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General

ENCLOSURE 14
RESPONSE TO NOD QUESTION 11

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IN PARTIAL RESPONSE TO QUESTION 11

Reconnaissance Sampling

Additional soil, sediment and water sampling was conducted at TA-16, Area P; TA-40 scrap detonation site; and TA-54 Area L and Area G; to help define the spatial distribution of any hazardous constituents. This reconnaisance sampling is detailed in Attachment 1..

1989 General

Vadose Zone Monitoring

Vadose zone monitoring (e.g., soil moisture monitoring with psychrometers and neutron probe, pore gas sampling) is being conducted at Technical Area 54 waste disposal Areas L and G, and in adjacent side canyons. These activities are fully addressed in response to question 15, Enclosure 22.

Environmental Surveillance of Low-level Radioactive Waste Management Areas

Environmental surveillance of radioactive waste management areas at Los Alamos documents compliance with appropriate standards, identifies undesirable trends that may require remedial actions, and monitors the performance of waste confinement. Radioactivity concentrations in air (particulates and moisture), water, soil, and sediment samples are measured, along with the levels of external penetrating radiation. Eleven radioactive waste management sites are monitored. One (Area G at TA-54) is currently active and the remainder (Areas A, B, C, E, F, T, U, V, W, and X) are closed or decommissioned. They are described in the yearly environmental surveillance reports (e.g., see pp. 66-70 in the report entitled "Environmental Surveillance at Los Alamos during 1984," Enclosure 18) and also in the following publications:

Attachment 2, W.R. Hansen, D.L. Mayfield, L.J. Walker, "Interim Environmental Surveillance Plan for LANL Radioactive Waste Areas," Los Alamos National Laboratory report LA-UR-80-3110 (1980)

Attachment 3: D. Mayfield and W.R. Hansen, "Surface Reconnaissance through 1980 for Radioactivity at Radioactive Waste Disposal Area G at the Los Alamos National Laboratory," Los Alamos National Laboratory LA-9656-MS (1983)

Attachment 4: unauthored, "Plan for Stabilization of Radioactive Materials Disposal Sites at the Los Alamos National Laboratory," unpublished report (1983)

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Reconnaissance Sampling

Reconnaissance sampling was conducted at TA-16, Area P; TA-40 scrap detonation site; and TA-54, Area L and Area G; to help define the spatial distribution of any hazardous contaminants.

Sample collection and sample analyses were conducted in accordance with EPA procedures (US EPA, 1985).

Soil and sediment samples were analyzed for the following inorganic chemical constituents: Extraction Process (EP) toxicity constituents (i.e., arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver), nickel, beryllium, cyanide, nitrate, sulfates and soil pH. Samples collected at TA-54 were also analyzed for PCB's.

Water samples were analyzed for the following inorganic chemical constituents: (1) Ag, As, Ba, Cd, Cr, F, Hg, Pb, Se and nitrate regulated under primary standards (US EPA, 1976) and (2) Ce, Cu, Fe, Mn, Zn, sulfate, total dissolved solids and pH regulated under secondary standards (US EPA, 1979).

Nine sediment samples were taken from drainages downgradient from TA-54, Area L and Area G. At TA-16, Area P, 5 soil samples were taken from the toe of the dump, and 4 water and 4 sediment samples were taken in Canon de Valle. Effluent discharged from Bldg. 260 was also sampled. The effluent furnishes base flow for Canon de Valle. At TA-40,

8 soil samples, 4 surface samples and a composite sample were taken. Fourteen samples, to a depth of 5.4 ft. were collected on a detonation pad.

Detailed sampling procedures for each site, with maps of sampling locations are given below.

References Cited

US EPA, 1976: U.S. Environmental Protection Agency "National Interim Primary Drinking Water Regulations," US EPA report EPA-570/9-76-003 (1976).

US EPA, 1979: U.S. Environmental Protection Agency "Natonal Secondary Drinking Water Regulations," Federal Register 44(140) (1979).

US EPA, 1985: U.S. Environmental Protection Agency, "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods" EPA-SW-846 (1985).

Sampling Procedure
Area P
October 29, 1985

Dump

Samples D-1, 2, 4, and 5 were taken from sediments in channels below dump; D-3 was taken from a low soil area at toe of dump. Samples were collected with a drive sampler 3 1/2 inches in diameter and 4 inches long.

Canon de Valle

Water samples were taken at the following locations:

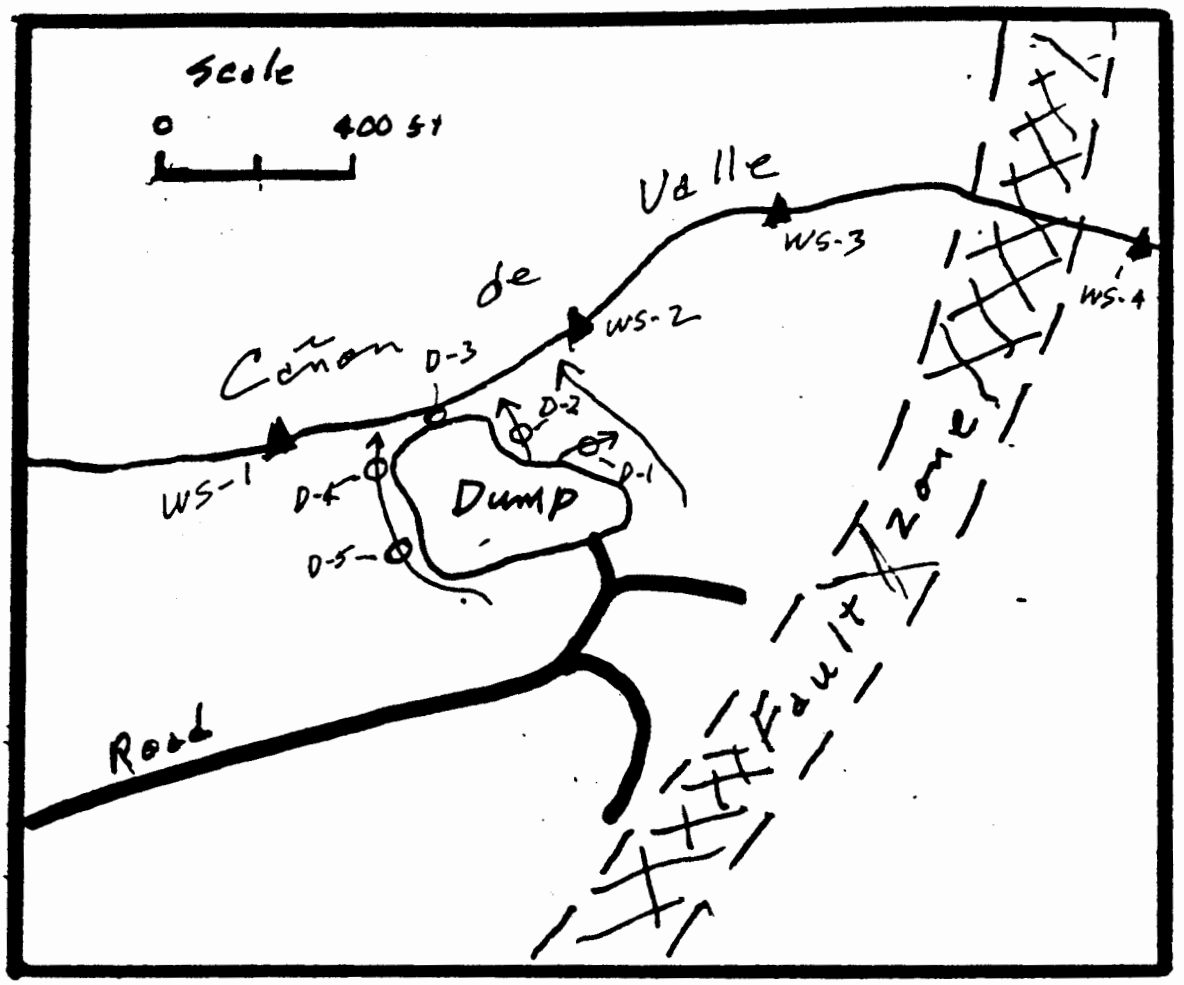
(1) W-1 500 ft. upgradient from dump.
(2) W-2 Below dump.
(3) W-3 500 ft. east of W-2.
(4) W-4 1000 ft. east of W-3.
(5) Effluent from Bldg. 260

Canon de Valle

Sediment (S-1, S-2, S-3, S-4) was sampled from the same location as water samples.

Background

Two background samples were taken with a drive sampler off of Two Mile Mesa Road.



▲ Water and Sediment Stations
○ Soil or Sediment Stations below Dump.

Figure 1.– Sketch Map showing Sampling Stations at Area P

Sampling Procedure
TA-40
October 28, 1985

Eight samples were taken with a sampler 3 1/2 inches in diameter and 4 inches long driven into the tuff. The volume of soil, sediment, or tuff collected averaged about 775 grams.

Samples 1A, 2A, 3A, and 4A were taken with a sampler 3 1/2 inches in diameter and 1 1/2 inches long driven into the soil, tuff, or sediment. The volume of material collected weighed an average of 300 grams. These sampling locations were offset from locations 1, 2, 3, and 4.

Sample 9 (composite sample) was taken with a 2 3/4 inch auger to a depth of 18 inches.

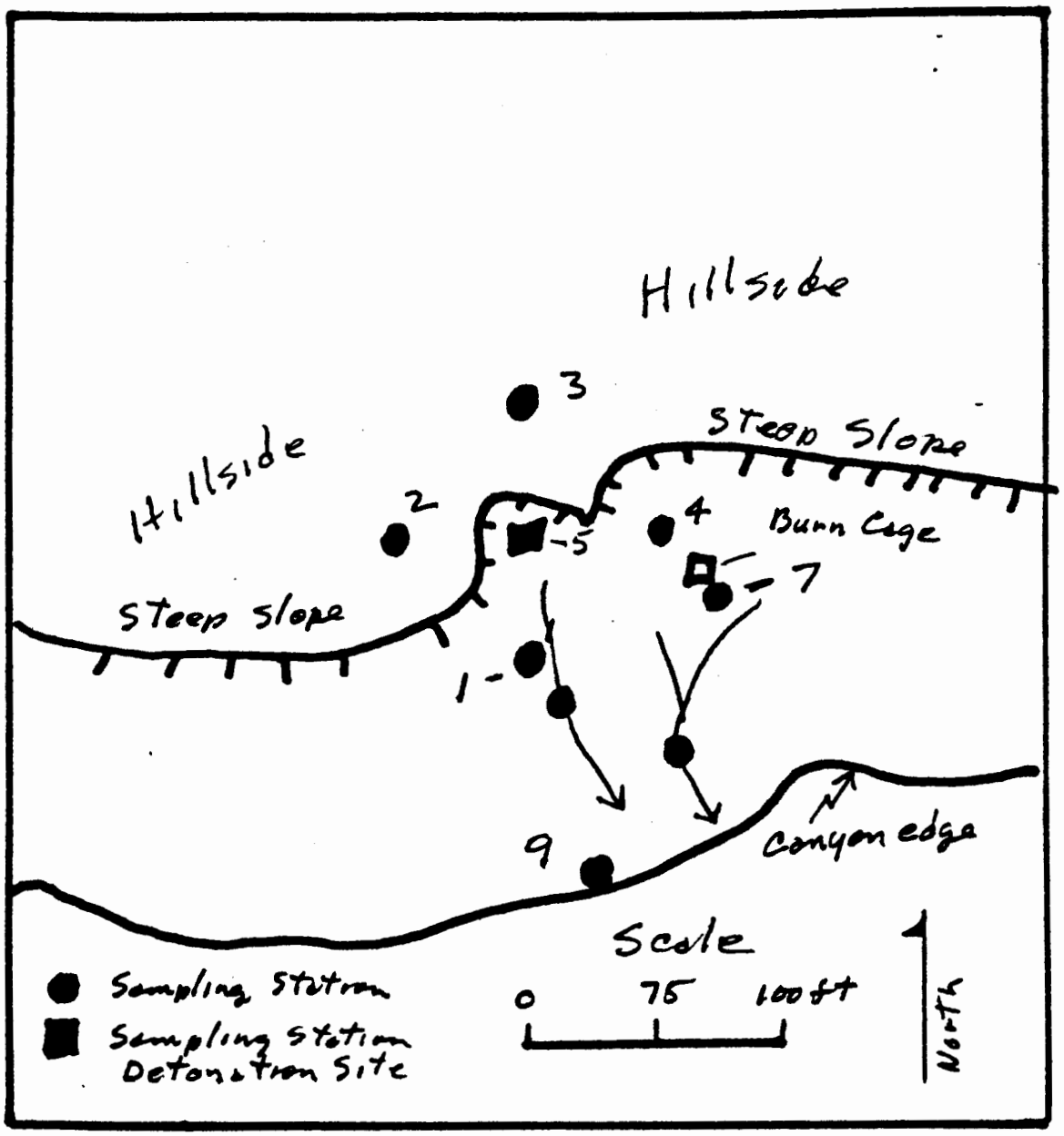
Samples 5A through 5M were collected on pad to a depth of 5.4 ft. using a 2 3/4 inch diameter auger. A core about 2 inches long was taken for each sample.

Sample No.	Depth (ft)*
5	0 to 0.6
A	0.6
B	1.0
C	1.4
D	1.8
E	2.2
F	2.6
G	3.0
H	3.4
I	3.8
J	4.2
K	4.6
L	5.0
M	5.2

*Note: At this time only samples 5, 5G, and 5M were submitted for analysis.

Samples 6 and 8 were taken in runoff channels (sediments) from firing pad (8) and burn pit (6). Sample 7 was taken adjacent to burn pit. The burn pit resembles a cage.

Sampling locations were modified to fit current drainage and to collect maximum possible contamination from explosions in an amphitheater.



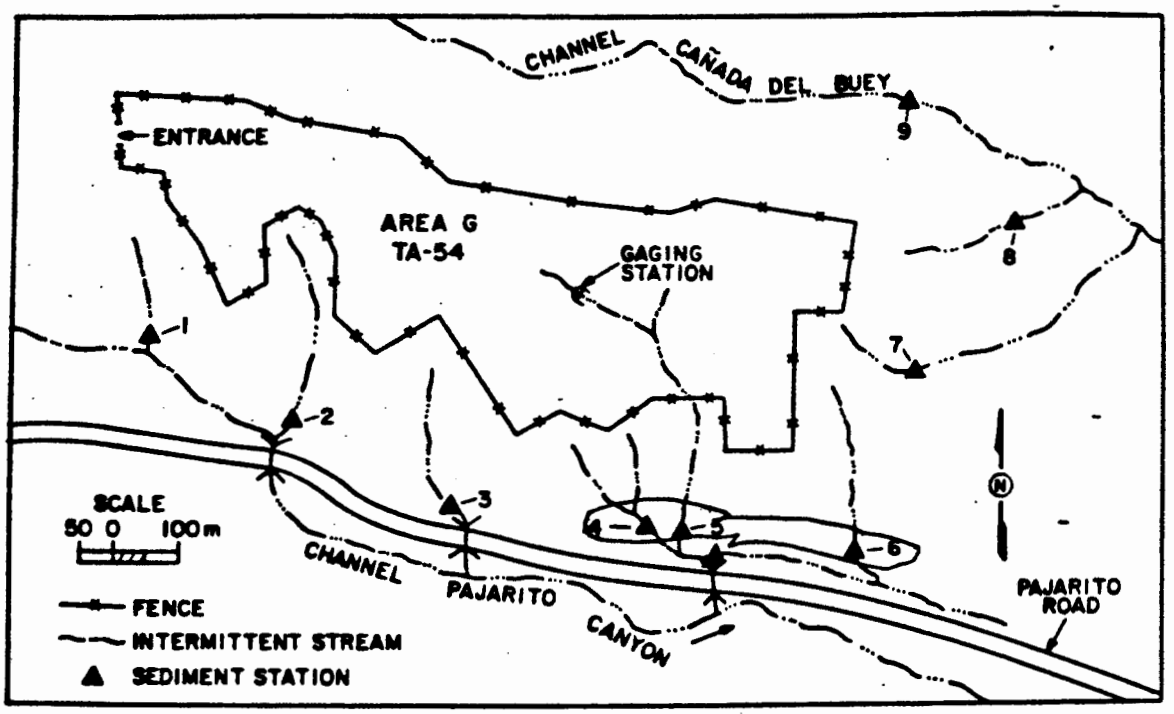
Sampling location at TA-40

Sampling Procedure
TA-54 (Areas L and G)
October 28, 1985

Sediment samples were collected in stream channels to a depth of about 2.5 inches. Samples were collected in 16 oz. glass bottles because analyses include PCBs.

Sample locations are shown on the map: Locations 1, 2, 3, (4, 5, and 6 combined at culvert) 7, 8, and 9 are in drainages from Area G. Location 10 is in the drainage from Area L above the confluence with Canada del Buey. Sample 10 is at the northeast corner of Area L. Sample 11 is at drainage from the northcentral part of Area L.

Station 10
below Area L



Sediment Station TA-54 below Area L and Area G. All runoff from Area L into channel of Cañada del Buey. Stations 4, 5, and 6 combined into one sample at culvert. Station 11, in Northeast cor. of Area L. Station 12 in northcentral part of Area L in drainage

EP TOXICITY ANALYTICAL RESULTS FOR AREA P
SOIL AND SEDIMENT SAMPLES

Parameter	Regulated Concentration[a] (mg/L)	EP Toxic Detection Limit[b] (mg/L)	D-1	D-2	D-3	D-4	D-5	S-1	S-2	S-3	S-4	Bkgd.	Bkgd.
Arsenic	5.0	0.05 ± 0.025	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Barium	100.	1.0 ± 1.0	600	520	1.5	26	14	120	7.7	14	50	ND	ND
Cadmium	1.0	0.1 ± 0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chromium	5.0	0.5 ± 0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead	5.0	0.5 ± 0.5	1.8	0.93	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury	0.2	0.001 ± 0.001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Selenium	1.0	0.05 ± 0.025	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Silver	5.0	0.5 ± 0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

[a]Hazardous Waste Management Regulations (HWMR) 201.B.5.
[b]ND = Not Detected.

MISCELLANEOUS ANALYTICAL RESULTS FOR AREA P
SOIL AND SEDIMENT SAMPLES
(concentrations in mg/L)

Parameter	Sampling Locations										
	D-1	D-2	D-3	D-4	D-5	S-1	S-2	S-3	S-4	Bkgd 1	Bkgd 2
Ni	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.42	<0.1	<0.1	<0.1
Be	1.4	1.2	1.3	1.1	1.1	0.9	0.6	0.9	1.0	1.5	1.3
Cn	0.13	0.39	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
SO_4	0.4	0.5	0.3	0.3	0.9	0.5	1.6	0.9	0.5	0.5	<0.2
pH	8.4	8.6	6.8	6.7	6.5	8.5	6.6	6.7	7.9	6.3	7.1
NO_3	<0.9	1.0	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9

EP TOXICITY ANALYTICAL RESULTS FOR TA-40 SOIL SAMPLES

Parameter	EP Toxic Regulated Concentration[a] (mg/L)	Detection Limit[b] (mg/L)	Sampling Locations														
			1	1A	2	2A	3	3A	4	4A	5	5G	5M	6	7	8	9
Arsenic	5.0	0.05 + 0.025	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Barium	100.0	1.0 + 1.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cadmium	1.0	0.1 + 0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chromium	0.5	0.5 + 0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead	5.0	0.5 + 0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury	0.2	0.001 + 0.001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Selenium	1.0	0.05 + 0.025	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Silver	5.0	0.5 + 0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

[a]Hazardous Waste Management Regulations (HWMR) 201.B.5.
[b]ND = Not Detected.

MISCELLANEOUS ANALYTICAL RESULTS FOR TA-40
SOIL SAMPLES
(concentrations in mg/L)

Parameter	Sampling Locations														
	1	1A	2	2A	3	3A	4	4A	5	5G	5M	6	7	8	9
Ni	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.01	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Be	1.5	1.6	2.0	1.8	1.8	1.9	1.8	1.9	2.5	1.7	1.9	1.9	2.1	2.4	2.5
Cn	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
SO_4	<0.2	<0.2	0.3	<0.2	<0.2	<0.2	<0.2	<0.2	0.4	0.6	0.2	<0.2	<0.2	<0.2	1.0
pH	6.6	6.4	6.3	6.6	6.6	6.6	6.8	6.7	8.4	8.8	6.5	5.9	7.5	6.7	7.4
NO_3	<0.9	<0.9	<0.9	1.3	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	1.3	<0.9	<0.9	<0.9

TABLE __ EP TOXICITY ANALYTICAL RESULTS FOR
TA-54 SEDIMENT SAMPLING STATIONS

Parameter	EP Toxic Regulated Concentration[1] (mg/L)	Detection Limit (mg/L)[2]	Depth Intervals in Feet									
			54-1	54-2	54-3	54-4	54-7	54-8	54-9	54-10	54-11	54-12
Arsenic	5.0	0.05 ± 0.025	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Barium	100.0	1.0 ± 1.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cadmium	1.0	0.1 ± 0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chromium	5.0	0.5 ± 0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead	5.0	0.5 ± 0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury	0.2	.001 ± 0.001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Selenium	1.0	0.05 ± 0.025	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Silver	[illegible]											

[1] Haz[illegible]
[2] ND =

MISCELLANEOUS ANALYTICAL RESULTS FOR TA-54
SEDIMENT SAMPLING STATIONS
(concentrations in mg/L)

Parameter	Sampling Locations									
	54-1	54-2	54-3	54-4	54-7	54-8	54-9	54-10	54-11	54-12
Ni	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Be	1.9	1.9	1.3	1.3	2.7	2.5	1.2	1.7	2.0	2.4
Cn	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.0.1
SO_4	0.2	<0.2	0.3	<0.2	<0.2	<0.2	<0.2	<0.2	0.3	0.3
pH	5.5	5.6	5.8	5.3	5.7	5.8	5.0	5.3	5.4	5.8
NO_3	<0.9	1.3	-	<0.9	1.7	<0.9	<0.9	<0.9	<0.9	<0.9
PCB (μg/g)	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2

CHEMICAL QUALITY OF WATER AT AREA P

Primary Chemical Quality (concentrations in mg/ℓ)

Sampling Location	Ag	As	Ba	Cd	Cr	F	Hg	N	Pb	Se
Area P-W-1	<0.001	0.001	4.9	<0.002	0.010	0.35	<0.001	1.0	<0.001	<0.003
Area P-W-2	<0.001	0.001	5.4	<0.002	0.009	0.31	<0.001	0.8	<0.001	<0.003
Area P-W-3	<0.001	0.001	6.0	<0.002	0.010	0.39	<0.001	0.9	<0.001	<0.003
Area-P-W-4	<0.001	0.001	6.2	<0.002	0.010	0.34	<0.001	0.8	<0.001	<0.003
Effluent Bldg. 260	<0.001	0.001	24.1	<0.002	0.010	0.44	<0.001	7.0	<0.001	<0.003
Primary Maximum Contaminant Level[a]	0.05	0.05	1.0	0.01	0.05	2.0	0.002	---	0.05	0.01

Secondary Chemical Quality (concentrations mg/ℓ)

Sampling Location	Cl	Cu	Fe	Mn	SO_4	Zn	TDS	pH
Area P-W-1	13	0.002	0.049	0.002	8.3	<0.001	138	7.2
Area P-W-2	12	0.002	0.028	0.010	9.1	<0.001	141	7.4
Area P-W-3	13	0.002	0.042	0.004	9.5	<0.001	139	7.5
Area P-W-4	11	0.002	0.012	0.002	7.7	<0.001	139	7.5
Effluent Bldg. 260	3	0.002	0.006	0.002	2.5	0.011	195	7.4
Secondary Maximum Contaminant Level[b]	250	1.0	0.3	0.05	250	5.0	500	6.5-8.5

Miscellaneous Chemical Analyses
(concentrations in mg/ℓ unless indicated otherwise)

Sampling Location	SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	P	Total Hard	Conduct Ms/m	Ni	Be
Area P-W-1	38	15	4.5	2.9	15.6	<0.5	71	<0.10	65	196	<0.05	<0.01
Area P-W-2	38	16	4.6	3.0	15.8	<0.5	72	<0.10	65	197	<0.05	<0.01
Area P-W-3	37	16	4.6	3.0	15.9	<0.5	73	<0.10	66	198	<0.05	<0.01
Area P-W-4	38	16	4.6	3.0	15.7	<0.5	74	<0.10	68	199	<0.05	<0.01
Effluent Bldg. 260	75	10	2.9	2.0	11.5	<0.5	59	<0.10	61	178	<0.05	<0.01

[a]Reference: US Environmental Protection Agency "National Interim Primary Water Regulations," U.S. EPA report EPA-570/9-76-003 (1976).
[b]Reference: U.S. Environmental Protection Agency "National Secondary Drinking Water Regulations," Federal Register 44 (140) (1979).

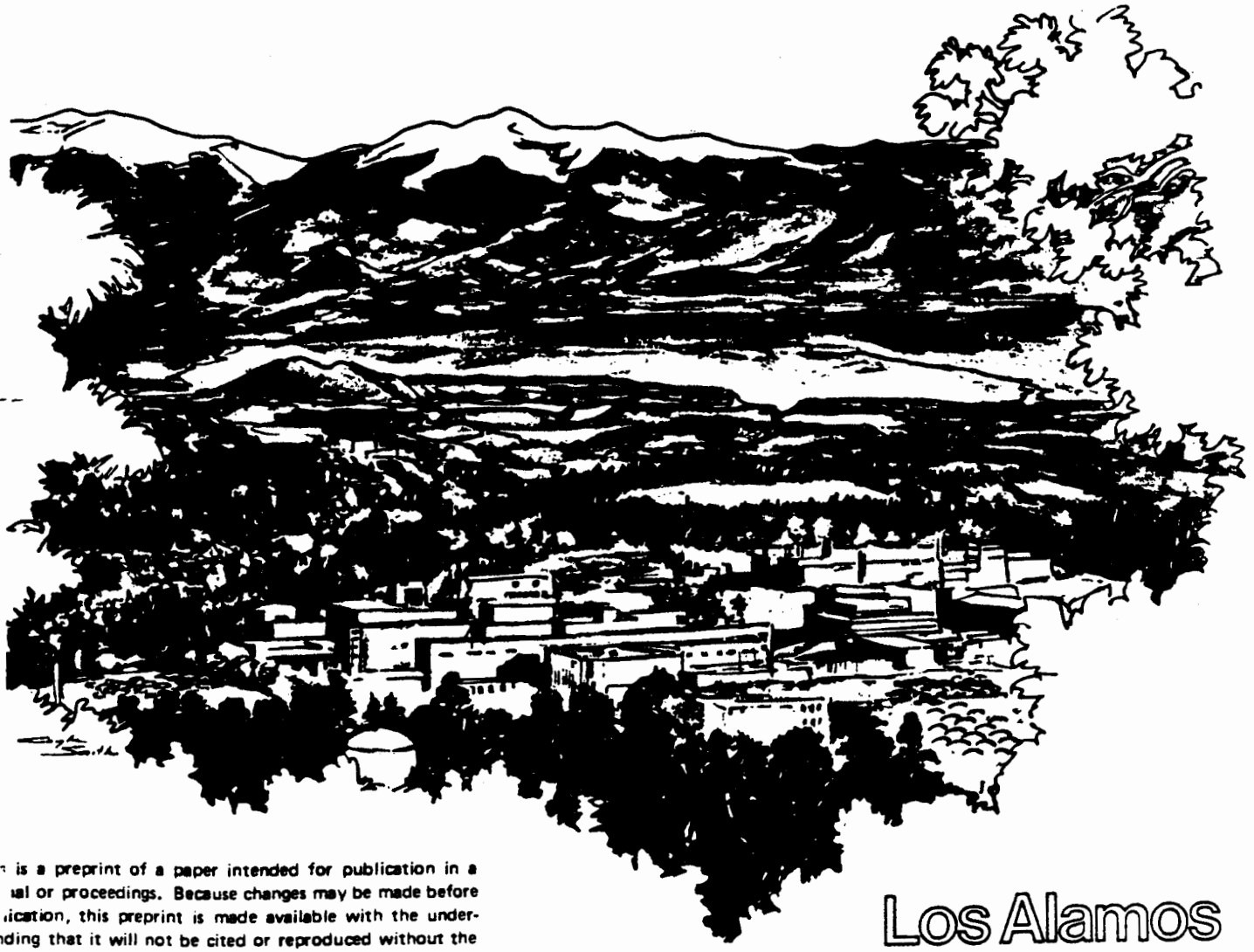
ENCLOSURE 14
ATT. 2: 1980 REPORT ENTITLED "INTERIM ENVIRONMENTAL S RVEILLANCE PLAN FOR LASL RADIOACTIVE WASTE AREAS"

LA-UR-80-3110

INTERIM ENVIRONMENTAL SURVEILLANCE PLAN FOR LASL RADIOACTIVE WASTE AREAS

Wayne R. Hansen, Donald L. Mayfield, Lewis J. Walker
Environmental Surveillance Group

1980



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Los Alamos
Los Alamos National Laboratory
Los Alamos, New Mexico 87545

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Appendices

a. Los Alamos Historical and Physical Setting with Emphasis on Radioactive Waste Management Areas.

b. Brief Descriptions of Radioactive Waste Materials, Amounts, Handling Methods and Locations of Waste Management Areas.

