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A Description of Radiological Problems at Inactive Uranium Mill Sites and Formerly Utilized MED/AEC Sites

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NOTICE: This document contains information of a preliminary nature. It is subject to revision or correction and therefore does not represent a final report.

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A DESCRIPTION OF RADIOLOGICAL PROBLEMS AT INACTIVE URANIUM MILL SITES AND FORMERLY UTILIZED MED/AEC SITES

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ABSTRACT

During the early years of development of the nuclear program in the United States, more than a hundred sites were used by the Manhattan Engineer District (MED), the U. S. Atomic Energy Commission (AEC), and/or its uranium suppliers. Many of these sites are no longer used for such activities, but, in many cases, the real estate remains contaminated with radioactivity and can be a potential source of exposure to members of the general public. In addition, 22 inactive uranium mill tailings sites exist in the western part of the United States.

Radioactive contamination conditions range from slight contamination on the surfaces of buildings and equipment to extensive contamination of the subsoil. The Department of Energy is conducting a program to assure that adequate precautions are taken in the management of these properties to provide for the cost-effective protection of public health while permitting further use of land and other resources. Several issues which should be considered in the development of an effective policy for long-term management of such properties are identified.

INTRODUCTION

During the early years of development of the nuclear program in the United States, a number of sites were used by the Manhattan Engineer District (MED), the U. S. Atomic Energy Commission (USAEC), and/or its uranium suppliers to conduct operations. The sites were used for uranium milling, sampling and assay of uranium and thorium ores, separation and purification of uranium, uranium rolling, milling and fabrication, and research and development of processes needed in the MED/AEC programs. Most of these sites are no longer used for such activities, but, in many cases, the real estate remains contaminated with low levels of radioactive materials. Since many of these properties have been released for unrestricted use, they can be a potential source of exposure to members of the general public. The Department of Energy (DOE) has been conducting surveys to determine the radiological status of these sites. If remedial actions are warranted, based on these surveys, they will be undertaken to assure the protection of public health and environmental quality.

SITES CONSIDERED FOR CURRENT REMEDIAL ACTION

One type of site used for MED/AEC activities is a uranium mill. Uranium milling is the step in which uranium is separated from the ore and concentrated into an intermediate product, uranium oxide or "yellowcake," which is later converted to uranium hexafluoride and used for feed in enrichment plants. In the milling operation, ores are crushed, ground, and chemically leached to remove uranium. The average assay of uranium in ore is only about 0.2% so the solid residual (the tailings) which contains most ($\sim$ 75-85%) of the natural radioactivity in the ore is nearly equal in volume to the input ore. The major radiological concerns are

associated with radionuclides in the ^{238}U decay chain, principally ^{230}Th, ^{226}Ra, ^{222}Rn, and ^{222}Rn daughters.[1] These nuclides are ubiquitous, but the concentrations in the tailings are several orders of magnitude above average concentrations in the earth's crust. Thorium-230 has a half-life of $\sim$ 83,000 years and ^{226}Ra $\sim$ 1600 years; thus, the residual tailings represent a potential source of elevated radiation exposures for many years into the future. Radon-222 is a noble gas and is quite mobile in the environment and, with its daughters, presents an exposure problem which is particularly difficult to control.

By 1975 over 125 million tons of uranium mill tailings had been accumulated at 39 privately-owned mills in the western United States with most sites located in Colorado, Wyoming, and New Mexico.[2] The smallest tailings pile is the 37,000 tons at the North Continent Mill in Slick Rock, Colorado and the largest is at the New Rifle Mill in Rifle, Colorado, where 2,700,000 tons had been accumulated as of 1972.

Twenty-four privately-owned mills no longer recover uranium; twenty-three of these are completely closed down,[3] but several of the inactive sites are being considered for further extraction of uranium from the tailings. The Union Carbide Mill at Rifle, Colorado, is being used only for recovery of vanadium. The mills at Edgemont, South Dakota and at Riverton, Wyoming are still under license. About a fifth of all accumulated uranium mill tailings are at inactive mill sites and a quarter of this amount is located at the four sites on the Navajo Reservation (Monument Valley and Tuba City, Arizona; Shiprock, New Mexico; and Mexican Hat, Utah). The inactive sites and the accumulated quantities of tailings are listed in Table I. Many of the tailings piles are in

remote locations, but one is located in metropolitan Salt Lake City, and others are located in smaller communities.

