an existing viable alternate location from which to get their water or a means of removing mine waste rock from stone masonry.

Focusing on the greatest potential exposures supported the overall project goal of exposure reduction. At the close of this project the evaluation risk and exposure reduction had been viewed in two ways, reducing or eliminated current exposures and preventing future exposures through the distribution of the findings and other educational materials. By locating the greatest exposures across all the major mining areas, the data were made available to begin addressing those exposures with appropriate exposure reduction actions such as removal of radioactive stone masonry in homes and locating alternative local water sources in areas with elevated metals. Although the project was not completed, the data are available to those who want to understand the situation.

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[1] Risk due to total gamma radiation can be assessed by comparing the estimated total gamma radiation exposures to a regulatory guideline of 0.1 rem per year in excess of background (Federal Register, December 23, 1994, pp. 66414-66428). This was the method used in the investigations of the King Tutt Mesa area of the Red Valley Chapter. The calculations and exposure assumptions are explained in the "Integrated Assessment, Draft for Comment" issued June 1997.

[2] The radiation meter reads in units of μR/hr. The following information will help provide a frame of reference, since exact risk posed by the radiation in the pit depends on the length of time one is there, and whether radioactive material is taken home. The regional radiation readings are in the range of 10 to 15 μR/hr. During the field investigations - for purposes of worker safety, a level of 40 μR/hr was used to create the first safety zone when evaluating an area during investigations. At this level, a plan of action for further characterization would have been developed (often from the field and via phone consultations with the health experts), including time restrictions on the investigation of specific areas.

[3] The definitions of the three categories shown on the water summary tables and maps are as follows:

The yellow dot represents the category of Less Risk: Total Cancer Risk is less than or equal to 1E-05 and Hazard Index is less than or equal to 1 and Lead is less than 4 μg/L and Total U less than 30 pCi/L.

The orange dot represents the category of Some Risk: Total Cancer Risk is less than or equal to 6E-04 but greater than 1E-05 or Hazard Index is less than 10 but greater than 1 or Lead is less than 15 μg/L but greater than 4 μg/L and total U less than 30 pCi/L.

The red dot represents the category of More Risk: Total Cancer Risk is greater than 6E-04 or Hazard Index is greater than 10 or Lead is greater than 15 μg/L or Total U equal to or greater than 30 pCi/L.

Reference for Water Samples:

	MCL (Maximum Contaminant Level) used for regulatory compliance monitoring. It is not based solely on risk, but on a cost-benefit analysis described in the Federal Register.	**PRG (Preliminary Remediation Goal) Health-Based level**
Arsenic	50 ug/L micro grams per liter, due to be lowered to 15 μg/L (The MCL is proposed at a new, lower level: 5 μg/L)	0.045 μg/L
Lead	15 μg/L	4 μg/L
Uranium	Proposed: 30 pCi/L picoCuries per liter of total U [20 μg/L] (The water summary tables referenced the proposed federal MCL above. On 12/07/2000 the final MCL was set at 30 μg/L)	U^{234} = 1.1 pCi/L U^{235} = 1.1 pCi/L U^{238} = 0.71 pCi/L
Gross Alpha	15 pCi/L picoCuries per liter of gross alpha particle activity (On 12/07/2000 the MCL was set at 15 pCi/L for the “adjusted gross alpha”, which excludes radium and uranium)	There is no PRG for alpha. The FR notice lists the 10-4 Cancer Risk at 5 pCi/L

[4] The ranking was determined using a mathematical system to normalize the risk represented by a number from 1 to X, with X being the number of samples in an area. First the units for the parameter in each column of ICLR, HI, and Lead were normalized. The normalized units were summed for each sample. The list of sums for each sample were then normalized to produce a series of numbers from 1 to X representing the position of each sample on the list.

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APPENDIX A.2

COMMUNITY INFORMATION AND EDUCATION SUMMARY

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INTRODUCTION

When the U.S. Environmental Protection Agency (USEPA) Region 9 started work on the Navajo Abandoned Uranium Mines project, there was a lot to learn about how to involve the Navajo communities in the work that lay ahead. The work would be taking place in a setting unlike the typical urban, suburban or agricultural environment. It would be like working in another country-the remoteness of the land, a different language, suspicion toward government-plus the memories of all those who died after working in the mines and those still suffering. A simple, direct approach was adopted. It was vital that those living in the affected areas take an active continuing role as the community partners.

What follows are examples of the outreach strategy for the two-way sharing of information, educational efforts to increase understanding and awareness of the mines and their possible effects, and what was learned from the people along the way.

The purpose of the project was to determine if the old abandoned uranium mines on the Navajo Nation currently, or could in the future, pose a health or safety concern for human beings or the environment. First it was necessary to determine where the old mines were located, since the existing information was unreliable. This was done using helicopter surveys that measured radiation over suspected mining areas in order to locate the current sources of radiation. From this information, the investigation continued by looking at water sources used for human consumption and mine waste rock used in home construction, the two most serious of the possible pathways of exposure to people living nearby.

THE START-UP

In October 1994, USEPA and the Navajo Superfund Program (NSP--part of the Navajo Nation Environmental Protection Agency), collaborated on how best to introduce the project to the area that would first be surveyed by helicopter. It was NSP's suggestion to arrange a Blessing Way Ceremony and traditional lunch at a chapter house in the subject area, having the helicopter on hand so people could see it and its crew. Preparation for the event began the night before with a "sheep slaughter" at the home of a NSP staff member and continued the next day at the Beclabito Chapter House. After a presentation about the project to the community by a chapter delegate (translated into Navajo by a member of NSP), the ceremony to bless the project was performed by Medicine Man, Willie Weaver in front of the helicopter. The prayers were for the success of the project so the people could be protected and that the helicopter remain aloft so it could do its job. The message of his ceremony was to bring the work full circle to restore harmony to the land and its people. Following the ceremony, it was the helicopter that took center stage, especially for the children from the adjacent school who had been observing the proceedings. With what was to become the first of many instances in which the young would teach the old, each child came up to the helicopter to have a photo taken with a Polaroid camera. This was not done simply for the amusement of the children, but also because they would bring the photos home to their parents and thereby spread the word about the project. The feast of mutton stew and all the trimmings followed. The day concluded with a successful three-way partnership between USEPA, NSP, and the communities.

WORKING WITH THE CHAPTERS

From 1994 to 2000, USEPA brought the project to approximately 30 chapters (there are 110 chapters on the Navajo Nation) by means of one-to-one communication. The following chapters were visited during this time period: Bodaway Gap, Cameron, Chilchinbeto, Coalmine Mesa, Dennehotso, Kayenta, Oljato, Shonto, Tuba City, Beclabito, Cove, Red Valley, Sanostee, Sweetwater, Teec Nos Pos, Two Grey Hills, Black Mesa, Chinle, Lukachukai, Many Farms, Nazlini, Rough Rock, Tachee/Blue Gap, Tselani/Cottonwood, Dilkon, Indian Wells, Lower Greasewood, Teesto, and Whitecone. Whether discussing aerial surveying or sampling of water and home construction materials, the approach was the same: talk in person to Chapter Officials to gain their permission to do the work, their support for the project, as well as their full participation. This was when the ability to communicate effectively was crucial -- to communicate with those personally affected by the legacy of the abandoned uranium mines.

The procedures were very simple. The USEPA Community Involvement Coordinator (CIC) set up appointments in advance by phone with chapter representatives to discuss whatever part of the project was intended for their area. The face-to-face meetings usually consisted of the CIC, the USEPA remedial project manager (RPM), or the U.S. Army Corps of Engineers (USACE) project manager and whatever Chapter Officials were available. One of the chapter representatives would translate what was said into Navajo as needed. Often the presentation was a part of the regularly scheduled chapter's executive planning meeting, as that was when many of the Chapter Officials would be present. Although attending a few general chapter meetings, it was preferable to initially talk about the project in a smaller, more relaxed forum. The communication objectives were to be as open, respectful, and non-threatening as possible and to be very conscious of the importance of listening.

OUTREACH MATERIALS

Fancy or detailed outreach materials were neither needed nor desired for this project. With the Navajo culture based in oral tradition, the written word was far less useful as a form of communication, especially when attempting to convey scientific information. Therefore, the simplest flyers and photographs did the job of providing something tangible that Chapter Officials could give out or refer to. Flyers and photos were posted in chapter houses and trading posts. Copies were delivered in person to police stations so they would know what the helicopter was doing. Furthermore, since many people cannot read and some of the elders speak only Navajo, non-written communication was, as stated earlier, critical. The outreach expanded to other media in Spring 1998. At that time, USEPA and NSP held an on-air interview with KTNN, the popular radio station of the Navajo Nation. The information on the project was presented in both English and Navajo. As the project continued, maps were developed from the aerial surveys. These maps were provided to Chapter Officials and discussed with them. Another set of maps with water sampling results and risk analysis was presented to chapters after the field team demobilized on January 31, 2000. These were designed specifically to simplify risk information through color coding so that the higher risk water sources would be easy to recognize.

HOW THE OUTREACH WAS RECEIVED

There were wide differences between chapters in how much they knew about the mining and their initial level of interest in the project. Once they knew that the project team was willing to work with them, on their schedule, and with their interests and concerns in mind, their commitment grew. The common theme was that the investigation was wanted and that the staff was welcome in each community. The team was always treated graciously and with appreciation for work being done. The more communities felt they were an important component of the project, the more engaged they became.

CONTINUING OUTREACH DURING FIELD WORK

Everyone connected to this project had to be sensitive to good community involvement techniques. This was especially true of the field team leader from the USACE whose responsibility was to continue establishing good rapport with the chapters in order to be able to collect the best possible data. The USEPA CIC and the USACE field manager made many trips to chapters together to discuss the results of the aerial surveys and plan for water sampling and home construction surveying. The field manager was specifically chosen because of his proven ability to not only do an impeccable job in the field but also because of his communication skills and sense of humor (a point that should not to be underestimated in this locale). He knew how to work with people so that they would feel part of an important effort. Prior to the fieldwork, outreach materials were distributed - just a simple flyer announcing the purpose of the work to be done and who to contact for more information. A critical part of the field sampling outreach effort was to enlist the assistance of Chapter Officials in identifying water sources used for human consumption. They were asked to recommend any homes to survey for possible radiation from construction materials (home surveying was provided at their request). Circumstances in each chapter varied widely, some had a full-time secretary and coordinator, while other chapters had no staff and no phone service. The communication arrangements were tailored to each chapter, even if that meant driving many hours to the chapter, simply to set up an appointment. After the initial meeting one of the Chapter Officials, typically the grazing member went with the field manager to locate the water sources by indicating the road to take or other directions, or by going with the field manager. This involved many hours, often over many days to accomplish.

THE ROLE OF EDUCATION

The teachers and students at the local schools were eager to get information on uranium, the mines, and the environment. At Monument Valley High School, the USEPA project manager and CIC gave a presentation to the entire student body on a variety of environmental issues, bringing numerous books and handouts from the Region 9 office in San Francisco. Similar materials were taken to the Cameron Chapter House along with the helicopter so people from the area could get a hands-on look at the project and learn more about USEPA. On the more technical side, the USACE field manager and chemist made several visits to science classes to teach the kids about the project and how sampling is performed. The schools visited during various classroom sessions included Monument Valley High School, Red Mesa High School, and Tse Bit Ai Middle School in Shiprock. The students were eager to learn about the work being done on the mines and the people doing the work. The students at Tsi Bit Ai Middle School made an electronic "thank you" for the field manager to show their appreciation for his taking the time to talk to them. In addition, USEPA received a letter from the students saying thank you for the school visit. It was signed by each of the students.

GAMMA GOAT BOOK

USEPA was fortunate to be able to create a coloring book for school children to teach them about uranium mines and radiation. Through funding of a National Network for Environmental Management Studies (sponsored by USEPA's Office of Environmental Education), a fellowship was awarded to a graduate student from the University of Michigan who could provide the necessary time and expertise toward developing a learning tool for children. Having been involved previously in educational work with Native American children and having spent time on the Navajo Nation, the student worked exclusively on this book during the Summer of 1998. Based on a coloring book that had been developed on the hanta virus, a new book, Gamma Goat...The Dangers of Uranium, was produced after much input and feedback from people on the reservation who knew what images and terminology would be most effective. With drawings provided by the student's brother, Gamma Goat has proven to be enormously popular with students and teachers. Distribution of the coloring book is continuing upon request.

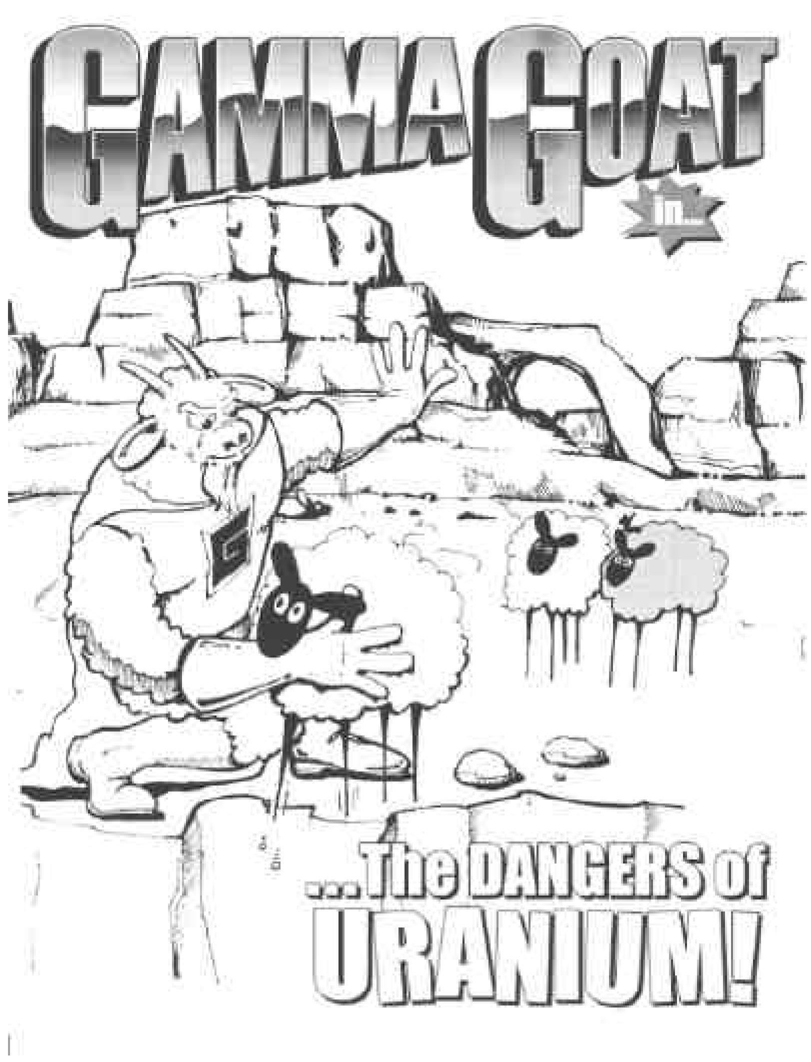
URANIUM EDUCATION PROGRAM

USEPA developed a productive relationship with the Uranium Education Program (UEP) at Dine College in Shiprock. An organization, whose goal is to promote better understanding of uranium, radiation, and health through education, UEP plays an invaluable role on the Navajo Nation. UEP has helped explain USEPA's project and the resulting data. In the various areas of abandoned uranium mines UEP has conducted public information meetings on the basics of uranium and radiation exposure as well as the hazards associated with the old mines. They are currently in the process of translating into Navajo three of the Public Health Statements from the Agency for Toxic Substances and Disease Registry (ATSDR) that contain information on uranium, arsenic and lead.

DECEMBER 2000 - STATUS OF THE COMMUNITY INFORMATION AND EDUCATION

The ability for USEPA to fully communicate sampling results and what they mean, as well as work with the communities to find solutions to problems, was halted in January 2000 at the written request of the Navajo Nation EPA. As a result of this cessation, a fundamental part of USEPA's communications strategy-following through on the commitment to the community partners-had not been accomplished as of December 2000. The incomplete work included going back to each chapter to discuss in detail the results of the sampling, health risks involved with the water sources, and possible solutions. This work also included the offer to assist in sampling additional local water sources used for human consumption if the communities requested. This was expected after they reviewed the results. Although the water data summary tables had been provided to the chapters, these tables were technical in nature and warranted one-to-one communication on what they meant.

Collaboration and follow-through, especially with the community partners, were essential parts of the success of the field operations and data collection. Therefore, leadership by all the various agencies involved is necessary in reestablishing the dialogue with the chapters and, ultimately, working out options for reducing radiation and other exposures. It is the timeliness and the quality of the communication with those directly affected that will lead to a successful conclusion.



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APPENDIX A.3

USDOE AERIAL MEASURING SYSTEM SUMMARY

Personnel and equipment provided by the U.S. Department of Energy (USDOE) Aerial Measuring System (AMS) were used in support of the U.S. Environmental Protection Agency (USEPA) Abandoned Uranium Mines Project. AMS equipment allowed USEPA to rapidly measure and map radiation sources over the large areas known or suspected to have had uranium mining activities. An Interagency Agreement between USDOE and USEPA was established and initial surveys were undertaken in 1994 in the Four Corners Area. Additional surveys were conducted in five other areas in 1997, 1998 and 1999. A total of 41 surveys covering 1,144 square miles were conducted within six areas shown on the Project Atlas maps. An overview map (Aerial Radiation Survey Area Map, page 1.13) provides a summary of the survey locations. The table presented on the following page provides a complete listing of the aerial surveys.

When the project began field operations in 1994 there were few records documenting the locations of the abandoned uranium mines. The locations of the mining areas or general districts of mining were known from old maps, publications, and oral history. The scientific and engineering resources of maps showing the locations of the old mines were on paper, in various scales and in a wide range of accuracy. Compiling the many paper records would have been an enormous undertaking, requiring considerable financial resources and many months, possibly even years of effort. Work efforts to compile these records are currently underway by several agencies. However, their work has not been published, nor was it available in the mid-1990s.

The benefits of using an aerial survey approach for this project were threefold:

1) To help focus the field investigations in areas of current rather than historic radiation; the Navajo Abandoned Mines Land Reclamation Program had already been working on the reclamation of old mines.

