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ENGINEERING EVALUATION OF THE BAYO CANYON SITE, LOS ALAMOS, NEW MEXICO

Formerly Utilized MED/AEC Sites

Remedial Action Program

September 1981

Ford, Bacon & Davis Utah Inc.

Salt Lake City, Utah

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CHAPTER 1

INTRODUCTION AND SUMMARY

CHAPTER 1

INTRODUCTION AND SUMMARY

The United States Government has instituted a program entitled "Formerly Utilized MED/AEC Sites Remedial Action Program", or FUSRAP. This remedial action program for the Manhattan Engineer District (MED)/Atomic Energy Commission (AEC) sites was initiated in 1974 by the AEC, was continued under the Energy Research and Development Administration (ERDA), and is presently being managed by the Department of Energy (DOE). The objectives of this DOE program include determining the radiological conditions of the former MED/AEC sites, proposing remedial action options that could be undertaken where corrective actions are necessary, analyzing the environmental impacts, and estimating the costs associated with the remedial action.

A portion of Bayo Canyon, located in Los Alamos County in north-central New Mexico, has been designated as a former MED/AEC site because between 1944 and 1961 it was used as a site for experiments employing conventional high explosives in conjunction with research on nuclear weapons development. The experiments were initially performed under the auspices of the MED and later for the AEC. The site was decontaminated and decommissioned in 1963, however, the southeast portion of the site still contains subsurface contamination.

1.1 PURPOSE

The purpose of this report is to develop and evaluate remedial action options that could be implemented in the contaminated areas at the Bayo Canyon site and to estimate the cost of these options. An environmental evaluation(1) will be prepared for the Bayo Canyon site which will describe the site environmental setting, discuss impacts and measures that can be taken to mitigate the impacts, and determine the risks associated with the remedial action options. The engineering and environmental evaluation reports will be used to select a proposed remedial action option.

1.2 SITE HISTORY

Facilities for experiments with high explosives were constructed in 1943 in Bayo Canyon for Project Y, sponsored by the MED. Between 1944 and 1961, experiments were carried out in conjunction with research on nuclear weapons. Nuclear weapons blast diagnostics were studied using conventional high explosives containing uranium and other radiation sources. The radiation sources used in the blast diagnostics tests contained from several hundred to several thousand curies of ^{140}La per test shot, along with a smaller amount of ^{90}Sr. The explosions scattered the radioactive materials around two firing points. The ^{140}La has decayed away, but the ^{90}Sr and its daughter ^{90}Y,

along with ^{238}U, remain on the site in measurable quantities. In addition, there are contaminated leach pits on the site because radioactive liquids and solid wastes from the radiochemistry laboratory were dispersed into them.

In the past, the Bayo Canyon site was referred to as Technical Area 10 (TA-10). As shown in Figure 1-1, the principal structures comprising TA-10 included a radiochemistry laboratory (TA-10-1), two assembly buildings (TA-10-10 and TA-10-12), an inspection building (TA-10-8), a personnel building (TA-10-21), and control buildings at two detonation control complexes (TA-10-13 and TA-10-15) with adjacent firing pads.

Decommissioning of the test site began in 1960 with the demolition of several buildings. In 1963, the remaining buildings were demolished, the sewer systems removed, the contaminated waste pits excavated, and the surface debris removed within a radius of about 2,500 ft (760 m) from the detonation control buildings. Debris was disposed of at the contaminated waste burial site of the Los Alamos National Laboratory (LANL).

After decommissioning, the land was transferred from the U.S. Government to Los Alamos County by quit claim deed on July 1, 1967. It was recognized at the time of decommissioning that some radioactive materials probably remained in the canyon. Consequently, several follow-up radiological surveys were conducted over the years.

A U.S. Geological Survey study in 1956 concluded, and a 1961 survey verified, as noted in Reference 2, that because of the basically dry conditions in Bayo Canyon, there was little possibility that contaminants from the surface or from liquid waste disposal pit seepage would move any significant distance in the shallow ground water. In 1961-1962, an aerial gamma-radiation survey was conducted for the AEC near the LANL nuclear facilities and in portions of northern New Mexico. The survey showed that the radiation measurements were not higher than normal for Bayo Canyon. In 1965 and 1970, sediments from two locations in the channel downstream from the Bayo Canyon site were analyzed and showed no contamination. In 1972, a survey of Kwage Mesa just south of Bayo Canyon showed that radiation levels were not statistically different from the reference location in northern New Mexico (the analysis did not include ^{90}Sr). Beginning in 1973, some resurvey work was undertaken in Bayo Canyon by the Health Division of LANL at the request of the AEC to determine the radiological conditions at the site. The subsurface contamination indicated by this 1973 survey led to the drilling of 11 auger holes in 1974. Samples from these holes showed elevated activity around the sanitary outfall and some migration through the tuff north of the TA-10-41 and TA-10-42 acid waste pits. In 1975, a second aerial survey that included west-to-east flights over Bayo

Canyon was performed. The results showed that radiation activity was only slightly higher than normal background levels for most areas in the southwestern United States.

In 1976, ERDA identified the Bayo Canyon site as a MED/AEC site. Consequently, LANL personnel began a resurvey in 1976 for possible residual contamination. The radiological survey was completed in 1977, and the final report(2) on the survey results was issued in June 1979. The results of this survey indicated that the Bayo Canyon site should be considered for remedial action.(3)

Bayo Canyon is currently used exclusively for recreation (picnics, trail riding, hiking, firearms practice, wood cutting, and pinon nut gathering). Projected future use includes possible residential development.

1.3 SITE DESCRIPTION

The site is located in Bayo Canyon in north-central New Mexico, in Los Alamos County, adjacent to and east of the town of Los Alamos. Albuquerque is about 62 mi (100 km) to the south-southwest, and Santa Fe is about 25 mi (40 km) to the southeast. Figure 1-2 shows the site location and Figure 1-3 is a site vicinity map. Access to the site is the New Mexico State Highway 4, onto a dirt road leading west to Pueblo Canyon, then to Bayo Canyon. Bayo Canyon is one of many canyons cut into the Pajarito Plateau, as shown in Figure 1-4.

As shown in the aerial view of the Bayo Canyon site, Figure 1-5, the canyon is bounded on the south by Kwage Mesa and on the north by Otowi Mesa. The mean elevation of the mesa tops is about 7,100 ft (2,160 m).(2) The elevation of the canyon floor is about 6,600 ft (2,012 m) above sea level and the canyon slopes to the southeast at a 3 percent grade.

Figure 1-1 shows the portion of the former test area designated as the site for the purpose of this report. The north boundary of the site is considered to be on a generally east-west line along the top of Otowi Mesa. The south boundary is an east-west line along the top of Kwage Mesa. The east boundary is a north-south line approximately 500 ft (152 m) east of the former radiochemistry laboratory TA-10-1. The west boundary lies approximately 1,000 ft (305 m) to the west of the former TA-10-15 firing site area.

Soil samples collected by LANL in 1976(2) from the firing sites, the canyon floor, and from the natural drainage route revealed the presence of small amounts of ^{90}Sr and ^{238}U at depths of about 1 to 12 in. (0 to 30 cm). Soil samples taken to depths of 65 ft (20 m) showed ^{90}Sr concentrations up to 4,310 pCi/g just east of the TA-10-43 liquid waste pit. The depth at which the highest concentrations occurred was 15 to 20 ft (4.6 to 6.1 m) below the surface.

Soil samples showed that the areas having contaminated material in excess of the proposed criteria are near the former waste pits. The contamination is at depths of 10 ft (3 m) to 40 ft (12 m) below the surface. Additional holes were drilled in 1980 by LANL for FB&DU to better define the extent of the contamination.

The combined effects of alpha and beta contamination were found to be acceptable at all locations within 10 ft (3 m) of the surface. At greater depths, where ^{90}Sr concentrations were found to be more than 100 pCi/g, the acceptable limits of combined alpha and beta contamination were exceeded.

External gamma radiation was measured by FB&DU on the canyon floor and surrounding slopes and mesas. Measurements ranged from 14 to 34 μR/hr. Background levels of external gamma radiation were determined to be about 14 to 22 μR/hr.

Low levels of radon were detected by FB&DU in Bayo Canyon which indicates that radium bearing materials have not been brought onto the Bayo Canyon site.

1.4 PROPOSED CLEANUP CRITERIA

Formal criteria have not yet been established for the FUSRAP program. Existing criteria from other programs and existing Federal regulations are applied to specific conditions at FUSRAP sites. In some cases, criteria do not exist for certain nuclides and proposed criteria are used to perform engineering evaluations.

The areas of the Bayo Canyon site to be considered for remedial action have been determined for this report by using proposed contaminated soil cleanup criteria.(4) A limit of 100 pCi/g has been proposed for ^{90}Sr, and 40 pCi/g has been suggested for ^{238}U. It has also been proposed that beta-gamma emitters shall not exceed an average level of 0.2 mrad/hr or a maximum level of 1.0 mrad/hr at a distance of 1.0 cm from contaminated surfaces.(5)

The only formal criterion for cleanup of contaminated soils is that of 5 pCi/g for ^{226}Ra established for the Uranium Mill Tailings Remedial Action Program.(6) However, this does not apply to the Bayo Canyon site where no materials containing ^{226}Ra were used. The only materials used at Bayo Canyon which remain in detectable quantities are ^{90}Sr and ^{238}U.

1.5 REMEDIAL ACTION OPTIONS

The process of selecting the appropriate remedial action for a specific site consists of several steps. First, the five basic alternative approaches to remedial action are considered:

1. No Action

2. Minimal Action

3. Stabilization

4. Partial Decontamination

5. Decontamination and Restoration

The site-specific conditions are then evaluated and options for remedial action are proposed. For the Bayo Canyon site, the options are shown below. The estimated costs of implementing each option are given in Table 1-1.

Option A - No Action

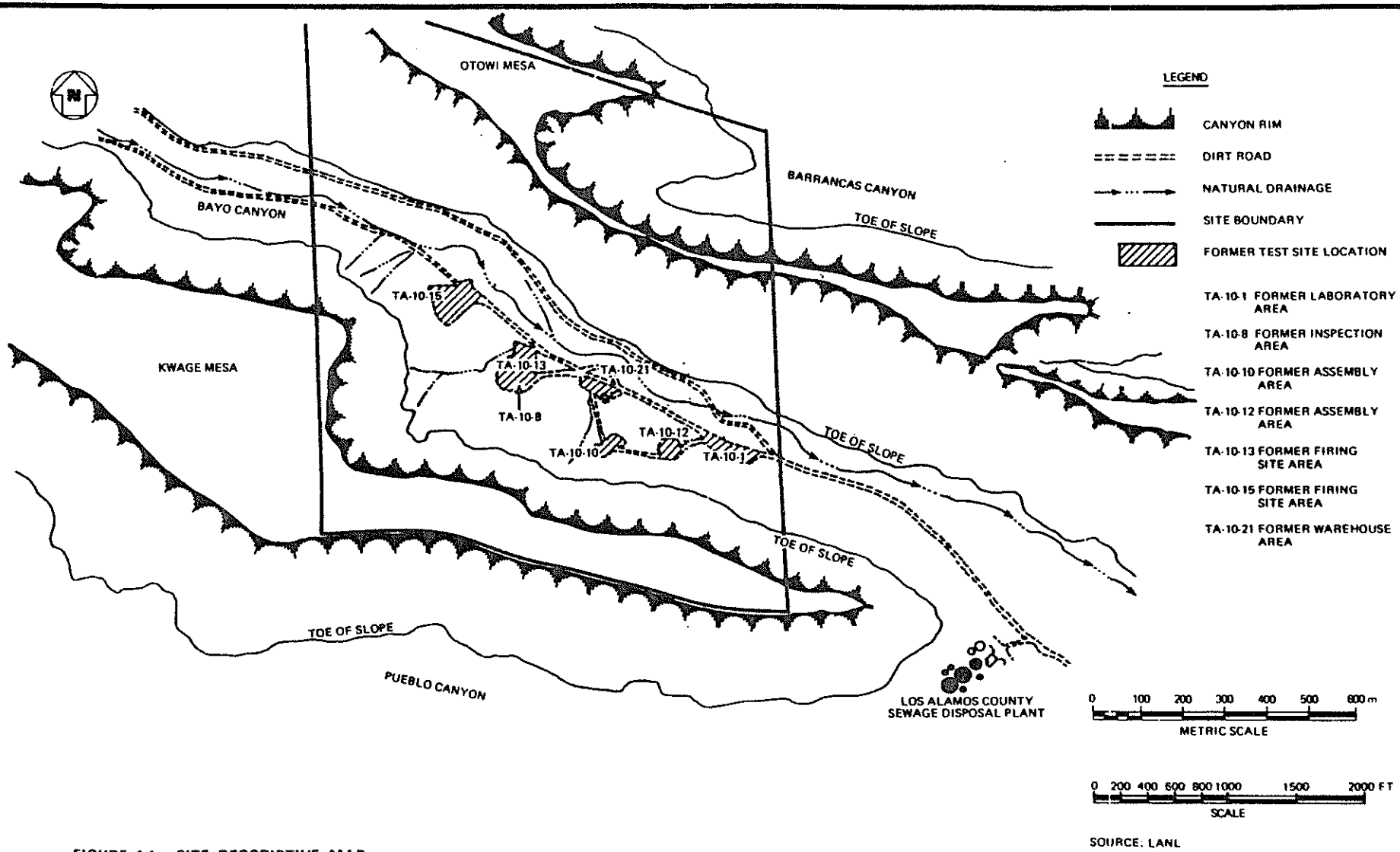
No action would be taken at all (the property would remain unchanged). This option can be used to compare the impacts of leaving the site in its current condition with the impacts of the other options.

Option B - Minimal Action

The areas which involve subsurface contamination, which is at least 10 ft (3 m) beneath the surface, would be designated restricted areas and the subsurface contamination left in place. Monument markers would be installed to restrict use of the land for approximately 160 years. Radiological surveys would be required before, during, and after implementation to verify that the remedial actions have accomplished the planned goals.

Option C - Decontamination and Restoration with Disposal

Option C specifies that the subsurface contamination be removed to meet the criteria for ^{90}Sr and ^{238}U. The contaminated soil would be excavated to whatever depth is necessary to achieve the guidelines. The pits would be backfilled to original grade with clean soil, followed by revegetation. The contaminated soils would be disposed of at the LANL waste site. After restoration, the site could be released for unrestricted use; government (or county) ownership and surveillance and monitoring would not be necessary.



SOURCE: LANL

FIGURE 1-1. SITE DESCRIPTIVE MAP

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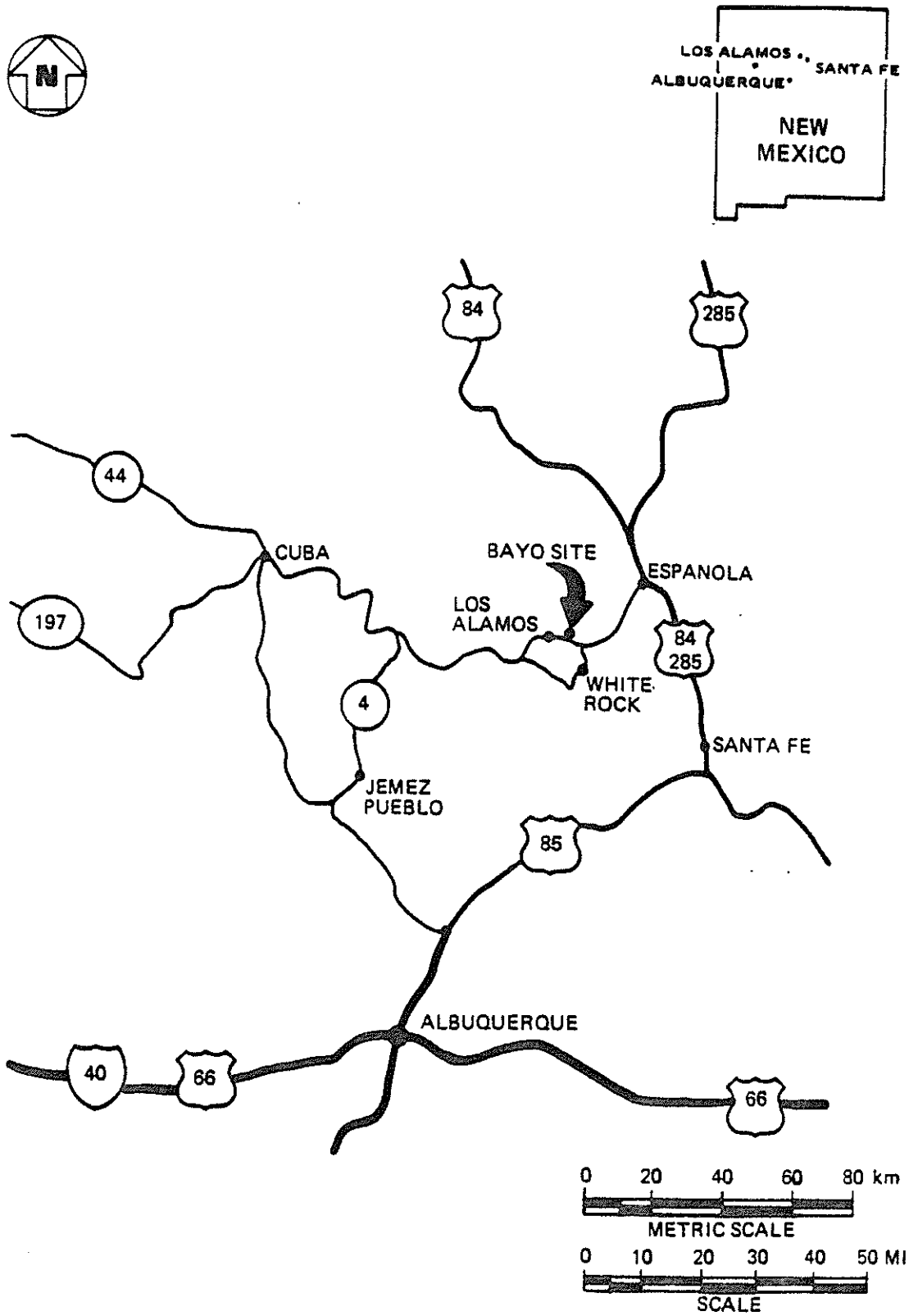


