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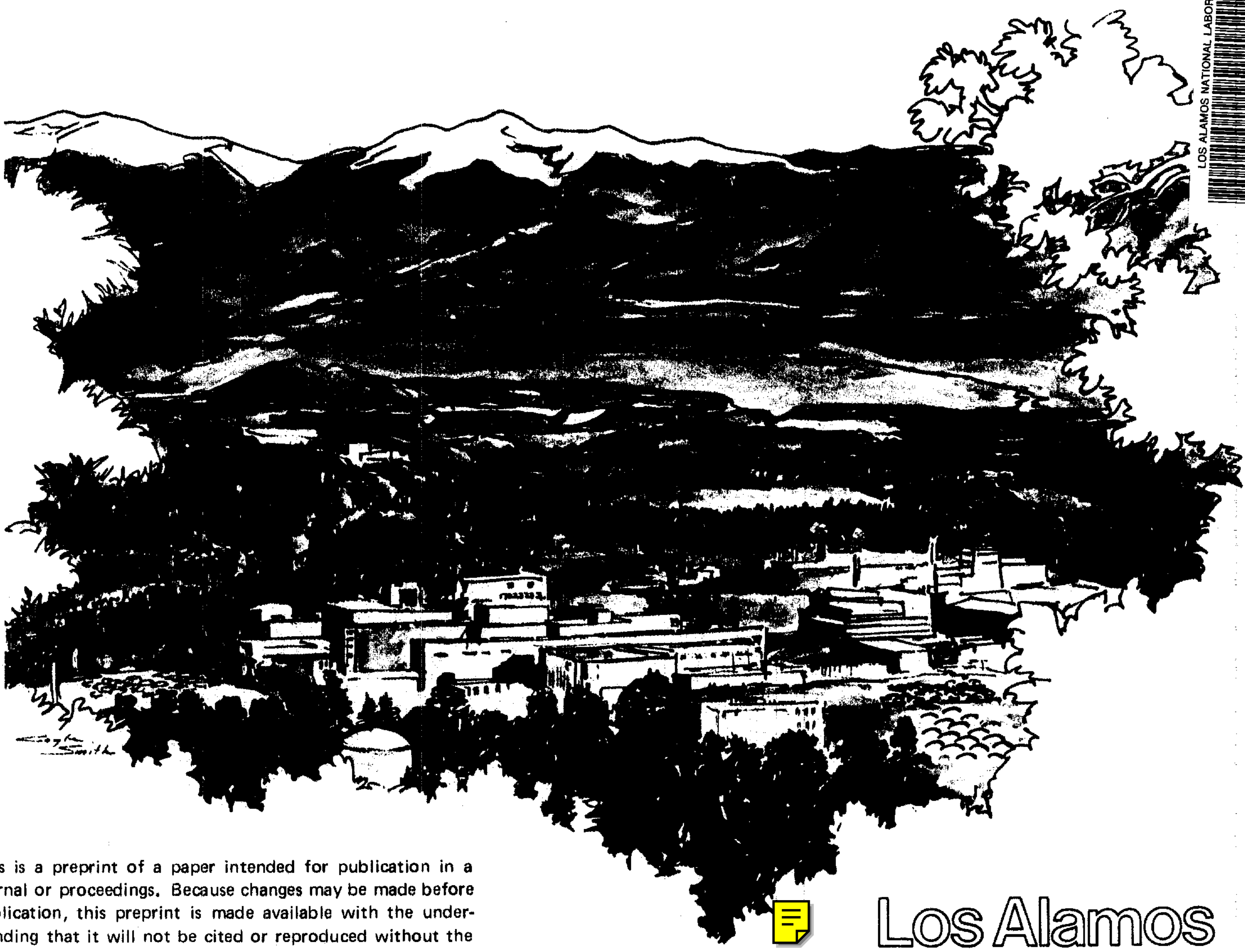
ENVIRONMENTAL SURVEILLANCE OF LOW-LEVEL RADIOACTIVE WASTE MANAGEMENT AREAS AT LOS ALAMOS DURING 1985

Environmental Science Group
Environmental Surveillance Group
Health and Environmental Chemistry Group



Los Alamos

Los Alamos National Laboratory
Los Alamos, New Mexico 87545

Attachment 1

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INTRODUCTION

This report was compiled from information generated by the Waste Management, Environmental Surveillance, Health and Environmental Chemistry and Environmental Science Groups as a part of the DOE-sponsored radioactive waste site surveillance program at Los Alamos National Laboratory. The report is intended, primarily, as a source document for data collected in CY85. However, an attempt is made to interpret the data as it relates to radionuclide transport to serve in guiding future waste site surveillance activities.

This report contains information on one active (Area G) and 11 inactive (Areas A, B, C, E, F, K, T, U, V, W and X) radioactive waste management areas at Los Alamos (Fig. 1). Sections are included on:

- use history, current status, and future stabilization needs for all sites,
- results of detailed surveillance activities at Areas G and C, and
- a dose evaluation based on the waste site and Laboratory environmental surveillance data.

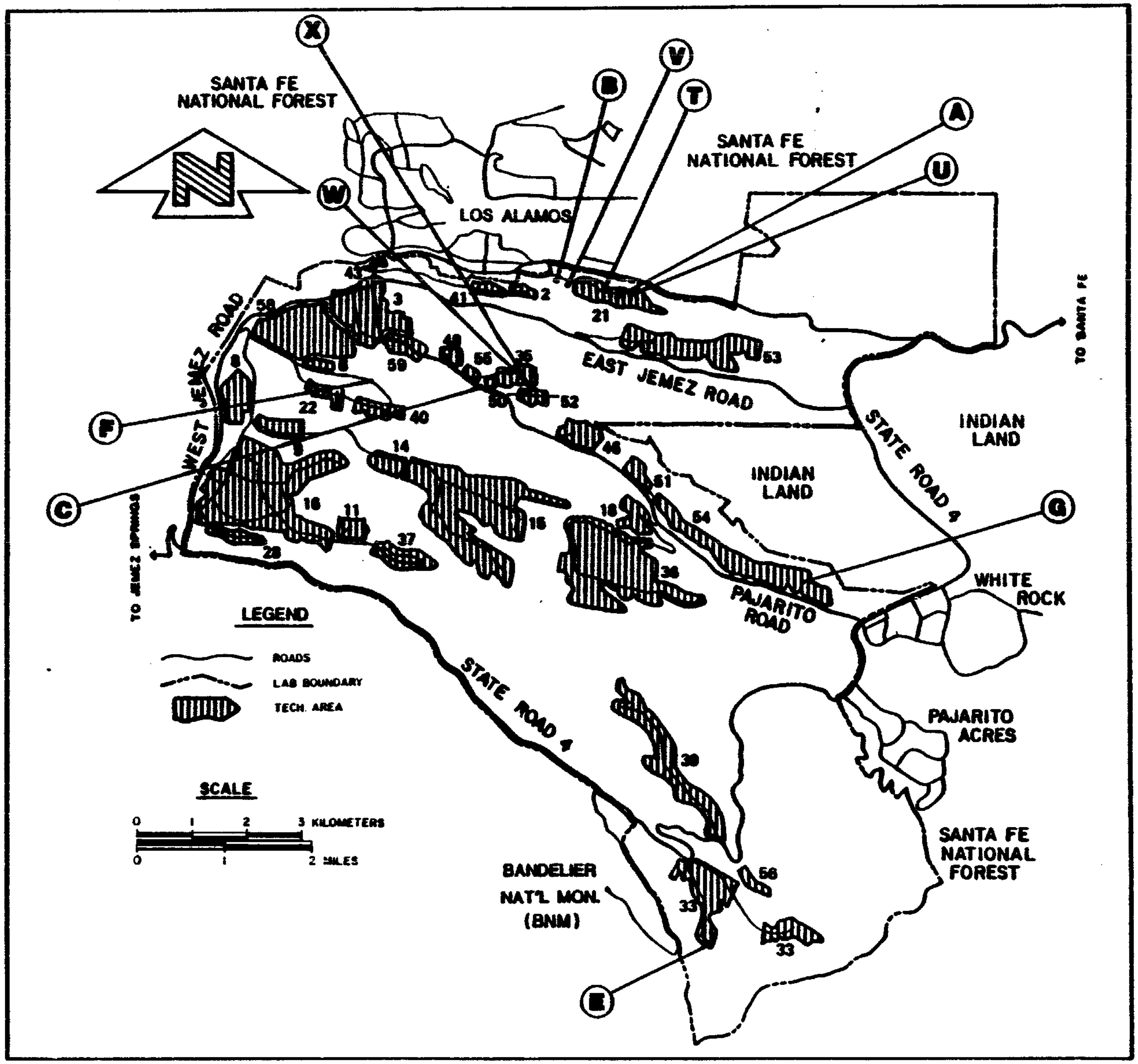
The information contained on site history is subject to modification as our records search progresses. The following information on the use history and chemical constituents of the waste sites was taken from a draft document being prepared by the Laboratory for the Comprehensive Environmental Assessment and Response Program (Ahlquist and Fritz, 1986).

SITE HISTORY/CURRENT STATUS

Area A

Inactive Material Disposal Area A, which is located at TA-21 (Fig. 1), consists of 5 pits and two storage tanks and is described in detail by Rogers (1977). The storage tanks are known as the "General's Tanks" after Maj. Gen. Leslie R. Groves, head of the Manhattan Engineer District during World War II. Waste solutions containing plutonium were stored in these tanks with the hope that chemical

Figure 1. Location of technical areas and materials disposal areas at Los Alamos National Laboratory.



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recovery processes would improve so that the plutonium in them could be recovered. Liquids in the tanks were removed for waste processing in CY1983. The bottom of the tanks presently contain a few centimeters of semi-solid precipitate (Ahlquist and Fritz, 1986).

Four small disposal pits, also in Area A, are believed to contain solid waste contaminated with polonium (now decayed away) and trace amounts of long-lived alpha emitters (probably plutonium). These pits were used between 1944 and 1947. A larger pit, constructed in 1969 contains building debris after the decommissioning of several facilities at TA-21. This pit was covered over in May 1978 (Ahlquist and Fritz, 1986).

Site stabilization was begun in FY85. This included sealing and covering the openings in the General's Tanks to prevent water entry, removing surface contamination, adding cover material, and recontouring, in preparation for reseeding the cover surface. Revegetation of the site has not been completed as of 12/86.

Area B

Inactive Material Disposal Area B is located south of DP Road near TA-21. (Fig. 1). With available information, the exact number of pits in Area B cannot be estimated. The waste consisted primarily of solids contaminated with various radionuclides including plutonium, polonium (since decayed away), uranium, americium, curium, and actinium. At least one truck contaminated with fission products from the Trinity tests is also buried in Area B. At the east end of the site, several small slit trenches were dug for chemical disposal. These trenches were about 1 m deep, 0.6 m wide, and less than 13 m long (Ahlquist and Fritz, 1986). Chemicals thought to be present in Area B include organics, perchlorates, ethers, and solvents. Part of the western portion of the site has been paved and leased to Los Alamos County, who in turn, rent spaces to the general public for storage of trailers, vehicles, etc.

A USGS study of the area in 1966 indicated some possible lateral movement of water - probably from a pit. However, radiochemical analyses of the soil and tuff from test holes around the site showed no indication of radionuclide contamination (Rogers, 1977). Studies on the unpaved eastern end of Area B in the late 1970s documented that plants contained slightly elevated concentrations of some radionuclides.

A remedial action was implemented on the unpaved part of Area B in 1984 and involved removal of all large vegetation, a herbicide treatment to retard root growth, and the application of 0.75 - 1 m of new cover. A study was initiated at Area B in conjunction with the remedial action to evaluate the performance of a layered soil and rock trench cap design compared with the conventional topsoil and crushed tuff design. Details concerning the experiment are presented in Barnes et al. (1985). Erosion on the south perimeter of Area B is a continuing problem that will require special attention in the future. During the remedial action in 1984, the perimeter fence on the south side of the unpaved portion of the site was moved an additional 3 m further south.

Area C

The 4.9ha (11.8 acre) inactive material disposal Area C is located on the north side of Pajarito Road adjacent to TA-50 (Fig. 1). It was opened in 1948 and is composed of 6 radioactive waste pits, one chemical pit, and 107 shafts (Rogers, 1977). Pit disposal ended in 1964 and shaft disposal ended in 1969 (Ahlquist and Fritz, 1986).

The type of radioactive waste buried at Area C includes building debris from the demolition of TA-1 and TA-10, laboratory trash, sludge from waste treatment plant operations, and tuballoy chips from the shops (Rogers, 1977). Plutonium contaminated sodium loops from TA-35 were buried in the shafts. Noncombustible waste was buried in the west end of pit 5 in 1957 (Ahlquist and Fritz, 1986).

Materials in the chemical pit include a variety of chemicals, pyrophoric metals, hydrides and powders, sealed vessels (containing sodium-potassium alloy or compressed gases), and equipment not suitable for disposal as salvage or in the municipal or radioactive waste dumps. High explosives, however, have never been placed in this pit. Normal uranium powders and hydrides have been disposed of in this pit, including some plutonium contaminated objects. Therefore, it should be assumed that the pit contains some above-background alpha activity.

A new surface cover, applied to the eastern half and extreme western end of the site in 1984, consisted of the addition of 0.15 - 1 m of topsoil over 0.5 m of crushed tuff, slope recontouring, and seeding of the cover with native grasses. The new cover was not applied to the extreme NE corner of Area C since this area does not include any of the waste trenches. A very heavy cover of white and yellow clover (Melilotus spp.) has invaded the site.

Area D

Area D is located at TA-33 (Fig. 1) and consists of two 1.9 m x 2.5 m concrete lined rectangular shafts which are about 14 m deep. An octagonal room is located adjacent to the bottom of each shaft. The shafts were used for tests on weapon components. The principal contaminant from the tests was Po-210 although small quantities of stable beryllium may also have been used. Shaft one was used in 1948. Shaft two was used in 1948, and in 1952. In 1952, 600 mCi of Po-210 (T1/2 physical = 138 days) was used. Essentially all of this material has decayed away in the ensuing 34 years.

Area E

Inactive material disposal Area E is also at TA-33 (Fig. 1) Although its history is not presently well known, it probably contains solid waste originally contaminated with Po-210 (now decayed away) and uranium. Engineering drawings indicate the presence of 6 pits and one test shaft. It is not known if all of the pits

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were used. The shaft was used for a weapons component test and contained only Po-210 and small quantities of beryllium as contaminants. Surface stabilization is scheduled for FY87.

Area F

Inactive material disposal Area F is located on Two Mile Mesa near TA-6 (Fig. 1). Maps indicate the presence of two pits but it is not certain if the maps accurately reflect all pit locations. Area F was opened in 1946 for disposal of unsalvageable classified objects potentially containing tuballoy, high explosives, primacord, and Cs-137. Surface stabilization, using R&D based technology, was completed at this site in FY86.

Area G

Area G is located at TA-54 (Fig. 1) and is the main active radioactive solid waste burial/storage site at the Laboratory. The area has been in use since 1957 and will likely continue to be used through the foreseeable future. In FY77 the site was expanded to encompass a total of 26 ha (63 acres). Future expansions are planned. Burial/storage facilities within the area include pits, shafts, trenches, and pads, all of varying dimensions. While early disposal records did not have details on curie contents, isotopic composition of waste was noted. Current accounting practice maintains detailed information on all aspects of the waste. Since 1971, solid waste contaminated with transuranic (TRU) radionuclides at activity levels exceeding 10 nCi/g of waste (100 nCi/g for Pu-238) have been stored retrieveably for possible future transport to a repository. The limit for all forms of retrieveable TRU waste was changed to 100 nCi/g in 1983. In addition to TRU waste, the main radioactive wastes are uranium and a variety of fission and activation products. For several years during the 1970s, plutonium and uranium waste was segregated into separate pits. In recent years, 50000 - 70000 Ci of tritium were buried in Area G each year. Additionally, asbestos wastes and materials contaminated with PCBs were placed in Area G under authority of an EPA permit.

A variety of special studies have been conducted at Area G including vadose zone monitoring to (1) determine physical properties (i.e., intrinsic permeability, moisture characteristic curves, and unsaturated hydraulic conductivity) in tuff cores from two 37.5 m deep holes, (2) core and pore gas analyses from two 30 m deep holes, and (3) moisture distribution in two 15 m deep holes with neutron probe and soil psychrometer installations.

Area K

Area K is composed of one or two small (about 1.5 x 2 m) sump pits, only one of which may be contaminated, that serve building TA-33-86. The principal contaminant from TA-33-86 is tritium with uranium as another possible radioactive contaminant. Chemical constituents of the waste are not presently known. The sumps are scheduled for removal when TA-33-86 is decommissioned (presently planned for FY87 and FY88). It is believed that the sumps were used to contain liquids generated during the maintenance and repair of an old style tritium transfer pumps. Solvents and oils were probably associated with the operation.

Area T

Inactive Material Disposal Area T consists of four absorption beds at TA-21 (Fig. 1). Untreated waste (14 million gallons) from the processing of plutonium was released to the pits from 1945 to 1952. Largely because the volume of liquid discharged had exceeded the holding capacity of the beds, wastes, after 1952, were treated in Building TA-21-35 and the effluent released to DP Canyon. However, at infrequent intervals, a few hundred gallons of treated wastes were discharged to the beds until 1967. Waste treatment operations shifted to a new treatment plant (TA-21-257) in 1968. Wastes sludges from that operation were mixed with cement and were pumped down shafts augered between two absorption beds. Beginning December 31, 1975, TRU wastes were mixed with cement and pumped into corrugated metal pipes that were stored in a pit dug between two absorption beds. In addition to plutonium, fluoride and ammonium citrate were also added to the absorption beds (Rogers, 1977).

The absorption beds consisted of trenches about 36 m long by 6.3 m wide by 1.3 m deep. The trenches were backfilled with coarse material, grading from 20 cm diameter boulders at the bottom, through gravel, to fine sand at the surface. The shafts, approximately 20 m deep and 2 to 2.5 m in diameter, were coated with asphalt prior to the disposal of the cement paste mixture (Rogers, 1977).

Several studies were conducted over the years to characterize the movement of radionuclides through the tuff. Five test holes were dug around the pits in 1953. Two of these holes penetrated through the pits and one was a 45-degree hole that angled below pit #1. Plutonium concentrations above background were found to 6.3 m below the surface. In 1961 a 9.4 m deep caisson was dug so that horizontal cores could be taken. It was concluded from this study that plutonium had penetrated to a depth of at least 8.8 m in the tuff beneath the pits and that penetration took place mainly along fractures in the tuff. In 1967 several test holes drilled outside the pits showed no alpha, beta, or gamma contamination but tritium was found in the pore water (Purtymun and Kennedy, 1966).

In a study completed in 1978 (Nyhan et al, 1985), four sampling holes were drilled to a depth of 31 m on and adjacent to two of the absorption beds. In samples from two holes that penetrated through the absorption beds, Am-241 and Pu-239 was found to about 31 m below the surface. Samples from the other two holes which were drilled adjacent to the beds, showed Am-241 and Pu-239 to depths of 14 m and 6.7 m, respectively.

In FY86, Area T was scheduled for surface stabilization and removal of the 158 corrugated metal pipes containing TRU waste mixed in cement. Work on these tasks is currently underway.

Area U

Inactive Material Disposal Area U, located at TA-21 (Fig. 1), contains two absorption beds similar to those in Area T. These beds were used for the subsurface disposal of contaminated liquid wastes between 1945 and 1968. The primary radionuclide in these wastes was Po-210 which has since decayed away. Several curies of Ac-227 (22 yr T1/2) were also discharged to these beds - principally from the effluents from a filter building that scrubbed Ac-227 from air from several process buildings at TA-21 (Ahlquist and Fritz, 1986). Remedial procedures were implemented at Area U in 1985 beginning with the removal of the piping from the absorption beds. Additionally, a trench (6.3 m wide, 31 m long, and 1.3 to 4 m deep) was dug in the beds. The excavated soil, contaminated with actinium, was removed to Area G although not all contamination was removed due to lack of time and money. A plastic lining was placed in the trench to indicate the boundary between the excavated and unexcavated areas and then the trench was filled with uncontaminated tuff. The excavated area was covered with 15 cm of top soil and revegetated. The revegetation effort was unsuccessful and needs to be repeated.

Area V

Area V, 0.4 ha in size, and is located at TA-21. Three absorption beds were used for the disposal of contaminated liquid waste from laundry operations from 1945 to 1961. An estimated 3 curies of Sr-89, Ba-140 and La-140, which have since decayed to undetectable levels, were discharged to these pits. Small quantities of Sr-90 and Pu-239 were also discharged to the pits (Ahlquist and Fritz, 1986). A new cap was applied to Area V in 1985 although the surface does not yet support an adequate plant cover. Erosion from parking lot runoff also is scheduled for correction.

Area W

Area W is located at TA-35 (Fig. 1) and consists of two vertical stainless steel tubes 10 cm in diameter and 37.5 m long that contain)etween 225 and 290 kg (approximately 310) of sodium and NaK (a sodium-potassi n alloy), which was used as coolant for the LAMPRE reactor. The stored materi s contain small amounts of fission products and Pu-239 although the exact am unts of the radioactive contaminants are not known. The reactor was shut dow in 1963 and 19 months after shutdown, the coolant showed Na-22, Cs-137, Co- 3 and Ta-182. Of these fission products, all would have decayed away by now ex ept for the Cs-137. The storage tubes were placed in separate steelcased drill hol s which were 36 m deep (Ahlquist and Fritz, 1986). The portions of the stainless st l tubing extending above the surface were entombed in a concrete structure in 197 . The structure lid can be removed and it is marked with a brass plate describi g the contents.