2) To locate and record the mining activities that were sources of radiation using a method that could be applied to large, regional areas, much faster than conventional scouting and measuring at ground level. Many of the survey areas involved rugged terrain and mining sites not readily accessible by roads.

3) To measure the levels of total radiation as well as the individual isotopes, such as $Bismuth^{214}$ that could be extracted through data processing and used as an indicator of mining activity.

The radiation was measured with sensitive detectors mounted on a helicopter. The helicopter was initially flown along flight lines placed 250 feet apart, at a nominal altitude of 150 feet above ground level. At this altitude, the sensor footprint, or ground area being measured, was determined to be approximately 300 feet in diameter. After analysis of data collected using this protocol, the line spacing was increased to 300 feet to increase operational data collection efficiency. There was no apparent loss of data resolution due to this increase.

Radiation sensor measurements were integrated and recorded at one-second intervals. Each measurement provides an average radiation level for the entire ground sample area. This means the data does not pinpoint the radiation levels within the ground sample area, (i.e., the 300 feet diameter footprint under the helicopter). For each ground sample area, the radiation source could be evenly distributed or it could be made up of a combination of radiation sources, like a higher-level mine waste debris pile sitting on soil that had lower regional radiation levels. Obtaining finer detail measurements of an individual radiation source requires additional ground level measurements.

The aerial survey used real-time differential Global Position System (GPS) equipment for both navigation and establishing the precise location of aerial measurements. The GPS locations provide accurate records of where to go during field investigations to find and detail any aspect of the radiation sources measured by the helicopter borne equipment. Field investigations involving ground level measurements were necessary to determine the specific nature of the source of radiation, for example, whether a large mine, several small mines, or mine waste were involved.

The Project Atlas presents the radiation data in two forms: gross count and excess $Bismuth^{214}$. The gross count data is indicative of the total radiation in an area. The $Bismuth^{214}$ radiation is indicative of the presence of uranium, making it a good indicator of old mines and mining related activities. The $Bismuth^{214}$ response, rather than a uranium response, is used because its unique photopeak can be readily distinguished from other radiation sources.

The calculation of potential exposure to radiation is evaluated through knowing both the location of the radiation source and its specific proximity to people and the land use. The specific proximity to people and the land use had not been determined when the field activities ended as of January 31, 2000.

For the USDOE Survey Report, contact the USEPA Region 9 Records Center after January 2001.

APPENDIX A.3
AERIAL RADIATION SURVEYS (continued)

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 which ranges from 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	5/17/98 5/18/98	18.58	irregular	-110.3669	-110.2077	35.2856	35.3353	6.48	0.84	3.73	10.61	12,004	5	5	2,4
	Indian Wells	Winslow A	5/18/98 6/6/98	248.68	irregular	-110.2238	-109.8235	35.3132	35.647	7.63	1.57	3.93	49.77	157,299	1,916	1938.6	2,4
	Teesto	Winslow B	5/13/98 5/18/98	75.42	irregular	-110.4133	-110.2057	35.3863	35.608	6.77	1.46	3.68	24.13	47,990	376	378.2	2,4
	Twin Buttes	Winslow K	5/18/98 6/6/98	5.09	rectangle	-109.9448	-109.9034	35.3049	35.3363	5.93	1.11	3.84	8.86	3,232	0	0	2,4
	Winslow A	Winslow D	6/6/98	14.47	irregular	-110.5841	-110.4869	35.0831	35.1455	6.34	1.46	3.98	16.05	9,212	4	4	2,4
	Winslow B	Winslow H	6/7/98	5.28	rectangle	-110.6221	-110.5816	35.008	35.0418	4.77	0.84	3.31	7.18	3,435	0	0	2,4
	Winslow C	Winslow G	6/6/98 6/7/98	5.21	rectangle	-110.7078	-110.6751	35.0774	35.1114	6.37	0.53	4.45	8.26	3,423	0	0	2,4
Cameron	Bodaway East	Cameron D	9/23/97 9/25/97	60.52	irregular	-111.4872	-111.335	35.9989	36.1818	9.21	3.04	2.4	47	40,868	2,732	2589.3	2,4
	Bodaway West	Cameron F	9/10/97	7.48	irregular	-111.6657	-111.5922	35.9886	36.0278	5.65	1.69	2.42	11.7	5,203	8	7.4	2,4
	Cameron	Cameron E	9/25/97 10/3/97	166.72	irregular	-111.469	-111.2532	35.626	35.9686	8.26	2.41	2.43	66.66	110,803	2,734	2632.8	2,4
	Cedar Wash	Cameron G	9/9/97 9/10/97	3.58	rectangle	-111.7802	-111.7434	35.5197	35.5469	5.68	1.16	2.54	9.5	2,595	0	0	2,4
	Coalmine Chapter	Cameron I	9/11/97	7.52	rectangle	-111.0713	-111.0008	35.9684	36.0194	4.56	0.58	3.32	7.77	4,984	0	0	2.4
	Coalmine Mesa A	Cameron B	9/10/97	3.8	rectangle	-111.1991	-111.1626	35.853	35.8806	4.75	2.23	2.3	11.22	2,658	0	0	2.4
	Coalmine Mesa B	Cameron A	9/23/97 9/24/97	3.69	rectangle	-111.1594	-111.1248	35.738	35.766	6.9	1.01	4.69	10.19	2,678	0	0	2,4
	Coalmine Mesa C	Cameron C	9/11/97 9/23/97	12.88	irregular	-111.2296	-111.1437	35.516	35.5756	6.43	1.04	2.06	15.33	8,768	6	5.6	2,4
	Tuba City	Cameron H	9/11/97 9/12/97	24.78	rectangle	-111.1771	-111.049	36.1055	36.1957	3.42	1.3	1.57	10.22	16,339	58	56.3	2,4
Central	Black Mesa East	Chinle CE	10/10/98 5/25/99	72.56	irregular	-109.9569	-109.799	36.1759	36.3956	9.03	1.86	3.31	30.51	47,475	236	230.8	2,4
	Chilchin-bito	Chinle A	5/24/99	11.53	irregular	-109.9792	-109.9058	36.4454	36.488	6.96	1.81	3.7	22.45	6,553	377	424.5	2,4
	Oraibi Wash	Chinle D	5/24/99 5/25/99	4.02	rectangle	-110.242	-110.2071	36.2334	36.2641	10.02	1.12	7.24	15.97	2,859	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
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

ABANDONED URANIUM MINES PROJECT ATLAS

APPENDIX A.4a

USACE PROJECT HISTORY SUMMARY

By: Glynn Alsup
USACE Field Project Engineer

CONGRESSIONAL HEARINGS

The U. S. Environmental Protection Agency (USEPA) Abandoned Uranium Mines-Navajo Lands Study began following the July 1993 Congressional committee report entitled "Deep Pockets: Taxpayer Liability for Environmental Contamination" and Congressional hearings on November 4, 1993. At that time, the Navajo Nation presented testimony on the abandoned uranium mines and requested assistance in determining if the old mines pose a health risk to residents. USEPA presented testimony on its federal authority under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) also known as Superfund, and how the USEPA could assist the tribe. U. S. Department of Energy (USDOE) and the U.S. Department of Interior (USDOI) also participated. USEPA Region 9 conducted the investigations with technical assistance provided by the USDOE Remote Sensing Laboratory at Nellis Air Force Base and the U.S. Army Corps of Engineers (USACE).

The sampling was accomplished under CERCLA. At a few sites within the study areas, limited information had been obtained from earlier studies, such as Preliminary Assessments (PA) and Site Investigations (SI) conducted by the Navajo Nation Environmental Protection Agency (NNEPA). Studies were conducted by NNEPA and Navajo Nation Abandoned Mines Land Reclamation Department (NNAMLRD) in the late 1980s and early 1990s. Reports of most of these studies have not been issued. Information obtained by USEPA regarding these studies has largely been verbal and very limited. The USEPA project was designed to build upon this available information by collecting additional data through site reconnaissance, and collecting environmental samples to analyze for the presence of hazardous substances.

MINING AREAS

Six mining areas were selected for investigation because of the numerous mining sites located in close proximity. This assisted in a helicopter survey of the areas. Other mining areas were better suited for ground surveys. The ground surveys did not occur prior to cessation of field operations in January 2000.

The six areas investigated between June 1998 and January 2000 were situated on land held in trust for the Navajo Nation by the USDOE Bureau of Indian Affairs. The areas contain abandoned uranium/vanadium mines that were operated between 1942 and 1967. Several companies operated mines in these areas including Vanadium Corporation of America, UTCO Uranium Corporation, and U.S. Vanadium Corporation. After mining activities stopped, the mining rights were returned to the Navajo Nation.

The six areas investigated were historical mining districts in Arizona, Utah, and New Mexico. Each of these areas contained abandoned uranium/vanadium mines. The areas were: Four Corners, Monument Valley, Cameron-Tuba City, Bidahochi, Central Area-Many Farms/Rough Rock, and Chinle. The Eastern Agency Sampling Area would be added after the initial investigations were completed.

The Eastern Agency was identified as an area of investigation as early as 1995. The Eastern Agency was scheduled to be the last area scheduled for investigation since the logistics of information distribution and permissions to sample was more complicated given the mixed ownership. USDOE completed an aerial survey of the Sanostee Chapter, which is located in the Eastern Agency, but USACE was not able to complete the sampling in the eastern agency chapters.

The following paragraphs describe more specific activities at mine locations within each area.

Red Valley/ Beclabito (Four Corners Area)

Mines in this area were adits, shafts, pits or trenches in ore-bearing Salt Wash Member of the Morrison Formation. The area was mined using a combination of conventional blasting techniques and manual labor for the removal of overburden and ore. Extracted ore was manually sorted on site with the higher grades being transported off site to processing mills and the lower grades (proto-ore) remaining on site in debris piles.

Monument Valley

During the period 1942 through 1946, three "carnotite" (uranium/vanadium ore) leases in Monument Valley produced a total of 156,237 pounds of vanadium oxide. Among the most productive mines were Monument 1, Alma-Seggin, Fern 1, Utah 1, Big Chief 3 & 4, and Radium Hill. In addition, 4,783 pounds of uranium oxide contained in the Utah 1 lease were sold.

Cameron-Tuba City

During it's lifetime, the Tuba City mill (operated by Rare Metals Corporation of America) processed 800,000 tons of ore, most of which was generated from the Orphan Lode Mine. Orphan Load closed in 1969. Peak production was in 1956 from Cameron area mines. The most significant Cameron area mines were Jack Daniel, Charles Huskon 4, Paul Huskon 3, Charles Huskon 3, Charles Huskon 1, and Ramco 20.

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. Late production (1961-1963) 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 mines.

Bidahochi

The most significant Bidahochi mines were Boot Jack Mine, Fern 1 Mine, Bidahochi Butte prospects, and the Calvin Chee prospect. No mining production information is available for this area.

Many Farms/Rough Rock

Significant mine leases included the Dan Taylor Mine, Tah Chee Wash leases 8 and 31, Rough Rock Slope 9, Begay and Bahe 1, Todecheenie 1, Charley 1, and Etsitty 1. No mining production information is available for this area.

Chinle/ Nazlini

There is no available information on mining activities in this area.

KING TUTT MESA STUDY

In 1994 USEPA, with the assistance of NNEPA, investigated the abandoned uranium mines in the area of Red Valley. From the King Tutt Mesa Study Area, a process was developed for investigating other areas with abandoned uranium mines. The process involved the following three steps:

1. A radiation survey conducted by helicopter to find the sources of radiation in the areas of old mines.
2. The testing of water used for human consumption.
3. The surveying of homes for construction with materials from the mines.

In July 1998, USEPA and Bechtel Environmental, Inc. issued an Integrated Assessment, Navajo Uranium Mines-King Tutt Mesa Study Area, Red Valley Chapter, Navajo Nation, Oak Spring, New Mexico 87420, Site EPA ID Number: NND 986667434. The Principal Investigator for USEPA Region 9 was Patti Collins. The Principal Investigator for Bechtel Environmental, Inc. was Kim Geisler. Project Investigators were: Bechtel Environmental, Inc., Field Reconnaissance and Field Sampling; Bechtel Nevada for the USDOE, Aerial Gamma Radiation Survey; Lockheed Environmental Systems & Technologies, Aerial Photography Review. Navajo Nation EPA and USEPA jointly completed an In-Home Radon Gas and Home Construction Study.

USEPA AND USACE

In March 1998, USEPA Region 9 and the USACE signed an inter-agency Agreement for technical and other assistance on the Abandoned Uranium Mines Study-Navajo Lands. The USACE formed a team to investigate the effects of uranium mines on the groundwater and water used for human consumption in the areas of abandoned uranium mines. The area of investigation for the work encompassed 17.5 million acres of very rugged terrain with a minimum amount of paved roads located in the states of Arizona, Utah and New Mexico.

The lead agency was the USEPA Region 9, with Patti Collins as the Project Manager and Senior Scientist and Vickie Rosen as the Community Involvement Coordinator. The other government agencies that worked with the USEPA on the project were: Navajo Nation Environmental Protection Agency (NNEPA), U.S. Department of Energy (USDOE), Navajo Nation Abandoned Mines Land Reclamation Department (NNAMLRD), and the USACE. USACE supplied or assisted in supplying technical support, water sampling, radiation monitoring, home surveys, community involvement, public relations, project management and data management under an inter-agency agreement with USEPA Region 9. USDOE supplied helicopter radiation surveys, maps of existing wells, springs, and mining areas, Global Positioning System (GPS) equipment, and Geographic Information System (GIS) services. USEPA provided the overall project management, funding, and the field radiation survey equipment to the field team.

APPENDIX A.4a (continued)

USACE PROJECT HISTORY SUMMARY

The USACE assembled a team of experts from various locations in the United States to obtain the expertise needed to accomplish the mission and assignments with USEPA Region 9. USACE utilized the Los Angeles District's Environmental Construction Branch for project management, field supervision, field technicians, community coordination, agency coordination, on-site safety and radiation officer, sampling services and training. USACE's Albuquerque District provided the Project Chemist, data management, sampling supplies and field personnel. Tulsa District provided the Health Physicist, personnel Thermo-Luminescence Dosimeter (TLD) monitoring and site safety reviews. Omaha HTRW-CX provided Quality Assurance for the project chemical data. Omaha's Waterways Experiment Station (WES) Chemical Quality Assurance Branch provided the laboratory services with a contract with Quanterra Environmental Laboratories.

The purpose of the Abandoned Uranium Mines-Navajo Lands Study was to identify the radiation sources, characterize the exposure, and recommend methods to reduce radiation exposure from abandoned uranium mines on the Navajo Nation. To evaluate risks to human health by ingestion of stable and radioactive metals in water, the USACE 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 as a source 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 would be sampled.

Samples were collected at locations determined in the field based on interviews with representatives of the Navajo Nation Chapters. Chapter Officials were the most knowledgeable in land and water uses in their communities.

The project objectives were:

1. Data representative of the condition and quality with respect to the stable and radioactive metals in the water.

2. Data at levels of precision and accuracy such that the data can be compared and evaluated against standard benchmarks of human risk of consuming the water.

3. Data of sufficient quality, documentation and verification to be available for use for the USEPA Superfund administrative and enforcement processes, including but not limited to the various removal and remedial actions intended for exposure reduction.

4. Provide data in a format that is easily accessible to the end user.

Providing education and outreach about the radiation and working with individual communities living in proximity to the abandoned mines was also an important component of the project.

Available information for certain sites within the study areas indicated the presence of several naturally occurring isotopes of uranium, thorium and radium; as well as metals such as arsenic, lead, mercury, antimony, beryllium, cadmium, selenium and thallium in drinking water.

The study areas are located in geologic terrain that contains deposits of uranium and vanadium ores in the sandstone beds of the Morrison Formation. The ore deposits vary with the region you are in, but are located at shallow depths beneath ground surfaces or exposed on slopes and mesa tops. The ore deposits contain naturally-occurring metals and radionuclides; parent isotopes uranium^{238}, thorium^{232}, and uranium^{235}, and daughter isotopes from their decay series (uranium, thorium, and actinium decay series, respectively).

Water quality data obtained from U.S. Geological Survey and USEPA, as well as the study from the Integrated Assessment Report for the King Tutt Mesa study Area, showed that groundwater in the six areas contain detectable levels of gross alpha and beta activity that in many cases exceed the MCLs. Radium^{226} and Radium^{228}, Uranium^{234}, Uranium^{235} and Uranium^{238}, and other radioisotopes have also been detected at concentrations above the MCLs. Metals detected in groundwater include aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, silver, sodium, thallium, vanadium, and zinc.

Using a format similar to sampling used during the 1994 fieldwork, USEPA Region 9, Bechtel Environmental, Inc., and USACE developed the 1998 Field Sampling Plan. The home surveys were conducted using a modified plan developed in the 1994 survey. Field operations accomplished by the USACE included water sampling, home construction surveys, radiation surveys, and mine surveys. Field operations covered 30 communities across 26,000 square miles of New Mexico, Utah and Arizona.

USACE completed 227 water samples, 27 Quality Control Samples (of which 14 were field blanks, and 13 were duplicates), 28 home surveys, and 34 radiation surveys.

ABANDONED URANIUM MINES PROJECT ATLAS

APPENDIX A.4b

USACE FIELD OPERATIONS SUMMARY

By: Glynn Alsup
USACE Field Project Manager

PROJECT GOAL

The Integrated Assessment (IA) process is for assessment for emergency or non-time critical removal actions and for collecting data for future use if remedial action is needed. At a few sites within the USEPA IA study areas, limited information had been obtained from preliminary studies, such as Preliminary Assessments (PA) and Site Inspections (SI), conducted by the Navajo Environmental Protection Agency (NNEPA). The USEPA IA was designed to build upon this available information by collecting additional data through site reconnaissance, and collecting environmental samples to analyze for the presence of hazardous substances.

