NM.4-2

CHUPADERA MESA AND NEAR-BY AREAS
SUMMARY REVIEW TO SUPPORT THE
DOE DESIGNATION/ELIMINATION DECISION

NOVEMBER 1985

CONTENTS

INTRODUCTION

This report is a summary of investigations conducted by the Department of Energy (DOE) and its predecessors to characterize the fallout zone near the Trinity atomic bomb test site. The report briefly describes the area investigated, types and results of investigations, and the analysis of the data to determine if the site warrants consideration for remedial action.

BACKGROUND

The Trinity atomic bomb test was conducted on 16 July 1945. It was the first atomic bomb test. The test was part of the Manhattan Project established during World War II to conduct the research necessary for the development and production of nuclear weapons. The test was conducted on the White Sands Missile Range in New Mexico. The fallout was blown in a northeastern direction over the White Sands Missile Range, Chupadera Mesa, and other ranching areas. Figure 1 shows the site of the test and the general direction of the fallout. Radiation measurements at ground zero and in the fallout zone began the same day as the test. Since then, a number of surveys or studies have been performed in the area by the University of California, the Environmental Protection Agency (EPA), and Los Alamos Scientific Laboratory (now National Laboratory), LANL.

The explosion took place some 60 miles from Alamagordo, New Mexico. Ground zero is located on what is now White Sands Missile Range and is 17 miles from the northeast boundary of the site. The site is fenced and access is controlled. Figure 2 shows the fallout zone and the site and sampling locations for the latest studies. The areas were divided into general regions which included:

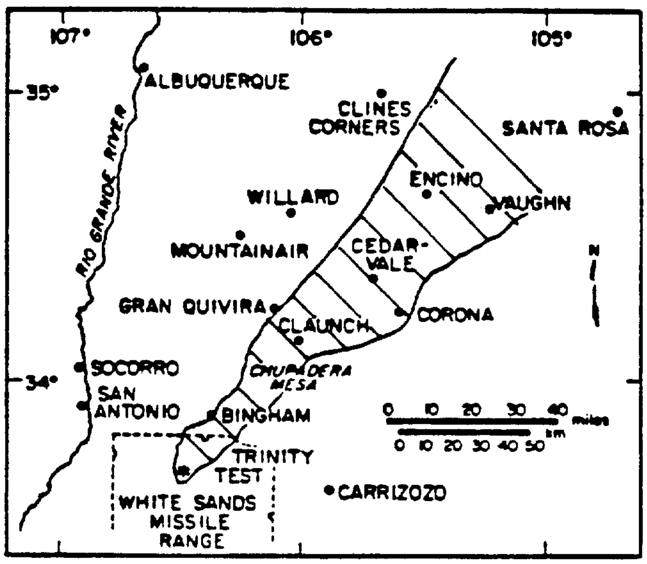

Figure 1. The Fallout Zone from the Trinity Test
As Determined by a 1945 Beta-gamma Survey