PREFACE

INTERIM ENVIRONMENTAL SURVEILLANCE PLAN FOR LASL RADIOACTIVE WASTE AREAS

This document describes the surveillance plan being implemented to monitor and assess environmental conditions at radioactive waste manage-sites of the Los Alamos Scientific Laboratory (LASL). For documentation of the general environmental surveillance of Los Alamos Scientific Laboratory, which includes some special sampling stations at waste areas, the reader is directed to the series of Annual Environmental Surveillance Reports. This report documents the methodology for assessing the surface conditions and subsurface conditions at radioactive waste sites. The execution of the plan may vary slightly for specific waste sites due to individual differences. The terms waste site, waste burial area, and waste management area are synonymous and interchangeable. The term soil refers to both soil and rock materials.

The general surveillance of the Los Alamos Scientific Laboratory and area includes food sampling, air sampling, soil and sediment sampling, and water sampling. The sampling locations are situated to detect migration from the waste areas as well as the operating facilities at the laboratory.

In 1979, the Department of Energy (DOE) issued interim operational criteria for radioactive waste areas owned or operated by DOE and its contractors. This document is meant to be responsive to the surveillance requirements listed in the DOE interim criteria.

1.0 INTRODUCTION

1.1 OBJECTIVES OF THE PLAN

The objectives of this surveillance plan are to:

- provide information to evaluate whether radioactive waste sites at LASL are being managed and maintained in an environmentally acceptable manner; and whether applicable criteria, such as the DOE Interim Criteria for Waste Management are met.
- identify and document possible changes over time for each area.
- provide data for the Annual Environmental Surveillance Report and
- other environmental documentation that might be required prior to changes or additions to activities at LASL.

1.2 SCOPE AND APPROACH

The objectives of the plan are expected to be met by taking pertinent measurements in the environs to enable an evaluation of critical pathways to man from waste management areas. The evaluation will include a comparison of results against applicable regulatory standards and guidelines. The scope of this plan is presently limited to radioactivity.

2.0 THE PLAN IN SUMMARY

Each waste disposal area will be evaluated for radiological conditions each year. This surveillance plan includes a brief survey of each site each year (Annual Survey), and an extensive survey at each of the two or three sites (depending on their size) each year (Detailed Survey).

2.0 THE PLAN IN SUMMARY (Continued)

The Annual Survey as described in Section 3.1, is a brief reconnaissance and assessment based on measurements intentially biased to emphasize the most likely locations of contamination. This bias is necessary to achieve brevity in the surveys. All areas will be surveyed for the first time the end of (FY) 1981 and annually thereafter. Portable radiation detection instruments will be used to scan the surface as described in Section 4.1. Samples of media may include soil, vegetation, and small rodents to provide a rapid indication of residual waste distribution in the environs. Airborne radioactivity and penetrating radiation in the vicinity of waste areas, as monitored by the routine environmental surveillance program, will be incorporated in evaluation of the waste management areas.

Soil samples will be taken at surface locations where unusual radiation has been observed or where waste migration would most likely occur. These samples will indicate qualitatively whether movement has been caused by surface runoff or wind. Occasional subsurface soil samples may be taken at selected locations to investigate the potential for subsurface migration. Vegetation samples would be gathered from the immediate area around soil samples to indicate qualitatively whether transfer to vegetation has occurred. Rodents would be trapped from transects as wide as the rodent's normal range around a location of known or suspected residual radioactivity to indicate qualitatively whether transfer to animals has occurred. Sampling and analytical methods are described in Sections 4.0 and 5.0.

The Detailed Survey is described more thoroughly in Section 3.2. This survey would be performed on each waste area at least once every

five years, with two or three areas being subject to the detailed survey any given year. The greater detail would permit quantitative interpretation of radiological conditions and trends. Soil sampling may include both surface and subsurface soils. Subsurface samples would be taken outside of or below disposal excavations (pits or shafts), but would avoid penetrating them.

3.0 THE PLAN IN DETAIL

Before the initial annual survey is begun, a literature and data review would be conducted in order to evaluate the known information about each disposal area. The evaluation will include data and documents such as inventories estimated for each waste area, the physical and chemical forms of the wastes, methods of handling and disposal, and existing pertinent environmental measurements. The initial compilation and evaluation will be updated for successive surveys - both annual and detailed.

Concurrent with the initial annual survey, a sampling grid will be established at the site by civil engineering surveys. This will

1) facilitate locating or relocating points from each survey, and
2) enable accurate mapping of sample points.

Both annual and detailed surveys will include: 1) surface scans and <u>in-situ</u> measurements for radioactivity; 2) samples from environmental media; 3) sample analysis; 4) data reduction, evaluation, and reporting. New data will be integrated with the compiled information to evaluate the condition of the waste area under study. The waste areas being evaluated are: A, B, C, G, T, and V, known or suspected to contain transuranic (TRU) wastes; U known to contain residue from ^{227}Ac wastes; E with known uranium and suspected ^{3}H wastes. F with

known ^{137}Cs and ^{90}Sr; H and K where ^{3}H has been observed; J where ^{3}H is suspected; W where irradiated Na is buried; Y expected to contain some longer lived activation products with ^{235}U, and Y known to certain uranium. These areas are discussed in greater detail in Appendix B of this plan.

3.1 ANNUAL SURVEY

Each year all waste areas except those scheduled for detailed survey will be given a brief annual survey. Tasks for the Annual Surveys will be:

1. Observe and denote the condition of access barriers, backfill, or anything obvious that might adversely influence the integrity of waste confinement; and maintain the sampling grid as needed (for example, replace missing survey stakes).

2. Scan surface areas with portable radiation detection instruments as described in Section 4.1 to locate spots of unusual radioactivity. In the absence of existing measurements, the area over the waste repositories (pits and shafts) and/or within access barriers would be scanned to delineate pathways from potential sources. Then a perimeter margin 20 to 30 meters (about 66 to 100 feet) wide would also be scanned subject to accessibility and safe working conditions. Results greater than the Minimum Detection Level of the instrument would be flagged and marked on a map of the area.

3. Collect in-situ spectra at locations where elevated radioactivity was observed in Task 2 or in prior surveys by means of a portable multichannel analyzer (MCA) connected to radiation detectors as described in Section 4.1. These spectra may help to identify x ray and gamma ray emitting radionuclides that may be present.

4. Collect soil samples at selected locations to provide data on concentrations lower than portable instrument limits, and, if possible, prior to emergence of spring growth to minimize complications during collection and interpretation. Sampling locations will include spots where elevated radiation readings were obtained, areas where subsidence is associated with disposal excavations, or spots where precipitation runoff could collect. These samples would be analyzed in the laboratory for appropriate radioisotopes (primarily $^{239,240}Pu$, ^{3}H, and uranium), leaving adequate sample for subsequent radioisotopic analyses and analyses for nonradioactive pollutants. Refer to Section 4.3.

5. Collect vegetation at soil sampling locations as described in Section 4.4 during the growing season of the species being collected. Submit samples to the analytical laboratory for radiochemical

3.1 ANNUAL SURVEY (Continued)

analyses (ordinarily $^{239,240}Pu$, ^{3}H, and uranium). Detection limits will be maintained well below regulatory standards or guidelines.

6. Collect small rodents from selected zones of the waste disposal area, if populations warrant and time permits. Tissues would be pooled for radioisotopic analysis as described in Section 4.5.

7. A summary of the survey, its conclusions and evaluation will be prepared including recommendations for remedial action or for desirable additional data.

3.2 DETAILED SURVEY

The tasks for the detailed survey would include all Tasks 1 through 7 of the Annual Survey (see Section 3.1) performed in such a way as to take advantage of previous Annual Survey information and to provide more detailed understanding. For example, methods or instruments used for scanning or spectra collection (Tasks 2 and 3) should encompass more locations or lower detection limits. Soil, vegetation, and rodent sampling (Tasks 4, 5, and 6), would be more intensive.

Additionally, the Detailed Survey would attempt to evaluate potential subsurface movement of contaminants by the following task:

Task 8: When appropriate, samples could be collected at depths of 1 to several meters below the depth of the original waste repositories, and adjacent to them at a sufficient distance to preclude penetration into the actual waste materials. Immediately after the collection of the samples, these holes could be cased for future use, such as well logging or moisture monitoring, for example. For more detail, see Section 4.3.2.

4.0 METHODS

4.1 FIELD INSTRUMENTS AND RADIOACTIVITY MEASUREMENTS

Portable radiation detection instruments will be used to scan and to take integrated measurements. These measurements cover the energy spectrum from 10 keV (the leading edge of 17 keV x-rays emitted during alpha decay of most transuranic materials) to 3000 keV. This includes essentially all x-ray and gamma rays that might be encountered in this survey. Equipment currently used for scanning includes micro-R meters and phoswich detectors operated in the rate meter mode. The phoswich is set to span the x-ray and gamma ray (photon) energies from 10 keV through 90 keV. The micro-R meter covers photon energies from 30 keV to 3000 keV.

In-situ x-ray and gamma ray spectra will be collected at selected locations during both the annual surveys and the detailed surveys. The equipment now in use consists of a portable multi-channel analyzer connected to either a phoswich detector for low energies (10 keV to 200 keV) or the analyzer's internal NaI (Tl) detector for high energies (60 keV to 2550 keV). In-situ x-ray and gamma ray spectra provide radioisotope identification by x-ray and gamma ray energies. Qualitative or quantitative relative abundance may be available depending on calibration control.

4.2 SAMPLING GRIDS AND TRANSECTS

The purpose of sampling grids is to facilitate locating or re-locating sampling points of the various surveys with adequate accuracy. The grid origin is randomly chosen to mitigate against bias in placement of grid points all across the grid. This is of importance for some statistical data treatments that may be useful. Key points, co-ordinate axes, perimeters, and a coarse rectangular grid will be installed at most areas by civil engineering survey to assure adequate accuracy.

Biota sampling locations will be established as needed. These

sampling locations will be organized in groups called transects. Vegetation transects would generally be circular with the soil sampling location at its center and a radius large enough to collect the necessary masses of the species sought. Small animal transects may be in the form of nested rectangles or straight lines with dimensions comparable to the range of these animals.

4.3 SOIL SAMPLING

4.3.1 SURFACE SOIL

Surface soil samples will consist of roughly 500 to 700 grams of soil from each of 3 depths in the top 30 cm of soil. Properly sized steel rings and spatulas will be used to sample the depths from 0 to 1 cm and 1 to 10 cm at a given location. Plastic pipe will be used to core sample the depth from 10 to 30 cm immediately below the ring sample, provided the soil is deep enough. Ring samples will be undercut with metal spatulas, removed from position and placed in a prelabelled plastic bag. Core samples will be removed and placed in a prelabelled plastic bag.

4.3.2 SUBSURFACE SOIL

Subsurface soil samples, i.e., below 30 cm, may be taken in any of three ways: 1) a hand auger if in loose soil, 2) with a drive spoon mounted on a mobile drill rig if in tuff, or 3) a mechanical auger mounted on a mobile drill rig. Samples of from 500 to 700 grams would be scooped from auger cuttings or taken from the drive spoon core and placed in a pre-labelled plastic bag. Labels on soil sample bags would include waste area survey, sample locations, depth of sample, date sampled, and initials of persons taking the sample.

During the detailed survey, soil samples will be collected from additional selected locations on the sampling grid, and subjected to more rigorous counting and/or analytical procedures.

4.3.2 SUBSURFACE SOIL (Continued)

The decision to collect deeper soil samples will be made on a case-by-case basis, depending upon consideration of surface scanning results, surface and near-surface soil sample results, and/or historical observations. Subsurface soil samples will be collected to depths of from one to several meters below the depths below the bottom of the waste pits to determine whether or not the waste has possibly migrated downward or laterally. Holes would be drilled far enough to the side of the pit to avoid penetrating into the actual waste materials. Any intentional penetration would require a separate proposal, appropriate review, and approval beyond the scope and objectives of this surveillance plan.

4.4 VEGETATION SAMPLING

During the Annual Survey, vegetation samples will be collected at locations where roots could penetrate to the waste repository or to waste residues migrating out of the waste area. Two or three dominant species would be selected and harvested from a circular area with the corresponding soil sample location at its center and a radius large enough to contain at least 500+ grams wet weight of each selected species' plant structure not in contact with the surface soil.

During the Detailed Survey, more vegetation samples will be collected than for the Annual Survey. Isotopic concentrations will be correlated by species, to determine whether certain species may preferentially concentrate certain chemicals. A comparison will be made against differences in root penetration depth among species that may give some species access to subsurface deposits of waste residues not available to the remaining species. Finally, some species may be important in critical pathways to man.

Vegetation sampling would occur during the growing season of the particular species. Each vegetation sample will be placed in a plastic bag identified by species, date sampled, grid location, survey, and surveyor. Soon after collection, the samples would be frozen until they can be weighed, ashed, and prepared for submittal to the analytical lab. (Freezing will reduce losses of ^{3}H and Hg from the samples.)

Among the species available at most of the LASL waste disposal areas are the following:

Species	Potential Root Depth (cm)	Life-Cycle
1. Pigweed	0-?	Annual
2. Cranesbill	0-?	Annual
3. Sweet Clover (Yellow and White)	0-10	Annual
4. Most Grasses	0-10	Annual
5. Mullen	0-100	Biennial
6. Apache Plume	0-100	Perennial
7. Mountain Mahogany	0-100	" "
8. Russian Olive	0-100+	" "
9. Willow	0-100+	" "
10. Cottonwood	0-100+	" "
11. Gambel's Oak	0-100	" "
12. Ponderosa Pine	0-100+	" "
13. Rabbit Brush	0-100	" "
14. Pinyon Pine	0-100	" "
15. One-seeded Juniper	0-100	" "

Note: This is not an all-inclusive listing, but rather a listing of typical vegetation found at most of the waste disposal areas at LASL. Prior to vegetation collection, a botanical inventory and mapping will be performed during Calendar Year 1980.

4.5 ANIMAL SAMPLING

Rodent populations would only be sampled if present in large enough numbers such that a two-week trapping period is likely to yield 60 to 100 specimens. Results from programs outside of this study would be used if available.

5.0 ANALYTICAL METHODS

Samples will be analyzed by screening methods or by detailed radiochemical or instrumental methods depending on the type of survey, the results of field measurements, and known or suspected wastes at the sampling location.

Analytical methods will generally be those used for the routine environmental surveillance program as described in Appendix C of Ref. 1 or other instrumental methods listed in Table 5.1. Detection limits are given in Table 5.2 for these radiochemical analyses and gamma spectrum analyses as performed by the H-8 Analytical Laboratory.

Annual Survey samples will be analyzed by less costly methods that will result in detection limits as much as two or three orders of magnitude higher than those specified in Table 5.2. Samples from the detailed survey will be analyzed by methods achieving the limits given in Table 5.2.

6.0 EVALUATION AND REPORTING

The report would summarize the survey results, conclusions drawn from the results and recommendations. The reports would state the survey objectives with the methods and approach employed to achieve those objectives. The new data would be integrated with other relevant information such as air sample results and compared against previous

6.0 EVALUATION AND REPORTING (Continued)

information of the waste disposal area under study to identify temporal trends. Once evaluated, a brief report of the conclusions and recommendations will be prepared. (Recommendations include corrective actions such as adding fill where subsidence is noted).

TABLE 5.1

ANALYTICAL METHODS

Analyte	Method	
Tritium	Evaporate and condense moisture. Count condensate in liquid scintillator.	Ref. 1
^{238}Pu	Separate Pu chemically from matrix soil. Count on alpha spectrometer at appropriate alpha energy.	Ref. 1
$^{239,240}Pu$	Same as ^{238}Pu.	Ref. 1
^{241}Am	Same as ^{238}Pu.	Ref. 1
^{90}Sr	Separate Sr chemically from matrix soil. Count in gas proportional counter.	Ref. 2
U (except ^{233}U)	Epithermal activation of raw sample.	Ref. 1
^{232}Th	Same as U.	Ref. 1
^{137}Cs	Count raw soil on GeLi (gamma spectrometer) at appropriate gamma energy.	Ref. 2
^{22}Na	Same a ^{137}Cs.	Ref. 2
^{60}Co	same as ^{137}Cs.	Ref. 2
^{227}Ac	Same as ^{137}Cs.	Ref. 2

Ref. 1 Environmental Surveillance at Los Alamos during 1978, LA-7800 ENV April 1979.

Ref. 2 Personal communication, W. E. Goode, LASL H8, April 11, 1980.

TABLE 5.2

ANALYTICAL DETECTION LIMITS

Parameter	Approximate Sample Volume or Weight (g)	Count Time(s)	Concentration	
Dry Weight Sample				
Tritium (as HTO)	1000	6×10^3 s	0.003 pCi/g	Ref. 1
^{137}Cs	100	5×10^4 s	0.1 pCi/g	Ref. 1
^{22}Na	100	5×10^4 s	0.2 pCi/g	Ref. 2
^{60}Co	100	5×10^4 s	0.2 pCi/g	Ref. 2
^{227}Ac	100	5×10^4 s	1.0 pCi/g	Ref. 2
^{238}Pu	10	8×10^4 s	0.003 pCi/g	Ref. 1
^{239}Pu	10	8×10^4 s	0.002 pCi/g	Ref. 1
^{241}Am	10	8×10^4 s	0.01 pCi/g	Ref. 1
^{232}Th	0.2		0.010 μg/g	Ref. 1
^{90}Sr	10	1.8×10^4 s	0.06 pCi/g	Ref. 2
^{226}Ra	100	5×10^4 s	0.5 pCi/g	Ref. 2
U	2		0.03 μg/g	Ref. 1

Ref. 1 Environmental Surveillance at Los Alamos During 1978, LA-7800-ENV April 1979.

Ref. 2 Personal Communication, W. E. Goode, LASL, H-8, April 11, 1980

APPENDIX A

LOS ALAMOS HISTORICAL AND PHYSICAL SETTING ON RADIOACTIVE WASTE DISPOSAL AREAS

The Los Alamos Scientific Laboratory is located on a remote mountain plateau 40 kilometers (km) (25 miles) by air northwest of Santa Fe, New Mexico.

This remote site was chosen in the interests of safety and security when LASL was established in the early 1940s for the development of nuclear weapons as part of the U.S. weapons program in World War II. The site had previously been used as a private school and ranch for boys. Since the end of World War II, LASL research and development work has broadened to include considerable non-nuclear work (alternative energy systems, biomedical research, laser fusion, and many other nonweapons programs).

The plateau on which Los Alamos is located is approximately 16 to 24 km (10 to 15 miles) wide and 40 to 48 km (25 to 30 miles) long. The LASL occupies about 111 km^2 (about 27,500 acres or about 43 square miles) of this plateau, which forms a part of the eastern flank of the Jemez Mountains. The plateau slopes to the east from an altitude of about 2400 meters (m) (7900 feet) above sea level along the western margin, to about 1800 m (5900 feet) on its eastern margin, where it terminates at the rim of the Rio Grande. The eastern margin of the plateau is cut into numerous mesas by southeast-trending intermittant streams. The dissected eastern margin is about 90 to 300 m (300 to 1000 ft) above the Rio Grande. Radioactive waste disposal areas are located on top of these mesas in pits dug out of solid rock. Municipal water supply is in an aquifer separated from the waste pits over 100 m[1,2] of unsaturated volcanic earth (predominantly consolidated rock) so there is no hydrologic connection between waste pits and potable water

supply. Los Alamos has a semi-arid Continental mountain climate, and rainfall in the area is sparse; evapo-transpiration exceeds the annual precipitation. Percolation from surface runoff is therefore unlikely to reach deposits of contaminated waste.

Greater geohydrological, ecological, and socio-economic description of the laboratory setting are provided in the Final Environmental Impact Statement for the LASL site.[3]

REFERENCES

1. Acid-Pueblo Canyon Resurvey Report - in preparation.
2. LA-6848-MS, Vol. 1, History and Environmental Setting of LASL Near-Surface Land Disposal Facilities for Radioactive Wastes (Areas A, B, C, D, E, F, G, and T), Margaret Ann Rogers, June 1977.
3. U.S. Department of Energy, Final Environmental Impact Statement, Los Alamos Scientific Laboratory Site, Los Alamos, New Mexico, Dec. 1979, DOE/EIS-0018.

APPENDIX B

BRIEF DESCRIPTIONS OF RADIOACTIVE WASTE DISPOSAL AREAS, MATERIALS, AMOUNTS, HANDLING METHODS, AND LOCATIONS

During the first few years of LASL operations, wastes were handled by the best available methods, but relatively little was known about some of the materials and time and manpower were limited. Solid wastes were buried in pits dug into the tuff on mesa tops or in shafts drilled vertically in the mesa surfaces - practices that, with refinements, are still considered the most effective method for this area.

The radioactive wastes are buried or stored at several sites located on the plateau between the woodlands of the Jemez Mountains to the west, and the desert grasslands of the Rio Grande Valley to the east.

Transuranic (TRU) wastes are defined as certain radioactive isotopes of the actinides (Uranium, Neptunium, Plutonium, Americium, and Curium) in concentrations equal to or greater than 10 nano-Curies per gram (10^{-9} Curies/g) (nCi/g) of waste. Low level (LL) denotes wastes containing TRU at less than 10 nCi/gram, or wastes contaminated with other radioactive materials, such as uranium, tritium, fission products and activation products.

The waste areas surveillance program addresses specific waste management areas at LASL. These include: five areas suspected or known to contain TRU wastes; two areas used for the subsurface disposal of liquid wastes; five areas that were used for the disposal or storage of specific items or specific wastes; one area identified as containing alpha-contaminated wastes, and two areas used for tritium contaminated materials. A brief description of each of these areas follows this background information in the text.

Typical wastes include tools, instruments, building materials (from the decontamination and decommissioning of older facilities), and general refuse that is lightly contaminated or suspected of being contaminated.

Waste burial at LASL has involved disposing of the wastes into pits or trenches, and shafts. Pits or trenches are typically about 8 to 11 m (25 to 40 ft) deep, 8 to 30 m (25 to 100 ft) wide, and 120 to 180 m (400 to 600 ft) long; however, these dimensions vary greatly. The wastes were placed in the pits to no closer than 1 m (3 ft) of the surface of the adjacent undisturbed terrain, with the usual practice of covering the wastes with clean fill, and then adding a final cover of 1 m (3 ft) of clean fill (soil or tuff). In locations where subsidence has occurred, additional fill has been or is to be added to bring the surface level with the surrounding terrain.

Shafts typically were drilled vertically to depths of a few meters to approximately 20 m (60 ft) and from approximately 0.6 m (2 ft) to 2.5 m (8 ft) in diameter. A few shafts are lined with concrete or metal, while most are not. The wastes were then placed in the shafts. If the dose rates at the surface warranted additional shielding, additional fill (dirt) was added above the wastes. In some cases, cement was added. When the wastes filled the shaft to not closer than 1 m (3 ft) of the surface, the usual practice has been to add a thin layer of dirt and then a poured cement cap to seal the shaft.

Before mid-1971, both TRU and LL wastes were buried together. At that time, a ruling by the AEC required that all TRU wastes be segregated and retrievably stored for a 20-year period.

To provide retrievability required special packaging and segregation. These packages included 210 ℓ (55 gal) DOT 17C drums and wooden plywood boxes treated with fiberglass reinforced polyester (FRP boxes). Placement

of these TRU containers is in designated, recorded locations, on special storage pads which are backfilled with a minimum cover of 1 m (3 ft) when filled. Certain special TRU wastes, because of higher activity and/or waste form, have been stored in concrete casks located in trenches, in vertical sections of Corrugated Metal Pipe (CMP) and in shielded casks placed in shafts. The CMPs are sections of metal pipe, cut to length and placed vertically in a surface excavation. These CMPs are used only for stored wastes, not buried wastes. Each CMP has a lower concrete plug 0.3 m (1 ft) thick. The wastes are placed in the CMP and then another concrete plug 0.3 m (1ft) is placed in the top. The top of the CMP is flush with the surrounding terrain.

Continued monitoring of all of the waste disposal areas over the years has shown that no safety or environmental hazards have resulted from LASL practices. For additional details, the interested reader is referred to the Final Environmental Impact Statement, Los Alamos Scientific Laboratory Site, Los Alamos, New Mexico, U.S. Department of Energy, December 1979, DOE/EIS-0018.

WASTE AREAS

Area A - Operated with four burial pits from 1945-1946. A fifth pit was opened in April, 1969, and used until mid-1978 for building demolition and destruction (D&D) wastes. Area A covers 5000 m^2 (1.25 acres, 53,800 ft^2) with the actual waste pits occupying about 2,600 m^2 (28,000 ft^2) of surface area. The total volume of the waste pits in Area A is estimated to be about 14, 159 m^3 (500,000 ft^3). Wastes in the first four pits probably do not contain plutonium, since Pu was in such short supply during these years. The fifth pit probably does contain Pu from wastes generated during demolition of the DP filter house. Area A was also used for the disposal of chemical wastes.

Area A also contains two steel undergound tanks, each with a capacity of 189,000 liters (ℓ, 50,000 gallons). In December, 1971, it was estimated that these two tanks contained 189,000 and 132,500 (50,000 and 35,000 gallons) with approximately 180 and 160 grams of plutonium respectively. Multiple small batches of this liquid have been removed for treatment and disposal, and by mid-1979, about 80% of the liquid had been removed. The remainder is estimated to contain about 94 grams of plutonium, with some americium ingrowth from plutonium decay.