Until recent years, these tailings were not perceived as hazardous by the public. In fact, they were used as stabilizing fill under concrete floors, as backfill around basement walls, and occasionally in cement and mortar in hundreds of residences, commercial buildings, and schools in Grand Junction, Colorado. In 1966, a general study of environmental radiation conducted in Grand Junction by the USAEC and the Colorado Department of Health discovered elevated levels of radon in buildings constructed over tailings.[4] The principal radiological impact was associated with the buildup of radon and its short-lived daughters in buildings. No evidence was found to suggest any significant exposure due to pathways other than radon diffusion and direct gamma radiation. This led to a further evaluation of the exposures in Grand Junction by the state health department, assisted by the U.S. Public Health Service (USPHS), the Environmental Protection Agency (EPA), and the USAEC. In July 1970, the Surgeon General of the USPHS, at the request of the Colorado Department of Health, provided a set of recommendations for remedial action guides based on average exposure rates;[5] these recommendations, later endorsed by the EPA, are discussed in a comparion document.[6]

In October 1971, the Subcommittee on Raw Materials of the Joint Committee on Atomic Energy conducted hearings on the use of uranium mill tailings for construction fill for private residences and public buildings, particularly in the area of Grand Junction, Colorado.[7] Public Law 92-314, which was passed by Congress in 1972 to provide

for a remedial action program in Grand Junction, incorporates the Surgeon General's guidelines.

The U.S. Public Health Service (USPHS) began collection and analysis of water and sediment samples from the Colorado River Basin for radioactive materials in 1950.[8] Early data showed elevated levels of radium downstream from operating uranium mills; consequently, extensive surveys of the levels of radioactivity in the Animas River were conducted by the USPHS during the summer of 1958 and the fall of 1959.[9,10] The Radium Monitoring Network, a surface water quality surveillance system consisting of water sampling stations throughout the Colorado River Basin, was established in 1961 under the provisions of the Federal Water Pollution Control Act. Data published for the period January 1961 through June 1972 by the EPA reveal that most mill operators have been successful in minimizing stream pollution.[11] Radium levels in streams have been well within drinking water standards throughout the period of sampling. Surface water in the vicinity of tailings has been monitored extensively, but much less information is available on groundwater contamination.[12] Some evidence of contamination of groundwater has been found in the vicinity of tailings piles in the Ambrosia Lake and Mexican Hat[13] areas of New Mexico.

Because the residual waste material in the milling cycle is nearly equal to the amount of ore processed, the tailings accumulation presents a land use problem as well as a potential health risk. Land used for storage of these wastes may be assumed to be committed forever. In addition, the economics of such practices should consider not only the land lost to direct storage, but also that land made marginally acceptable for other purposes because of proximity to the disposal site.

In addition to the inactive uranium mill sites, there are several other properties throughout the United States which had been used for various operations involving handling of radioactive materials under the Manhattan Engineer District (MED) and/or the AEC. The locations of some of these sites and of the inactive uranium mill sites are shown in Figure 1. DOE currently has a program to conduct radiological surveys at these sites and to develop complete documentation of the radiological status. Remedial actions are planned which will permit release of as many of the sites as possible for totally unrestricted use so that no continual or periodic surveillance will be required in future years.

Within the overall MED program, a variety of research and development activities were conducted in addition to commercial material handling operations. Domestic and imported uranium ores were stored for short periods, transported to sampling plants and then sent to mills and refineries for extraction of uranium. Considerable effort was given to the removal and accumulation of radium from all extraction processes involving pitchblende ores. Radium was precipitated along with other actinides and discarded in raffinate residue cakes in the processing of other ores. Thorium was also processed in a number of facilities. Much of the research and development activity for thorium was centered at the National Laboratories, but commercial firms were contracted to produce the needed raw and finished material.

Once material was extracted from ores, a mill concentrate was obtained. This material was then refined and converted to other uranium or thorium compounds or reduced to metal and shipped to other sites. Private commercial firms conducted a wide variety of activities, including

ore transport and storage; dissolution and leaching of ores; production of mill concentrate (yellowcake); refining of mill concentrate; conversion of refined product to other compounds and/or metal; smelting, rolling, extrusion, cutting, and packaging uranium and thorium metal products for distribution to other institutions such as the National Laboratories; and the recovery of uranium from scrap and salvaged material..

In the overall MED/AEC program, a variety of radioactive materials were handled in research and development programs. In most cases the major concerns are with the radionuclides in the uranium decay series. However, some sites are contaminated with radionuclides in the thorium decay series, mixed fission products, transuranics, or tritium.

A review of Nuclear Regulatory Commission records[14] has revealed a number of sites formerly licensed by the AEC to handle source material containing residual contamination,[15] which constitutes a potential source of exposure to members of the general public.

For many of the sites formerly utilized by the Manhattan Engineer District (MED) and the Atomic Energy Commission (AEC), available records before the resurvey were not adequate to identify the radiological condition at the time government controls were relinquished.[14] Records for some formerly licensed sites are similarly lacking in pertinent radiological information.[14] Both the DOE and the Nuclear Regulatory Commission have programs to determine the adequacy of documentation and to make new surveys if warranted. The DOE program is known as the Formerly Utilized Sites Remedial Action Program (FUSRAP).