FIGURE 1-2. SITE LOCATION MAP

409-317 9/81

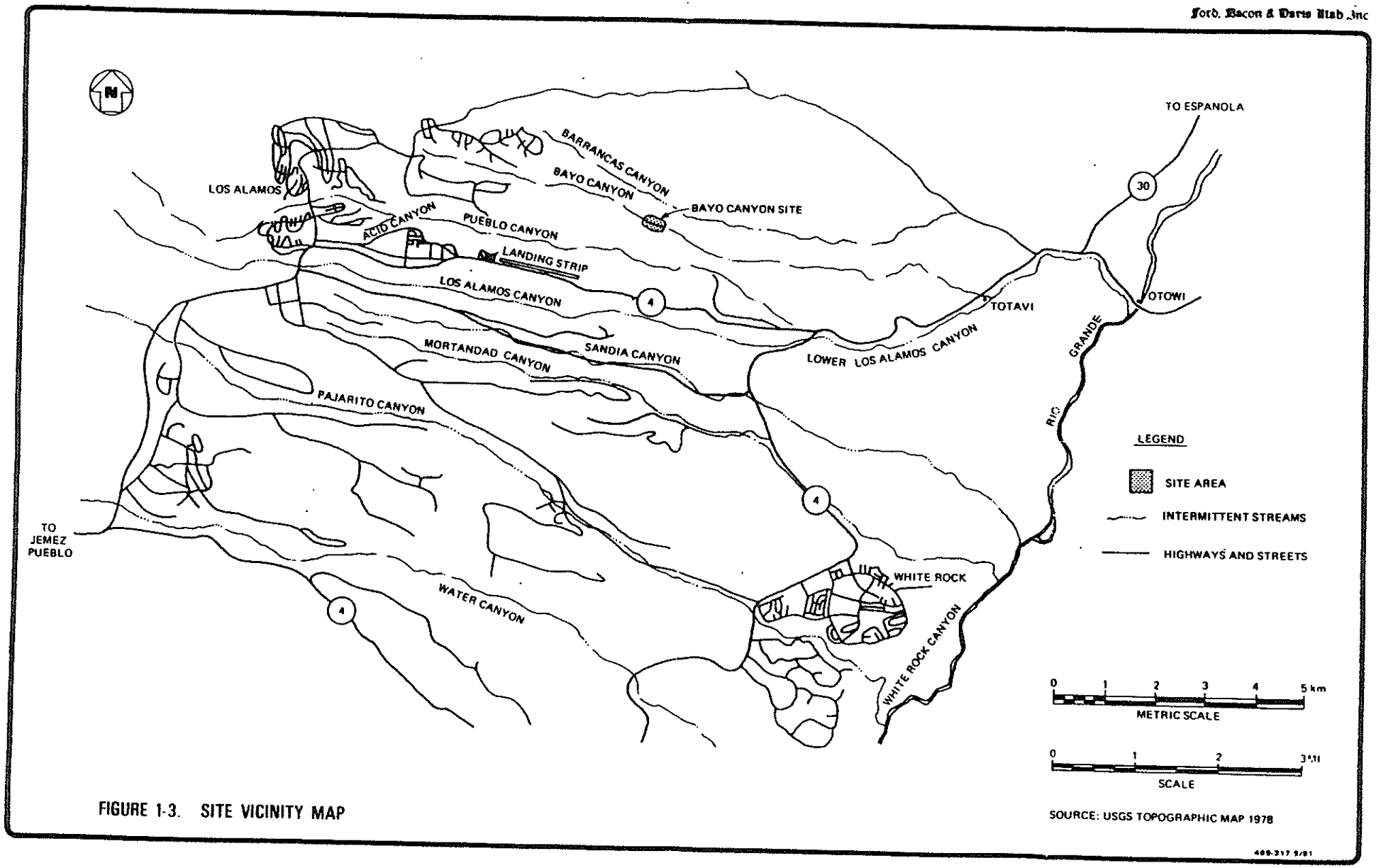


FIGURE 1-3. SITE VICINITY MAP

SOURCE: USGS TOPOGRAPHIC MAP 1978

489-217 5/81

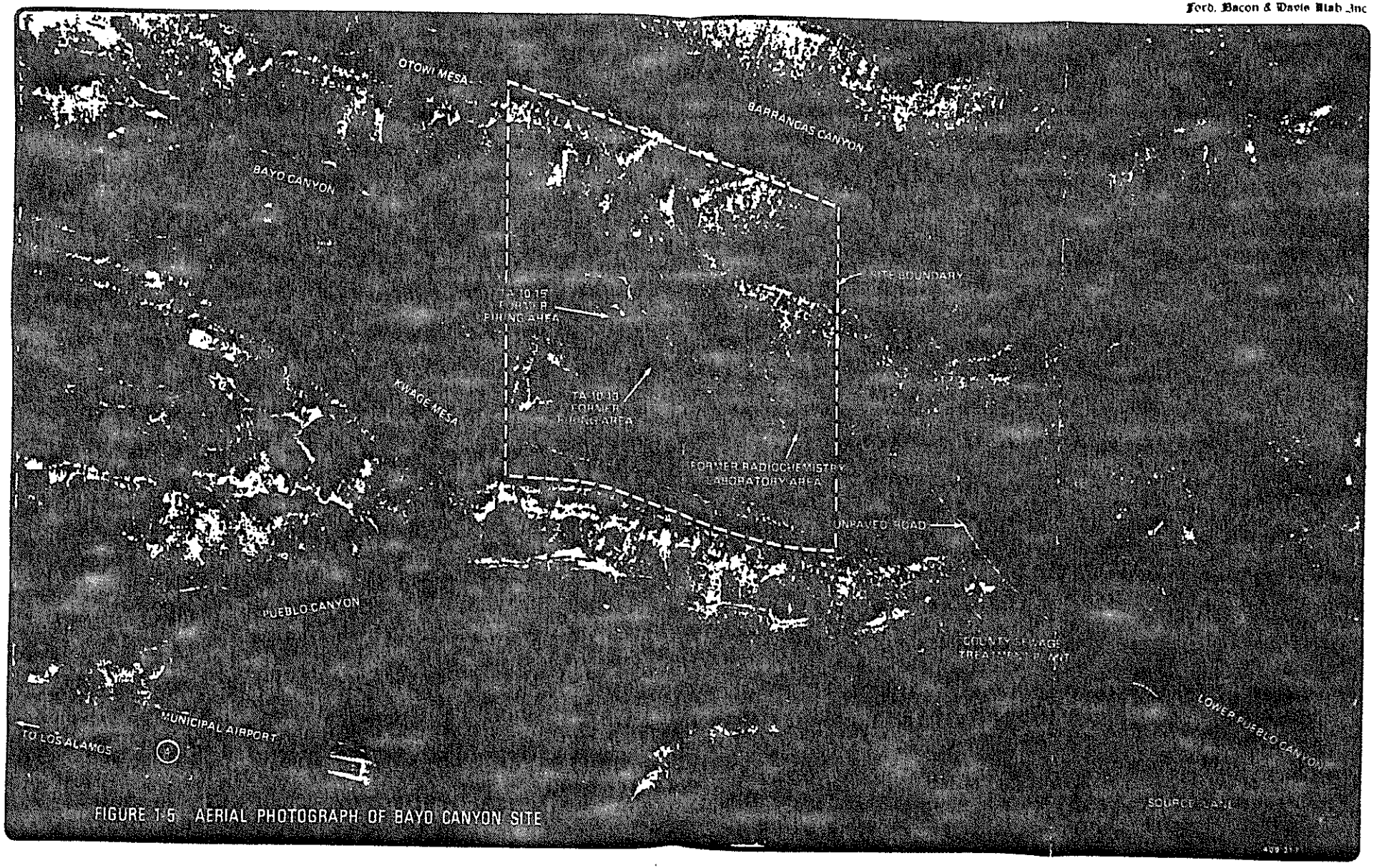


FIGURE 1-5 AERIAL PHOTOGRAPH OF BAYO CANYON SITE

TABLE 1-1

COST ESTIMATES (IN THOUSANDS OF 1981 DOLLARS)

Remedial Action Item	Remedial Action Option A[a]	B[b]	C
Clear Site	-0-	-0-	4.5
Soil Excavation	-0-	-0-	78.8
Truck Haulage to LANL Site	-0-	-0-	19.5
Backfill	-0-	-0-	57.3
Seed, Fertilize, Mulch	-0-	-0-	2.7
Disposal Charge at Federal Site	-0-	-0-	103.2
Health Physics Coverage	-0-	3	52.2
Monument Markers	-0-	6	-0-
Surveillance and Security Fund	-0-	50	-0-
SUBTOTAL	-0-	59	318
Engineering (15%) and Contingency (30%)	-0-	4	143
TOTAL	-0-	63	461

[a] No Action.

[b] Contingencies are not applied to surveillance and security funds.

CHAPTER 1 REFERENCES

1. "Environmental Analysis of the Bayo Canyon Site; Los Alamos, New Mexico;" Los Alamos National Laboratory; Los Alamos, New Mexico (in preparation).

2. "Radiological Survey of Bayo Canyon, Los Alamos, New Mexico;" Final Report, by Los Alamos Scientific Laboratory, Los Alamos, New Mexico; for U. S. Department of Energy, Assistant Secretary for Environment, Division of Environmental Control Technology, Washington, D. C.; under Contract No. W-7405-ENG-36; June 1979.

3. "A Background Report for the Formerly Utilized MED/AEC Sites, Remedial Action Program;" Draft Report; by Environmental Controls and Analysis Directorate, Eastern Technical Divison, The Aerospace Corporation; for the Division of Environmental Control Technology, Assistant Secretary for Environment, U. S. Department of Energy; under Contract No. EX-76C-03-110 (PA-10); Dec 1978.

4. J. W. Healy, J. C. Rogers, and C. L. Wienke; "Interim Soil Limits for D & D Projects;" LASL Report No. LA-UR-79-1865-Rev; Los Alamos Scientific Laboratory; Los Alamos, New Mexico; Sept 1979.

5. "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source or Special Nuclear Material;" U. S. Nuclear Regulatory Commission; Washington, D. C., Nov 1976.

6. Interim Cleanup Standards for Inactive Uranium Processing Site; U. S. Environmental Protection Agency; Federal Register Vol 45, No. 79; Apr 22, 1980.

CHAPTER 2

SITE DESCRIPTION

CHAPTER 2

SITE DESCRIPTION

The purpose of this chapter is to describe the physical and radiological conditions of the Bayo Canyon site.

2.1 PHYSICAL CONDITIONS

The Bayo Canyon site as defined by FB&DU encompasses an area of approximately 350 acres, roughly in the shape of a parallelogram, as shown in Figure 1-5.

Since the decommissioning of the Bayo Canyon test site in 1963, the only remaining physical structures indicating former test activities are a concrete pad from a former warehouse, an asphalt pad at the former personnel building, an asphalt pad (parking area) at the former radiochemistry building, and deteriorated asphalt paved areas where firing tests were performed. The road through the site is paved but the paving is in a deteriorated condition.

Bayo Canyon has a semiarid mountain climate characterized by normally fair weather. The average temperature in July is about 73°F (23°C) and in January about 21°F (-6°C).(1) Thundershowers in late summer provide most of the total annual precipitation, and winter snows provide the remainder. Water flow in the canyon stream is intermittent, with most of the runoff occurring in July and August during heavy thunderstorms. The runoff period is generally short, e.g., several hours. The average annual precipitation increases from about 9 in. (23 cm) along the Rio Grande River to about 18 in. (46 cm) on the mesa plateaus, to about 30 in. (76 cm) along the crest of the mountains in the immediate vicinity of Los Alamos.(1)

Bayo Canyon heads on the Pajarito Plateau and is tributary to the lower reach of Los Alamos Canyon, which in turn drains into the Rio Grande River. Available data suggest that there is no hydrological connection between any Bayo Canyon surface water and the main aquifer, which is about 790 ft (241 m) below the surface.

Clay soils and tuff outcrops on top of Otowi Mesa on the north and Kwage Mesa south of the site support a pinon-juniper brushland. A sandy soil that has developed on the talus slope facing north from Kwage Mesa and on the canyon floor supports pine and fir mixed with pinon and scrub oak, grading into grass and sagebrush on the canyon floor.(2)

The site is underlain by the Otowi member of the Bandelier Tuff.(3) This member is a massive aggregate of poorly sorted rhyolitic pumice fragments and some fine pumice glass. It contains only a limited amount of perched groundwater. From

?
reference

a point about 1 mi (1.6 km) downstream from the site to the confluence with Los Alamos Canyon, Bayo Canyon is underlain by the conglomerate of the Puye Formation, a member of the Santa Fe Group. This member consists of interbedded silt, sand, and gravel derived from contemporaneous erosion and volcanism.(3)

The Bayo Canyon site is located in a seismic Zone 2 area, where moderate damage from earthquakes can be expected to occur.(4) The earthquake recorded nearest to the site occurred in Santa Fe County to the southeast on May 19, 1918. The quake was graded at intensity VII-VIII (Modified Mercalli scale). The most recently recorded event occurred on January 22, 1966, at Dulce, about 80 mi (113 km) northwest of the site. The magnitude of this event was measured at 5.5 on the more recently developed Richter scale.

2.2 RADIOLOGICAL CONDITIONS

The LANL performed a radiological survey of the Bayo Canyon test site for DOE in 1976-1977.(2) Data on surface and subsurface soils, air concentrations, and gamma surveys were obtained. The information presented in the following paragraphs is a summary of the findings of the radiological surveys performed by LANL and supplemented by FB&DU in 1980. The LANL survey data are included as Appendix A of this report.

2.2.1 Soil Samples

Soil samples were collected by LANL from the firing sites, the canyon floor, and the natural drainage area. Analysis of these samples revealed the presence of small amounts of ^{90}Sr and ^{238}U at depths of about 0 to 12 in. (0 to 30 cm). To better define the limits of contamination, additional holes were drilled in 1980 by LANL for FB&DU. The locations of these holes are shown in Figure 2-1. Soil samples were collected at 3-ft (1-m) intervals in each hole down to 15 ft (4.6 m) in depth and at 5 ft (1.5 m) intervals thereafter. The results of the analysis are indicated in Table 2-1.

correlate to Table 2-1

Samples were taken by LANL near and at the former waste pits and near the radiochemistry laboratory area to depths of about 65 ft (20 m). The ^{90}Sr concentrations ranged up to 4,310 pCi/g at 15 to 20 ft (5 to 6 m) below the surface at location 43 E, which is just east of the TA-10-43 liquid waste pit.

correlate

The LANL soil samples were tested for gross alpha and gross beta. A representative number of these samples were also tested for specific nuclides including ^{90}Sr. Gross beta concentrations were due not only to ^{90}Sr but also ^{40}K (a beta emitter) which was present in concentrations from 20 to 37 pCi/g. In every sample analyzed, where gross beta was greater than 100 pCi/g, ^{90}Sr was also greater than 100 pCi/g and where gross beta was less than 100 pCi/g, ^{90}Sr was also less than 100 pCi/g. Gross

beta appears to be a conservative indicator for soil concentrations of ^{90}Sr. From the standpoint of radiation protection, it is also conservative to assume that alpha contamination was due to ^{238}U.

The combined effect of alpha and beta contamination also was considered. When two or more radionuclides are present in a soil sample, the maximum permissible concentration (MPC) of each will be reduced from the normal MPC for a single radionuclide. If C_1, C_2, C_3,... C_n represent the concentrations of each nuclide present in a particular soil sample, and if M_1, M_2, M_3,... M_n represent the MCP's of these radionuclides, then the permissible concentration of each radionuclide in the sample is given by the equation:

$$\frac{C_1}{M_1} + \frac{C_2}{M_2} + \cdots \frac{C_n}{M_n} \leq 1.00$$

Table 2-2 contains data on both types of contamination as a fraction of the remedial action criteria. The sum of the two fractions is called the hazard index (HI). An HI of 1.0 is considered as the upper limit above which remedial action is required. The combination of alpha (α) and beta (β) concentrations were normalized, according to the following equation:

$$HI = \frac{\text{Concentration } \alpha}{40} + \frac{\text{Concentration } \beta}{100}$$

For each sample location, the combined HI fraction was calculated to see if the combined exposure risk required remedial action. This calculation was relatively easy using Table 2-2. At each level of gross α lower than 40 pCi/g (120 µg/g of ^{238}U) a corresponding HI fraction is given in column 2. Column 3 then lists the corresponding limit of gross that will give an HI fraction (column 4) which, when added to the gross β fraction, totals an HI of 1.0.

At all sampling locations on the test site within 10 ft (3 m) of the surface, the combined gross alpha and gross beta hazard index was less than 1.0. At points below 10 ft (3 m) in depth, the only places where this index exceeded 1.0 were the waste pits where ^{90}Sr concentrations exceeded 100 pCi/g.

2.2.2 External Gamma Radiation

External gamma radiation was measured by FB&DU in Bayo Canyon using a Ludlum Model 125 Micro R Meter calibrated with a ^{137}Cs source. Measurements were made on the canyon floor, talus slopes, the tops of Kwage and Otowi Mesas, and the

opposite side of Otowi Mesa into Barrancas Canyon (see Figure 2-2). Measurements ranged from 14 to 34 μR/hr. The higher direct gamma readings generally were not in the immediate vicinity of the firing pads. This was observed independently by LANL and by FB&DU personnel.