Area B - Used from 1946 through 1948. Area encompasses 24,000 m^2 (6.0 acres, 250,250 ft^2) of which the buried waste pits occupy about 4,650 m^2 (50,000 ft^2) with an estimated total volume of about 21,240 m^3 (750,000 ft^3). Wastes may contain some small amounts of TRU among other radionuclides such as fission products and naturally occurring radionuclides as well as some hazardous wastes such as chemicals and gas cylinders.

Area B - Continued - It is estimated that the pits may possibly contain as much as 100 grams of plutonium.

Area C - Pits opened in 1948 with six buried pits used through 1964, and about 100 shafts were used through 1969. Area covers 48,000 m^2 (11.8 acres or 516,480 ft^2) with the pits occupying 20,900 m^2 (225,000 ft^2) with an estimated total volume of 103,400 m^3 (3,650,000 ft^3).

Shafts - Wastes containing larger quantities of radioactive material were placed in vertical shafts beginning in 1958, and the use of shafts in Area C continued through 1969. About 100 shafts were used. Some were lined with corrugated metal pipe (CMP), and others were not. One shaft was used exclusively for the disposal of ^{90}Sr wastes. The total volume of wastes in these shafts is estimated to be about 142 m^3 (5000 ft^3). It is estimated that 42 shafts may contain TRU wastes, while 55 probably do not.

Area E - Used between 1949 and the mid-1960s. Contains four buried pits with a surface area of about 307 m^2 (3,300 ft^2) and a total volume of about 340 m^3 (12,000 ft^3). Contains materials contaminated with uranium (^{239}U) and beryllium, and some short-life Polonium -210 (essentially all of which has decayed).

Area F - Used from 1946 through the early 50's, for the local disposal of wastes, before the organization of a Laboratory-wide disposal section. Disposal was into shallow trench burial. There are two pits, one larger and one smaller, with estimated surface areas of about 550 m^2 (5,950 ft^2) and 205 m^2 (2,200 ft^2) respectively. The smaller pit is considered to contain some ^{90}Sr, about 30 milli Curies (10^{-3} Curies) of ^{137}Cs, and some

Area F - Continued - high explosive wastes, which are contaminated with radioactivity. The estimated total volume of the smaller pit is 740 m^3 (26,100 ft^3). The larger pit is estimated to contain only high explosive wastes. The estimated volume of the larger pit is 2020 m^3 (71,400 ft^3).

Area G - Area G is the primary solid waste disposal and storage area at LASL. It has been in use since 1957 and is still in use, with 21 pits used or in use (as of 1980). The larger pits are typically 30 m (100 ft) wide by 180 m (600 ft) long by 8 m (25 ft) deep with smaller pits of varying dimensions. Additionally, there are several trenches, some of which are used for the retrievable storage of TRU wastes. Pits number 1 through 6 contain mixed TRU and LL wastes. Pit 1 is known to contain about 100 grams of plutonium, mixed with sand, in about thirty 114 liter (30 gallon) drums. Pit 2 contains drums of sludge with greater than 10 nCi/g of TRU waste, mixed in concrete. The first six pits occupy a surface area of about 33,440 m^2 (360,000 ft^2) with an estimated total pit volume of about 170,000 m^3 (6 million ft^3). In addition, pit 8 is known to contain several drums containing TRU waste. Pit 9 is used solely for the retrievable storage of TRU wastes. All other pits are considered to contain only buried wastes.

Shafts - About 120 vertical shafts are located in Area G, with an estimated surface area of about 580 m^2 (6,200 ft^2) and an estimated total volume of about 424 m^3 (15,000 ft^3). Some of these shafts contain both TRU and LL wastes. Typically, the more radioactive wastes have been disposed of in shafts rather than in pits, and the majority of this TRU waste in the shafts is associated with beta-gamma activity.

Area G - (Continued)

Area G burial pits shafts contain tritium, mixed fission products, uranium, activation products, a few grams of ^{238}Pu, and small amounts of other TRU elements (such as ^{241}Am and ^{237}Np).

Area H - No unclassified records are available to determine what wastes were placed in this area, however, it is known that the area contains vertical shafts, which were used for the disposal of classified materials, and that some radioactive material (principally tritium and uranium) were also disposed of in these shafts.

Area J - This area was used as a classified materials waste area. However, tritium has been detected in tuff samples taken by the waste pits.

Area K - This area was also used as a septic tank and here again, tritium has been observed by Health Research Division personnel.

Area T - This area has been used in two different ways. From 1945 to 1967, four absorption beds were used for the subsurface disposal of liquid wastes resulting from the recovery of plutonium. Beginning in 1968, treated liquid wastes were mixed with cement and placed in vertical shafts.

The absorption beds were four trenches approximately 35 m (115 ft) long by 6 m (920 ft) wide by 1.2 m (4 ft) deep, which were excavated in the tuff, and backfilled with coarse material, grading from 0.2 m (8 inch) boulders in the bottom, through gravel, to fine sand at the surface. Liquid wastes containing plutonium and americium were discharged to these beds from 1945 to 1952. From 1945 to 1967, the beds received effluent from a liquid waste treatment facility. The use of these beds was discontinued in 1967.

Area T (Continued) -

The operation of the liquid waste treatment facility resulted in the production of a sludge residue contaminated with plutonium and americium. For many years, this material was placed in steel drums for disposal at Areas C and G. In 1968, the use of a pug mill was initiated, which mixed the residue with cement, which was then pumped directly into asphalt-coated shafts that were approximately 20 m (65 ft) deep and 2 to 2.4 m (6 to 8 ft) in diameter. Starting in 1975, this sludge and cement paste has been disposed of as non-retrievable waste in shafts. This waste contains less than retrievable amounts of TRU (^{238}Pu and ^{241}Am) and also contains ^{90}Sr, ^{132}Cs, and uranium. It is estimated that the absorption beds contain approximately 10 Curies of TRU activity.

The total surface area of Area T is about 1870 m^2 (20,100 ft^2) with an estimated total volume of about 7020 m^3 (248,000 ft^3). It is estimated or known that 56 of the shafts and all of the CMP sections contain TRU wastes, while six of the shafts do not.

Area U - Used 1945-1968, this area contains two absorption beds similar to those in Area T. The area contains actinium contamination. The surface area is about 167 m^2 (1,800 ft^2) with an estimated total volume of about 510 m^3 (18,000 ft^3), and probably contains no TRU wastes.

Area V - Used 1945-1961, with three absorption beds receiving waste water from a laundry. These absorption beds were also similar to those described in Area T. The estimated surface area is about 1,390 m^2 (15,000 ft^2) with an estimated volume of contaminated material of about 4,250 m^3 (150,000 ft^3). Area V contained approximately 3 Curies of ^{90}Sr, ^{140}Ba, ^{140}La, and also Pu at concentrations that meet the

10 nCi/gram definition of TRU wastes. The Ba and La have half-lives measured in days and hours, and have therefore all decayed.

Area W - Used 1963 to the present, for the subsurface storage of two coolant tanks associated with the LAMPRE reactor, which was dismantled in 1963. These tanks are 20 centimeters (cm) (8 inches) in diameter x 30.5 (100 ft) long, and contain 110 to 115 liters (30 gallons) of irradiated metallic sodium, in temporary storage. Each tank is encased in a carbon steel sleeve and placed in a separate vertical shaft about 35 m (115 ft) deep. The total volume of the wastes is estimated to be 2.8 m^3 (100 ft^3). The tops were entombed with a concrete structure in 1979.

Area X - Used from 1964 to present, for the subsurface storage of the LAMPRE reactor vessel. Estimated to contain some of the longer lived activation products and some residual ^{235}U. LASL is planning on removing the reactor vessel to burial in Area G.

Area Y - Used from 1966 to present, for disposal of waste from dynamic testing operations, principally wastes contaminated with high explosives. It is estimated that the wastes contain slight amounts of depleted uranium.

ENCLOSURE 14
ATT. 3: 1983 REPORT ENTITLED "SURFACE RECONNAISSANCE THROUGH 1980 FOR RADIOACTIVITY AT RADIOACTIVE WASTE DISPOSAL AREA G AT THE LOS ALAMOS NATIONAL LABORATORY"

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Surface Reconnaissance Through 1980 for Radioactivity at Radioactive Waste Disposal Area G at the Los Alamos National Laboratory

Don Mayfield
Wayne R. Hansen

Los Alamos
Los Alamos National Laboratory
Los Alamos, New Mexico 87545

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SURFACE RECONNAISSANCE THROUGH 1980 FOR RADIOACTIVITY AT RADIOACTIVE WASTE DISPOSAL AREA G AT THE LOS ALAMOS NATIONAL LABORATORY

by

Don Mayfield and Wayne R. Hansen

ABSTRACT

Surface transport of waste residues was investigated at Waste Disposal Area G by sampling soil, air, and water at the site surface. Sampling locations for soil and vegetation were deliberately selected at (1) the most likely points of occurrence of radionuclides or (2) likely points of occurrence with theoretically the highest concentrations of radionuclides if radionuclides were transported from burial to the site surface. Data obtained from this reconnaissance showed that ^{3}H, $^{239,240}Pu$, and γ-emitting radionuclide concentrations occasionally increase modestly above regional background levels. The data also indicated that ^{3}H is migrating from waste repositories, whereas $^{239,240}Pu$ and γ-emitters are not migrating out of repositories. The latter were probably deposited on the surface by occasional spills during disposal operations or as a result of surface storage and holding practices. However, all radionuclide concentrations remain orders of magnitude below applicable standards and guides used to assure that their concentrations in environmental media would not lead to unnecessary or unsafe levels of exposure to the public.

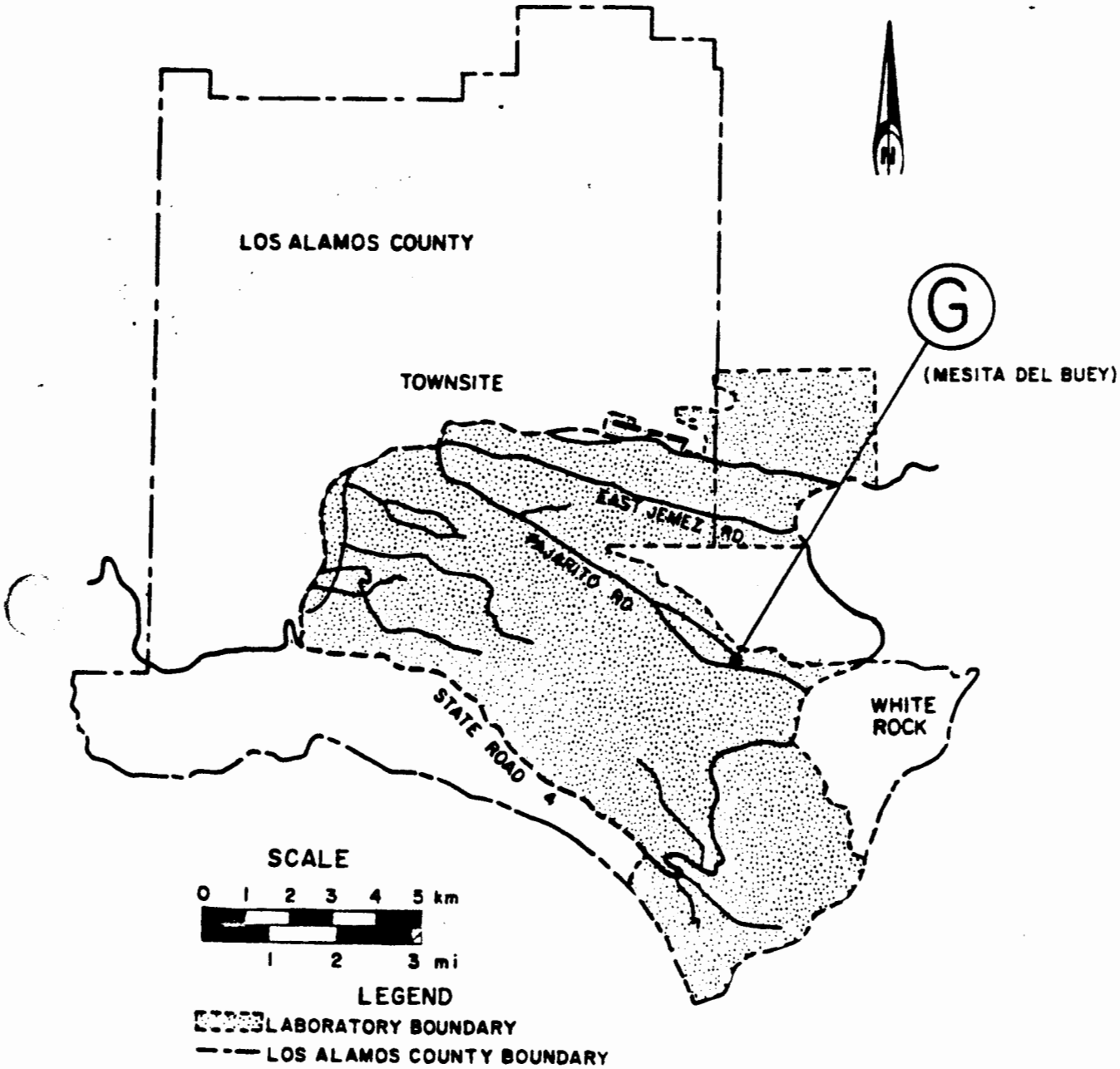

Fig. 1. Area G location within Los Alamos County.

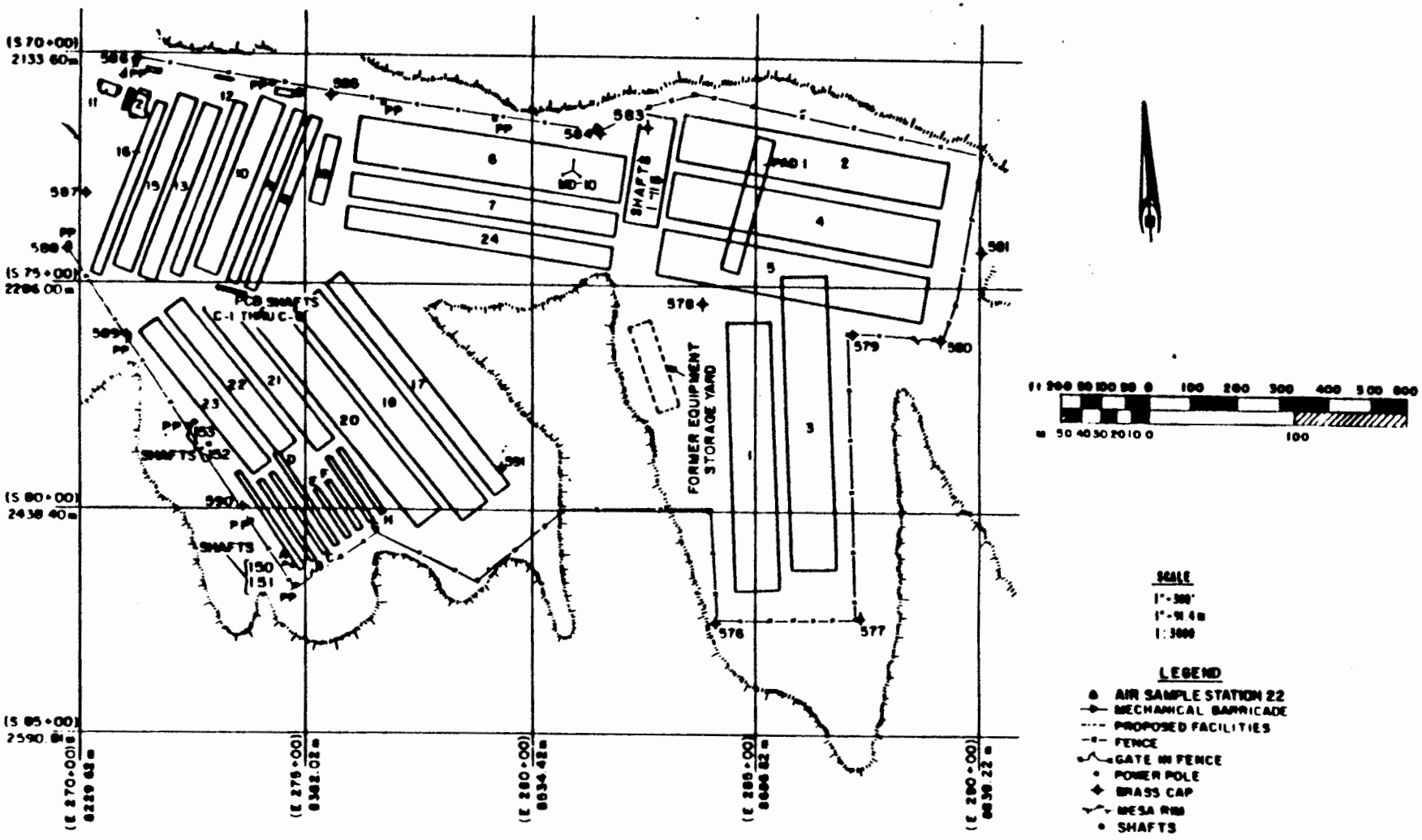

Fig. 3. Portion of Area G surveyed in 1980.

transuranic* (TRU) elements (such as ^{241}Am and ^{237}Np). See Tables I and II for more detail.

The wastes placed in the pits were no closer than 1 m (3 ft) from the surface of the adjacent undisturbed terrain. The current practice is to cover the wastes with clean fill on a daily basis and then add a final cover of 1 m (3 ft) of clean fill (soil or tuff). Should subsidence occur, additional fill would be added to bring the surface level with the surrounding terrain. The first six pits were about 30 m (100 ft) wide by 180 m (600 ft) long by 8 m (25 ft) deep, occupying a surface area of about 33 440 m^2 (360 000 ft^2) with an estimated total pit volume of about 170 000 m^3 (6 000 000 ft^3). The remaining 16 pits have been smaller and their dimensions vary considerably. One of the pits is used for the retrievable storage of TRU wastes.

Pits numbered 1 through 6 contain mixed TRU and low-level** (LL) wastes. Pit 1 is known to contain about 600 grams of plutonium, mixed with sand, in about thirty 114-ℓ (30-gal.) drums. Pit 2 contains drums of TRU sludge mixed in concrete. In addition, Pit 8 is known to contain several drums containing TRU waste. Pit 9 is used solely for the retrievable storage of TRU wastes. All other pits are considered to contain only buried LL wastes.

The 120 or so vertical shafts located in Area G have an estimated surface area of about 580 m^2 (6 200 ft^2) and an estimated total volume of about 424 m^3 (15 000 ft^3). Shafts typically are drilled vertically to depths of a few meters to approximately 20 m (60 ft) and from approximately 0.6 m (2 ft) to 2.5 m (8 ft) in diameter. A few shafts are lined with concrete, asphalt, or metal, while most are not. Casks containing TRU wastes mixed with high levels of β/γ emitters also have been placed in some shafts. If the dose rates at the surface warranted additional shielding, additional fill (dirt) was added above the wastes. In some cases, concrete was added. When the wastes have filled the shaft to not closer than 1 m (3 ft) of the surface, the usual practice has been to add a thin layer of dirt and then a poured concrete cap. This seals the shaft to prevent intrusion of precipitation and biota.

Before mid 1971, both TRU and LL wastes were buried together. At that time, the Atomic Energy Commission (AEC) required that all TRU wastes be

---

*Transuranics are metals of greater atomic number than uranium although ^{233}U and its daughter products are included because of their relatively severe radiological properties compared with those other TRU nuclides. Both ^{238}Pu and ^{241}Pu are omitted because of their relatively less severe radiological properties. At Los Alamos ^{238}Pu wastes above 100 Ci/g have been stored as TRU wastes.

**Low-level wastes have been any radioactive waste containing less than 10 nCi/g TRU and not classed as high-level waste or uranium mill tailings. Effective 9/30/82 the 10 nCi/g definition level for TRU wastes has been increased to 100 nCi/g. (DOE 5820.1)

D. Survey Design Features and Survey Methods

The survey was designed to indicate whether or not waste components are migrating away from confinement in sufficient concentrations to warrant more extensive surveillance or remedial action. The design basis is deliberate selection of samples most likely to indicate waste residues transported to the environment. Results generally cannot be taken as representative of conditions at the waste disposal site, but rather as indicative of an upper limit of these conditions. Appropriate samples include surface soil (with rock), vegetation, animals, and air. [Air samples were taken near and downwind from a portion of Area G that was used for contaminated equipment storage in the late 1960s and early 1970s (Fig. 3). Most, but not all, of this area was covered with uncontaminated soil in 1979.]

Survey methods adopted for this work began with a literature search of previous surveys and operating records. This review was conducted concurrently with efforts to 1) develop a survey grid and map specific to Area G, and 2) visit Area G to locate (a) obvious or apparent breaches in confinement and (b) the dominant runoff channels and associated catch basins. Next, the surface over the waste disposal site and a margin around it were scanned with portable radiation detectors to identify areas of unusual radioactivity. Such anomalous radioactivity, should it occur, or features suggesting possible breaches in confinement, should they be observed, would serve as a basis for selecting sampling locations likely to have associated waste residues. Also, catch basins in dominant runoff channels would collect surface-deposited waste residue transported by runoff. Such locations were selected to provide x-ray and gamma-ray spectra, soil samples, and vegetation samples. A concurrent study by the Environmental Science Group (Group LS-6) provided rodent samples for this project. Air-sample results from the Los Alamos Environmental Surveillance air net were compared with soil-sampling results from the present survey.[10-14]

Radioactivity survey meters used for the surface scans are shown in Fig. 4. The phoswich was used to detect x rays and low-energy gamma rays. The μR meter was used for higher or more commonly observed gamma-ray energies. These instruments are described elsewhere.[16] The multichannel analyzer used is also shown connected to the phoswich and connected to the 2 x 2 NaI detector in Fig. 4. Figure 5 shows the equipment used in soil sampling and vegetation sampling.

Data from the annual surveillance reports were also used. Neither air samples nor environmental dosimeters were used in the surface reconnaissance. Rather, results from the Los Alamos environmental-surveillance nets reported for the years from 1976 through 1980 have been adopted for this report. Environmental dosimeters (thermoluminescent dosimeters or TLDs) are described

in Refs. 7-14, and air sampling is described in Ref. 17. Soil sampling and air sampling are also discussed in Appendix A. Analytical chemistry methods are described in Appendix B.

Vegetation samples collected during the present survey were identified by species. Transpiration samples were not taken, although ^{3}H was analyzed from moisture removed during sample preparation. Other analyses on these samples were gamma spectra, $^{239,240}Pu$, and total uranium.

Rodents were trapped from two different grid locations. They were pooled for analysis, but before analysis they were segregated by whole-body counting. The four mice from both grids showing the highest radioactivity were analyzed separately from the remainder of the pool.

II. RESULTS

A. 1980 Current Site Visit

Subsidence has occurred at Pits 7 and 8. Subsidence at Pit 8 was caused by short-term departure from burial methods used at Area G. Pit 8 was backfilled to remedy the subsidence. Subsidence at Pit 7 was a singular occurrence, which has been documented. It attests to the improvement in burial techniques relative to those used at earlier disposal areas.[5] No artifacts were observed as a result of subsidence at Area G. A number of windblown artifacts (some rather large) have been observed near Area G and suggest the importance of wind as a local transport agent. None of these artifacts gave a positive indication of associated radioactivity, and all are believed to originate from site operations rather than from any waste materials. All were cleaned up during routine housekeeping of Area G.

The security fence at Area G is in excellent condition and access is carefully controlled at each gate. There is evidence that small animals, perhaps coyotes, have occasionally dug under the fence, and deer have been observed within the fence. Rodent activity is evident and some relevant radioecological studies have been completed.[18] No erosion associated with waste pits was evident. In fact, various grasses have been planted in most areas where burial has been completed to provide ground cover. Inspection of basins in the local drainage pattern led to the selection of locations G-7, G-8, G-9, G-10, G-11, G-12, G-13, and G-14 for soil and vegetation sampling (Fig. 6).

B. Field Measurements and Radioactivity

The entire area within the exclusion fence and east of the operations building constitutes the active part of the disposal site. It was surveyed

with the μR meter and the phoswich. In addition, a margin along each side of the access road and the margin around the site were surveyed with both instruments. Positive results occurred 1) near a storage building by some loaded waste drums, 2) at the southwest end of Pit 1, and 3) in the vicinity of the disposal shafts west of Pit 1 and shafts west of Pits 2 and 4 (Fig. 6). Since increased radioactivity was expected in the vicinity of the disposal shafts, sampling points were not established there on the basis of radioactivity scans. Surface transport of residue from the vicinity of shafts west of Pit 1 would be caught in the soil-sampling location G-7 for the arroyo (Fig. 7). Surface transport from the vicinity of the shafts west of Pits 2 and 4 would be caught at either G-7 or G-5. The remaining scan results led to the selection of locations G-1 and G-2 for sampling and in situ spectra.

In situ gamma- and x-ray spectra indicated ^{241}Am (and an as yet unidentified emission at 32 keV) on the southwest side of Pit 1. No unusual 660-keV activity to implicate ^{137}Cs was observed. This location was subsequently decontaminated and sampling location G-2 was selected a few meters away. Spectra from the new sampling location indicated low levels of activity below 30 keV, possibly from TRU isotopes.

Instrument-scan results were elevated just north of the storage buildings, but these results were suspected of being caused by a group of waste barrels in temporary storage close by. Neither x-ray nor gamma-ray spectra, taken when some of the barrels were present, indicated any unusual radiations. An x-ray spectrum taken after the barrels were removed also indicated that no unusual x-radiations were present. In addition to positive results at Pit 1, unusual, and as yet unidentified, peaks at 43, 96, and 177 keV occurred in spectra taken a few meters north and a little east of the northeast corner of Area G at G-13 (Fig. 6 shows location of G-13.) Subsequent analyses of soil samples by gamma-spectrum analyses did not support this field observation, suggesting that when the phoswich was operated in the ungated mode, spectra from its CsI crystal were superimposed on the spectra from its NaI crystal.