A total of 43 radiological surveys have been deemed necessary for the FUSRAP sites. Several of the sites have been found to be either

adequately decontaminated (no radiation detected during visit), or the facilities have been demolished and removed. Surveys have been completed, and draft reports have been prepared for most of the sites needing to be surveyed. Table 2 lists the possible sources of contamination at the sites. Seven sites have been or are being surveyed by the current owners according to DOE survey specifications. Several of the sites will not meet the radiological requirements used today for uncontrolled release of property[16,17] and may require further decontamination. Some sites may require extensive remedial action, such as excavation and removal of large volumes of soil and partial or total removal of structures, while other sites will require only minor remedial measures to meet current requirements.

Seven of the sites being reviewed under this program are now under control of other Federal agencies: four are under military control and one each is under control of the Bureau of Radiological Health of the Federal Drug Administration, Tennessee Valley Authority (TVA), and the Department of the Interior.

The NRC has indicated that several sites either have or have had a license with NRC, the AEC, or with a state. Those having current licensed activities are conducting a different type of radiological work than was done under the former AEC contract. A list of sites is presented in Appendix I which was compiled from information supplied by USDOE.[18]

PATHWAYS AND MODES OF RADIATION EXPOSURE

Residual contamination of property and facilities represents a potential source of radiation exposure through a number of environmental pathways and exposure modes. Several radiological assessments have been

made which indicate that the most important pathways for human exposure from uranium mill sites[19-26] occur due to:

(1) Radon diffusion and inhalation,

(2) External gamma-ray exposures, and

(3) Resuspension of particulates followed by inhalation or ingestion.

(4) Dissolution by ground waters.

Other pathways of exposure at uranium mills have been considered (Table 3), but they are largely site dependent and their contributions to radiation dose are likely to be less. The relative importance of the various pathways may change with time after active management has ceased.

The above pathways of exposure will likely be the major ones of importance for the formerly used MED/AEC sites where radium is the principal contaminant. In humid climates, the migration of radium in the ground may be of increased significance. However, a variety of radionuclides may be present at the different sites requiring evaluations of the specific processes important for the various contamination conditions.

POLICY ISSUES OF IMPORTANCE

Public acceptance of nuclear power is strongly linked to the question of protection of public health and environmental quality. The health and environmental risks, real or perceived, must be dealt with in a straightforward manner, with emphasis on consistency in policies and facts presented for public scrutiny. An effective policy is needed to assure adequate protection of public health while permitting further use of the real estate. Several of the sub-issues which must be addressed in the development of such policies have been identified below.

What constitutes an acceptable level of cleanup for future unrestricted use of the property?

Criteria and guidelines for cleanup of contaminated property should have a number of characteristics in order to achieve a broad level of acceptability. A distinction needs to be made between criteria and guidelines. Criteria are word statements of desired outcomes, whereas numerical guidelines may specify levels of risk, exposure and/or contamination level in various environmental media. The criteria and guidelines should:

1. Provide for a limiting *level of risk* to public health and environmental quality that is broadly acceptable to the stakeholders involved.

The International Commission on Radiological Protection recommends that radiation doses be kept as low as reasonably achievable but, in any case, they should not exceed prescribed annual dose limits for individual members of the general public[27] and the National Council on Radiation Protection and Measurements has similar recommendations.[28] Attention also needs to be given to collective doses to population groups and to projected radiation doses to current and future members of the public throughout their lifetimes.

2. Be *consistent insofar as practicable with other standards, regulations and guidelines* which have already gained acceptability by regulatory and environmental protection authorities.

The so-called Surgeon General's Guidelines in 10 CFR 712 - Grand Junction Remedial Action Criteria, established numerical guidelines

for remedial action to limit radiation exposure to individuals in Grand Junction, Colorado, from the use of uranium mill tailings as construction fill or construction material.[5] These guidelines specifically address external gamma radiation levels and indoor radon daughter concentration levels.

The Atomic Energy Control Board of Canada has provided criteria to be used in the investigation and cleanup of homes and other buildings in communities where present or past association with the uranium industry resulted in radioactive contamination.[29]

3. Be *achievable and enforceable.*

The numerical guidelines should be expressed in rather simple terms to facilitate their enforcement and the levels specified should be measurable using available instruments and methods.

4. Take into account *natural background levels and its variability* both geographically and temporally.

Because the background levels of uranium and thorium vary widely in the earth's crust, the numerical guidelines should not require reduction of residual concentrations below normal background of the area. Some background levels of radiation, such as radon, vary with time and must be averaged over appropriate periods to provide truly representative background conditions.

5. Be *flexible* enough to allow good judgement to be exercised during remedial action.
6. Encourage the implementation of any further cost-effective, good management practices that will permit reduction of radiation doses to levels *as low as reasonably achievable.*

If cleanup for unrestricted use is not practicable, what management practices and restrictions on further use of the property are required?

In some cases it may not be practicable to conduct remedial actions to the extent that unrestricted use can be made of currently contaminated property. Also the radioactive materials which are removed must be stored on a restricted site. In these cases it is suggested that:

1. *Off-site contamination should be cleaned up and the material moved to a restricted site wherever practicable.*

In many situations, erosion by wind and water has caused movement of radioactively contaminated materials from the site originally contaminated, and some material has been transported from the site by people. The magnitude of radiation exposures associated with the off-site contamination depends on the level of contamination and the particular uses of the contaminated land. Cleanup of such contaminated land should conform with the numerical guidance for unrestricted site use.