Delta measurements were conducted by FB&DU to determine the general extent of surface contamination. Delta measurements are made by holding a scintillation probe with 1 x 1 in. (2.54 x 2.54 cm) NaI (TL) crystal detector near the ground and taking two readings: one with the crystal unshielded and one with a 1/2-in. thick (1.27 cm-thick) lead shield between the probe and the ground. The lead shield attenuates the 168 keV gamma from ^{226}Ra and the 48 keV gamma from ^{238}U more nearly completely than those from such natural soil constituents as ^{40}K (1,460 keV). The difference in the two readings, called the "delta," is thus an indication of the presence of radium or uranium in the soil. It has been experimentally determined by FB&DU personnel using Ludlum Measurements instrumentation that a delta of 400 counts per minute corresponds to a soil concentration of ^{226}Ra of approximately 5 pCi/g. However it should be noted that ^{90}Sr, the primary contaminant at Bayo Canyon, does not emit a gamma ray. Therefore, this measurement does not define the limits of ^{90}Sr contamination.

Figure 2-2 depicts the results of the gamma measurements made by FB&DU. The upper number at each grid point is the "delta," while the lower number represents the external gamma radiation level at that location, in μR/hr.

Background gamma radiation levels measured by LANL ranged from 19 to 23 μR/hr, and from 14 to 22 μR/hr as measured by FB&DU at 4 locations: One above (west) and one below (east) of the test site in Bayo Canyon, and two in Los Alamos townsite.

2.2.3 Radon and Radon Daughter Concentrations

Since ^{90}Sr and ^{238}U are the only contaminants introduced by the previous testing activities, there should be no radium or radium daughter concentrations above those expected from native uranium in the soil. Radon and radon daughter concentrations were measured at locations indicated in Figure 2-3. The concentrations measured were consistent with the expected flux from the background concentrations of natural uranium present in the soils. These findings are consistent with the statement[2] that: "Surface uranium averaged about 4.9 μg/g or about 1.5 times the amount usually present in the volcanic-derived soils of the area."

2.2.4 Water Samples

Neither LANL nor FB&DU personnel collected water samples in Bayo Canyon. Surface water only flows in the canyon after a thunderstorm, and no groundwater was found in holes drilled by

FB&DU as deep as about 36 ft (11 m) below the surface. Data from LANL indicate that the main aquifer is about 790 ft (241 m) below the canyon surface.(2) Based on the great distance between the lowest depths of contamination and the aquifer, and on knowledge of the area geology, it is improbable that a hydrological connection exists between the surface water and ground water.

No Data

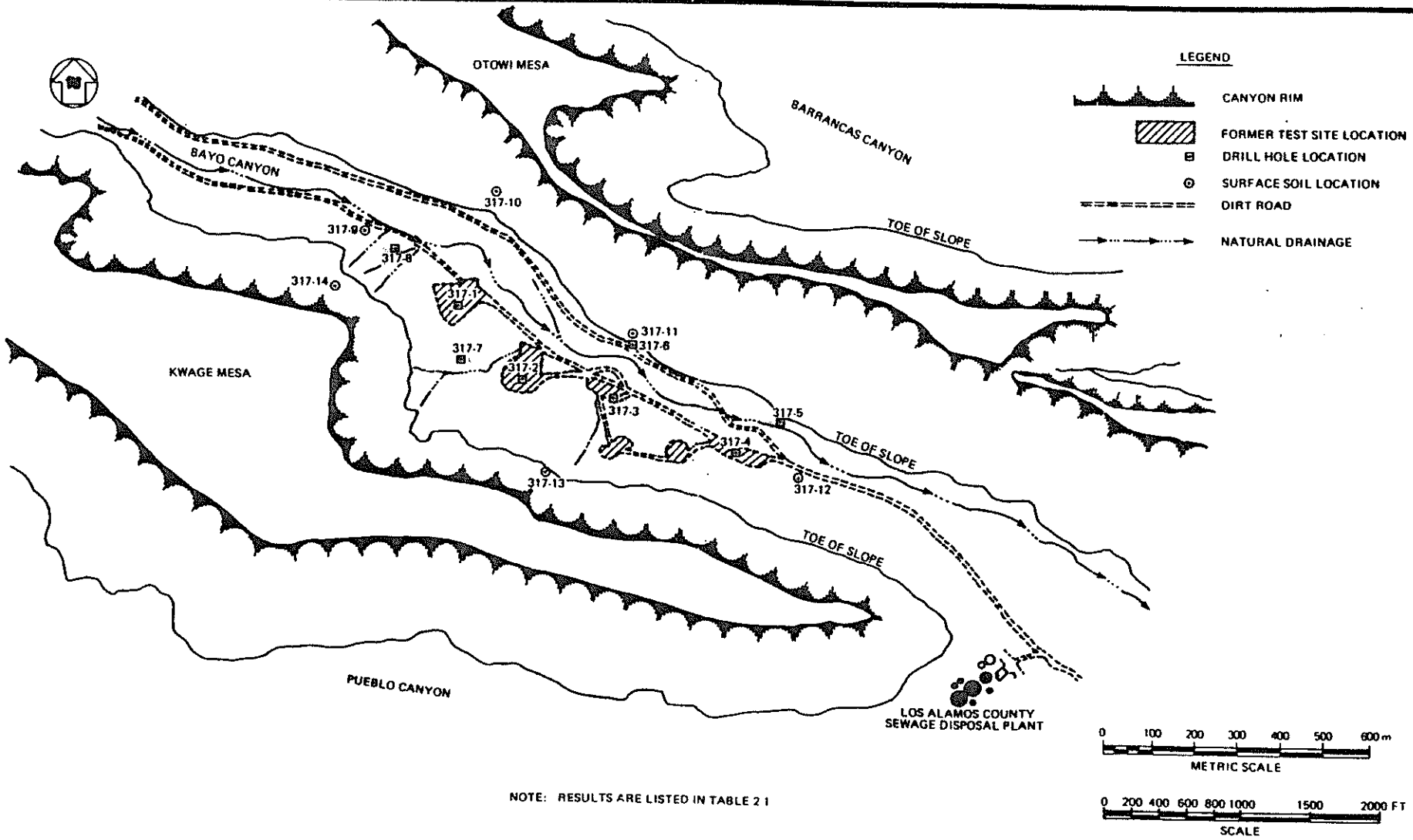
2.2.5 Contaminated Areas

Based on soil data from LANL and FB&DU, the only areas having contaminated material in excess of the proposed criteria are within an area which includes the former waste pits TA-10-41, -42, and -48, at depths ranging from 10 ft (3 m) to 40 ft (12.2 m) below the surface (see Figures 2-4 and 2-5). Volumes of contaminated soil have been estimated from the 1977 LANL survey data (contained in Appendix A of this report).

Contamination was found at a depth of 10 to 25 ft (3.0 to 7.6 m) in a sample hole at former solid waste pit TA-10-48. Contamination was not found in four other nearby sample holes. This would indicate the limited extent of the contamination.

Contamination was found at a depth of 10 to 30 ft (3.0 to 9.1 m) in two sample holes at former waste pit TA-10-41. Samples from five adjacent test holes did not show any contamination above guideline criteria. This would indicate the contamination is limited to a fairly small area.

Samples from four test holes near former waste pit TA-10-42 showed contamination at a depth of 10 to 40 ft (3 to 12.2 m). Contamination was not found in the samples from three other nearby test holes. The contaminated area appears to be larger than at the other two waste pits but seems to be confined to an area of less than 1,000 ft^2 (93 m^2).



NOTE: RESULTS ARE LISTED IN TABLE 2 1

FIGURE 2-1. FB&DU SOIL SAMPLE LOCATIONS

SOURCE. FBDU SURVEY, NOV 1980

409-317 9/81

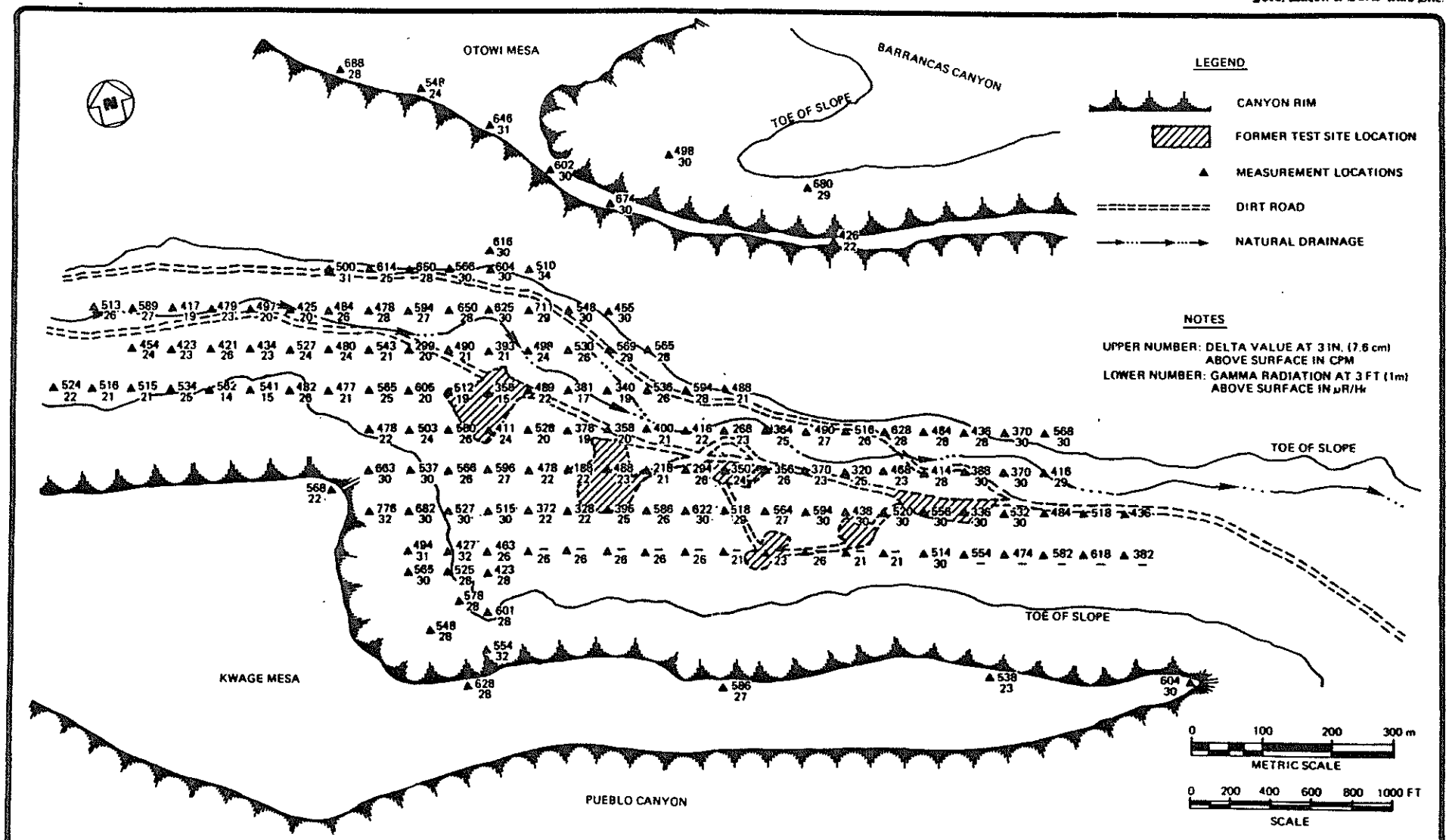
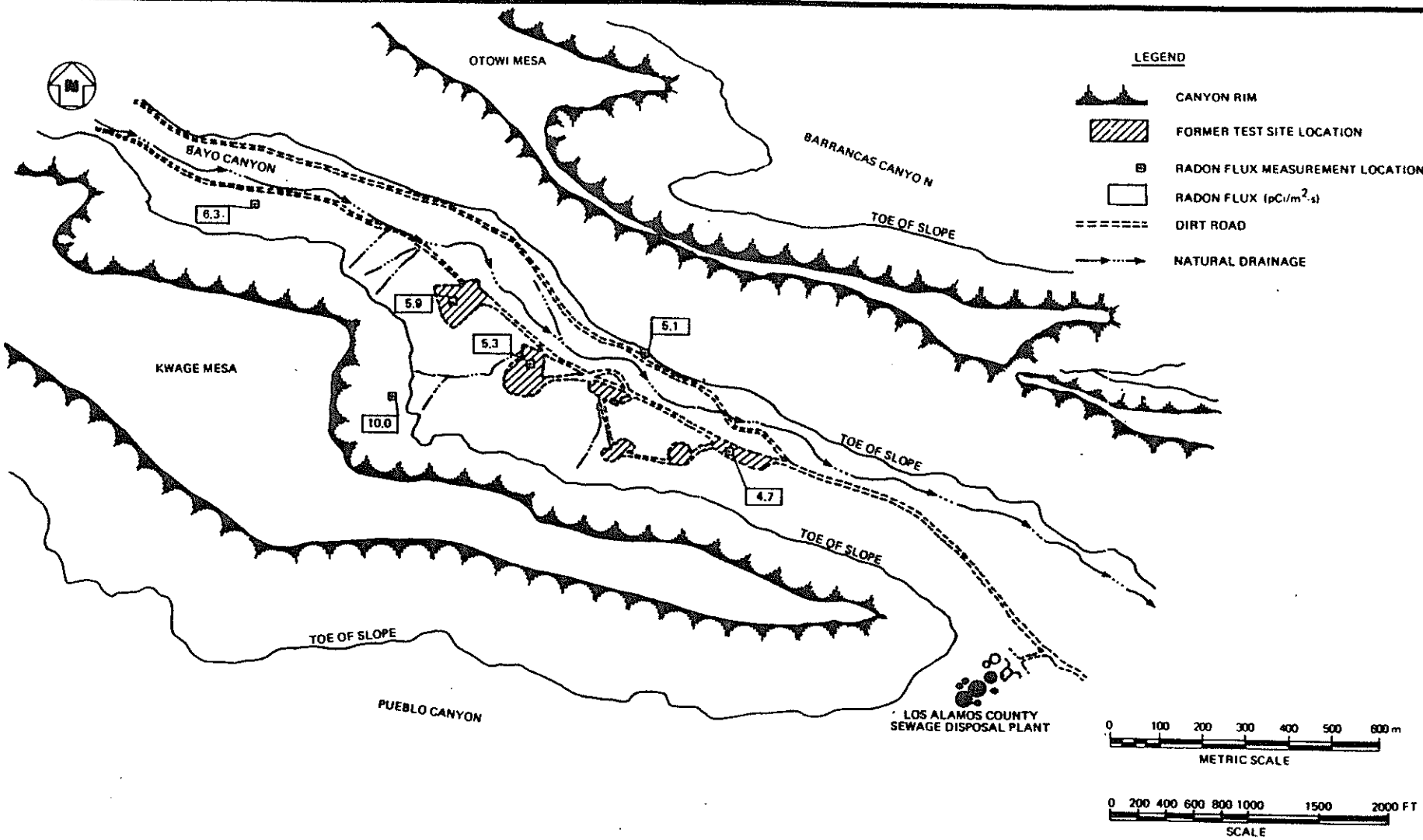


