VERIFICATION SURVEY OF THE OLD CONSERVATION YARD, BUILDING T064 SIDE YARD, AND BUILDING T028 SANTA SUSANA FIELD LABORATORY ROCKWELL INTERNATIONAL VENTURA COUNTY, CALIFORNIA

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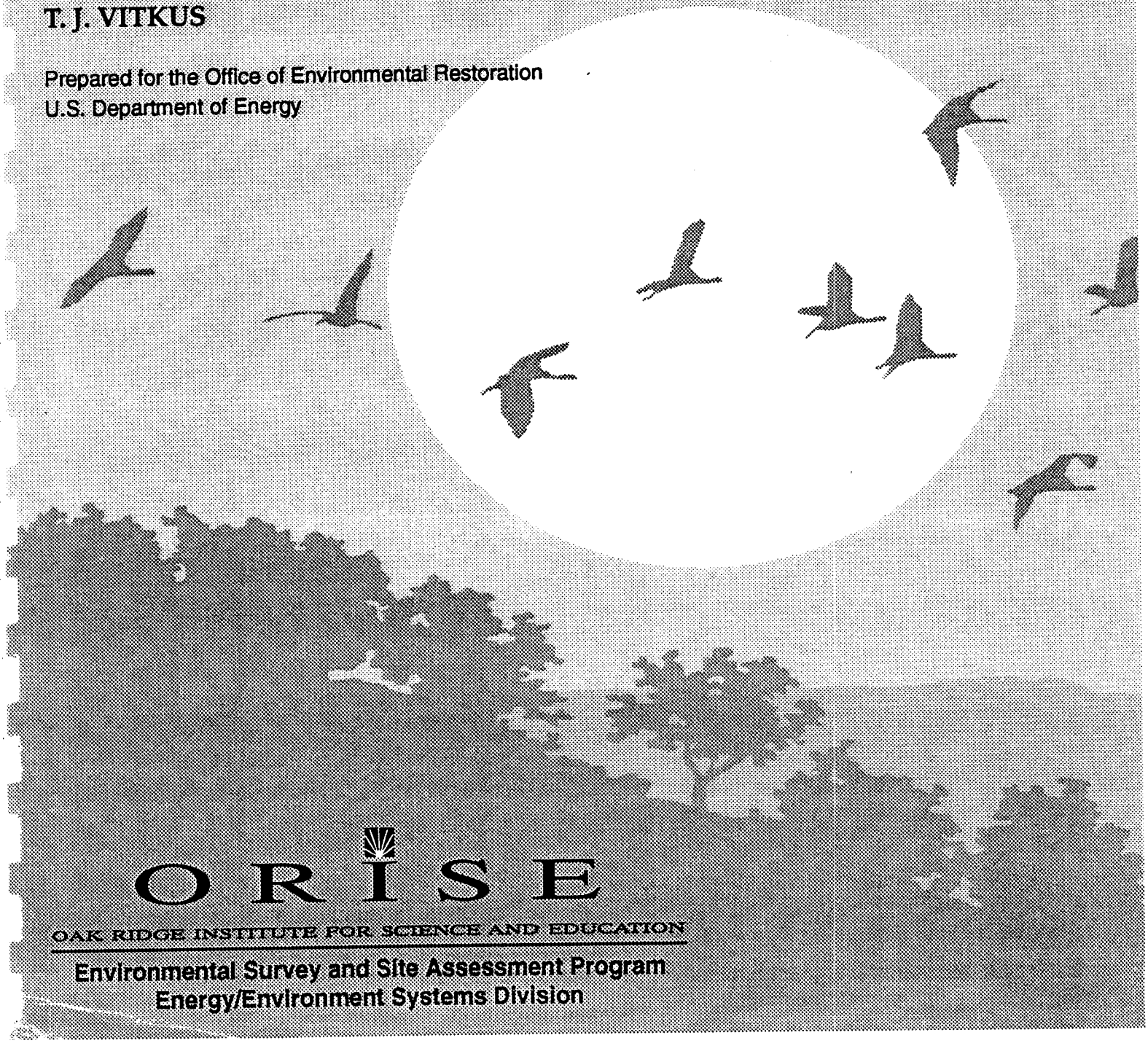
Prepared for the Office of Environmental Restoration
U.S. Department of Energy