The six areas investigated are historic mining districts in Arizona, Utah, and New Mexico. Each of these areas contains abandoned uranium/vanadium mines. The areas are: Four Corners, Monument Valley, Cameron-Tuba City, Bidahochi, Central Area-Many Farms/Rough Rock, and Chinle. USEPA has previously conducted water sampling and analysis in the Four Corners-Red Valley/Beclabito area. The results of that work were presented in the *Site Integrated Assessment, Navajo Uranium Mines - King Tutt Mesa Study Area, Red Valley Chapter, Navajo Nation, Oak Spring, New Mexico 87420 (Draft for Comment by BEI, June 1997).*

Available information for certain sites within the study areas indicated the presence of several naturally occurring isotopes of uranium, thorium, and radium, as well as metals such as arsenic, lead, mercury, antimony, beryllium, cadmium, selenium, and thallium in water used for human consumption.

PROJECT FIELD SAMPLING PLAN DEVELOPMENT

The Field Sampling Plan (FSP) was prepared by Bechtel Environmental, Inc., (BEI) in cooperation with USEPA and USACE. The sampling described in the FSP was part of an IA under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund). The FSP addressed sampling and analysis of water used for human consumption within the boundaries of the Navajo Lands in Arizona, New Mexico, and Utah.

DESCRIPTION OF SAMPLING PROGRAM

The purpose of the USEPA IA was to evaluate risks to human health by ingestion of radionuclide and metal contaminants in water. Therefore, the sampling program was designed to measure analyte concentrations in water sources used for human consumption within the study areas. The sampling program consisted of collecting one water sample at each well, tap, spring, pit, or tank identified as a source for human consumption. If there was a common source for multiple users, such as a community well or tap only the common source location will be sampled. 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.

Samples were collected at locations determined in the field based on interviews with representatives of the Navajo Chapters in the study areas. Initial information was obtained using field questionnaires and community contacts. Not all of the known wells were sampled, as many were abandoned, sealed, or not usable for obtaining water suitable for human consumption.

DESCRIPTION OF ANALYTICAL PROGRAM

Radioisotopes for analysis were selected by reviewing all of the radioactive isotopes in the naturally occurring Uranium^{238}, Thorium^{232}, and Uranium^{235} decay chains. The radioisotopes selected for analysis were those which: 1) are abundant; 2) are persistent (that is, have relatively long half-lives); 3) have established analytical methods; and 4) have established Preliminary Remediation Goal s (PRGs) or Maximum Contaminant Levels (MCLs). These are Lead^{210}; Radium^{226} and Radium^{228}; Thorium^{228}, Thorium^{230}, and Thorium^{232}; and Uranium^{234}, Uranium^{235}, and Uranium^{238}. Measurement of these radioisotopes allowed a comprehensive assessment of the risks due to naturally occurring radionuclides. In addition, analysis was conducted for gross alpha and beta activities because they provide a gross screening assessment.

The rationale for selection of the metals analytes was that heavy metals are commonly found in association with mining activity or ore processing. While certain heavy metals such as arsenic or lead are more likely to be associated with mining areas, measurement of Contract Laboratory Procedures (CLP), Target Analyte List (TAL), metals was recommended for several reasons. First, using this comprehensive analytical suite enabled a more thorough assessment of the cumulative effects of multiple radiological and metal contaminants and chronic low-level risk associated with concentrations in water. Second, measurement of the full suite of metals is routine and can be done at little additional cost. Third, the information regarding TAL metals, even if not necessarily associated with mining activities, may be useful to future investigators.

APPENDIX A.4b (continued)

USACE FIELD OPERATIONS SUMMARY

USACE PROJECT PLANNING HISTORY

On November 17, 1997, the USEPA and the USACE began discussions regarding working together on the Abandoned Uranium Mines Study on the Navajo Lands. The USACE initiated development of work plans and training standards to prepare team members to assist the USEPA Region 9 and Bechtel Environmental, Inc., in the fieldwork.

On March 10, 1998, the USEPA and the USACE, Los Angeles District, entered into an Inter-Agency Agreement (IAG), No. DW96955370-01-0. The IAG was established with the purpose of providing technical and field support to USEPA Region 9.

On March 13, 1998, the USACE submitted to Patti Collins, Project Manager and Senior Scientist of USEPA Region 9, a list of team members for her approval. In a letter, dated April 9, 1998, Patti Collins selected Glynn Alsup as the Field Project Manager. Other team members included:

Brian Jordan, Project Chemist
David Hays, Project Health Physicist
Dr. James Tang, Industrial Hygienist/Occupational Health
Jeffery Devine, Geologist
Mark Chapman, Geologist
Wayne Schiemann, Environmental Engineer
Steve Messinger, Environmental Engineer.

During the 1998-1999 field season, USEPA added Data Management to USACE's tasks. To accomplish this task, USACE added the following members to our team:

Rich Meyer, Ph.D., Chemist
Shel McQuire, Chemist
Laurie Percifield, Chemist
John Nebelsick, Chemist
Art Moncayo, Lab Technician
Raymond Salas, Lab Technician
Jim Miller, Lab Technician.

Jeffery Franklin, Environmental Scientist and Julie Molton, Environmental Engineer, of CH2M Hill had joined the field team for one week in January 2000 to assist in operating the bacterial laboratory.

During the months of March and April 1998, the USACE had meetings with Kim Geisler of Bechtel Environmental, Thane Hendricks and Jim Beckett of DOE, Patti Collins and Vicki Rosen of USEPA Region 9. During this time team members reviewed maps, previous studies and developed work plans. Team members coordinated computer systems so they could maintain electronic files between all agencies.

On April 22, 1998, USACE met with Bechtel Environmental in San Francisco to review historical files on the uranium mining on the Navajo Lands. During the following week, USACE reviewed the following documents to prepare for the work on the Navajo Nation:

Grand Canyon Geology by Stanley Beus and Michael Morales, New York Oxford, Oxford University press, Museum of Northern Arizona Press, 1990.

Previous Bechtel Environmental contract files, home surveys, Integrated Assessment and field reports from the 1994 study.

Technical Resource Document Extraction and Beneficiation of Ores and Minerals, Volume 5, Uranium, USEPA, Office of Solid Waste, Washington D.C.

Geohydrology and Water Chemistry of Abandoned Uranium Mines and Radiochemistry of Spoil Materials Leachate, Monument Valley and Cameron Areas, Arizona and Utah. U.S. Geological Survey-Water Resources Investigation Report 93-4226 with the NNEPA.

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Work Plan dated June 1995.

Testimony of the Navajo Nation Before The Subcommittee on the Native American affairs Regarding Abandoned Uranium Mines on the Navajo Nation, dated November 4, 1993.

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Radioactive Occurrences and Uranium Productions in Arizona (Final Report) Arizona Bureau of Geology and Mineral technology- March 1981.

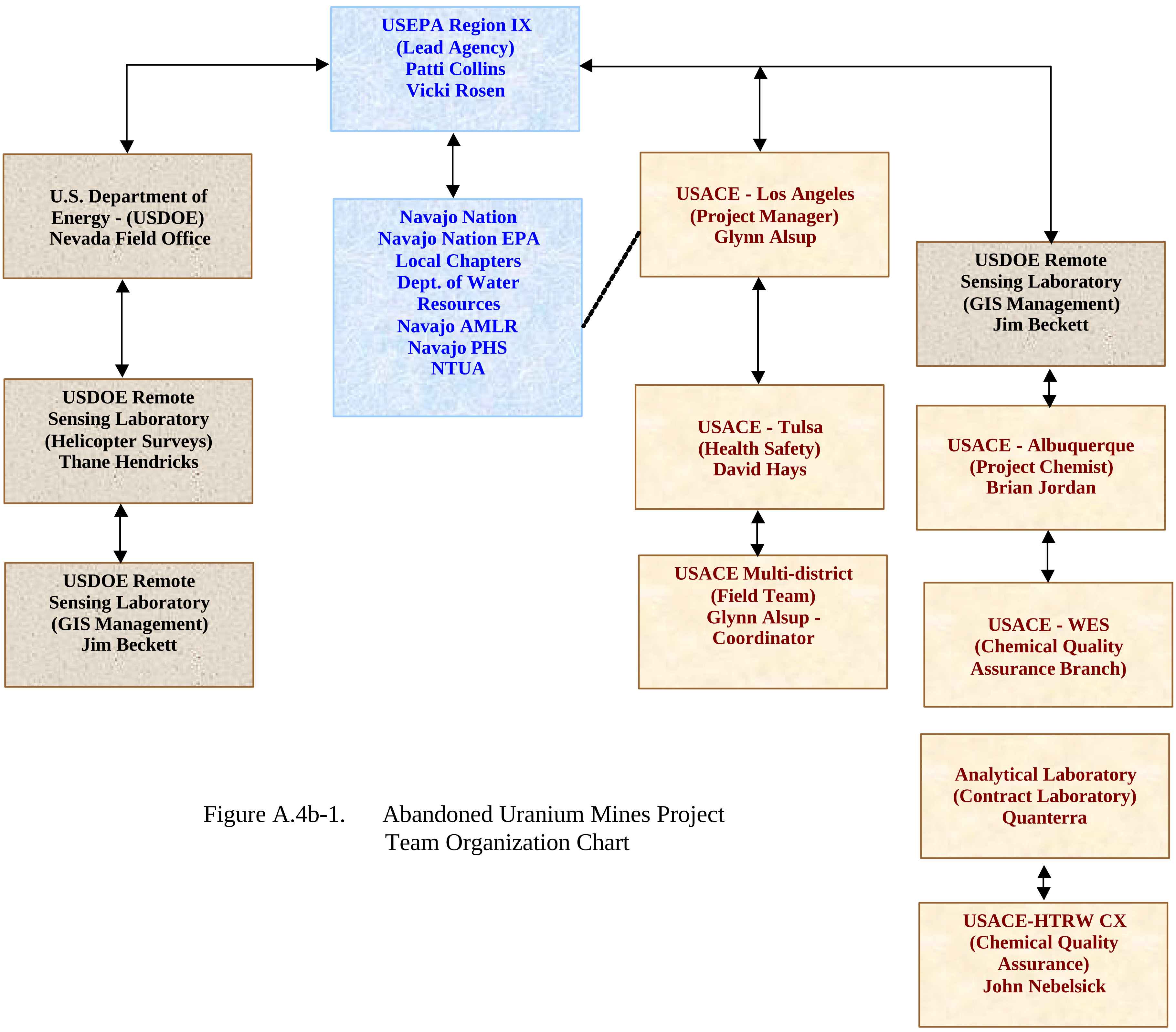


Figure A.4b-1. Abandoned Uranium Mines Project Team Organization Chart

These documents provided a wealth of information used in the development of the project's safety plan, project sampling plan and work plans. On May 30, 1998, the USACE submitted to USEPA Region 9 Book I, General Guidance, Navajo Abandoned Uranium Mines, United States Environmental Protection Agency Region 9 and Book 2, General Guidance, Volume 2, Navajo Abandoned Uranium Mines, United States Environmental Protection Agency Region 9. USACE also submitted the Field Home Survey Form, Daily Safety Form, Daily Reports Forms and QA/QC Forms that would be used in the fieldwork for approval by USEPA Region 9. On the April 1, 1998, USACE submitted the site-specific safety plan in electronic form to USEPA, with a signed copy given on June 6, 1998.

Bechtel Environmental, Inc., developed the sampling plan in cooperation with USEPA Region 9 and the USACE. Bechtel Environmental, Inc. was going to provide the data management and the laboratory for the project. In June 1998, Bechtel Environmental, Inc., informed USEPA Region 9 that they could not furnish a laboratory. USEPA Region 9 asked USACE if they could provide a contract with Quanterra Environmental Laboratories. USACE's project manager and project chemist went to Omaha, Nebraska, on June 8-11 to make arrangements for the USACE to provide a laboratory. With diligent efforts from Brian Jordan, Doug Taggart, Glynn Alsup and John Nebelsick the contract was in place at the end of the week.

Bechtel Environmental, Inc., with assistance from USEPA Region 9 and the USACE prepared the Field Sampling Plan on May 11, 1998. This copy was reviewed by Patti Collins, USEPA Region 9, Vance Fong, USEPA, B. Lee, Bechtel Environmental, Inc., and Glynn Alsup and Brian Jordan, USACE. After review comments were received by various agencies, Bechtel Environmental prepared Revision I completed on June 24, 1998 (see Supporting Documentation Books 13 and 14). This revision addressed the comments and responses supplied by National Air and Radiation Environmental Laboratory (NAREL), USEPA Region 9 and the USACE. This revision also has a summary of revisions of the May 11, 1998 submittal. The USACE received an electronic copy on June 24, 1998.

USACE FIELD OPERATIONS SUMMARY

On May 21, 1998, USEPA, USACE and NNEPA had a meeting in Window Rock with the following personnel present: Melvin Badonie, Department of Water Resources, Ft. Defiance, Arizona; Lydelle Davies, Eugene Esplain, Stanley Edison, Levon Benally, Jr., of NNEPA, Superfund Section; Tom Morris, NNEPA, Water Quality; Ray Russell and Perry Charley, AML Reclamation of Abandoned Mine Lands; Juanitor R Francis, Navajo Tribal Utility Authority (NTUA); Patti Collins and Vicki Rosen of USEPA Region 9, and Glynn Alsup, USACE. The agencies discussed the purpose of the project, the schedule, the work plans, areas to be covered, protocols for sampling, and established contact points. Glynn Alsup, USACE, would discuss the progress and findings with Stanley Edison, NNEPA. Stanley Edison would then brief the Navajo Agencies on the work accomplished.

On May 27, 1998, USACE met with DOE in Las Vegas, Nevada, and went to the Nevada Test Site to test the GPS and radiation monitoring equipment.

On May 28, 1998, Glynn Alsup, USACE, and Vicki Rosen, USEPA, met with chapter officials establishing appointments with the chapters to discuss sampling in their areas. Field work began on June 28, 1998.

In the early part of January 1999, USACE was asked by USEPA Region 9 to manage the data for the project because Bechtel's contract was expiring. USACE developed a Data Management Plan for the project and submitted the plan for USEPA's approval on January 20, 1999. To accomplish the data management task, Brian Jordan, USACE, was moved from the fieldwork to an office position to manage the data returning from the laboratory (see Supporting Documents Book 3). Brian Jordan was replaced in the field with two laboratory technicians from the USACE's El Monte laboratory. Arthur Moncayo and Raymond Salas alternated every two weeks (see Figure A.4b-1).

USACE mobilized the team for sampling on June 26, 1998. Over the weekend, USACE inventoried supplies, calibrated equipment, conducted a team meeting and preparatory meeting reviewing all work plans, safety plans, forms, Material Safety Data Sheets (MSDS), and work protocols.

TRAINING AND SAFETY

USACE Tulsa District provided assistance with training and safety reviews. USACE conducted training for all field personnel in Los Angeles and Phoenix before field work began. Each person is trained in Hazardous Toxic Radiological Waste (HTRW), Off-Road Driving, CPR, Radiation Training, first aid and cultural issues. USACE Tulsa District's Health Physicist reviewed the project work plan and the project health and safety plan. They compared the plans to the USACE requirements of EM 385-1-1, ER 385-1-80 and EM 385-1-80.

All personnel had previous field experience in sampling or oversight on Superfund projects. Before work began, each individual read the project plans and they were trained on specific procedures required on this project.

Thermo-Luminescence Dosimeters (TLD) were provided to the USACE Project Manager. The Project Manager maintained daily distribution of the TLDs to each employee. The TLDs were then returned to USACE Tulsa District to Process through the U.S. Army Ionizing Dosimeter Center (USAIRDC) in accordance army regulations and directives.

FIELD PROTOCOLS

Our sampling protocol directed the USACE Project Manager to meet with chapter officials to discuss daily work. Historical mining documents, radiation surveys, area maps with USGS spring and water source locations and Chapter Officials' knowledge of their areas were used to determine sampling points of water sources used for human consumption. The team had developed 1:100,000 area planning maps with GPS coordinates for the areas wells, springs and known water sources and the known locations of mines in the sampling area. This information was used to determine sample locations requested by chapter officials.

After analytical laboratory results from the samples were received, USACE were to return to the chapters with the information. Local chapters officials would then assist in determining if additional samples or follow-up sampling to determine if an alternative water source was available. On the follow-up samples, bacterial sampling would be conducted.

At each chapter, the USACE Project Manager met with the chapter officials, giving them a copy of the planning map for their area. The planning maps showed the locations of abandoned mines determined from old mining claims, historical documents and helicopter surveys. The maps also contained USGS data of known springs, wells and water sources located in the area. The protocols required the field team to sample water sources requested by the Chapter Officials. The conditions for a water source to be sampled were: (1) it had to be a water source used for human consumption, (2) be requested by a chapter official, (3) or requested by NNEPA personnel.

Each morning the field equipment was calibrated and documented on the Daily Calibration Form. Daily safety meetings were conducted and documented on the Toolbox Safety Form.

At each sample, the field team maintained a daily field log, an electronic field log, a video of the site, a 35mm photo of the site and on most sites, a digital photo of the site. The video was used as a visual field log. The tapes were not edited. The tapes enable agencies to have a visual document of the sampling event and the conditions at the time of the sample.

Glynn Alsup, USACE Project Manager, or Brian Jordan, USACE Project Chemist, maintained the Chain of Custody forms. At each sampling event, the sample labels were completed and the chain of custody forms were filled out before USACE left the site. All coolers were maintained in storage in the motel rooms when not used in the field for sampling. Team members would inspect the samples before shipment, checking the labels, the chain of custody forms and the packaging of each bottle. The bottles were each doubled bagged in zip-lock bags inside the coolers. The chain of custody form was completed for shipment, and placed in a zip-lock bag and taped to the inside of the lid of the cooler. Each cooler was strapped with two high-strength taped wraps with a minimum of two wraps per strap. Custody seals were placed on two hinges. Glynn Alsup would notify Brian Jordan and the USACE's Omaha laboratory that the samples were ready for shipment. Brian Jordan maintained a spreadsheet to document the Fed-Ex tracking number, the shipment date, the date of receipt, and would follow the holding times through the laboratory. Upon arrival at the USACE's Omaha lab, the laboratory would open the cooler and inspect the contents and forms before sending the cooler to Quanterra Environmental Laboratories for analysis. USACE did not experience any lost shipments or any broken containers during shipment.