FIGURE 2-2. GAMMA RADIATION LEVELS

SOURCE FBDU SURVEY, NOV 1980



SOURCE: FBDU SURVEY, NOV 1980

FIGURE 2-3. RADON FLUX CANISTER LOCATIONS

409-317 9/81

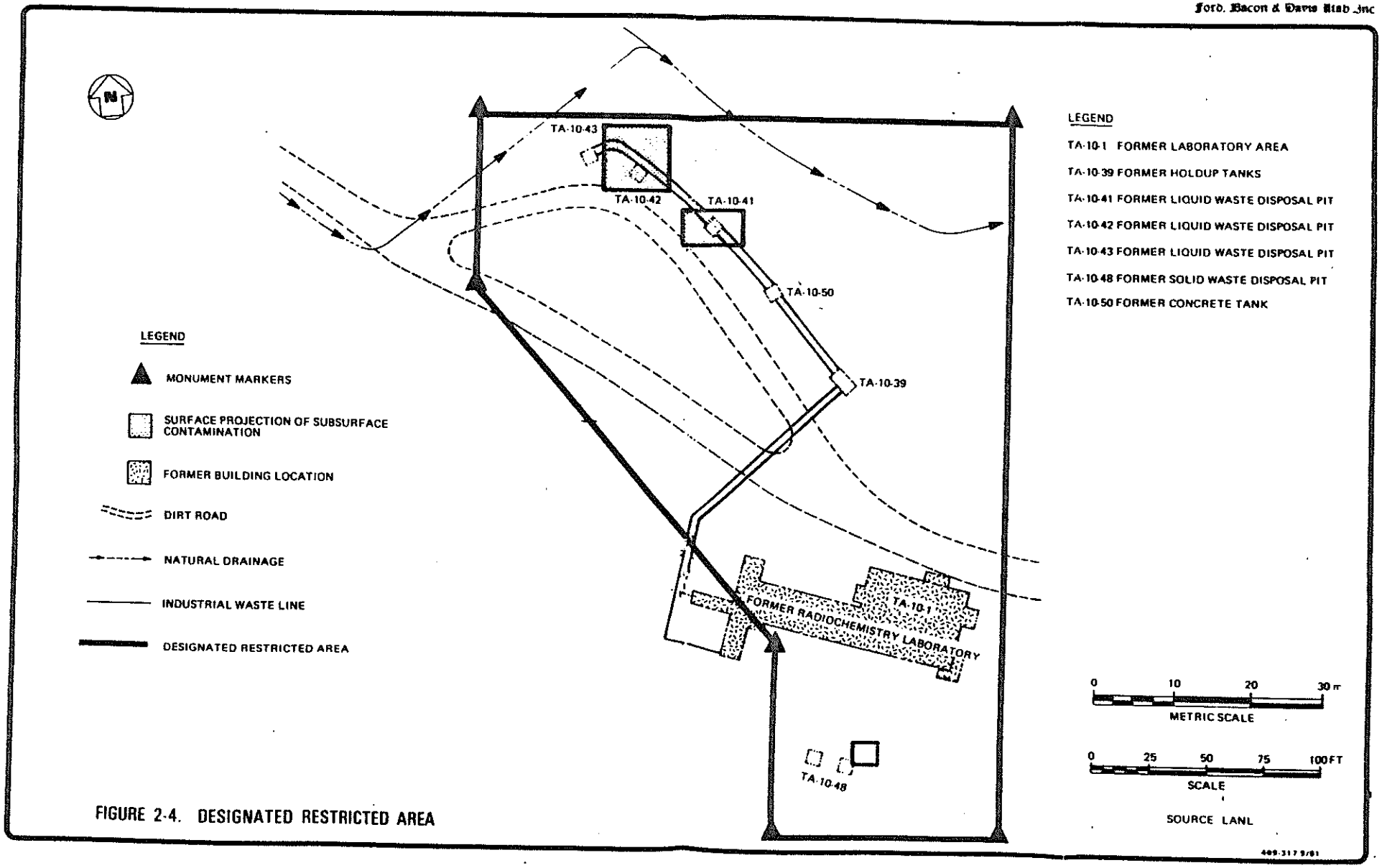
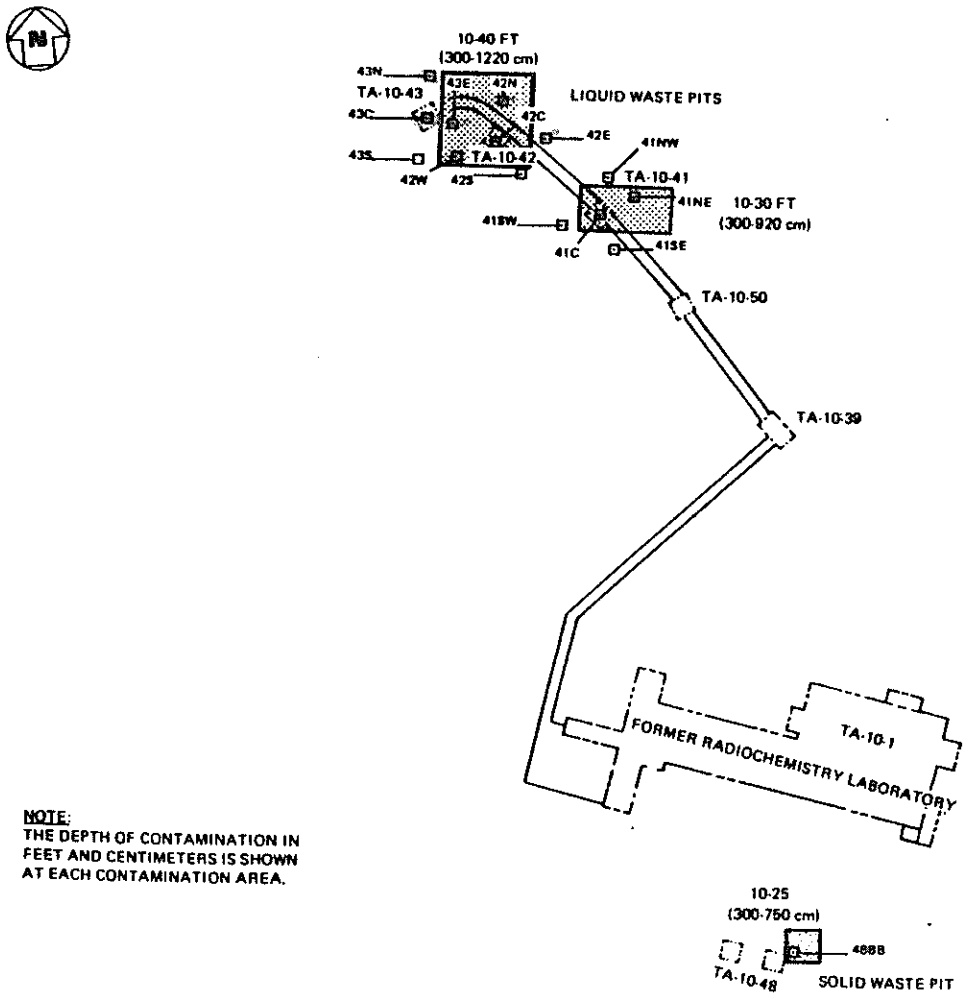


FIGURE 2-4. DESIGNATED RESTRICTED AREA

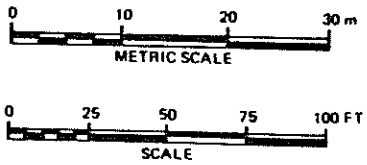


LEGEND

- LANL DRILL HOLE LOCATIONS (SEE APPENDIX A FOR DATA)
- SURFACE PROJECTION OF SUBSURFACE CONTAMINATION

TA-10-1 FORMER LABORATORY AREA
TA-10-39 FORMER HOLDUP TANKS
TA-10-41 FORMER LIQUID WASTE DISPOSAL PIT
TA-10-42 FORMER LIQUID WASTE DISPOSAL PIT
TA-10-43 FORMER LIQUID WASTE DISPOSAL PIT
TA-10-48 FORMER SOLID WASTE DISPOSAL PIT
TA-10-50 FORMER CONCRETE TANK

NOTE:
THE DEPTH OF CONTAMINATION IN FEET AND CENTIMETERS IS SHOWN AT EACH CONTAMINATION AREA.



SOURCE LANL

FIGURE 2-5. SURFACE PROJECTION OF SUBSURFACE CONTAMINATION

499-317 9/81

TABLE 2-1

FB&DU SOIL SAMPLES FROM BAYO CANYON

Sample No.	Depth[a] (ft)	^{90}Sr (pCi/g)	^{238}U[b] (pCi/g)	^{40}K (pCi/g)
1A	0-3	1.60	1.5	26.3
1B	3-6	0.20	1.5	30.4
1C	6-9	<0.05	1.7	22.7
1D	9-12	0.38	1.6	29.0
1E	12-15	1.00	1.7	20.8
1F	12-20	<0.05	1.4	26.9
1G	20-25	<0.05	1.6	23.1
2A	0-3	<0.05	1.3	30.4
2B	3-6	<0.05	1.3	17.6
2C	6-9	<0.05	1.4	39.1
2D	9-12	<0.05	1.4	28.4
2E	12-15	<0.05	1.4	24.4
2F	15-20	<0.05	1.4	29.5
2G	20-25	<0.05	1.4	27.4
2H	25-30	0.37	1.6	27.7
2I	30-37	<0.05	1.8	33.2
3A	0-3	<0.05	1.1	24.9
3B	3-6	<0.05	1.2	33.5
3C	6-9	<0.05	1.1	26.9
3D	9-12	<0.05	1.2	31.9
3E	12-15	<0.05	1.5	31.3
3F	15-20	<0.05	1.9	28.9
4A	0-3	0.25	1.5	23.8
4B	3-6	0.12	1.5	27.4
4C	6-9	<0.05	1.9	21.6
4D	9-12	<0.05	2.0	61.1
4E	12-15	<0.05	1.4	24.9
4F	15-20	<0.05	1.1	25.6
4G	20-25	<0.05	1.4	27.3
5A	0-3	<0.05	0.63	22.6
5B	3-6	<0.05	1.3	28.5
5C	6-9	<0.05	0.97	30.8
5D	9-12	0.31	1.2	29.9
5E	12-15	<0.05	1.3	24.8
5F	15-20	0.14	1.5	28.9
5G	20-25	<0.05	1.3	25.5
5H	25-30	0.11	1.3	26.6
5I	30-37	<0.05	--	25.4

TABLE 2-1 (Cont)

FB&DU SOIL SAMPLES FROM BAYO CANYON

Sample No.	Depth[a] (ft)	^{90}Sr (pCi/g)	^{238}U[b] (pCi/g)	^{40}K (pCi/g)
6A	0-3	<0.05	0.77	22.0
6B	3-6	<0.05	0.77	25.3
6C	6-9	<0.05	--	25.4
6D	9-12	<0.05	0.83	25.8
6E	12-15	<0.05	0.90	25.6
6F	12-20	<0.05	1.0	26.3
6G	20-25	<0.05	1.2	28.3
6H	25-30	<0.05	1.6	30.4
6I	30-37	4.32	1.7	37.1
7A	0-3	<0.05	1.7	31.7
7B	3-6	<0.05	1.7	31.9
7C	6-9	<0.05	1.8	24.8
7D	9-12	<0.05	1.8	33.5
7E	12-15	<0.05	1.9	27.2
7F	15-18	<0.05	1.5	19.7
8A	0-3	<0.05	1.6	24.1
8B	3-6	<0.05	1.5	25.5
8C	6-9	<0.05	1.5	14.1
8D	9-12	<0.05	1.2	22.7
9	0-1	<0.05	1.5	20.2
10	0-1	0.69	1.0	27.4
11	0-1	0.12	1.6	23.1
12	0-1	0.22	1.4	29.9
13	0-1	<0.05	1.6	23.2
14	0-1	0.20	1.6	25.3

[a] Meters = $\frac{ft}{3.3}$

[b] LANL analysis of FB&DU samples.

TABLE 2-2

COMBINATION HAZARD INDEX AT BAYO CANYON SITE
FOR GROSS α PLUS GROSS β

Gross α (pCi/g)	HI	Gross β (pCi/g)	HI
40	1.000	0.0	0.000
39	0.975	2.5	0.025
38	0.950	5.0	0.050
37	0.925	7.5	0.075
36	0.900	10.0	0.100
35	0.875	12.5	0.125
34	0.850	15.0	0.150
33	0.825	17.5	0.175
32	0.800	20.0	0.200
31	0.775	22.5	0.225
30	0.750	25.0	0.250
29	0.725	27.5	0.275
28	0.700	30.0	0.300
27	0.675	32.5	0.325
26	0.650	35.0	0.350
25	0.625	37.5	0.375
24	0.600	40.0	0.400
23	0.575	42.5	0.425
22	0.550	45.0	0.450
21	0.525	47.5	0.475
20	0.500	50.0	0.500
19	0.475	52.5	0.525
18	0.450	55.0	0.550
17	0.425	57.5	0.575
16	0.400	60.0	0.600
15	0.375	62.5	0.625
14	0.350	65.0	0.650
13	0.325	67.5	0.675
12	0.300	70.0	0.700
11	0.275	72.5	0.725
10	0.250	75.0	0.750
9	0.225	77.5	0.775
8	0.200	80.0	0.800
7	0.175	82.5	0.825
6	0.150	85.0	0.850
5	0.125	87.5	0.875
4	0.100	90.0	0.900
3	0.075	92.5	0.925
2	0.050	95.0	0.950
1	0.025	97.5	0.975
0	0.000	100.0	1.000

CHAPTER 2 REFERENCES

1. "Radiological Survey of the Site of a Former Radioactive Liquid Waste Treatment Plant (TA-45) and the Effluent Receiving Areas of Acid, Pueblo, and Los Alamos Canyons;" Draft Report; Los Alamos Scientific Laboratory; Los Alamos, New Mexico; Contract W-7405-ENG-36; June 1980.

2. "Radiological Survey of Bayo Canyon, Los Alamos, New Mexico;" Final Report; Los Alamos Scientific Laboratory, Los Alamos, New Mexico; for U.S. Department of Energy, Assistant Secretary for Environment, Division of Environmental Control Technology, Washington, D.C.; under Contract No. W-7405-ENG-36; June 1979.

3. R.L. Griggs; "Geology and Ground-Water Resources of the Los Alamos Area, New Mexico;" U.S. Geological Survey Water-Supply Paper 1753; Washington, D.C.; 1964.

4. "Earthquake Information Bulletin;" Vol 7; No. 3; U.S. Department of the Interior, U.S. Geological Survey; May-June 1975.

CHAPTER 3

BASIC REMEDIAL ACTION ALTERNATIVES AND PROPOSED OPTIONS

CHAPTER 3

BASIC REMEDIAL ACTION ALTERNATIVES AND PROPOSED OPTIONS

The proposed options for remedial action for the contaminated areas at the Bayo Canyon site have been formulated based on the site-specific conditions described in Chapter 2 and on the basic remedial action alternatives considered in this chapter. A presentation of the basic alternatives and proposed options follows.

3.1 BASIC REMEDIAL ACTION ALTERNATIVES

There are five basic alternatives for categorizing the remedial actions for contaminated properties. From these five basic alternatives, three options for remedial action are described for the contaminated areas at the Bayo Canyon site. The five basic alternatives are defined in the paragraphs that follow.

3.1.1 Basic Alternative I - No Action

In this alternative, no action is taken at all; consequently, the contaminated property remains unchanged. This basic alternative is one of the possible courses of action that requires consideration based on Council of Environmental Quality guidelines.[1] From this alternative comes the base case against which population health effects analyses can be judged, and also the basis for comparing current environmental impacts with the impacts that would result from implementation of other alternatives.

3.1.2 Basic Alternative II - Minimal Action

Minimal action implies that no remedial actions are taken to clean up the contaminants. Minimal action involves only those measures which effectively limit public exposure to radioactive sources, such as restricting access to a contaminated property.

In general, this alternative requires that the property be purchased by a government agency and held in perpetuity, secured by fencing and posted with appropriate warning signs, maintained, and radiologically monitored periodically for water, soil, and air contamination.

3.1.3 Basic Alternative III - Stabilization/Entombment

Stabilization refers to the covering of a contaminated area with a required amount of compacted clean soil. Entombment involves the total encapsulation of contaminated materials with a permanent casing such as concrete.

Access to a site could be restricted, as could uses for the site. Periodic radiological monitoring of the environment normally is required, as is periodic maintenance.

3.1.4 Basic Alternative IV - Partial Decontamination

Partial decontamination involves remedial actions formulated to remove or contain easily accessible active or potentially active sources to prevent further contamination. For open lands, for example, surface contamination could be removed to prevent spreading. Highly radioactive soil could be removed, leaving soil with lower levels of contamination to be removed later. Contaminated ditches and streams could be cleaned up to stop the spread of contamination, leaving adjacent soil to be removed at a later time.

Access to the contaminated areas of the site could be restricted. A program of surveillance and maintenance normally is required to ensure containment of contamination.

3.1.5 Basic Alternative V - Decontamination and Restoration

Decontamination and restoration remedial actions are formulated so that all contamination can be removed from a property in order to make it available for unrestricted use. Contaminated soils are excavated to the extent needed to meet the appropriate decontamination criteria. All contaminated debris from buildings and contaminated soils are transported safely to an appropriate disposal site. Restoration of the property follows after completion of decontamination efforts. Certification by the DOE of decontamination then allows unrestricted use of the property.

3.2 REMEDIAL ACTION OPTIONS

In consideration of the basic alternative presented above, three remedial action options have been formulated for the areas containing subsurface contamination. Future use of the contaminated areas is dependent on the actions specified for each option.

Basic alternative II (Minimal Action) can be used as a foundation for an option for the Bayo Canyon site. The contaminants are effectively stabilized in place by overlayment of below-guideline soils and are separated from the water table. This eliminates the need for fencing and periodic radiological monitoring. Site surveillance would be performed to help prevent or detect any intrusion into the subsurface materials.

Basic alternative III (Stabilization/Entombment) is not used as a basis for formulation of an option for the Bayo Canyon site for several reasons. Foremost is that the surface contamination is of very low level and does not represent a hazard to persons using the area for recreational purposes.(2)

If the land use were changed (e.g. building houses, raising food, and digging into the subsurface contamination) health effects occur. The soil covering the subsurface contamination prevents health impacts. Entombment is impractical and would be more costly than complete decontamination and restoration. For these reasons this basic alternative is not a sound basis for formulating an option for the Bayo Canyon site.

Basic alternative IV (Partial Decontamination) appears to be impracticable for the Bayo Canyon site since no surface contamination exists and the subsurface contamination begins 10 ft (3 m) below the ground surface. Partial decontamination was accomplished by LANL when the site was decommissioned. Consequently, there is no readily available (surface) above-guideline contamination to be removed.

Basic alternative V (Decontamination and Restoration) is a viable approach for formulating an option for the Bayo Canyon site. An option based on this basic alternative would allow unrestricted use of the site property.

3.2.1 Option A - No Action

In this option, no action would be taken at the Bayo Canyon site, which means the property would remain unchanged and no costs would be incurred. The public would be informed that no action would be taken. Implementation of Option A must be considered so that the impacts of the current conditions can be compared with impacts that would result from implementation of other options. The impacts are addressed in the LANL environmental report.[2]

3.2.2 Option B - Minimal Action

For Option B, the area in which the above-guideline contamination is located is referred to as the "designated restricted area." (See Figure 2-4.) This area includes approximately 1.4 acres containing the former radiochemistry laboratory area and the former solid and liquid waste disposal areas. Implementation of Option B would not result in reducing the subsurface contamination. The LANL survey identified one surface sample location with above criteria contamination. The LANL reported that this evidently was an isolated spot that was eliminated when they took the soil sample. The LANL has not been able to relocate the contaminated spot. This indicates that above criteria surface contamination is not present at the Bayo Canyon site.

The designated restricted area in which the subsurface contamination exceeds the guideline criteria would require U.S. Government (or county) control or ownership to prevent the construction of housing, gardens, etc. until that time when radioactivity on the site has decayed to below-guideline levels. This restrictive covenant would last for approximately 160 yr.

This length of time would deplete the ^{90}Sr to less than 100 pCi/g. The requirement for governmental ownership and control is needed due to the intent of Los Alamos County to make Bayo Canyon available for a residential subdivision. This is being done because of the lack of suitable areas for expansion near the Los Alamos townsite. Monument markers would be emplaced in the six corners of the designated restricted area to note the presence of subsurface radioactivity. A crew of 4 would require from 5 to 10 days to complete the remedial actions. Finally, radiological surveys would be required before, during, and after remedial action to ensure that decontamination efforts accomplish the planned goals.

Peregrine falcons, an endangered species, nest near the site in Pueblo Canyon. They should not be disturbed between mid-April and August. Any remedial action should be accomplished with a minimum of noise during this period. Option B could be accomplished during this time period due to the nature of the minor actions involved. Actual remedial action dates and conditions would be subject to review and approval of the U.S. Fish and Wildlife Service.