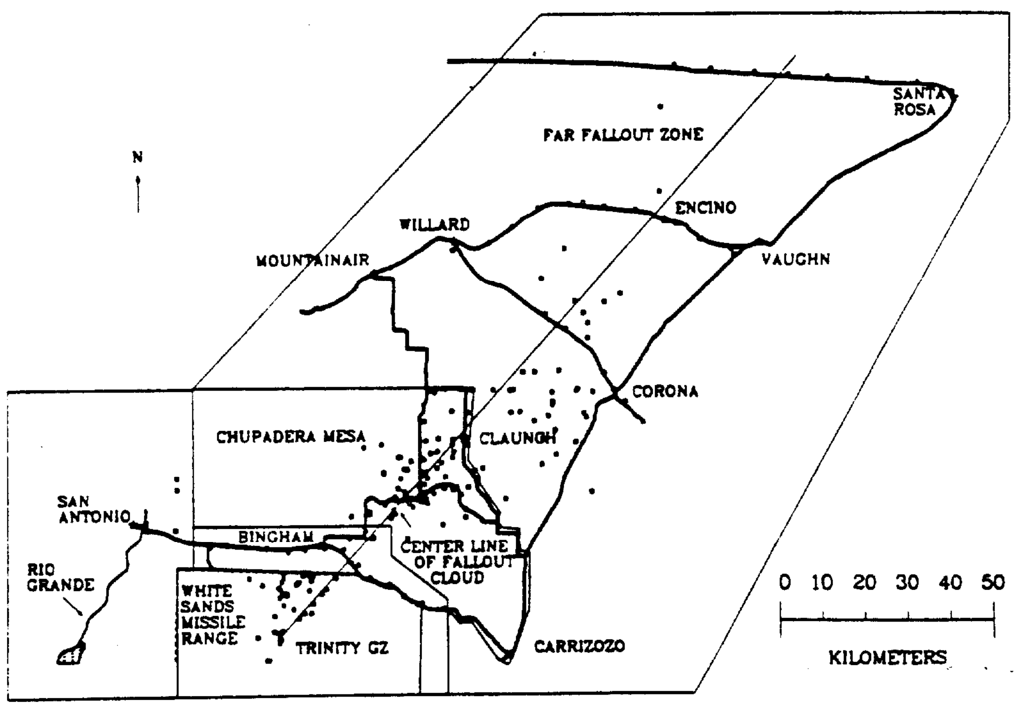

Figure 2. General Sampling Locations Along Path of Fallout Cloud and Out-of-Cloud Zone Sampling Locations Near San Antonio

Trinity Ground Zero
White Sands Missile Range
Bingham Area
Chupadera Mesa Area
Far Fallout Area
San Antonio Area (area out of the fallout cloud).

This report only considers the off-site fallout area Chupadera Mesa, Bingham, and the Far Fallout area. Sampling results from the San Antonio area which is out of the path of the fallout cloud are also reviewed. Ground zero which is a National Historic Landmark and the White Sands Missile range are not discussed.

The fallout zone covers privately and publically (BLM, State, and U.S. Forest Service) owned lands. The land use on the mesa is primarily cattle grazing. Areas further out are used for some crop production (alfalfa and row crops), but are also mostly cattle grazing areas. The total area potentially contaminated by the fallout cloud (including the White Sands Missile Range) was estimated at about 2500 square miles.

RADIOLOGICAL CONDITION

Radioactive decay over the 40 odd years since the Trinity test has resulted in substantial reductions of the fallout levels such that only the longer lived radionuclides from the fallout, Sr-90, Cs-137, and plutonium plus some europium, remain to any measurable extent. In the years since the test, environmental and biological transport mechanisms have acted to redistribute the long lived radionuclides. Early surveys indicated that the maximum concentrations outside the controlled access areas were on the Chupadera Mesa about 28 miles from ground zero. Plutonium was found in amounts up to 19 pCi per square foot (0.02 pCi per square centimeter) on the mesa and no plutonium was measured south of the test site. These early studies indicated that essentially all of the plutonium inventory was located in the top 5 cm of soil. Studies by LASL (now LANL) in 1972 indicated that about 50 percent of the plutonium in the fallout zone was at the 5 to 20 cm depth.

A 1973 and 1974 study by EPA was consistent with the other studies. It identified the highest concentrations of plutonium near ground zero and indicated that concentrations decreased with increasing distance from the site and laterally with increasing distance from the center line of the direction of travel of the fallout. The highest concentration observed in the mesa area was 86 nCi per square meter (8.6 pCi per square centimeter). The EPA study also involved air sampling over a 10 month period at locations on the mesa and out of the fallout zone (background). The samples were analyzed for plutonium -239, -240, and -238. The results of the sampling indicated that air concentrations were well below EPA proposed limits for transuranics.

Because the EPA study was limited to plutonium, DOE (then ERDA) and LANL decided a resurvey of the fallout zone was needed to verify the results for fission products as well as plutonium. LANL began this study in 1977. Additional measurements were made in the ground zero area in 1983. This resurvey effort was designed to supplement existing data so as to provide sufficient information to estimate potential radiation doses based on land use.

The data generally showed a fairly rapid decrease in plutonium concentrations in the soil with depth of soil with the exception of one location on the mesa which appeared to be a sediment trap. This location indicated relatively high concentrations of Pu-239 (>1 pCi/g) down to 15 cm. Most other locations had Pu-239 concentrations of less than 0.1 pCi/g after the first 5 cm sample. The highest concentration on the mesa area was 6.7 pCi/g, but the majority of samples were less than 1 pCi/g Pu-239.