Area X

Area X consists of the LAPRE II (Los Alamos Plutor um Reactor Experiment) reactor pressure vessel and associated piping and the r nains of the associated pump pit (TA-35-28). The gold-lined pressure vessel ed a plutonium nitrate solution for fuel. The fuel has been removed from the v ssel. Area X is located at the southeast end of TA-35-2 (Fig. 1). Presently the ea is paved over and is unmarked.

DETAILED MONITORING AT AREAS G AND C

Materials and Methods

Data collected during the detailed survey at Areas 3 and C included:

- radionuclide concentrations in air, soil, sedime t and vegetation
- radiation doses as measured with thermolumin scent dosimeters
- external penetrating radiation doses as measur l with field instruments, and
- various meteorological parameters

Most of the sampling and analytical methods used in the survey are described in Appendices A-D in Los Alamos National Laboratory report, LA-10421-ENV (Environmental Surveillance Group, 1985). The field radiation survey was conducted with combinations of 3 different instruments to provide qualitative data on the presence or absence of external penetrating radiation. The phoswich (phosphor sandwich) instrument consists of a thin sodium iodide crystal backed by a cesium iodide crystal coupled to an anti-coincidence circuit. The detector gives low-background count rates for photons in the 5-150 keV range and is used primarily to detect low energy x-rays from decay of transuranic materials. The instrument is calibrated before each field use with an Am-241 source. The property number of the detector used in these studies was PN 346298 (revised number is PN 693794).

The micro-R meter contains a 1.3 cm diameter sodium iodide crystal, and is used in a count rate mode to detect photons above 100 keV in energy. The meter is calibrated semiannually using a Ra-226 source. The meter used in this work had property number PN 286215.

The high pressure ion chamber (HPIC) consists of a 25.4 cm diameter sphere, filled to 25 atmospheres with argon gas, connected to a sensitive electrometer to quantify ionization. The instrument can accurately measure gamma- and cosmic-radiation to within 1 micro R/hour. The HPIC used in this study, PN 270242 (new PN 693790), was calibrated using a Cs-137 source.

Specific sampling locations for the various measurements made at Area G and C are identified in the figures depicting the results. Most of those locations at Area G were around the perimeter exclusion fence although a qualitative field instrument survey and the meterological measurements were made within the site. A sampling grid, with 20 m grid intersections, was established at Area C. Samples were taken at about 150 grid intersections both within and outside the perimeter fence.

Techniques to contour radionuclide concentration data require a sufficient number of sample points to create smooth contour lines. However, field sample schemes often do not provide enough resolution for the contours to be developed. In recent years, kriging has been used to analyze spatially varied data and to interpolate the patterns of the data between sampling points. The kriging procedure also yields contours which pass through the observed data points and estimates the error variance of the prediction.

Briefly, the procedure performs the following:

1) It identifies the statistics and major trends in the data. The data value can be considered to be composed of a deterministic and stochastic component. By fitting low-order polynomials, linear and quadratic trend surfaces, the deterministic component can be removed.

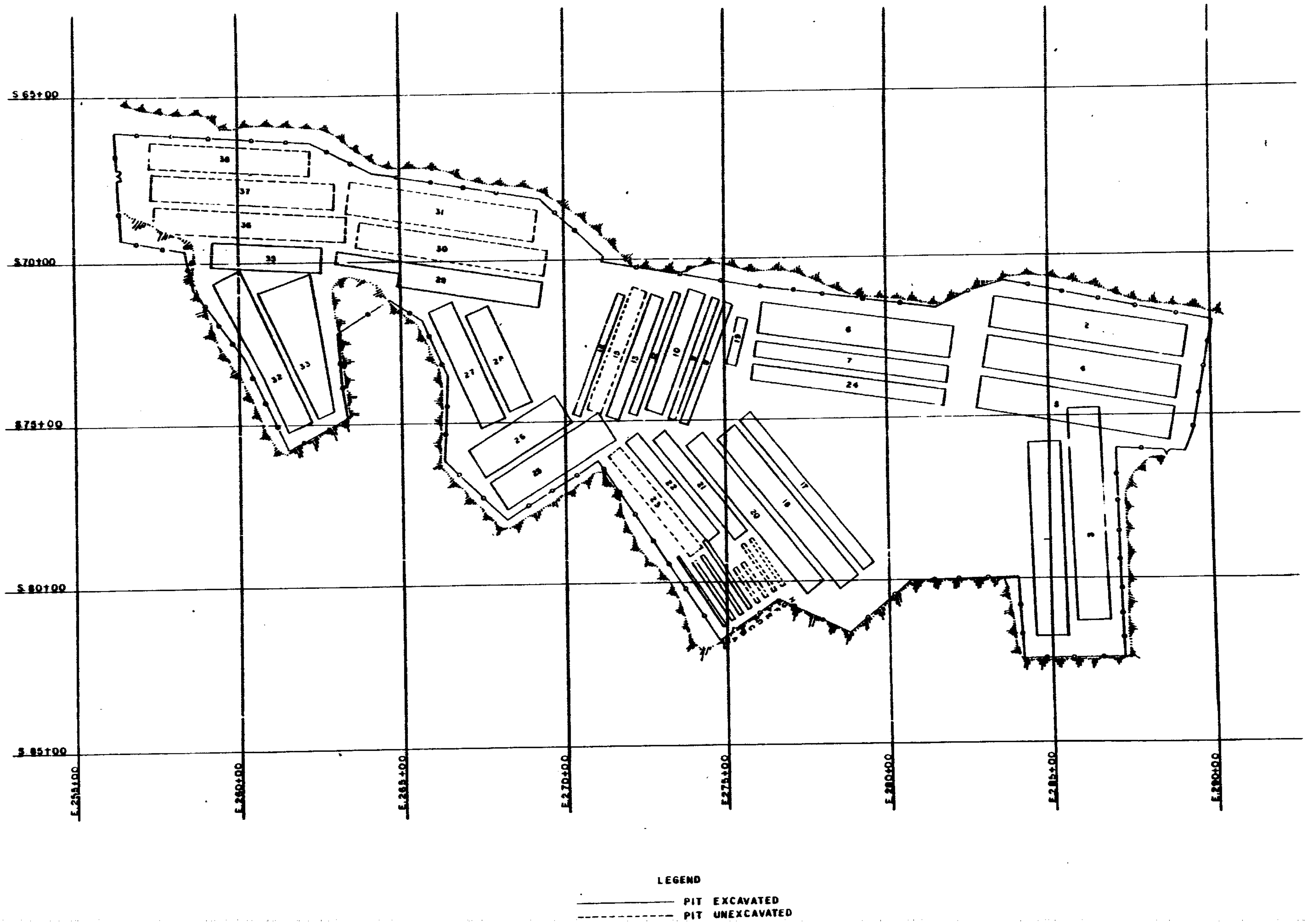
2) Using the residuals, a theoretical variogram is fitted using the kriging program of Skirvan and Karlinger (1980). This process is iterative and will require solving n-1 linear equations, n times where n is the number of observations. In all analyses, the theoretical semivariogram was assumed to be an exponential form.

3) Following optimization of the semivariogram, the program from Skirvan and Karlinger was used to interpolate data points over a grid of the area. These data points were then used for creating the contour maps. A complete description of kriging, both theoretical and applied, can be found in Journel and Huijbregts (1978).

Results from Area G

A site map of Area G (Fig. 2) shows the present and planned trenches used for burial of low-level waste. Area G is located on a mesa and is bordered by Canada del Buey on the north and Pajarito Canyon on the south. Area G is 1.4 km west of the community of White Rock, New Mexico.

Figure 2. Active materials disposal Area G showing perimeter fence and trench layout in 1985.



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Meteorological Measurements

A 10.5 meter high meteorological tower is located in the north east quadrant of Area G. The parameters measured and the measurement heights above the ground surface are presented in Table 1. Fifteen minute average data are recorded by a data acquisition system. A 24-hour summary is also recorded, including maximum and minimum temperature, relative humidity, maximum wind gust, average wind speed, total solar radiation, and total precipitation.

Average maximum and minimum daily temperatures at Area G for selected months during 1985 are presented in Table 2. The length of the data record at Area G is not long enough to develop long term averages for comparison. However, the range of values is consistent with long term averages measured at TA-59.

Twelve days during 1985 exceeded 30 ^{o}C (86 ^{o}F); the highest temperature recorded was 33.1 ^{o}C (91.6 ^{o}F) on July 6. The coldest temperature recorded was -19.7 ^{o}C (-3.5 ^{o}F) on February 1.

The precipitation data for 1985 at Area G are incomplete due to rain gauge malfunctions. Based on a 5 year comparison (1980-1984), the annual precipitation at Area G was estimated to be 75% of the total at TA-59. The estimated 1985 quarterly precipitation totals for Area G are presented in Table 3.

Precipitation totals during 1985 were well above normal, due to wet snows during March and much above average rainfall in April, May, June, September, and October. Maximum precipitation totals occurred during July through September, which is characteristic of the summer thunderstorm period. The 30 year average precipitation total at TA-59 is 45.26 cm (17.82 in).

The predominant wind direction (Fig. 3) is from the south-southwest, reflecting the channeling effect of the Rio Grande Valley. The frequent occurrence of weak synoptic scale pressure gradients allows differential solar heating of terrain surrounding Los Alamos to produce a large diurnal variation of winds at the site.

Attachment 1

Table 1. Meteorological measurements made at Area G during 1985.

Measurement variable	Height of measurement above ground (m)
wind speed	1.2, 3.5, 10.5
temperature	0.08, 1.2, 10.5
solar radiation	3
relative humidity	1.2
precipitation	1.2

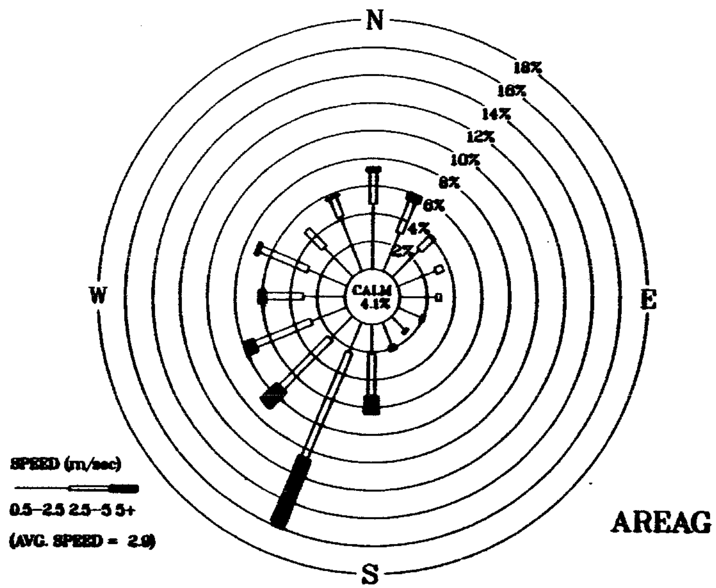
Table 2. Average maximum and minimum daily temperatures, 1.2 m above the ground, at Area G during 1985.

	Maximum		Minimum	
	°C	(°F)	°C	(°F)
January	1.4	(34.5)	-7.8	(18.1)
April	16.4	(61.6)	2.3	(36.1)
July	28.0	(82.3)	13.7	(56.7)
October	16.4	(61.5)	4.0	(39.2)

Table 3. Estimated precipitation at Area G during 1985.

	cm	(in)
Jan - Mar	8.79	(3.46)
Apr - Jun	13.77	(5.42)
Jul - Sep	18.57	(7.31)
Oct - Dec	7.59	(2.99)

Figure 3. Average wind rose at Area G during 1985.


N
S
E
W
18%
16%
14%
12%
10%
8%
6%
4%
2%
CALM
4.1%
SPEED (m/sec)
0.5–2.5 2.5–5 5+
(AVG. SPEED = 2.9)
AREAG

The daytime wind rose (Fig. 4) shows a maximum frequency of occurrence from the south-southwest, indicating wind flow up the Rio Grande Valley. A secondary pattern is from the north-northeast through northeast as a consequence of down valley winds developing over the Rio Grande drainage during the night and continuing past sunrise due to thermal inertia. At night, the predominant pattern is light winds flowing down the Pajarito Plateau from the west to the east (Fig. 5). The large component of northerly winds may be caused by the interaction of down plateau winds from the northwest and down Rio Grande winds from the northeast.

Los Alamos is a light wind site; the annual average wind speed at Area G is 2.9 m/sec. with over 40% of wind speeds less than 2.5 m/sec. High wind speeds are observed in the spring months, however, when large scale low pressure systems move out of the Rocky Mountains onto the Great Plains. Wind gusts of 31 m/sec (70 miles per hour) have been recorded during these storms.

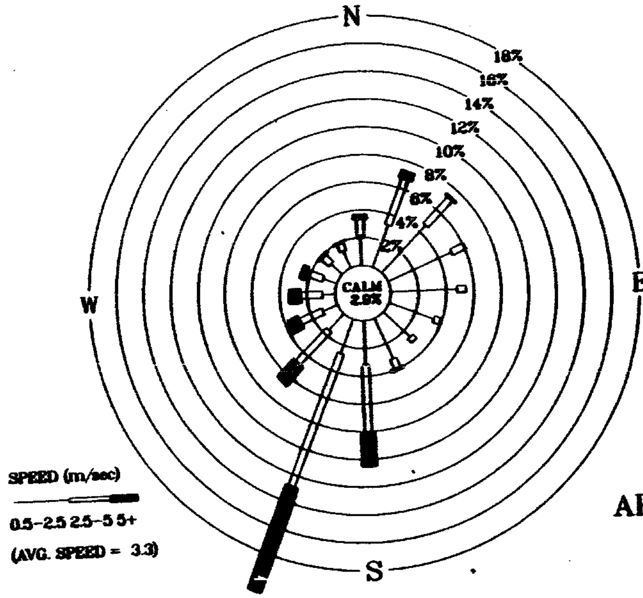
Field Instrument Survey

The results of the qualitative field instrument survey over the entire Area G site are shown in Fig. 6 along with the location of the perimeter sampling sites. Note that elevated phoswich responses (>40 counts/sec) were obtained near the north east quadrant and near pits 21, 22, 23, A through H (see Fig. 2), and the associated disposal shafts located by the south perimeter fence.

Instrument radiation survey data from the perimeter locations (see Fig. 6) suggest that counts from the south side of Area G, (locations 5, 6, 7, 10, 12) are slightly elevated (Table 4). Stations 5, 6, and 7 are in close proximity to pits (21, 22, 23), A through G, and the associated shafts where elevated field instrument response was obtained during the general reconnaissance of the site (Fig. 6). Other than the fact that stations 10 and 12 are located in channels draining Area G, the source areas for the radionuclides at these locations are not known.

External radiation doses were also measured at 27 locations (Fig. 7) at Area

Figure 4. Average daytime wind rose at Area G during 1985.


N
18%
16%
14%
12%
10%
8%
6%
4%
2%
CALM
2.8%
E
W
S
SPEED (m/sec)
0.5–2.5 2.5–5 5+
(AVG. SPEED = 3.3)

AREAG

Figure 5. Average nighttime wind rose at Area G during 1985.

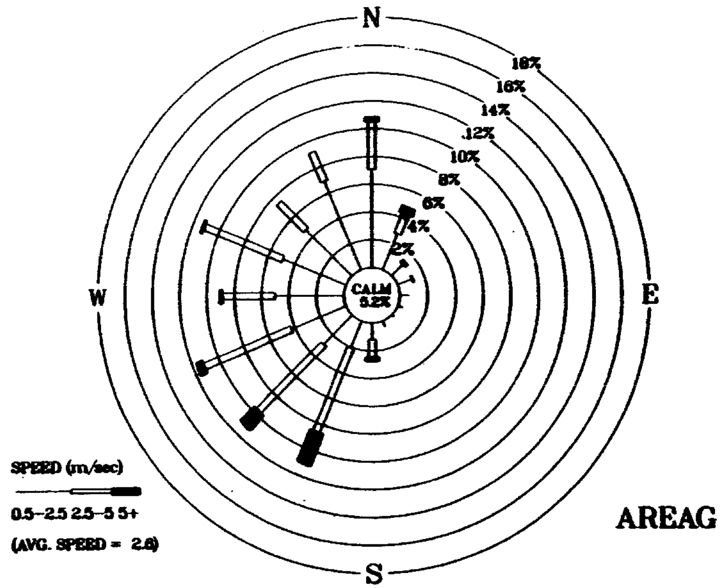

N
E
S
W
18%
16%
14%
12%
10%
8%
6%
4%
2%
CALM
SPEED (m/sec)
0.5–2.5 2.5–5 5+
(AVG. SPEED = 2.6)
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Figure 6. The sixteen perimeter sampling locations and results of low resolution phoswich survey at Area G in 1985.

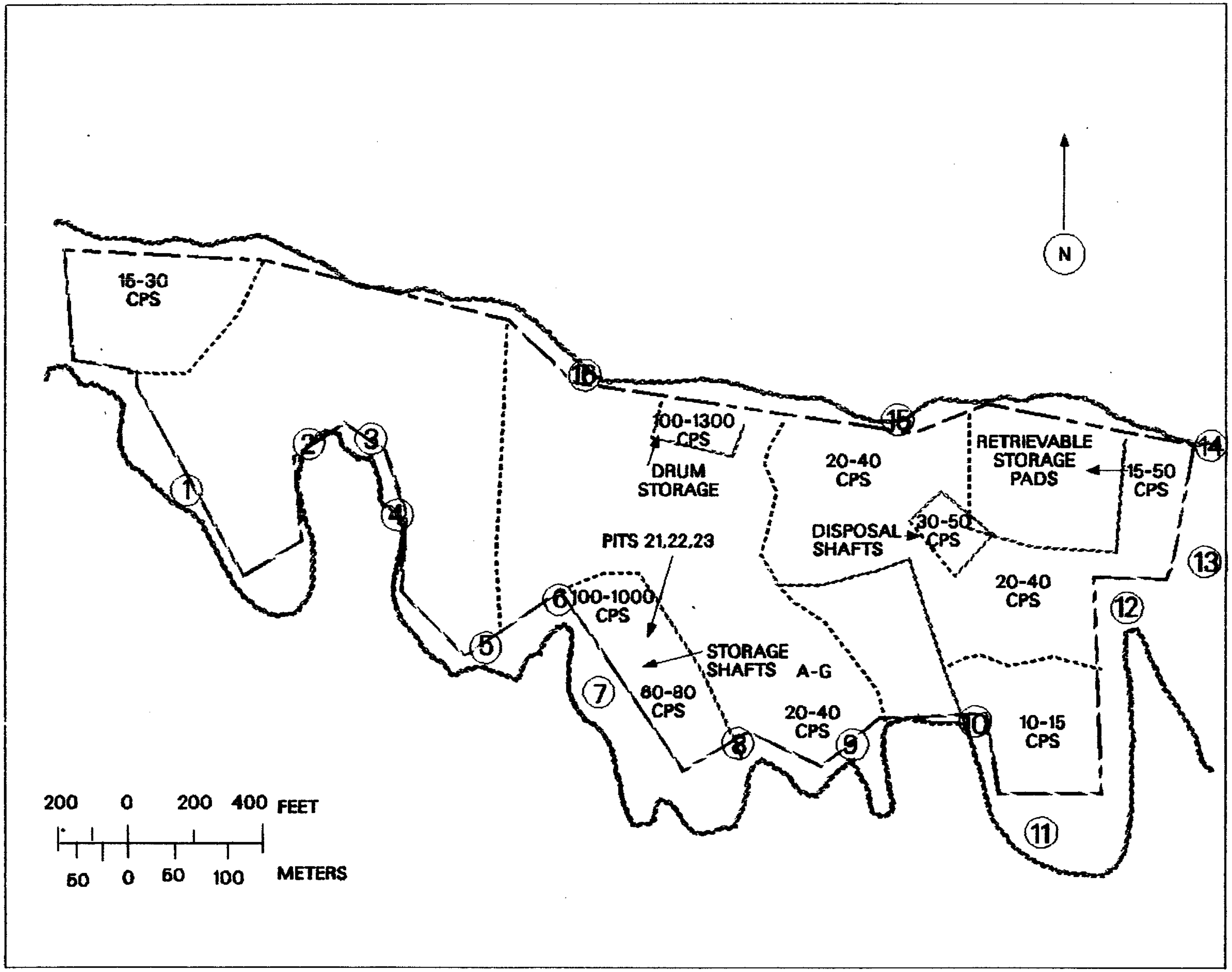

N
15-30
CPS
100-1300
CPS
DRUM
STORAGE
20-40
CPS
RETRIEVABLE
STORAGE
PADS
15-50
CPS
DISPOSAL
SHAFTS
30-50
CPS
PITS 21,22,23
20-40
CPS
100-1000
CPS
STORAGE
SHAFTS A-G
60-80
CPS
20-40
CPS
10-15
CPS
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
200 0 200 400 FEET
50 0 50 100 METERS

Table 4. Field instrument survey results (uncorrected for background) from perimeter locations at Area G in 1985.