3.2.3 Option C - Decontamination and Restoration with Disposal

Decontamination to meet the criteria for ^{90}Sr and ^{238}U would be completed in the contaminated areas. Excavation to a depth of approximately 25 ft (7.6 m) would be required at former solid waste pit TA-10-48, to a depth of approximately 30 ft (9.1 m) at former liquid waste pit TA-10-41, and to a depth of approximately 40 ft (12.2 m) at the TA-10-42 waste pit.

Excavation would be performed with conventional earthmoving equipment. The sides of the excavations would be sloped at approximately 45 degrees to prevent cave-ins. Sloped trenches would also be dug to provide equipment access to the excavation. Uncontaminated soil would be stockpiled at the excavation site to be reused later as backfill. Contaminated soil would be transported by truck to the LANL waste disposal site. The in situ volume of contaminated soil is estimated to be approximately 1520 yd^3. Although this is a relatively small volume, it would be necessary to excavate approximately 16,000 yd^3 of uncontaminated soil to accomplish the removal of the contaminated soil.

Soil stockpiled during excavation would then be returned to the resulting pits and compacted into place. Additional fill material would be required to replace contaminated soil. This material would be obtained as close to the site as possible as was done when the site was decommissioned in 1963. The area disturbed by excavation and stockpiling operations would then be revegetated. It is estimated that approximately 30,000 ft^2 would be disturbed by excavation and that approximately 45,000 ft^2 of the canyon floor would be disturbed by stockpiling the uncontaminated soil. Little top soil exists near the

site and revegetation would be accomplished directly on the backfill material. This approach was used successfully when the site was decommissioned.

After restoration, the site could be released for unrestricted use, and consequently neither U.S. Government control or ownership nor periodic surveillance or monitoring would be necessary. A crew of approximately 10 would require about 55 to 65 working days to complete the remedial actions. The suggested treatment involving the Peregrine falcon, described in Option B, also applies to this option.

TABLE 3-1

ACTIONS ASSOCIATED WITH PROPOSED OPTIONS
FOR REMEDIAL ACTION FOR THE BAYO CANYON SITE

Planning and Training[a]

1. Formulate remedial action specifications and plans.

   a. Determine areal extent of contamination.

   b. Determine depth of contamination.

2. Train labor force to work with contaminated materials and special equipment when required.

Option A - No Action

1. Inform public that no action is to be taken.

Option B - Minimal Action

1. Maintain federal (or county) ownership of the designated restricted area for a period of approximately 160 years so that activities can be controlled and disturbances of the subsurface contamination can be prevented (e.g., housing construction and gardening would not be allowed).

2. Install monument markers to note presence of subsurface contamination.

3. Provide precautionary health physics coverage when monuments are installed.

4. Institute quarterly federal (or county) surveillance to ensure compliance with restricted use in designated areas.

Option C- Decontamination and Restoration

1. Clear site.

2. Provide health physics coverage during remedial action.

3. Remove subsurface contamination to the depth necessary to meet guideline criteria and stockpile clean soil for backfill.

TABLE 3-1 (Cont)

Option C- Decontamination and Restoration (Cont)

4. Transport contaminated soils to the LANL disposal site.

5. Restore excavated areas with excavated clean fill and imported backfill.

6. Revegetate by seeding, fertilizing, and mulching.

7. Perform radiological surveys before, during, and after decontamination efforts to verify that remedial actions accomplish planned goals.

8. Obtain DOE certification of decontaminated areas, and release site for unrestricted use.

[a] All options will include planning and training. Typical planning and training steps for Option C are listed here and are not repeated under each option.

TABLE 3-2

ADVANTAGES AND DISADVANTAGES OF OPTIONS FOR REMEDIAL ACTION

Option	Advantages	Disadvantages
A[a]	1) No cost	1) Above-guideline subsurface contamination remains on site with potential for spread of contaminants
		2) ^{90}Sr contamination does not decay to 100-pCi/g level for 160 yr
B	1) Low cost	1) Above-guideline subsurface contamination remains on site with potential for spread of contaminants
	2) Accomplished quickly	2) ^{90}Sr contamination does not decay to 100-pCi/g level for 160 yr
	3) Exposure to surface radiation are below guideline levels	3) Some uses remain restricted for many years
		4) Governmental maintenance, periodic (e.g. quarterly) surveillance
		5) Government (or county) must maintain title to or control of designated restricted area
C	1) Permanent disposition of all excavated waste	1) Highest cost option

TABLE 3-2 (Cont)

Option	Advantages	Disadvantages
C (Cont)		
	2) Removal of the source of potential health impacts due to radioactivity on the site	2) Highest potential for accidents to occur
	3) No surveillance or radiological monitoring required after decontamination	3) Greatest short-term environmental impact
	4) No government or county ownership or control of designated restricted area required	
	5) Entire Bayo Canyon site available for unrestriced use	

[a] Although Option A contains no remedial action, it is included in the table for comparison.

CHAPTER 3 REFERENCES

1. "Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act"; Council on Environmental Quality, Executive Office of the President; 43FR55987-56007, 40CFR, Parts 1500-1508; Nov 29, 1978.

2. "Environmental Analysis of the Bayo Canyon Site, Los Alamos, New Mexico;" Los Alamos National Laboratory; Los Alamos, New Mexico; (in preparation).

CHAPTER 4

COST ESTIMATES

CHAPTER 4

COST ESTIMATES

The cost estimates for the proposed options for remedial action at Bayo Canyon in New Mexico are preliminary estimates developed to allow comparison between the options. The cost components include labor, material, equipment, demolition, excavation, transportation, disposal charges, restoration, health physics coverage, site maintenance, and site engineering. Other costs include overhead, engineering, and contractor fees. Estimated contingencies include but are not limited to such uncertainties and unpredictable expenses as strikes, bad weather delays, and procurement delays that impact the cost of implementation. All costs are presented in constant 1981 dollars without provisions for escalation, inflation, or the time value of money.

A summary of selected unit costs used in developing the cost estimates is shown in Table 4-1. These costs are from FB&DU's construction history, area contractors, equipment vendors, the current Robert Snow Means Company "Building Construction Cost Data" book, the McGraw-Hill Company "Dodge Guide", and the Nuclear Energy Services Inc. "Decommissioning Handbook" as prepared for the U.S. Department of Energy (Nov 1980).

A summary of working days and the number of workers that pertain to each option for remedial action is listed in Table 4-2. Specific contractors would use equipment, crew sizes, and schedules to meet their individual situations, and Table 4-2 is therefore valid only for relative comparison. Table 4-3 lists the options with their associated costs. The costs shown in Table 4-3 have been rounded in thousands of dollars on an individual line basis, and consequently may not match exactly the line item costs given in the body of this chapter. Totals, however, match to the closest thousand dollars. A summary of costs for each option is included in paragraph 4.4.

The Chapter 2 and Chapter 3 descriptions and the unit cost information presented in this chapter have been used to develop the costs for each option that are presented in the paragraphs that follow.

4.1 OPTION A - NO ACTION

Since no remedial action is performed, no expenses are incurred. The option is required for possible future NEPA processing and also provides the base case against which the costs and health effects of other options can be compared.

4.2 OPTION B - MINIMAL ACTION

As explained in Chapter 3, this option provides for federal or county government control of the designated restricted area by restrictive covenant for 160 yr. The designated restricted area comprises about 1.4 acres, which includes the radiochemistry laboratory area. Above-guideline contamination would remain undisturbed below the surface, and activities in the designated restricted area would be controlled by restrictive covenant. The restrictive covenant has no direct cost. Annual radiological monitoring is not needed under this option due to the overlying 10 ft (3 m) of below-guideline soil and separation from the ground water. Quarterly surveillance would be required to help prevent or detect any human intrusion into the contaminants. Surveillance would only involve a visual inspection of the property and would cost approximately $3,000 per year. A perpetual fund has been costed by using a 6 percent interest rate to generate the $3,000 required. An initial $50,000 would therefore be needed to establish the perpetual fund. Permanent monument markers would be placed in each corner of the designated restricted area. The costs associated with this option are shown below.

	Item	Cost ($)
a.	Surveillance and security fund of $50,000 at 6% interest = $3,000/yr	50,000
b.	Monument markers, 6 @ $1,000 each	6,000
c.	Health physics coverage during remedial action	3,000
	SUBTOTAL	$59,000
d.	Engineering 15%, (does not apply to surveillance and security fund)	1,350
e.	Contingency 30%, (does not apply to surveillance and security fund)	2,700
	TOTAL	$63,050
	ROUNDED TOTAL	$63,000

4.3 OPTION C - DECONTAMINATION AND RESTORATION WITH DISPOSAL

This option specifies the removal of all contamination at or above guideline criteria, regardless of depth. There are approximately 17,420 yd^3 to be removed. Of this total, 1,520 yd^3 (in-situ) are contaminated. This 1,520 yd^3 when excavated becomes 1,910 yd^3 bulk for transport to the LANL waste site. 1160 m^3

1460 m^3

The stockpiled soil and imported borrow would be placed in the excavation and compacted to the original density. Restoration would be completed by revegetating all disturbed areas.

Alternative methods of excavation could be considered in an effort to reduce the volume of excavated material. The use of sheet piling to shore the excavations might be one such method. However, the cost per cubic yard of excavation using such a method would be considerably higher. Conventional excavation methods have been used in this report. If a decontamination option is selected, detailed studies would be performed to consider other methods, such as the use of sheet piling, during the preparation of remedial action plans.

After implementing this option, the site would be released for unrestricted use. The costs associated with this option are:

	Item	Cost ($)
a.	Clear site, 1.75 acres	4,450
b.	Excavate clean soil, 15,900 yd^3	63,600
c.	Excavate contaminated soil, 1,520 yd^3	15,200
d.	Truck haulage to LANL site, 1,910 yd^3 bulk	19,500
e.	Disposal charges, 51,600 ft^3	103,200
f.	Place stockpiled clean soils, 15,900 yd^3	47,700
g.	Place imported backfill, 1,910 yd^3	9,550
h.	Seed, fertilize, and mulch 1.75 acres	2,650
i.	Health physics coverage	52,200
	SUBTOTAL	$318,050
j.	Engineering (15%)	47,700
k.	Contingency (30%)	95,400
	TOTAL	$461,150
	ROUNDED TOTAL	$461,000

4.4 COST SUMMARY

The estimated total cost of each option is summarized below:

Option	Title	Total Estimated Cost ($)
A	No Action	- 0 -
B	Minimal Action	63,000
C	Decontamination and Restoration with Disposal	461,000

TABLE 4-1

SELECTED UNIT COSTS FOR
BAYO CANYON SITE REMEDIAL ACTIONS

	Item	Unit	Cost ($)
a.	Site clearing	Acre	2,550.00
b.	Excavate clean soil	yd^3	4.00
c.	Excavate contaminated soil	yd^3	10.00
d.	Truck haulage to LANL waste site	yd^3	10.20
e.	Disposal charges	ft^3	2.00
f.	Place stockpiled backfill	yd^3	3.00
g.	Place imported backfill	yd^3	5.00
h.	Seed, fertilize, and mulch	Acre	1,500.00

TABLE 4-2

ESTIMATES OF REQUIRED WORKING DAYS AND CREW SIZES

Option	No. of Working Days	Average Crew Size
A	0	0
B	5-10	4
C	55-65	10

TABLE 4-3

COST ESTIMATES (IN THOUSANDS OF 1981 DOLLARS)

Remedial Action Item	Remedial Action Option A[a]	B[b]	C
Clear Site	-0-	-0-	4.5
Soil Excavation	-0-	-0-	78.8
Truck Haulage to LANL Site	-0-	-0-	19.5
Backfill	-0-	-0-	57.3
Seed, Fertilize, Mulch	-0-	-0-	2.7
Disposal Charge at Federal Site	-0-	-0-	103.2
Health Physics Coverage	-0-	3	52.2
Monument Markers	-0-	6	-0-
Surveillance and Security Fund	-0-	50	-0-
SUBTOTAL	-0-	59	318
Engineering (15%) and Contingency (30%)	-0-	4	143
TOTAL	-0-	63	461

[a] No Action.

[b] Contingencies are not applied to surveillance and security funds.

BAYO CANYON GLOSSARY

BAYO CANYON GLOSSARY

Abbreviations/Terms	Definitions
AEC	Atomic Energy Commission
alpha particle (α)	A positively charged particle emitted from certain radioactive material. It consists of two protons and two neutrons, hence is identical with the nucleus of the helium atom. It is the least penetrating of the common radiation (α, β, γ), hence is not dangerous unless alpha-emitting substances have entered the body.
aquifer	A water-bearing formation below the surface of the earth; the source of wells
background radiation	Naturally occurring low-level radiation to which all life is exposed. Background radiation levels vary from place to place on the earth.
beta particle (β)	A particle emitted from some atoms undergoing radioactive decay. A negatively charged beta particle is identical to an electron. A positively charged beta particle is called a positron. Beta radiation can cause skin burns and beta emitters are harmful if they enter the body.
Ci	Curie (the unit of radioactivity of any nuclide, defined as precisely equal to 3.7×10^{10} disintegrations/second)
daughter product	The nuclide remaining after a radioactive atom (parent) has undergone radiaoctive decay. A daughter atom also may be radioactive, producing further daughter products.

EGR	External gamma radiation (gamma radiation emitted from a source(s) external to the body, as opposed to internal gamma radiation emitted from ingested or inhaled sources)
EPA	Environmental Protection Agency
ERDA	Energy Research and Development Administration
erg	The basic unit of work or energy in the centimeter-gram-second system (One erg is equal to 7.4×10^8 ft-lb.)
exposure	Magnitude of radiation to which a person is subjected. It is defined and measured by electrical charge produced per unit mass of air.
exhalation	Emission of radon from earth (usually thought of as coming from a uranium tailings pile, but actually from any location)
FB&DU	Ford, Bacon & Davis Utah, Inc.
gamma background	Natural gamma ray activity everywhere present, originating from two sources: (1) cosmic radiation, bombarding the earth's atmosphere continually, and (2) terrestrial radiation. Whole body absorbed dose equivalent in the U.S. due to natural gamma background ranges from about 60 to about 125 mrem/yr.
gamma ray (γ)	High energy electromagnetic radiation emitted from the nucleus of a radioactive atom, with specific energies for the atoms of different elements and having high penetrating power
ground water	Subsurface water in the zone of full saturation which supplies wells and springs

health effect	Adverse physiological response to pollutants from tailings (In this report, one health effect is defined as one case of lung cancer produced from inhalation of radioactive materials.)
Interim Primary Drinking Water Regulations	Title No. 40 of the Code of Federal Regulations, EPA Chapter 1, Part 141, dated Jul 9, 1976.
μR/hr	Microroentgen per hour
mR/hr	Milliroentgen per hour
MPC	Maximum permissible concentration (the highest concentration in air or water of a particular radionuclide permissible for occupational or general exposure without taking steps to reduce exposure)
noble gas	One of the gases, such as helium, neon, radon, etc., with completely filled electron shells which is therefore chemically inert
NRC	Nuclear Regulatory Commission
nuclide	A general term applicable to all atomic forms of the elements; nuclides comprise all the isotopic forms of all the elements. Nuclides are distinguished by their atomic number, atomic mass, and energy state.
ORNL	Oak Ridge National Laboratory
pCi/l	Picocurie per liter
R	Roentgen (a unit of exposure to ionizing radiation. It is that amount of gamma or X-rays required to produce ions carrying 1 electrostatic

rad	The basic unit of absorbed dose of ionizing radiation. A dose of one rad means the absorption of 100 ergs of radiation energy per gram of absorbing material.
radioactivity	The spontaneous decay or disintegration of an unstable atomic nucleus, usually accompanied by the emission of ionizing radiation
radioactive decay chain	A succession of nuclides, each of which transforms by radioactive disintegration into the next, until a stable nuclide results. The first member is called the parent, the intermediate members are called daughters, and the final stable member is called the end product.
radium	A radioactive element chemically similar to barium, formed as a daughter product of uranium (^{238}U). The most common isotope of radium, ^{226}Ra, has a half-life of 1,600 yr. Radium is present in all uranium-bearing ores. Trace quantities of both uranium and radium are found in all areas, contributing to the gamma background.
radon	A radioactive, chemically inert gas, having a half-life of 3.8 days (^{222}Rn); formed as a daughter product of radium (^{226}Ra)
radon background	Low levels of radon gas found in an area, due to the presence of uranium or radium in the soil
radon concentration	The amount of radon per unit volume.
radon daughter	One of several short-lived radioactive daughter products of radon (Several of the daughters emit alpha particles.)

RDC	Radon daughter concentration (the concentration in air of short-lived radon daughters, expressed usually in pCi/l; also measured in terms of working level (WL))
radon flux	The quantity of radon emitted in a unit time per unit area (typical units are in pCi/m^2-s)
recharge	The processes by which water is absorbed and added to the zone of saturation of an aquifer, either directly into the formation or indirectly by way of another formation
rem	(Acronym for roentgen equivalent man) The unit of dose for any ionizing radiation which produces the same biological effect as a unit of absorbed dose of ordinary X-rays, numerically equal to the absorbed dose in rads multiplied by the appropriate quality factor for the type of radiation. The rem is the basic recorded unit of accumulated dose to personnel.
scintillometer	A radiation detection instrument used for monitoring small changes in background and for low-level radiation, normally utilizing a NaI crystal as a scintillator
WL	Working level. A unit of radon daughter exposure, equal to any combination of short-lived radon daughters in 1 liter of air that will result in the ultimate emission of 1.3×10^5 MeV of potential alpha energy. This level is equivalent to the energy produced in the decay of the daughter products RaA, RaB, RaC, and RaC' that are present under equilibrium conditions in a liter of air containing 100 pCi of ^{222}Rn. It does not include decay of RaD

(22 yr half-life) and subsequent daughter products.

WLM	Working level month. One WLM is equal to the exposure received from 170 WL hours.