2. *Provisions should be made for the long-term stabilization of areas contaminated above acceptable levels.*

Stabilization should be used to restrict rates of radon emanation, to reduce external gamma radiation, and to reduce removal by leaching and erosion by wind and water. Stabilization should be regarded as only a temporary and partial solution as periodic inspection and maintenance will be required.[19] To restrict radon emanation rates significantly a substantial covering of earth material (> 3 meters) would be needed.[19]

3. *Removal of contaminated materials by the general public should be prevented.*

Unacceptable radiation exposures have resulted from the use of uranium mill tailings as backfill and in construction materials. Future use of such materials should be prevented.

4. *Institutional arrangements should be implemented which are compatible with the long-term control of radium-contaminated real estate.*

There is no currently available method for permanently preventing radiation exposure from radium contaminated materials. Although institutional control cannot be guaranteed for the physical life of the critical radionuclides, some control must be exercised. The Department of Energy has a major responsibility for institutional control, but other federal agencies, such as the Nuclear Regulatory Commission and the Environmental Protection Agency, as well as state and local agencies should be represented in the decision-making and compliance processes.

What program of measurements, documentation, and control are needed to demonstrate compliance with cleanup criteria?

In order to demonstrate compliance with decommissioning criteria following decontamination a radiological monitoring program must be conducted. Also, for facilities that are not released for unrestricted use, a continuing surveillance and security program must be maintained by a responsible agency. Decommissioning criteria should include specifications of the measurement program.

The basic requirement is the characterization of radiation levels and residual radioactivity on a site from a limited number of data points. Even if measurements are made at essentially all points (for example, if surfaces are scanned with a Geiger-Muller (GM) meter), it is not possible to record and report measurements for every point; hence the surveyor must select the "most descriptive" measurements. To avoid biasing the data, a scheme should be devised whereby the surveyor selects points of measurement and reports results according to some fixed rules.[30] The monitoring program must be comprehensive enough to accommodate variability and yet remain simple enough to permit radiological assessment with a reasonable amount of effort.

A statistical evaluation of the data should be made to determine if average and worst-case conditions have been adequately defined.[30]

Where structures exist, radon daughter measurements should be made and annual averages estimated as prescribed in 10 CFR 712. Where structures do not exist, estimates of the contribution of residual radium to radon daughter levels in projected structures can be made by relating working levels to the measured profile of Ra-226 in the soil.

All data from monitoring should be documented and those data used to demonstrate compliance should be certified.

What will be the public health and environmental impacts of alternative methods available for cleanup?

The cleanup activities may involve the movement of substantial quantities of contaminated structural and earth materials, causing major impacts on local traffic for the duration of the cleanup.

Precautions may be needed to prevent inhalation of contaminated dust, both by workers involved in the remedial actions and by members of the nearby public. Even if the levels of radioactive contamination are low, the generation of dust may constitute a local nuisance. Removal of vegetation and surface soil will lead to increased surface erosion until vegetation is reestablished.

What protocol, information, and cost-benefit considerations are needed to develop management plans for specific properties?

Generally, the implementation of remedial actions on currently contaminated real estate appears to be a beneficial exercise. As noted above, however, there are some negative impacts that may persist at least for the duration of the remedial action program. In order to adequately address the sub-issues suggested in this report, a planning process appropriate for individual properties is needed. The planning process should balance the costs of remedial action against the ultimate benefits to be derived from improvement in the radiological status of the site and its release for further use. The process must allow decision makers to consider such trade-offs explicitly; the needs and viewpoints of interested stakeholders must be represented. There are several ways in which this may be accomplished, including one that has been suggested in our program.[31]

The ALARA concept cannot be defined by a single set of numerical guidelines for cleanup, but must take into consideration site specific factors affecting potential radiation exposures as well as costs and practicability of potential remedial actions.

What institutional arrangements are needed?

The Department of Energy has major responsibility for the management of the 22 inactive uranium mill sites and the approximately 30 excessed MED/AEC sites for which remedial action is likely. However, the Environmental Protection Agency, the Nuclear Regulatory Commission, and various state and local authorities also have responsibilities for protection of public health and environmental quality. The needs of each authority should be considered and the resultant policies and management plans should be consistent with these needs.

Each of the above sub-issues needs to be addressed during the development of a comprehensive policy. Congress and the various federal agencies are currently resolving the delegation of responsibility for sub-issues.