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ABBREVIATIONS AND ACRONYMS

ac	acres
AEC	Atomic Energy Commission
cm	centimeter
DOE	Department of Energy
dpm/100 cm^2	disintegrations per minute per 100 square centimeters
EML	Environmental Measurement Laboratories
ER	Office of Environmental Restoration
ERDA	Energy Research and Development Administration
ESG	Energy Systems Group
ESSAP	Environmental Survey and Site Assessment Program
ETEC	Energy Technology Engineering Center
ft	feet
ft^2	square feet
ha	hectares
in	inch
km	kilometer
m	meter
m^2	square meter
mi	mile
mrem	millirem
NIST	National Institute of Standards and Technologies
OCY	Old Conservation Yard
ORISE	Oak Ridge Institute for Science and Education
pCi/g	picocurie per gram
STR	Shield Test Reactor
SSFL	Santa Susana Field Laboratory
STIR	Shield Test and Irradation Reactor
μR/h	microroentegens per hour

VERIFICATION SURVEY
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INTRODUCTION AND SITE HISTORY

Rockwell International's Rocketdyne Division operates the Santa Susana Field Laboratory (SSFL) for the Department of Energy (DOE). The facility, known as the Energy Technology Engineering Center (ETEC), began nuclear energy research and development programs in 1946. Contract work for the Atomic Energy Commission (AEC) and the Energy Research and Development Administration (ERDA), predecessor agencies to the DOE, began in the early 1950's. Specific programs conducted for AEC/ERDA/DOE involved the engineering, development, testing, and manufacturing of nuclear reactor systems and components. Other site activities have also been conducted for the Nuclear Regulatory Commission, the Department of Defense, and other government related or affiliated organizations and agencies.

Numerous buildings and land areas became radiologically contaminated as a result of facility operations and site activities which included ten reactors, seven criticality test facilities, fuel fabrication, reactor and fuel disassembly, laboratory work, and on-site storage of nuclear material. Potential radioactive contaminants identified at the site are uranium (in natural, depleted, and enriched isotopic abundances), plutonium, americium-241, fission products (primarily cesium-137 and strontium-90), activation products (cobalt-60, europium-152, nickel-63, promethium-147, and tantalum-182) and tritium. Chemical contaminants, mainly chlorinated organic solvents, have also been identified in groundwater.

Decontamination and decommissioning of facilities began in the late 1960's and continues as specific DOE-sponsored projects are phased out. In addition to radiological surveys to support current facility decontaminations, Rockwell/Rocketdyne determined that the documentation describing the radiological status for a number of early projects was inadequate; therefore,

surveys or resurveys of selected sites were initiated in 1985. Sites surveyed in these recent investigations included the Old Conservation Yard (OCY), Building T064 Side Yard, and Building T028.

From 1952 until 1977, the OCY and surrounding land areas were used for the storage of excessed equipment some of which was contaminated with either uranium or mixed fission products. The 1988 radiological survey of the OCY identified elevated concentrations of Cs-137 in soil, with assumed equivalent concentrations of Sr-90. Although there is no available confirming documentation, the source of the contamination is believed to be the result of a contaminated liquid spill. The area was further investigated to delineate the areal extent of contamination. This investigation identified a 37 m^2 (400 ft^2) area with contamination to a depth of 15 cm (6 in). A Cs-137 clean-up guideline was established through the use of the DOE computer code RESRAD.[1] Contaminated soil was excavated, and post-remedial action measurements and sampling were performed and documented.

Building T064, which was formerly known as the Source and Special Nuclear Material Storage Facility, was used for the storage of packaged items of source and special nuclear materials prior to 1980; it is currently used to store non-nuclear components and equipment and metal boxes containing low-level contaminated soil. Site history indicates that the area around the building and the side yard was occasionally used for storage of recoverable uranium scrap, irradiated fuel elements, and miscellaneous radioactive wastes, which included in the early 1960's a lead-pig cask containing irradiated "Seawolf" fuel and contaminated water. The drain plug in the cask failed, allowing the water to leak onto the Side Yard. A 65 m^2 area was excavated immediately following the incident; however, a 1988 comprehensive radiological survey of the area around Building T064 identified elevated soil concentrations of Cs-137 (assumed equivalent amount of Sr-90). Further investigations determined that a 47 m^2 area of contamination was located within the northeast fence line and extended in a northeast direction past the fence line over an additional area of 370 m^2. A Cs-137 guideline was developed and the top 41 cm of soil was subsequently excavated from the area and a post-remedial action survey performed and documented.