APPENDIX A

LANL RADIOLOGICAL DATA

Extracted verbatim from "Radiological Survey of the Bayo Canyon, Los Alamos, New Mexico;" prepared for U.S. Department of Energy; prepared by Los Alamos Scientific Laboratory under contract W-7405-ENG-36; Final Report, Appendix D; June 1979.

APPENDIX D

SURVEY DATA

The data in this appendix consist of the 1977 survey results organized into 32 tables of which the first 30 deal with radioactivity in soil. Tables XXXI and XXXII deal with radioactivity in grasses. Corresponding data for rodents were omitted as unreliable because of insufficient biomass.

Gross alpha and gross beta results for soils (soils and bedrock) were obtained by scintillation counting described in Appendix B, Instrumentation. Available radiochemical analyses of some samples are presented with scintillator counter results to allow comparisons. Tables of results are arranged according to depth in the soil, and depth in turn is related to the sampling method as described in Section III, Methods. Tables D-I and D-II include ring samples and the 0-5 cm depth of profile samples. Tables D-III through D-V span the profile intervals from 5 cm to 30 cm. Tables D-VI through D-X relate to the 0-30 cm depth of soil. Samples from the latter were taken by core sampling. Table D-XI and D-XII are from the samples scooped from trenches dug by backhoe. The latter samples were used to evaluate the interval from 60 to 120 cm. Tables D-XIII through D-XXX were taken in 150 cm increments to as deep as 2000 cm by auger drill to evaluate depth intervals below 120 cm. Tables D-XXXIII and D-XXXIV contain data on penetrating radiation measurements. An index of tables precedes the actual data tables.

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TABLE D-I

GROSS-ALPHA AND -BETA ACTIVITY IN 0-5 CM LAYER
(pCi/g)

Location	Gross β	Gross α	Location	Gross β	Gross α	Location	Gross β	Gross α
CTR	1	25	C5-15	2	35	C7-24	3	8
CTR-5	0	32	C6-1	3	13	C7-25	3	19
CTR-5b	0	32	C6-2	2	32	C7-26	2	17
C1-1	3	44	C6-3	2	25	C7-27	2	10
C1-2	2	48	C6-4	4	14	C7-28	3	10
C1-3	4	27	C6-5	3	12	C7-29	2	14
C2-1	3	80	C6-6	0	23	C7-30	3	35
C2-2	3	27	C6-7	2	13	C8-1	6	8
C2-3	2	50	C6-8	2	0	C8-2	5	10
C2-4	4	36	C6-9	2	27	C8-3	6	11
C2-5	4	44	C6-10	1	19	C8-4	6	19
C2-6	3	29	C6-11	5	5	C8-5	5	25
C3-1	3	12	C6-12	2	19	C8-6	6	8
C3-2	2	36	C6-13	2	30	C8-7	4	27
C3-3	4	23	C6-14	2	14	C8-8	5	35
C3-4	2	41	C6-15	2	30	C8-9	3	37
C3-5	6	44	C6-16	2	36	C8-10	3	7
C3-6	2	31	C6-17	3	11	C8-11	5	10
C3-7	4	30	C6-18	3	22	C8-12	7	30
C3-8	2	16	C6-19	1	24	C8-13	5	21
C4-1	4	47	C6-20	2	30	C8-14	6	1
C4-2	1	5	C7-1	2	20	C8-15	5	25
C4-3	6	30	C7-2	2	45	C8-16	5	10
C4-4	3	20	C7-3	1	29	C8-17	6	10
C4-5	3	20	C7-4	3	22	C8-18	4	9
C4-6	8	25	C7-5	3	8	C8-19	4	29
C4-7	3	12	C7-6	3	16	C8-20	4	4
C4-8	3	23	C7-7	1	17	C8-21	3	25
C4-9	3	18	C7-8	2	2	C8-22	2	20
C4-10	3	30	C7-9	2	16	C8-23	3	5
C5-1	1	26	C7-10	2	7	C8-24	3	0
C5-2	6	14	C7-11	1	29	C8-25	3	16
C5-3	3	36	C7-12	4	2	C8-26	1	0
C5-4	4	20	C7-13	4	13	C8-27	4	16
C5-5	3	74	C7-14	3	10	C8-28	1	7
C5-6	4	27	C7-15	3	13	C8-29	2	0
C5-7	3	23	C7-16	2	25	C8-30	3	32
C5-8	4	16	C7-17	3	11	C9-1	4	12
C5-9	4	41	C7-18	3	13	C9-2	3	18
C5-10	3	29	C7-19	2	27	C9-3	5	26
C5-11	4	29	C7-20	2	25	C9-4	4	15
C5-12	3	29	C7-21	1	18	C9-5	4	18
C5-13	3	26	C7-22	4	22	C9-6	5	22
C5-14	4	45	C7-23	3	23	C9-7	1	60

TABLE D-I (cont)

Location	Gross β	Gross α
C9-8	4	57
C9-9	7	32
C9-10	4	53
C9-11	5	38
C9-12	5	36
C9-13	4	24
C9-14	7	18
C9-15	3	44
C9-16	4	23
C9-17	4	34
C9-18	3	33
C9-19	3	54
C9-20	2	38
C9-21	1	14
C9-22	5	24
C9-23	5	10
C9-24	3	18
C9-25	3	10
C9-26	4	5
C9-27	4	16
C9-28	4	32
C9-29	5	10
C9-30	5	2
C9-31	5	22
C9-32	4	2
C9-33	4	17
C9-34	3	27
C9-35	3	14
C9-36	5	16
C9-37	8	10
C9-38	6	13
C9-39	4	20
C9-40	5	12
C9-41	5	7
C9-42	7	15
C9-43	4	10
C9-44	3	9
C9-45	5	15
WA-1	5	44
WA-2	2	14
WA-3	1	12
WA-4	1	16
WA-5	5	14
WB-1	3	23
WB-2	1	10
WB-3	3	8
WB-4	2	11
WB-5	2	24
WC-1	4	8
WC-2	3	17
WC-3	7	11

Location	Gross β	Gross α
WC-4	1	7
WC-5	3	6
WD-5	2	8
WD-6	7	6
EA-1	1	4
EA-2	1	24
EA-3	1	20
EA-4	5	24
EA-5	3	10
EA-6	2	30
EB-1	3	14
EB-2	2	23
EB-3	36	2
EB-4	3	8
EB-5	2	6
EB-6	2	18
EC-1	6	22
EC-2	2	7
EC-3	2	17
EC-4	1	8
EC-5	0	22
EC-6	4	17
ED-1	1	6
ED-2	6	14
ED-3	1	22
ED-4	3	10
ED-5	1	11
ED-6	2	18
C2-1P	4	38
C3-5P	7	32
C6-17P	6	22
C7-18P	5	5
C8-2P	5	10
C8-14P	5	1
C9-3P	5	26
C9-45P	3	23
WB-5P	5	39
WC-3P	5	2
EB-2P	6	24
EC-1P	6	22
SC-2BP	4	17
SC-4CP	2	14
SC-6CP	1	0
SC-7CP	3	4
TA10-1#1	2	18
TA10-1#2	2	14
TA10-3	4	19
TA10-4	3	19
TA10-5	3	4
TA10-7	2	7
TA10-21	3	26

TABLE D-II

GROSS-ALPHA AND -BETA ACTIVITY VS SELECTED RADIOCHEMICAL ANALYSES IN THE 0-5 CM LAYER

(pCi/g except as noted)

Location	Gross β	^{90}Sr	^{137}Cs	Gross α	U-T[a]	^{238}Pu	^{239}Pu
CTR	1	0.75	0.12	25	4.2	0.0	0.014
CTR-5	0	0.78	0.21	32	4.1	0.0	0.014
CTR-5b	0	0.46	0.0	32	4.4	0.0	0.027
C1-3	4	3.45	---	27	9.5	---	---
C2-1	3	(3.40)[b]	---	80	(0.54)[b]	---	0.058
C2-4	4	4.13	---	36	7.8	---	---
C5-2	6	3.27	0.15	14	4.3	0.0	0.0
C5-5	3	0.60	---	74	4.0	---	---
C5-11	4	1.95	---	29	8.9	---	---
C6-11	5	0.41	---	5	4.6	---	---
C7-9	2	0.61	---	16	4.7	---	---
C7-21	1	0.23	---	18	7.0	---	---
C8-1	6	0.89	1.49	8	3.6	0.027	0.03
C8-16	5	0.79	---	10	4.5	0.14	8.76
C8-17	6	2.5	2.13	10	3.7	0.0	0.079
C9-8	4	0.45	0.579	58	3.5	0.0	0.032
C9-10	4	0.49	0.688	53	3.3	0.0	0.066
C9-14	7	0.69	---	18	4.5	---	---
C9-19	3	1.00	1.85	54	3.2	0.0	0.166
C9-33	4	3.7	---	17	5.9	---	---
WA-1	5	0.87	---	44	3.6	---	---
WA-5	5	0.48	---	14	3.4	---	---
WD-6	7	0.97	---	6	5.6	---	---
EA-4	5	0.30	0.33	24	3.7	0.0	0.022
EB-3	36	132.0	1.14	2	2.4	0.009	0.076
EC-6	4	0.221	0.16	17	2.6	0.0	0.0
ED-2	6	0.29	0.20	14	4.6	0.0	0.03
C2-1P	4	3.4	---	38	0.54	---	---
C3-5P	7	3.8	---	32	12.0	---	---
C6-17P	6	0.218	---	22	2.9	---	---
C7-18P	5	0.62	---	5	4.1	---	---
C8-2P	5	0.55	0.20	10	2.5	0.0	0.0
C8-14P	5	0.207	---	2	3.0	---	---
C9-3P	5	0.63	0.73	26	3.9	0.0	0.013
C9-45P	3	0.34	0.30	23	6.8	0.0	0.20
WB-5P	11	0.191	---	39	3.9	---	---
WC-3P	5	0.73	---	2	4.8	---	---
EB-2P	6	0.09	0.50	24	3.4	0.0	0.020
EC-1P	6	0.98	1.51	22	2.9	0.0	0.052
SC-2BP	4	8.20	---	17	7.6	---	---
SC-4CP	2	0.0	---	14	4.7	---	---
SC-6CP	1	0.078	0.0	0	2.1	0.003	0.0
SC-7CP	3	0.36	0.49	4	2.5	0.0	0.013
TA10-1#1	2	5.40	0.25	18	3.2	0.004	0.098
TA10-1#2	2	2.81	0.38	14	2.3	0.015	0.030
TA10-3	4	1.54	0.47	19	1.7	0.0	0.029
TA10-4	3	1.92	0.18	19	1.3	0.0	0.019
TA10-5	3	1.87	0.38	4	1.5	0.006	0.02
TA10-7	2	0.69	0.18	7	2.1	0.005	0.008
TA10-21	3	0.47	0.31	26	2.4	0.001	0.0113

[a]Total uranium in $\mu g/g$.

[b]See C2-1P

TABLE D-III

GROSS-ALPHA AND -BETA ACTIVITY VS SELECTED RADIOCHEMICAL ANALYSES IN THE 5-10 CM LAYER
(pCi/g except as noted)

Location	Gross β	^{90}Sr	^{137}Cs	Gross α	U-T[a]	^{239}Pu	^{238}Pu
C2-1P	4	0.31	---	22	3.0	---	---
C3-5P	6	1.73	---	21	5.9	---	---
C6-17P	6	0.08	---	2	2.7	---	---
C7-18P	4	0.43	---	25	4.1	---	---
C8-2P	4	0.40	0.0	34	2.2	0.0	0.0
C8-14P	4	0.55	---	18	3.1	---	---
C9-3P	5	0.82	0.48	36	3.6	0.0	0.018
C9-45P	4	0.30	0.19	26	1.6	0.0047	0.018
WB-5P	4	0.289	---	22	3.1	---	---
WC-3P	6	0.173	---	2	4.4	---	---
EB-2P	5	1.03	0.0	23	3.4	0.0	0.0
EC-1P	4	0.10	0.0	15	2.1	0.0	0.0
SC-2BP	6	2.77	---	41	2.3	---	---
SC-4CP	3	0.28	---	18	3.1	---	---
SC-6CP	3	0.26	0.0	8	1.9	0.0017	0.004
SC-7CP	3	0.20	0.0	5	2.1	0.0	0.0076
TA10-1#1	4	3.99	0.11	30	2.6	0.014	0.007
TA10-1#2	4	3.85	0.071	17	1.4	0.0	0.054
TA10-3	2	2.64	0.17	14	2.5	0.034	0.076
TA10-4	3	1.41	0.12	4	1.4	0.0	0.0
TA10-5	3	2.93	0.24	23	1.4	0.004	0.030
TA10-7	3	0.48	0.09	29	2.0	0.0	0.0101
TA10-21	3	0.15	0.042	37	2.0	0.0	0.007

[a]Total uranium in $\mu g/g$.

TABLE D-IV

GROSS-ALPHA AND -BETA ACTIVITY VS SELECTED RADIOCHEMICAL ANALYSES IN THE 10-20 CM LAYER
(pCi/g except as noted)

Location	Gross β	^{90}Sr	^{137}Cs	Gross α	U-T*	^{239}Pu	^{240}Pu
C2-1P	4	0.211	---	37	3.4	---	---
C3-5P	3	0.025	---	23	3.1	---	---
C6-17P	5	0.07	---	8	2.8	---	---
C7-18P	4	0.07	---	26	3.2	---	---
C8-2P	5	0.177	0.0	30	2.2	0.0	0.015
C8-14P	7	0.34	---	16	3.1	---	---
C9-3P	4	0.52	0.0	2	3.7	0.0	0.013
C9-45P	3	0.38	0.14	5	2.9	0.0077	0.013
WB-5P	6	0.193	---	10	3.4	---	---
WC-3P	5	0.172	---	10	4.8	---	---
EB-2P	5	0.212	0.0	9	3.1	0.0	0.013
EC-1P	4	0.110	0.0	14	2.4	0.0	0.021
SC-2BP	4	2.62	---	37	3.0	---	---
SC-4CP	2	0.61	---	26	3.1	---	---
SC-6CP	1	0.23	0.08	2	1.2	0.0	0.011
SC-7CP	3	0.32	0.47	7	1.6	0.0039	0.0087
TA10-1#1	4	3.30	0.0	23	2.2	0.0	0.011
TA10-1#2	3	3.56	0.071	23	1.9	0.0076	0.019
TA10-3	3	5.17	0.22	18	2.3	0.0	0.122
TA10-4	1	0.70	0.0	8	1.9	0.0	0.0
TA10-5	3	2.91	0.02	20	1.4	0.005	0.036
TA10-7	3	0.23	0.035	23	2.9	0.014	0.011
TA10-21	4	0.18	0.0	22	2.0	0.0	0.0

*Total uranium in $\mu g/g$.

TABLE D-V

GROSS-ALPHA AND -BETA ACTIVITY VS SELECTED RADIOCHEMICAL ANALYSES IN THE 20-30 CM LAYER
(pCi/g except as noted)

Location	Gross β	^{90}Sr	^{137}Cs	Gross β	U-T[a]	^{238}Pu	^{239}Pu
C2-1P	5	0.05	---	1	2.9	---	---
C3-5P	4	0.189	---	24	2.9	---	---
C6-17P	3	0.243	---	6	2.8	---	---
C7-18P	4	0.0	---	8	3.9	---	---
C8-2P	5	0.222	0.0	22	2.6	0.0	0.011
C8-14P	4	0.19	---	5	3.5	---	---
C9-3P	2	0.215	0.0	2	3.3	0.0	0.0
C9-45P	3	0.17	0.10	13	3.1	0.0088	0.019
WB-5P	4	0.141	---	15	3.1	---	---
WC-3P	6	0.06	---	2	4.4	---	---
EB-2P	4	0.254	0.0	20	3.2	0.0	0.016
EC-1P	4	0.114	0.0	12	2.4	0.0	0.0
SC-2BP	5	3.81	---	38	2.8	---	---
SC-4CP	4	1.00	---	11	3.2	---	---
SC-6CP	1	0.29	0.12	6	1.5	0.0	0.003
SC-7CP	3	0.27	0.50	5	1.8	0.0	0.020
TA10-1#1	2	2.23	0.034	10	1.6	0.0	0.012
TA10-1#2	4	4.16	0.057	25	1.1	0.010	0.019
TA10-3	2	0.57	0.07	32	1.9	0.004	0.031
TA10-4	3	0.54	0.051	10	2.5	0.0	0.002
TA10-5	4	1.04	0.0	10	3.3	0.0	0.005
TA10-7	3	0.16	0.042	17	2.5	0.0022	0.0045
TA10-21	2	0.27	0.058	13	3.6	0.0	0.005

[a]Total uranium in $\mu g/g$.