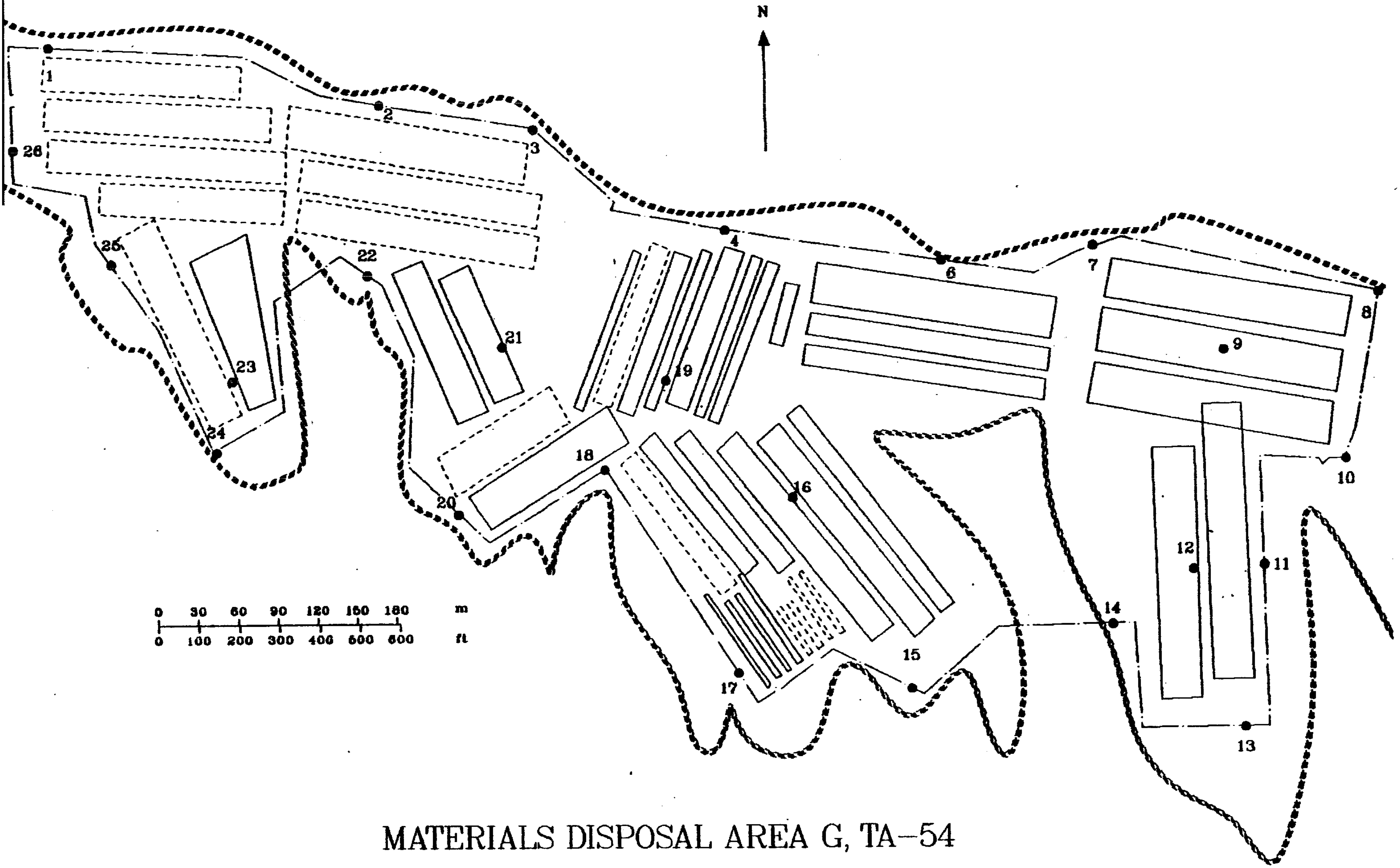
Location	Phoswich (counts/min)[1]	uR meter (uR/hr)[2]
1	650	15
2	690	20
3	[1668][3]	[40]
4	1150	25
5	[5017]	[40]
6	[2760]	[60]
7	[2313]	27
8	[1669]	25
9	1360	25
10	[3649]	25
11	1367	25
12	[2111]	[40]
13	[1690]	20
14	1009	25
15	1427	25
16	871	20

[1] background ≅500 cpm, window set at 10-100 keV

[2] background $\lesssim$ 20 μR/hr

[3] boxes denote upper range of values

Figure 7. Thermoluminescent dosimeter sampling network at Area G in 1985.



MATERIALS DISPOSAL AREA G, TA-54

G using lithium fluoride thermoluminescent dosimeters (TLD). Annual doses (mrem) by location are presented in Table 5 along with the range and mean. Annual radiation doses exceeding background were measured in the same areas where field instruments exhibited elevated response. Those areas were in the north-east quadrant of the site and near the pits on the southern perimeter. Doses up to three times the background of 125 mrem/yr were measured although the average was only about a fifth higher than background.

Radionuclides in Air

One (#22) of the 26 air sampling stations operated for the routine Laboratory air monitoring network is located in Area G. Four additional stations have been operated in and around Area G since 1984 (Fig. 8). Annual average air concentrations, (based on monthly values), of H-3, natural U, Pu-238, and Pu-239 were measured at all stations including Area G.

Concentrations of plutonium, uranium, and tritium exceeding background in air were measured in at least one of the five sampling locations at Area G (Table 6). In general, the concentrations of both isotopes of plutonium and uranium were elevated in samples collected on the south and north-east side of the site (sampling locations 22, G-1, G-2) in the same general area where field instrument and TLD measurements were elevated. Tritium concentrations exceeded background at all locations but especially so at sampler G-2, adjacent to the pits and shafts on the south-central perimeter of the site (Fig. 2). While some concentrations of the four radionuclides exceeded background, the levels were less than 0.1% of the Department of Energy's Concentration Guides for controlled areas.

Radionuclides in Perimeter Soil and Vegetation

For future reference, Table 7 identifies the species of vegetation that were collected at each perimeter location in 1985 at Area G. Radionuclide concentrations in soil and vegetation are presented in Tables 8-12.

Table 5. External radiation doses as measured by thermoluminscent dosimeters at Area G in 1985.

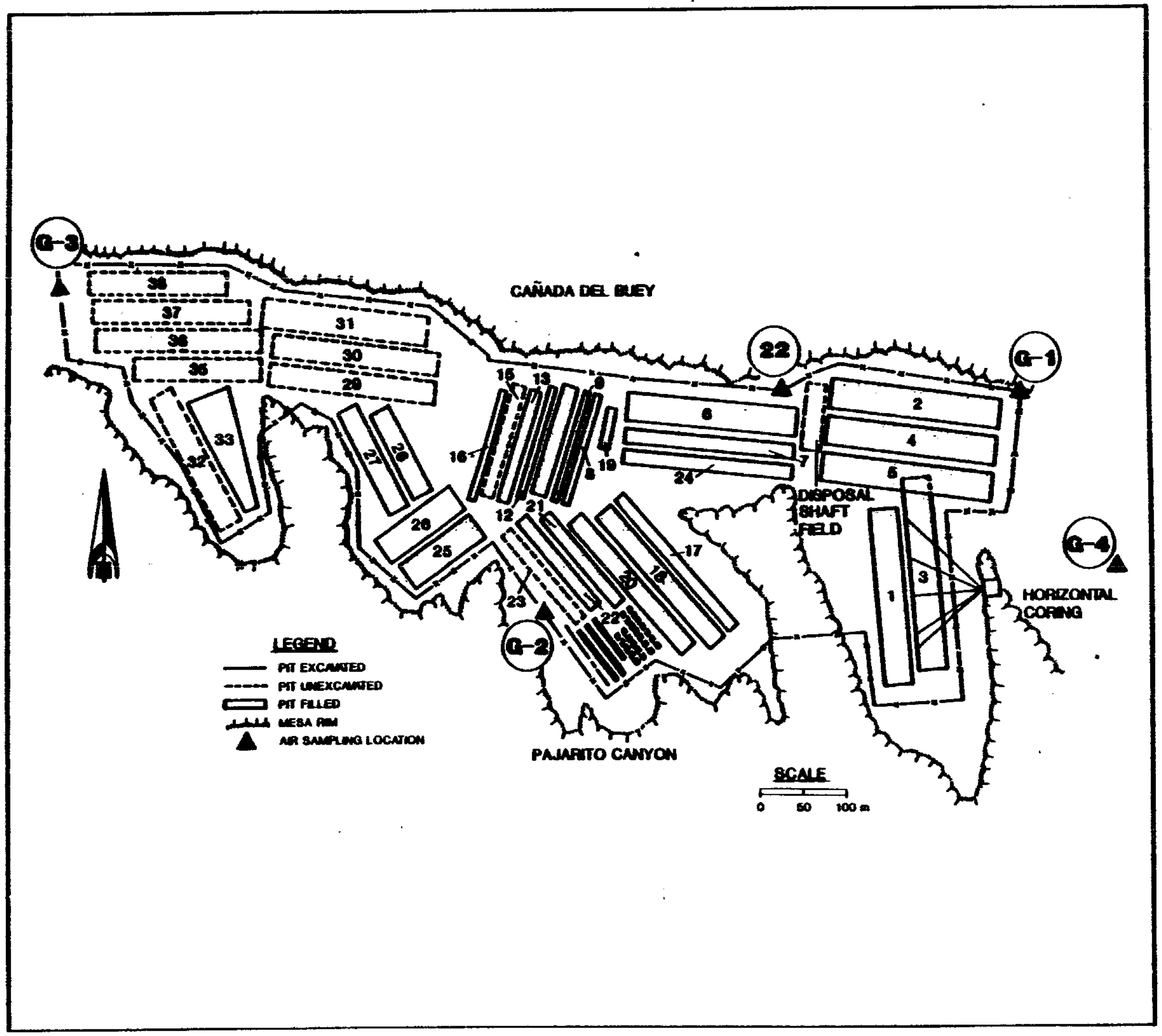
Station Number	Annual Dose (mrem/yr)[1]
1	127
2	122
3	128
4	[177][2]
5	[160]
6	134
7	[169]
8	[151]
9	[373]
10	[142]
11	134
12	137
13	129
14	[141]
15	135
16	135
17	[143]
18	[235]
19	[154]
20	[141]
21	[149]
22	137
23	[140]
24	137
25	[148]
26	135
27	127
	122 minimum
	373 maximum
	153 mean

[1]Annual background dose averages 125 mrem/y (Environmental Surveillance Group, 1986)

[2]Boxes denote upper range of values

Attachment 1

Figure 8. Air sampling network at Area G in 1985.



Attachment 1

Table 6. Average annual concentrations of radionuclides in air samples from Area G in 1985.

	max[1]	min[1]	mean[1]	mean as % of CG[2]
Pu-238 (aCi/m^3)				
station 22	5.6± 1.1	1.1± 0.6	[2.9 ± 1.7]	<0.1
G-1	9.3± 1.3	0.0± 0.5	[4.2 ± 3.9]	<0.1
G-2	0.8± 0.5	0.3± 0.4	0.49± 0.18	<0.1
G-3	12± 1.5	0.3± 0.2	0.38± 4.7	<0.1
G-4	0.5± 0.6	0.2± 0.1	0.3 ± 0.2	<0.1
Regional	1.1± 2.3	-1.5± 2.8	-0.4 ± 0.4	<0.1
Pu-239,240 (aCi/m^3)				
station 22	51± 3.3	4.2± 1.0	[30± 20]	<0.1
G-1	16± 1.8	0.4± 0.4	[4.8± 6.2]	<0.1
G-2	19± 2.0	0.2± 0.3	[4.9± 8.0]	<0.1
G-3	3.6± 0.9	0.2± 0.4	1.7± 1.2	<0.1
G-4	22± 1.3	0.2± 0.5	[6.6± 9.1]	<0.1
Regional	9.9± 1.2	-1.5± 1.4	0.8± 1.3	<0.1
Uranium (pg/m^3)				
station 22	83.0± 9.3	35± 3.7	[64± 21]	<0.1
G-1	207±21	7.2± 0.7	[116±85]	<0.1
G-2	44± 4.4	23± 2.6	32± 7.5	<0.1
G-3	83± 8.3	50± 5.0	[65± 13]	<0.1
G-4	46± 5.1	14± 1.5	33± 12	<0.1
Regional	65± 7.2	20± 2.2	46± 11	<0.1
H-3 (mCi/m^3)				
station 22	190± 40	9 ± 2	[76±15]	<0.1
G-1	100± 70	9 ± 2	[41± 8.3]	<0.1
G-2	4200±800	600 ±100	[1570±360]	<0.1
G-3	500±300	1 ± 1	[53± 43]	<0.1
G-4	1100± 40	4 ± 1	[115± 94]	<0.1
Regional	27± 6	- 2 ± 1	3.2± 0.3	<0.1

[1] Uncertainties are ± 1σ. Averages of 1985 air concentrations at three regional locations, Espanola, Pojoaque, and Santa Fe, have been included for comparison (see Environmental Surveillance Group, 1986).

[2] Controlled Area DOE Concentrations Guides are

Pu-238	2,000,000	aCi/m^3
Pu-239,240	2,000,000	aCi/m^3
U	200,000,00	pg/m^3
H-3	5,000,000	pCi/m^3

[3] boxes denote upper range of values

Table 7. Vegetation species sampled at perimeter locations at Area G in 1985.

Location*	Species 1	Species 2
1	*Quercus gambelli*	*Pinus edulis*
2	*P. ponderosa*	*Q. gambelli*
3	Unidentified forb	*P. edulis*
4	*Q. gambelli*	*Juniperus monosperma*
5	*J. monosperma*	*A. gambelli*
6	Unidentified forb	*P. edulis*, *Q. gambelli*
7	*J. monosperma*	*Q. gambelli*
8	Unidentified shrub	*J. monosperma*
9	*J. monosperma*	*Chrysothamnus sp.*
10	*J. monosperma*	
11	*J. monosperma*	
12	*P. edulis*	*Artemisia sp.*
13	*Q. gambelli*	*P. edulis*
14	*P. edulis*	
15	Unidentified forb	*J. monosperma*
16	*J. monosperma*	*P. edulis*

*See Fig. 6.

Tritium concentrations in soil and vegetation samples (Table 8), exceeding background, were generally associated with the southern perimeter locations. Elevated tritium concentrations were also found in the 1-10 cm depth zone in soils suggesting that diffusion from a subsurface source (i.e. the disposal shafts) was probably occurring.

Uranium concentrations in soils and vegetation (Table 9) were at or below background levels for nearly all samples (an exception was for station 13, 1-10 cm depth). If the uranium content of perimeter samples is indicative of those in soil and vegetation over the whole site, then we would recommend a much reduced sampling emphasis for uranium at Area G.

Plutonium concentrations in soils and vegetation are summarized in Tables 10 and 11. Elevated concentrations of both $^{239,240}Pu$ and ^{238}Pu are primarily associated with the east and northeast perimeter sampling locations. Concentrations of both plutonium isotopes decreased with soil depth suggesting that the plutonium was initially deposited on the soil surface.

The concentration ratio (CR) is used as a rough approximation of the transfer of a radionuclide from one environmental component to another. For example, the ratio formed by:

$$\frac{\text{concentration of Pu in vegetation}}{\text{concentration of Pu in soil}}$$

is a relative index (CR) of the transfer of plutonium from soils to plants.

Plutonium CRs (Tables 10 and 11), based upon those concentrations that exceeded background, ranged from 0.02 to values exceeding one. The range of plutonium CR's observed at Area G is consistent with other field data from Los Alamos (Hakonson et al., 1981). Plant versus soil CR's exceeding 0.001 generally reflect that much of the plutonium in vegetation samples is associated with soil particles present <u>on</u> the plant surfaces rather than plutonium incorporated <u>in</u> plant tissue via root uptake. CR's exceeding 1 (see Table 11) are possible because:

Table 8 . Tritium concentrations (pCi/ℓ unbound water) in soil and vegetation from Area G perimeter sampling locations in 1985.

	Soil Depth (cm)			Vegetation	
Location	0-1	1-10	10-30	Sample 1	Sample 2
1	1200	700	-----	700	400
2	1500	2400	300	300	400
3	3900	-----	-----	100	400
4	1300	1000	-----	1100	1600
5	2300	2400	-----	[3300]	[3000]
6	[12000]	3600	1300	[6800]	[17000]
7	[35000]	[27000]	[26000]	[48000]	[22000]
8	[11000]	[7800]	[91000]	[77000]	120
9	1600	[11000]	[20000]	[13000]	[8100]
10	500	2400	[12000]	[10000]	
11	100	1000	3900	[6100]	
12	600	1200	2600	[6600]	[3500]
13	800	500	2700	[3900]	[5200]
14	800	300	200	[3900]	
15	[9000]	110	160	390	150
16	1400	1200	1000	[26000]	[2800]

[1] background concentrations in soil = 4600 pCi ^{3}H/ℓ, in vegetation = 1500 pCi ^{3}H/ℓ (Environmental Surveillance Group, 1986).

[2] boxes denote upper range of values

Table 9. Uranium concentrations (ppm) in soils and vegetation from perimeter sampling locations at Area G in 1985.

Location	Soil Depth 0-1 cm	Soil Depth 1-10 cm	Soil Depth 10-30 cm	Veg
1	4.5[1]	4.6	----	4.5
2	4.5	3.3	3.4	0
3	2.9	----	----	0
4	3.9	4.1	----	0
5	4.7	4.7	----	0
6	3.5	3.1	4.0	0
7	4.4	4.6	4.6	0
8	3.1	3.4	4.4	0
9	4.2	3.9	4.4	
10	4.3	5.2	4.6	0
11	3.8	3.9	4.2	0
12	4.7	3.9	3.5	0
13	4.2	9.0	4.3	0
14	4.4	4.7	4.0	0
15	4.7	4.3	4.4	0
16	3.7	4.4	4.3	0

[1]background total U in soil = 4.0 ± 1.0 ppm (Environmental Surveillance Group, 1986)

Table 10. Plutonium-239 concentrations (fCi/g) in soil and vegetation from perimeter sampling locations at Area G in 1985.

Location	Soil Depth 0-1 cm	Soil Depth 1-10 cm	Soil Depth 10-30 cm	Vegetation[3] Sp. 1	Vegetation[3] Sp. 2	Average Concentration Ratio[2]
1	12[1]	3.5	----	17	21	----
2	12	19	15	20		----
3	29	----	----	14	28	----
4	44	47	----	30	10	----
5	**233**[4]	**140**	----	10	7	0.04
6	44	25	66	47	6	----
7	71	75	**97**	13	9	----
8	9	11	0.5	14	18	----
9	40	70	2	15		----
10	**250**	80	4	**123**		0.49
11	74	83	9	13		----
12	**7020**	**1140**	**114**	**176**	**1040**	0.09
13	----	**1191**	**204**	**160**	**140**	----
14	**1080**	**280**	15	**100**		0.09
15	**1300**	**174**	85	**95**	**570**	0.26
16	70	30	4	**1500**	**4830**	----

[1]Average maximum background Pu-239 concentration (Environmental Surveillance Group, 1986) based on samples collected from 1978-1982:

Soil = 81 fCi ^{239}Pu/g

Vegetation = <1fCi ^{239}Pu/g

[2] $CR = \frac{\text{fCi/g vegetation}}{\text{fCi/g soil (0-1 cm depth)}}$

[3]See Table 7 for species identification

[4]boxes denote upper range of values

Table 11. Plutonium-238 concentrations (fCi/g) in soil and vegetation from periment sampling locations at Area G in 1985.

	Soil Depth			Vegetation		Average Concentration
Location	0-1 cm	1-10 cm	10-30 cm	Sp. 1[3]	Sp. 2	Ratio[2]
1	1.3[1]	0	----	2.8	2.5	----
2	7.2	3.6	6.6	20	10	----
3	7.6	-----	----	21	68	----
4	9.5	3.1	----	10	6	----
5	8.2	1.9	----	13	6	----
6	29	15	11	37	16	0.91
7	7.9	3.4	0.5	4	1	----
8	3.9	2.9	1.1	9	9	----
9	4.1	2.4	0.5	4	1	----
10	25	2.8	0.4	11	----	0.44
11	7.7	5.0	0.5	6	----	----
12	350	34	6.9	42	80	0.17
13	2030	108	14	81	970	0.44
14	702	64	5.4	1490		2.1
15	2470	1320	1910	29	72	0.02
16	53	2.2	2.6	210	220	4.1

[1]Average maximum background ^{238}Pu concentrations (Environmental Surveillance Group, 1986) based on samples collected from 1978-1982:

Soil = 6.0 fCi ^{238}Pu/g

Vegetation = <1 fCi ^{238}Pu/g

[2]$$CR = \frac{\text{fCi } ^{238}\text{Pu/g plant}}{\text{fCi } ^{238}\text{Pu/g soil (0-1 cm depth)}}$$

[3]See Table 7 for species identification

[4]boxes denote upper range of values

- the-soil particles deposited on the plant surfaces are generally very small (i.e. < 50 μm diameter), and
- the very small soil particles are enriched in plutonium by as much as a factor of 10 over coarser soil particles.