C. Soil Sampling

Soil-sampling methods are discussed in Ref. 1. Briefly, 500 to 900 g of soil were sampled from each of the 0- to 1-cm, 1- to 10-cm, and 10- to 30-cm layers of the soil profile for radiochemical analysis. Since soil-sampling locations were selected where waste residues might be expected, the data produced biased results (see Table III). The biased sample selection scheme cannot yield representative estimates of concentrations, nor can it specify the distribution of concentrations across the sampling grid. It can, however, highlight focal points of concentrations if one draws isopleths of concentrations suggested by the biased data points. The sampling results are

TABLE III

SUMMARY SOIL CONCENTRATION STATISTICS

	Fenced			External Margin		
	0-1 cm deep	1-10 cm deep	10-30 cm deep	0-1 cm deep	1-10 cm deep	10-30 cm deep
^{3}H (nCi/ℓ)						
Range	3.70 to 204.00	3.20 to 185.00	4.70 to 633.00	3.10 to 81.00	3.50 to 75.40	3.10 to 307.00
$\bar{X} \pm S^{a}$	67.10 ± 73.94	50.57 ± 69.64	163.66 ± 249.59	29.28 ± 29.37	16.51 ± 24.09	45.71 ± 105.69
N	7	7	7	8	8	8
Total U (μg/g)						
Range	3.40 to 4.60	3.70 to 4.70	4.10 to 5.00	3.90 to 5.80	3.80 to 6.30	2.50 to 5.10
$\bar{X} \pm S^{a}$	4.29 ± 0.53	4.31 ± 0.36	4.46 ± 0.36	4.55 ± 0.58	4.70 ± 0.78	4.10 ± 0.84
N	7	7	7	8	8	8
$^{239,240}Pu$ (pCi/g)						
Range	0.032 to 8.25	0.017 to 4.51	0.033 to 1.79	0.07 to 1.59	0.032 to 1.66	00.58 to 2.46
$\bar{X} \pm S^{a}$	1.37 ± 3.05	0.83 ± 1.63	0.41 ± 0.621	0.64 ± 0.57	0.69 ± 0.64	0.90 ± 0.98
N	7	7	7	8	8	8

	1980 BACKGROUND (Ref 12) 0-5 cm deep		
	Regional	Perimeter	On Site
^{3}H (nCi/ℓ)			
Range	0.9 to 2.5	0.6 to 14.0	0.5 to 440
$\bar{X} \pm S^{a}$	1.6 ± 0.75	3.4 ± 4.55	25.5 ± 100.4
N	6	8	19
Total U (μg/g)			
Range	2.1 to 3.1	3.3 to 4.9	3.3 to 8.2
$\bar{X} \pm S^{a}$	2.4 ± 0.35	4.0 ± 0.5	4.5 ± 1.2
N	6	8	19
$^{239,240}Pu$ (pCi/g)			
Range	0.003 to 0.017	0.009 to 0.169	-0.001 to 0.610
$\bar{X} \pm S^{a}$	0.009 ± .00065	0.048 ± 0.053	0.089 ± 0.1565
N	6	10	22

[a]67% Confidence.

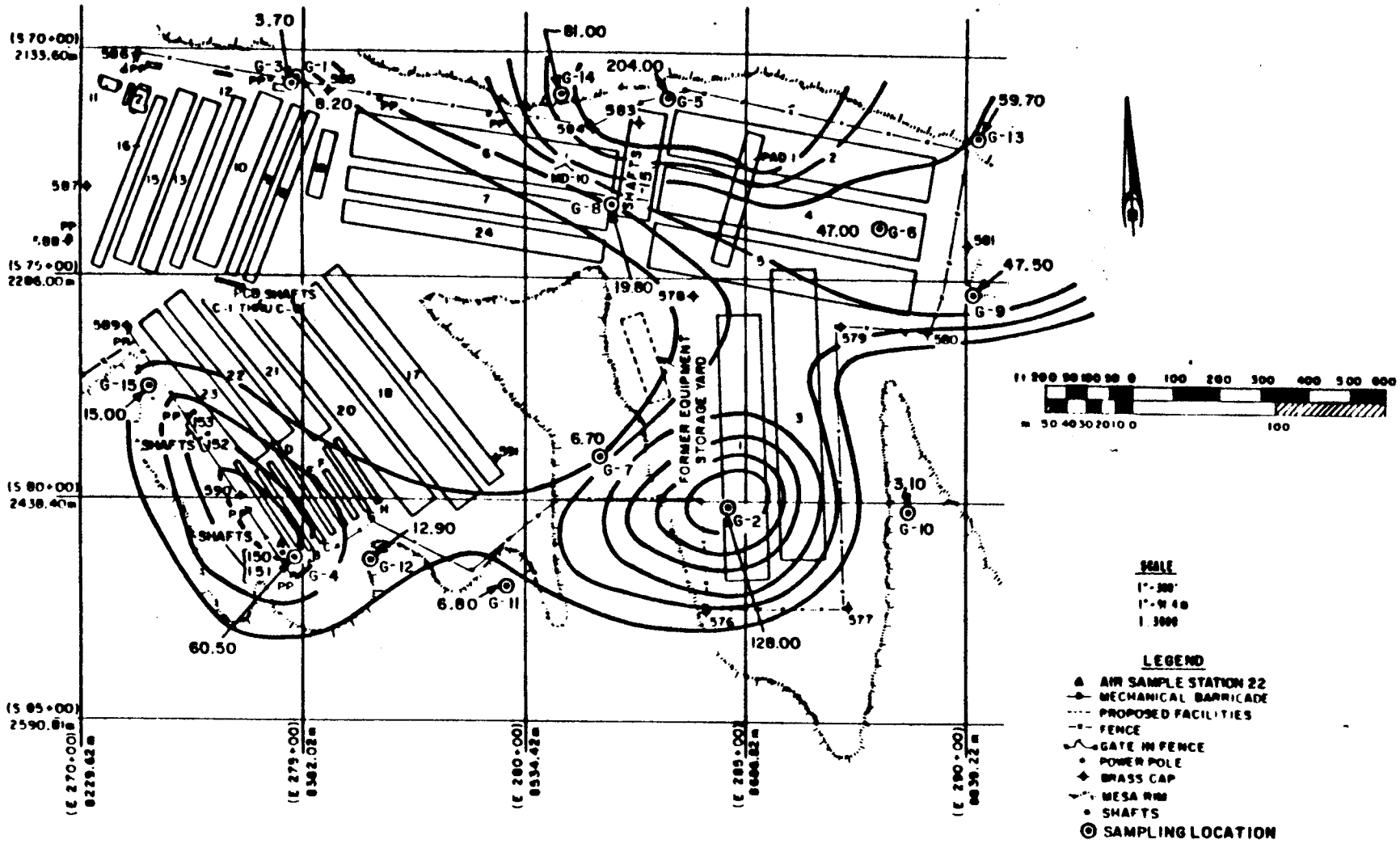

Fig. 8. Tritium concentrations in soil (0 to 1 cm).

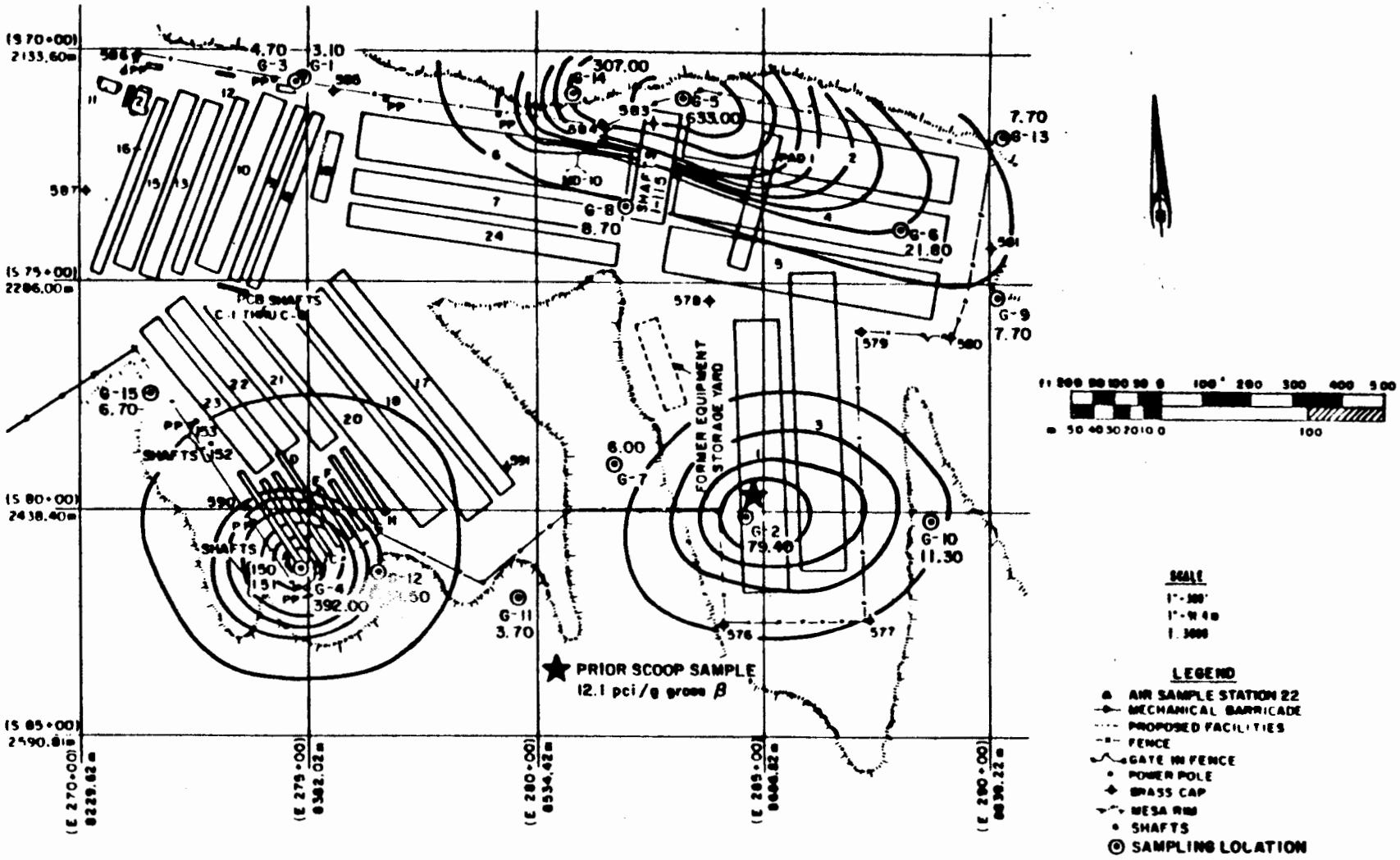

Fig. 10. Tritium concentrations in soil (10 to 30 cm).

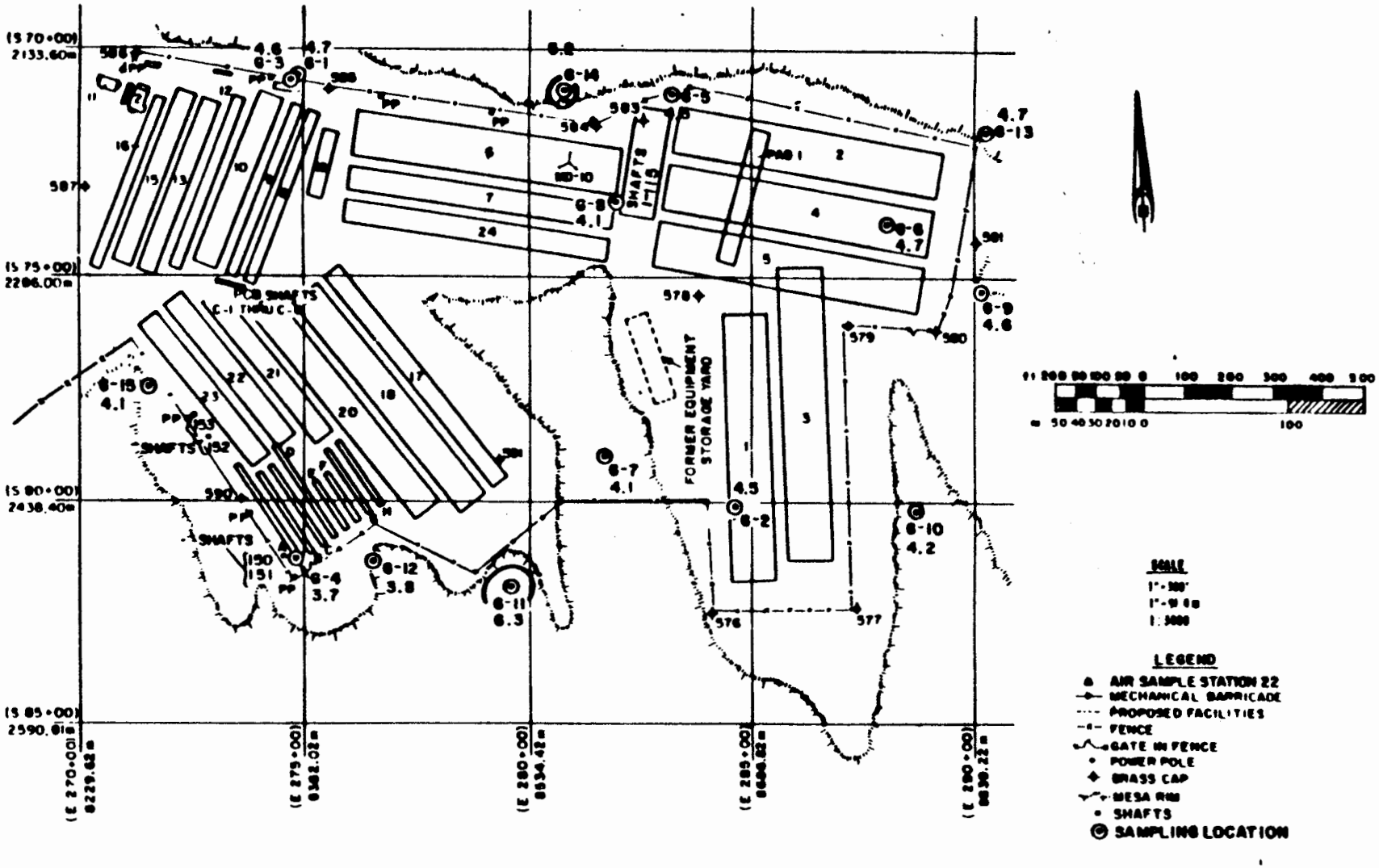

Fig. 12. Total uranium concentrations in soil (1 to 10 cm).

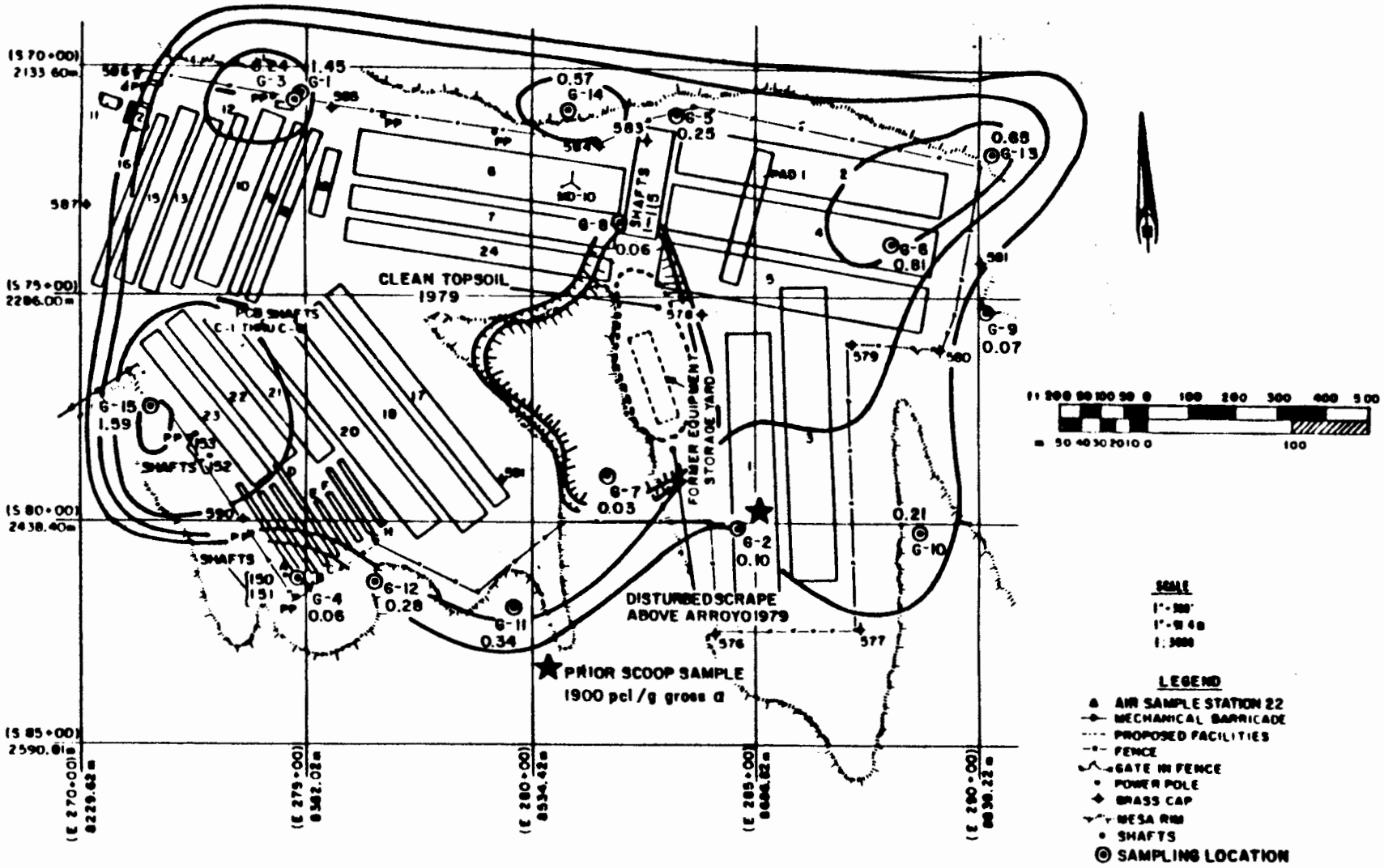

Fig. 14. Plutonium-239,240 concentrations in soil (0 to 1 cm).

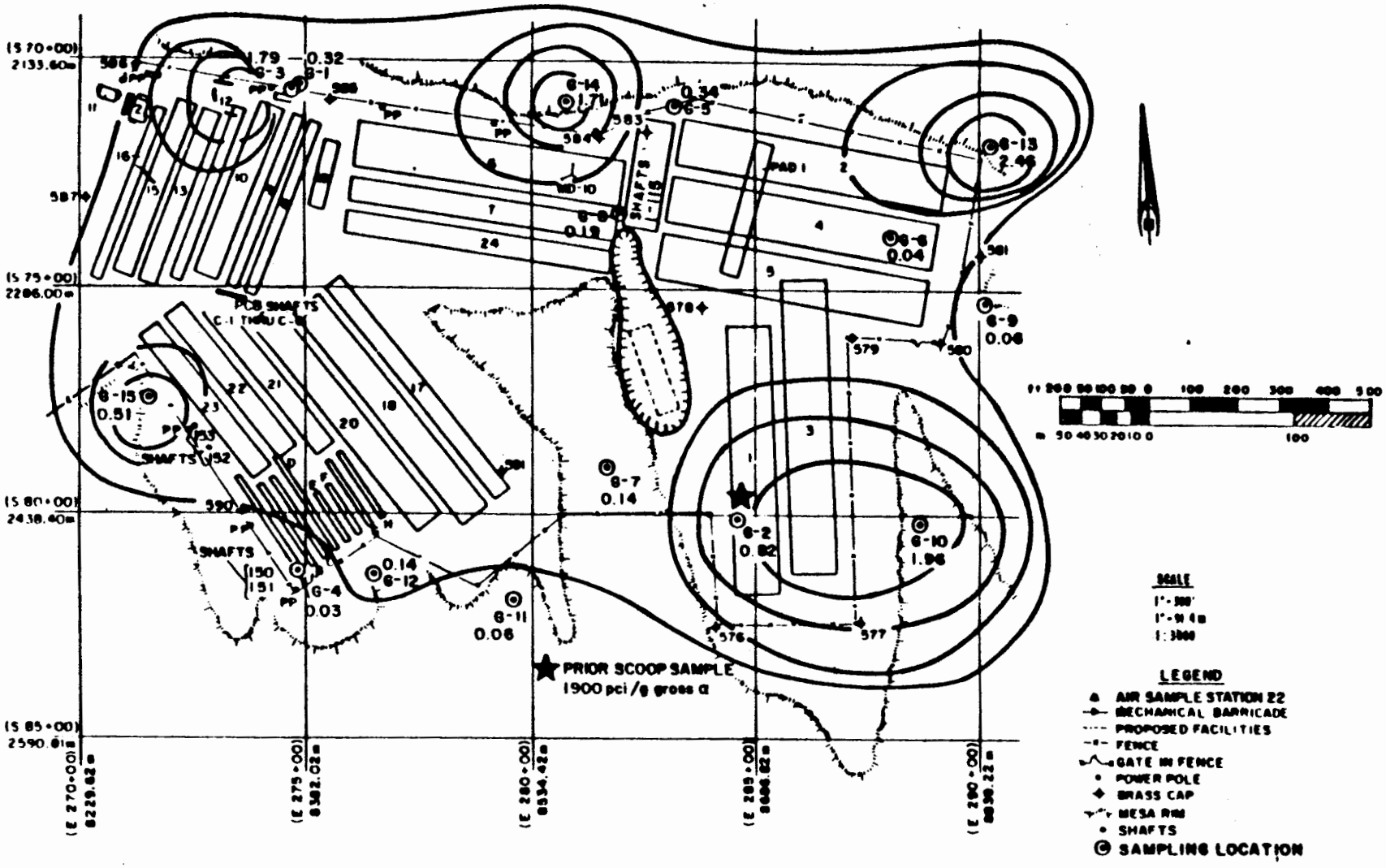

Fig. 16. Plutonium-239,240 concentrations in soil (10 to 30 cm).

TABLE IV

ANNUAL AIR NET $^{239,240}Pu$ RESULTS IN 10^{-18} µCi/mℓ AT 95% CONFIDENCE

	76	77	78	79	80
Area G Sample (TA-54)	26.8 ± 2.9	34 ± 30	80 ± 120	23 ± 70	13 ± 13
Samples farther from Area G					
-12 White Rock	5.2 ± 1.1	17 ± 26	19 ± 35	4.2 ± 6.5	2.6 ± 3.4
-21 Booster P-2	5.8 ± 1.0	21 ± 39	24 ± 41	3.2 ± 5.5	1.6 ± 2.4
-24 TA-33	5.3 ± 1.0	18 ± 30	28 ± 46	6.9 ± 8.6	3.5 ± 3.9
Regional Average	4.1 ± 0.5	16 ± 24	20 ± 39	5 ± 15	1.1 ± 0.9
Perimeter Average	5.2 ± 0.3	26 ± 94	27 ± 43	8.1 ± 30	8.1 ± 8.3
On-Site Average	22.5 ± 1.1	21.1 ± 33	32 ± 67	8.3 ± 33	6.7 ± 5.2

TABLE VI

ANNUAL AIR NET TOTAL ^3H RESULTS IN pg/m^3 AT 95% CONFIDENCE

	76	77	78	79	80
Area G Sample (TA-54)	300 ± 32	187 ± 362	57 ± 84	35 ± 74	53 ± 21
Samples farther from Area G					
-12 White Rock	23 ± 2	17 ± 25	7 ± 14	4.1 ± 5.4	11 ± 9
-21 Booster P-2	34 ± 2	27 ± 37	14 ± 45	8.1 ± 31	12 ± 9
-24 TA-33	59 ± 5	8 ± 329	25 ± 54	40 ± 42	44 ± 17
Regional Average	15 ± 2	13 ± 33	4 ± 9	2.7 ± 8.7	7.7 ± 5.8
Perimeter Average	23 ± 1	25 ± 55	13 ± 23	4.9 ± 15	10 ± 4
On-Site Average	60 ± 2	52 ± 184	18 ± 48	12 ± 42	17 ± 5

TABLE VII

SUMMARY VEGETATION CONCENTRATION STATISTICS

	Fenced			External Margin		
	Grass	Forb	Tree/shrub	Grass	Forb	Tree/shrub
^{3}H (nCi/ℓ)						
Range	3.3 ± 0.3	3.3 - 3860	2.6 - 19,100	0.4 - 43.	248 ± 4	3.7 - 35.7
$\bar{X}\pm S^{a}$	3.3 ± 0.3	1001 ± 1488	7028 ± 9272	17.8 ± 16.2	248 ± 4	15.0 ± 12.4
N	1	7	5	5	1	5
Total U (μg/g ash)						
Range	0.440 ± 0.04	0.09 ± 0.009	-	0.380 - 1.08	0.780 ± 0.071	-
$\bar{X}\pm S^{a}$	0.440 ± 0.04	0.09 ± 0.009		0.588 ± 0.258	0.780 ± 0.071 N	
N	1	1	0[b]	6	1	0[b]
$^{239,240}Pu$ (pCi/g ash)						
Range	0.51 ± 0.02	0.027 - 0.286	0.259 - 1.55	0.130 - 10.6	0.5 ± 0.02	0.450 - 3.28
$\bar{X}\pm S^{a}$	0.51 ± 0.02	0.124 ± 0.094	0.767 ± 0.445	1.841 ± 3.871	0.5 ± 0.02	1.11 ± 1.08
N	1	6	6	7	1	1
γ-spec comment						

1980 BACKGROUND
FRUITS AND VEGETABLES

	Regional	Perimeter	On site
^{3}H (nCi/ℓ)			
Range	-0.9 to 0.2	-0.4 to 0.5	0.2 to 4.1
$\bar{X}\pm S$			
N	15	10	5
Total U (μg/g ash)	b	b	b
Range	0.0 to 15.8 or <70	0.0 to 4.3 or <48	0.0 to 18.7 or <20
$\bar{X}\pm S$			
N	15	10	5
$^{239,240}Pu$ (pCi/g ash)			
Range	-12 to 2.7	-2.1 to 0.60	-0.10 to 64
$\bar{X}\pm S$			
N	15	10	3

[a]67% confidence.
[b]Whichever is greater.

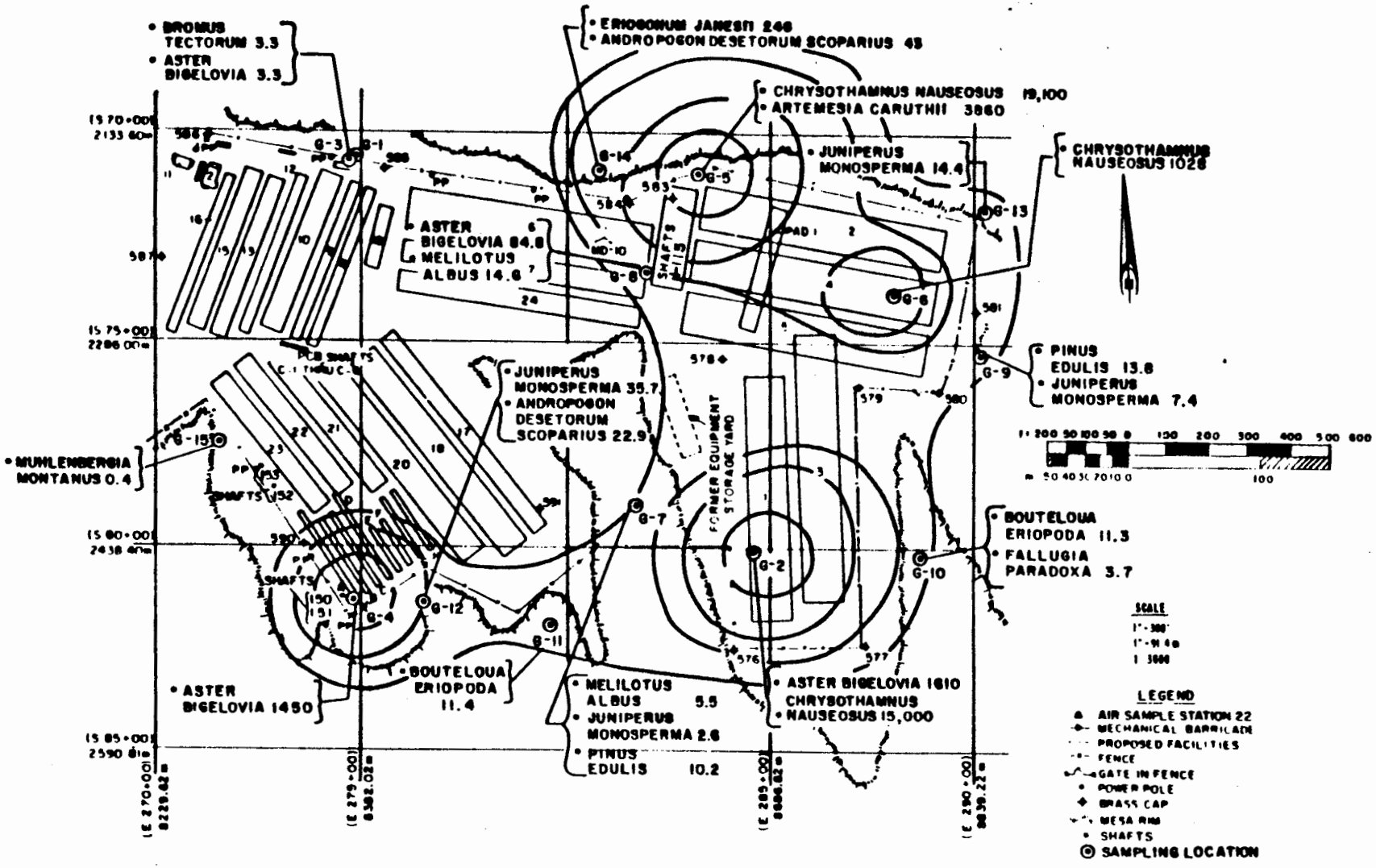

Fig. 18. Tritium concentrations in vegetation.