Each employee received annual physicals, and was monitored daily with a Thermo-Luminescence Dosimeter (TLD). Glynn Alsup, the on-site Radiation Safety Officer maintained the TLDs and the control TLD. The TLDs were provided by David Hays, the Project Health Physicist and processed through a contract with an independent lab. David Hays also provided plan and document reviews, on-site training, oversight and monitoring of procedures to ensure the safety and health of the employees. Logs were maintained of the assignment of the badges, and reports were given to each person issued a badge. Permanent files are maintained by the USACE on exposures of each person issued a badge on the project.

RADIATION MONITORING

At each site, radiation levels were monitored and recorded. Radiation levels were recorded at a height of one meter from the ground surface. On home surveys, team members took measurements 25 feet away from the structure exterior, and four readings, north, south, east and west of the structure. Readings one meter from the surface of the structure were also taken. Readings inside the structures were taken when entry was permitted. Home surveys were provided as a service to Chapters, but were accomplished only when requested.

FIELD DOCUMENTATION

Daily Reports

Daily reports were kept for each day work was accomplished in the field. The Daily Report listed personnel on the site; the tasks accomplished for the day, TLD distribution, any variations to the safety plan, visitors on site, Chapter Officials contacted, and any additional comments. The Project Manager signed the daily reports. A review of the daily reports demonstrates the collection of the samples followed project requirements.

Sample Reports

Sample Reports were developed to list the sample ID, name of the site, date of sample, coordinates, elevation, PH, Conductivity, Oxidation Reduction Potential, and temperature of the water sample, radiation readings, number of samples taken, and comments.

Daily Calibration of Equipment Sheet

A Daily Calibration of Equipment Sheet was used to document the daily calibration of the equipment used. The data sheet listed the name of the equipment, serial number, model number, and proper operation or specific problems found during calibrations. The equipment on the calibration sheets are: Ludlum Model 19, Ludlum model 14C, ATI Orion PH Meter Model 265, ATI Orion Conductivity Meter, Landstar GPS Fieldworker Pro and Newton Message Pad. A review of the daily calibrations demonstrate the equipment used was calibrated before use in the filed, ensuring accurate measurements were taken.

Toolbox Safety Meeting Report

The Toolbox Safety Meeting Report, SPL Form 393, documented the daily safety meetings. The report documents the date of the meeting, personnel in attendance, subjects discussed, and a brief outline of the topic discussed. The on-site Safety Officer and Radiation Safety Officer signed the daily report. The daily safety meetings attributed to an accident-free project with radiation exposure limits at ten percent of the allowable exposure limit.

Chain of Custody Forms

Chain of Custody Forms were maintained to record the handling of water samples from the field to the laboratory. Lab ID's were established to maintain data packages. The forms listed the client, address, project name, Project Manager and contact points, telephone numbers, signature of the sampler, analysis required, number of containers, sample ID number, date sample was taken, time of sample, sample type, type and size of container, method of preservation, signature blocks showing relinquished by and received by, method of shipment, shipment number, and comments. FedEx bills were maintained to track shipment to the laboratory and to document cost.

The chain of custody forms demonstrate proper care of the samples from the time of collection to receipt at the laboratory. No samples were lost during shipment. The Sample Log-In Sheet demonstrates the diligence used in tracking the samples from the field though the laboratory process to the receipt of data.

Field Overview Checklist

A Field Overview Checklist was maintained to document general procedures, safety, records, QA/QC procedures and custody of the sample.

Diligent effort was expended to document the sampling events and to maintain the integrity of the samples from the gathering of the sampling to the processing of the data. This was accomplished by acquiring highly skilled field personnel, training the field team to project standards and requirements, and by daily meetings to remind personnel of those standards and requirements.

Maintaining the checklist is demonstrated in the acceptance of all sample shipments with no problems noted.

CONCLUSION

The conclusions about the USACE field operations are in two parts:

1. Conclusions for work that was completed.
2. Conclusions for work that was planned but not completed.

Conclusions about work that was completed

By using aerial surveys conducted by DOE and USACE conducting field radiation surveys, home construction surveys and conducting extensive water sampling, USEPA was able to:

1. Identify radiation sources,
2. Assign health risk values for water used for human consumption,
3. Identify homes or structures needing remedial action, and
4. Characterize exposures in the areas studied.

The Sampling Plan and Data Management Plans were followed. The study was well documented from the fieldwork to the laboratory and into the final summary.

Our project Data Quality Objectives were met for the samples completed.

1. Data representative of the condition and quality with respect to the stable and radioactive metals in the water were collected and maintained.
2. Data are at levels of precision and accuracy such that the data can be compared and evaluated against standard benchmarks of human risk of consuming the water.
3. Data is of sufficient quality, documentation and verification to be available for use for the USEPA Superfund administrative and enforcement processes, including but not limited to the various removal and remedial actions intended for exposure reduction.
4. The data are presented in a format that is easily accessible to the end user.

Conclusions for work that was planned but not completed

On January 25, 2000, USACE received a letter from Michael Feeley of USEPA Region 9. A portion of the letter read as follows, "In response to a request from Derrith Watchman-Moore, Executive Director of the Navajo Nation Environmental Protection Agency (NNEPA), to cease all visits to tribal chapters, I am requesting that you begin demobilization of your field team immediately and complete the demobilization by January 31, 2000." USACE complied with USEPA's request to demobilize. On January 26, 2000 one vehicle and the USACE field team members returned to Los Angeles. The Project Manager stayed to process the remaining samples and to pack up the remaining equipment and supplies. Demobilization was completed on January 31, 2000.

The following planned activities were not completed:

1. Follow-up sampling.
2. Sampling in the eastern agency.
3. Sampling to determine alternative water sources.
4. Discussions with local chapters and agencies on methods to reduce radiation exposure.
5. Explaining the result to local chapter officials and communities.

The circumstances for follow up sampling envisioned in the Field Sampling Plan and later analysis of field conditions falls into four categories.

1. During the planning for the project it was initially thought that community members may wish to bring samples for analysis to the project field team from remote water sources or culturally sensitive areas. If the sample from the community member showed concentrations at levels of concern a follow up sample collected by the field team would be warranted.

   No follow up sampling is needed for this contingency. The field team using the sampling methods included in the FSP collected all samples.

2. If data quality issues arose concerning the representative nature of a sample with respect to the sampling methods employed or analytical method used for analysis it was to be followed up with an appropriate method of sample collection and analysis.

   The one and only instance where a follow up activity was needed to better reflect the conditions encountered in the field is the ongoing Hydrogeologic Investigation being carried out at the Cameron mining pit Yazzie 312. Turbidity of the samples after a field filtration at 5 microns remained extensive enough to bias the water analysis. Modifications include the centrifuging of field samples to decrease suspended sediments contained in the pit water. The analysis of pit samples has been modified to more accurately quantify high concentration samples from the pit. A monitoring well has been installed to ascertain the impacts of the pit on groundwater in the area.
   No follow up actions were required to evaluate the risk posed by these waters. Further investigations are ongoing to and warranted at these locations to evaluate exposure reduction activities.

3. Follow up actions were warranted where sample results were unusual or inconsistent with the data set as a whole or with regional information.

   The Shonto well below the Rare Metals facility in Tuba City was referred to the Department of Energy for follow up sampling due to some unusual radiological findings from the spring with respect to other samples obtained from the Moenkopi Wash area. Subsequent sampling at the spring but at a different outlet has not shown the same unusual pattern of results. Shonto well has been added to the Department of Energy's monitoring program associated with the Rare Metals facility. This is the only location where unusual or inconsistent results were obtained with respect to other samples in the same area.

4. The finding of local alternative water sources to replace sources identified as having elevated risk was to initiate follow up actions.

   This activity was started in the Coal Mine Mesa chapter but not completed prior to the decision to stop field activities. This sampling is needed for the purpose of finding of local alternative water sources to replace sources identified in the initial phase of the project as presenting a potential risk to the community members.

   The field team adhered to the quality assurance/quality control procedures outlined in the plans. Documentation supports this compliance. The procedures followed ensured the quality of the data. Although additional work is needed to complete this study, the data gathered to this point complies with the project data objectives and project plans.

ABANDONED URANIUM MINES PROJECT

APPENDIX A.4c

USACE DATA MANAGEMENT SUMMARY

By: Brian Jordan
USACE Project Chemist

DESCRIPTION OF DATA MANAGEMENT PROGRAM

The Data Management Plan was developed by USACE for USEPA on January 20, 1999. The goal of the Data Management Plan was to provide the end user with data that met the objectives of the project.

The project Data Quality Objectives are the following:

1. Data representative of the condition and quality with respect to the stable and radioactive metals in the water.

2. Data at levels of precision and accuracy such that the data can be compared and evaluated against standard benchmarks of human risk of consuming the water.

3. Data of sufficient quality, documentation and verification to be available for use for the USEPA Superfund administrative and enforcement processes, including but not limited to the various removal and remedial actions intended for exposure reduction.

4. Provide data in a format that is easily accessible to the end user.

PROJECT DATA FLOW DIAGRAM

The flow of data throughout the project is summarized in Figure 1. The left side of Figure 1 presents the flow and review of data on a typical Superfund project. The right side of the figure presents the flow and reviews performed for the Abandoned Uranium Mines-Navajo Lands Project. The two flows are presented to provide any future reviewers of the project information the ability to compare and contrast the data flow processes of a typical Superfund project with the processes employed on the Abandoned Uranium Mines-Navajo Lands Project. The comparison will assist in understanding the necessity of multiple levels of review on the project. The review processes presented for the project provided for the use of data prior to the completion of all the data collection and analysis for the project.

The right side of Figure 1 contains three additional Quality Control (QC) procedures. The review of sample handling and packaging in box 3b provided a check of field procedures and sample identification protocols. This review insured that samples entered the database system correctly, which was an important aspect of supporting the data quality objective of providing data in a format that is easily accessible to the end user.

The Recalculation Validation performed by TechLaw, Inc., in box 8b provided an additional review the project data including a recalculation of the data from the calibration data provided in the data packages. Samples for this level of validation were determined first on finding samples with results that span the linear extent of the results obtained during the project and second on ensuring that at least one sample from each chapter had results that went trhough the recalculation validation process. This review assisted in ascertaining the accuracy of data with respect to calibration assumptions and calculations, which supports the data quality objective of obtaining data of known precision and accuracy.

The QA review performed by the HTRW Center of Expertise in box 6b provided a review of the review validation procedures accomplished by the CQAB and a review of the laboratory method Standard Operating Procedures. The review supports the obtainment of data with sufficient quality, documentation and verification.

Quality assurance split samples collected on a typical Superfund project (box 2a) were not collected for the project. It was determined by the project team that performance evaluation samples would better serve the purpose of evaluating the accuracy of data provided by the laboratory.

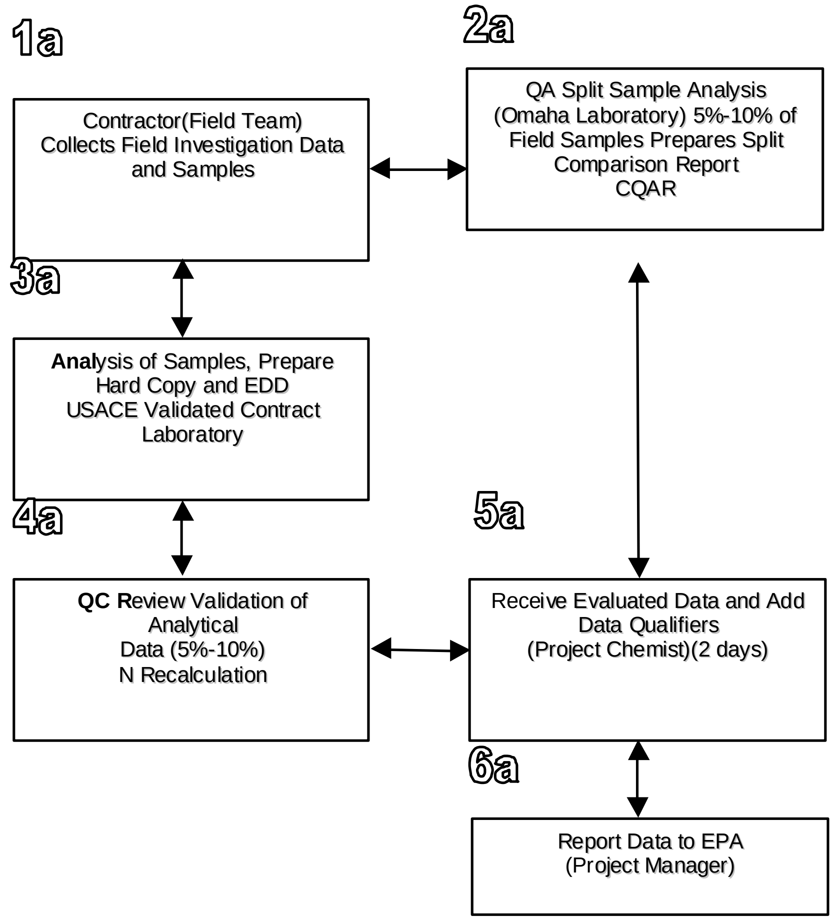
GIS and Database capabilities supplied by CH2M Hill in boxes 10b and 11b provided end of project data, which can be efficiently queried and presented to a wide variety of audiences. The development of these formats and applications provides data that is easily accessible to the end user.

The following discussion describes the project flow of data as presented on the right side of Figure 1.

Field Operations (box 1b) represent the beginning of data collection. This started with the initial background research performed by the team. It included the capturing of GPS information, field gamma measurements, and capturing the setting presented at each location as well as the collection of water for analytical analysis.

Field Database management (box 2b) provided a quality control check to insure that field data electronically recorded was sufficient and complete. It also provided the project chemist an opportunity to track samples through the laboratory and establish scheduling for analytical results delivery.

Typical Superfund Data Review



Abandoned Uranium Mines-Navajo Lands Data Review

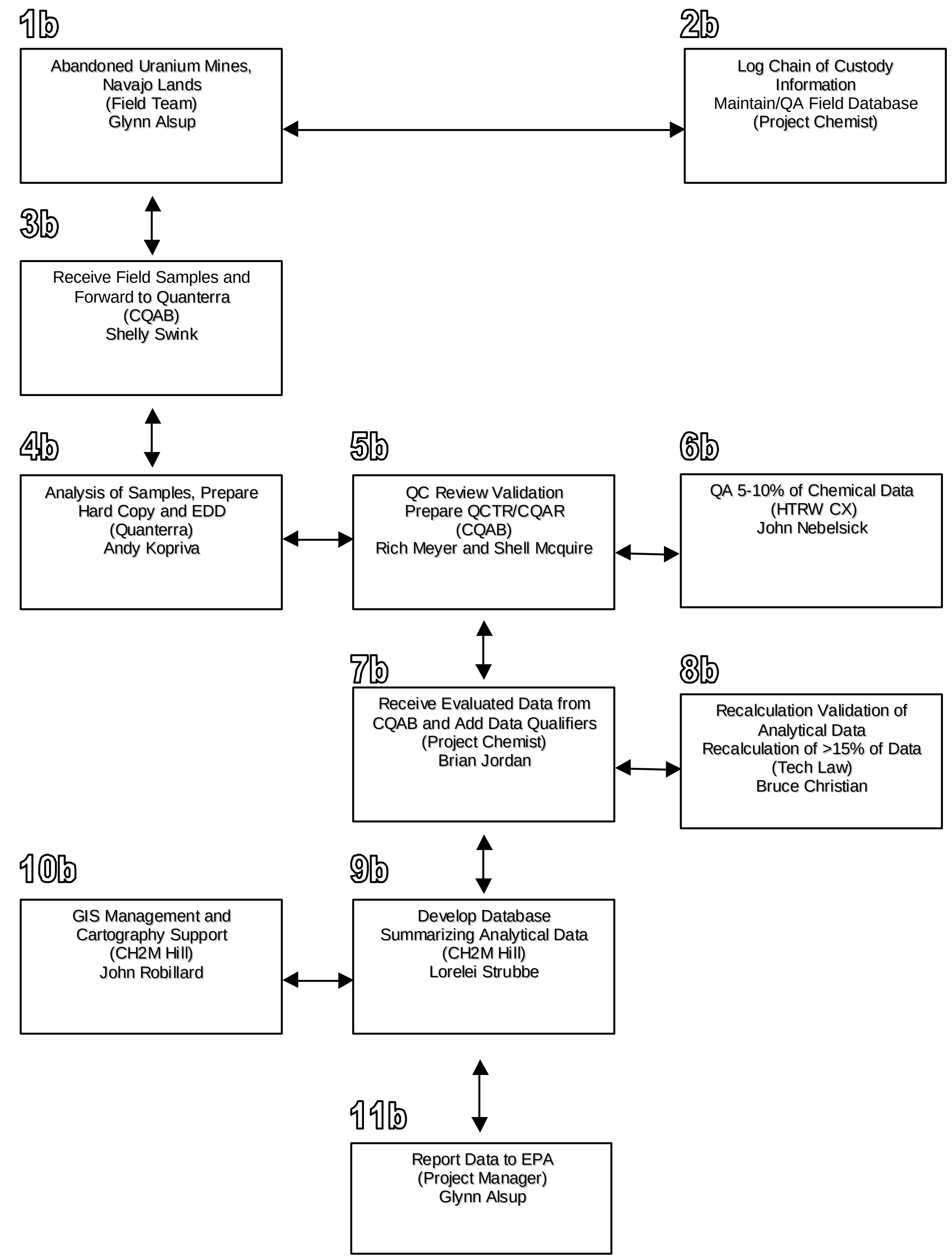


Figure A.4c-1 - Project Data Flow

Upon receipt of the coolers (box 3b) the samples were examined and logged into the CQAB system with a number that identifies that sample only. A cooler receipt form was filled out for each sample delivery group.

Laboratory analysis (box 4b) was provided by three laboratories. The laboratories used were Quanterra Environmental Laboratory in Richland WA, Energy Laboratories, Inc., in Caspar WY, and the Chemical Quality Assurance Branch of USACE. Laboratory standard operating procedures were reviewed prior to the initiation of work.