Qualitative measures of the ^{137}Cs content of perimeter soils also show the same trends with location and sampling depth as plutonium (Table 12). Cesium levels generally decreased with sampling depth and were highest in the northeast and south-central perimeter locations.

Relationships between field instrument response and the concentrations of radionuclides in soil and vegetation from the 16 perimeter locations were examined using least squares procedures. In no case was the concentration of radionuclide in soil or vegetation correlated significantly ($p \leq 0.05$) with either the phoswich or uR-meter readings at the corresponding sampling locations. The lack of significant relationships is puzzling and needs to be investigated further. Possible correlations between instrument response and specific radionuclides in environmental samples would be very useful in developing an efficient and cost effective site specific monitoring plan.

Radionuclide Transport in Sediments and Run-Off at Area G

Because soils are the major reservoir of most radionuclides in the environment, hydrologic erosion processes are important in the spatial redistribution of those nuclides deposited on the soil surface. Nine sampling stations were established in 1982, outside the perimeter fence at Area G, to monitor for the transport of radionuclides by storm runoff and associated sediments (Fig. 9). These stations are sampled annually (Environmental Surveillance Group, 1986).

The ^{137}Cs, total uranium, and gross gamma activity in channel sediments from the nine locations were near or below background levels (Table 13). In contrast, tritium was above the background of 7 pCi/ml at stations 4, 5, 6, and 8 and ranged

Table 12. Cesium-137 (net counts per minute in cesium-137 photopeak) in soil from perimeter sampling locations at Area G in 1985.

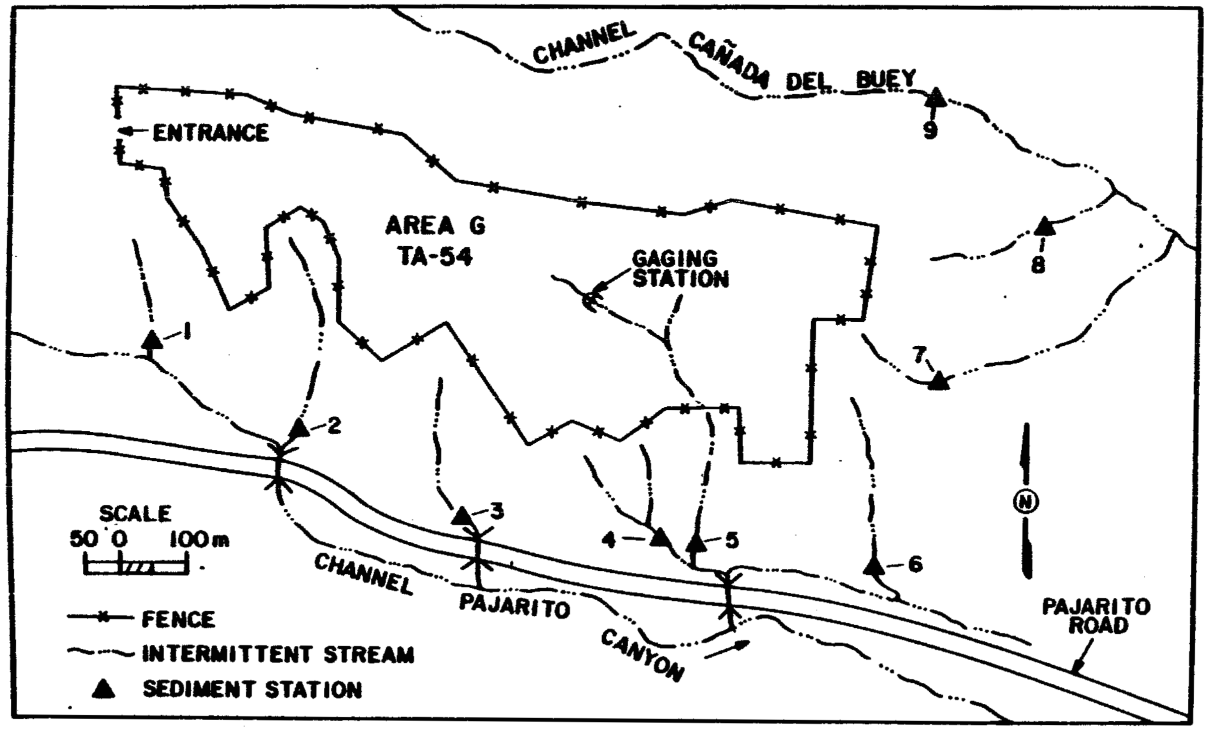
Location	Soil Depth 0-1 cm	1-10 cm	10-30 cm
1	1.1[1]	0	----
2	0	0	0.77
3	1.7	----	----
4	[3.1][2]	[2.6]	----
5	[9.8]	[3.9]	----
6	1.4	0.85	0
7	[2.34]	1.2	0.75
8	0	0	0
9	0.92	1.1	0
10	[3.2]	1.4	0
11	[2.5]	[2.7]	0
12	[3.3]	1.3	0
13	1.2	1.4	1.2
14	[3.4]	1.9	0
15	1.5	0.88	0.5
16	0.75	0	1.3

[1] net counts after subtraction of +2σ background counts under photopeak

[2] boxes denote upper range of values

Attachment 1

Figure 9. Runoff and sediment sampling locations at Area G in 1985.



Attachment 1

Table 13. Radiochemical analyses of runoff and sediments, Area G, TA-54.

Sediments (October 16, 1986)

Station	^{137}Cs (pCi/g)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	^{3}H ($10^{-6}\mu Ci/m\ell$)	Total U ($\mu g/\ell$)	Gross Gamma (counts/min/ℓ)
1	0.20±0.08	0.000±0.001	0.016±0.003	4.8±0.6	2.0±0.2	2.4±0.4
2	0.25±0.10	0.003±0.001	0.007±0.002	3.5±0.5	2.6±0.3	4.4±0.5
3	0.23±0.08	0.000±0.001	0.009±0.002	2.9±0.5	2.4±0.2	3.4±0.4
4	0.10±0.07	*0.008±0.002	0.012±0.002	*27 ±3.0	3.2±0.3	6.4±0.7
5	0.23±0.08	0.003±0.001	0.008±0.002	*11 ±1.0	*4.1±0.4	6.1±0.7
6	0.22±0.08	*0.021±0.003	*0.319±0.016	*9.0±1.0	3.4±0.3	4.0±0.5
7	0.15±0.08	*0.061±0.006	*0.165±0.011	7.4±0.9	2.6±0.3	4.4±0.5
8	0.32±0.10	0.005±0.003	0.007±0.003	25±3.0	2.8±0.3	4.6±0.5
9	0.08±0.07	*0.011±0.006	0.014±0.002	3.4±0.5	2.4±0.2	3.1±0.4
Background (1978-1985)[a]	1.18	0.005	0.036	7.1	3.5	7.1
Limits of Detection	0.1	0.003	0.002	0.7	0.03	0.1

Runoff at Area G Gaging Station

	Solution						Suspended Sediments	
Date	^{137}Cs ($10^{-9}\mu Ci/m\ell$)	^{238}Pu ($10^{-9}\mu Ci/m\ell$)	$^{239,240}Pu$ ($10^{-9}\mu Ci/m\ell$)	^{3}H ($10^{-6}\mu Ci/m\ell$)	Total U ($\mu g/\ell$)	Gross Gamma (counts/minℓ)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)
4-30-85	66±65	0.004±0.010	0.013±0.010	0.4±0.4	0.3±0.5	-30±60		
6-25-85	21±40	0.008±0.008	0.004±0.007	-0.5±0.4	-0.7±0.5	-30±60	*0.236±0.010	0.063±0.004
7-30-85	77±41	0.013±0.018	0.009±0.012	-0.8±0.4	0.0±0.5	-140±60	*0.270±0.017	0.099±0.009
8- 1-85	--	0.005±0.010	0.016±0.012	-1.5±0.4	---	-40±60	*0.181±0.013	0.123±0.010
8- 6-85	--	*0.035±0.015	0.016±0.009	-1.0±0.4	---	----	0.004±0.008	-0.004±0.008
Background	200[b]	0.027[c]	0.082[c]	5.8[b]	3.5[c]	200[b]	0.042[c]	0.138[c]
Limit of Detection	40	0.009	0.03	0.7	1	50	0.003	0.002

[a] background soil analyses (Gladney, 1986).
[b] from the Rio Grande, Rio Chama, and Jemez River.
[c] from Rio Grande above Otowi, 1985 (solution and suspended sediments).

Attachment 1

from 9.0 to 27 pCi/ml unbound water. Plutonium-238 concentrations exceeded the background of 0.005 pCi/g at stations 6, 7, and 9, ranging from 0.011 to 0.061 pCi/g. Plutonium-239,240 concentrations in sediment exceeded the background 0.036 pCi/g at stations 6 and 7 by a factor of 5 and 10, respectively. The source of elevated plutonium in sediment samples appears to be the east and northeast end of Area G. Elevated tritium concentrations in sediments was primarily associated with south-central perimeter locations.

Five samples of runoff were collected at the gaging station in the center of Area G during 1985 (Fig. 9). The samples were analyzed for several radioactive constituents in solution and for plutonium in suspended sediments (Table 13). Radioactivity in solution was defined as filtrate passing through a 0.45 m pore-size filter, whereas the radioactivity in the sediments was defined as the residue on the filter.

The ^{137}Cs, total uranium, tritium, and gross gamma content of runoff water was below background levels (Table 13). Of the five runoff events sampled, only one (on 8-6-85) contained ^{238}Pu in solution above background while all of the $^{239,240}Pu$ concentrations in solution were below the background of 0.082×10^{-9} Ci/ml. The ^{238}Pu concentrations in suspended sediments ranged from 0.181 to 0.270 pCi/g compared to the background of 0.042 pCi/g. All $^{239,240}Pu$ concentrations were below the background of 0.138 pCi/g. Plutonium was not detectable in sediments collected at State Road 4 in Canada del Buey or in Pajarito Canyon at the east boundary of the Laboratory.

<u>Summary of Area G Results</u>

All of the data collected during the field survey at Area G, in 1985, point to 3 general source areas within the site as contributing radionuclides to air, soil, sediments, and vegetation samples collected at the perimeter of the site. Those areas are the:

- north-central area (elevated TLD's, radionuclides in air, soil and vegetation),
- the northeast and east area (elevated phoswich, TLD's, and radionuclides in air, soil and vegetation), and
- the south-central area (elevated phoswich, uR, TLD's, and radionuclides in air, soil and vegetation).

Results From Area C

A site map of Area C (Fig. 10) indicates the presence of 7 major pits (one for chemical waste) and a large number of disposal shafts. The drainage from the site is to Ten-Site Canyon on the north-east and to Pajarito Canyon on the south.

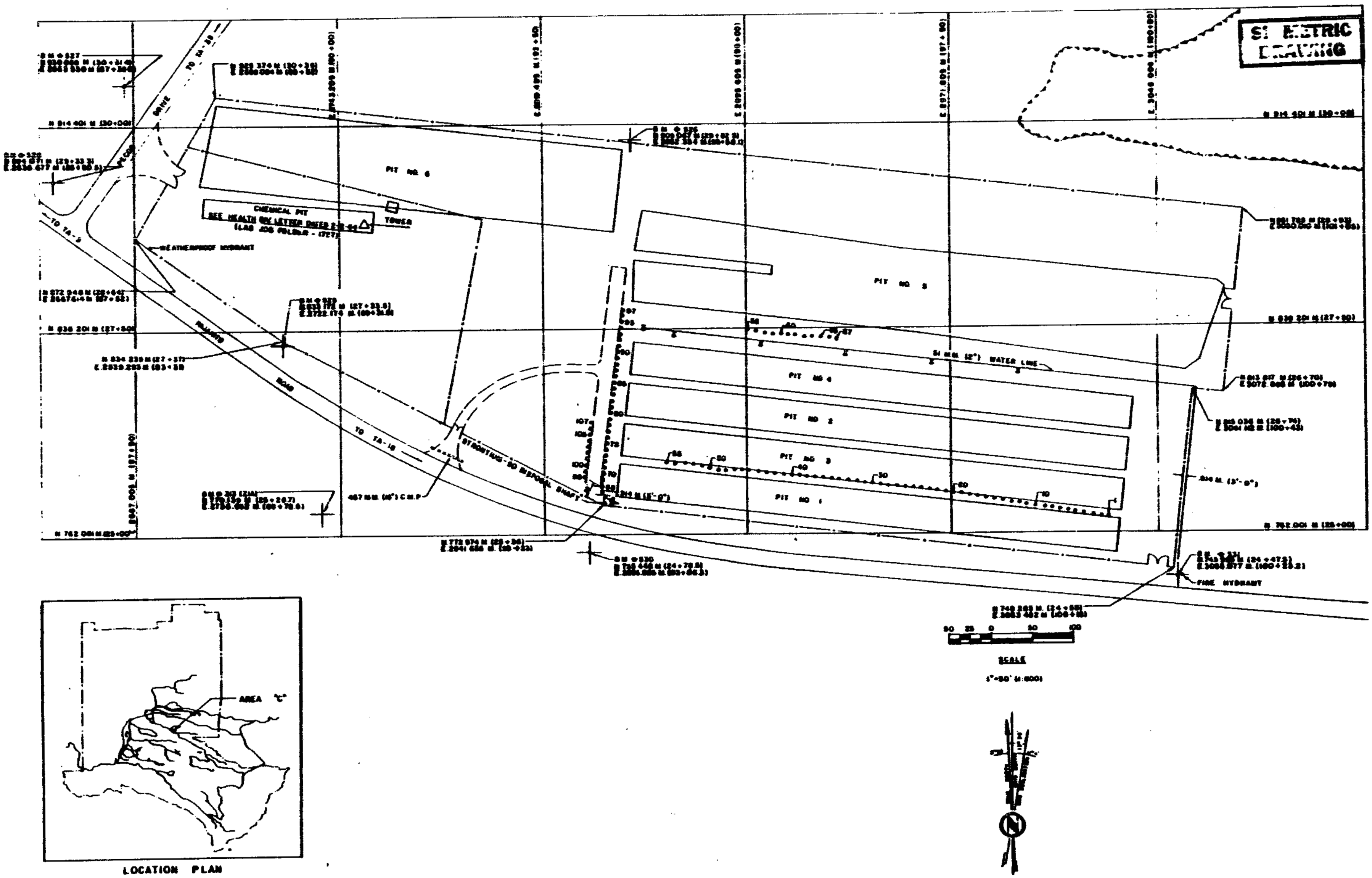
Radiation Monitoring

Annual radiation doses from external penetrating radiation, as measured with thermoluminescent dosimeters at 18 locations (Fig. 11) at Area C, were all at background levels of about 125 mrem/year (Table 14). The maximum and mean annual doses measured in 1985 were 124 mrem and 118 mrem, respectively, compared to an annual maximum and mean dose of 146 mrem and 131 mrem in 1984. While the variability in annual radiation dose is relatively large, the slight apparent reduction in dose in 1985 may be due to the addition of a new cover over the site during late 1984. In any event, significant radiation source areas within Area C, that could contribute to external radiation doses, were not identifiable with the TLD monitoring array.

Raw count data from the Phoswich and HPIC field instrument surveys are presented in Figs. A1 and A2. A three dimensional plot of those data are presented in Figs. 12 and 13 and the kriged contour maps in Figs. 14 and 15.

Phoswich data (Fig. 12) which primarily reflect low energy x- and gamma-ray sources, are indicative of background conditions over most of the site. Recall that a major renovation of the surface cover at Area C was completed in 1984. A few

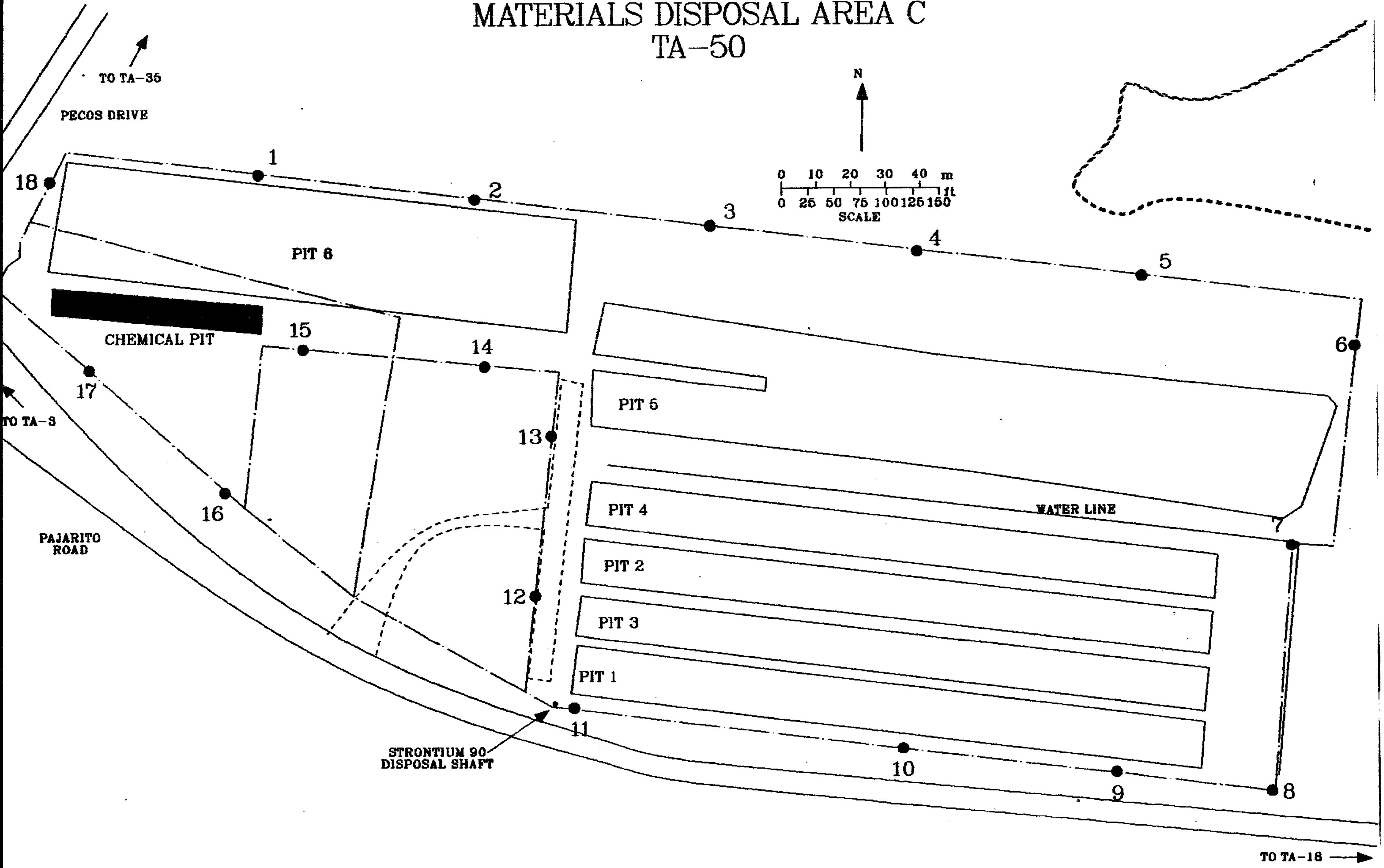
Figure 10. Inactive materials disposal Area C showing perimeter fence and trench layout in 1985.



Attachment 1

Figure 11. Thermoluminescent dosimeter sampling network at Area C in 1985.