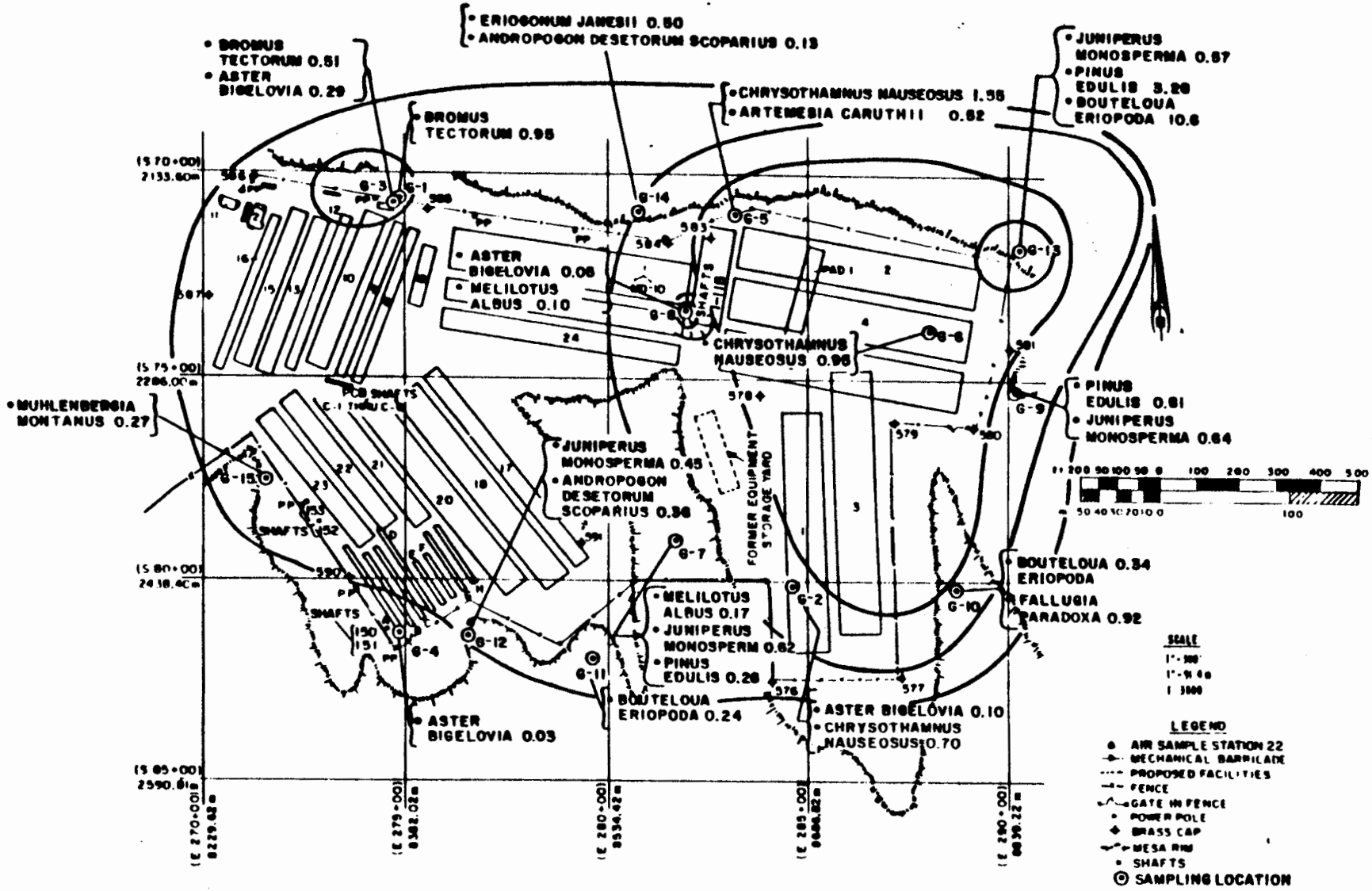

Fig. 20. Plutonium-239,240 concentrations in vegetation.

analyte. Table VIII summarizes statistics based on the data obtained from analyzing the rodents. These data are given in Table C-III of Appendix C.

Tritium was taken from moisture collected while we were drying the samples. Tritium concentrations in pooled rodent tissues ranged from roughly 600 to 4000 nCi/ℓ. The one organ sample (carcass from the four highest counting animals) that generated enough moisture for analysis was only about 1000 nCi/ℓ or about half of either the pooled internal or external averages (Table VIII). This indicates considerable variability in ^{3}H . Concentrations of ^{3}H in internal and external pooled fractions showed close numerical correspondence. Total uranium analyses were not run because sample mass was usually too small to spare any sample for total uranium.

Plutonium-239,240 concentrations in pooled internal rodent tissues differed from pooled external rodent tissues (Table VIII). The range of pooled internal tissue concentrations ranged one to two orders of magnitude lower than the pooled external tissues concentrations. Pooled internal tissue concentrations also averaged two orders of magnitude lower than pooled external tissue concentrations. The standard deviation for internal as well as external pools was roughly double the average for each. Pooled internal (carcass and liver) samples of the "four highest" had concentrations of ~0.02 pCi/g. This is an order of magnitude higher than the lowest internal fraction of sample (0.004 pCi/g) and an order of magnitude lower than the highest internal fraction of sample (0.2 pCi/g). Pooled internal concentrations from the four highest pool (0.02 pCi/g) are comparable to the pooled internal average (0.06 pCi/g). External or pelt, GI tract, and lung pools of the four highest ran roughly an order of magnitude higher (~0.04 pCi/g) than the lowest internal fraction of pooled sample (0.004 pCi/g) and two orders of magnitude lower than the highest external fraction of pooled sample (15.0 pCi/g), as well as an order of magnitude lower than the external average (3.8 pCi/g). One internal fraction of pooled sample corresponded to its external fraction on a one-to-one basis (Table C-III, Appendix C). The rest were one and two orders of magnitude lower than their respective external fractions.

In vitro gross γ-results also shown in Table VIII indicate that the gross γ-activity is indeed higher in the selected four highest pool as one might expect from the screen counting process, which responds to the same gross γ-activity observed in the *in vitro* analysis. All of the four highest came from the north transect. These positive results conflict with results showing no positive γ-radioactivity associated with pocket gopher diggings at the north transect.[18]

2. Bees and Honey. The environmental surveillance effort at Los Alamos has used bees and honey for several years as indicators of environmental

dispersion of radionuclides from the laboratory.[13,14] Table IX compares results from a sampling station near Area G with results from three background locations. Table IX also gives radionuclide concentrations in honey and in bees for the years 1979 and 1980. Radionuclides in honey include ^{137}Cs, ^{3}H, total U, and $^{239,240}Pu$. However, there are no data for $^{239,240}Pu$ in honey for 1979 and only total U data are available for bees.

The meaning of ^{137}Cs concentrations in honey is obscure because of the uncertainty in the value of the Area G data and the Chimayo background data. At tens of pCi/ℓ, the ^{137}Cs concentrations are obviously very low.

The ^{3}H concentration in Area G honey ranged from roughly 10 to 21.4 pCi/mℓ, which is 2 to 20 times background levels. Data from Pajarito Acres reflect operations at the TA-33 site nearby. The 1980 concentration at Area G (21.4 pCi/mℓ) is several multiples of the background locations (0.6 to 4 pCi/mℓ) or more nearly in agreement with expectations for Area G, based on consideration of ^{3}H in soil, air, vegetation, and rodent samples of the present survey.

Total uranium concentrations in honey were below detection limits, but concentrations in bees were tens of parts per billion. Among bees, there seems to be no difference in total uranium concentrations at Area G and the background locations, assuming that background may vary through the range 0 to 59 ppb.

The $^{239,240}Pu$ concentration in honey at Area G is 0.05 fCi/g or midrange for the background locations, i.e., between 0.03 fCi/g at Pajarito Acres and 0.08 fCi/g at Barranca Mesa.

III. INTERPRETATION OF DATA

A. Uranium

Total uranium measurements were made in soil, air, vegetation, honey, and bees. None of these environmental media indicated unusual concentrations of total uranium. It is concluded that uranium as a waste residue is not detectable above natural background at Area G, so further discussion of uranium will be limited in this section to a few cases that support or clarify interpretation of other radionuclide data. For further discussion of uranium results, see Appendix D.

B. Soil

The horizontal distribution of ^{3}H at all three depths of soil (0 to 1 cm, 1 to 10 cm and 10 to 30 cm) corresponds by location, G-5, G-2, and G-4 being

principal foci shown in Figs. 8, 9, and 10. G-5 and G-2 are in the eastern-most fraction of Area G over Pits 1 through 5, and G-4 is near the tritium disposal shafts on the west side of trench A in the southwest corner of Area G. Tritium concentrations at G-1, G-9, G-10, G-12, G-13, G-14, and G-15 are all above local and regional background and they are all outside of the fence. These traces attest to the high environmental mobility of ^{3}H, but their magnitude is low (less than 700 nCi/ℓ) relative to current cleanup practice (8870 nCi/ℓ) adopted at Los Alamos in the absence of prior governmental or industrial guidelines.[19] Concentrations observed at G-5 are expected since it is north of the disposal shaft between Pits 4 and 6 (see Fig. 8). Some of these shafts have been used for ^{3}H disposal. G-2 is over Pit 1 for which ^{3}H is not expected based on existing records. G-4 is near disposal shafts 155 and 156, which have been used for ^{3}H wastes disposal. Note that G-8 is closer to the disposal shaft area between Pits 4 and 6 than G-5 is, yet ^{3}H concentrations at G-8 are one to two orders of magnitude lower, suggesting irregular position and inventory, unequal integrity of confinement in the storage shafts, or unequal migration mechanics near the shafts. References 20, 21, and 22 indicate that all three possibilities play a part in this distribution. The vertical distribution of ^{3}H concentrations at G-5 and G-4 increases with depth, whereas that at G-2 decreases. This suggests a surface or near-surface deposit at G-2 or that G-2 is somewhat remote horizontally from the source. About equal numbers of samples (~5) show no vertical change in concentration compared with those that increase (~5) or those that decrease (~5). Topography and differential mobility in the tuff structure may play a part in this observation, but there is no clear pattern to explain it.

The horizontal distribution of $^{239,240}Pu$ based on the biased samples taken is more general than the horizontal distribution of ^{3}H. The foci of this distribution appear to be G-1/G-3, G-10, G-13, G-14, and G-15 as shown in Figs. 14, 15, and 16. G-1 and G-3 are near the storage building north and west of the old decontamination pit, and barrels containing wastes have been held nearby before disposal. G-10 is in a mound of overburden near the excavation made for horizontal drilling tests during 1976 described in Reference 23. However, the mound is not from that excavation according to W. D. Purtymun who supervised the drilling. G-13 is in a major drainage path away from the northeast corner of Area G. G-14 is in a drainage path north of the shafts and Pit 6, and G-15 is west of disposal shafts 153 and 154 and Pit 23. All sample locations referenced in this paragraph except G-3 are outside of the exclusion fence. The two lowest samples, G-7 and G-8, are from within the fence. G-7 is in the stream channel that may be periodically scoured out by runoff. G-8 may have been influenced by cleanup of the former equipment storage area or by closure activities over Pits 6, 7, and 24. All 45 $^{239,240}Pu$ samples except the 0- to 1-cm depth of G-7 and G-8, the 10- to 30-cm depth of G-4 and G-6, and the 1- to 10-cm depth of G-9 are more than three standard deviations above regional background in soil. This wide distribution

before 1975 (Fig. 3). Soil contaminated in this way is resuspended and intercepted by the Area G sample station. The storage yard was removed and in 1979 the surface soil was also removed. The area was covered with uncontaminated soil. The distribution of $^{239,240}Pu$ in Area G soil shown in Figs. 14, 15, and 16 suggests that airborne concentrations will reach, or perhaps have reached, a plateau that will decrease very slowly over the years without further remedial action. Since this plateau is still three orders of magnitude below applicable guidelines, remedial action would be extravagant.

Once again the uncertainty in some measurements overwhelms the results, i.e., for 1977, 1978, and 1979. The large averages and associated wide variations for the three years 1977, 1978, and 1979 are interpreted as contributions from atmospheric weapons tests conducted by the People's Republic of China in late 1976. The influence of these tests lasted into 1979 and perhaps 1980.[14]

D. Vegetation

Figures 8, 9, and 10 give the distribution of ^{3}H in soil based on the biased selection, and Fig. 18 shows a corresponding distribution in vegetation using the same selection basis. The variation in ^{3}H concentrations in vegetation is much wider than that in soil since roots may reach much deeper and therefore closer to buried sources of ^{3}H than the 30-cm maximum depth of soil samples. As with the soil sampling results, the vegetation results show ^{3}H concentration foci at sample locations G-5 and G-2 over Pits 1, 2, 3, 4, and 5; and sample location G-4 over trenches A through H (Fig. 18). The substantial concentrations in some vegetation further support the contention that the major pathway to air for buried ^{3}H is evapotranspiration. Evidently, conditions of species succession in recovery from the disturbed state, species differences in uptake and root depth, and both horizontal and vertical distributions of ^{3}H concentrations in soil have conspired to produce the highest concentrations in brush and forbs growing where soil concentrations of ^{3}H are highest. The highest values are among samples of *Chrysothamnus nauseosus*, *Artemesia caruthii*, *Aster bigelovia*, and *Eriogonum janesii* ranging from 19 000 nCi/ℓ for *Chrysothamnus* at G-5 down through 248 nCi/ℓ for *Eriogonum janesii* at G-14.

Distribution of $^{239,240}Pu$ concentrations in vegetation ash corresponds reasonably well with the distribution in soil, although this correspondence is not as good as that for ^{3}H (Fig. 20). As with ^{3}H, dominant $^{239,240}Pu$ concentrations both in soil and vegetation ash are in the section to the east, which contains Pits 1-5. The highest $^{239,240}Pu$ concentrations are in piñon pine and gramma grass to the northeast of this area (Station G-13) in the dominant wind direction and outside of its fence. This observation further suggests that the dominant $^{239,240}Pu$ source has been the

the Federal Republic of Germany.[26] Tritium concentrations at 21 pCi/ℓ for Area G in 1980 were three to seven times the ^{3}H concentrations from background locations. However, 1979 data did not support this observation. 1980 measurements of $^{239,240}Pu$ concentrations in honey indicated no differences between honey from Area G at 0.05 fCi/g and that from background locations at 0.03 to 0.08 fCi/g. Observations of $^{239,240}Pu$ concentrations in honey collected near Area G agree with observations from the Federal Republic of Germany, indicating that any plutonium, which might theoretically be transported from Area G to the surface biosphere, is not large enough to be differentiated from fallout.[26]

IV. INTEGRITY OF CONFINEMENT

Area G wastes are adequately confined in pits, trenches, and shafts to assure that exposure to the public is below applicable standards. They are also adequately confined to assure that any exposure to the public is as low as is readily achievable.

The Laboratory has made continued improvements in waste confinement methods across the years. Subsidence, which has been more common at older waste disposal sites, was only observed in one location over Pit 7 at Area G and that occurrence was remedied quickly. The observed reduction in subsidence is undoubtedly a result of precautions taken to avoid subsidence at Area G. Vegetation cover is being tested to prevent erosion of overburden caps over waste pits and trenches.

Intrusion by biota appears to be limited. Although deer and coyotes have been seen inside the fence, there is no indication that unauthorized personnel can pass the exclusion fence without exceptional effort and no indication that those coyotes that have passed it have attempted to dig into the overburden confining the wastes. Pocket gophers routinely intrude into this overburden, but as yet there is no evidence that such intrusions are capable of compromising the integrity of confinement. On the other hand, mice, which scarcely intrude into the overburden, if at all, are burdened with traces of ^{3}H and $^{239,240}Pu$. Also, above ground fractions of several varieties of vegetation contain traces of ^{3}H and $^{239,240}Pu$. Tritium in vegetation is from evapotranspiration while ^{3}H in mice is from ingestion, immersion, and inhalation. Plutonium-239,240 in mice and vegetation is an accumulation of $^{239,240}Pu$ from surface-deposited waste residue, stored equipment, or decontamination operations. There is little evidence of other contaminants either from *in situ* gamma-ray spectra or from gamma-ray spectra of soil samples or vegetation samples.

Tritium released by evapotranspiration is not confined. However, concentrations are not likely to exceed exposure standards since (1) present

with an improved analysis scheme; (6) additional air sampler data from additional air sampler stations; and (7) more extensive vegetation studies (corresponding to more intensive soil studies required for distribution evaluation).

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B. Statistical Analysis

Measurements of the air particulate samples require that chemical or instrumental backgrounds be subtracted to obtain net values. Thus, negative net values are included in the population. Although negative net values are not physical realities, they must be included to obtain a valid average of that data set of which they are a part.[A1]

Uncertainties reported for maximum and minimum concentrations reflect uncertainties introduced both in the field (flow rate and time determinations) and laboratory (counting, pipetting, etc.). These values indicate the precision of the maximums and minimums and represent twice the propagated measurement uncertainties.

Standard deviations for station and group (regional, perimeter, and on-site) means are calculated using the following equation:

$$s_{\bar{c}} = \sqrt{\frac{\sum_{i=1}^{N} (\bar{c} - c_i)^2}{N(N-1)}} ,$$

where

$s_{\bar{c}}$ = standard deviation of c,
$\bar{c}$ = annual mean of a station or group of stations,
c_i = concentration for station i, and
N = number of concentrations (sampling periods).

An analysis of variance is done with groups (regional, perimeter, and on-site) and sampling period (month or quarter) as sources of variation. A commercially available software package[A2] is used for this analysis. The purpose of the analysis is to detect significant differences among regional, perimeter, and on-site means. Differences are declared significant at $P < 0.05$. This means there is a 5% probability of error, that is, of concluding a difference exists when there is none.

Next, all radioactive constitutents that exhibit significant differences among regional, perimeter, and on-site annual means are analyzed using a modified t-test for unpaired observations and unequal variances[A3]. The t-test is used to compare regional/perimeter, on-site/perimeter, and regional/on-site group annual means and to specifically determine if a particular group differed from the other two groups.

APPENDIX B

ANALYTICAL CHEMISTRY METHODS*

I. PROCEDURES

A. Plutonium Soil and Sediment Samples

Plutonium soil and sediment samples are dried, milled for 2 to 6 hours, and split into 10-g aliquots. Each aliquot is leached with $HF-HNO_3$.

Air filters are ignited in platinum dishes, treated with $HF-HNO_3$ to dissolve silica, wet-ashed with $HNO_3-H_2O_2$ to decompose the organic residue, and treated with HNO_3HCl to ensure isotopic equilibrium.

Vegetation samples are ashed in a high-temperature oven and thereafter treated as soil samples. During dissolution, all samples are spiked with standardized ^{242}Pu, which serves as a chemical recovery tracer.

Dissolved samples are thoroughly digested in 7.2 M HNO_3, and 1 M $NaNO_2$ is added to ensure that plutonium is in the tetravalent state. The solution is passed through a preconditioned anion exchange column. The initial eluate and the first 20 mℓ of a 7.2 M HNO_3 wash contains ^{241}Am, so it is discarded. The column is then washed with 7.2 M HNO_3 and 8 M HCl. Plutonium is eluted with a freshly prepared solution of 1 g/ℓ NH_4I in 1 M HCl. The eluate is appropriately conditioned and plutonium is electrodeposited from a 4% solution of $(NH_4)_2C_2O_4$. The plated plutonium is counted on an alpha spectrometer. Values reported for ^{239}Pu are the sum of ^{239}Pu and ^{240}Pu because both have identical alpha energies.

B. Tritium

Soils are heated to evaporate the soil moisture, the condensate is trapped, and 5-mℓ aliquots are transferred to scintillation vials.

Atmospheric water is trapped in a desiccator in the field. Moisture is removed from the desiccant in the laboratory, and appropriate aliquots are taken for scintillation counting. Fifteen mℓ of scintillation liquid are added to each sample, which is then vigorously shaken.

*Ref 12.

For samples with uranium concentrations greater than 100 ppm, another epithermal irradiation may be used. Following a 5-min irradiation and 10-min decay, we can observe the 75-keV gamma ray from ^{239}U directly rather than waiting for the total decay to ^{239}Np. Results from both epithermal methods have been reported in the literature.[B2-B4]

An advantage to having both uranium techniques available is that samples containing enriched uranium may be measured. The ^{235}U content may be determined by delayed neutrons and the ^{238}U content, by epithermal activation. Total uranium is the sum of these, and a rough indication of the isotope ratio may also be given.

A comparison of these methods with the more traditional fluorometric technique for uranium analysis in soils has been published.[B5]

II. ANALYTICAL CHEMISTRY QUALITY EVALUATION PROGRAM

Control samples are analyzed in conjunction with the normal analytical chemistry workload. Such samples consist of two general types. Blanks are matrix materials containing quantities of analyte below the detection limit of the analytical procedures. Standards are materials containing known quantities of the analyte. Analyses of control samples fill two needs in the analytical work. First, they provide quality control over the analytical procedures so that problems that might occur can be identified and corrected. Second, data obtained from the analysis of control samples permit the evaluation of the capabilities of a particular analytical technique under a certain set of circumstances. The former function is one of analytical control; the latter is called quality assurance.

Quality control samples are obtained from outside agencies and prepared internally. The EPA provides water, foodstuff, and air filter standards for analysis of gross alpha, gross beta, ^{3}H, ^{40}K, ^{90}Sr, ^{106}Ru, ^{134}Cs, ^{137}Cs, ^{226}Ra, ^{239}Pu, and ^{241}Am as part of the ongoing laboratory intercomparison program. The Environmental Measurements Laboratory (EML) provides soil, water, bone, tissue, vegetation, and air filter samples each containing many of the same radionuclides. These are part of a laboratory intercomparison of DOE-supported facilities. Uranium standards obtained from the Canadian Geological Survey (CGS) and the International Atomic Energy Agency (IAEA) are used to evaluate the uranium analysis procedures. Internal standards are prepared by adding known quantities of analyte to blank matrix materials.

No attempt is made to make control samples that are unknown from the standpoint of the analyst. Control samples are submitted to the laboratory at regular intervals and analyzed in association with other samples; that is, they are not normally handled as a unique set of samples. We feel that it would be difficult for the analyst to give the samples special attention even

TABLE B-I

ANALYTICAL QUALITY ASSURANCE STANDARDS FOR SELECTED RADIOCHEMICAL ANALYSES

Analysis	Soil (R ± s)[a]	Biological (R ± s)
^{137}Cs	1.13 ± 0.12 (9)[b]	
U	1.00 ± 0.08 (248)	1.02 ± 0.09 (6)

[a] Three or more samples required to calculate s.
[b] Number of samples used in determination.

TABLE B-II

RADIOCHEMICAL QUALITY ASSURANCE ON EPA AND EML PROGRAMS (1980)

Analysis	No. of Samples	R ± s
^{3}H	12	0.94 ± 0.17
^{137}Cs	7	1.18 ± 0.07
^{239}Pu	10	0.83 ± 0.10
U natural	7	0.99 ± 0.08

TABLE B-III

QUANTITY OF CONSTITUENT REPORTED IN BLANKS (1980)

Analysis	No. of Samples	Quantity $(\bar{x} \pm s)^a$	Units
^{239}Pu	11	0.0003 ± 0.0064	pCi
Uranium (Delayed neutron)	12	13 ± 8	ng
Uranium (Epithermal activation)	24	13 ± 12	ng

[a]Mean is calculated by weighting each value (x_i) by its variance (s^2_i).

TABLE B-IV

DETECTION LIMITS FOR ANALYSES OF TYPICAL ENVIRONMENTAL SAMPLES

Parameter	Approximate Sample Volume or Weight	Count Time	Detection Limit Concentration
Air Sample			
Tritium	3 m^3	100 min	1×10^{-12} μCi/mℓ
^{239}Pu	2.0×10^4 mm^3	8×10^4 s	3×10^{-18} μCi/mℓ
Uranium (Delayed neutron)	2.0×10^4 m^3	60 s	1 pg/m^3
Soil Sample			
Tritium	1 kg	100 min	0.003 pCi/g
^{137}Cs	100 g	5×10^4 s	10^{-1} p Ci/g
^{239}Pu	10 g	8×10^4 s	0.002 pCi/g
Uranium (Delayed neutron)	2 g	20 s	0.03 μg/g

APPENDIX C

SURVEY DATA

The data in this appendix consist of the 1979 and 1980 survey results organized into three tables. Table C-I deals with radioactivity in soil, Table C-II deals with radioactivity in vegetation, and Table C-III deals with radioactivity in rodents. Results were obtained by radiochemistry described in Appendix B, Analytical Chemistry Methods. Radioactivity in soils (soils and bedrock) is presented according to depth in soil. Tritium in soil is presented in terms of soil moisture. Tritium in biota is presented in terms of tissue moisture. Other radionuclides are presented in terms of dry soil, ashed vegetation, and dry mouse tissues. Sampling methods are presented in Section I.D., Survey Design Features and Survey Methods, and in Appendix A, Sampling Procedures and Statistical Treatment of Data.