The CQAB Review Validation (box 5b) was started after the analyses were complete for a sample delivery group. CQAB compiled the Quality Assurance Test Results for the Project Chemist to review. This data package includes a list of the samples, sampling dates, sample matrix, analyses requested, custody papers, cooler receipt forms, radiochemistry and metals results, and any relevant method Quality Control (QC), method blanks, matrix spikes, laboratory control samples, and laboratory duplicates. A review of the sample batch quality control was included at the beginning of the Quality Assurance Test Results (QATR). Specific comments were made for method blanks, matrix spike recoveries, laboratory control sample recoveries, duplicate analyses, and holding times. This review would be comparable to the review of data provided in the QC review validation of analytical data (Box 4a).

The Quality Assurance Review (box 6B) conducted by the USACE HTRW Center of Expertise, evaluated the standard operating procedures carried out by the project laboratories and the review procedures conducted by the CQAB laboratory.

The receipt of evaluated data (box 7b) from the CQAB involved a review of the CQARs and the assigning of project relevant data qualifiers. Data packages were forwarded to TechLaw, Inc., for Recalculation Validation and assignment of data qualifiers. The electronic data was also reformatted and evaluated prior to transmittal to CH2M Hill.

The recalculation validation (box 8b) performed by TechLaw, Inc., involved the recalculation of analytical results from the batch QC data provided in the laboratory data packages. It also provided another review of other aspects of the QC performed by the laboratory including the analysis of method blank, matrix spike, laboratory control, and calibration samples.

The incorporation of all the project data into a GIS and an database (boxes 9b and 10b) allowed the distribution of data quickly to the end users. The processing of data is subject to errors introduced by formatting and translation of data files. Through the process of data interpretation and presentation, quality control evaluations were made to insure that the data were correctly represented.

Project Quality Control Samples

QC duplicate samples and field blank samples were collected throughout the project. A total of 26 quality control samples (13-field blanks, 13-duplicate samples) were collected. The ratio of quality control samples to investigative samples is 11.5%. The sampling plan target was a ratio of 10%.

Duplicate samples were collected and analyzed to assess laboratory performance through comparison of the duplicate sample pair results. Duplicate sample results are in agreement with the primary sample result. Duplicate samples were submitted to the laboratory without their knowledge of the sample being a QC split sample. There is the expected variability in result reported between the detection limit and reporting limit. Sample CT990310TCW005 illustrates the possible variability in samples collected at differing times of the year. The sample collected in August 1998, was during a high use period for the windmill and the March 1999 sample during a limited use period for the windmill. Future investigations may need to address this variability.

Field blank samples were collected to evaluate field sampling and handling procedures. Field blank samples were prepared by placing deionized water directly into a pre-cleaned sample container, then adding preservatives in the field. The blank sample results illustrate that the field procedures minimized the chance of contamination of investigative samples from sample containers or the preservative used in the field, with respect to the laboratory reporting limit. The blank samples are in agreement with laboratory quality control method blank results. Field blank samples generated from the field and processed by the laboratory indicate no false positive bias to the data. One quality assurance sample was processed through an independent laboratory.

One Radiological Chemistry Performance Evaluation sample was prepared for the project but was not able to be analyzed before the project field operations were stopped. The project laboratories prior to the start of the project completed performance evaluation samples for metals analyses. The performance evaluation sample prepared for radiological analysis would have provided an additional assessment of analytical accuracy.

LABORATORY ANALYTICAL QUALITY OBJECTIVES

Laboratory Analytical Quality Objectives were developed to assist in achieving the project Data Quality Objective of obtaining data at levels of precision and accuracy such that the data can be compared and evaluated against standard benchmarks of human risk of consuming the water.

Specific analytical objectives for precision and instrument calibration were outlined in the analyte specific methods selected for the project. Discussions with the laboratories were made throughout the project to discuss the possibility of making improvements where necessary to analytical procedures to obtain relevant data at the detection limit goal. The usability of analytical data that is close to or below a detection limit is always difficult to assess. To avoid the over assigning of risk to an analyte that was not quantified at the PRG it was decided to assign a value of zero to analyte concentrations reported below the detection limit.

The Minimum Detectable Activity (MDA) reported for Pb^{210} is one of the analytes, which presented this problem in assessing the total risk. The method selected would not provide data of value at or below the PRG of 0.047 pCi/L without involving the collection of a sample volume > 5 gallons or extending the method count time to many weeks. For sample results below the MDA the concentration of the analyte cannot be ascertained with confidence, but the concentration of the analyte is not above the MDA. The MDA for an analysis is computed for each analysis. The incremental life cancer risk for Pb^{210} associated with a sample at the MDA is approximately 2.0 $x10^{-5}$.

The analytical methods for arsenic, cadmium, lead, selenium and thallium were changed from 6010b to 7000 series methods utilizing graphite furnace atomic absorption. This change in method was made to improve the detection of the analytes at the laboratory analytical quality objective of 0.045 mg/L for arsenic, 0.3 mg/L for cadmium, 2 mg/L for lead, 4 mg/L for selenium and 2.9 mg/L for thallium.

FOLLOW UP ACTIONS

The circumstances for follow up sampling envisioned in the Field Sampling Plan and later analysis of field conditions falls into four categories.

1. During the planning for the project it was initially thought that community members may wish to bring samples for analysis to the project field team from remote water sources or culturally sensitive areas. If the sample from the community member showed concentrations at levels of concern a follow up sample collected by the field team would be warranted. No follow-up sampling is needed for this contingency. The field team using the sampling methods included in the FSP collected all samples.

2. If data quality issues arose concerning the representative nature of a sample with respect to the sampling methods employed or analytical method used for analysis it was to be followed up with an appropriate method of sample collection and analysis. The one and only instance where a follow up activity was needed to better reflect the conditions encountered in the field is the ongoing Hydrogeologic Investigation being carried out at the Cameron mining pit Yazzie 312. Turbidity of the samples after a field filtration at 5 microns remained extensive enough to bias the water analysis. Modifications include the centrifuging of field samples to decrease suspended sediments contained in the pit water. The analysis of pit samples has been modified to more accurately quantify high concentration samples from the pit. A monitoring well has been installed to ascertain the impacts of the pit on groundwater in the area. No follow-up actions were required to evaluate risk posed by these waters. Further investigations are ongoing and warranted at these locations to evaluate exposure reduction activities.

3. Follow up actions were warranted where sample results were unusual or inconsistent with the data set as a whole or with regional information. The Shonto well below the Rare Metals facility in Tuba City was referred to the Department of Energy for follow up sampling due to some unusual radiological findings from the spring with respect to other samples obtained from the Moenkopi Wash area. Subsequent sampling at the spring but at a different outlet has not shown the same unusual pattern of results. Shonto well has been added to the Department of Energy’s monitoring program associated with the Rare Metals facility. This is the only location where unusual or inconsistent results were obtained with respect to samples taken in the same area.

4. The finding of local alternative water sources to replace sources identified as having elevated risk was to initiate follow up actions. This activity was started in the Coal Mine Mesa chapter but not completed prior to the decision to stop field activities. This sampling is needed for the purpose of finding of local alternative water sources to replace sources identified in the initial phase of the project as presenting a potential risk to the community members.

PROJECT DATA QUALITY OBJECTIVES ATTAINMENT

1. The data are representative of the condition and quality with respect to the stable and radioactive metals in the water at the point of use.

2. The data are at levels of precision and accuracy such that the data can be compared and evaluated against standard benchmarks of human risk for consumption of water.

3. The data are of sufficient quality, documentation and verification to be available for use by the USEPA Superfund administrative and enforcement processes, including but not limited to the various removal and remedial actions intended for exposure reduction.

4. The Data are presented in formats that are easily accessible to the end user.

ABANDONED URANIUM MINES PROJECT ATLAS

APPENDIX B

DATA REFERENCES

The following table provides a data inventory for the Project Atlas. The data references are divided into two tables that identify basemap and thematic features. The first table references basemap features used in most maps. Basemap features provide background information for the thematic features (second table). Basemap data includes features such as roads, county boundaries, and school locations. The basemap feature references follow.

BASEMAP FEATURES

Feature	Reference
Churches	Environmental Systems Research Institute, Inc. and Geographic Data Technology, Inc., 1998, Detailed States and Counties, ESRI Data and Maps 1 (CD), Redlands, California, 1998, in ESRI Data and Maps 2 (CD), Redlands, California, 1998, Environmental Systems Research Institute, Inc.
County Boundaries	Environmental Systems Research Institute, Inc. and Geographic Data Technology, Inc., 1998, Detailed States and Counties, ESRI Data and Maps 1 (CD), Redlands, California, 1998, in ESRI Data and Maps 2 (CD), Redlands, California, 1998, Environmental Systems Research Institute, Inc.
Digital Raster Graphic (DRG), 1:500,000 Scale Topographic Maps	VisiCom, 2000, Sure!MAPS RASTER, Continental United States, 1:500K: San Diego, California, VisiCom.
Digital Raster Graphic (DRG), 1:100,000 Scale Topographic Maps	VisiCom, 1999, Sure!MAPS RASTER, Arizona, 1:100K: San Diego, California, VisiCom. VisiCom, 1999, Sure!MAPS RASTER, Colorado, 1:100K: San Diego, California, VisiCom. VisiCom, 1999, Sure!MAPS RASTER, New Mexico, 1:100K: San Diego, California, VisiCom. VisiCom, 1999, Sure!MAPS RASTER, Utah, 1:100K: San Diego, California, VisiCom. Data and metadata are on each CD-ROM.
Hospitals	Environmental Systems Research Institute, Inc. and Geographic Data Technology, Inc., 1998, Detailed States and Counties, ESRI Data and Maps 1 (CD), Redlands, California, 1998, in ESRI Data and Maps 2 (CD), Redlands, California, 1998, Environmental Systems Research Institute, Inc.
Hydrographic Features	U.S. Geological Survey, 1999, Hydrography Features of the United States: National Atlas of the United States, U.S. Geological Survey, Reston, Virginia. Online_Linkage: <http://edcftp.cr.usgs.gov/pub/data/nationalatlas/hydrogm020.tar.gz> for the data and <http://nationalatlas.gov/hydrom.html> for the FGDC metadata.
Landsat MSS	Earth Resources Observation Systems Data Center, 1995, North American Landscape Characterization Triplicates: Sioux Falls, South Dakota, U.S. Geological Survey. Data and metadata are on CD-ROM.
Navajo and Hopi Boundaries	Francis, M., Hoskie, G., and Begay, J., 1997, Navajo Nation Boundaries: Window Rock, Arizona, Navajo Land Department.
Navajo Chapter Houses	Francis, M., Hoskie, G., and Begay, J., 1997, Selected Navajo Chapter House Locations: Window Rock, Arizona, Navajo Land Department.
Populated Places	U.S. Geological Survey, 1981, Geographic Names Information System, in ESRI Data and Maps 2 (CD), Redlands, California, 1998, Environmental Systems Research Institute, Inc. U.S. Bureau of the Census, 1990, United States Populated Places, Summary Tape File 1C (STF-1C), in ESRI Data and Maps 1 (CD), Redlands, California, 1998, Environmental Systems Research Institute, Inc. Data and metadata are on CD-ROM.
Roads; Arizona, Colorado, New Mexico, and Utah	Geographic Data Technology, Inc., 1995, Major Roads, in ESRI Data and Maps 3 (CD), Redlands, California, 1998, Environmental Systems Research Institute, Inc.
Schools	Environmental Systems Research Institute, Inc. and Geographic Data Technology, Inc., 1998, Detailed States and Counties, ESRI Data and Maps 1 (CD), Redlands, California, 1998, in ESRI Data and Maps 2 (CD), Redlands, California, 1998, Environmental Systems Research Institute, Inc.
Shaded Relief Imagery	Earth Resources Observation Systems Data Center, 1995, North American Landscape Characterization Triplicates: Sioux Falls, South Dakota, U.S. Geological Survey. Data and metadata are on CD-ROM.
State Boundaries	Environmental Systems Research Institute, Inc. and Geographic Data Technology, Inc., 1998, Detailed States and Counties, ESRI Data and Maps 1 (CD), Redlands, California, 1998, in ESRI Data and Maps 2 (CD), Redlands, California, 1998, Environmental Systems Research Institute, Inc.

APPENDIX B (continued)

DATA REFERENCES

The second table references the thematic features shown on top of the basemap features. The thematic features are the subject of this atlas and include such data features as radiation contours, ground water sample locations, and mapped geological units. The thematic feature references follow.

THEMATIC FEATURES

Feature	Reference
Annual Precipitation	Chris, D. and Taylor, G., 1998, Western U.S. Average Monthly or Annual Precipitation, 1961-90: Portland, Oregon, USA, Water and Climate Center of the Natural Resources Conservation Service. Online_Linkage: http://www.ocs.orst.edu/prism/prism_new.html for the data and FGDC metadata.
Bismuth 214 Radiation Contours	U.S. Department of Energy, 1999, Bismuth 214 and Gross Count Radiation Information, Abandoned Uranium Mines Project, NM, AZ, UT, Navajo Lands: Las Vegas, NV: U.S. Department of Energy.
Federal Lands	U.S. Geological Survey, 1999, Federal and Indian Lands of the United States: National Atlas of the United States, U.S. Geological Survey, Reston, Virginia. Online_Linkage: <http://edcftp.cr.usgs.gov/pub/data/nationalatlas/fedlanp020.tar.gz> for the data and http://nationalatlas.gov/fedlandsm.html for the FGDC metadata.
Geology	Green, Gregory N., 1992, The Digital Geologic Map of Colorado in ARC/INFO Format: U.S. Geological Survey Open File Report 92-0507, 10 p., Online_Linkage: http://greenwood.cr.usgs.gov/pub/open-file-reports/ofr-92-0507 for the data and FGDC metadata. Green, G. N. and Jones, G. E., 1997, The Digital Geologic Map of New Mexico in ARC/INFO Format, in RGIS Clearinghouse Resource Data, Volume 1b, Version 2.0, 1998, Albuquerque, New Mexico, Resource Geographic Information System Program. Data and FGDC metadata are on CD-ROM. Hintze, L. F., Willis, G. C. Laes, D. Y. M., Sprinkel, D. A., and Brown, K. F., comps., 2000, Digital Geologic Map Of Utah: Salt Lake City, Utah Geological Survey Map 179DM [Digital Map]. Data and FGDC metadata are on CD-ROM. Richard, S. M. and Kneale, S. M., 1997, Geologic Map of Arizona, GIS Database: Tucson, Arizona, Digital Information Series DI-8, Version 2.0, Arizona Geological Survey, 10 p., includes a 3.5" diskette.
Gross Count Radiation Contours	U.S. Department of Energy, 1999, Bismuth 214 and Gross Count Radiation Information, Abandoned Uranium Mines Project, NM, AZ, UT, Navajo Lands: Las Vegas, NV: U.S. Department of Energy.
Major Land Resource Areas	Bliss, Norman B. 1989, A National Natural Resource Data Base: Techniques for Linking the Major Land Resource Area map, the 1982 National Resources Inventory and the Soils Interpretations Record Data Bases in a Geographic Information System. Eros Data Center, Sioux Falls, SD. Online_Linkage: http://water.usgs.gov/lookup/getspatial?mlra for the data and FGDC metadata.
Native American Lands, Other	U.S. Geological Survey, 1999, Federal and Indian Lands of the United States: National Atlas of the United States, U.S. Geological Survey, Reston, Virginia. Online_Linkage: <http://edcftp.cr.usgs.gov/pub/data/nationalatlas/fedlanp020.tar.gz> for the data and http://nationalatlas.gov/fedlandsm.html for the FGDC metadata.
Physiographic Provinces	U.S. Geological Survey, 1992, Physical divisions of the United States: U.S. Geological Survey Special Map. Online Linkage: <http://water.usgs.gov/lookup/getspatial?physio> for the data and FGDC metadata.
Private Lands	Stulz, Mary Beth, comp., 1999, Land Status by State: Denver, U.S. Bureau of Land Management . Online Linkage: <http://www.blm.gov/gis/narsc/data.html> for data.
Ground Water Samples	U.S. Army Corps of Engineers, 1999, Ground Water Sample Locations: Albuquerque, New Mexico, U.S. Army Corps of Engineers.
Springs	U.S. Geological Survey, 1981,Geographic Names Information System: Reston, VA, U.S. Geological Survey. Online Linkage: <http://mapping.usgs.gov/www/gnis/gnisftp.html> for the data and FGDC metadata.
State Lands	Stulz, Mary Beth, comp., 1999, Land Status by State: Denver, U.S. Bureau of Land Management . Online Linkage: <http://www.blm.gov/gis/narsc/data.html> for data.
Survey Flight Areas	U.S. Department of Energy, 1999, Aerial Radiation Survey Flight Boundaries, Abandoned Uranium Mines Project, NM, AZ, UT, Navajo Lands: Las Vegas, NV: U.S. Department of Energy.
Uranium Mines	U.S. Department of Energy, 2001, Abandoned Uranium Mines Survey Technical Report: San Francisco, CA, United States Environmental Protection Agency - Superfund Record Center, 95 Hawthorne Street, Suite 403S, San Francisco, CA 94105, (415)744-1500, Project Code: 4807.

ABANDONED URANIUM MINES PROJECT ATLAS

APPENDIX C

GAZETTEER

This Gazetteer provides location information for selected feature types that were identified by a proper name and were shown on an Atlas Overview or Survey Area map page. It is organized first by feature type, including selected Chapter Houses and populated places, and all known schools, churches, and hospitals. Each section of the table has a heading that identifies the feature type (e.g. POPULATED PLACES). The features within each feature type section are arranged alphabetically by feature name. Feature Name identifies the official name of a given feature. Latitude and Longitude are in degrees, minutes, and seconds followed by a one-character directional indicator (N or W). The geographic coordinates given are accurate to within ± 5 seconds of latitude or longitude. The Overview Map Name lists each overview map on which a feature is located. The Survey Area Map Name lists each survey area map on which a feature is located. The Flight Area Name is identified for a given feature where it is located within a flight area. An Overview Map or Survey Area Map can be located using the Table of Contents at the front of this Atlas. Flight areas are shown and named on the Overview Maps of this Atlas.