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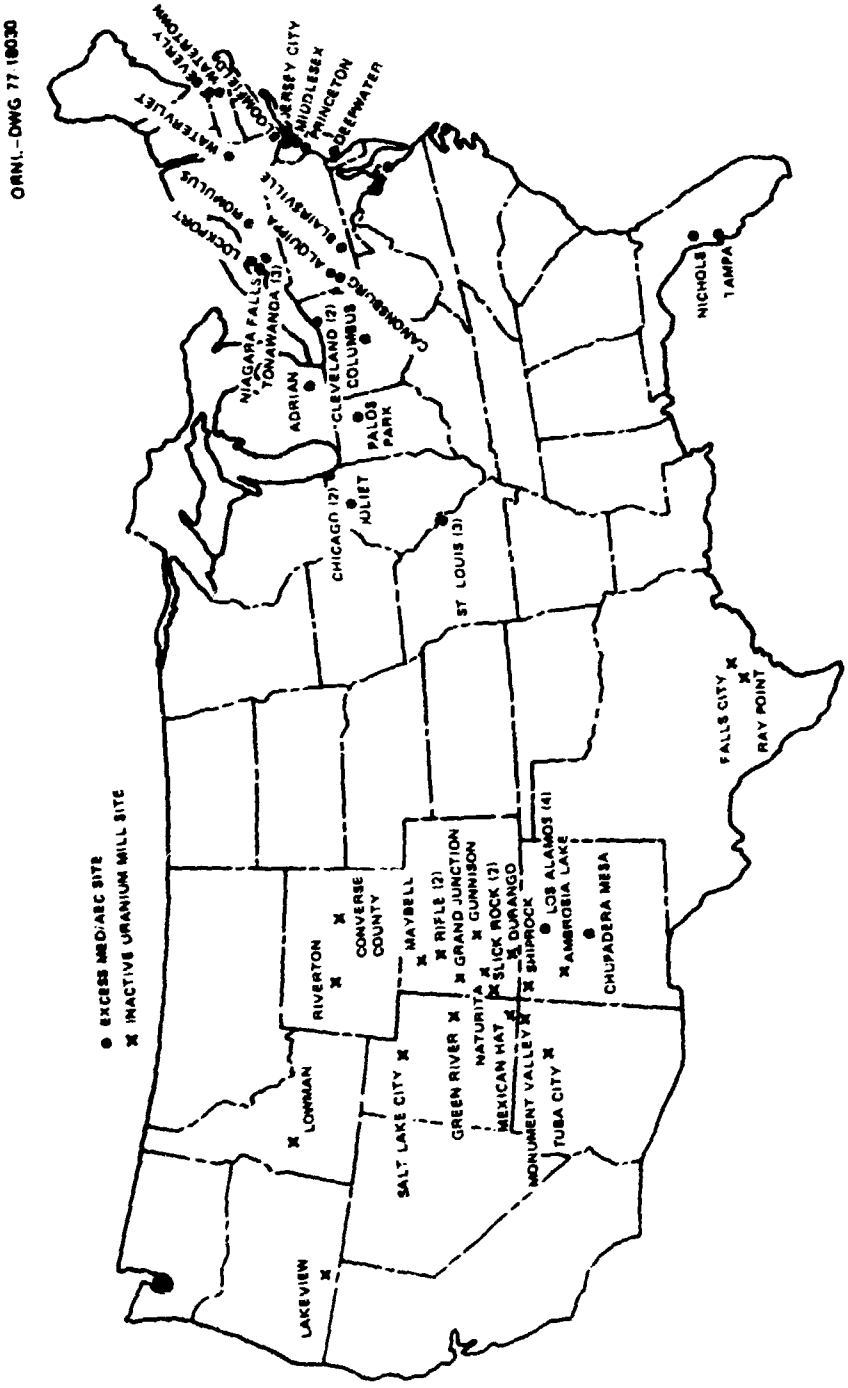

LOCATIONS OF URANIUM MILL TAILINGS AND EXCESS MED/AEC SITES REQUIRING RADIOLOGICAL SURVEY

Fig. 1

Table I
Tailings Accumulated at Inactive Uranium Mills[26]

	Years Operated	Tons of Tailings	Ra in Ci	Condition of Tailings	1970 Census Population within 10 Mile Radius
Arizona					
Monument	1955 - 1967	1,200,000	50	U	524
Tuba City	1956 - 1966	800,000	670	U	3,128
Colorado					
Durango	1943 - 1963	1,555,000	1,200	P	12,350
Grand Junction	1951 - 1970	1,900,000	1,350	S	43,500
Gunnison	1958 - 1962	540,000	200	S	4,968
Maybell	1957 - 1964	2,600,000	640	S	500
Naturita	1939 - 1963	704,000	490	S	7,859
New Rifle	1958 - 1972	2,700,000	2,130	P	3,142
Old Rifle	1924 - 1958	350,000	320	S	3,771
Slick Rock (NC)	1931 - 1943	37,000	30	S	378
Slick Rock (UCC)	1957 - 1961	350,000	70	S	378
Idaho					
Lowman	1955 - 1960	90,000	10	U	120
New Mexico					
Ambrosia Lake	1958 - 1963	2,600,000	1,520	U	20
Shiprock	1954 - 1968	1,500,000	950	P	12,221
Oregon					
Lakeview	1958 - 1960	130,000	50	U	4,136
Texas					
Falls City	1961 - 1973	2,500,000	1,020	P	1,977
Ray Point	1970 - 1973	490,000	230	P	3,527
Utah					
Green River	1958 - 1961	123,000	20	S	1,073
Mexican Hat	1957 - 1965	2,200,000	1,560	U	314
Monticello	1961	90,000	744	S	?
Salt Lake City	1951 - 1968	1,700,000	1,380	U	443,874
Wyoming					
Converse County	1962 - 1965	187,000	60	U	10
Riverton	1963	91,000	544	P	?
Totals		24,430,000	15,238		