Building T028 housed the Shield Test Reactor (STR) from 1961 until 1964, at which time STR was modified and renamed the Shield Test and Irradiation Reactor (STIR) which operated until 1972. The reactor was dismantled and the building decontaminated. From 1977 to 1981, experiments were conducted in the building to investigate the behavior of molten uranium oxide, which resulted in recontamination of building and equipment surfaces. Decontamination of the building was performed in 1988 and the above-grade portion demolished in 1989, leaving only the concrete slab floor, below-grade concrete test vault, and stairwell intact.

DOE's Office of Environmental Restoration (DOE/ER), Northwestern Area Programs, San Francisco Operations Division is responsible for oversight of a number of remedial actions that have been or will be conducted at the SSFL. It is the policy of DOE to perform independent (third party) verification of remedial action activities conducted within Office of Environmental Restoration programs. The Environmental Survey and Site Assessment Program (ESSAP) of the Oak Ridge Institute for Science and Education (ORISE) has been designated as the organization responsible for this task at SSFL. This report describes the results of the verification surveys.

SITE DESCRIPTION

The SSFL is located near Chatsworth in the Simi Hills of southeastern Ventura County, California, approximately 47 km (29 mi) northwest of downtown Los Angeles (Figure 1). The site is comprised of a total of approximately 1090 hectares (2700 acres) and is divided into four administrative areas (Areas I - IV) and a Buffer Zone. DOE operations are conducted in Rockwell International-owned and DOE-owned facilities located within the 117 ha Area IV. The ETEC portion of Area IV consists of government-owned buildings that occupy 36 ha. The Area IV plot plan is provided in Figure 2 and indicates the locations of those areas addressed by this report.

The OCY is located in the northeast quadrant of Area IV and is a portion of adjacent land groupings totaling 2 ha, termed the Old Energy Systems Group (ESG) Salvage Yard,

Rocketdyne Barrel Storage Yard and the New Salvage yard (also known as T583). The OCY occupies an area at the corner of G Street and the Old Salvage Yard Road (Figure 3). The surface is paved with asphalt and is currently used for trailer storage.

Building T064 is in the northeast quadrant of Area IV, north of and above G Street (Figure 4). The Side Yard is located to the east of T064 and includes an area of approximately 0.8 ha.

Building T028 is located in the north-central portion of Area IV. The above-grade concrete slab is approximately 300 m^2 in area. The below-grade vault measures approximately 60 m^2 with 6 m (20 ft) ceilings. Construction consists of a concrete slab floor with concrete walls and ceiling.

OBJECTIVE

Through document reviews and independent surveys, an independent evaluation is performed. The purpose of the evaluation is to validate that cleanup procedures and survey methods utilized by Rockwell/Rocketdyne were adequate. In addition, independent verification provides assurance that the post-remediation data is sufficient, accurate, and demonstrates that remedial actions were accomplished in accordance with appropriate standards and guidelines, and that authorized limits were met.

DOCUMENT REVIEW

The final decontamination and survey reports for the OCY, Building T064 Side Yard, and Building T028 were reviewed for general thoroughness, accuracy, and completeness.[2,3,4] The procedures used and data developed for area characterization and post-remedial action monitoring were evaluated to determine if surveys had been adequately performed, areas of contamination were identified and remediated, and that the DOE guidelines had been met.

PROCEDURES

ESSAP personnel conducted independent measurement and sampling activities at SSFL on June 9 and 10, 1992. Survey activities were performed in accordance with a site specific survey plan, using procedures and instruments described in the ESSAP Survey Procedures Manual and summarized in Appendices A and B.

SURVEY PROCEDURES: OCY AND T064 SIDE YARD

Reference Grid

A reference grid, consisting of 10 m x 10 m grid blocks, was established on outdoor areas associated with the OCY and T064 Side Yard (Figures 5 and 6). The remaining 2 ha and 0.8 ha land areas were not gridded. Measurements and samples from ungridded surfaces were referenced to prominent site features.