Cs-137 was measured in soils in and around the Chupadera Mesa area. The data indicated that the Cs-137 is being slowly transported with rainfall runoff and consolidated in drainage collection points. The Cs-137 concentrations were several times those measured in near-by areas outside of the Trinity fallout cloud path. Sr-90 was also measured; however, due to the more complex measurements required to identify Sr-90, fewer samples were analyzed for Sr-90 than for Cs-137. The concentrations in samples taken averaged 10 to 40 times higher than those in south central New Mexico and near-by mountain states.

In addition, several other fission products and activation products from the Trinity test and the more recent Chinese tests were identified and investigated. These products included Zr-95, Nb-95, Be-7 and Ru-103. These radionuclides are short-lived (half-lives on the order of days), and as a result were identified as having originated from the 4 megaton Chinese test in 1976. Average area concentrations for Zr-95, Nb-95, Be-7 and Ru-103, over the 2500 square mile area investigated during the 1977 survey, were 2.4 nCi/sq m, 3.8 nCi/sq m, 8.1 nCi/sq m, and 0.21 nCi/sq m, respectively.

Concentrations of Co-60, and Eu-152 and -155 were also observed. Due to the longer half-lives of these nuclides (years) they were considered to be from the Trinity test. The mean, minimum, and maximum values measured on the mesa, the Bingham area, and far fallout area (that area along the fallout cloud centerline but beyond the mesa area, on the order of 50 miles from the Trinity site) are provided in Tables 1, 2, and 3, respectively, for plutonium, Cs-137, Sr-90, europium, Zr-95, Nb-95, Be-7, Ru-103 and Co-60, where they were measured. Table 4 contains similar data for the San Antonio area.

External gamma exposure rates were also measured. Cs-137 contributed some increase over the natural background. Total exposure rates on the mesa in the 1977 study area, about 30 miles from the Trinity site, were 8.1 microRoentgen per hour. Approximately two-thirds of this was estimated to be from natural background and one-third from the Cs-137.

Table 1. Chupadera Mesa Surface Soil Measurements

Radionuclide		Depth (cm)	Mean ± S.E.	Min	Max
^{7}Be		—	8.8 ± 1.1 nCi/m^2	<MDA[a]	26
^{60}Co		—	0.58 ± 0.16 nCi/m^2	<MDA	4.2
^{137}Cs		—	280 ± 30 nCi/m^2	30	947
^{152}Eu[b]		—	0.48 ± 0.48 nCi/m^2	<MDA	24
^{155}EU		—	4.2 ± 2.4 nCi/m^2	<MDA	86
^{95}Nb		—	4.65 ± 0.15 nCi/m^2	<MDA	6.6
^{95}Zr		—	2.55 ± 0.15 nCi/m^2	<MDA	4.2
^{103}Ru		—	0.28 ± 0.07 nCi/m^2	<MDA	1.9
^{238}Pu		0–5	0.083 ± 0.020 pCi/g	<MDA	0.32
		5–10	0.023 ± 0.013 pCi/g	<MDA	0.19
		10–15	0.006 ± 0.004 pCi/g	<MDA	0.06
		15–20	0.003 ± 0.003 pCi/g	<MDA	0.01
$^{239,240}Pu$	(1948)	0–2.5	3.1 ± 1.3 pCi/g	<MDA	10.8
	(1950)	0–2.5	3.2 ± 1.2 pCi/g	0.2	11
	(1972)	0–2.5	0.80 ± 0.34 pCi/g	<MDA	1.4
	(1972)	2.5–10	0.15 ± 0.10 pCi/g	0.02	0.34
	(1972)	10–30	0.033 ± 0.015 pCi/g	0.01	0.06
	(1973)	0–5	20.6 ± 4.3 nCi/m^2 (0.29pCi/g)[c]	0.4	86
	(1977)	0–5	1.7 ± 0.41 pCi/g	0.03	6.7
	(1977)	5–10	0.38 ± 0.27 pCi/g	<MDA	3.9
	(1977)	10–15	0.11 ± 0.07 pCi/g	<MDA	1.2
	(1977)	15–20	0.033 ± 0.03 pCi/g	<MDA	0.09
^{90}SR		0–5	2.3 ± 1.0 pCi/g	0.20	6.8
		10–15	0.76 ± 0.47 pCi/g	0.22	1.7
^{137}Cs		0–5	2.81 ± 0.52 pCi/g	<MDA	10.4
		5–10	0.16 ± 0.02 pCi/g	0.12	0.22
		10–15	0.04 ± 0.02 pCi/g	<MDA	0.21
		20–25	0.05	—	—

[a]<MDA = less than minimum detectable activity.