Code for Condition of Tailings
S - Stabilized, but requires improvement
P - Partially stabilized
U - Unstabilized

Table 2. Possible Sources of Contamination at Formerly Used MED/AEC Sites

- Building surfaces
- Surface soil
- Subsoil
- Radon in structures
- Groundwater
- Drains, sewers, and tanks

Table 3. Principal Radionuclides Involved in Pathways from Tailings Piles to Man*

Pathway	Radionuclides	Pathway Processes	Exposure Hazard
Radon Diffusion	^{222}Rn	1. Diffusion to pile surface. 2. Atmospheric transport. 3. Inhalation.	Inhalation of ^{222}Rn decaying to ^{218}Po, ^{214}Pb, ^{214}Bi, ^{214}Pc in the body.
Airborne Activity	^{230}Th, ^{231}Pa	1. Resuspension from pile surface. 2. Atmospheric transport. 3. Inhalation. 4. Body surface contamination.	Inhalation of airborne activity carried by respirable particles.
Terrestrial	^{226}Ra, ^{210}Pb	1. Resuspension from pile surface. 2. Atmospheric transport. 3. Deposition on soil or foliage. 4. Uptake by plants. 5. Uptake by animals. 6. Consumption of contaminated plants, meat, and milk. 7. Consumption of contaminated soil.	Ingestion of ^{226}Ra, ^{210}Pb.
Aquatic	^{226}Ra, ^{210}Pb	1. Dissolution of radionuclide in pile. 2. Migration through soil to water. 3. Migration in water. 4. a. Uptake by aquatic organisms. b. Consumption of aquatic organism. 5. a. Use of water for irrigation. b. Uptake by plants c. Consumption of plants. 6. Consumption of contaminated drinking water. 7. Immersion in contaminated water.	Ingestion of ^{226}Ra; whole body gamma irradiation.
External Gamma	^{226}Ra daughters	1. Attenuation by pile material. 2. Air-distance attenuation. 3. External exposure	External exposure to gamma radiation produced by the decay of ^{226}Ra and its daughters.

*From Reference 19.

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APPENDIX I

As a result of DOE's effort to identify all sites formerly used by the MED or AEC and subsequently turned over for other uses, a total of 126 sites were determined to have played some role. Adequate documentation of radiological conditions was found for all but the 73 sites on the following list, reprinted from a list of sites taken from *DOE Information Bulletin* R78-226, Office of Public Affairs, Washington, D.C., June 29, 1978.

SITE	
Alabama	
Tennessee Valley Authority Uranium Recovery Pilot Plant and Laboratory	Site visited in 1977. No radioactivity detected above natural background. No survey required.
Arizona	
University of Arizona (formerly U.S. Bureau of Mines, Southwestern Experiment Station Buildings) Tucson	Site visited in 1978. No radioactivity detected above background. No survey required.
California	
A. D. Little Co. (formerly Merrill Co. Laboratory) 322 Battery Street San Francisco	Site visit in 1977 confirmed facility demolished and replaced by large commercial center. No further action required.
Dow Chemical Company Research Building Pittsburg	Site visited in 1977. No radioactivity detected above background. No survey required.
*University of California Gilman Hall Berkeley	Building surveyed in 1976. Traces of radioactivity identified. University has proposed controls on building maintenance and repair activities.
Colorado	
Colorado School of Mines Research Institute Golden	Sites visited in 1977. Radiation detected above background. Site operating under NRC license, monitored by School of Mines. No DOE survey planned.

Connecticut	
American Brass Co. Fabric Metal Goods Plant and West Tube Mill Waterbury	Determination made that the potential for measurable contamination at this site is insignificant and further DOE investigations are not warranted.
Bridgeport Brass Co. Seymour	Site visited in 1977. No radiation detected above background. No survey required.
Delaware	
Agricultural Department Union Texas Petroleum Division (formerly Allied Chemical and Dye Corp., General Chemical Division) North Claymont	Determination made that the potential for measurable contamination at this site is insignificant and further DOE investigations are not warranted.
Florida	
*Conserv, Inc. (formerly Virginia-Carolina Chemical Co., Uranium Recovery Pilot Plant) Nichols	Site visited in 1977. Radiological survey completed. Draft report in preparation.
*Gardinier, Inc. (formerly U.S. Phosphoric Plant Uranium Recovery Unit) Tampa	Site visited in 1977. Radiological survey completed. Draft report in preparation.
International Mineral & Chemical Co. Pilot Facility Mulberry	Site visited in 1977. No radioactivity detected above background. No survey required.
International Mineral & Chemical Co. Uranium Recovery Unit at Bonnie Chemical Plant Bartow	Site visited in 1977. No radioactivity detected above background. No survey required.
U. S. Steel Corporation (formerly Armour Fertilizer Co. Pilot Plant) Bartow	Site visited in 1977. No radioactivity detected above background. No survey required.
W. R. Grace Co. (formerly Davis Chemical Corp. Uranium Recovery Testing Facility) Bartow	Site visited in 1977. No radioactivity detected above background. No survey required.