MATERIALS DISPOSAL AREA C
TA–50

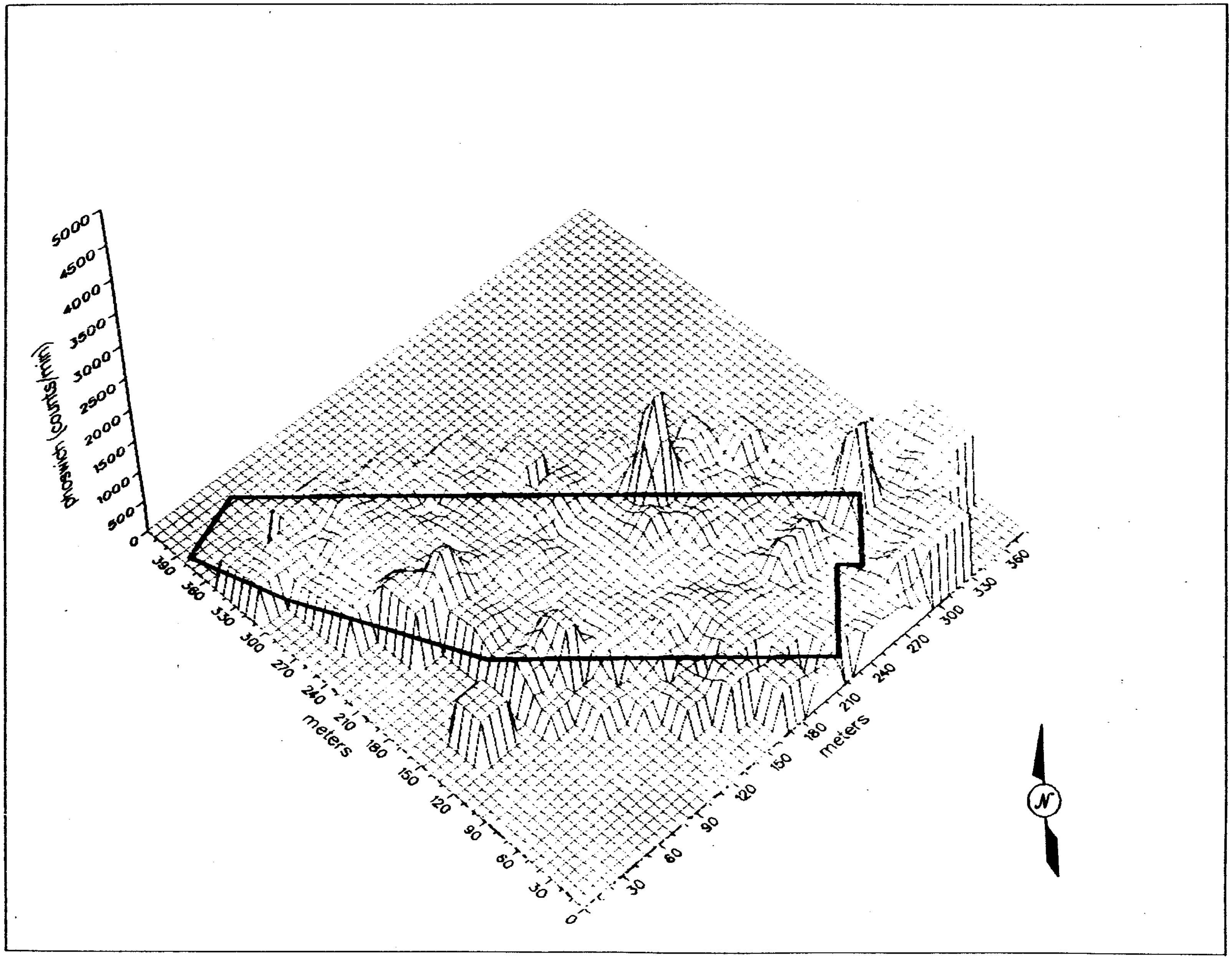


Attachment 1

Table 14. Annual external penetrating radiation doses at Area C during 1985 as measured by thermoluminescent dosimeters.

Sampling Location	Dose (mrem)
1	113
2	121
3	120
4	124
5	123
6	112
7	119
8	116
9	117
10	121
11	117
12	113
13	120
14	118
15	108
16	110
17	117
18	118
	108 minimum
	124 maximum
	118 mean

Figure 12. Three dimensional representation of the phoswich count data obtained from Area C in 1985.



Attachment 1

Figure 13. Three dimensional representation of the high pressure ionization chamber rates obtained at Area C in 1985.

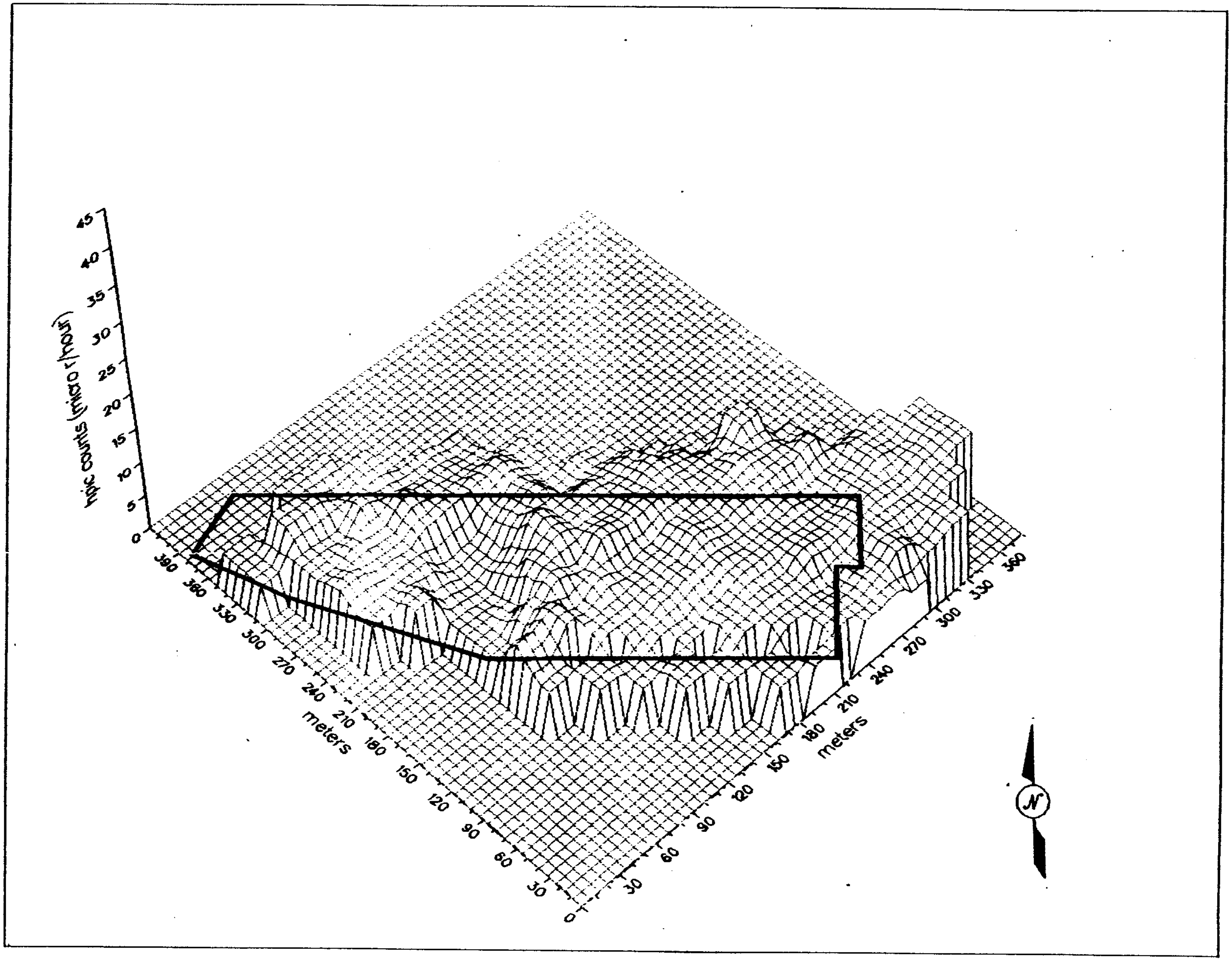
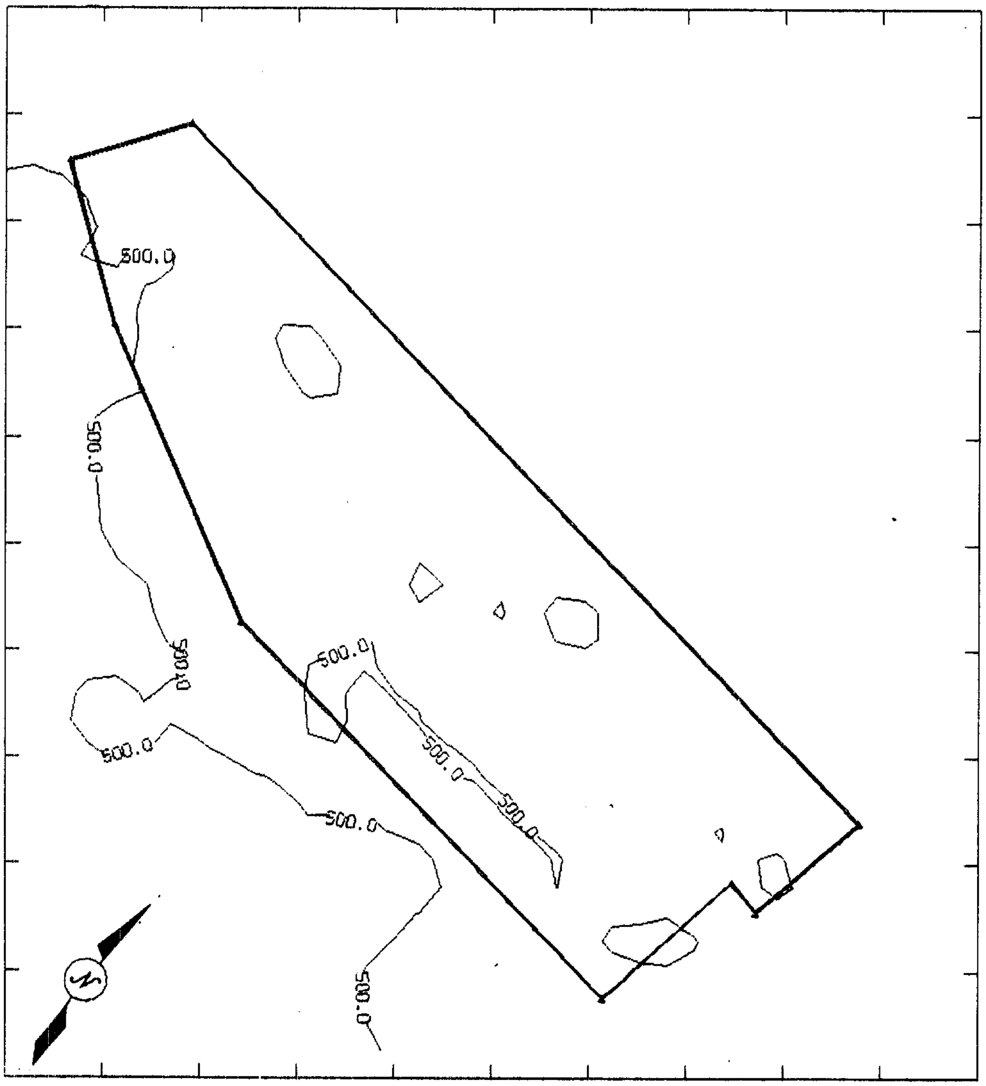

hpic counts (micro r/hour)
0
5
10
15
20
25
30
35
40
45
meters
0
30
60
90
120
150
180
210
240
270
300
330
360
390
meters
30
60
90
120
150
180
210
240
270
300
330
360
N

Figure 14. Kriging contour map of the phoswich count data obtained from Area C in 1985.

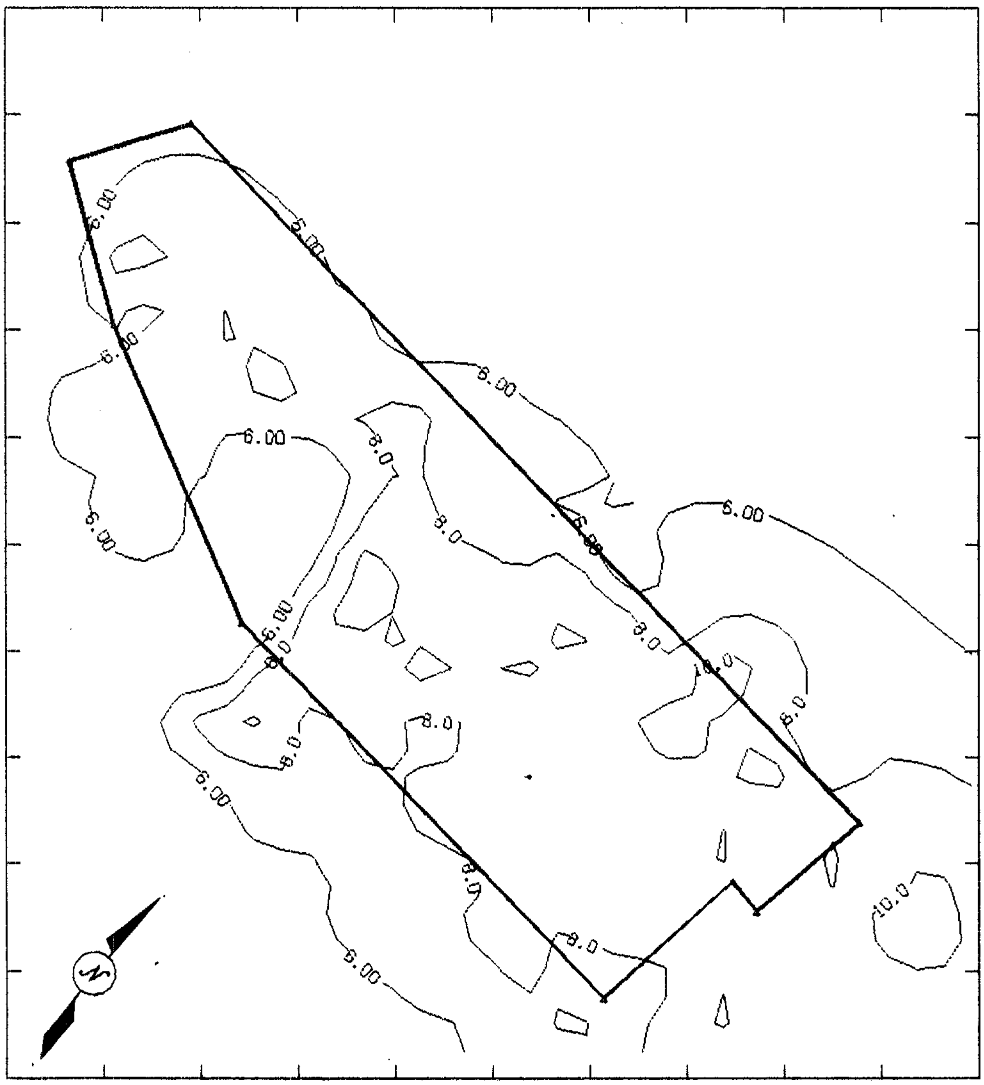
AREA C PLOT FOR PHOSWICH COUNTS



CONTOUR FROM 500.00 TO 3500.0 CONTOUR INTERVAL OF 1000.0
X INTERVAL= 38.000 Y INTERVAL= 42.000

Figure 15. Kriging contour map of the high pressure ionization chamber data obtained at Area C in 1985.

AREA C PLØT FØR HPIC



CØNTØUR FRØM 6.0000 TØ 12.000 CØNTØUR INTERVAL ØF 2.0000
X INTERVAL= 38.000 Y INTERVAL= 42.000

measurements exceeded the background of about 500 counts/200 sec particularly in the north and east perimeter locations outside of the area receiving the new cover in 1984 (Fig. 12). Drainage from the east half of Area C is to the northeast into Ten-Site Canyon.

The high pressure ionization chamber (HPIC) data (Fig. A-2 and 13) also identify the northeast quadrant both within and outside the perimeter fence, as a low-strength source of gamma emitting radionuclides. However, the relative increase in the dose rate in that quadrant was, at most, a few percent.

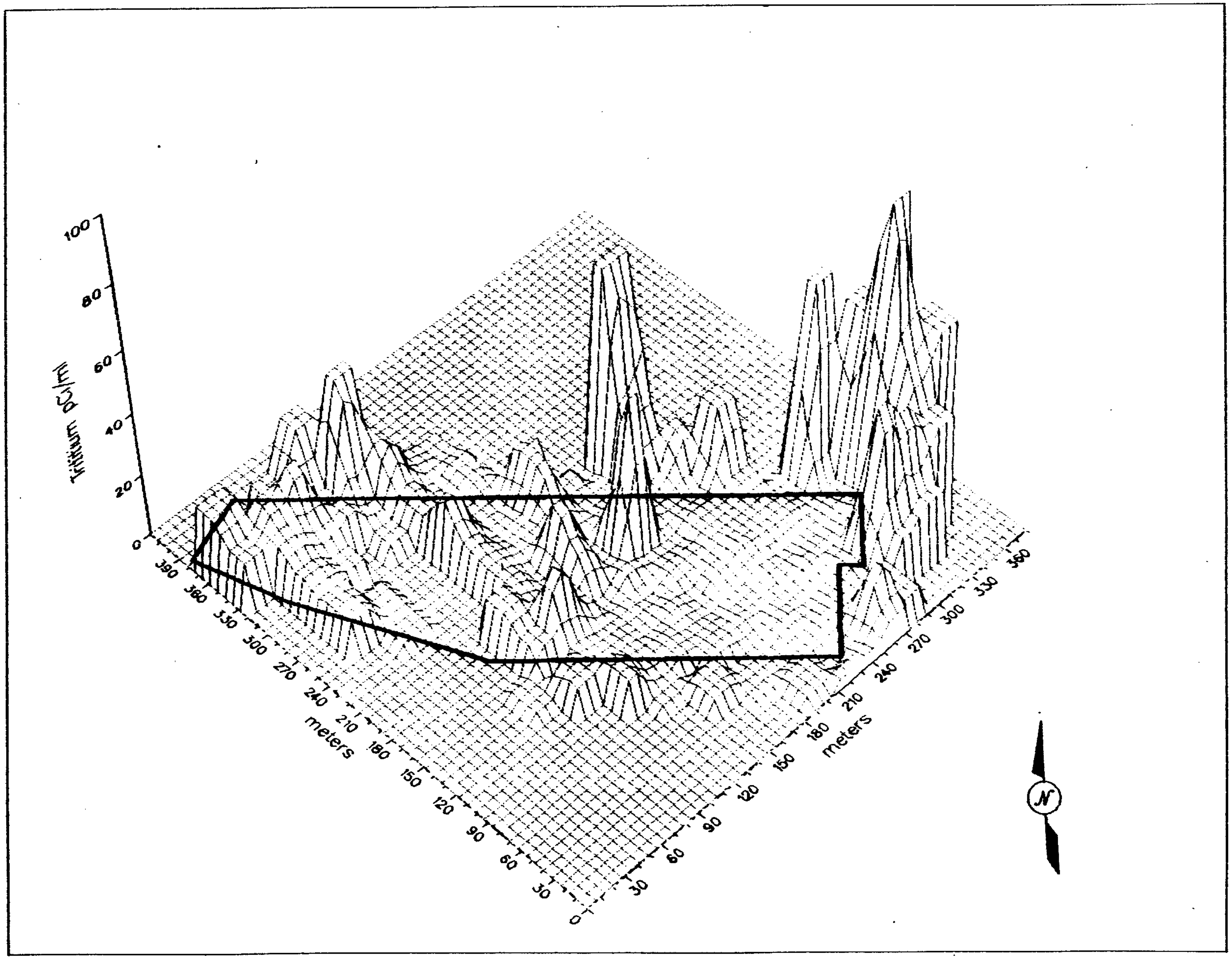
The contour maps (Figs. 14 and 15), generated with the kriging procedure, provide further definition of the distribution of count data over the site. Note that the phoswich survey (Fig. 14) identified discrete x- or gamma-ray sources at the west and east end of pit 5, in the general area of shaft numbers 1-55. The contour map of the HPIC data suggest that dose rates over the eastern half of the site average slightly higher than those measured over the western half.

Radionuclides in Soils

Concentrations of tritium, plutonium-239,240, plutonium-238, and total uranium in two soil profiles are summarized in Figs. A3 through A9. Three-dimensional plots of the data for the 0-1 cm depth profile appear in Figs. 16-19 and the kriged data in Figs. 20-22 (exclusive of uranium).

Tritium concentrations in soil water were at or below the average background of about 4 pCi/ml in about half of the samples and exceeded the average background in the remaining samples (Figs. A3 and A4). Samples from the east half of the site, were consistently low in tritium, while samples from the north and east perimeter and the west third of the site exceeded background (Fig. 16). A discrete source of tritium appears to be located on the west end of pit 5 with lesser sources on the west end of pits 2 and 4 and/or the disposal shafts associated with this area. Another peak was measured over pit 6 in the northwest portion of the site. In many

Figure 16. Three dimensional plot of the tritium (pCi/ml) concentrations in the 0-1 cm soil profile at Area C in 1985.



Attachment 1

cases, tritium levels in soil water samples increased with sampling depth (Figs. A3 and A4) suggesting that the tritium was emanating upward from a subsurface source.

The $^{239,240}Pu$ and ^{238}Pu concentrations in soil samples (Figs. A5-A8) generally show the same patterns as those observed for tritium in soil water [compare Fig. 16 with Figs. 17 and A7 (for Pu-238)]. Low level contamination of perimeter soils (up to 10 pCi $^{239,240}Pu/g$ and 30 pCi $^{238}Pu/g$) is widespread on the north and east sides of Area C (Figs. A6 and A7). Relatively few of the concentrations in samples from within the site exceeded the background of about 0.1 pCi $^{239,240}Pu/g$ and < 0.01 pCi $^{238}Pu/g$. However, concentrations exceeding background (Figs. A6 and A7) were found on the west end of pits 2, 4, and 5 (and the associated disposal shafts) in areas corresponding to those where elevated tritium levels were observed (Fig. 16) in soil water samples.

Concentrations of plutonium generally decreased with sampling depth (compare Fig. A5 with A6 and A7 with A8) although there were some cases where this pattern was reversed. The processes leading to the presence of plutonium on and near the surface of Area C have not been identified at this time but could include the mechanical disturbance associated with the remedial action in 1984 as well as environmental factors.

The total uranium content of the 0-1 cm soil profile are presented in Figs. A8 and 19. Concentrations in soils from within the site boundary and most perimeter locations were all less than the 4 ppm background level. However, a very few samples on the north and east perimeter of the site measured up to about 17 ppm.