TABLE C-I (cont)

Location	Sample Depth (cm)	^{3}H (nCi/ℓ)[a]	Total U (μg/g)[b]	$^{239,240}Pu$ (pCi/g)[b]	γ-spectra
G-11	0-1	6.8 ± 0.4	5.8 ± 0.5	0.34 ± 0.01	trace ^{137}Cs
	1-10	4.3 ± 0.4	6.3 ± 0.6	0.20 ± 0.01	trace ^{137}Cs
	10-30	3.7 ± 0.4	5.1 ± 0.5	0.06 ± 0.00	none
G-12	0-1	12.9 ± 0.5	4.4 ± 0.5	0.28 ± 0.01	trace ^{137}Cs
	1-10	10.1 ± 0.5	3.8 ± 0.5	0.18 ± 0.01	none
	10-30	18.5 ± 0.6	2.5 ± 0.5	0.14 ± 0.01	none
G-13	0-1	59.7 ± 1.1	4.3 ± 0.4	0.65 ± 0.01	none
	1-10	6.4 ± 0.8	4.7 ± 0.5	1.35 ± 0.02	none
	10-30	7.7 ± 0.4	4.5 ± 0.5	2.46 ± 0.06	none
G-14	0-1	81.0 ± 2.0	4.9 ± 0.5	0.57 ± 0.02	none
	1-10	75.4 ± 1.3	5.2 ± 0.5	1.22 ± 0.04	none
	10-30	307.0 ± 5.0	4.6 ± 0.5	1.71 ± 0.05	none
G-15	0-1	15.0 ± 0.5	4.5 ± 0.5	1.59 ± 0.03	none
	1-10	10.9 ± 0.5	4.1 ± 0.4	0.74 ± 0.02	none
	10-30	6.7 ± 0.5	3.2 ± 0.4	0.51 ± 0.01	none

[a]Liters of soil moisture.
[b]Grams of dry soil.
[c]None means no traces of radionuclides above normal background.

TABLE C-II (cont)

Location	Species	^{3}H (nCi/ℓ)[a]	Total U (μg/g)[b]	$^{239,240}Pu$ (pCi/g)[b]	γ-spectra
G-8	Aster bigelovii (Bigelow's aster)	64.8 ± 1.1	--	0.05 ± 0.00	none
	Melilotus albus (white sweet clover)	14.6 ± 0.5	--	0.10 ± 0.01	none
G-9	Pinus edulis (pinon pine)	13.8 ± 0.4	--	0.81 ± 0.04	none
	Juniperus monosperma (one-seeded juniper)	7.4 ± 0.4	--	0.62 ± 0.02	trace ^{137}Cs
G-10	Bouteloua eriopoda (black gramma)	11.3 ± 0.4	--	0.34 ± 0.01	--
	Fallugia paradoxa (Apache plume)	3.7 ± 0.3	--	0.92 ± 0.02	trace ^{137}Cs
G-11	Bouteloua eriopoda (gramma grass)	11.4 ± 0.4	0.570 ± 0.05	0.24 ± 0.01	trace ^{137}Cs
G-12	Juniperus monosperma (one-seeded juniper)	35.7 ± 0.7	--	0.45 ± 0.01	trace ^{137}Cs
	Andropogon desetorum scoparius (little blue stem)	22.9 ± 0.6	0.610 ± 0.06	0.36 ± 0.02	trace ^{137}Cs
G-13	Juniperus monosperma (one-seeded juniper)	14.4 ± 0.5	--	0.57 ± 0.02	trace $^{7}Be/^{137}Cs$
	Pinus edulis engelum (pinon pine)	--	--	3.28 ± 0.07	--
	Bouteloua eriopoda (black gramma)	-2.0 ± 0.3	0.380 ± 0.03	10.6 ± 0.02	trace ^{137}Cs
G-14	Eriogonum janesii (antelope sage)	248 ± 4	0.780 ± 0.071	0.50 ± 0.02	none
	Andropogon desetorum scoparius (little blue stem)	43 ± 0.8	0.390 ± 0.04	0.13 ± 0.01	trace ^{137}Cs
G-15	Muhlenbergia montanus (mountain muhley)	0.4 ± 0.3	0.500 ± 0.05	0.27 ± 0.01	trace $^{137}Cs/^{60}Co$

[a]Liters of tissue moisture.
[b]Grams of tissue ash.
[c]None means no traces of radionuclides above normal background.

APPENDIX D

DISCUSSION OF URANIUM RESULTS

Uranium is at ambient background levels in all environmental media that were sampled and analyzed. Soil samples, for example, ranged from 2.50 µg total uranium per gram of soil to 6.30 µg/g (Table III). Averages inside and outside the fence were statistically indistinguishable at each layer of soil--0 to 1, 1 to 10, and 10 to 30 cm. Moreover, those averages ranged from 4.10 to 4.55 µg/g. Local soils tend to be high in uranium because of igneous geological formations (rather than as a result of transport from local facilities). Table III values for some regional and local soils range from 2.1 to 8.2 µg/g. This range is scarcely wider than the range 2.50 to 6.30 µg/g observed at Area G, so Area G soil samples do not indicate uranium as a component of waste residue that might be transported out of the waste pits, trenches, or shafts, or that might have been deposited on the soil surface during disposal operations and subsequently transported beyond the exclusion fence. Figures 9, 10, and 11 do not indicate any special groupings or focal points of samples with higher concentrations of uranium. Soil sample results do not support the argument that uranium is being transported out of Area G waste repositories or beyond Area G as a component of transported waste residues.

Table V provides (1) results of uranium analyses on air samples collected at Area G and at three comparison stations roughly 5 km from Area G and 120° from each other and (2) averages of airborne uranium concentrations sampled within the Laboratory boundary, in the perimeter just beyond the Laboratory boundary, and at three stations representative of northern New Mexico. The data cover the years 1976 through 1980. Uncertainty in the data is greatest in 1977 and decreases through 1980. Uncertainty in 1980 data is generally greater than uncertainty in 1976 data. Although this pattern would be consistent with influence from recent atmospheric weapons testing by the People's Republic of China, it is probably attributable to variable dust loading of the filters and to variability in the natural uranium content of resuspended soil.

On the other hand, 1976 results at Area G and at booster P-2 are statistically greater than results from White Rock, TA-33, averages from the Laboratory itself, the perimeter beyond the Laboratory, or from the northern New Mexico region. However, these results are no higher than results occurring at Area G, the three local comparison stations, and the averages for the Laboratory, its perimeter, and the region during the peak years of 1977 and 1978. This airborne concentration pattern is consistent with the known

In summary, the data gathered during the present surveillance effort and other pertinent studies do not indicate that waste residue of uranium is being transported out of the waste disposal facilities at Area G to surface soil, air, or biota. Uranium concentrations in air and biota are orders of magnitude lower than normal levels of uranium occurring naturally in local soils. This is expected if the uranium in air and biota originates from uranium occurring naturally in the soil.

TABLE E-I

DOE RADIOACTIVITY CONCENTRATION GUIDES (CGs)

Concentration Guides for Uncontrolled Areas[a,b]			Concentration Guides for Controlled Areas[a,b]		
Nuclide	CG for Air (μCi/mℓ)	CG for Water (μCi/mℓ)	Nuclide	CG for Air (μCi/mℓ)	CG for Water (μCi/mℓ)
^{3}H	2×10^{-7}	3×10^{-3}	^{3}H	5×10^{-6}	1×10^{-1}
^{7}Be	--	2×10^{-3}	^{7}Be	--	5×10^{-2}
^{137}Cs	5×10^{-10}	2×10^{-5}	^{137}Cs	1×10^{-8}	4×10^{-4}
^{238}Pu	7×10^{-14}	5×10^{-6}	^{238}Pu	2×10^{-12}	1×10^{-4}
^{239}Pu[c]	6×10^{-14}	5×10^{-6}	^{239}Pu[d]	2×10^{-12}	1×10^{-4}
^{241}Am	2×10^{-13} (pg/m^3)[c]	4×10^{-6}	^{241}Am	6×10^{-12} (pg/m^3)[c]	
U, natural[d]	6×10^{6}	6×10^{-7} 1.8×10^{-6}[c]	U, natural[c]	1.8×10^{8}	2×10^{-5} 6×10^{-5}[e]

[a]This table contains the most restrictive CGs for nuclides of major interest at the Laboratory (DOE Order 5480.1, Chapter XI).

[b]CGs apply to radionuclide concentrations in excess of those occurring naturally or because of fallout.

[c]The CGs of ^{239}Pu and ^{90}Sr are the most appropriate to use for gross alpha and gross beta CG respectively.

[d]One curie of natural uranium is equivalent to 3000 kg of natural uranium. Hence, uranium masses may be converted to the DOE "uranium special curie" by using the factor 3.3×10^{-13} mCi/pg.

[e]For purposes of this report, concentrations of total uranium in water are compared with the ICRP recommended values that consider chemical toxicity.

REFERENCES

E1. United States Department of Energy, "Order 5480.1: Environmental Protection, Safety, and Health Protection Program for DOE Operations," US Department of Energy Draft Operating Orders (February 1981).

E2. International Commission on Radiological Protection (ICRP), "Recommendations of the International Commission on Radiological Protection," ICRP Publication 6 (Pergamon Press, New York, 1964).

★ U.S. GOVERNMENT PRINTING OFFICE: 1983-0-676-026/27

Remedial Action — A411

Gunderson

Los Alamos
Los Alamos National Laboratory
Los Alamos, New Mexico 87545

DATE August 4, 1983
IN REPLY REFER TO HSE-7C 83-100
MAIL STOP E516
TELEPHONE (505) 667-5398

ENCLOSURE 14
ATT. 4: 1983 UNPUBLISHED REPORT ENTITLED "PLAN FOR STABILIZATION OF RADIOACTIVE MATERIALS DISPOSAL SITES AT THE LOS ALAMOS NATIONAL LABORATORY"

Mr. Jim Bresson
Waste Management and Transportation
Development Division
Albuquerque Operations Office
U.S. Department of Energy
P.O. Box 5400
Albuquerque, NM 87115

Dear Jim,

Enclosed is the report "Plan for Stabilization of Radioactive Materials Disposal Sites at the Los Alamos National Laboratory". This report requested by Julie D'Ambrosia, DOE-HQ/IWO, completes the milestone task "Develop Overall Plan for Burial Ground Stabilization".

Please call John Warren if you have any questions concerning this report.

Sincerely,

for L. C. Borduin
Group Leader
HSE-7 Waste Management

LCB:mec

Enc. a/s

Cy: J. Aragon, HSE-DO, MS P228
W. Hansen, HSE-8, MS K490
J. Warren, HSE-7, MS E516
M. Salazar, HSE-7, MS J592
CRMO (2), MS A150
HSE-7 Files

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PLAN FOR STABILIZATION OF RADIOACTIVE MATERIALS DISPOSAL SITES AT THE LOS ALAMOS NATIONAL LABORATORY

July 1983

Plan for Stabilization of Radioactive Materials
Disposal Sites at the Los Alamos National Laboratory
July 1983

This report addresses actual or potential remedial actions at thirteen separate areas at Los Alamos which contain known or suspected subsurface radioactive contamination. These are disposal Areas A, B, C, D, E, F, G, K, T, U, V, W, and X in Figure 1. Environmental surveillance of these sites show current ranges of surface contamination and/or radioactive releases from nondetectable to several orders of magnitude below DOE unrestricted release limits. Remedial actions identified for each site will address the following concerns: identified presence of low levels of residual surface contamination; surface erosion; inadequate surface cover over the waste; slumping or subsidence of the pit covers; invasion of native flora and fauna; and access control.

Detailed project plans for each site will be formulated by a Laboratory committee composed of Health, Safety, and Environment (HSE) Division personnel at a future date before each remedial operation commences. General remedial actions will consist of: decontamination and disposal operations; clearing and grubbing; application of herbicides; addition of compacted cover material; grading for drainage; construction of drainage structures; revegetation; and fencing of the areas. Table 1 presents a summary of the remedial actions for each site.

Area A

Area A is located on the north side of TA-21 between DP-East and DP-West. It was opened in late 1944 or early 1945, and closed in 1974 (Figure 2). It covers a 5×10^3 m^2 (1.25 acre) area. Originally it contained pits for burial of TA-21-generated polonium- and possibly some plutonium-contaminated wastes, and two buried tanks (designated the "general's tanks") for storage of solution containing ^{239}Pu and ^{241}Am. Investigations indicate that these tanks, which contained an alpha activity equivalent to 94 g of ^{239}Pu (about half of which was

from ^{241}Am), have not leaked. During the late-1970's, the liquid was pumped to a nearby liquid waste plant for treatment. Each tank still contains a few inches of semisolid precipitate.

Area A was reactivated in April 1969, with the excavation of a fifth pit to be used for burial of low-level debris from TA-21 demolition work. This pit remained active thru FY77, and in May 1978, it was backfilled.

Remedial action in FY85 will consist of: disposition of the TRU semisolid precipitate in the tanks (under evaluation); removal and disposition of the auxiliary piping; removal and disposition of a small structure (TA-21-40); removal of any contaminated soil; haul of clean fill material and topsoil into the area; compaction of fill material; grading of area; and revegetation of the area.

Area B

Area B is located about 0.4 km (0.25 mile) west of TA-21 and covers 2.44×10^4 m^2 (6.03 acres) (Figure 3). It was used from 1946 through 1948. The waste in these pits is contaminated with all types of radioactive materials used at Los Alamos, and the entire area is estimated to contain no more than 100 g of ^{239}Pu. The fenced area has been divided into three sections. The larger section has been covered with asphalt and made available to Los Alamos County for rental spaces for storage of private camper trailers and other types of vehicles. The second section (about 1/3 the total) was involved in a project in FY82 to decontaminate and stabilize the ground surface. Investigations in recent years showed considerable areas of surface contamination, and slumping of burial pit covers which had left wastes exposed. Undesirable vegetation was removed from the site and approximately 9000 m^3 (12000 yd^3) of new cover material was compacted over the area. Topsoil was added and the new surface was reseeded with a mixture of native grasses. Total project cost, funded by IWO, was approximately $90K.

Remedial action on the third much smaller section at far western end of Area B (1.05×10^3 m^2 or 0.26 acre) will entail emplacing a cap

cover over the subsided area followed by grading and revegetation. This work is scheduled for FY85. The asphalt paved area will continue to receive yearly maintenance. The stabilized area on the eastern end will require a "baseline" environmental survey.

Area C

Area C is located south of TA-50 and occupies 4.8×10^4 m^2 (11.8 acres) (Figure 4). It contains 7 pits (one of which was designated a hazardous chemical pit), and 108 disposal shafts. The pits and shafts contain alpha and beta-gamma wastes. Area C was used from 1948 to 1969. There are some low levels of residual surface contamination and significant slumping of pit covers within Area C.

The project currently planned for Area C consists of splitting the work into four segments. Work is scheduled for FY83 and 84, with a possibility of extending into FY85. General remedial action will consist of filling in the subsided areas, grading the area, and revegetation. Some fencing and addition of a gate also are planned, along with the removal of some surface debris. Total cost of the Area C work currently is estimated to be approximately $340K.

Area D

Area D covers 1.2×10^2 m^2 (0.03 acre) in the eastern part of TA-33 (Figure 5). This site contains two underground chambers that were used for detonation of experimental devices in 1948. The chambers were contaminated with polonium (now decayed) and perhaps a trace of uranium. One shaft since has been backfilled.

This is a low priority area with no definite plans at present for remedial action as it is not known if any contamination now is present.

Area E

Area E is located in the southern part of TA-33 and consists of approximately 2.8×10^3 m^2 (0.69 acre) (Figure 6). The site contains 6 pits and an underground chamber. The chamber was destroyed by

experimentation in 1950 and is probably contaminated with polonium (now decayed) and perhaps some uranium. The pits were in use from 1951 to the mid-sixties for disposal of polonium, uranium, and beryllium contaminated solid wastes.

The underground chamber is overlaid by a concrete slab with a center opening. The opening will be plugged with concrete and sloped to drain outward from the shaft. In addition, backfill will be hauled to the site which will be compacted, graded, and revegetated. A power pole and some miscellaneous concrete blocks will be removed and disposed of at Area G. This work is scheduled for FY86. In FY83, a chain link fence and vehicle gate will be constructed to properly enclose the area.

Area F

In 1946, a 739 m^2 (0.18 acre) tract on Two-Mile Mesa east of TA-6 was set aside for a one-time burial of obsolete materials (Figure 7). The pits contain small amounts of ^{90}Sr-, ^{137}Cs-, and HE- contaminated wastes.

The areas will be fenced in FY83, and in FY86 some surface stabilization will be done on the north side where erosion is occurring. Some fill will be hauled in and compacted, and erosion control structures will be constructed. The area will then be revegetated.

Area G

Area G is located on top of the Mesita del Buey Mesa in TA-54 and is the main active radioactive solid waste burial/storage site at the Laboratory (Figure 8). The area has been in use since 1957, and is expected to remain active through the next 20-25 years. The area was expanded to a total area of 2.55×10^5 m^2 (63 acres) in FY77; future expansions of this area are planned. Burial/storage facilities within the area include pits, shafts, trenches, and pads, all of varying dimensions. A more detailed description of the use of these facilities and of current waste management operations is contained in Los Alamos Final Environmental Impact Statement. Ongoing operational site

maintenance takes care of minor remedial work; no major immediate remedial needs have been identified.

Area K

This area is located at TA-33 and occupies approximately 10 m^2 (0.003 acre) (Figure 9). A shallow pit (slump) in the area was used for disposal of tritium contaminated solutions between 1950 and 1959. Septic tanks in the area have received liquid wastes contaminated with ^{233}U and ^{238}U. One other septic tank received two releases of plutonium-contaminated liquid in 1961. No estimates have been made of the curie content of these various wastes.

The septic tanks are in current use. Detailed surveys and surveillance will be conducted to evaluate the need for any remedial action required. Any work required will be planned for FY87.

Area T

Area T occupies 3.6×10^3 m^2 (0.88 acre) and is located on the north side of TA-21 to the west of Area A (Figure 10). Four absorption beds handling DP-West liquid waste from 1945 through 1952 are located there. From 1952 to 1967, the beds were used infrequently for overflows and for wastes that were not treated adequately. In 1968, the area between the absorption beds was chosen for a shaft field for disposal of cement paste waste from the waste treatment plant TA-21-257. This paste has been pumped into 1.2-m (4-ft) to 2.4-m (8-ft)-diameter by 18.3 (60-ft)-deep disposal shafts. A storage pit was dug in late 1974 beyond the shaft field in the western portion of the area. This pit contains the corrugated metal pipes filled with transuranic cement paste.

Detailed surface and subsurface evaluations will be conducted to determine the amount of surface cover and stabilization required. The area will require some fill to cover an open trench. General grading of the area to provide proper drainage, and revegetation efforts will be conducted. Disposal of the filled corrugated metal pipes will be performed at a much later date (beyond 1990) in conjunction with

retrieval and shipment of TRU wastes to WIPP. The area will require additional fencing. This work is planned for FY85 and/or FY86, as funding permits.

Area U

This area, located on the north side of DP-East, TA-21, covers 1.2 x 10^3 m^2 (0.3 acre) and contains several absorption beds similar to those in Area T (Figure 11). The beds were used for subsurface disposal of contaminated liquid wastes between 1945 and 1968. The primary contaminant was ^{210}Po. No records exist of the amount discharged; however, the short half-life of the material has by now resulted in decay to innocuous levels. During 1953, approximately 2.5 Ci of ^{227}Ac were discharged into these pits.

Trees and shrubs in the area will be removed and herbicides applied to deep rooted plants. Fill material will be hauled in and compacted, and revegetation with native grasses is planned. The pedestrian gate will be sealed and a vehicle gate installed. Decontamination and disposal of an existing drainage line (inactive) will be accomplished concurrently with this work scheduled for FY85.

Area V

This area is located southwest of TA-21, and was used for the disposal of contaminated liquid waste from laundry operations between 1945 and 1961, using absorption beds similar to those at Area T (Figure 12). The area covers approximately 4 x 10^3 m^2 (1.0 acre); it received wastes containing an estimated total of 3 Ci of ^{89}Sr, ^{140}Ba, and ^{140}La. Small quantities of ^{90}Sr and ^{239}Pu were also contained in the waste.

Scheduled work for FY83 consists of fencing the area. In FY85 the remedial work will be completed. This work will consist of bringing in fill material, compacting and grading the area, and revegetating with native seeds. Decontamination and removal of an acid tank and associated piping needs to be resolved.

Area W

At this location at TA-35 (Figure 13) are two buried 0.20-m (8-in)-diameter x 30-m (100-ft)-long stainless steel tanks. When the LAMPRE reactor was shut down in 1964, the sodium coolant was drained into these tanks and the tanks were sealed. Each tank contains 100-150 L (25-40 gal) of irradiated sodium known to be contaminated with ^{137}Cs, ^{22}Na, and ^{239}Pu. Work was completed in early FY80 to "entomb" the tops of the tanks (at ground level) in a reinforced concrete structure (Figure 14). Consequently, no further work currently is anticipated for this site.

Area X

This is a 2×10^2 m^2 (0.05 acre) tract that is the burial site of the containment shell of the LAPRE II Reactor decommissioned in 1959 and buried in 1960 (Figure 15). The vessel that housed the LAPRE II Reactor is buried under a paved area south of building TA-35-2. It is activated and contains small amounts of uranium. Depending on the availability of future D&D funding, it may be removed and buried at the laboratory radioactive waste disposal site. This would require office trailers now in the area to be relocated at least temporarily. The location has been marked and no detectable radiation levels exist at the pavement surface.

If the reactor core ever is removed, some fill material would be compacted in the hole left by the excavated vessel. Associated piping also would be excavated and removed. Repaving of the parking lot and revegetation of disturbed areas would complete the remedial work.

LOS ALAMOS NATIONAL LABORATORY

Radioactive Waste Disposal ARea

TABLE I

Waste Area	Dates Used	Waste Type	Size - Acres	Remedial Date and Plan
A	1944-47 1969-77 mid-1940's	General Lab Decommissioning Liquid/Sludge (TRU)	1.25	FY85 - Disposition of tanks, removal and disposition of piping, structure, and contaminated soil. Addition of surface cover and revegetation.
B	1946-48	General Lab - TRU	6.00	3.75 acres asphalt paved, with yearly maintenance performed. FY82 - 2 acres stabilized. FY85 - 0.26 acres will receive a surface cover and revegetation.
C	1948-69	General Lab - TRU	11.80	FY83-84(85) - Removal and disposal of surface debris, addition of surface cover and revegetation, addition of fencing and access gate.
	1948	Polonium (now decayed), Uranium (?)	3.00	No plans developed, site under evaluation, work as required FY87.

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Radioactive Waste Disposal ARea

TABLE I (Page 2)

Waste Area	Dates Used	Waste Type	Size - Acres	Remedial Date and Plan
E	1951 to mid-1960's	U, Be Solids	0.70	FY83 - Fencing and access control. FY87 - Plugging of shaft with concrete, additional surface cover, and revegetation.
F	1946	Special equipment	0.18	FY83 - Fencing and access control. FY86 - Clearing and disposal of deep rooted vegetation, addition of fill material, erosion control structures constructed, and revegetation of area.
G	1957 to present	General Lab - TRU	63.00	FY83 to immiedate future - This is an active site and ongoing maintenance takes care of minor remedial work; no immediate needs rerequired.
K	1950-59	H-3, U-238, U-233 solutions	.003	FY87 - Work as required. The area needs to be evalua-

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Radioactive Waste Disposal ARea

TABLE I (Page 3)

Waste Area	Dates Used	Waste Type	Size - Acres	Remedial Date and Plan
				ted and no plans have been formulated. The area is in current use.
T	1945-67 1968-present 1975-82	TRU Liquids Cement Paste Burial TRU Storage	0.88	FY85-86 - Surface cover and revegetation required. Some fencing will be added. Addition of surface cover and revegetation, construction of drainage structures.
U	1945-68	Ac-227 Liquids	0.30	FY85 - Clearing of trees and shrubs, application of herbicides, addition of a surface cover, revegetation of the area.
V	1945-61	Sr-90, Pu-239 Laundry liquids	1.00	FY83-84 - Fencing of the area. FY85 - Addition of a surface cover and revegetation. Decontamination and removal of an acid tank and piping (under evaluation).

LOS ALAMOS NATIONAL LABORATORY

Radioactive Waste Disposal Area

TABLE I (Page 4)

Waste Area	Dates Used	Waste Type	Size Acres	Remedial Date and Plan
W	1964	Sodium in tanks	.002	FY80 - Sodium tanks entombed.
X	1960	Reactor Shell	0.05	Evaluation not completed; no remedial action currently required.