Surface Scans

Gamma surface scans were performed over the remediated portions of the OCY and T064 Side Yard. In addition, portions of the respective 2 ha and 0.8 ha adjacent areas were also surface scanned. Scans were performed with NaI detectors, coupled to ratemeters with audible indicators. Locations of elevated direct radiation identified by surface scans were marked for further investigation.

Soil Sampling

Composite surface (0-15 cm) soil samples were collected from three 100 m^2 areas within the OCY and T064 Side Yard. Two additional soil samples were collected from the T064 Side Yard at locations of elevated direct radiation detected during surface scans. Figures 5 and 7 show soil sampling locations.

SURVEY PROCEDURES: BUILDING T028

Reference Grid

A reference grid, consisting of 1 m^2 grid blocks, was established on the above-grade concrete slab and on the floor and lower walls (up to 2 m) of the below-grade vault (Figures 8 and 9). Upper walls, ceilings and the stairwell were not gridded. Measurements and samples from ungridded surfaces were referenced to the floor or lower wall grid or to prominent building features.

Surface Scans

Surface scans for alpha, beta, and gamma activity were performed on the concrete slab and below-grade floors, walls and overhead surfaces using ZnS scintillation, GM, and NaI detectors coupled to ratemeters or ratemeter-scalers with audible indicators.

Surface Activity Measurements

The primary contaminant within Building T028 was uranium in natural and depleted isotopic abundances. Uranium emits both alpha and beta radiations at approximate ratios of 1:1 and 1:1.6 for natural and depleted uranium, respectively. The surface contamination guidelines for uranium are in units of alpha dpm/100 cm^2; however, because rough, dirty, or damp surfaces selectively attenuate alpha radiation, beta activity was also measured.

Direct measurements for total alpha and total beta activity were performed on a total of ten randomly selected grid blocks located in the vault or on the above-ground concrete slab. One set of five direct measurements was obtained from each grid block. Measurements were performed at the center and four points equidistant from the center and grid block corners. Single-point alpha and beta measurements were performed at six locations on upper walls and

ceiling of the vault and at three locations in the stairwell. Direct measurements were made using ZnS and GM detectors coupled to ratemeter-scalers. A smear sample, for determining gross alpha and gross beta activity, was collected from the location within each grid block corresponding to the highest total direct measurement and from each single-point measurement location. Figures 8 through 10 indicate measurement and sampling locations.

SAMPLE ANALYSIS AND DATA INTERPRETATION

Samples and data were returned to ORISE's ESSAP laboratory in Oak Ridge, TN for analysis and interpretation. Soil samples were analyzed by gamma spectrometry for Cs-137 and uranium. Spectra were also reviewed for other identifiable photopeaks. Soil samples were also analyzed by wet chemistry methods for Sr-90. Soil sample results are reported in units of pCi/g. Smear samples were analyzed for gross alpha and gross beta activity using a low background proportional counter. Smear sample results and direct measurement data were converted to units of disintegrations per minute per 100 cm^2 (dpm/100 cm^2).

FINDINGS AND RESULTS

DOCUMENT REVIEW

ESSAP's review of the SSFL decontamination and survey reports identified several procedural, analytical, and data findings where clarification would provide additional support that the sites have been adequately characterized and meet the requirements for release without radiological restrictions. These findings were provided in a June 5, 1992 correspondence.[5]

OCY AND T064 SIDE YARD

Surface Scans

Gamma surface scans of the OCY and T064 Side Yard identified three locations of elevated direct radiation, each measuring less than 1 m^2 in area, within the T064 Side Yard (Figure 6). All other gamma surface scans were within the range of ambient site background.

Radionuclide Concentration In Soil

Radionuclide concentrations in soil samples are summarized in Table 1. Concentrations in samples from two of the locations of elevated direct radiation that were individually sampled were: Cs-137, 35.1 and 210 pCi/g; Sr-90 <0.4 and 2.0 pCi/g; U-235, 0.3 pCi/g; U-238, 0.9 and 1.4 pCi/g. Concentrations in the composite samples, which represent the averages in 100 m^2 areas, were as follows: 0.6 to 27.7 pCi/g Cs-137; <0.5 to 1.9 pCi/g Sr-90; 0.1 to 0.4 pCi/g U-235; and 0.9 to 1.6 pCi/g U-238.