The contour maps, based on the kriging procedure, identify several discrete source areas for tritium (Fig. 20) and only one or, perhaps, two for both isotopes of plutonium (Figs. 21 and 22). Within the site boundary, the discrete sources of tritium appear to be located on the west end of pits 1, 5, and 6 with more diffuse, but elevated levels across the west half of the site (Fig. 20). A discrete source of

Figure 17. Three dimensional plot of the plutonium ^{239,240} concentration (pCi/g) in the 0-1 cm soil profile at Area C in 1985.

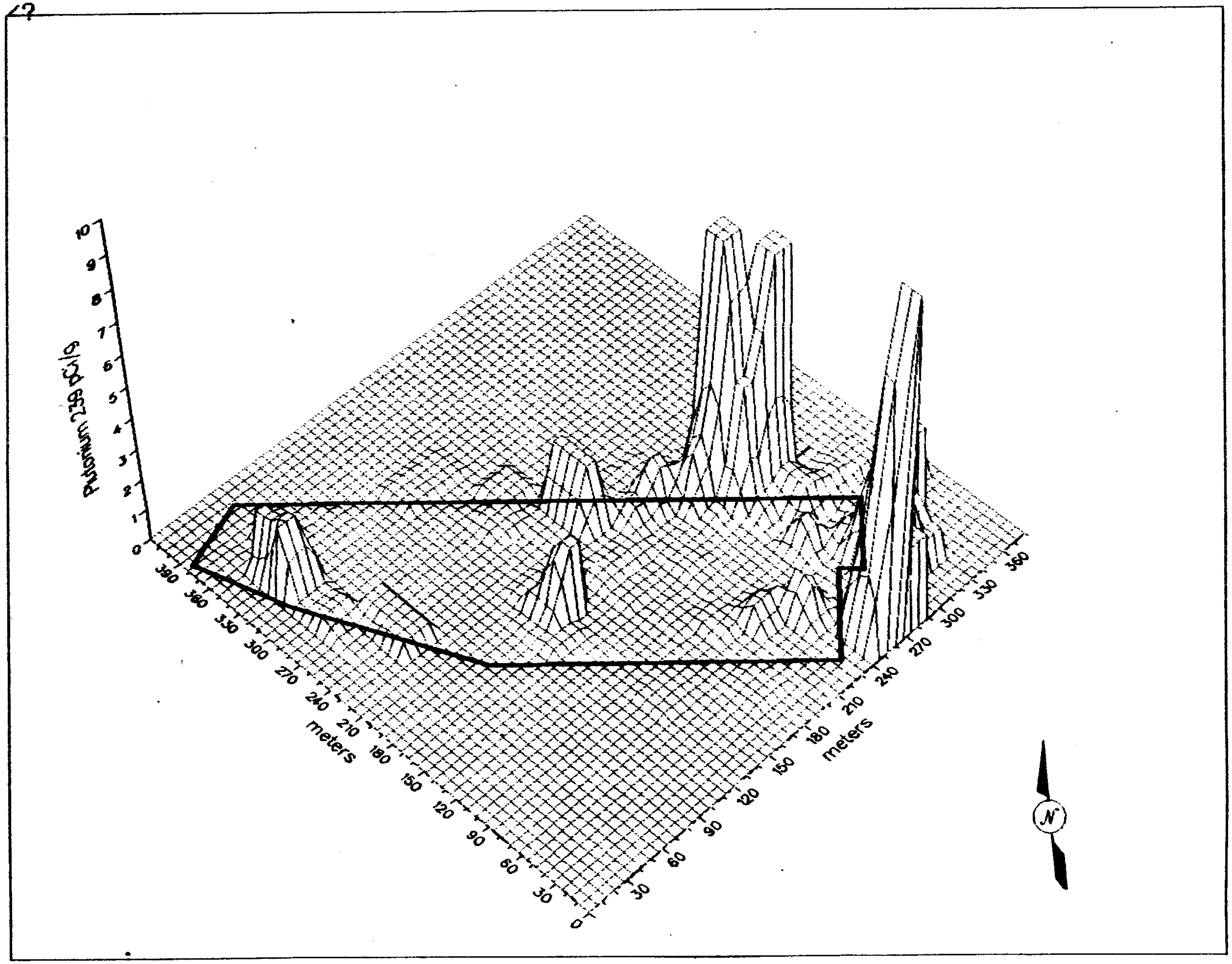
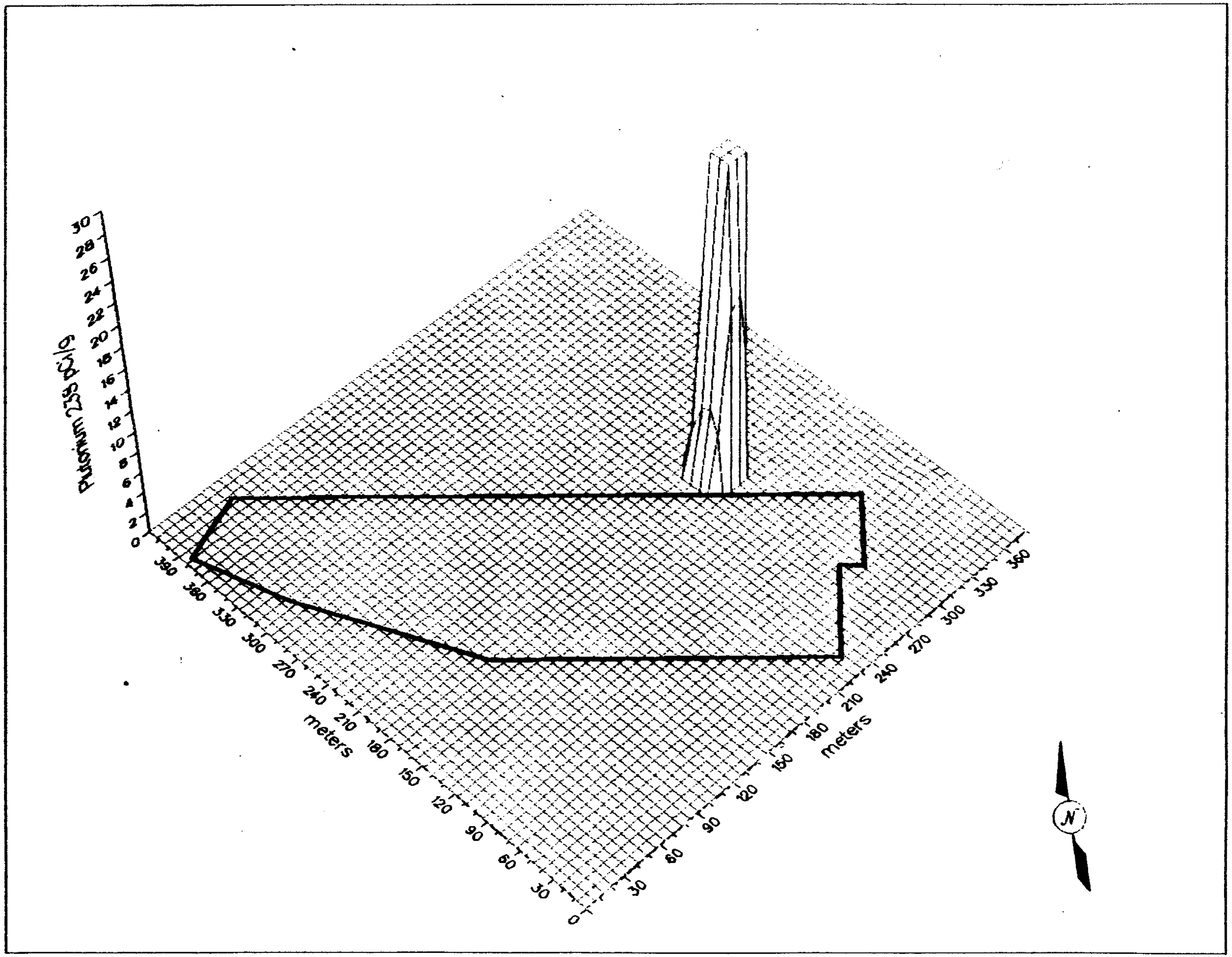

Plutonium 239 pCi/g
0
1
2
3
4
5
6
7
8
9
10
meters
meters
0
30
60
90
120
150
180
210
240
270
300
330
360
390

Figure 18. Three dimensional plot of the plutonium-238 concentrations (pCi/g) in the 0-1 cm soil profile at Area C in 1985.



Attachment 1

Figure 19. Three dimensional plot of the uranium concentrations (ppm) in the 0-1 cm soil profile at Area C in 1985.

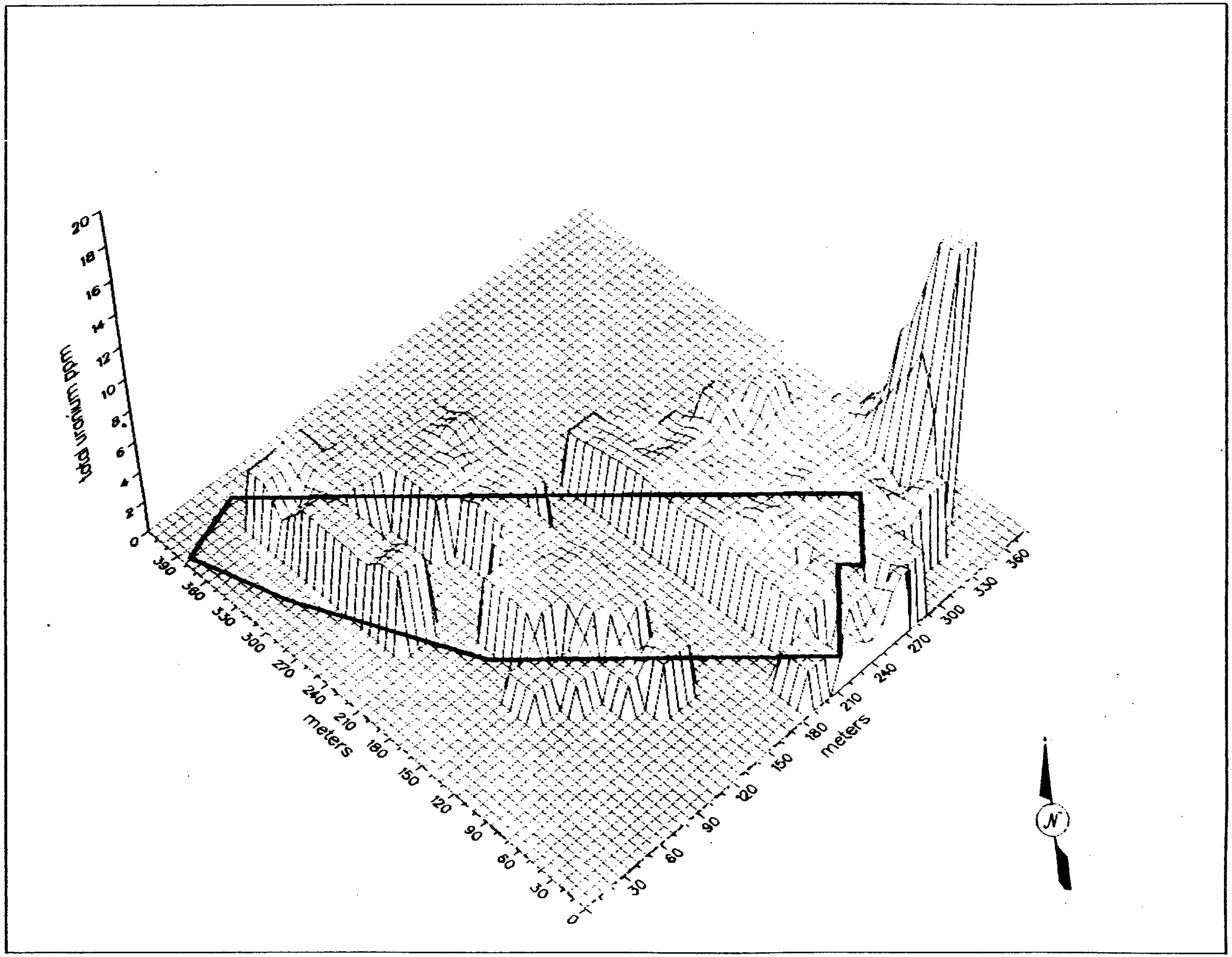
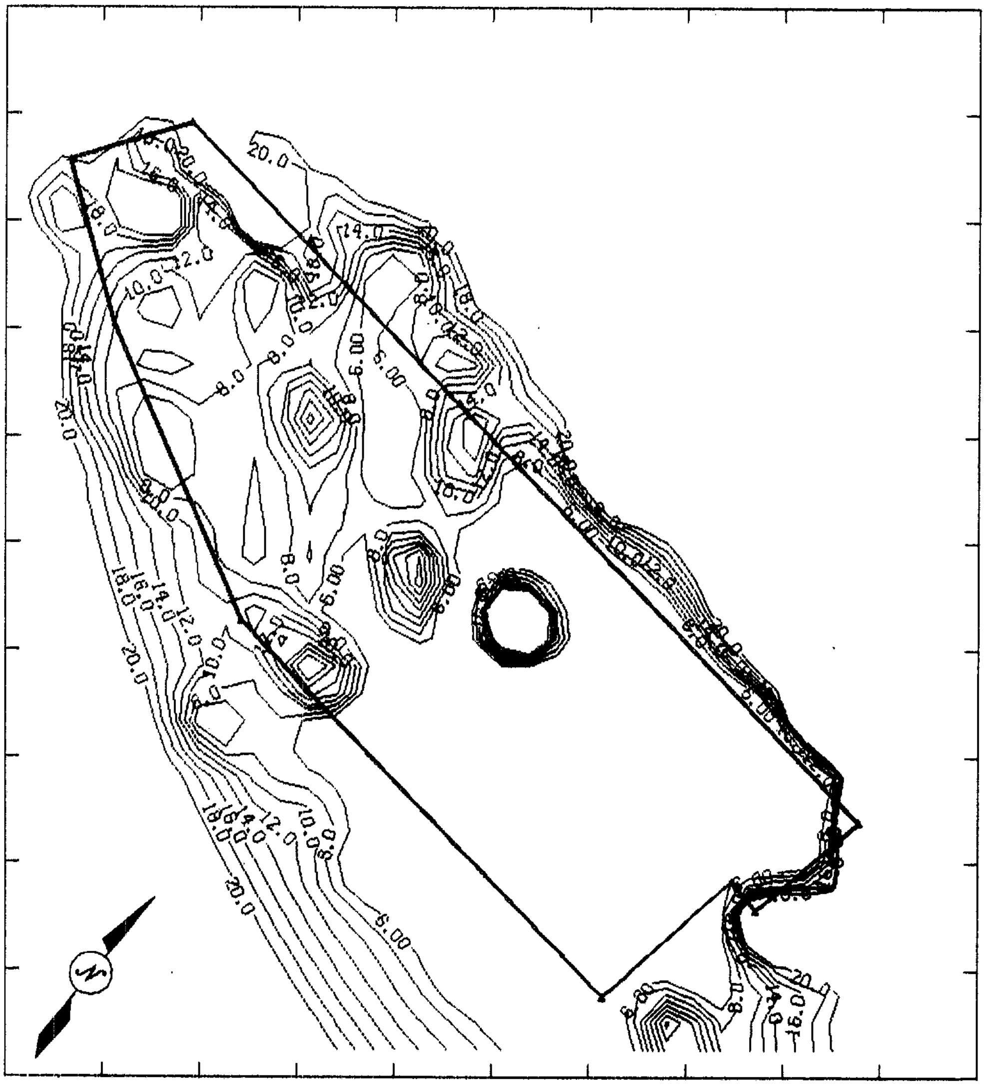

total uranium ppm
0
2
4
6
8
10
12
14
16
18
20
meters
390
360
330
300
270
240
210
180
150
120
90
60
30
0
meters
30
60
90
120
150
180
210
240
270
300
330
360
N

Figure 20. Kriging contour map of the tritium concentrations in the 0-1 cm soil profile at Area C in 1985.

AREA C PLØT FØR TRITIUM

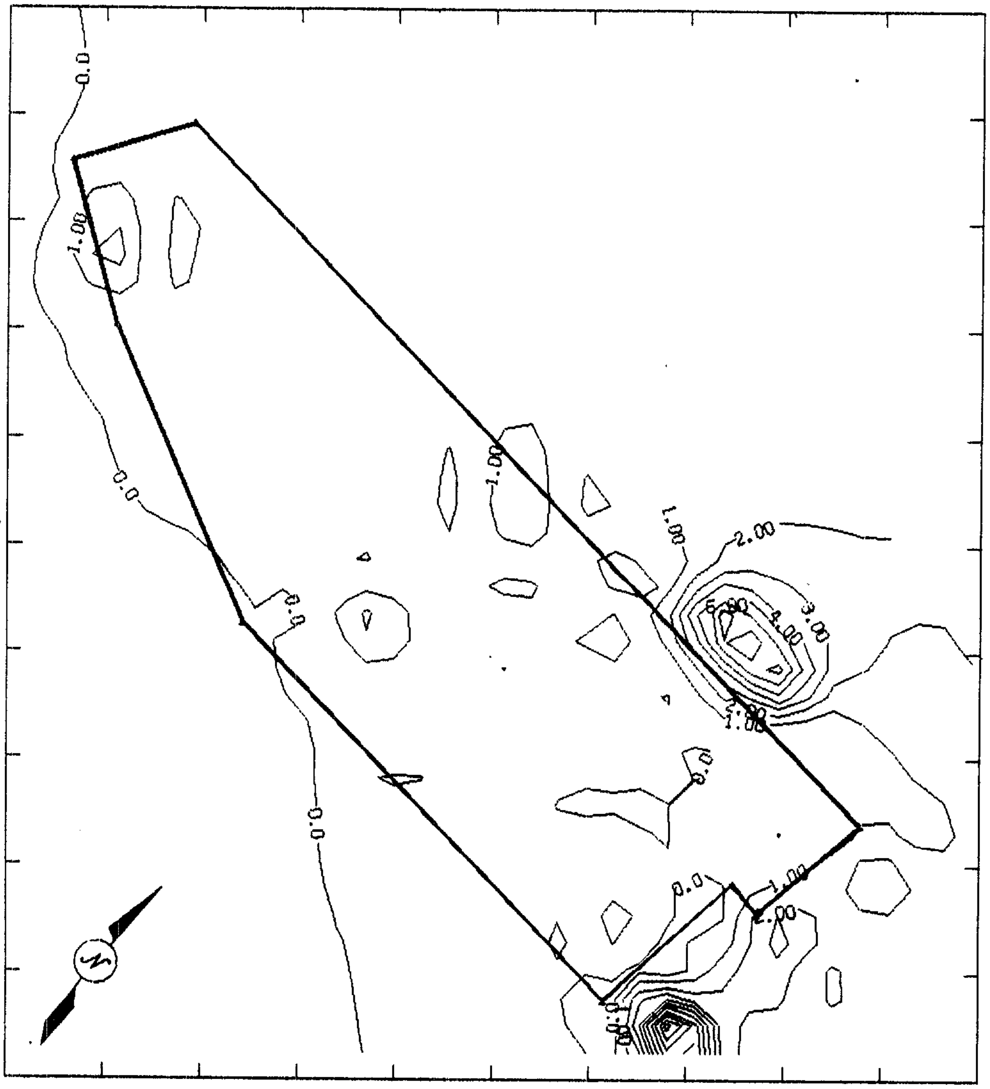


CØNTØUR FRØM 6.0000 TØ 20.000 CØNTØUR INTERVAL ØF 2.0000
X INTERVAL= 38.000 Y INTERVAL= 42.000

Attachment 1

Figure 21. Kriging contour map of the plutonium ^{239,240} concentrations in the 0-1 cm soil profile at Area C in 1985.