Illinois	
Billings Hospital Small Animal Facility Chicago	Identification of former facility yet to be established. May have been demolished.
*Blockson Chemical Co. (formerly Olin Mathieson Uranium Recovery Unit) Joliet	Site visited in 1978. Radiological survey completed. Draft report in preparation.
Museum of Science & Industry East Pavilion Chicago	Site visited in 1977. Radiological survey completed in 1978. Draft report in preparation.
*National Guard Armory Chicago	Site visited in 1977. Radiological survey completed in 1978. Draft report in preparation.
RESCO Air Conditioning, Refrigeration & Heating Co. (formerly GSA Warehouse) Chicago	Site visited in 1977. Radiological survey completed in 1977. Draft report in preparation.
*Site A, Palos Park Cook County Forest Preserve Chicago	Radiological survey report (DOE/EV-0005/7) published April 1978. Low levels of tritium contamination found in well water. Tritium levels within EPA health and safety guidelines. Environmental monitoring to continue. DOE considering options and costs for remedial action.
*University of Chicago Echert Hall, Jones Laboratory, Kent Laboratory, and Ryerson Hall Chicago	Radiological survey completed in 1978. Draft report in preparation.
Indiana	
Joslyn Stainless Steel Co. (formerly Joslyn Manufacturing Uranium Metal Rolling Operation) Ft. Wayne	Site visited in 1975. No radioactivity detected above background. No survey required.
Iowa	
*Iowa State University Ames Laboratory Ames	Radiological survey completed in 1977. Draft report in preparation.

Maryland	
W. R. Grace Co. Baltimore	During visit to W. R. Grace Co.'s Florida plant, it was determined that no survey of this plant is required.
Massachusetts	
Massachusetts Institute of Technology Hood Building Cambridge	Site visited in 1976. Building previously demolished. No survey required.
U. S. Public Health Service Northeast Radiological Laboratory (formerly Winchester Engineering & Analytical Center, operated by National Lead Co.) Winchester	Site visited in 1977. Facility under control of U.S. Food & Drug Administration. No survey required.
Ventron, Inc. (formerly Metal Hydride, Inc.) Beverly	Site visit in 1977 determined that a survey is needed. Further discussions with Ventron management necessary.
Watertown Arsenal Watertown	Site visit in 1977 determined facility has been demolished. Survey conducted of area. Draft report in preparation.
Michigan	
General Motors Co. (formerly Bridgeport Brass Plant) Adrian	Site visit in 1977 identified some areas of contamination in building. General Motors conducted decontamination effort. Survey report in preparation.
Missouri	
*Mallinckrodt Chemical Co. Destraham St. and Broadway Avenue Plants St. Louis	Site visit in 1977 determined need for survey. Survey conducted in 1978 and draft report is in preparation.
*St. Louis Airport Storage Site near Brown Road St. Louis	Site survey conducted in 1976. Final report in preparation.

Nevada	
University of Nevada Mackey School of Mines Reno	Site visit in 1977 determined no survey required.
New Jersey	
*E. I. duPont Chamber Works Deepwater	Site survey conducted in 1977. Final report in preparation.
*Kellex Corporation Jersey City	Site survey conducted in 1977. Final report in preparation.
*Middlesex Municipal Landfill Site Middlesex	Site survey in 1974. Further survey and assessment done in 1978. Report in preparation.
Princeton University Palmer Physical Laboratory Princeton	Site surveyed in 1977. Princeton University conducted necessary decontamination. Report in preparation.
*U. S. Marine Sixth Motor Transport Battalion Reserve Training Center (formerly Middlesex Sampling Plant) Middlesex	Radiological survey report (DOE/EV-0005/1) published December 1977. Elevated radiation levels found in and around buildings on site. Radiation surveys, including aerial survey of area (May 1978) continuing. Fence set up around drainage ditch south of site. Engineering assessments underway to determine options and costs for remedial actions.
Vitro Corporation Vitro Laboratories West Orange	Site visit in 1977 confirmed no survey required.
Westinghouse, Inc. Building #7 Bloomfield	Site visited in 1977. Identified spotty locations of contamination. Westinghouse conducted necessary decontamination. Report in preparation.
New Mexico	
*Acid/Pueblo Canyon Los Alamos	Site surveyed in 1977. Draft report in preparation.