[b]Forty-eight observations for ^{152}Eu were below MDA.

[c]Calculation of the pCi/g based on 0.0143 $(pCi/g)/(nCi/m^2)$.

Table 2. U.S. Highway 380 Corridor—
Bingham Area Soil Measurements

Radionuclide		Depth (cm)	Mean ± S.E.	Min	Max
^{7}Be		—	5.8 ± 5.8 nCi/m^2	<MDA[a]	12
^{60}Co		—	0.6 ± 0.6 nCi/m^2	<MDA	1.2
^{137}Cs		—	52 ± 28 nCi/m^2	34	69
^{95}Nb		—	11.4 ± 0.19 nCi/m^2	1.2	1.6
$^{239,240}Pu$	(1948)	0-1.5	0.9 ± 0.4 pCi/g	0.5	1.3
	(1972)	0-2.5	0.21 ± 0.08 pCi/g	0.13	0.29
	(1972)	2.5-10	0.43 ± 0.32 pCi/g	0.12	0.75
	(1972)	10-30	0.085 ± 0.085 pCi/g	<MDA	0.17
	(1973)	0-5	0.5 ± 3.3 nCi/m^2/ (0.070 pCi/g)[b]	0.56	48

[a]<MDA = less than minimum detectable activity.

[b]Calculation of the pCi/g based on 0.0143 (pCi/g)/(nCi/m^2).

Table 3. Far Fallout Area Surface Soil Measurements

Radionuclide		Depth (cm)	Mean ± S.E.	Min	Max
^{7}Be		—	12 ± 1.2 nCi/m^2	<MDA[a]	21
^{60}Co			0.82 ± 0.61 nCi/m^2	<MDA	16
^{137}Cs			152 ± 34 nCi/m^2	10	765
^{95}Nb			4.5 ± 0.29 nCi/m^2	<MDA	6.4
^{95}Zr			2.9 ± 0.24 nCi/m^2	<MDA	5.8
^{103}Ru			0.25 ± 0.10 nCi/m^2	<MDA	1.6
^{238}Pu		0–5	0.018 ± 0.005 pCi/g	<MDA	0.06
		5–10	0.008 ± 0.005 pCi/g	<MDA	0.03
		10–15	<MDA	—	—
$^{239,240}Pu$		0–2.5	0.77 pCi/g	—	—
	(1950)	0–2.5	0.94 ± 0.46 pCi/g	<MDA	4.1
	(1973)	0–5	3.2 ± 0.88 nCi/m^2 (0.046 pCi/g)[b]	0.32	21
	(1977)	0–5	0.30 ± 0.009 pCi/g	<MDA	1.2
		5–10	0.15 ± 0.08 pCi/g	<MDA	1.5
		10–15	0.008 ± 0.005 pCi/g	<MDA	0.04
^{90}SR		0–5	1.47 ± 0.68 pCi/g	0.71	3.5
		5–10	2.16 pCi/g	—	—
		10–15	0.30 pCi/g	—	—
		20–25	0.21 pCi/g	—	—
^{137}Cs		0–5	2.0 ± 0.19 pCi/g	0.95	3
		5–10	0.24 ± 0.19 pCi/g	<MDA	1.0
		10–15	<MDA	—	—

[a]<MDA = less than minimum detectable activity.
[b]Calculation of the pCi/g based on 0.0143 (pCi/g)/(nCi/m^2).

Table 4. San Antonio Area Surface Soil Measurements

Radionuclide	Depth (cm)	Mean ± S.E.	Min	Max
^{7}Be	—	3.9 ± 2.0 nCi/m^2	<MDA[a]	14.6
^{60}Co	—	9.7 ± 6.0 nCi/m^2	<MDA	50
^{137}Cs	—	67 ± 20 nCi/m^2	<MDA	220
^{95}Nb	—	2.0 ± 0.3 nCi/m^2	<MDA	3.5
^{95}Zr	—	1.5 ± 0.33 nCi/m^2	<MDA	2.6
$^{239,240}Pu$	0-5	0.01 ± 0.004 pCi/g	<MDA	0.02
$^{239,240}Pu$	5-10	0.003 ± 0.003 pCi/g	<MDA	0.01
$^{239,240}Pu$	10-15	<MDA	—	—

[a]<MDA = less than minimum detectable activity.

