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.

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.

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.

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[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.