BUILDING T028

Surface Scans

Surface scans of the above-ground concrete slab, below-grade vault, and the stairwell for alpha, beta, and gamma activity did not identify any locations of elevated direct radiation.

Surface Activity Levels

Surface activity levels for Building T028 are summarized in Table 2. The average surface activity levels within surveyed 1 m^2 grid blocks were <83 dpm/100 cm^2 for alpha and ranged from <860 to 1200 dpm/100 cm^2 for beta. Individual direct measurements ranged from <83 to 89 for alpha and <860 to 1400 dpm/100 cm^2 for beta. Removable activity levels were <12 dpm/100 cm^2 for gross alpha and <15 to 25 dpm/100 cm^2 for gross beta.

COMPARISON OF RESULTS WITH GUIDELINES

Rockwell/Rocketdyne identified Cs-137 as the primary contaminant within the Building T064 Side Yard and the OCY and assumed that there was an equivalent concentration of Sr-90 present. Guidelines for these radionuclides are developed on a site-specific basis and Rockwell/Rocketdyne used the RESRAD computer code to determine both a two nuclide and a single nuclide limit for the Building T064 Side Yard and the OCY.[1] The two nuclide guideline limits developed were 60.4 pCi/g and 314 pCi/g each of Cs-137 and Sr-90 for the Building T064 Side Yard and the OCY, respectively.

ESSAP's soil sample analytical results were compared with these guidelines. Samples collected from the OCY verified the Rockwell/Rocketdyne results and conclusions regarding soil status relative to the guidelines. Samples from the Building T064 Side Yard indicated that small area "hot spots" were still present which exceeded the guideline. In addition, the assumption that equivalent concentrations of Sr-90 were present could not be verified.

Subsequent to ESSAP's findings, Rockwell/Rocketdyne remediated the hot spots and revised the Building T064 Side Yard guidelines to meet a more restricive 10 mrem/yr maximum dose rate for the residential scenario. The guidelines were a single nuclide (Cs-137) limit of 7.08 pCi/g average in a 100 m^2 area and a maximum concentration of 70.8 pCi/g in a 100 m^2 area. The final status guidelines and results were provided in a September 22, 1993 transmittal as Appendix F to the original 1990 report.[3] The data provided in the report indicated that the contaminated locations had been remediated to levels below the average guideline limit.

The site characterizations did not identify uranium as a contaminant; therefore, a guideline was not developed. Uranium concentrations in verification soil samples were comparable to the Rockwell/Rocketdyne determined average background levels of 0.7 pCi/g and 0.1 for U-238 and U-235, respectively.

Surface activity levels in Building T064 were compared to the guidelines for residual surface contamination for uranium which are:

Total Activity

5000 α dpm/100 cm^2, averaged over 1 m^2

15,000 α dpm/100 cm^2, maximum in a 100 cm^2 area

Removable Activity

1000 α dpm/100 cm^2

The more conservative 1:1 alpha to beta decay ratio of natural uranium was used to compare beta surface activity levels to the alpha guidelines. All of the ESSAP independent measurement data were well within these guideline levels.

ESSAP reviewed the SSFL exposure rate data for compliance with the DOE guideline of 20 μR/h above background. The site has chosen to use a more conservative criteria of 5 μR/h above background and exposure rates are, therefore, within the DOE guideline.

SUMMARY

At the request of the U.S. Department of Energy, the Environmental Survey and Site Assessment Program of the Oak Ridge Institute for Science and Education performed a verification survey of the Old Conservation Yard, Building T064 Side Yard, and Building T028 located at the Santa Susana Field Laboratory near Chatsworth, California. Activities included document reviews, surface scans, surface activity measurements, soil sampling, and sample analyses.

The documentation prepared by Rockwell/Rocketdyne provides descriptions of characterization, remediation, and post-remedial action survey procedures as well as the current radiological status of each area. ESSAP provided specific comments which suggest modifications to the current procedures and investigative approaches used at SSFL. If the suggested modifications are adapted by Rockwell/Rocketdyne on future projects, a more accurate and complete appraisal of the pre- and post-remedial action site conditions would be possible.