The following abbreviations are used:

Center	Cntr.	Junior High School	JHS
Civilian Conservation Center	CCC	Middle School	MS
Community	Comm.	Preschool	PS
Elementary School	ES	School	Sch.
Grade School	GS	University	Univ.
High School	HS		

Feature Name	Latitude	Longitude	Overview Map Name	Survey Area Map Name	Flight Area Name
CHAPTER HOUSES					
Black Mesa Chapter House	36º 20' 45" N	110º 03' 54" W	Central, Chinle, Monument Valley	Central	
Cameron Chapter House	35º 52' 11" N	111º 24' 58" W	Cameron / Tuba City	Cameron / Tuba City - South	Cameron
Chapter House	36º 54' 39" N	109º 06' 18" W	Chinle, Four Corners	Four Corners	
Chapter House	36º 35' 51" N	109º 03' 33" W	Chinle, Four Corners	Four Corners	
Chilchinbito Chapter House	36º 31' 41" N	110º 04' 53" W	Central, Chinle, Monument Valley	Central	
Chinle Chapter House	36º 09' 11" N	109º 33' 32" W	Bidahochi, Chinle, Central, Four Corners, Monument Valley	Chinle, Central	
Cottonwood Chapter House	36º 04' 14" N	109º 53' 21" W	Bidahochi, Chinle, Central, Four Corners, Monument Valley	Chinle, Central	
Cove Chapter House	36º 35' 04" N	109º 11' 26" W	Central, Chinle, Four Corners	Four Corners	
Dilkon Chapter House	35º 23' 09" N	110º 19' 20" W	Bidahochi, Central	Bidahochi	
Greasewood Chapter House	35º 31' 43" N	109º 51' 15" W	Bidahochi, Chinle, Central	Bidahochi	
Indian Wells Chapter House	35º 24' 03" N	110º 05' 03" W	Bidahochi, Chinle, Central	Bidahochi	Indian Wells
Kayenta Chapter House	36º 43' 28" N	110º 15' 17" W	Central, Monument Valley	Monument Valley	
Nazlini Chapter House	35º 53' 57" N	109º 26' 41" W	Bidahochi, Chinle, Central, Four Corners, Monument Valley	Chinle	Nazlini West
Rough Rock Chapter House	36º 24' 43" N	109º 51' 40" W	Central, Chinle, Four Corners, Monument Valley	Central, Four Corners	
Shonto	36º 07' 25" N	109º 48' 02" W	Bidahochi, Chinle, Central, Four Corners, Monument Valley	Chinle, Central	
Shonto Chapter House	36º 35' 39" N	110º 38' 40" W	Central, Cameron / Tuba City, Monument Valley	Monument Valley, Central, Cameron / Tuba City - North	
Teesto Chapter House	35º 29' 45" N	110º 24' 14" W	Bidahochi, Central	Bidahochi	
Tuba City Chapter House	36º 07' 33" N	111º 14' 09" W	Cameron / Tuba City	Cameron / Tuba City - South	
Whitecone Chapter House	35º 33' 42" N	110º 04' 48" W	Bidahochi, Chinle, Central	Bidahochi	Indian Wells
POPULATED PLACES					
Big Water, UT	37º 04' 07" N	111º 39' 42" W	Cameron / Tuba City		
Black Rock, NM	35º 05' 10" N	108º 47' 24" W	Chinle		
Blanding, UT	37º 37' 29" N	109º 28' 48" W	Four Corners, Monument Valley		
Cameron, AZ	35º 50' 54" N	111º 25' 55" W	Cameron / Tuba City	Cameron / Tuba City - South	Cameron
Chinle, AZ	36º 09' 07" N	109º 34' 48" W	Bidahochi, Chinle, Central, Four Corners, Monument Valley	Chinle	
Cortez, CO	37º 21' 06" N	108º 34' 38" W	Four Corners		
Dennehotso, AZ	36º 49' 17" N	109º 53' 02" W	Central, Chinle, Four Corners, Monument Valley	Monument Valley, Four Corners	
Dolores, CO	37º 28' 28" N	108º 29' 52" W	Four Corners		
Flagstaff, AZ	35º 11' 20" N	111º 37' 11" W	Cameron / Tuba City		
Fort Defiance, AZ	35º 44' 37" N	109º 03' 60" W	Chinle, Four Corners	Chinle	
Gallup, NM	35º 31' 14" N	108º 44' 07" W	Chinle		
Ganado, AZ	35º 42' 27" N	109º 33' 07" W	Bidahochi, Chinle, Central, Four Corners	Chinle	
Grand Canyon Village, AZ	36º 02' 47" N	112º 09' 12" W	Cameron / Tuba City	Cameron / Tuba City - South	
Greasewood, AZ	35º 31' 41" N	109º 51' 36" W	Bidahochi, Chinle, Central	Bidahochi	
Heber-Overgaard, AZ	34º 24' 50" N	110º 34' 08" W	Bidahochi		
Holbrook, AZ	34º 54' 46" N	110º 09' 19" W	Bidahochi		
Hotevilla, AZ	35º 55' 26" N	110º 39' 27" W	Bidahochi, Cameron / Tuba City, Central, Monument Valley	Cameron / Tuba City - South	
Kachina Village, AZ	35º 05' 49" N	111º 41' 31" W	Cameron / Tuba City		
Kaibito, AZ	36º 35' 21" N	111º 06' 37" W	Cameron / Tuba City	Cameron / Tuba City - North	
Kayenta, AZ	36º 43' 05" N	110º 15' 09" W	Central, Monument Valley	Monument Valley	
Keams Canyon, AZ	35º 48' 57" N	110º 12' 32" W	Bidahochi, Central		
Kykotsmovi Village, AZ	35º 52' 27" N	110º 37' 22" W	Bidahochi, Cameron / Tuba City, Central, Monument Valley		
Leupp, AZ	35º 17' 43" N	111º 00' 02" W	Bidahochi, Cameron / Tuba City		
Lukachukai, AZ	36º 24' 00" N	109º 15' 25" W	Central, Chinle, Four Corners	Central	
Many Farms, AZ	36º 21' 01" N	109º 37' 06" W	Central, Chinle, Four Corners, Monument Valley	Central, Four Corners	
Mexican Hat, UT	37º 07' 43" N	109º 54' 56" W	Central, Four Corners, Monument Valley	Monument Valley	
Mexican Springs, NM	35º 47' 15" N	108º 48' 26" W	Chinle, Four Corners	Chinle	
Moenkopi, AZ	36º 06' 39" N	111º 13' 20" W	Cameron / Tuba City	Cameron / Tuba City - South	
Montezuma Creek, UT	37º 15' 36" N	109º 18' 48" W	Central, Four Corners		

ABANDONED URANIUM MINES PROJECT ATLAS

APPENDIX C (continued)

GAZETTEER

Feature Name	Latitude	Longitude	Overview Map Name	Survey Area Map Name	Flight Area Name
POPULATED PLACES					
Naschitti, NM	36º 03' 44" N	108º 40' 52" W	Chinle, Four Corners	Chinle	
Navajo, NM	35º 53' 47" N	109º 01' 53" W	Chinle, Four Corners	Chinle	
Newcomb, NM	36º 16' 60" N	108º 42' 25" W	Chinle, Four Corners	Chinle	
Page, AZ	36º 54' 15" N	111º 27' 28" W	Cameron / Tuba City		
Pinon, AZ	36º 06' 03" N	110º 13' 17" W	Bidahochi, Central, Monument Valley	Central	
Polacca, AZ	35º 50' 08" N	110º 21' 56" W	Bidahochi, Central		
Rough Rock, AZ	36º 24' 34" N	109º 52' 03" W	Central, Chinle, Four Corners, Monument Valley	Central, Four Corners	
Sanostee, NM	36º 26' 05" N	108º 52' 22" W	Chinle, Four Corners	Four Corners	
Sawmill, AZ	35º 53' 30" N	109º 09' 13" W	Chinle, Four Corners	Chinle	
Second Mesa, AZ	35º 49' 03" N	110º 30' 13" W	Bidahochi, Central		
Shiprock, NM	36º 47' 31" N	108º 41' 46" W	Chinle, Four Corners	Four Corners	
Shongopovi, AZ	35º 49' 05" N	110º 32' 02" W	Bidahochi, Central		
Shonto, AZ	36º 35' 17" N	110º 39' 15" W	Central, Cameron / Tuba City, Monument Valley	Central, Monument Valley, Cameron / Tuba City - North	
Snowflake, AZ	34º 31' 19" N	110º 05' 03" W	Bidahochi		
St. Michaels, AZ	35º 39' 42" N	109º 05' 37" W	Chinle, Four Corners	Chinle	
Taylor, AZ	34º 26' 60" N	110º 06' 42" W	Bidahochi		
Teec Nos Pos, AZ	36º 55' 45" N	109º 04' 56" W	Chinle, Four Corners	Four Corners	
Tohatchi, NM	35º 51' 01" N	108º 45' 00" W	Chinle, Four Corners	Chinle	
Towaoc, CO	37º 12' 36" N	108º 43' 38" W	Four Corners		
Tsaile, AZ	36º 18' 13" N	109º 12' 53" W	Central, Chinle, Four Corners	Chinle	
Tuba City, AZ	36º 07' 30" N	111º 14' 33" W	Cameron / Tuba City	Cameron / Tuba City - South	
Williams, AZ	35º 15' 53" N	112º 10' 22" W	Cameron / Tuba City		
Window Rock, AZ	35º 40' 15" N	109º 03' 52" W	Chinle, Four Corners	Chinle	
Winslow, AZ	35º 01' 40" N	110º 42' 25" W	Bidahochi	Bidahochi	
Zuni Pueblo, NM	35º 04' 21" N	108º 50' 60" W	Chinle		
Albert R Lyman MS	37º 37' 60" N	109º 28' 34" W	Four Corners, Monument Valley		
SCHOOLS					
Arizona State College	35º 11' 30" N	111º 39' 18" W	Cameron / Tuba City		
Aztec Montessori Sch.	35º 31' 41" N	108º 44' 31" W	Chinle		
Battle Rock Sch.	37º 20' 12" N	108º 50' 20" W	Four Corners		
Blanding Sch.	37º 37' 16" N	109º 28' 48" W	Four Corners, Monument Valley		
Blue Gap Sch.	36º 10' 13" N	109º 56' 46" W	Bidahochi, Chinle, Central, Four Corners, Monument Valley	Chinle, Central	
Bluff Sch.	37º 17' 02" N	109º 33' 04" W	Central, Four Corners, Monument Valley		
Bonnie Brennan ES	35º 02' 27" N	110º 43' 30" W	Bidahochi	Bidahochi	
Calkins JHS	37º 20' 51" N	108º 34' 59" W	Four Corners		
Canyon del Muerta Sch.	36º 11' 20" N	109º 26' 10" W	Bidahochi, Chinle, Central, Four Corners, Monument Valley	Chinle, Central	Chinle
Canyon del Muerto Sch.	36º 11' 20" N	109º 26' 10" W	Bidahochi, Chinle, Central, Four Corners, Monument Valley	Chinle, Central	Chinle
Carrizo Mission Sch.	36º 54' 13" N	109º 06' 14" W	Chinle, Four Corners	Four Corners	
Cathedral HS	35º 31' 07" N	108º 44' 28" W	Chinle		
Central JHS	35º 31' 29" N	108º 44' 35" W	Chinle		
Chee Dodge ES	35º 31' 41" N	108º 44' 31" W	Chinle		
Chevelon Butte Sch.	34º 32' 09" N	110º 55' 05" W	Bidahochi		
Chi Chil Tah Jones Ranch Sch.	35º 09' 22" N	108º 52' 26" W	Chinle		
Chinie JHS	36º 28' 43" N	109º 06' 54" W	Chinle, Four Corners	Four Corners	
Chinle Elementary Boarding Sch.	36º 09' 05" N	109º 33' 25" W	Bidahochi, Chinle, Central, Four Corners, Monument Valley	Chinle, Central	
Chinle HS	36º 09' 21" N	109º 34' 52" W	Bidahochi, Chinle, Central, Four Corners, Monument Valley	Chinle, Central	
Chinle HS	36º 09' 31" N	109º 34' 44" W	Bidahochi, Chinle, Central, Four Corners, Monument Valley	Chinle, Central	
Chinle Public ES	36º 08' 56" N	109º 33' 07" W	Bidahochi, Chinle, Central, Four Corners, Monument Valley	Chinle, Central	
Church Rock ES	35º 31' 41" N	108º 44' 31" W	Chinle		
Chuska Boarding Sch.	35º 51' 32" N	108º 45' 40" W	Chinle, Four Corners	Chinle	
Chuska Sch.	35º 50' 55" N	108º 44' 42" W	Chinle, Four Corners	Chinle	
Coal Mine Mesa Sch.	35º 57' 34" N	110º 56' 20" W	Bidahochi, Cameron / Tuba City, Monument Valley	Cameron / Tuba City - South	
Coconino HS	35º 12' 58" N	111º 37' 23" W	Cameron / Tuba City		
College of Ganado	35º 42' 43" N	109º 32' 42" W	Bidahochi, Chinle, Central, Four Corners	Chinle	
Cottonwood Day Sch.	36º 04' 25" N	109º 53' 28" W	Bidahochi, Chinle, Central, Four Corners, Monument Valley	Chinle, Central	
Cove Sch.	36º 33' 32" N	109º 13' 05" W	Central, Chinle, Four Corners	Central, Four Corners	Lukachukai
David Skeet Elementary	35º 09' 22" N	108º 52' 16" W	Chinle		
Dilcon Sch.	35º 22' 12" N	110º 19' 48" W	Bidahochi, Central	Bidahochi	
Dilkon Indian Mission	35º 20' 09" N	110º 20' 02" W	Bidahochi, Central	Bidahochi	
Dowa Yalanne Sch.	35º 03' 48" N	108º 50' 53" W	Chinle		
Downey Sch.	37º 21' 11" N	108º 35' 13" W	Four Corners		
East Flagstaff JHS	35º 13' 07" N	111º 36' 50" W	Cameron / Tuba City		
East Lakeview Sch.	37º 24' 28" N	108º 27' 29" W	Four Corners		
Educational Development Cntr.	35º 31' 41" N	108º 44' 31" W	Chinle		
Emerson Sch.	35º 12' 01" N	111º 39' 07" W	Cameron / Tuba City		
Flagstaff HS	35º 12' 16" N	111º 39' 00" W	Cameron / Tuba City		
Flagstaff JHS	35º 12' 15" N	111º 39' 14" W	Cameron / Tuba City		
Fort Defiance ES	35º 44' 24" N	109º 04' 05" W	Chinle, Four Corners	Chinle	
Fort Defiance JHS	35º 44' 22" N	109º 03' 58" W	Chinle, Four Corners	Chinle	
Free Trinity Sch.	35º 34' 20" N	108º 45' 54" W	Chinle		
Gallup Christian Sch.	35º 31' 41" N	108º 44' 42" W	Chinle		
Gallup HS	35º 31' 02" N	108º 42' 29" W	Chinle		
Gallup MS	35º 31' 02" N	108º 42' 29" W	Chinle		
Ganado ES	35º 42' 38" N	109º 32' 13" W	Bidahochi, Chinle, Central, Four Corners	Chinle	
Ganado HS	35º 42' 44" N	109º 31' 55" W	Bidahochi, Chinle, Central, Four Corners	Chinle	
Ganado JHS	35º 42' 37" N	109º 31' 52" W	Bidahochi, Chinle, Central, Four Corners	Chinle	
Grand Canyon ES	36º 03' 08" N	112º 08' 10" W	Cameron / Tuba City	Cameron / Tuba City - South	
Grand Canyon HS	36º 03' 08" N	112º 08' 17" W	Cameron / Tuba City	Cameron / Tuba City - South	