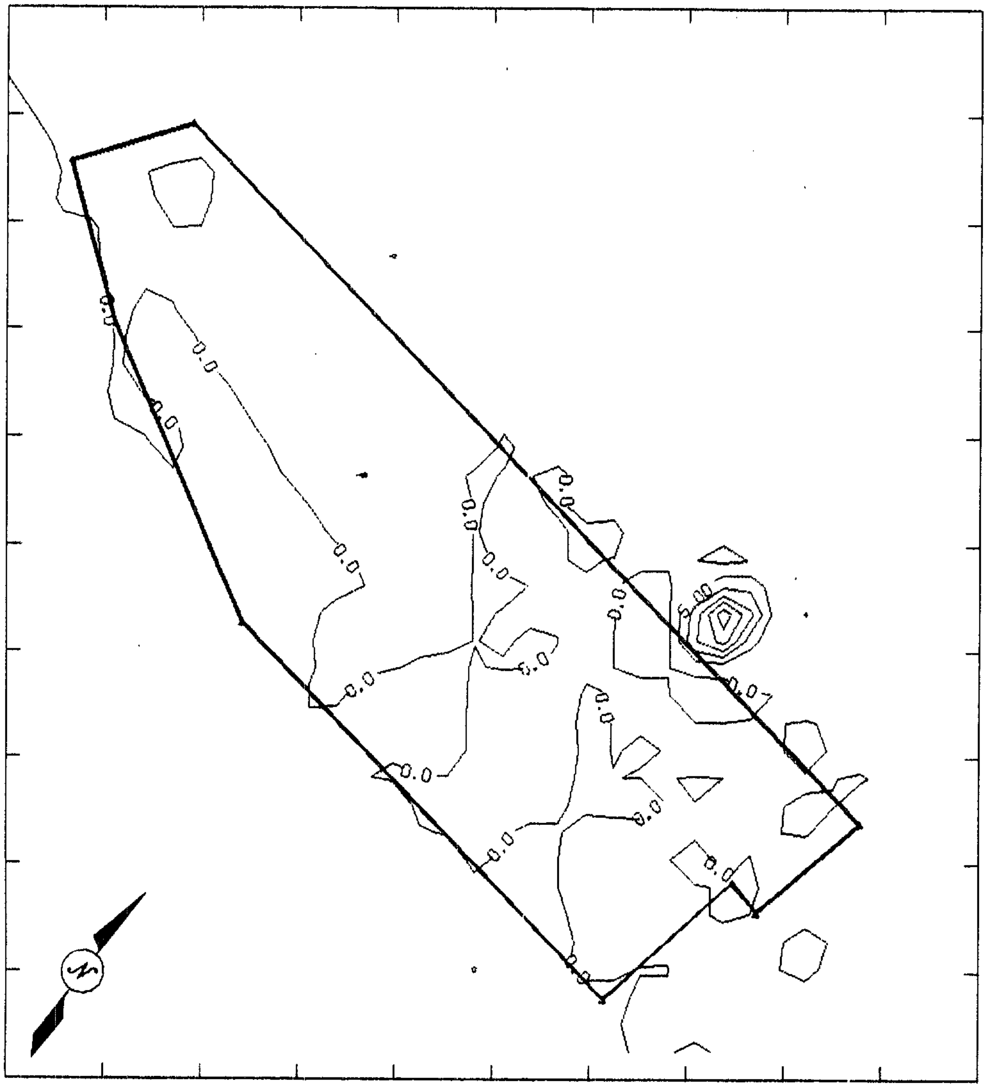
AREA C PLOT FOR PU239



CONTOUR FROM 0.00000E+00 TO 10.000 CONTOUR INTERVAL OF 1.0000
X INTERVAL= 38.000 Y INTERVAL= 42.000

Figure 22. Kriging contour map of the plutonium-238 concentrations in the 0-1 cm soil profile at Area C in 1985.

AREA C PLØT FØR PU238



CØNTØUR FRØM 0.00000E+00 TØ 30.000 CØNTØUR INTERVAL ØF 5.0000
X INTERVAL= 38.000 Y INTERVAL= 42.000

Attachment 1

both plutonium isotopes was identified on the north-east perimeter (Figs. 21 and 22), and in the case of $^{239,240}Pu$, on the south east perimeter of the site. Plutonium concentration patterns within the site are less discernable, but generally follow the that observed for tritium.

SUMMARY OF AREA C DATA

Measurements at 18 perimeter locations demonstrated that significant penetrating radiation sources were not identifiable with the thermoluminscent dosimeter monitoring array. There did appear to be about a 15% reduction in annual average radiation dose between 1984 and 1985, possibly due to the addition of a new cover over the site in late 1984.

Field instrument and radionuclide concentration data for soils identified a consistent pattern of low level contamination across Area C, independent of the radionuclide measured. For example, slightly elevated concentrations of tritium, $^{239,240}Pu$, ^{238}Pu and uranium were found in soils on the north and east perimeter of the site in an area that was undisturbed by the remedial action implemented in 1984. Within the site boundary, radionuclide levels in excess of background were usually associated with the west ends of pits 2, 4, 5 and 6 and/or the associated disposal shafts.

Attempts to correlate field instrument measurements with the concentrations of specific radionuclides, using only the data that exceeding background for soil, were unsuccessful. Correlation coefficients from least squares regressions of field instrument data versus radionuclide concentrations were all non-significant ($p<0.05$). The lack of relationships between the phoswich and plutonium concentration data cannot be explained at this time. The presumption made in making the phoswich measurements is that they provide a relatively rapid and inexpensive method of detecting alpha contamination (i.e. x-rays) on the ground surface. The general problem of correlating field instrument and concentration data is currently under investigation.

Of the radionuclides measured, tritium has the greatest potential for migration out of Area C. Tritium in soil water is subject to evaporation and plant transpiration to the atmosphere. At Los Alamos at least 75% of the precipitation that falls on the land surfaces is returned to the atmosphere by evapotranspiration. Tritium can also be removed from the site by surface runoff and by lateral and downward flow in subsurface soils. In contrast, plutonium and uranium transport from the Area C environs is very likely dominated by hydrologic erosion of contaminated cover soils.

DOSE ASSESSMENT

While the monitoring data from Areas C and G indicate the presence of radionuclides on and near the ground surface, both within and outside the perimeter fence, the levels measured are low. Dose estimates to members of the public, based on the monitoring data from the waste sites and general Laboratory area, were made for 1985 and are reported in the annual Environmental Surveillance Report (1986).

Based upon the inhalation pathway and the air monitoring data from Area G, the maximum 50 year dose committment relative to the DOE Radiation Protection Standard for the public, is less than 0.45 mrem/yr to the bone surface. That dose is 0.6% of the DOE's protection standard of 75 mrem/yr to any organ by the inhalation pathway. It also represents the worst case dose based on all possible pathways.

Possible ingestion doses resulting from Laboratory (and waste) operations were estimated to be less than 0.1% of the DOE's 100 mrem/yr Radiation Protection Standard, which applies to all pathways, including ingestion (Environmental Surveillance Group, 1986). There is currently no evidence of any radionuclides in drinking water that could be attributed to Laboratory (and waste) operations.

Doses from penetrating radiation from waste operations are also similarly small as measured with the HPIC and thermoluminescent dosimeters especially considering the distances separating the waste sites from the general public.

ACKNOWLEDGEMENTS

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REFERENCES

1. Ahlquist, J. and L. Fritz. 1986. Draft report on use history of low level radioactive waste sites at Los Alamos, Los Alamos National Laboratory report (in preparation).

2. Barnes, F. J., J. C. Rodgers, T. Foxx and G. Tierney. 1985. Designing stable vegetative cover systems for shallow land burial of hazardous waste, Los Alamos National Laboratory report, LA-UR-84-3090.

3. Environmental Surveillance Group, 1986. Environmental surveillance at Los Alamos during 1985, Los Alamos National Laboratory report, LA-10721-ENV.

4. Hakonson, T. E., R. L. Watters and W. C. Hanson. 1981. The transport of plutonium in terrestrial ecosystems, Health Phys. 40:63-69.

5. Journel, A. G. and Ch. J. Huijbregts. 1978. Mining geostatistics, Academic Press, New York, NY, 600 pp.

6. Nyhan, J. W., B. J. Drennon, W. V. Abeele, M. L. Wheeler, W. D. Purtymun, G. Trujillo, W. J. Herrera and J. W. Booth. 1985. Distribution of plutonium and americium beneath a 33-year-old liquid waste disposal site at Los Alamos, New Mexico, J. Environ. Qual. 14:501-509.

7. Purtymun, W. D. and W. R. Kennedy. 1966. Distribution of moisture and radioactivity in the soil and tuff at the contaminated waste pit near Technical Areas 21, Los Alamos, New Mexico, U. S. Geological Survey open file report.

8. Rogers, M. A. 1977. History and environmental setting of LASL near-surface land disposal facilities for radioactive wastes (Areas A, B, C, D, E, F, G and T), Los Alamos National Laboratory report, LA-6848-MS, Vol. I.

9. Skrivan, J. A. and M. R. Karlinger. 1980. Semi-variogram estimation and universal kriging program, U. S. Geol. Survey, Computer Contribution, Tacoma, Wash., 998 pp.

APPENDIX A

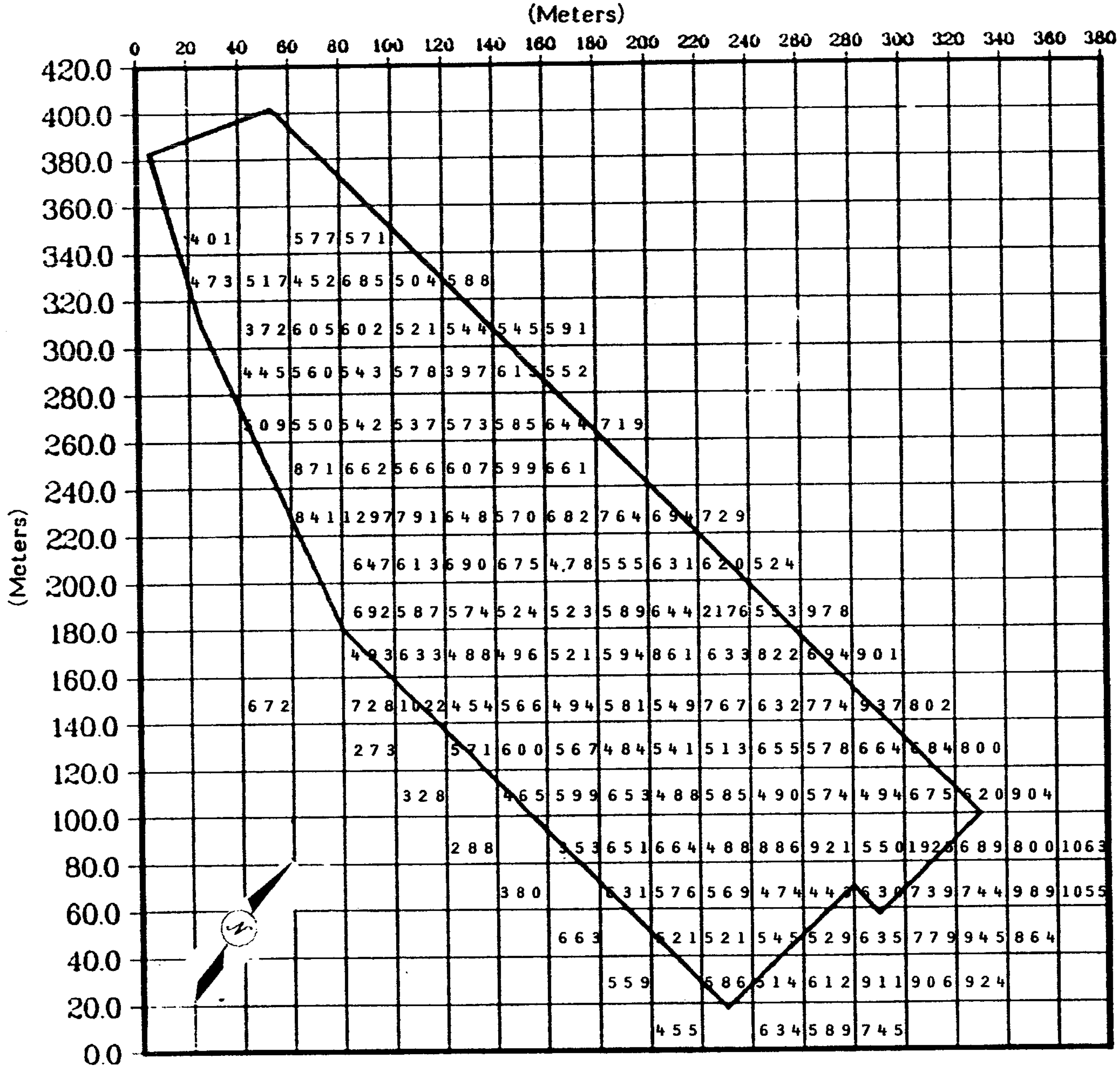

Figure A-1. Phoswich counts 200 sec (uncorrected for background of about 500 counts/ 200 sec) on sampling grid at Area C in 1985.

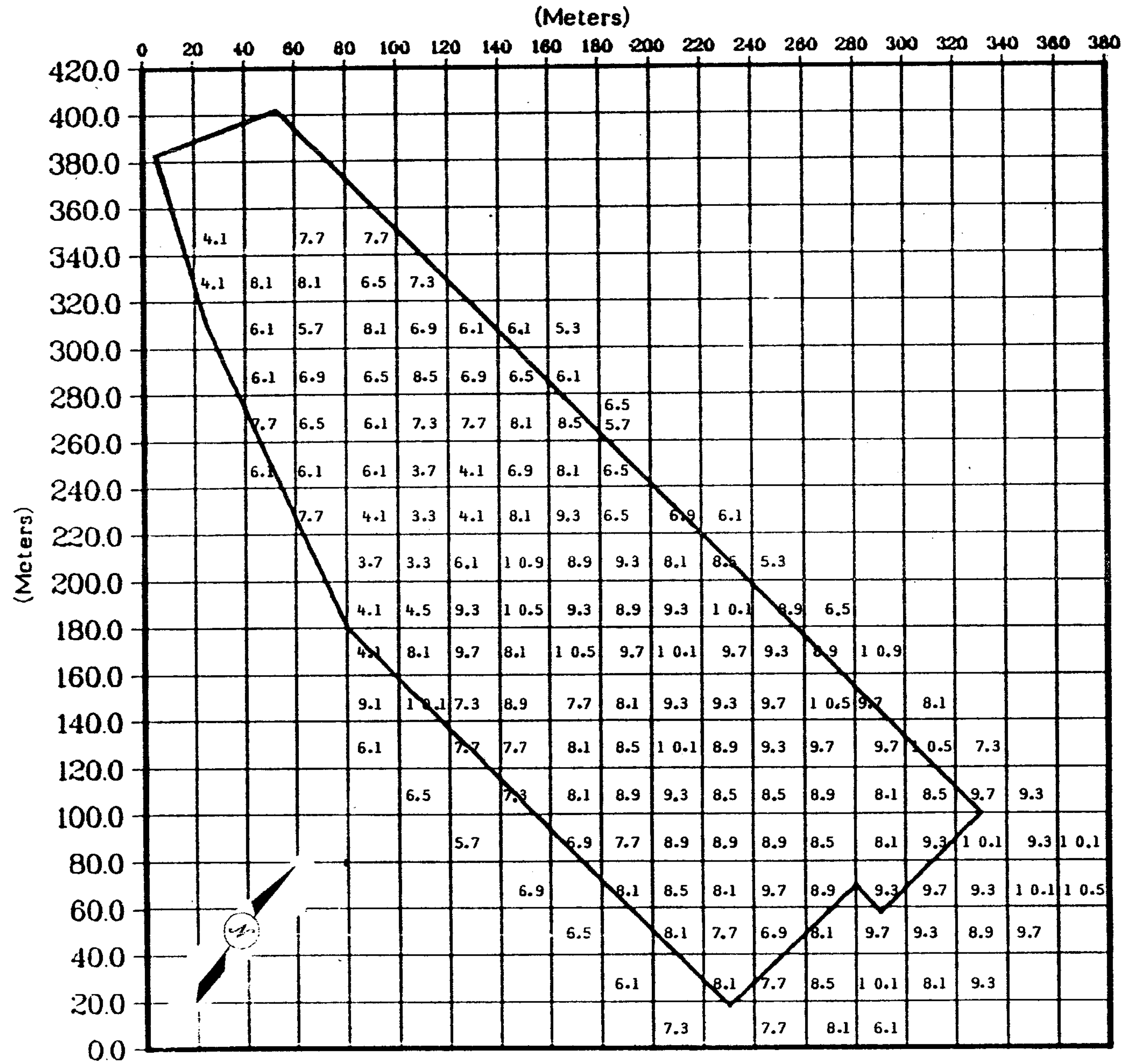

Figure A-2. HPIC dose rates (μr/hr) (uncorrected for background) on sampling grid at Area C in 1985.

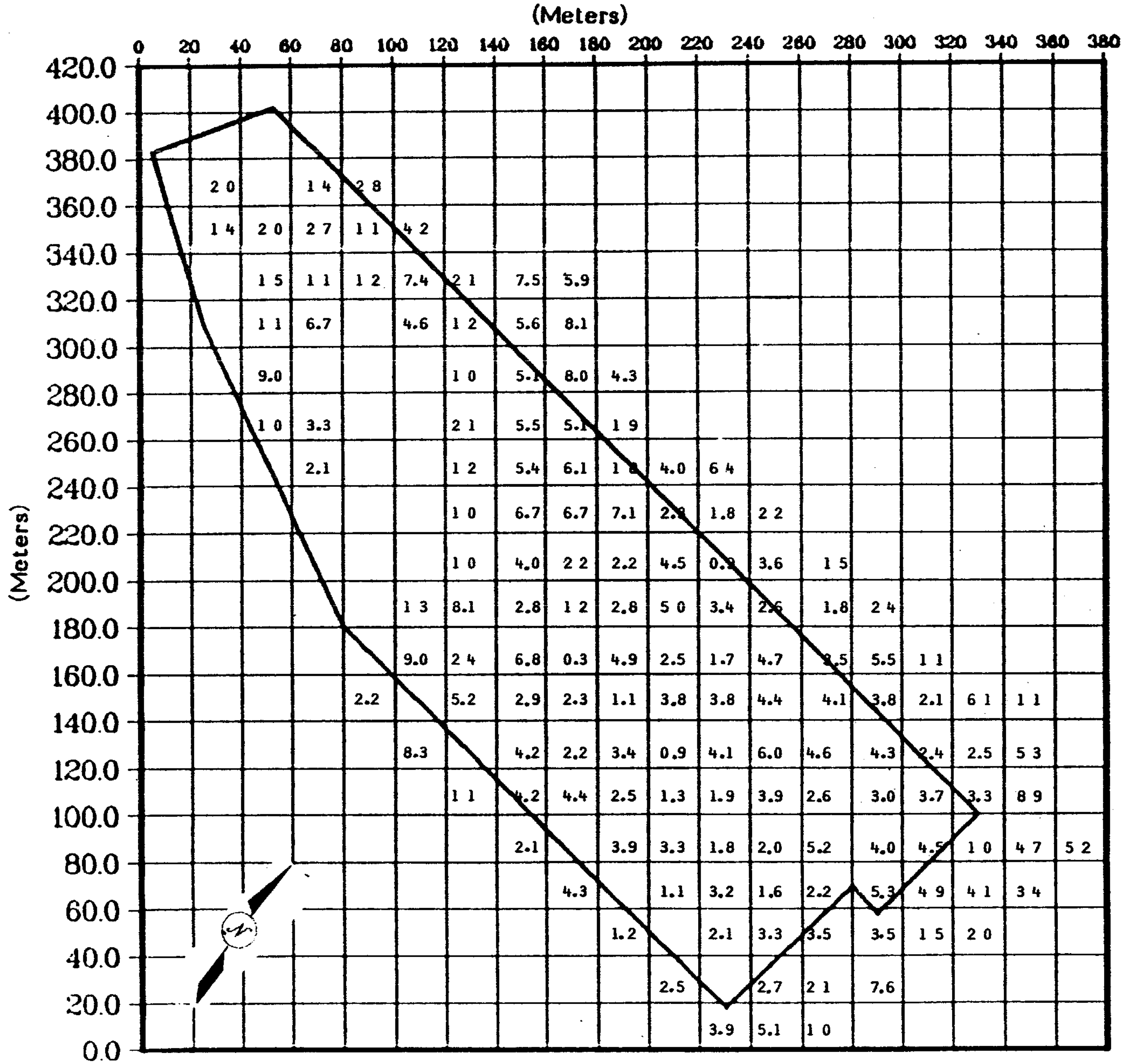

Figure A-3. Tritium concentrations (pCi/ml) in soil solution (0-1 cm depth) from Area C in 1985.

Attachment 1

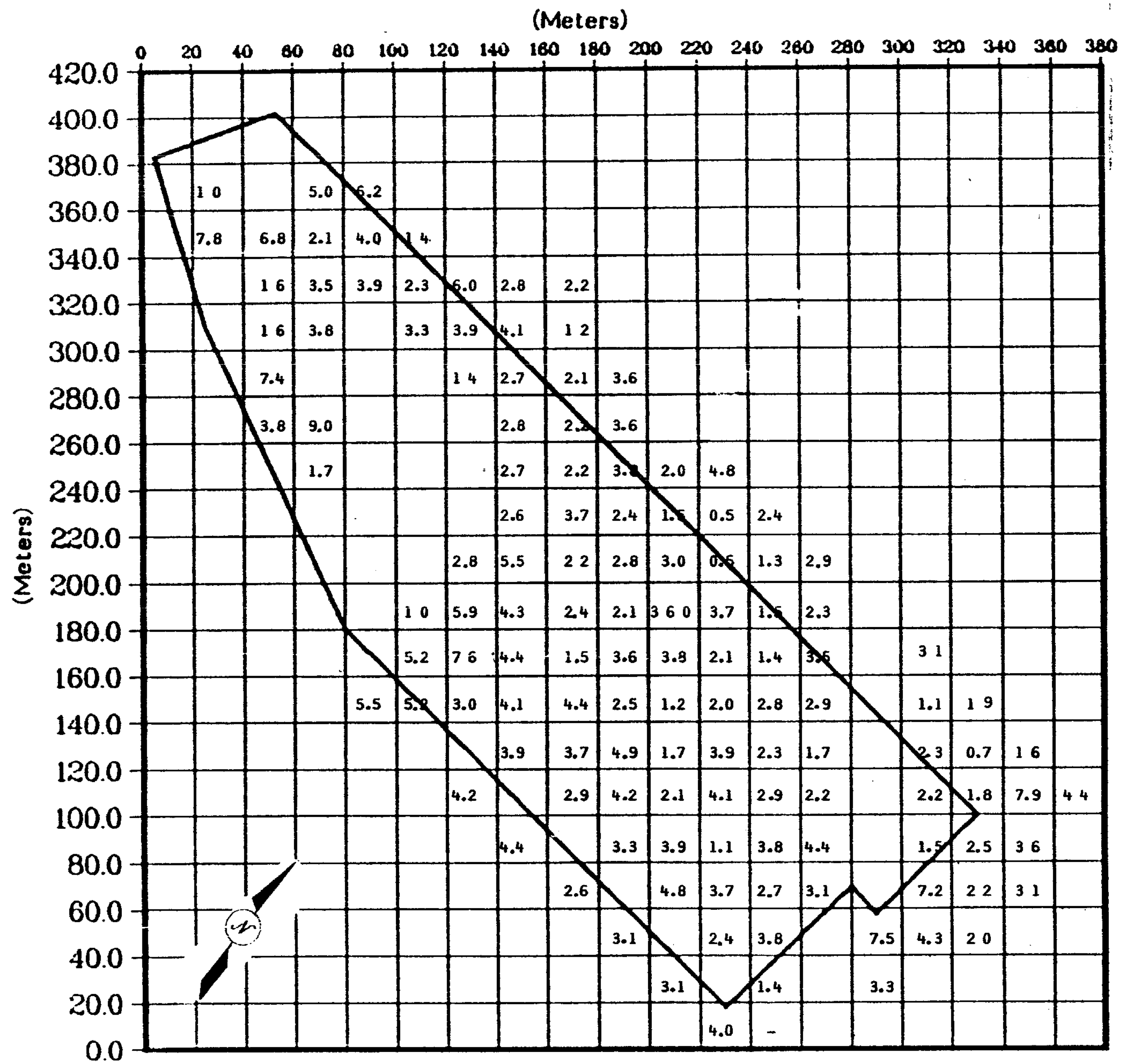

Figure A-4. Tritium concentration (pCi/ml) in soil solution (1-10 cm depth) from Area C in 1985.