Bayo Canyon Area Los Alamos	Site surveyed in 1977. Draft report in preparation.
*Chupadera Mesa Area Central New Mexico	Draft report in preparation.
Los Alamos City Underground MED Pipelines (under Central Avenue, Canyon Road, and Hospital wing)	Most radioactive material was excavated during road building operations in spring 1977. No further survey required.

New York

AL-TECH Specialty Steel Co. (formerly Allegheny-Ludlum) Watervliet	Site visited in 1976. No radioactivity detected above background. No survey required.
*Ashland Oil Co. (formerly Haist Property, Tonawanda Storage Site) Tonawanda	Site surveyed in 1976. Radiological survey completed in 1977. Report in publication.
Bethlehem Steel Co. Lackawanna	Site visited in 1976. No radioactivity detected above background. No survey required.
Columbia University Pupin, Nash, Schemerhorn and Havemeyer Buildings New York City	Site visited in 1976. Current radiological work being conducted under New York City license. No survey required.
Electromet Corporation Union Carbide-Metals Division Albany	Site visited in 1976. No radioactivity detected above background. No survey required.
Hooker Chemical Co. Buildings 6, 7, 8, and 9 Niagara Falls	Radiological survey report (DOE/EV-0005/2) published May 1978. Radiation levels on building surfaces and in air and water found to be below NRC guidelines for unrestricted property use. No further remedial action needed.
*Linde Refinery Tonawanda	Site visited in 1976. Survey completed in 1977. Report in publication.
National Lead Co. Plant Nuclear Metals Division Albany	Site visited in 1977. Plant operating under NRC license. No survey required.

*Seaway Industrial Park Tonawanda	Site visited in 1976. Survey in 1977. Report in publication.
*Seneca Army Depot Romulus	Site survey conducted in 1976. Final report in preparation.
*Simonds Saw & Steel Co. Rolling Mill & Forging Shop Area	Site survey conducted in 1976. Draft report undergoing review.
Sylvania-Corning Metallurgical Laboratory Bayside, Long Island	Site visited in 1977. Confirmed no survey required.
Ohio	
Battelle Memorial Institute Columbus	Site survey in 1976. Battelle conducted necessary decontamination in 1977. Report in preparation.
Brush-Wehland Co. (formerly Brush-Berryllium, 4201 Perkins & 3714 Chestnut St. Cleveland	Site visited in 1977. No radioactivity detected above background. No survey required.
*Clecon Metals Inc. (formerly Horizons, Inc.) Cleveland	Survey conducted in 1977. Draft report under review.
Standard Oil Co. of Ohio Property (formerly E. I. duPont Co., Grazelli Plant Laboratory) Cleveland	Site visited in 1976. No radioactivity detected above background. No survey required.
*Harshaw Chemical Co., Plant C Cleveland	Limited site survey conducted in 1976. Further site survey being conducted in 1978.
Oregon	
*U. S. Bureau of Mines (formerly Metallurgy Research Center) Albany	Initial site survey conducted in January 1978. Full radiological survey conducted in June 1978.

Pennsylvania	
*Canonsburg Industrial Park (formerly Vitro Rare Metals Plant) Canonsburg	Interim radiological survey report (DOE/EV-0005/3) published April 1978. Elevated radon levels found in buildings on site. Aerial radiation survey of Canonsburg area conducted April 1978. Engineering assessments underway to determine options and costs of remedial actions.
*Penn Central Transportation Company property (formerly Pennsylvania Railroad landfill site) Blairsville, Burrell Township	Site surveyed in 1977. Draft report under review. Engineering assessment being conducted to determine options and costs of possible remedial actions.
Rohm & Haas 5000 Richmond Street Philadelphia	Site visit in 1977 confirmed no survey required.
Teledyne-Columbia-Summerville (formerly Columbia Steel Co.) Pittsburgh	Site erroneously identified. No nuclear contract work performed there. No further action required.
Universal Cyclops, Inc. (formerly Vulcan Crucible Steel Co. Rolling Mill) Aliquippa	Site surveyed in 1978. Draft report in preparation.
Westinghouse Atomic Power Development Plant Pittsburgh	Site visited in 1976. No radioactivity detected above background. No survey required.
Texas	
Borden Chemical Division of Borden, Inc. (formerly Texas City Chemical Co. Uranium Recovery Unit) Texas City	Site visited in 1977. Determined no survey required.
Olin Mathieson Pilot Plant Pasadena	Site visited in 1977. Determined no survey required.
Utah	
U. S. Bureau of Mines Metallurgy Research Center Salt Lake City	Site visited in 1977. Determined no survey required.

University of Utah Medical Research Center and Old Mines Building Salt Lake City	Site visited in 1977. Determined no survey required.

Virginia

Mobil Oil Corporation (formerly Virginia-Carolina Chemical Co. Laboratories) Richmond	Discussions with Mobil representatives concluded that work involved insignificant quantities of uranium. No survey required.

*Sites which DOE believes may require additional remedial action have been identified by an asterisk (*).