SCHOOLS					
Feature Name	**Latitude**	**Longitude**	**Overview Map Name**	**Survey Area Map Name**	**Flight Area Name**
Hatch Trailer Sch.	37º 23' 28" N	109º 13' 37" W	Four Corners		
Headstart Sch.	35º 17' 38" N	111º 00' 18" W	Bidahochi, Cameron / Tuba City		
Headstart Sch.	36º 34' 14" N	109º 12' 47" W	Central, Chinle, Four Corners	Four Corners	Lukachukai
Holbrook HS	34º 54' 18" N	110º 09' 43" W	Bidahochi		
Holbrook JHS	34º 54' 22" N	110º 09' 50" W	Bidahochi		
Hopi Mission Sch.	35º 52' 49" N	110º 36' 25" W	Bidahochi, Cameron / Tuba City, Central, Monument Valley		
Hotevilla Sch.	35º 55' 18" N	110º 39' 58" W	Bidahochi, Cameron / Tuba City, Central, Monument Valley	Cameron / Tuba City - South	
Hulet ES	34º 54' 20" N	110º 09' 50" W	Bidahochi		
Hunters Point Boarding Sch.	35º 35' 36" N	109º 06' 11" W	Chinle		
Indian Hills ES	35º 31' 41" N	108º 44' 31" W	Chinle		
Indian Mission Boarding Sch.	34º 58' 20" N	110º 03' 50" W	Bidahochi		
Jefferson ES	35º 01' 60" N	110º 41' 35" W	Bidahochi	Bidahochi	
Jefferson Sch.	35º 31' 38" N	108º 42' 54" W	Chinle		
John F Kennedy MS	35º 31' 41" N	108º 44' 31" W	Chinle		
John Q Thomas ES	35º 13' 07" N	111º 35' 56" W	Cameron / Tuba City		
Jones Ranch Sch.	35º 16' 35" N	108º 58' 48" W	Chinle		
Joseph City ES	34º 57' 53" N	110º 19' 52" W	Bidahochi		
Joseph City HS	34º 57' 55" N	110º 19' 52" W	Bidahochi		
Juan De Onate ES	35º 31' 41" N	108º 44' 31" W	Chinle		
Kaibito Boarding Sch.	36º 34' 53" N	111º 05' 31" W	Cameron / Tuba City	Cameron / Tuba City – North	
Kayenta Boarding Sch.	36º 43' 41" N	110º 15' 11" W	Central, Monument Valley	Monument Valley	
Kayenta ES	36º 43' 50" N	110º 15' 25" W	Central, Monument Valley	Monument Valley	
Kayenta PS	36º 43' 29" N	110º 15' 14" W	Central, Monument Valley	Monument Valley	
Keams Canyon Boarding Sch.	35º 48' 37" N	110º 11' 24" W	Bidahochi, Central		
Keams Canyon Day Sch.	35º 48' 35" N	110º 11' 20" W	Bidahochi, Central		
Kemper Sch.	37º 21' 05" N	108º 34' 34" W	Four Corners		
Kinlichee Sch.	35º 44' 38" N	109º 26' 24" W	Bidahochi, Chinle, Central, Four Corners	Chinle	
Kinsey Sch.	35º 10' 50" N	111º 38' 53" W	Cameron / Tuba City		
Lakeview Sch.	37º 23' 12" N	108º 31' 34" W	Four Corners		
Leupp Boarding Sch.	35º 17' 54" N	111º 00' 32" W	Bidahochi, Cameron / Tuba City		
Leupp Sch.	35º 17' 42" N	111º 00' 29" W	Bidahochi, Cameron / Tuba City		
Lewis-Arriola Sch.	37º 28' 16" N	108º 39' 22" W	Four Corners		
Lincoln ES	35º 31' 41" N	108º 44' 31" W	Chinle		
Lincoln ES	35º 01' 41" N	110º 41' 46" W	Bidahochi	Bidahochi	
Lincoln Sch.	35º 31' 18" N	108º 44' 53" W	Chinle		
Lukachukai Boarding Sch.	36º 24' 59" N	109º 13' 44" W	Central, Chinle, Four Corners	Central, Four Corners	
Manaugh Sch.	37º 20' 39" N	108º 34' 48" W	Four Corners		
Many Farms Boarding Sch.	36º 21' 58" N	109º 37' 41" W	Central, Chinle, Four Corners, Monument Valley	Central, Four Corners	
Many Farms Child Development Cntr.	36º 21' 15" N	109º 37' 16" W	Central, Chinle, Four Corners, Monument Valley	Central, Four Corners	
Many Farms ES	36º 21' 57" N	109º 37' 41" W	Central, Chinle, Four Corners, Monument Valley	Central, Four Corners	
Many Farms HS	36º 22' 22" N	109º 37' 30" W	Central, Chinle, Four Corners, Monument Valley	Central, Four Corners	
Many Farms Public Sch.	36º 20' 54" N	109º 37' 05" W	Central, Chinle, Four Corners, Monument Valley	Central, Four Corners	
Marshall Sch.	35º 12' 27" N	111º 39' 04" W	Cameron / Tuba City		
Mennonite Mission	35º 29' 05" N	109º 52' 30" W	Bidahochi, Chinle, Central	Bidahochi	
Mesa ES	36º 47' 10" N	108º 40' 48" W	Chinle, Four Corners	Four Corners	
Mesa Sch.	37º 20' 17" N	108º 35' 38" W	Four Corners		
Mexican Hat Sch.	37º 07' 42" N	109º 53' 06" W	Central, Four Corners, Monument Valley	Monument Valley	Mexican Hat
Mildred Sch.	37º 24' 48" N	108º 34' 55" W	Four Corners		
Moenkopi ES	36º 06' 36" N	111º 13' 12" W	Cameron / Tuba City	Cameron / Tuba City – South	
Montezuma Creek Sch.	37º 15' 37" N	109º 18' 14" W	Central, Four Corners		
Monument Valley HS	36º 43' 42" N	110º 14' 38" W	Central, Monument Valley	Monument Valley	
Mount Elden Sch.	35º 12' 39" N	111º 36' 54" W	Cameron / Tuba City		
Naschitti ES	36º 08' 36" N	108º 42' 25" W	Chinle, Four Corners	Chinle	
Natanni Nez ES	36º 47' 10" N	108º 40' 48" W	Chinle, Four Corners	Four Corners	
National Park Service Training Cntr.	36º 02' 59" N	112º 07' 55" W	Cameron / Tuba City	Cameron / Tuba City – South	
Nativity Sch.	35º 12' 05" N	111º 38' 53" W	Cameron / Tuba City		
Navajo Bible Sch.	35º 39' 25" N	109º 02' 10" W	Chinle, Four Corners	Chinle	
Navajo Comm. College	36º 47' 08" N	108º 41' 10" W	Chinle, Four Corners	Four Corners	
Navajo Comm. College	36º 17' 36" N	109º 12' 58" W	Central, Chinle, Four Corners	Chinle	
Navajo Comm. College	36º 22' 16" N	109º 37' 34" W	Central, Chinle, Four Corners, Monument Valley	Central, Four Corners	
Navajo ES	35º 53' 60" N	109º 01' 59" W	Chinle, Four Corners	Chinle	
Navajo Mission Sch.	34º 53' 06" N	110º 11' 35" W	Bidahochi		
Navajo Mountain Sch.	37º 01' 08" N	110º 47' 38" W	Cameron / Tuba City, Monument Valley	Monument Valley	
Neil V Christensen ES	35º 13' 33" N	111º 35' 02" W	Cameron / Tuba City		
Nenahnezad Indian Sch.	36º 43' 54" N	108º 24' 25" W	Four Corners		
Newcomb ES	36º 17' 05" N	108º 42' 18" W	Chinle, Four Corners	Chinle	
Newcomb HS	36º 17' 05" N	108º 42' 18" W	Chinle, Four Corners	Chinle	
Newcomb JHS	36º 17' 05" N	108º 42' 18" W	Chinle, Four Corners	Chinle	
Nizhoni ES	36º 47' 10" N	108º 40' 48" W	Chinle, Four Corners	Four Corners	
Northern Arizona Univ.	35º 11' 24" N	111º 39' 29" W	Cameron / Tuba City		
Old Kaibito Boarding Sch.	36º 35' 50" N	111º 04' 26" W	Cameron / Tuba City	Cameron / Tuba City – North	
Old Second Mesa Sch. (historical)	35º 47' 58" N	110º 31' 12" W	Bidahochi, Central		
Oraibi Day Sch.	35º 52' 35" N	110º 36' 50" W	Bidahochi, Cameron / Tuba City, Central, Monument Valley		
Our Lady of Guadalupe Sch.	35º 11' 43" N	111º 39' 29" W	Cameron / Tuba City		
Page ES	36º 54' 45" N	111º 27' 29" W	Cameron / Tuba City		
Page HS	36º 54' 47" N	111º 27' 29" W	Cameron / Tuba City		
Park ES	34º 54' 18" N	110º 09' 00" W	Bidahochi		
Pinon Boarding Sch.	36º 06' 05" N	110º 13' 23" W	Bidahochi, Central, Monument Valley	Central	

APPENDIX C (continued)

GAZETTEER

SCHOOLS					
Feature Name	Latitude	Longitude	Overview Map Name	Survey Area Map Name	Flight Area Name
Pittman ES	34º 54' 20" N	110º 10' 01" W	Bidahochi		
Polacca Day Sch.	35º 49' 50" N	110º 23' 17" W	Bidahochi, Central		
Puerco ES	35º 13' 05" N	109º 19' 55" W	Chinle		
Red Mesa Day Sch.	36º 57' 39" N	109º 21' 43" W	Central, Chinle, Four Corners	Four Corners	
Red Rock Boarding Sch.	36º 35' 54" N	109º 03' 29" W	Chinle, Four Corners	Four Corners	
Red Rock ES	35º 31' 41" N	108º 44' 31" W	Chinle		
Red Rock Sch.	36º 35' 53" N	109º 03' 29" W	Chinle, Four Corners	Four Corners	
Rehoboth Christian ES	35º 31' 44" N	108º 39' 14" W	Chinle		
Rehoboth Christian HS	35º 31' 44" N	108º 39' 14" W	Chinle		
Roat Sch.	35º 30' 54" N	108º 46' 08" W	Chinle		
Rock Point Boarding Sch.	36º 43' 01" N	109º 37' 12" W	Central, Chinle, Four Corners, Monument Valley	Monument Valley, Four Corners	
Rocky Ridge Sch.	36º 04' 19" N	110º 35' 35" W	Bidahochi, Central, Monument Valley	Central	
Roosevelt ES	35º 31' 41" N	108º 44' 31" W	Chinle		
Roosevelt ES	35º 01' 00" N	110º 41' 49" W	Bidahochi	Bidahochi	
Roosevelt Sch.	35º 31' 26" N	108º 44' 02" W	Chinle		
Rough Rock Demonstration Sch.	36º 24' 27" N	109º 51' 36" W	Central, Chinle, Four Corners, Monument Valley	Central, Four Corners	
Round Rock Day Sch.	36º 30' 50" N	109º 28' 23" W	Central, Chinle, Four Corners, Monument Valley	Central, Four Corners	
Sacred Heart Academy	36º 45' 08" N	108º 27' 11" W	Four Corners	Four Corners	
Sacred Heart Cathedral ES and MS	35º 34' 20" N	108º 44' 53" W	Chinle		
Saint Anthony Mission Sch.	35º 04' 19" N	108º 51' 07" W	Chinle		
Saint Anthony Zuni Indian Sch.	35º 04' 10" N	108º 50' 53" W	Chinle		
Saint Francis of Assisi Sch.	35º 34' 20" N	108º 44' 53" W	Chinle		
Saint Francis Sch.	35º 31' 54" N	108º 44' 38" W	Chinle		
Saint Isabel Mission	36º 25' 06" N	109º 13' 52" W	Central, Chinle, Four Corners	Central, Four Corners	
Saint Josephs Catholic Sch.	35º 02' 07" N	110º 41' 46" W	Bidahochi	Bidahochi	
Saint Michaels Indian Sch.	35º 38' 45" N	109º 05' 46" W	Chinle, Four Corners		
San Juan HS	37º 37' 47" N	109º 28' 34" W	Four Corners, Monument Valley		
Seba Dalkai	35º 29' 59" N	110º 26' 53" W	Bidahochi, Central	Bidahochi	
Sechrist Sch.	35º 13' 22" N	111º 39' 11" W	Cameron / Tuba City		
Second Mesa Day Sch.	35º 47' 35" N	110º 30' 22" W	Bidahochi, Central		
Sheldon ES	34º 54' 09" N	110º 09' 36" W	Bidahochi		
Shiprock Alternative Kindergarten Sch.	36º 47' 10" N	108º 40' 48" W	Chinle, Four Corners	Four Corners	
Shiprock Alternative Sch.	36º 47' 10" N	108º 40' 48" W	Chinle, Four Corners	Four Corners	
Shiprock HS	36º 47' 10" N	108º 40' 48" W	Chinle, Four Corners	Four Corners	
Shonto Boarding Sch.	36º 35' 54" N	110º 39' 14" W	Central, Cameron / Tuba City, Monument Valley	Monument Valley, Cameron / Tuba City, Central	
Sitgreaves Sch.	34º 23' 21" N	110º 33' 07" W	Bidahochi		
Sitgreaves Sch.	34º 25' 38" N	110º 35' 46" W	Bidahochi		
Sky City Sch.	35º 32' 18" N	108º 44' 24" W	Chinle		
Snowflake ES	34º 30' 26" N	110º 04' 52" W	Bidahochi		
Snowflake JHS	34º 29' 26" N	110º 04' 55" W	Bidahochi		
Snowflake Taylor ES	34º 27' 50" N	110º 05' 06" W	Bidahochi		
South Beaver Sch.	35º 11' 30" N	111º 39' 04" W	Cameron / Tuba City		
Stagecoach ES	35º 31' 41" N	108º 44' 31" W	Chinle		
Sunnyside Sch.	35º 31' 58" N	108º 44' 13" W	Chinle		
Teec Nos Pos Boarding Sch.	36º 54' 17" N	109º 06' 14" W	Chinle, Four Corners	Four Corners	
Tegakwithan Mission	35º 16' 38" N	109º 12' 58" W	Chinle		
Todahaidekani PS	37º 09' 30" N	109º 34' 01" W	Central, Four Corners, Monument Valley	Monument Valley	
Tohatchi ES	35º 51' 32" N	108º 45' 40" W	Chinle, Four Corners	Chinle	
Tohatchi HS	35º 51' 32" N	108º 45' 40" W	Chinle, Four Corners	Chinle	
Tohatchi MS	35º 51' 32" N	108º 45' 40" W	Chinle, Four Corners	Chinle	
Tohatchi Special Education and Training Cntr.	35º 51' 32" N	108º 45' 40" W	Chinle, Four Corners	Chinle	
Tolani Lake Day Sch.	35º 26' 02" N	110º 50' 31" W	Bidahochi, Cameron / Tuba City	Bidahochi	
Toyei Sch.	35º 42' 15" N	109º 56' 13" W	Bidahochi, Chinle, Central, Four Corners	Chinle	
Tribal Headstart PS	35º 48' 18" N	110º 29' 53" W	Bidahochi, Central		
Tsaile ES	36º 18' 07" N	109º 12' 40" W	Central, Chinle, Four Corners	Chinle	
Tse' Bit' ai MS	36º 47' 10" N	108º 40' 48" W	Chinle, Four Corners	Four Corners	
Tse Bonita Sch.	35º 37' 42" N	108º 57' 18" W	Chinle		
Tuba City ES	36º 08' 23" N	111º 14' 24" W	Cameron / Tuba City	Cameron / Tuba City - South	
Tuba City HS	36º 08' 21" N	111º 14' 10" W	Cameron / Tuba City	Cameron / Tuba City - South	
Tuba City JHS	36º 08' 21" N	111º 14' 17" W	Cameron / Tuba City	Cameron / Tuba City - South	
Tuller PS	35º 39' 26" N	109º 05' 46" W	Chinle, Four Corners		
Twin Buttes HS	35º 32' 03" N	108º 38' 10" W	Chinle		
Twin Lakes ES	35º 31' 41" N	108º 44' 31" W	Chinle		
Union HS	34º 30' 23" N	110º 04' 55" W	Bidahochi		
Univ. of New Mexico Gallup Branch	35º 31' 41" N	108º 44' 31" W	Chinle		
Valley HS	35º 13' 18" N	109º 19' 48" W	Chinle		
Washington ES	35º 31' 41" N	108º 44' 31" W	Chinle		
Washington ES	35º 01' 42" N	110º 41' 53" W	Bidahochi	Bidahochi	
Washington Sch.	35º 31' 51" N	108º 45' 04" W	Chinle		
Weitzel Sch.	35º 13' 14" N	111º 36' 50" W	Cameron / Tuba City		
Whippoorwill Sch.	36º 01' 47" N	110º 04' 48" W	Bidahochi, Chinle, Central, Monument Valley	Central	
White Horse HS	37º 15' 59" N	109º 18' 40" W	Central, Four Corners		
Whitehorse HS	37º 15' 35" N	109º 18' 22" W	Central, Four Corners		
Wildcat Christian Academy	35º 31' 41" N	108º 44' 42" W	Chinle		
Williams Grade Sch.	35º 14' 50" N	112º 11' 10" W	Cameron / Tuba City		
Williams HS	35º 14' 42" N	112º 11' 31" W	Cameron / Tuba City		

APPENDIX C (continued)