ESSAP's independent investigation supports Rockwell/Rocketdyne's field and analytical data for the Old Conservation Yard and following the additional remediation, the Building T064 Side Yard. ESSAP's independent measurement and sampling data for Building T028 were within the generic surface contamination DOE guidelines. It is, therefore, ESSAP's opinion that these areas meet the requirements for release to unrestricted use.

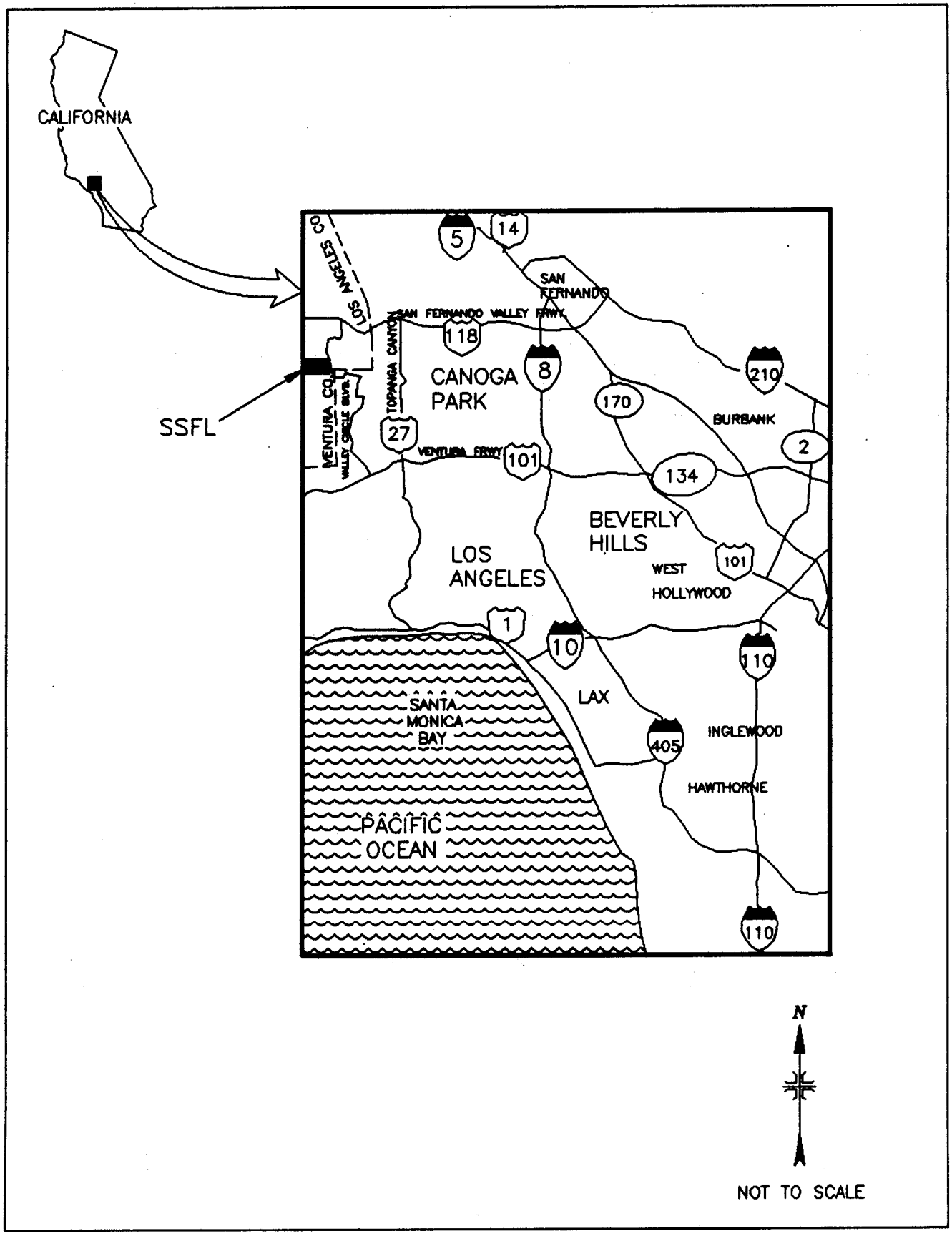

FIGURE 1: Los Angeles California Area, Location of Santa Susana Field Laboratory Site