TABLE D-VI
GROSS-ALPHA AND -BETA ACTIVITY IN 0-30 CM LAYER
(pCi/g)

Location	Gross β	Gross α	Location	Gross β	Gross α	Location	Gross β	Gross α
CTR	2	35	C6-5	1	22	C8-2	6	25
C1-1	2	52	C6-6	5	26	C8-3	6	20
C1-2	3	51	C6-7*			C8-4	3	15
C1-3	2	32	C6-8	1	19	C8-5	5	10
C2-1	1	29	C6-9	2	44	C8-6	6	26
C2-2	2	62	C6-10	3	22	C8-7	5	8
C2-3	2	29	C6-11	3	17	C8-8	4	46
C2-4	2	39	C6-12	3	23	C8-9	4	42
C2-5	3	23	C6-13	2	32	C8-10	5	26
C2-6	1	39	C6-14	3	37	C8-11	5	17
C3-1	1	20	C6-15	2	19	C8-12*		
C3-2	3	25	C6-16	2	22	C8-13	5	4
C3-3	2	24	C6-17	1	29	C8-14	4	15
C3-4	1	47	C6-18	1	23	C8-15	5	11
C3-5	3	25	C6-19	2	29	C8-16	4	20
C3-6	4	16	C6-20	2	26	C8-17	4	35
C3-7	4	30	C7-1	2	41	C8-18	6	25
C3-8	4	32	C7-2	5	14	C8-19	5	19
C4-1	3	51	C7-3	5	27	C8-20	5	11
C4-2	2	12	C7-4	4	27	C8-21	4	20
C4-3	3	38	C7-5	1	17	C8-22	3	5
C4-4	4	25	C7-6*			C8-23	3	5
C4-5	3	26	C7-7	2	29	C8-24	3	2
C4-6	2	45	C7-8	2	19	C8-25	3	14
C4-7	2	47	C7-9*			C8-26	3	1
C4-8	2	30	C7-10	2	22	C8-27	4	11
C4-9	2	35	C7-11	1	18	C8-28	2	4
C4-10	4	48	C7-12	3	13	C8-29	2	22
C5-1	2	30	C7-13	2	13	C8-30	2	32
C5-2	2	27	C7-14	5	0	C9-1	7	15
C5-3	4	26	C7-15	2	17	C9-2	2	15
C5-4	1	29	C7-16	6	9	C9-3	4	21
C5-5	4	38	C7-17	3	30	C9-4	4	24
C5-6	3	23	C7-18	2	41	C9-5	4	45
C5-7	3	26	C7-19	3	12	C9-6	3	12
C5-8	3	12	C7-20	4	23	C9-7*		
C5-9	4	19	C7-21	4	23	C9-8	4	53
C5-10	7	42	C7-22	2	22	C9-9	3	45
C5-11	4	32	C7-23	2	7	C9-10	3	73
C5-12	3	12	C7-24	3	11	C9-11	5	50
C5-13	3	23	C7-25	2	10	C9-12*		
C5-14	3	24	C7-26	4	20	C9-13	4	16
C5-15	0	35	C7-27	2	14	C9-14	3	23
C6-1	2	36	C7-28	1	0	C9-15	4	21
C6-2	6	10	C7-29	2	30	C9-16	3	54
C6-3	3	24	C7-30	2	23	C9-17	3	36
C6-4	1	16	C8-1	2	36	C9-18*		

*Not sampled; bedrock < 30 cm.

TABLE D-VI (cont)

Location	Gross β	Gross α	Location	Gross β	Gross α	Location	Gross β	Gross α
C9-19*			EB-6	6	22	SC-6C1	2	11
C9-20*			EC-1	1	6	SC-6C2	3	50
C9-21	4	22	EC-2	1	0	SC-6C3	1	4
C9-22	4	14	EC-3	1	13	SC-7C1	2	17
C9-23	9	8	EC-4	5	1	SC-7C2	2	2
C9-24	6	21	EC-5	3	10	SC-7C3	1	12
C9-25	4	24	EC-6	2	16	SC-8C1	2	48
C9-26	5	4	ED-1	2	20	SC-8C2	2	50
C9-27	4	10	ED-2	2	0	SC-8C3	3	37
C9-28	5	10	ED-3	2	17	SC-1D1	2	27
C9-29	5	9	ED-4	2	10	SC-1D2	3	25
C9-30*			ED-5	2	12	SC-1D3	2	36
C9-31*			ED-6	5	26	SC-2D1	2	25
C9-32	4	10	C2-1P	4	24	SC-2D2	4	30
C9-33*			C3-5P	5	37	SC-2D3	2	47
C9-34	3	19	C6-17P	5	10	SC-3D1	2	33
C9-35	2	30	C7-18P	5	16	SC-3D2	2	23
C9-36	4	15	C8-2P	5	24	SC-3D3	2	27
C9-37	5	24	C8-14P	5	10	SC-4D1	3	18
C9-38	6	10	C9-3P	4	17	SC-4D2	2	27
C9-39	5	36	C9-45P	3	17	SC-4D3	1	16
C9-40*			WB-5P	5	22	SC-2BP	5	33
C9-41	6	28	WC-3P	6	4	SC-4CP	3	17
C9-42	5	23	EB-2P	5	19	SC-6CP	2	4
C9-43	6	6	EC-1P	5	16	SC-7CP	3	5
C9-44	4	7	SC-1A1	4	17	10-1N	4	33
C9-45	5	12	SC-1A2	4	17	10-1E	4	29
WA-1	2	38	SC-1A3	6	23	10-2E	3	22
WA-2	1	23	SC-2A1	7	41	10-3E	2	35
WA-3	1	18	SC-2A2	3	30	10-4E	2	24
WA-4	1	12	SC-2A3	2	42	10-5E	3	37
WA-5	3	25	SC-1B1	5	35	10-6E	2	12
WB-1	3	13	SC-1B2	4	19	10-7E	4	16
WB-2	1	12	SC-1B3	6	18	10-8E	0	30
WB-3	5	10	SC-2B1	4	37	10-1W	2	30
WB-4	1	19	SC-2B2	4	37	10-2W	1	33
WB-5	2	22	SC-2B3	3	39	10-3W	2	18
WC-1	5	13	SC-3B1	12	14	10-4W	3	25
WC-2	2	12	SC-3B2	5	25	10-5W	4	27
WC-3	2	14	SC-3B3	7	35	10-6W	3	12
WC-4	3	0	SC-1C1	2	12	10-7W	2	33
WC-5	1	10	SC-1C2	1	19	1001	1	17
WD-5	2	20	SC-1C3	2	17	1002	4	1
WD-6	2	6	SC-2C1	2	42	1003	3	19
EA-1	2	47	SC-2C2	2	8	1004	3	33
EA-2	2	7	SC-2C3	3	18	1005	3	25
EA-3	1	29	SC-3C1	2	19	1006	2	19
EA-4	3	22	SC-3C2	3	31	1008	5	27
EA-5	4	24	SC-3C3	1	33	TA10-1*1P	3	20
EA-6	2	41	SC-4C1	1	22	TA10-1*2P	3	20
EB-1	4	24	SC-4C2	2	14	TA10-3P	3	21
EB-2	2	32	SC-4C3	1	17	TA10-4P	3	10
EB-3	4	19	SC-5C1	1	35	TA10-5P	3	14
EB-4	3	22	SC-5C2	2	36	TA10-7P	3	19
EB-5	1	23	SC-5C3	2	31	TA10-21P	3	24

*Not sampled; bedrock <30 cm.

TABLE D-VII

GROSS-ALPHA AND -BETA ACTIVITY VS SELECTED RADIOCHEMICAL ANALYSES IN THE 0-30 CM LAYER
(pCi/g except as noted)

Location	Gross β	^{90}Sr	^{137}Cs	Gross α	U-T[a]	^{238}Pu	^{239}Pu
CTR	2	0.34	0.0	35	3.6	0.0	0.027
C3-3	2	0.41	---	24	7.0	---	---
C3-7	4	4.05	---	30	12.0	---	---
C4-2	2	0.36	---	12	6.9	---	---
C5-9	4	0.61	---	18	4.6	---	---
C6-2	6	1.23	0.0	10	4.9	0.0	0.0
C6-6	5	0.49	---	26	3.8	---	---
C6-15	2	0.23	---	19	4.9	---	---
C7-2	5	0.54	0.19	14	4.4	0.0	0.0
C7-16	6	0.79	---	9	5.5	---	
C8-9	4	0.27	---	42	3.4	---	---
C8-21	4	0.23	---	20	7.8	---	---
C9-1	7	0.43	0.0	15	3.3	0.0	0.12
C9-24	6	0.45	---	21	4.5	---	---
WB-3	5	0.237	---	10	2.9	---	---
WC-1	5	0.223	---	13	3.8	---	---
EB-6	6	0.267	0.26	22	3.3	0.0	0.026
EC-4	5	0.60	0.0	1	1.6	0.0	0.08
ED-6	5	0.144	0.26	26	4.1	0.0	0.026
C2-1P	4	0.70	---	24	2.69	---	---
C3-5P	5	0.99	---	37	4.98	---	---
C6-17P	5	0.15	---	10	2.80	---	---
C7-18P	5	0.20	---	16	3.70	---	---
C8-2P	5	0.29	0.05	24	2.38	0.0	0.01
C8-14P	5	0.30	---	10	3.18	---	---
C9-3P	4	0.49	0.30	17	3.63	0.0	0.01
C9-45P	3	0.29	0.18	17	3.40	0.01	0.02
WB-5P	5	0.19	---	22	3.3	---	---
WC-3P	6	0.23	---	4	4.60	---	---
EB-2P	5	0.34	0.13	19	3.2	0.0	0.01
EC-1P	5	0.26	0.38	16	2.4	0.0	0.0
SC-3B1	12	4.27	---	14	7.2	---	---
SC-3B2	5	8.77	---	25	5.9	---	---
SC-3B3	7	23.2	---	35	19.0	---	---
SC-8C1	2	0.17	0.19	48	1.5	0.0	0.007
SC-8C2	2	0.59	0.50	50	2.5	0.004	0.022
SC-8C3	3	0.28	0.14	37	1.6	0.0	0.024
SC-2BP	5	3.97	---	33	3.97	---	---
SC-4CP	3	0.58	---	17	3.53	---	---
SC-6CP	2	0.23	0.05	4	1.68	0.0	0.0
SC-7CP	3	0.29	0.37	5	2.00	0.0	0.01
10-1N	4	0.95	---	33	4.2	---	---
10-1E	4	3.5	---	29	6.6	---	---
10-2E	3	1.86	---	22	3.6	---	---
10-3E	2	2.18	---	35	3.8	---	---

TABLE D-VII (cont)

Location	Gross β	^{90}Sr	^{137}Cs	Gross α	U-T*	^{238}Pu	^{239}Pu
10-4E	2	1.64	---	24	3.4	---	---
10-5E	3	4.23	---	37	3.0	---	---
10-6E	2	3.95	---	12	3.1	---	---
10-7E	4	3.64	---	16	5.4	---	---
10-8E	0	2.18	---	30	11.1	---	---
10-1W	2	1.55	---	30	3.4	---	---
10-2W	1	2.59	---	33	50.0	---	---
10-3W	2	2.86	---	18	10.0	---	---
10-4W	3	1.55	---	25	3.3	---	---
10-5W	4	4.09	---	27	3.4	---	---
10-6W	3	3.00	---	12	3.1	---	---
10-7W	2	0.62	---	33	3.5	---	---
1001	1	2.36	---	17	1.7	---	---
1002	4	1.14	---	1	8.4	---	---
1003	3	0.41	---	19	7.4	---	---
1004	3	2.91	---	33	6.5	---	---
1005	3	3.86	---	25	3.3	---	---
1006	2	2.00	---	19	5.7	---	---
1008	5	6.91	---	27	3.3	---	---
TA10-1#1P	3	3.73	0.10	20	2.40	0.0	0.03
TA10-1#2P	3	3.60	0.14	20	1.68	0.01	0.03
TA10-3P	3	2.48	0.23	21	2.10	0.01	0.06
TA10-4P	3	1.17	0.09	10	1.78	0.0	0.01
TA10-5P	3	2.19	0.16	14	1.90	0.0	0.02
TA10-7P	3	0.39	0.09	19	2.38	0.01	0.01
TA10-21P	3	0.27	0.10	24	2.50	0.0	0.01

*Total uranium in $\mu g/g$.

TABLE D-VIII
GROSS-ALPHA AND -BETA ACTIVITY VS PENETRATING DOSE FROM THE 0-30 CM LAYER
(pCi/g vs μR/h)

Location	Gross β	Gross α	Pen. Dose[a]
CTR	2	35	20.00
C1-1	2	52	20.00
C2-1	1	29	20.80
C2-4	2	39	21.00
C3-1	1	20	21.18
C4-5	3	26	20.00
C4-8	2	30	20.00
C5-1	2	30	21.00
C5-5	4	38	20.00
C5-10	7	42	18.00
C6-1	2	36	18.00
C6-2	6	10	21.00
C6-3	3	24	21.00
C6-4	1	16	21.00
C6-7	---	---	23.00
C6-10	3	22	23.00
C6-13	2	32	20.00
C6-16	2	22	20.00
C6-19	2	29	18.00
C7-1	2	41	20.50
C7-3	5	27	19.43
C7-4	4	27	21.00
C7-5	1	17	22.00
C7-7	2	29	22.00
C7-10	2	22	23.00
C7-15	2	17	22.00
C7-16	6	9	24.26
C7-17	3	30	21.34
C7-18	2	41	20.50
C7-19	3	12	20.54
C7-20	4	23	20.04
C7-21	4	23	20.92
C7-22	2	22	21.84
C7-23	2	7	22.30
C7-24	3	11	24.14
C7-25	2	10	22.60
C7-26	4	20	23.12
C7-27	2	14	20.29
C7-28	1	0	18.83
C8-1	2	36	20.00
C8-2	6	25	19.18
C8-3	6	20	19.67
C8-4	3	15	22.00
C8-13	5	4	21.70
C8-14	4	15	26.12
C8-15	5	11	22.77
C8-16	4	20	21.70
C8-17	4	35	20.85
C8-18	6	25	21.00
C8-19	5	19	22.23
C8-20	5	11	22.61
C8-22	3	5	22.75
C8-23	3	5	24.83
C8-24	3	2	24.70
C8-25	3	14	22.75
C8-26	3	1	23.03
C8-27	4	11	23.73
C8-28	2	4	21.66
C9-1	7	15	21.18
C9-2	2	15	18.96
C9-3	4	21	23.73
C9-4	4	24	22.00
C9-7	---	---	19.52
C9-8	4	53	18.70
C9-9	3	45	19.55
C9-10	3	73	19.08
C9-11	5	50	18.97
C9-12	---	---	18.48
C9-16	3	54	20.19
C9-17	3	36	18.20
C9-18	---	---	19.36
C9-19	---	---	19.21
C9-20	---	---	19.08
C9-22	4	14	23.72
C9-23	9	8	21.00
C9-24	6	21	21.22
C9-25	4	24	21.03
C9-26	5	4	17.66
C9-27	4	10	21.60
C9-28	5	10	23.38
C9-29	5	9	24.35
C9-30	---	---	24.35
C9-33	---	---	22.00
C9-40	---	---	20.00

[a]Total penetrating photon dose from all sources in μR/h.

TABLE D-IX

NATURALLY OCCURRING URANIUM AND THORIUM IN SURFACE SOIL
(μg/g)

Location	U-T[a]	^{232}Th
C8-17	3.70	16.8
C9-8	3.50	20.1
C9-10	3.30	16.6
C9-19	3.20	15.7
EB-3	2.40	11.9
SC-8C1	1.60	12.3
SC-8C2	2.50	11.5
SC-8C3	1.50	9.2

[a]Total uranium

TABLE D-X

IN SITU MEASUREMENT[a] OF NATURALLY OCCURRING RADIONUCLIDES VS PENETRATING DOSE ESTIMATES[b]

Location	^{40}K (pCi/g)	U-T (μg/g)	^{232}Th (μg/g)	μR/hr
No. Mesa (GLO Landmark)	35.5	6.09	19.5	23.89
No. Mesa (Stables)	29.5	3.98	15.1	20.44
WB-3	32.7	5.09	16.4	21.54
Bayo Floor (Pit under Bayo Point)	33.9	5.33	16.9	22.16
C9-27	37.3	8.09	22.7	26.14
EB-3	35.0	3.91	13.8	20.55
Otowi Mesa (Survey Landmark)	32.8	0.51	16.1	18.95

[a]GeLi γ spectral analyses.

[b]Estimate includes 0.45 μR/h for fallout and ~7 μR for cosmic influence.

TABLE D-XI
GROSS-ALPHA AND -BETA ACTIVITY IN 60-120 CM LAYER

(pCi/g)

Location	Gross β	Gross α	Location	Gross β	Gross α	Location	Gross β	Gross α
BDH-1	4	47	BDH-26	4	49	BDH-46	3	49
BDH-2	2	26	BDH-27	8	42	BDH-47	2	39
BDH-3	1	24	BDH-28	7	36	BDH-48	2	62
BDH-4	4	20	BDH-29	2	37	BDH-49&50	4	26
BDH-5	2	18	BDH-30	13	41	BDH-51	3	35
BDH-6	4	44	BDH-31	3	29	BDH-52	4	56
BDH-7	4	27	BDH-32	3	39	BDH-53	2	20
BDH-8&9	3	47	BDH-33	2	41	BDH-54	9	44
BDH-10	5	23	BDH-34	4	22	BDH-55	2	23
BDH-11	2	49	BDH-33&34	2	32	BDH-56	2	36
BDH-12	2	48	BDH-35	3	36	BDH-57	3	51
BDH-13	2	47	BDH-36	4	25	BDH-58	2	8
BDH-14	2	39	BDH-35&36	4	38	BDH-59	12	6
BDH-15	1	25	BDH-38	2	27	BDH-60	48	0
BDH-16	2	43	BDH-39	2	29	BDH-61	4	27
BDH-17	2	33	BDH-40	3	49	BDH-62	2	23
BDH-18	2	37	BDH-39&40	3	12	BDH-63	2	18
BDH-19	4	26	BDH-41	3	36	BDH-64	3	32
BDH-20&21	5	42	BDH-42	3	22	BDH-65	4	44
BDH-22	2	27	BDH-41&42	2	24	BDH-66	2	14
BDH-23	1	30	BDH-43	3	30	BDH-67	3	17
BDH-24	2	12	BDH-44	1	37	BDH-69	3	4
BDH-24&25	3	20	BDH-45	3	26			

TABLE D-XII
GROSS-ALPHA AND -BETA ACTIVITY VS SELECTED RADIOCHEMICAL ANALYSES IN THE 60-120 CM LAYER

(pCi/g except as noted)

Location	Gross β	^{90}Sr	^{137}Cs	Gross α	U-T[a]	^{238}Pu	^{239}Pu
BDH-1	4	5.08	---	47	---	---	---
BDH-8&9	3	0.11	---	47	---	---	---
BDH-20&21	5	5.81	---	42	---	---	---
BDH-24&25	3	9.46	---	20	---	---	---
BDH-30	13	26.2	---	41	---	---	---
BDH-49&50	4	0.37	---	26	---	---	---
BDH-60	48	67.2	0.0	0	1.00	0.0	0.0
BDH-69	3	0.06	---	4	---	---	---

[a]Total uranium in μg/g.