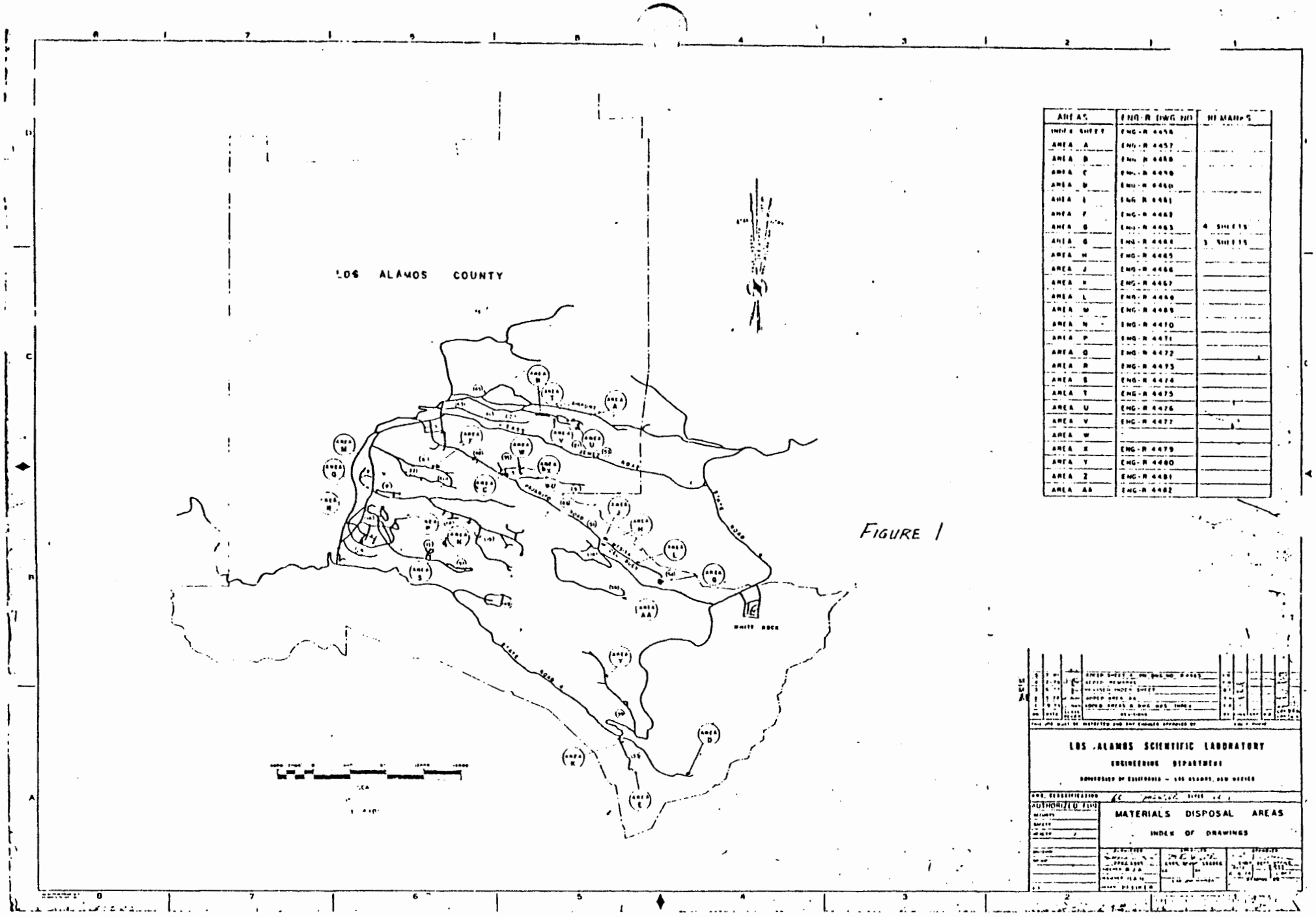


Figure 1 Los Alamos Waste Disposal Areas

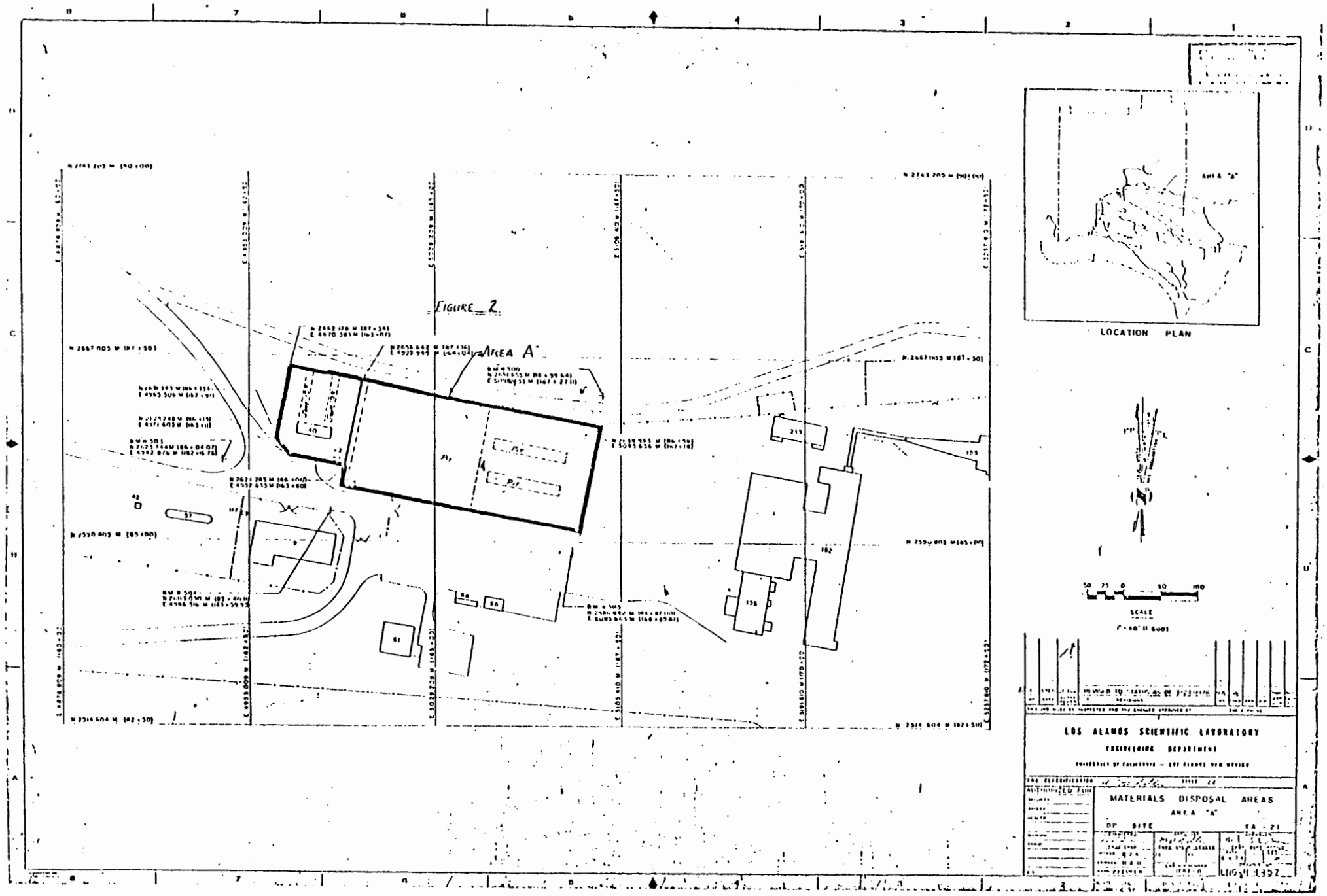


Figure 2 Waste Disposal Area A

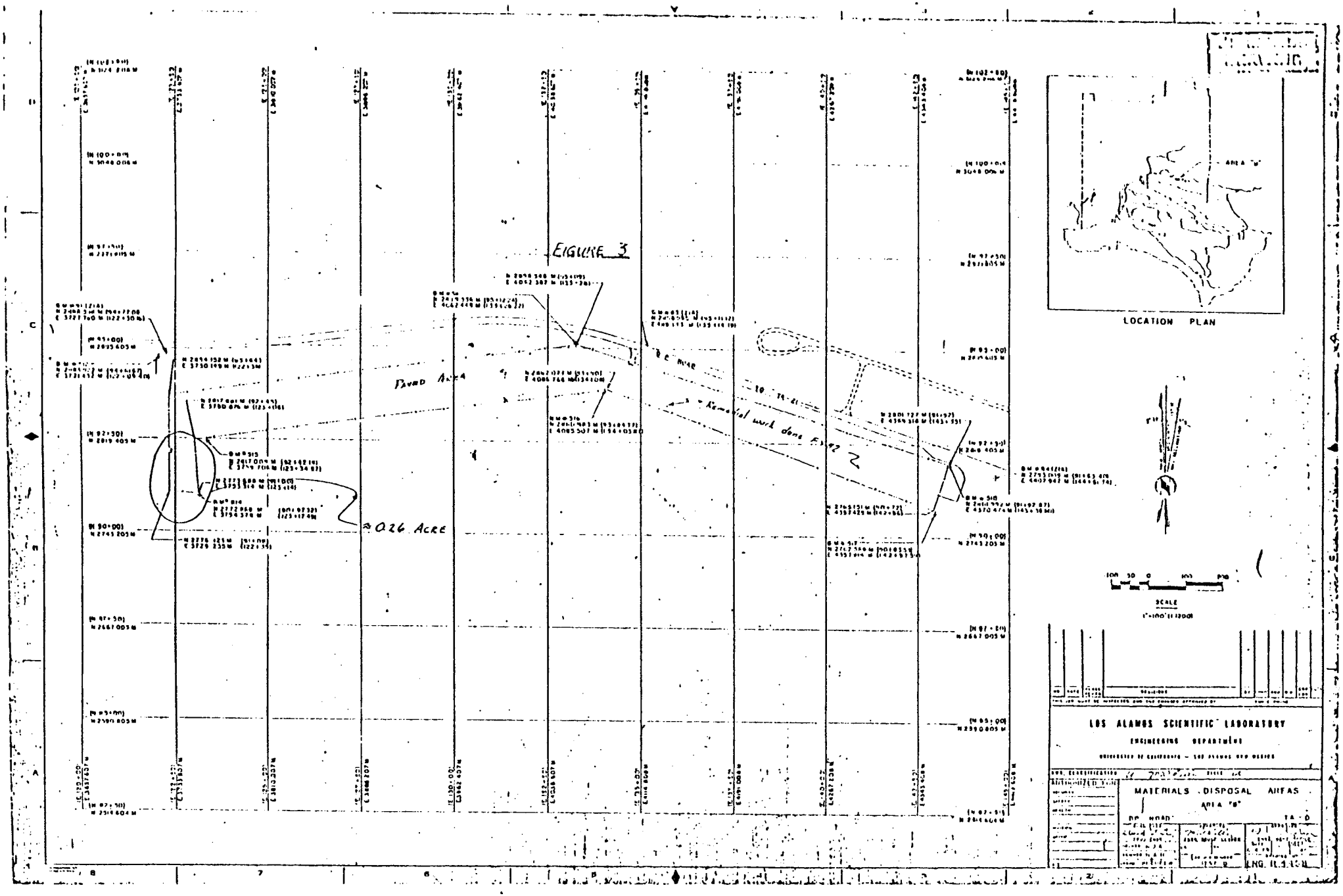
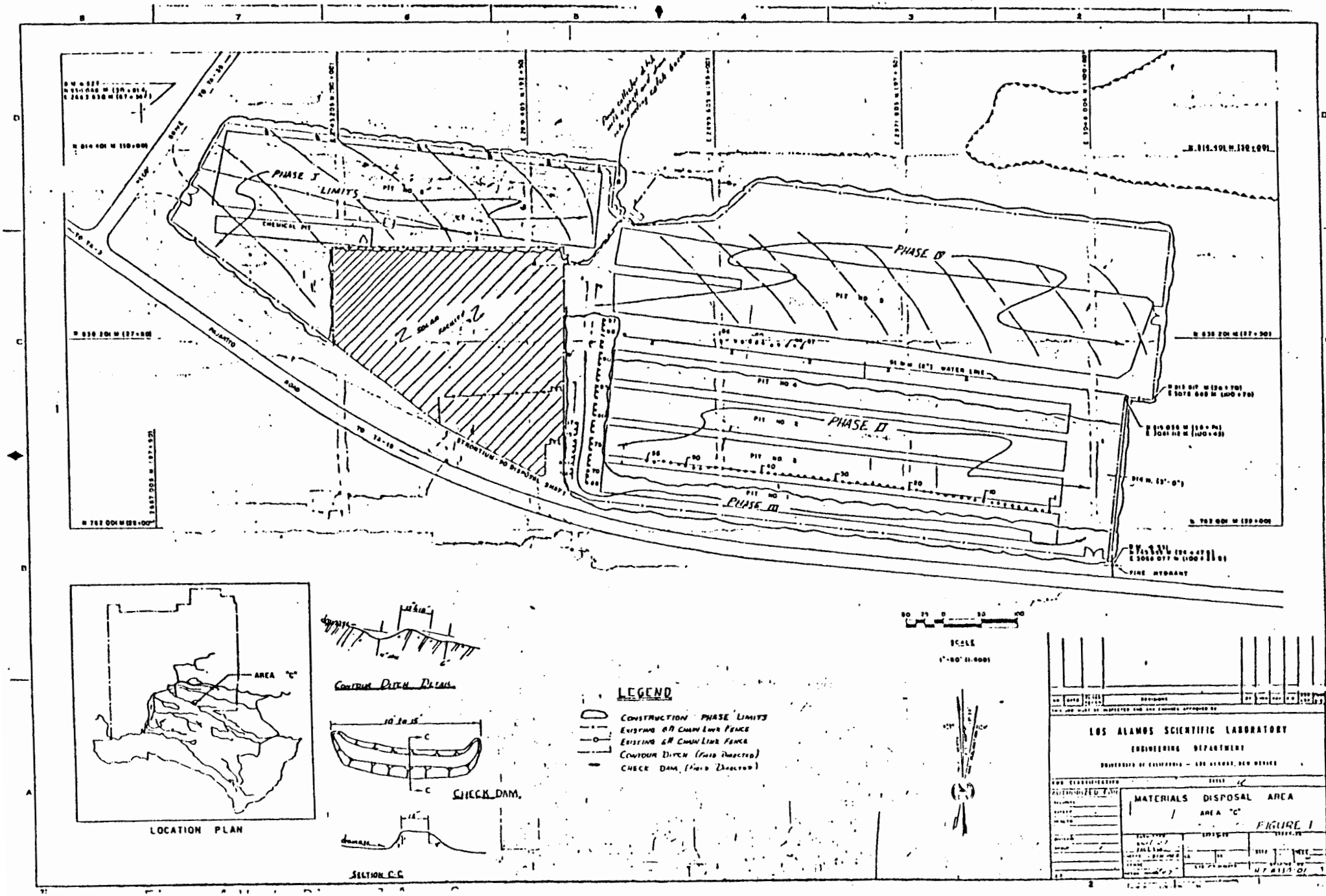


Figure 3 Waste Disposal Area B


PHASE I LIMITS
CHEMICAL PIT
PIT NO. 8
PHASE IV
PIT NO. 9
PIT NO. 4
PIT NO. 2
PIT NO. 3
PIT NO. 1
PHASE II
PHASE III
WATER LINE
FIRE HYDRANT
STRONTIUM-90 DISPOSAL SHAFT
LOCATION PLAN
AREA "C"
CONTOUR DITCH DETAIL
CHECK DAM
SECTION C-C
LEGEND
CONSTRUCTION PHASE LIMITS
EXISTING 6ft CHAIN LINK FENCE
EXISTING 6ft CHAIN LINK FENCE
CONTOUR DITCH (FLOW DIRECTION)
CHECK DAM (FLOW DIRECTION)
SCALE
LOS ALAMOS SCIENTIFIC LABORATORY
ENGINEERING DEPARTMENT
MATERIALS DISPOSAL AREA
AREA "C"
FIGURE 1