POTENTIAL DOSES

Potential radiation doses were estimated for individuals using the Chupadera Mesa area, the Bingham area and the Far Fallout area as well as San Antonio. The analyses included direct exposure, inhalation and ingestion pathways and assumed conservative occupancy and use factors. The calculations were based on theoretical models and factors from standard references and health physics literature. Dose models employed in the calculations were based primarily on the methodology and recommendations of the ICRP.

Doses estimated for inhalation utilized a theoretical resuspension model and assumed continuous occupancy in the area of the contaminated soil. Table 5 gives the dose estimates for the Chupadera Mesa, the far fallout zone, Bingham and San Antonio. A comparison of the theoretically calculated air concentrations to measured values suggests that these dose estimates are conservative (high) by a factor of three.

Dose estimates for ingestion of radionuclides assumed that all the individual's meat (all beef), and milk products and one-half of his produce and vegetables were raised in the contaminated areas. Table 5 shows the estimated potential dose from this pathway for the same four areas discussed in the inhalation pathway.

Doses due to direct irradiation due to external gamma radiation can be estimated from the measured exposure rates. For the areas outside of the White Sands Missile Range, the mesa had the highest incremental increase in external gamma, 2 microRoentgen per hour. Continuous exposure to this level of gamma radiation would increase an individual's dose by 17 mrem/yr whole body dose.

A separate potential dose was also estimated for individuals involved in home gardening. The primary cause of dose increase during this operation would be inhalation of resuspended radionuclides resulting from the tilling of the soil for farming. Incremental doses due to this pathway are also presented in Table 5.

Table 5. Incremental Doses

	Bingham	Chupadera Mesa	Far Fallout Zone	San Antonio	Radiation Protection Standard	EPA Proposed Guidance
Mean External Whole Body Increment above Natural Background (mrem/yr)	1.7	13	5	1.7	500	---
MREM/YR (50-YEAR COMMITTED DOSE)						
Inhalation Total from Resuspension[a]						
Whole Body	0.0049	0.088	0.016	0.00058	500	---
Bone	0.051	0.91	0.17	0.0056	1500	150
Lung	0.053	0.95	0.17	0.0058	1500	10
Liver	0.025	0.45	0.083	0.0028	1500	---
Ingestion Total from Foods[b]						
Whole Body	1.6	1.9	1.2	0.1	500	---
Bone	19	37	16	0.2	1500	---
Liver	2.3	8.1	1.8	0.2	1500	---
GI-LLI	1.2	1.5	1.0	0.05	1500	---
Inhalation of Dust by Home Gardener[a]						
Whole Body	0.039	0.083	0.017	c	500	---
Bone	0.40	0.86	0.19	c	1500	150
Lung	0.42	0.87	0.17	c	1500	10
Liver	0.20	0.42	0.086	c	1500	---

[a]Major Dose contributed by transuranics.
[b]Major dose contributed by transuranics and ^{90}Sr.
[c]Not calculated by LANL because other inhalation doses are small.

As is apparent from the table the potential doses to the hypothetical individuals using the areas are far below applicable radiation protection guidance. The potential doses estimated and presented in the table are also well below background doses that would be received by individuals normally using the area. The natural background dose includes that from cosmic radiation, natural terrestrial radiation and natural radioactivity in the body. LANL estimated the natural background dose to be about 150 mrem per year.

POTENTIAL RISKS

The impact of incremental doses to the hypothetical individuals and scenarios evaluated in the LANL survey report can be assessed by estimating potential risk of cancers induced by these doses and comparing the risks to those from background radiation or risks normally experienced in everyday life. To estimate risks from exposure to radiation, doses are multiplied by dose to risk conversion factors. The National Academy of Sciences has recommended use of the following risk factors:

For uniform wholebody dose

- 0.00012 fatal cancers per rem

For specific organs

- 0.00009 fatal cancers per rem to the lung
- 0.000003 fatal cancers per rem to the bone
- 0.00003 fatal cancers per rem to the liver

The total potential doses to the wholebody and organs and estimated risks associated with these doses are provide in Table 6. As can be seen from the table the incremental risks ranged from about 2 in 10,000,000 to 2 in 1,000,000 potential fatal cancers per year for the fallout zone. This range is about one to two orders of magnitude lower than risks associated with natural background doses. These risk

Table 6. Estimates of Risk Based on Exposures Attributable to Residual Contamination in Areas of Fallout From the Trinity Test[a]