TABLE D-XIII

GROSS-ALPHA AND -BETA ACTIVITY IN THE 0-150 CM LAYER (pCi/g)

Location	Gross β	Gross α	Location	Gross β	Gross α
48A-1	2	29	41SW-1	3	32
48B-1	2	17	41C-1	6	20
48AA-1	2	46	42N-1	6	8
48BB-1	2	33	42S-1	4	22
48C-1	0	36	42E-1	8	8
50AL-1	8	30	42W-1	5	22
50BL-1	1	14	42C-1	6	8
50CL-1	4	10	43N-1	3	8
50DL-1	2	32	43S-1	4	46
50EL-1	3	27	43E-1	7	22
50FL-1	2	23	43W-1	5	15
50GL-1	10	33	43C-1	5	24
2168A-1	1	22	44N-1	3	6
2168B-1	2	17	44S-1	4	8
41NW-1	4	20	44E-1	4	29
41SE-1	4	15	44W-1	3	20
41NE-1	3	11	44C-1	2	20

TABLE D-XIV

GROSS-ALPHA AND -BETA ACTIVITY VS ^{90}Sr ACTIVITY IN THE 0-150 CM LAYER (pCi/g)

Location	Gross β	^{90}Sr	Gross α
41SE-1	4	2.46	15
42S-1	4	0.21	22
43N-1	3	1.13	8
43S-1	4	0.31	46

TABLE D-XV

GROSS-ALPHA AND -BETA ACTIVITY IN 150-300 CM LAYER (pCi/g)

Location	Gross β	Gross α
48A-2	3	42
48B-2	2	51
48AA-2	4	17
48BB-2	5	39
48C-2	4	20
50AL-2	4	5
50BL-2	1	16
50CL-2	3	14
50DL-2	3	12
50EL-2	3	33
50FL-2	2	22
50GL-2	2	10
2168A-2	2	24
2168B-2	2	24
41NW-2	4	13
41SE-2	3	0
41NE-2	3	0
41SW-2	3	39
41C-2	35	32
42N-2	3	17
42S-2	5	22
42E-2	4	22
42W-2	8	29
42C-2	17	6
43N-2	3	5
43S-2	4	25
43E-2	5	10
43W-2	2	17
43C-2	5	51
44N-2	2	11
44S-2	4	20
44E-2	3	20
44W-2	2	24
44C-2	2	22

TABLE D-XVI

GROSS-ALPHA AND -BETA ACTIVITY VS ^{90}Sr ACTIVITY IN THE 150-300 CM LAYER (pCi/g)

Location	Gross β	^{90}Sr	Gross α
41NW-2	4	0.23	13
41SE-2	3	1.04	0
41NE-2	3	1.90	0
42N-2	3	2.90	17
43N-2	3	0.04	5
43S-2	4	0.15	25
44E-2	3	0.10	20

TABLE D-XVII

GROSS-ALPHA AND -BETA ACTIVITY IN 300-460 CM LAYER
(pCi/g)

Location	Gross β	Gross α	Location	Gross β	Gross α
48A-3	3	23	41SW-3	4	6
48B-3	15	12	41C-3	501	32
48AA-3	7	41	42N-3	3	11
48BB-3	91	22	42S-3	4	13
48C-3	3	38	42E-3	3	22
50AL-3	2	10	42W-3	169	25
50BL-3	2	13	42C-3	4	27
50CL-3	1	12	43N-3	2	22
50DL-3	2	16	43S-3	3	24
50EL-3	1	17	43E-3	905	24
50FL-3	3	13	43W-3	4	15
50GL-3	2	36	43C-3	69	18
2168A-3	2	24	44N-3	4	29
2168B-3	1	26	44S-3	2	17
41NW-3	4	13	44E-3	3	1
41SE-3	3	1	44W-3	4	18
41NE-3	4	3	44C-3	3	43

TABLE D-XVIII

GROSS-ALPHA AND -BETA ACTIVITY VS ^{90}Sr AND URANIUM IN 300-460 CM LAYER
(pCi/g except as noted)

Location	Gross β	^{90}Sr	Gross α	U-T[a]
48B-3	15	---	12	2.80
48BB-3	91	---	22	5.60
41C-3	501	1140.00	32	---
43E-3	905	1290.0	24	---

[a]Total uranium in μg/g.

TABLE D-XIX

GROSS-ALPHA AND -BETA ACTIVITY IN 460-600 CM LAYER
(pCi/g)

Location	Gross β	Gross α
48A-4	5	24
48B-4	5	25
48AA-4	4	17
48BB-4	291	24
48C-4	2	27
50AL-4	---	--
50BL-4	3	29
50CL-4	3	54
50DL-4	2	35
50EL-4	0	29
50FL-4	3	18
50GL-4	2	18
2168A-4	0	22
2168B-4	2	25
41NW-4	4	6
41SE-4	10	32
41NE-4	4	11
41SW-4	3	11
41C-4	539	20
42N-4	48	30
42S-4	4	22
42E-4	3	22
42W-4	206	24
42C-4	185	17
43N-4	3	13
43S-4	3	29
43E-4	2214	27
43W-4	4	27
43C-4	33	30
44N-4	4	8
44S-4	5	15
44E-4	3	13
44W-4	4	25
44C-4	3	49

TABLE XX

GROSS-ALPHA AND -BETA ACTIVITY VS SELECTED RADIOCHEMICAL ANALYSES IN 460-600 CM LAYER
(pCi/g except as noted)

Location	Gross β	^{90}Sr	^{137}Cs	Gross α	U-T[a]	^{239}Pu	^{240}Pu
48BB-4	291	810.0	0.025	24	1.9	0.0	0.9
41NW-4	4	0.30	---	6	---	---	---
41NE-4	4	2.60	---	11	---	---	---
41SW-4	3	0.10	---	11	---	---	---
41C-4	539	1060.0	---	20	---	---	---
43N-4	3	0.20	---	13	---	---	---
43S-4	3	0.00	---	29	---	---	---
43E-4	2214	4310.0	---	27	---	---	---
43W-4	4	0.00	---	27	---	---	---

[a]Total uranium in $\mu g/g$.

TABLE D-XXI

GROSS-ALPHA AND -BETA ACTIVITY IN 600-760 CM LAYER
(pCi/g)

Location	Gross β	Gross α
48A-5	2	32
48B-5	3	25
48AA-5	3	6
48BB-5	46	17
48C-5	3	22
50AL-5	---	---
50BL-5	2	61
50CL-5	1	31
50DL-5	1	44
50EL-5	2	25
50FL-5	2	41
50GL-5	1	45
2168A-5	3	26
2168B-5	4	29
41NW-5	4	24
41SE-5	5	20
41NE-5	105	46
41SW-5	4	18
41C-5	355	18
42N-5	109	25
42S-5	3	32
42E-5	4	10
42W-5	839	29
42C-5	47	22
43N-5	3	13
43S-5	4	24
43E-5	389	8
43W-5	3	36
43C-5	12	22
44N-5	3	8
44S-5	4	15
44E-5	2	20
44W-5	1	20
44C-5	3	41

TABLE D-XXII

GROSS-ALPHA AND -BETA ACTIVITY VS SELECTED RADIOCHEMICAL ANALYSES IN 600-760 CM LAYER
pCi/g except as noted)

Location	Gross β	^{90}Sr	^{137}Cs	Gross α	U-T[a]	^{238}Pu	^{239}Pu
48BB-5	46	169.00	0.0	17	4.1	0.0	0.011
2168A-5	3	1.59	---	26	---	---	---
2168B-5	4	0.15	---	29	---	---	---
41NE-5	105	90.00	---	46	---	---	---
41SW-5	4	0.50	---	18	---	---	---
42N-5	109	176.0	---	25	---	---	---
43N-5	3	0.09	---	13	---	---	---
43S-5	4	0.09	---	24	---	---	---
43W-5	3	0.22	---	36	---	---	---

[a]Total uranium in $\mu g/g$.

TABLE D-XXIII

GROSS-ALPHA AND -BETA ACTIVITY IN 760-920 CM LAYER
(pCi/g)

Location	Gross β	Gross α	Location	Gross β	Gross α
48A-6	3	31	41C-6	208	55
48B-6	3	25	42N-6	49	30
48AA-6	2	36	42S-6	4	32
48BB-6	23	25	42E-6	5	29
48C-6	2	29	42W-6	227	18
50AL-6	2	42	42C-6	52	32
50BL-6	2	74	43N-6	4	15
50CL-6	3	51	43S-6	4	32
50DL-6	2	58	43E-6	224	43
50EL-6	3	49	43W-6	4	39
50FL-6	4	14	43C-6	20	20
50GL-6	4	60	44N-6	4	18
41NW-6	4	51	44S-6	5	25
41SE-6	4	32	44E-6	4	13
41NE-6	22	41	44W-6	2	20
41SW-6	3	17	44C-6	3	36

TABLE D-XXIV

GROSS-ALPHA AND -BETA ACTIVITY VS ^{90}Sr AND URANIUM IN THE 760-920 CM LAYER
(pCi/g except as noted)

Location	Gross β	^{90}Sr	Gross α	U-T[a]
48BB-6	23	---	25	5.00
41NW-6	4	0.32	51	---
41SW-6	3	0.61	17	---
43N-6	4	0.20	15	---
43S-6	4	0.0	32	---
43W-6	4	0.10	39	---

[a]Total uranium in μg/g.

TABLE D-XXV

GROSS-ALPHA AND -BETA ACTIVITY IN 920-1070 CM LAYER
(pCi/g)

Location	Gross β	Gross α	Location	Gross β	Gross α
48A-7	5	22	41C-7	140	24
48B-7	5	18	42N-7	4	43
48AA-7	5	14	42S-7	4	36
48BB-7	20	13	42E-7	5	15
48C-7	3	10	42W-7	108	36
50AL-7	4	58	42C-7	39	8
50BL-7	5	38	43N-7	4	20
50CL-7	4	61	43S-7	3	18
50DL-7	4	77	43E-7	318	18
50EL-7	6	57	43W-7	6	15
50FL-7	4	38	43C-7	30	15
50GL-7	4	41	44N-7	3	8
41NW-7	5	55	44S-7	3	29
41SE-7	5	56	44E-7	4	29
41NE-7	14	39	44W-7	3	39
41SW-7	4	55	44C-7	3	48

TABLE D-XXVI

GROSS-ALPHA AND -BETA ACTIVITY VS ^{90}Sr IN 920-1070 CM LAYER
(pCi/g)

Location	Gross β	^{90}Sr	Gross α
48A-7	5	0.50	22
48B-7	5	0.77	18
48AA-7	5	0.71	14
48BB-7	20	37.2	13
48C-7	3	0.16	10
50AL-7	4	0.31	58
50BL-7	5	0.07	38
50CL-7	4	0.12	61
50DL-7	4	0.16	77
50EL-7	6	0.18	57
50FL-7	4	0.22	38
50GL-7	4	0.12	41
41SW-7	4	0.0	55
41C-7	140	335.0	24
43N-7	4	0.0	20

TABLE D-XXVII

GROSS-ALPHA AND -BETA ACTIVITY IN 1070-1220 CM LAYER (pCi/g)

Location	Gross β	Gross α
48A-8	3	16
48B-8	3	12
48AA-8	4	6
48BB-8	5	10
50AL-8	4	52
50BL-8	4	54
50CL-8	3	83
50DL-8	3	62
50EL-8	4	33
50FL-8	3	107
50GL-8	4	38
41NW-8	6	55
41SE-8	6	56
41NE-8	19	34
41SW-8	4	74
41C-8	85	63
42N-8	8	110
42S-8	6	44
42E-8	7	17
42W-8	138	22
42C-8	20	27
43N-8	5	55
43S-8	5	36
43E-8	148	25
43W-8	6	25
43C-8	11	13
44N-8	5	24
44S-8	5	37
44E-8	3	49
44W-8	4	56
44C-8	6	46

TABLE D-XXVIII

GROSS-ALPHA AND -BETA ACTIVITY IN 1220-1370 CM LAYER (pCi/g)

Location	Gross β	Gross α
48A-9	3	22
48B-9	3	22
48AA-9	2	4
48BB-9	8	14
50AL-9	4	43
50BL-9	3	42
50CL-9	4	25
50DL-9	4	39
50EL-9	5	49
50FL-9	3	64
50GL-9	5	54

TABLE D-XXIX

GROSS-ALPHA AND -BETA ACTIVITY IN 1370-1530 CM LAYER (pCi/g)

Location	Gross β	Gross α
48A-10	4	16
48B-10	3	14
48AA-10	3	10
48BB-10	8	4
50AL-10	2	42
50BL-10	2	51
50CL-10	4	56
50DL-10	4	39
50EL-10	5	35
50FL-10	6	77
50GL-70	4	43

TABLE D-XXX

GROSS-ALPHA AND -BETA ACTIVITY IN 1530-2000 CM LAYER (pCi/g)

Location	Gross β	Gross α
50AL-11	4	37
50AL-12	4	37
50AL-13	1	36

TABLE D-XXXI

BACKGROUND RADIOACTIVITY IN GRASSES
(pCi/g except as noted)

Location	^{90}Sr	^{137}Cs	U-T[a]	^{238}Pu	^{239}Pu
2NE	0.205	0.181	0.07	0.00075	0.00227
4NW	0.205	0.210	0.10	0.0	0.00280
4SW	0.236	0.221	0.09	0.0	0.00489
8SE	0.208	0.150	0.06	0.00107	0.00208
G.G.	0.263	0.307	0.06	0.00039	0.00071
7NW	2.31	0.192	0.06	0.00042	0.0035
8NE	0.179	0.217	0.08	0.00137	0.0036
7SE	0.505	0.285	0.07	0.0	0.00453
8SW	0.789	0.256	0.06	0.0065	0.0041

Total uranium in $\mu g/g$.

TABLE D-XXXII

RADIOACTIVITY IN BAYO SITE GRASSES
(pCi/g except as noted)

Location	^{90}Sr	^{137}Cs	U-T[a]	^{238}Pu	^{239}Pu
EG	0.491	0.061	0.05	0.00069	0.00128
EA-2	0.791	0.109	0.05	0.0	0.00209
EC-2&3	0.852	0.046	0.14	0.0	0.00222
EC-4&5	0.505	0.178	0.05	0.0	0.00241
WB-2	0.408	0.105	0.06	0.00028	0.00207
WB-3	0.572	0.032	0.04	0.0	0.00127
C2-5	0.594	0.062	0.05	0.0	0.00195
C6-10	0.185	0.081	0.07	0.0	0.00152
C6-20	0.0365	0.037	0.06	0.0	0.00131
C7-28	0.246	0.067	0.03	0.00015	0.00557
C7-30	0.446	0.071	0.06	0.00020	0.00178
C8-1	0.375	0.111	0.0001	0.00039	0.00239
C8-20	0.326	0.045	0.06	0.00016	0.00124
C9-2	0.341	0.168	0.10	0.0	0.00287
C9-25	0.198	0.109	0.07	0.00078	0.00261

[a]Total uranium in $\mu g/g$.

TABLE D-XXXIII

EXTERNAL PENETRATING RADIATION IN THE TOWNSITE

TLD Station	Results $\mu R/h$[a]
1. Barranca School	17.3
2. Cumbres School	17.6
3. Golf Course	18.5
4. Arkansas Avenue	18.8
5. Diamond Drive	18.8
6. 48th Street	19.0
7. Fuller Lodge	21.2
8. Acorn Street	17.9
10. Los Alamos Airport	19.7
28. Pajarito Acres	15.9
29. White Rock Sewer Treatment Plant	17.4
	$\bar{x} \pm \sigma = 18.4 \pm 1.4$

[a]4th Quarter 1976 measurements by high-pressure ion chamber.

TABLE D-XXXIV

EXTERNAL PENETRATING RADIATION*
AT THE FORMER BAYO SITE

Canyon Floor

Location	μR/hr	Location	μR/hr	Location	μR/hr	Location	μR/hr	Location	μR/hr
C2-1	20.8	C7-21	20.9	C7-30	19.0	C9-1	21.2	EB-3	18.1
C3-1	21.2	C7-22	21.3	C8-2	19.2	C9-2	19.0	EB-4	20.5
C7-2	19.1	C7-23	22.3	C8-3	19.7	C9-25	21.0	EB-5	19.4
C7-3	19.4	C7-24	24.1	C8-16	21.7	C9-26	17.7	EB-6	20.2
C7-13	20.0	C7-25	22.6	C8-17	20.9	C9-27	21.6	EC-2	18.7
C7-16	24.3	C7-26	23.1	C8-18	21.0	C9-28	23.4	EC-3	18.4
C7-17	21.3	C7-27	20.3	C8-19	22.2	C9-44	20.2	EC-4	19.0
C7-18	20.5	C7-28	18.8	C8-20	22.6	C9-45	19.7	EC-5	19.2
C7-19	20.5	C7-29	19.3	C8-30	20.7	EB-2	21.0	EC-6	19.9
C7-20	20.1								

Talus Slopes

Location	μR/hr	Location	μR/hr
C7-15	22.0	C9-3	23.7
C8-13	21.7	C9-22	23.7
C8-14	26.1	C9-23	21.0
C8-15	22.8	C9-24	21.2
C8-22	22.7	C9-29	19.3
C8-23	24.8	C9-30	24.4
C8-24	24.7	C9-31	23.5
C8-25	22.7	C9-37	24.6
C8-26	23.0	C9-41	24.2
C8-27	23.7	C9-42	23.3
C8-28	21.7	C9-43	23.8

Mesa Tops

Location	μR/hr	Location	μR/hr
C9-7	19.2	C9-16	20.2
C9-8	19.0	C9-17	18.2
C9-9	17.8	C9-18	19.4
C9-10	19.2	C9-19	19.2
C9-11	19.1	C9-20	18.0
C9-12	18.5	C9-40	20.3
C9-13	20.2		

*Measurements by High Pressure Ion Chamber.