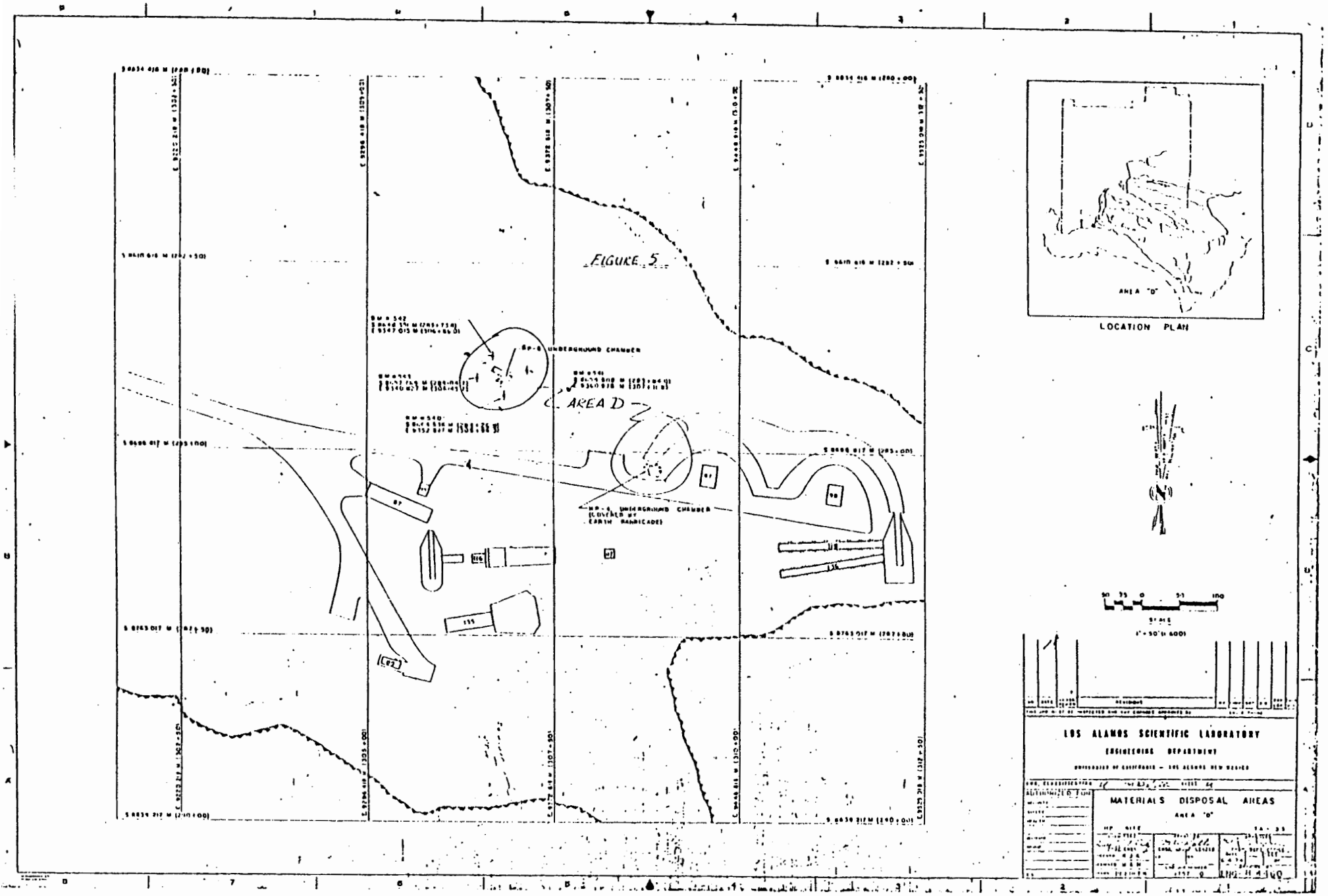


Figure 5 Waste Disposal Area D

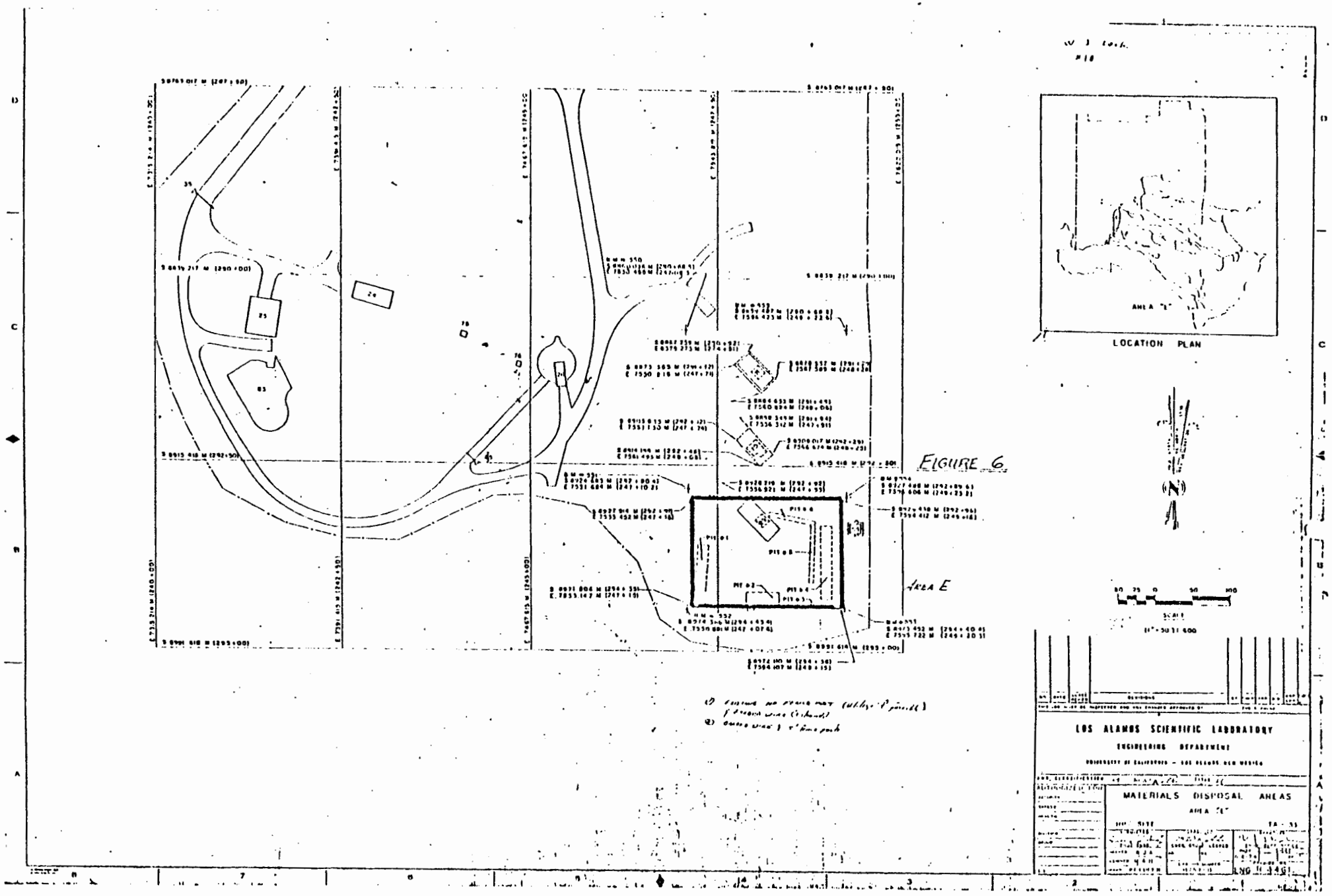


Figure 6 Waste Disposal Area E

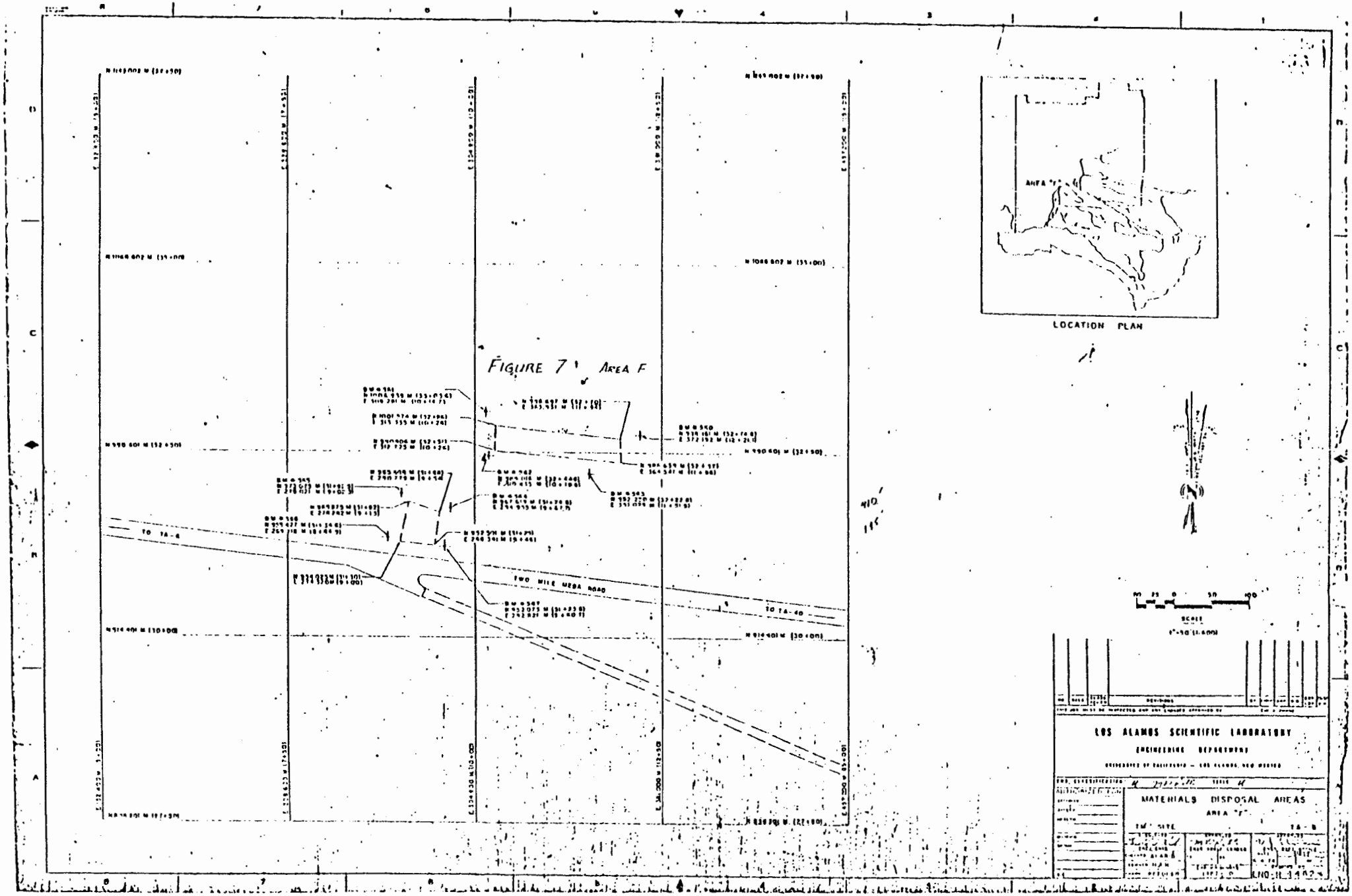


Figure 7 Waste Disposal Area F

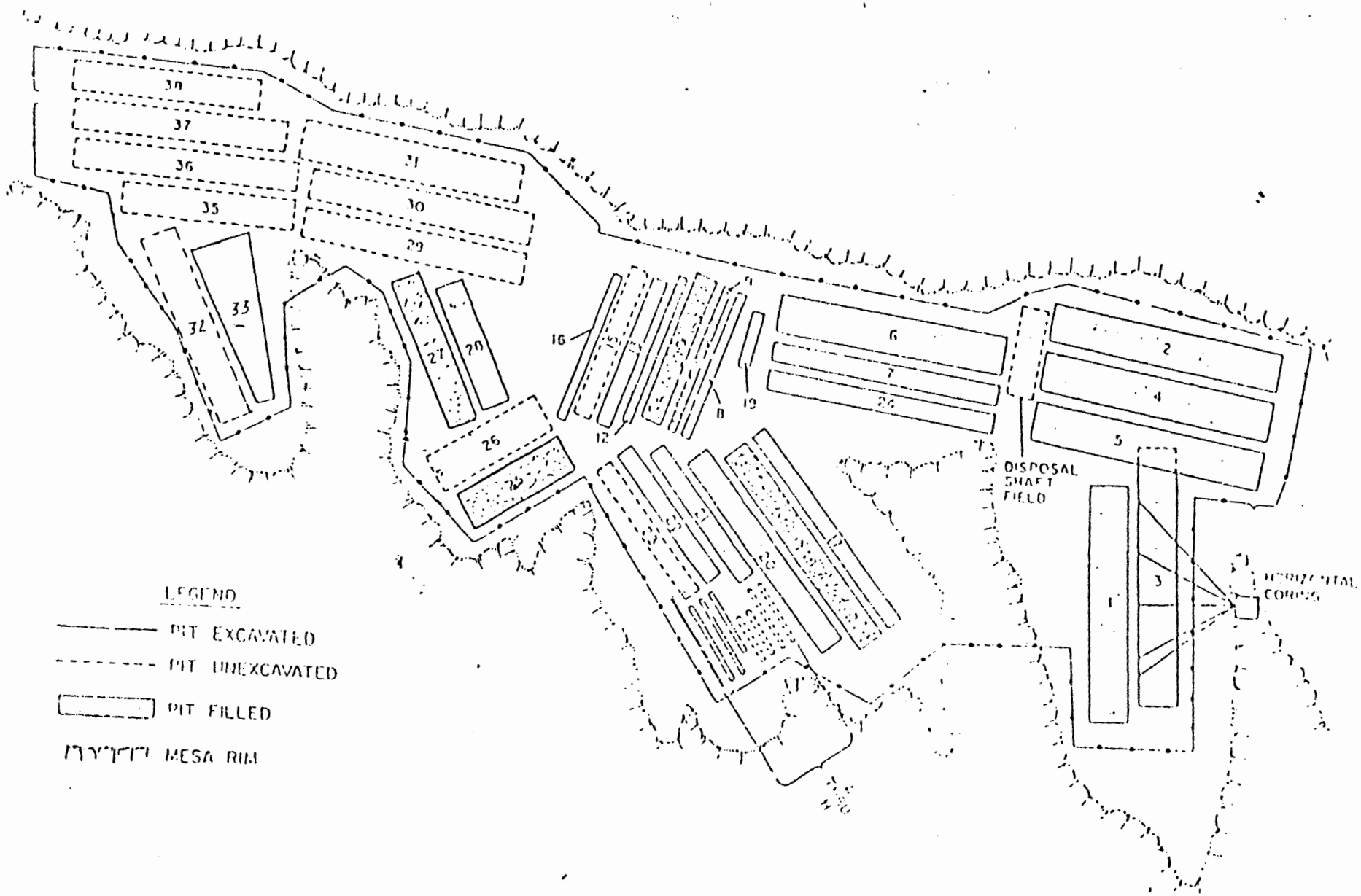


Figure 8 Waste Disposal Area G

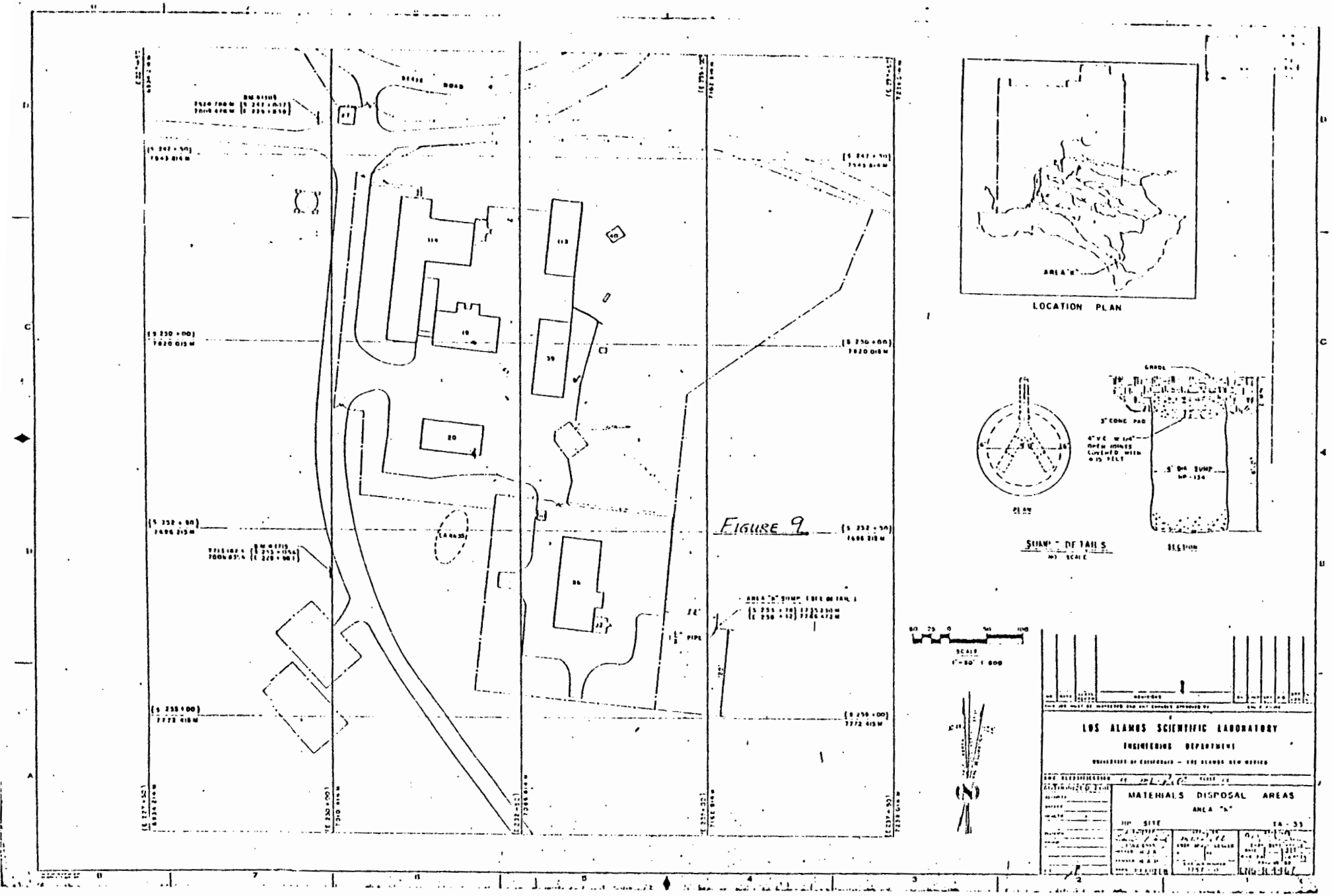


Figure 9 Waste Disposal Area K

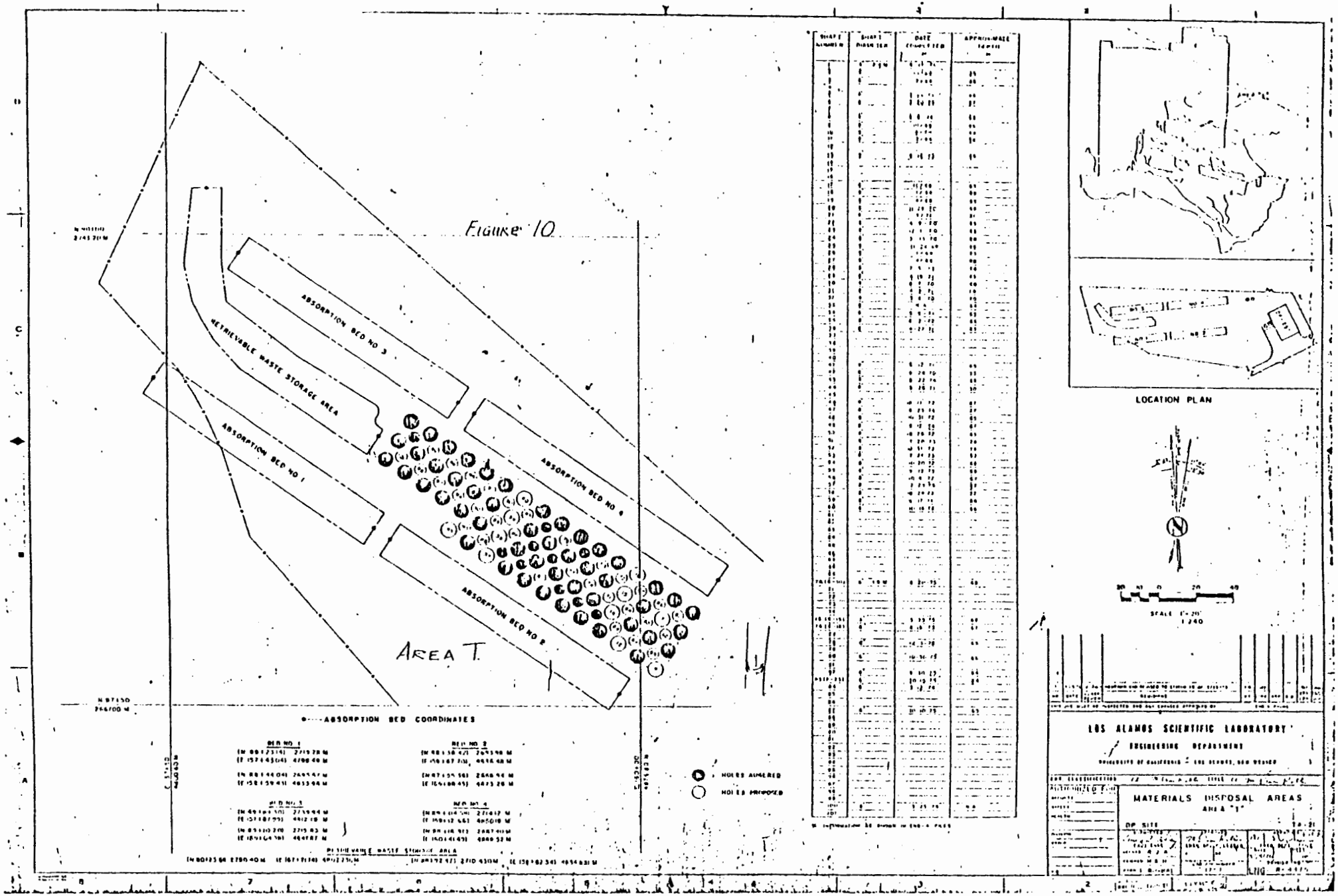
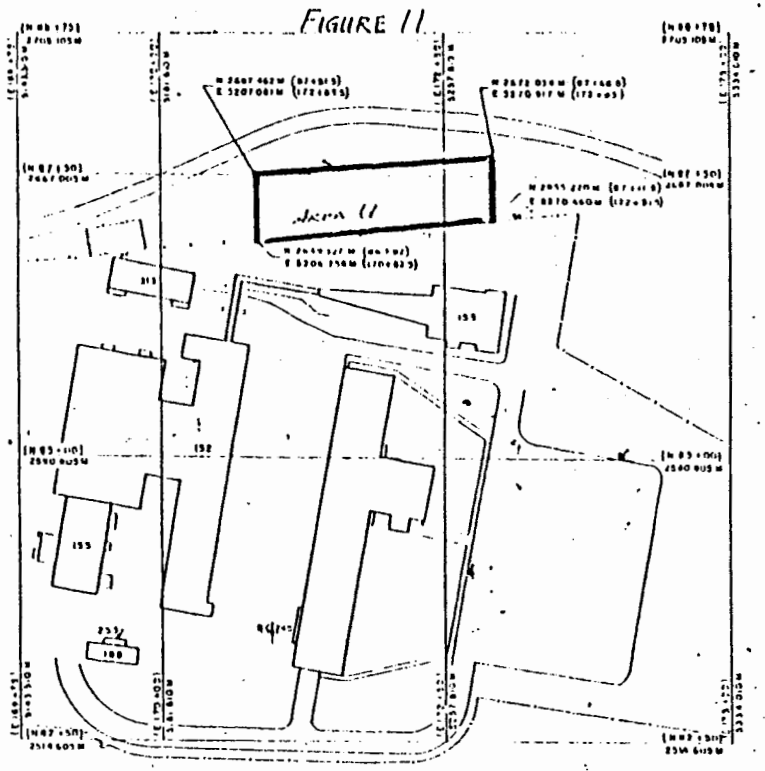
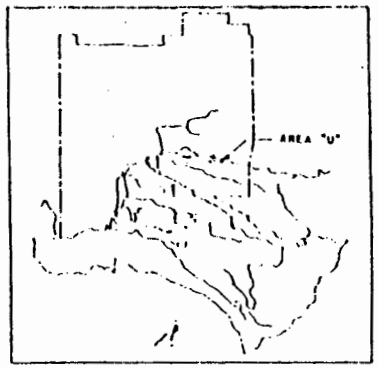
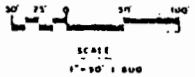


Figure 10 Waste Disposal Area T





LOCATION PLAN



LOS ALAMOS SCIENTIFIC LABORATORY

ENGINEERING DEPARTMENT

MATERIALS DISPOSAL AREAS

AREA "U"

Figure 11 Waste Disposal Area U

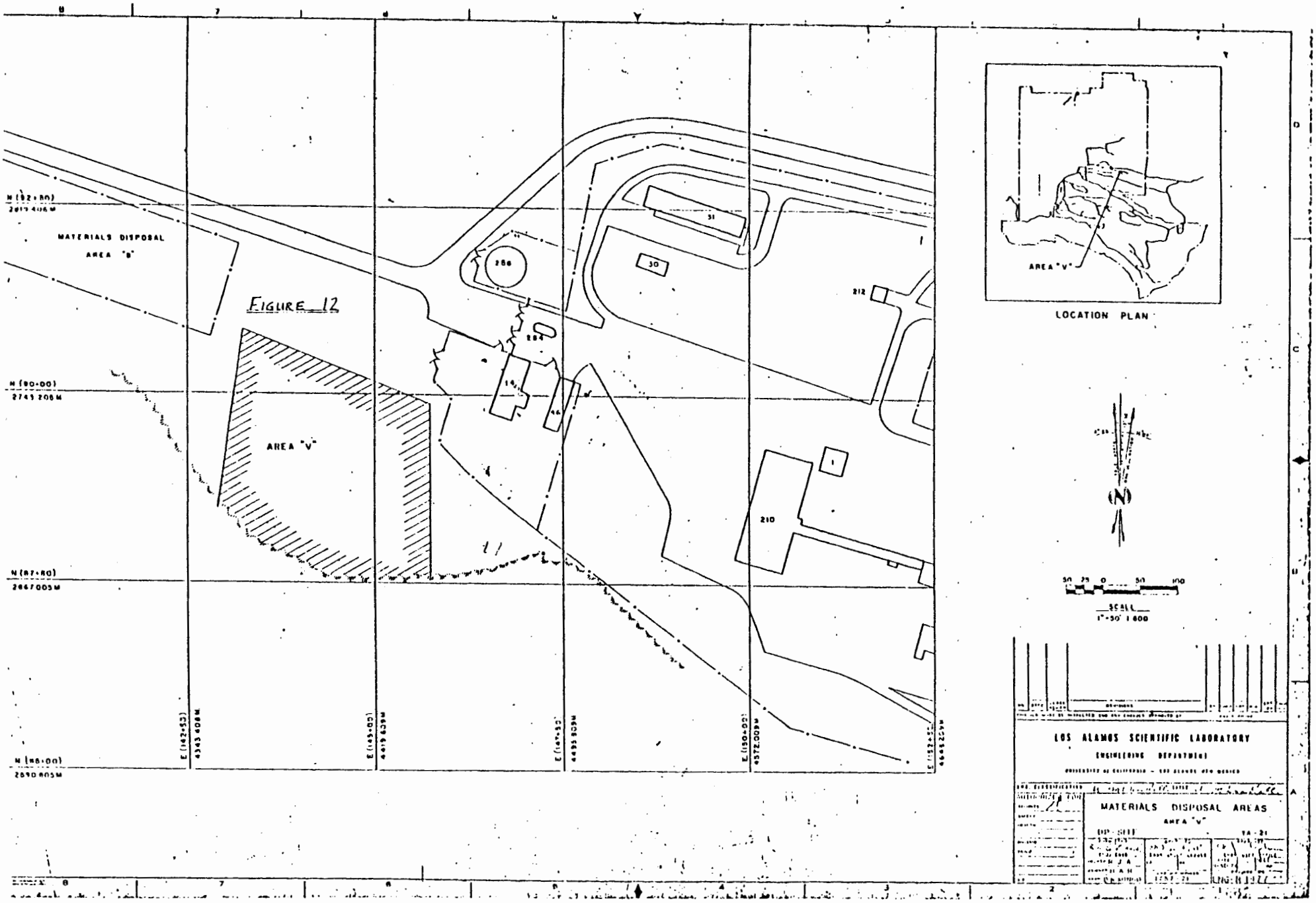


Figure 12 Waste Disposal Area V

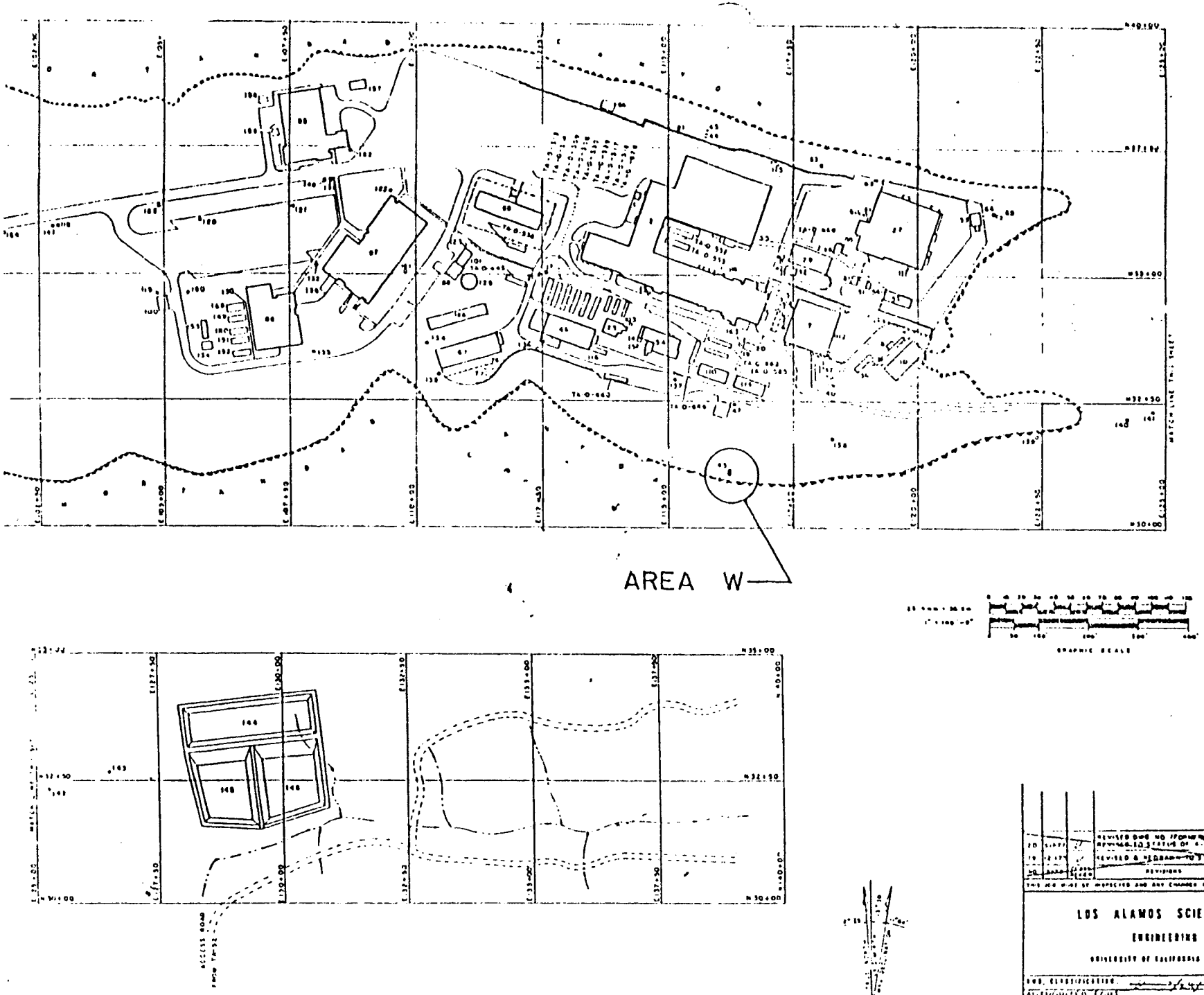


Figure 13 Waste Disposal Area W

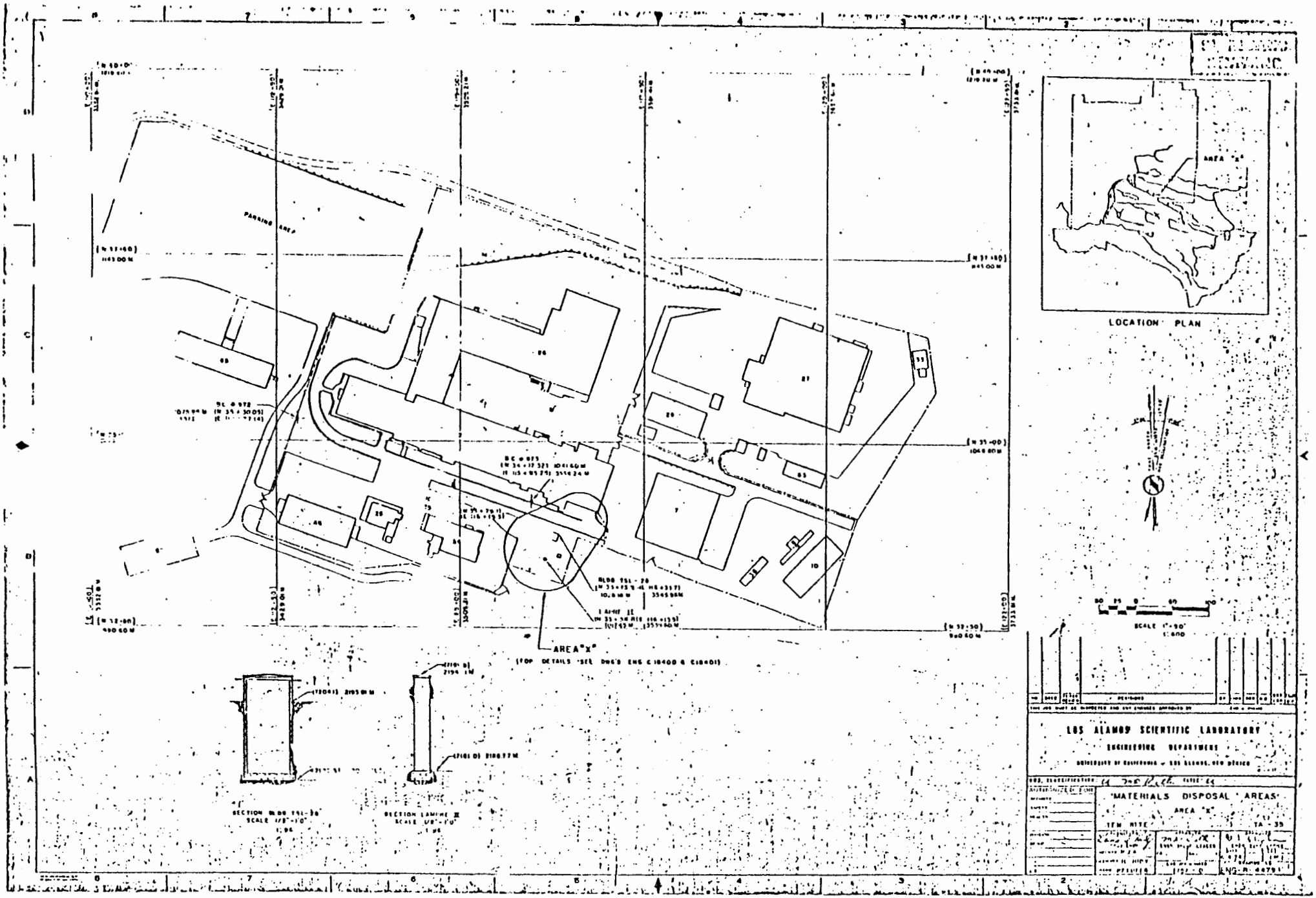


Figure 15 Waste Disposal Area X

SAMPLING PROCEDURES/ANALYTICAL METHODS/CHAIN OF CUSTODY/ AND QUALITY ASSURANCE PROGRAM

SAMPLING PROCEDURES

Quality assurance (QA) in sampling is critical to the production of useful data because it must be assumed that the acquired sample is representative of the process or effluent stream under investigation. The sampling plans must be sufficiently comprehensive to ensure that this level of representativeness is obtained and, as such, combines good sampling practices with a QA program, both of which are monitored for effectiveness through the QA program.

The Laboratory follows the sampling procedures required in the standard analytical references, which are part of the federal regulatory guidelines establishing test procedures for the analysis of pollutants.

ANALYTICAL PROCEDURES

Quality assurance in analysis is accomplished by: establishing good laboratory practices; maintaining a QA program; and monitoring the accuracy, precision, and detection limits with which results are produced. Analytical methods recognized and/or required by the Environmental Protection Agency (EPA)* are utilized. A QA program using sample blanks, duplicates, spiked samples, and standards is employed.

CHAIN OF CUSTODY

To ensure that environmental measurement activities result in data of known quality that are complete, respresentative, comparable, valid, of known precision and accuracy, and legally defensible, it is necessary to use reliable chain-of-custody procedures applicable to both field and laboratory operations. A comprehensive chain-of-custody system is utilized on regulatory-related sampling as dictated by professional judgement. Accurate documentation is maintained on all samples collected regardless of the rationale for sample collection.

QUALITY ASSURANCE

The U.S. Code of Federal Regulations is consulted on all environmental regulatory programs in order to ensure the Laboratory's sampling programs are in compliance with all regulatory requirements for sampling and analysis*. EPA guidance is used as a framework for sample collection, sample preservation, transportation, chain-of-custody, and

analysis. Most recently, the EPA National Enforcement Investigation Center has been contacted and a field monitoring and laboratory training course has been scheduled to further improve the Laboratory's quality assurance program.

*40 CFR Part 136 Guidelines Establishing Test Procedures for the Analysis of Pollutants

40 CFR Part 261 "Identification & Listing of Hazardous Wastes"

SW846 "Test Methods for Evaluating Solid Waste"

EPA-625-/6-74-003a

METHODS FOR CHEMICAL ANALYSIS OF WATER AND WASTES

ENVIRONMENTAL MONITORING AND SUPPORT LABORATORY

Environmental Research Center

Cincinnati, Ohio 45268

U.S. ENVIRONMENTAL PROTECTION AGENCY

Technology Transfer

1974

~~1976~~

TABLE 1

Preservative	Action	Applicable to:
$HgCl_2$	Bacterial Inhibitor	Nitrogen forms, Phosphorus forms
Acid (HNO_3)	Metals solvent, prevents precipitation	Metals
Acid (H_2SO_4)	Bacterial Inhibitor	Organic samples (COD, oil & grease organic carbon), Nitrogen-phosphorus forms
	Salt formation with organic bases	Ammonia, amines
Alkali (NaOH)	Salt formation with volatile compounds	Cyanides, organic acids
Refrigeration	Bacterial Inhibitor, Retards chemical reaction rates	Acidity-alkalinity, organic materials, BOD, color, odor, organic P, organic N, carbon, etc., biological organism (coliform, etc.)

In summary, refrigeration at temperatures near freezing or below is the best preservation technique available, but it is not applicable to all types of samples.

The recommended choice of preservatives for various constituents is given in Table 2. These choices are based on the accompanying references and on information supplied by various Regional Analytical Quality Control Coordinators.

TABLE 2 (Continued)

Measurement	Vol. Req. (ml)	Container	Preservative	Holding Time(6)
Fluoride	300	P, G	Cool, 4°C	7 Days
Hardness	100	P, G	Cool, 4°C HNO_3 to pH <2	7 Days
Iodide	100	P, G	Cool, 4°C	24 Hrs.
MBAS	250	P, G	Cool, 4°C	24 Hrs.
Metals				
Dissolved	200	P, G	Filter on site HNO_3 to pH <2	6 Mos.
Suspended			Filter on site	6 Mos.
Total	100		HNO_3 to pH <2	6 Mos.
Mercury				
Dissolved	100	P, G	Filter HNO_3 to pH <2	38 Days (Glass) 13 Days (Hard Plastic)
Total	100	P, G	HNO_3 to pH <2	38 Days (Glass) 13 Days (Hard Plastic)

TABLE 2 (Continued)

Measurement	Vol. Req. (ml)	Container	Preservative	Holding Time(6)
Hydrolyzable	50	P, G	Cool, 4°C H_2SO_4 to pH <2	24 Hrs.(4)
Total	50	P, G	Cool, 4°C	7 Days
Total, Dissolved	50	P, G	Filter on site Cool, 4°C	24 Hrs.(4)
Residue				
Filterable	100	P, G	Cool, 4°C	7 Days
Non-Filterable	100	P, G	Cool, 4°C	7 Days
Total	100	P, G	Cool, 4°C	7Days
Volatile	100	P, G	Cool, 4°C	7 Days
Settleable Matter	1000	P, G	None Req.	24 Hrs.
Selenium	50	P, G	HNO_3 to pH <2	6 Mos.
Silica	50	P only	Cool, 4°C	7 Days
Specific Conductance	100	P, G	Cool, 4°C	24 Hrs. (5)
Sulfate	50	P, G	Cool, 4°C	7 Days

STANDARD METHODS

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