GAZETTEER

Feature Name	Latitude	Longitude	Overview Map Name	Survey Area Map Name	Flight Area Name
SCHOOLS					
Williams JHS	35º 14' 55" N	112º 10' 59" W	Cameron / Tuba City		
Wilson Sch.	35º 31' 44" N	108º 43' 34" W	Chinle		
Window Rock ES	35º 41' 03" N	109º 03' 25" W	Chinle, Four Corners	Chinle	
Window Rock HS	35º 44' 21" N	109º 03' 50" W	Chinle, Four Corners	Chinle	
Wingate ES	35º 28' 04" N	108º 32' 28" W	Chinle		
Wingate HS	35º 28' 43" N	108º 32' 46" W	Chinle		
Winslow HS	35º 01' 38" N	110º 41' 31" W	Bidahochi	Bidahochi	
Winslow Job Corps CCC	35º 04' 54" N	110º 49' 52" W	Bidahochi	Bidahochi	
Winslow JHS	35º 01' 50" N	110º 41' 24" W	Bidahochi	Bidahochi	
Yahta Indian Sch.	34º 54' 19" N	110º 09' 43" W	Bidahochi		
Zuni Christian Reformed Mission Sch.	35º 04' 10" N	108º 50' 53" W	Chinle		
Zuni HS	35º 32' 03" N	108º 38' 10" W	Chinle		
Zuni MS	35º 32' 03" N	108º 38' 10" W	Chinle		
CHURCHES					
Ba'hai Comm. Of Gallup Church	35º 31' 41" N	108º 44' 31" W	Chinle		
Beclabito Chapel	36º 47' 08" N	108º 41' 10" W	Chinle, Four Corners	Four Corners	
Bethany Christian Reformed Church	35º 31' 41" N	108º 44' 31" W	Chinle		
Bethlehem Church	35º 39' 13" N	108º 44' 38" W	Chinle, Four Corners	Chinle	
Black Falls Bible Church	35º 34' 34" N	111º 05' 49" W	Cameron / Tuba City	Cameron / Tuba City - South	
Black Mountain Mission	36º 07' 44" N	109º 52' 41" W	Bidahochi, Chinle, Central, Four Corners	Chinle, Central	
Blue Gap/Four Corners United Methodist Church	36º 47' 08" N	108º 41' 10" W	Chinle, Four Corners	Four Corners	
Calvary Southern Baptist Church	35º 31' 41" N	108º 44' 31" W	Chinle		
Casa San Martin	35º 31' 41" N	108º 44' 31" W	Chinle		
Cathederal of the Sacred Heart	35º 31' 41" N	108º 44' 31" W	Chinle		
Catholic Diocese of Gallup Church	35º 31' 41" N	108º 44' 31" W	Chinle		
Catholic Indian Center	35º 31' 41" N	108º 44' 31" W	Chinle		
Church of the Holy Spirit	35º 31' 41" N	108º 44' 31" W	Chinle		
Emanuel Baptist Temple and Christian Academy	35º 31' 41" N	108º 44' 31" W	Chinle		
Emmanuel Church	37º 32' 41" N	108º 44' 10" W	Four Corners		
First Assembly of God Church	35º 31' 41" N	108º 44' 31" W	Chinle		
First Baptist Church	37º 37' 24" N	109º 28' 55" W	Four Corners, Monument Valley		
First Baptist Church	36º 47' 08" N	108º 41' 10" W	Chinle, Four Corners	Four Corners	
First Baptist Church	35º 31' 41" N	108º 44' 31" W	Chinle		
First Baptist Church Fellowship Center	35º 31' 41" N	108º 44' 31" W	Chinle		
First Indian Baptist Church	35º 31' 41" N	108º 44' 31" W	Chinle		
First United Methodist Church	35º 31' 41" N	108º 44' 31" W	Chinle		
Francis Xavier Church	37º 13' 07" N	108º 40' 26" W	Four Corners		
Full Gospel Assemmbly of God Church	35º 30' 51" N	108º 50' 42" W	Chinle		
Gallup Baptist Church	35º 31' 41" N	108º 44' 31" W	Chinle		
Gallup Christian Center	35º 31' 41" N	108º 44' 31" W	Chinle		
Gallup Church of Christ	35º 31' 41" N	108º 44' 31" W	Chinle		
Gamerco Church of God	35º 34' 20" N	108º 45' 54" W	Chinle		
Good News Mission	35º 17' 01" N	109º 14' 53" W	Chinle		
Good News Parish	35º 31' 41" N	108º 44' 31" W	Chinle		
Good Shepherd Mission	35º 44' 36" N	109º 04' 08" W	Chinle, Four Corners	Chinle	
Hogan Church	36º 59' 58" N	110º 16' 34" W	Central, Monument Valley	Monument Valley	Oljato
Indian Assembly of God Church	35º 31' 41" N	108º 44' 31" W	Chinle		
LDS Blanding Wards 1 5 8	37º 37' 28" N	109º 28' 41" W	Four Corners, Monument Valley		
LDS Blanding Wards 2 3 7	37º 38' 14" N	109º 28' 44" W	Four Corners, Monument Valley		
LDS Blanding Wards 4 6	37º 37' 43" N	109º 28' 23" W	Four Corners, Monument ValleyMonum		
LDS Bluff Ward	37º 17' 04" N	109º 33' 11" W	Central, Four Corners, Monument Valley		
LDS Mexican Hat Ward	37º 07' 32" N	109º 53' 10" W	Central, Four Corners, Monument Valley	Monument Valley	Mexican Hat
LDS Montezuma Creek Ward	37º 15' 40" N	109º 18' 29" W	Central, Four Corners		
LDS Ticaboo Ward	37º 41' 44" N	110º 40' 26" W	Monument Valley		
Mesa View Assembly Church	36º 47' 08" N	108º 41' 10" W	Chinle, Four Corners	Four Corners	
Navajo Church	35º 21' 12" N	108º 43' 23" W	Chinle		
Navajo Lutheran Missions	36º 54' 18" N	109º 06' 14" W	Chinle, Four Corners	Four Corners	
Navajo Mission	35º 16' 40" N	108º 58' 08" W	Chinle		
Navajo Mission	35º 26' 54" N	108º 44' 46" W	Chinle		
Navajo Mission	35º 35' 29" N	109º 06' 07" W	Chinle		
Newcomb Assembly of God	36º 17' 05" N	108º 42' 18" W	Chinle, Four Corners	Chinle	
Pentecostal Church of God Navajo Mission	35º 31' 41" N	108º 44' 31" W	Chinle		
Pine Tree Mission	35º 15' 57" N	108º 45' 11" W	Chinle		
Pinedale Indian Assebly of God Church	35º 31' 44" N	108º 39' 14" W	Chinle		
Rock Spring Navajo Mission	35º 36' 35" N	108º 49' 44" W	Chinle		
Saint Ann Church	36º 16' 60" N	109º 10' 44" W	Chinle, Four Corners	Chinle	
Saint Anselm Mission	35º 17' 10" N	109º 09' 36" W	Chinle		
Saint Anthony Parish	35º 04' 10" N	108º 50' 53" W	Chinle		
Saint Christophers Mission	37º 17' 09" N	109º 30' 47" W	Central, Four Corners, Monument Valley		
Saint Eleanor Parish	35º 28' 04" N	108º 32' 28" W	Chinle		
Saint Francis of Assisi Church	35º 31' 41" N	108º 44' 31" W	Chinle		
Saint Jeromes Church	35º 31' 41" N	108º 44' 31" W	Chinle		
Saint John Vianney Parish	35º 31' 41" N	108º 44' 31" W	Chinle		

ABANDONED URANIUM MINES PROJECT ATLAS

APPENDIX C (cintinued)

GAZETTEER

Feature Name	Latitude	Longitude	Overview Map Name	Survey Area Map Name	Flight Area Name
CHURCHES					
Saint Mary Church	35º 51' 32" N	108º 45' 40" W	Chinle, Four Corners	Chinle	
Saint Michaels Mission	35º 39' 15" N	109º 06' 40" W	Chinle, Four Corners		
Saint Patrick Catholic Church	35º 16' 26" N	108º 45' 14" W	Chinle		
Saint Phillips Mission Indian Village	35º 32' 02" N	108º 35' 56" W	Chinle		
Saint Valerian Catholic Church	35º 31' 42" N	108º 44' 31" W	Chinle		
Saint William Church	35º 31' 41" N	108º 44' 31" W	Chinle		
Seventh Day Adventist Church	35º 31' 41" N	108º 44' 31" W	Chinle		
Shiprock United Methodist Church	36º 47' 08" N	108º 41' 10" W	Chinle, Four Corners	Four Corners	
Spanish Assembly of God Church	35º 31' 41" N	108º 44' 31" W	Chinle		
Spanish Baptist Church	35º 31' 41" N	108º 44' 31" W	Chinle		
The Chapel	37º 17' 11" N	108º 37' 23" W	Four Corners		
The Church of Jesus Christ of Latter Day Saints Fort Wi	35º 28' 04" N	108º 32' 28" W	Chinle		
The Church of Jesus Christ of Latter Day Saints Gallup	35º 31' 41" N	108º 44' 31" W	Chinle		
Toyee	35º 49' 11" N	108º 26' 53" W	Four Corners		
Trinity Lutheran Church	35º 31' 41" N	108º 44' 31" W	Chinle		
Twin Buttes Church of the Nazarene	35º 31' 41" N	108º 44' 31" W	Chinle		
United Pentecostal Church	35º 31' 41" N	108º 44' 31" W	Chinle		
West Mesa Assembly of God Church	35º 31' 41" N	108º 44' 31" W	Chinle		
Westminister United Presbyterian Church	35º 31' 41" N	108º 44' 31" W	Chinle		
Westminster Presbyterian Church	35º 31' 41" N	108º 44' 31" W	Chinle		
Zuni Mission Historic Site	35º 07' 10" N	108º 50' 53" W	Chinle		
HOSPITALS					
Chinle Extended Care Cntr.	36º 09' 35" N	109º 36' 22" W	Bidahochi, Chinle, Central, Monument Valley, Four Corners	Chinle, Central	
Department of Health Indian Hospital	35º 48' 47" N	110º 11' 31" W	Bidahochi, Central		
Flagstaff Comm. Hospital	35º 12' 32" N	111º 38' 42" W	Cameron / Tuba City		
Grand Canyon Hospital	36º 02' 49" N	112º 07' 37" W	Cameron / Tuba City	Cameron / Tuba City - South	
Monument Valley Adventist Hospital	37º 00' 35" N	110º 12' 29" W	Central, Monument Valley	Monument Valley	Oljato
Rehoboth McKinley Christian Hospital	35º 31' 44" N	108º 39' 14" W	Chinle		
Sage Memorial Hospital	35º 42' 37" N	109º 32' 35" W	Bidahochi, Chinle, Central, Four Corners	Chinle	
Shiprock Comm. Health Cntr.	36º 47' 08" N	108º 41' 10" W	Chinle, Four Corners	Four Corners	
Tuba City Hospital	36º 08' 10" N	111º 14' 17" W	Cameron / Tuba City	Cameron / Tuba City - South	
U.S. Forest Service Clinic	37º 31' 00" N	110º 42' 29" W	Monument Valley		
United States Indian Hospital	35º 30' 28" N	108º 43' 44" W	Chinle		
Williams Hospital	35º 14' 50" N	112º 11' 31" W	Cameron / Tuba City		
Zuni Cooperative Comm. Health Cntr.	35º 04' 10" N	108º 50' 53" W	Chinle		
PHYSIOGRAPHICAL FEATURES					
Black Mesa, AZ	36º 20' 00" N	110º 24' 00" W	Central Area, Monument Valley		
Carrizo Mountains, AZ	36º 48' 42" N	109º 10' 25" W	Central Area, Chinle, Four Corners		
Cedar Mesa, UT	37º 23' 05" N	109º 55' 46" W	Four Corners		
Chaco Mesa, NM	35º 47' 41" N	107º 29' 26" W			
Chaco River, NM	36º 46' 37" N	108º 39' 11" W	Chinle, Four Corners		
Chinle Valley, AZ	36º 48' 58" N	109º 42' 29" W	Central Area, Chinle, Four Corners, Monument Valley		
Chuska Mountains, AZ	36º 30' 00" N	109º 12' 00" W	Chinle, Four Corners		
Chuska Mountains, NM	36º 10' 00" N	108º 55' 00" W	Chinle, Four Corners		
Coconino Plateau, AZ	35º 50' 00" N	112º 30' 05" W	Cameron/Tuba City		
Colorado River, AZ	38º 51' 36" N	111º 36' 36" W	Cameron/Tuba City		
Comb Ridge, AZ	36º 49' 08" N	110º 03' 23" W	Central Area, Chinle, Four Corners, Monument Valley		
Defiance Plateau, AZ	35º 50' 00" N	109º 14' 30" W	Central Area, Chinle, Four Corners		
El Malpais, NM	34º 53' 02" N	107º 59' 38" W			
First Mesa, AZ	35º 59' 20" N	110º 13' 07" W	Bidahochi, Central Area, Monument Valley		
Grand Canyon, AZ	36º 06' 46" N	113º 59' 43" W	Cameron/Tuba City		
Kaibab Plateau, AZ	36º 35' 00" N	112º 10' 00" W			
Kaibito Plateau, AZ	36º 26' 55" N	111º 17' 10" W	Cameron/Tuba City		
Kaiparowits Plateau, UT	37º 30' 00" N	111º 35' 00" W			
Lake Powell, UT	37º 03' 36" N	111º 18' 00" W			
Little Colorado River, AZ	36º 11' 28" N	111º 48' 11" W	Cameron/Tuba City		
Mesa Prieta, NM	35º 28' 48" N	107º 03' 00" W			
Meteor Crater, AZ	35º 01' 41" N	111º 01' 21" W			
Moenkopi Plateau, AZ	35º 57' 07" N	111º 04' 20" W	Cameron/Tuba City		
Monument Valley, UT	37º 08' 23" N	110º 12' 24" W	Central Area, Monument Valley		
Navajo Lake, NM	36º 40' 20" N	107º 03' 05" W			
Painted Desert, AZ	35º 30' 01" N	110º 05' 00" W	Bidahochi, Chinle		
Paria Plateau, AZ	36º 48' 56" N	111º 56' 27" W	Cameron/Tuba City		
San Francisco Peaks, AZ	35º 21' 11" N	111º 41' 37" W	Cameron/Tuba City		
San Juan Mountains, CO	37º 34' 26" N	106º 58' 52" W			
San Juan River, NM	36º 59' 59" N	109º 00' 04" W	Chinle, Four Corners		
San Mateo Mountains, NM	35º 11' 26" N	107º 39' 12" W			
Second Mesa, AZ	35º 53' 43" N	110º 30' 12" W	Bidahochi, Central Area, Monument Valley		
Sierra Naciemento, NM	35º 55' 48" N	106º 51' 36" W			
Straight Cliffs, UT	37º 21' 27" N	111º 11' 39" W			
Third Mesa, AZ	35º 56' 10" N	110º 38' 51" W	Bidahochi, Central Area, Monument Valley		
Tovar Mesa, AZ	35º 33' 45" N	110º 34' 15" W	Bidahochi, Central Area, Monument Valley		

PHYSIOGRAPHICAL FEATURES					
Feature Name	Latitude	Longitude	Overview Map Name	Survey Area Map Name	Flight Area Name
Vermillion Cliffs, UT	37º 03' 54" N	112º 18' 00" W			
Ward Terrace, AZ	35º 48' 47" N	111º 13' 29" W	Cameron/Tuba City		
White Cliffs, UT	37º 21' 23" N	112º 05' 32" W			
Zuni Mountains, NM	35º 10' 04" N	108º 18' 58" W			

ABANDONED URANIUM MINES PROJECT ATLAS

APPENDIX D

GLOSSARY

Activity	The intensity of radiation produced by a radioactive source.
Adit	A horizontal entrance to a mine.
Alpha-emitting	A substance which gives off helium nuclides during radioactive decay.
Aquifer	A region of rock, gravel, or sand below ground surface containing water in sufficient quantity to produce water in a well.
Background	Naturally occurring baseline condition; usually referring to regional levels or quantities of a substance.
Beta-emitting	A substance which gives off electrons during radioactive decay.
Cosmic ray	A very high energy form of radiation which originates in outer space.
Curie	A measure of the intensity of radiation produced by a radioactive source (abbreviated Ci).
Daughter product	Any nuclide which is the result of radioactive decay of a more massive nuclide (e.g., $Bismuth^{214}$ is a daughter product resulting from the radioactive decay of $Uranium^{238}$.
Debris pile	Waste rock consisting of overburden and lower grade ore left behind by mining operations.
Exposure	Contact with ionizing radiation or radioactive material. The contact is measured as the amount of radiation coming into contact with an individual and given in Roentgen (R)
Gamma radiation	A form of radiation that originates from radioactive materials such as uranium and cosmic rays.
Gross alpha	Total intensity of radiation from a source attributable to alpha-emitting radionuclides.
Gross beta	Total intensity of radiation from a source attributable to beta-emitting radionuclides.
Isotope	One of different forms of the same element, each having a different mass (e.g., $Uranium^{238}$ and $Uranium^{235}$).
Nuclide	Nucleus of an atom identified by the name and mass of the atom (e.g., $Radium^{226}$)
Pico	A prefix which means 10^{-12} (e.g., a picocurie is $1x10^{-12}$ Curie).
Preliminary Remediation Goals	Preliminary Remediation Goals published semi-annually by the USEPA Region 9 for use as risk-based guidance for compounds in soil.
Proto-ore	Low-grade ore.
Radioactivity	A property of certain kinds of chemical elements whose atomic nuclei are unstable: in time each such nucleus achieves stability by a process of internal change called radioactive decay, which involves a release of energy in a form known as radiation.
Radionuclides	Nuclei of atoms that are radioactive. They are identified by the name and mass of the atom (e.g., $Bismuth^{214}$ and $Uranium^{238}$).
Radon	An unreactive or inert, radioactive gas.
Roentgen Equivalent in Man	A roentgen equivalent in man (Rem) is a unit of absorbed radiation corrected for various factors such as the type of radiation. A dosage of radiation that will produce a biological effect approximately equal to that produced by one roentgen of gamma radiation.
Risk	The degree or probability that a material can cause cancer or other adverse health effects.
Risk-based guideline	Guideline for acceptable concentration of a material in soil or water based on the probability that the material will cause adverse health effects.
Roentgen	The basis unit of measure for radiation exposure equal to approximately $2.2x10^{-6}$ calories of radiation energy absorbed per gram of absorbing material.
Shaft	A vertical entrance to a mine.
Talus slope	A slope formed by an accumulation of loose rock fragments

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APPENDIX E

ACRONYMS

AEC	Atomic Energy Commission
AML	Abandoned Mine Lands
AMS	Aerial Measuring System
ATSDR	Agency for Toxic Substances and Disease Registry
BEI	Bechtel Environmental, Inc.
BI	Bismuth
BN	Bechtel Nevada
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Information System
CIC	Community Involvement Coordinator
CLP	Contract Laboratory Program
CQAB	Chemical Quality Assurance Branch
CQAR	Chemical Quality Assurance Report
CX	Center of Expertise
DRG	Digital Raster Graphic
EERF	Eastern Environmental Radiation Facility
ESI	Expanded Site Expansion
ESRI	Environmental Systems Research Institute
FSP	Field Sample Plan
GIS	Geographic Information System
GPS	Global Positioning System
HI	Hazard Index
HRS	Hazard Ranking System
HTRW	Hazardous, Toxic and Radioactive Waste
IA	Integrated Assessment
IAG	Interagency Agreement
ILCR	Incremental Lifetime Cancer Risk
KTM	King Tutt Mesa
MCL	Maximum Contaminant Level
MDA	Method Detection Activity
µG/L	micrograms per liter
mg/kg	milligrams per kilogram
mg/l	milligrams per liter
µR/hr	microRoentgen per hour
MRC	Metals Reserve Company
MSS	Multispectral scanner
NALC	North American Landscape Characterization

ABANDONED URANIUM MINES PROJECT ATLAS

APPENDIX E (continued)

ACRONYMS

NAREL	National Air and Radiation Environmental Laboratory
NASA	National Aeronautics and Space Administration
NCRP	National Council for Radiation Protection and Measurements
NNAMLRD	Navajo Nation Abandoned Mines Lands Reclamation Department
NNEPA	Navajo Nation Environmental Protection Agency
NNLPO	Navajo Nation Land Planning Office
NNPHS	Navajo Nation Public Health Services
NNWQD	Navajo Nation Water Quality Division
NPL	National Priorities List
NSP	Navajo Superfund Program
NTUA	Navajo Tribal Utility Authority
PA	Preliminary Assessment
PCi/g	picocuries per gram
PCi/l	picocuries per liter
PRG	Preliminary Remediation Goal
QA	Quality Assurance
QATR	Quality Assurance Test Results
QC	Quality Control
RAS	Routine Analytical Services
REDAR	Radiation and Environmental Data Acquisition and Recorder System
REM	Roentgen Equivalent in Man
RPM	Remedial Project Manager
RRL	Regional Reference Level
RRR	Regional Reference Range
SARA	Superfund Amendments and Reauthorization Act of 1986
SDWA	Safe Drinking Water Act
SI	Site Inspection
SMCRA	Surface Mining Control and Reclamation Act
TAL	Target Analyte List
TCL	Target Compound List
TLD	Thermo-luminescence Dosimeter
UEP	Uranium Education Program
USACE	United States Army Corps of Engineers
USAIRDC	U.S. Army Ionizing Dosimeter Center
USDOE	United States Department of Energy
USDOI	United States Department of Interior

APPENDIX E (continued)

ACRONYMS

USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WES	Waterways Experiment Station

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APPENDIX F

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