Location[b]/Exposure Hypothetical Resident	Incremental Risk Increased Probability Based on 50-Year Committed Doses[c]: Overall Cancer Mortality	Bone Cancer	Lung Cancer	Liver Cancer	Committed Dose mrem in 50 years from 1-Year Occupancy: External Whole Body	Body	Bone	Lung	Liver
Bingham	4.0×10^{-7}	5.7×10^{-8}	4.2×10^{-8}	7.5×10^{-8}	1.7	1.6	19	0.47	2.5
Chupadera Mesa	1.8×10^{-6}	1.2×10^{-7}	1.6×10^{-7}	2.7×10^{-7}	13	2.1	39	1.8	9.0
Far Fallout Zone	7.4×10^{-7}	4.8×10^{-8}	3.1×10^{-8}	3.6×10^{-8}	5	1.2	16	0.34	1.2
San Antonio	2.2×10^{-7}	6.0×10^{-10}	1.8×10^{-10}	1.5×10^{-9}	1.7	0.1	0.2	0.2	0.05
Natural Radiation Exposure, Los Alamos									
1-year occupancy	1.6×10^{-5}	---	---	---	134	---	---	---	---
50-year occupancy	8.0×10^{-4}	---	---	---	6700	---	---	---	---
Radiation Protection[d]	---	---	---	---	500	500	1500	1500	1500

[a]All calculations based on current conditions.
[b]Locations are described in more detail in Chapter 4.
[c]Probabilities are expressed in exponential notation; they can be converted to expressions of chance by taking the numerical value in front of the multiplication sign (x) as "chances" and writing a one (1) followed by the number of zeros given in the exponent. For example, 9.7×10^{-7} becomes 9.7 chances in 10,000,000.
[d]These dose limits represent standards at the time of the survey. Current FUSRAP standards are 500 mrem/year whole body doses for short-term exposures and 100 mrem/year for long-term exposures (over 5 years). These same limits are applied to the organ doses utilizing the ICRP-26 weighting factors and the Committed Dose equivalent concept.

estimates are very conservative; it is very unlikely that any individual will actually experience a risk as high as 2 in 1,000,000 per year from the levels of contamination measured on the Mesa.

The International Commission on Radiation Protection report #26, January 1977, recommends that doses to members of the general public be maintained below 500 mrem per year and that incremental risks be below 1 in 1,000,000 to 1 in 100,000 fatal cancers per year. Potential doses and associated risks estimated for this site are within these guidelines.

The lifetime risk of mortality due to all forms of cancer from all causes for the United States population is about 2 in 10. Incremental lifetime exposure to dose in the range of those estimated for the Trinity fallout area would range from about 1 in 100,000 to 1 in 10,000. This represents an increment of less than 0.06 percent that of the normal risk of cancer.

INCLUSION ANALYSIS

In order to determine if a site should or can be considered for remedial action the Department of Energy assesses each site on the basis of five questions. The following is a summary of the Department's review of these issues.

1. Was the site or operation owned by a DOE predecessor or did a DOE predecessor have significant control over the operations?

   Though not owned by any DOE predecessor, the Chupadera Mesa and surrounding areas were contaminated as a result of the Trinity Atomic Bomb test which was conducted by the Manhattan Engineer District (MED) a DOE predecessor. The MED had complete control and responsibility for the test.

2. Was a DOE predecessor responsible for maintaining or ensuring the environmental integrity of the site?

   Yes. The MED was responsible for the test and safety issues associated with it.

3. Is the waste, residue, or radioactive material on the site the result of DOE predecessor-related operations?

   Yes. While fallout from other nuclear tests were identified on the Mesa areas, an increment of the radioactive material identified was related to the MED test.

4. Is the site in need of further clean up and was the site left in unacceptable condition as a result of DOE predecessor-related activity?

   No. All radiation levels and concentrations of radioactive material on the Mesa were within those allowed under applicable standards and guidelines. Associated doses and risks from the residual radioactive material are as low as is reasonably achievable.

5. Did the present owner accept responsibility for the site with knowledge of its contaminated condition and that additional clean up or remedial measures would be needed to make the site acceptable for nonrestricted use by the general public?

   Not Applicable. The site is not in need of remedial measures or further clean up.

In summary, the Department has found that there is authority under the Atomic Energy Act of 1954 as ammended to conduct any needed remedial actions at this site; however, none appear warranted.

REFERENCES

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