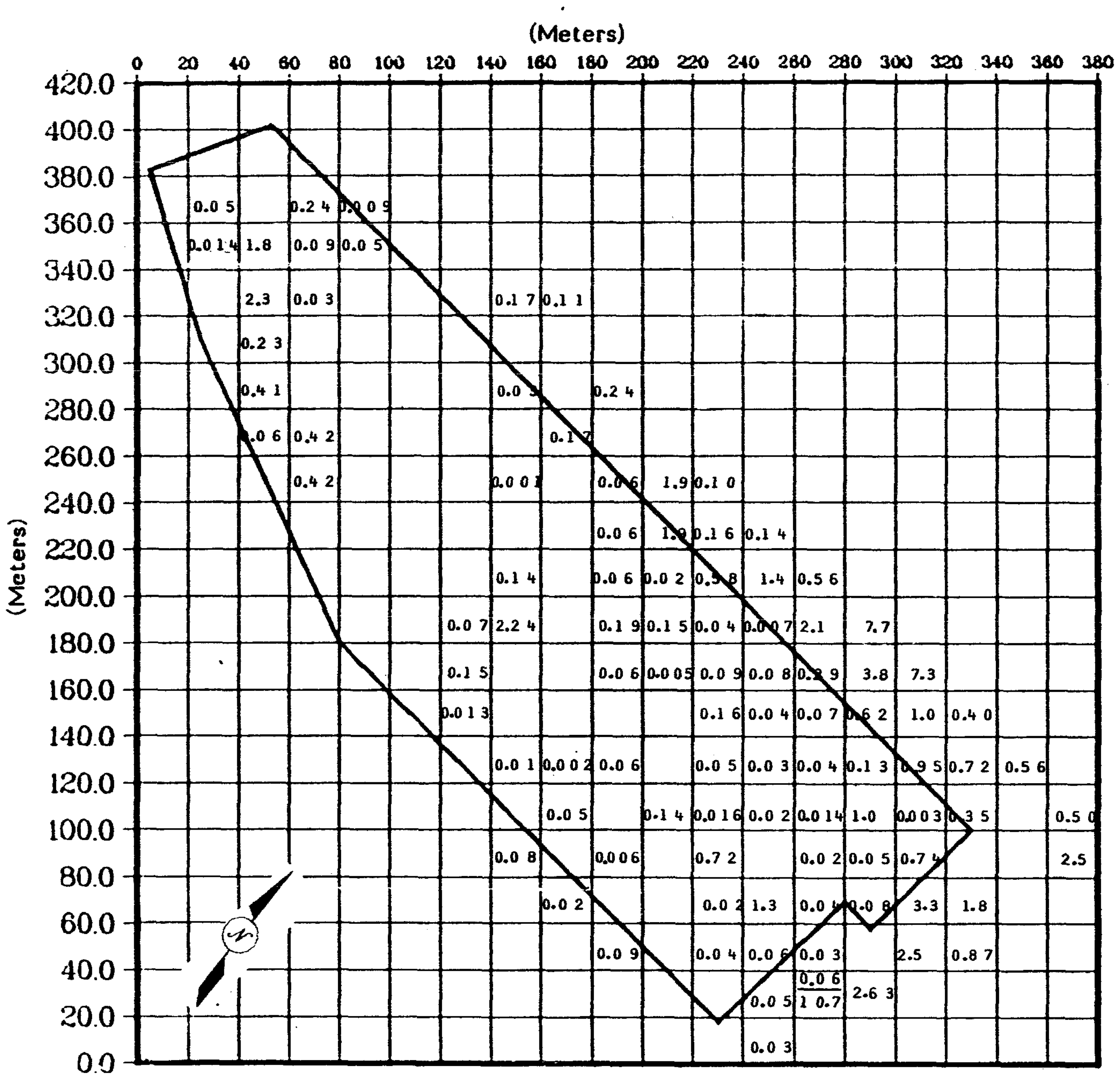

Figure A-5. Plutonium-239,240 concentrations (pCi/g) in soil (0-1 cm depth) from Area C in 1985.

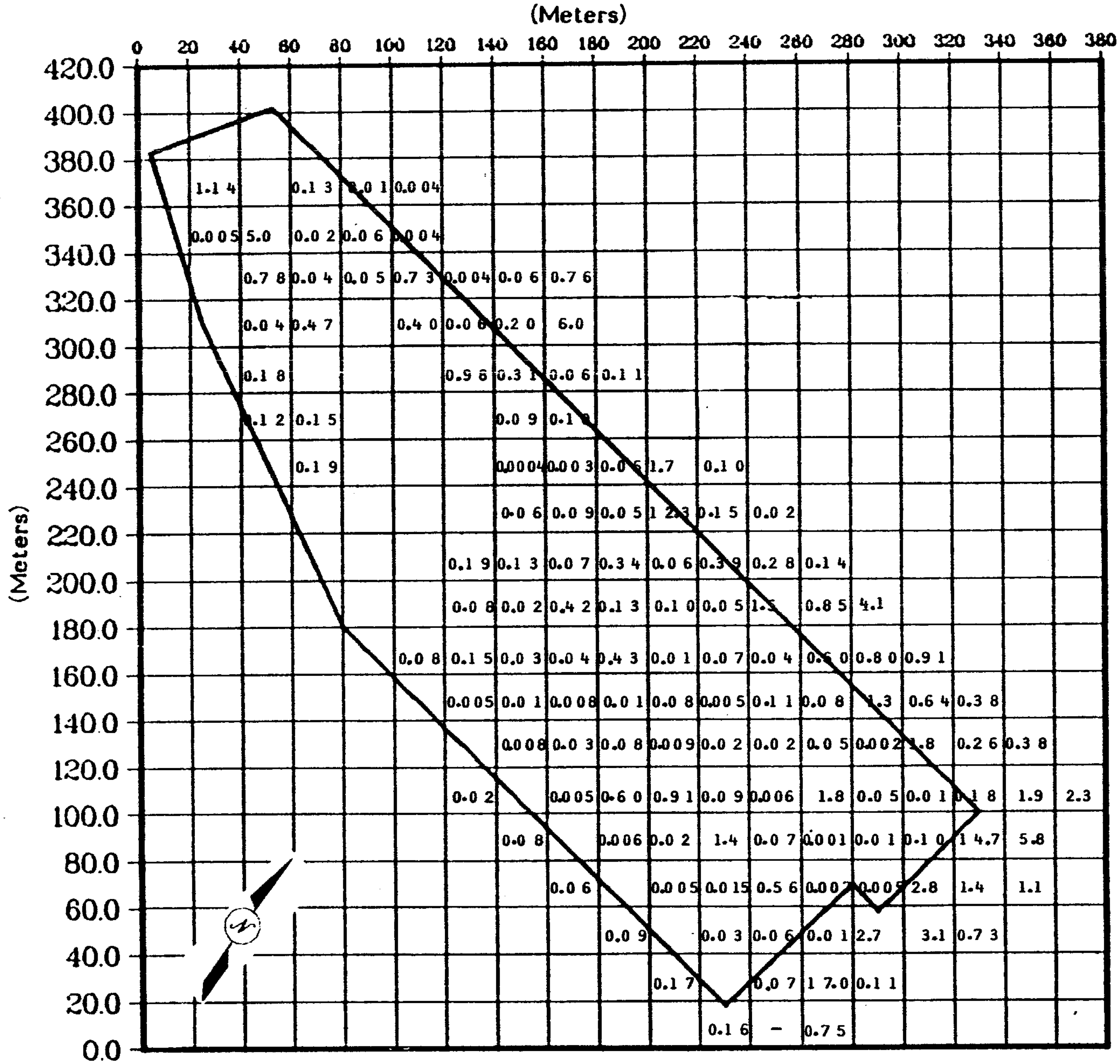

Figure A-6. Plutonium-239,240 concentrations (pCi/g) in soil (1-10 cm depth) from Area C in 1985.

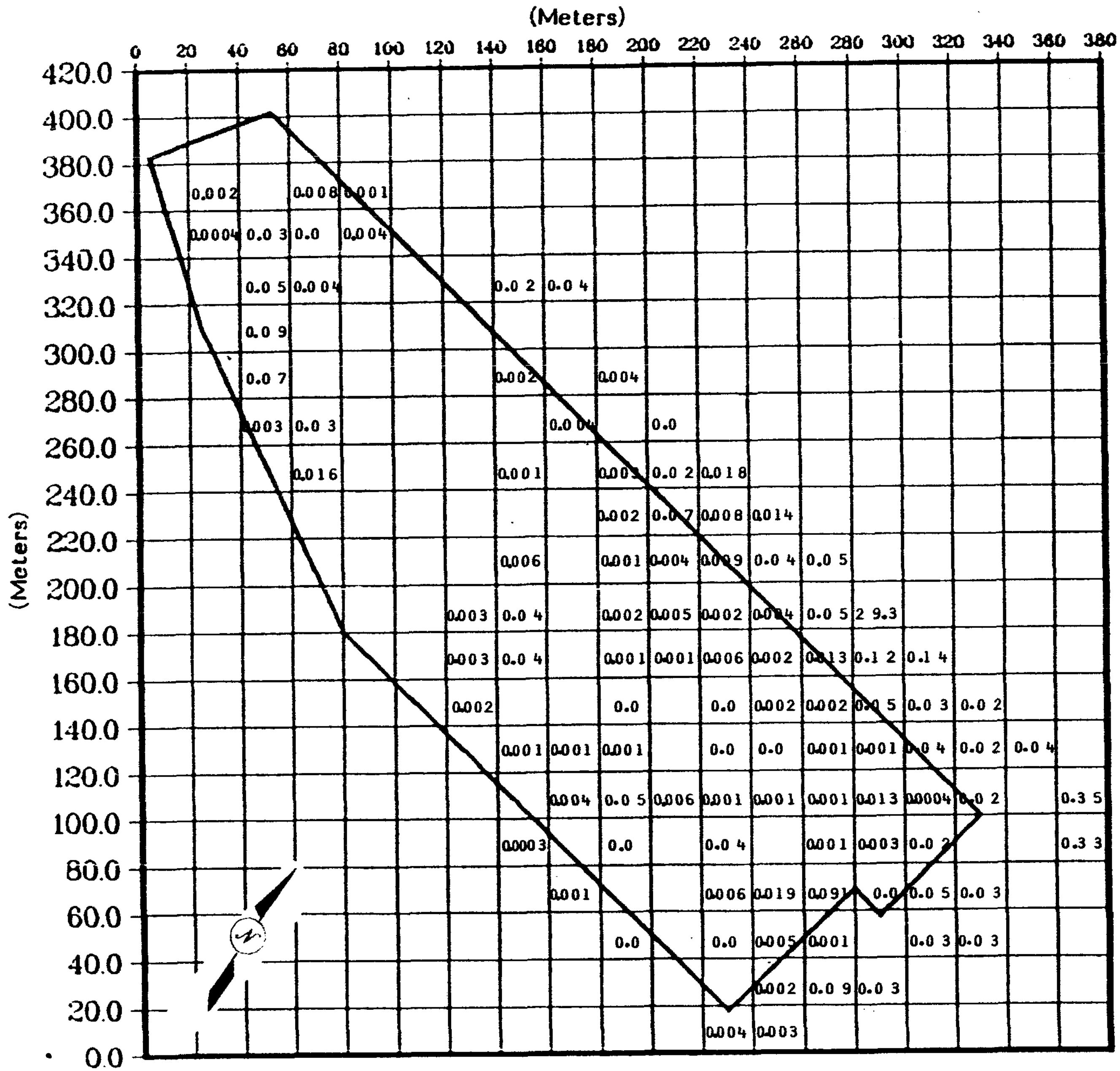

Figure A-7. Plutonium-238 concentrations (pCi/g) in soil (0-1 cm depth) from Area C in 1985.

Attachment 1

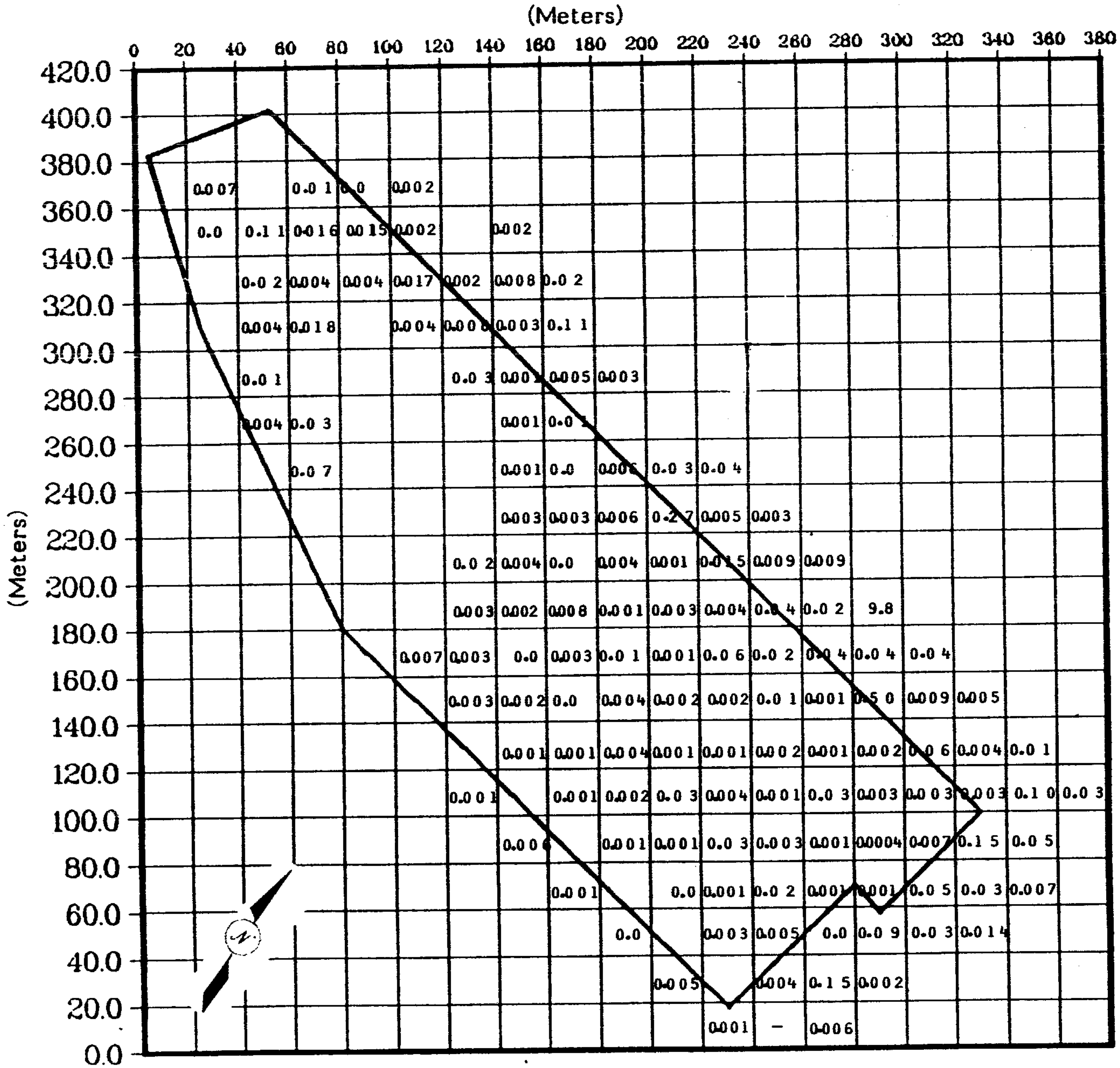

Figure A-8. Plutonium-238 concentrations (pCi/g) in soil (1-10 cm depth) from Area C in 1985.

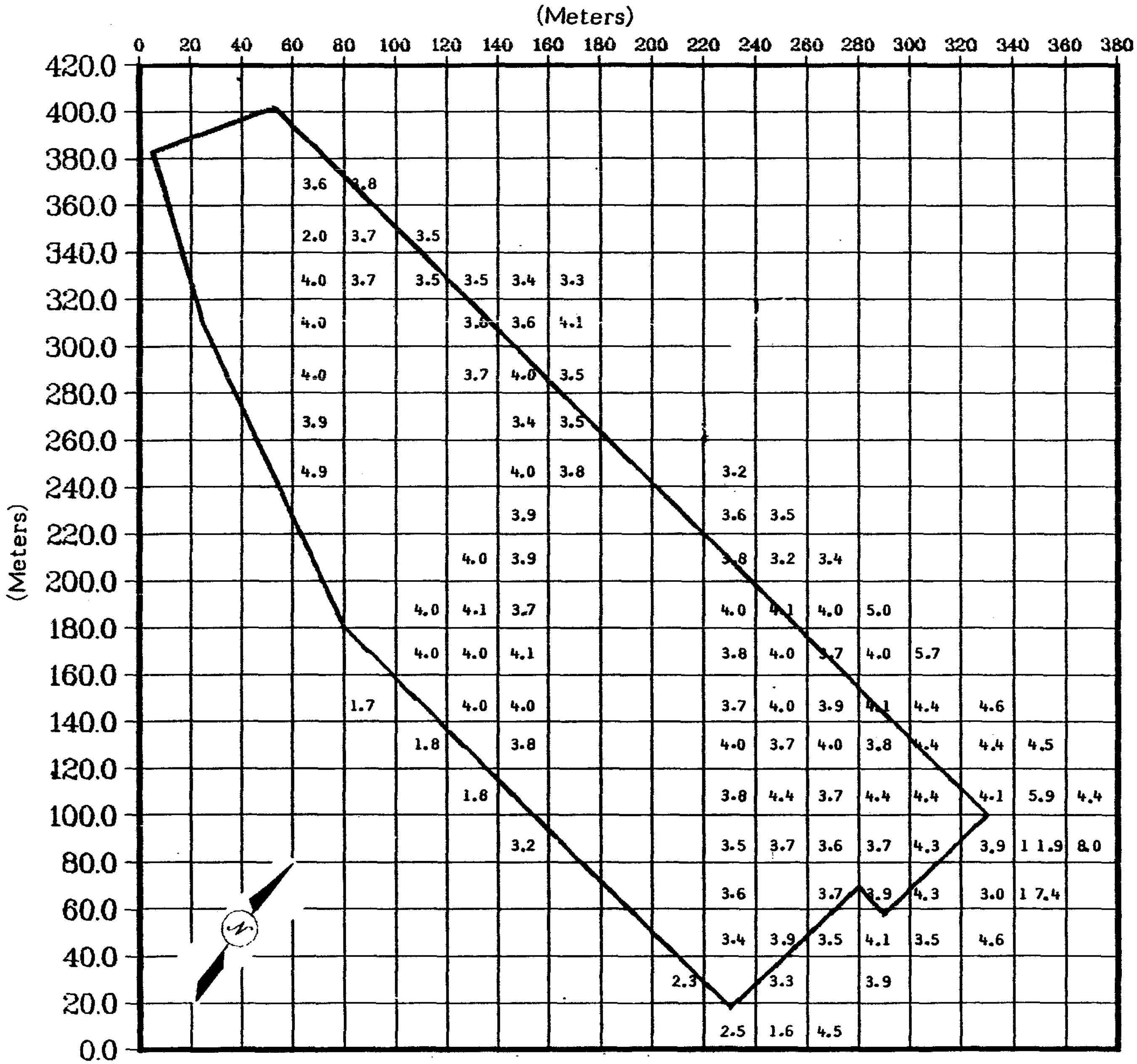

Figure A-9. Total uranium concentrations (ppm) in soil (0-1 cm depth) from Area C in 1985.