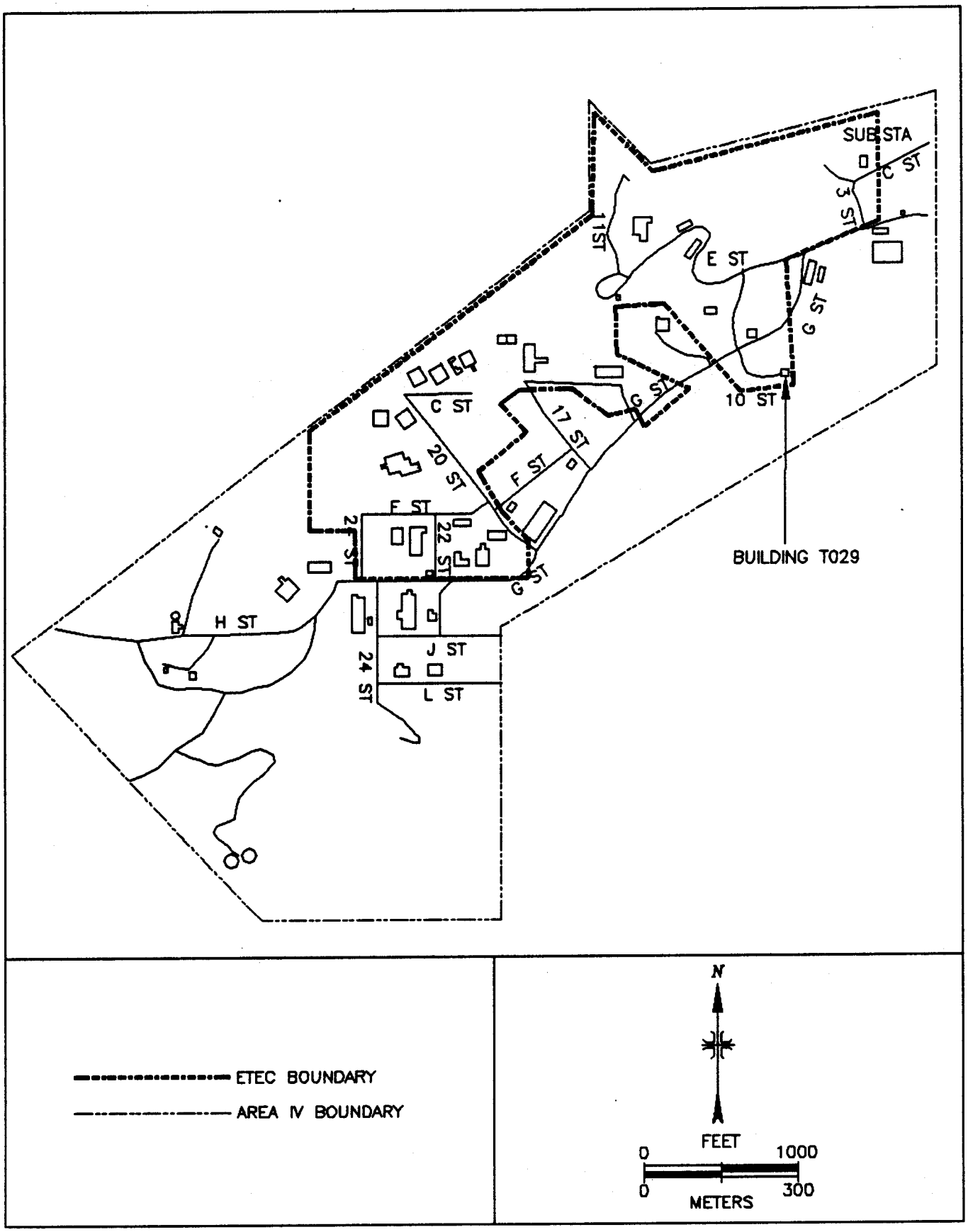

FIGURE 2: Plot Plan of Santa Susana Field Lab Area IV

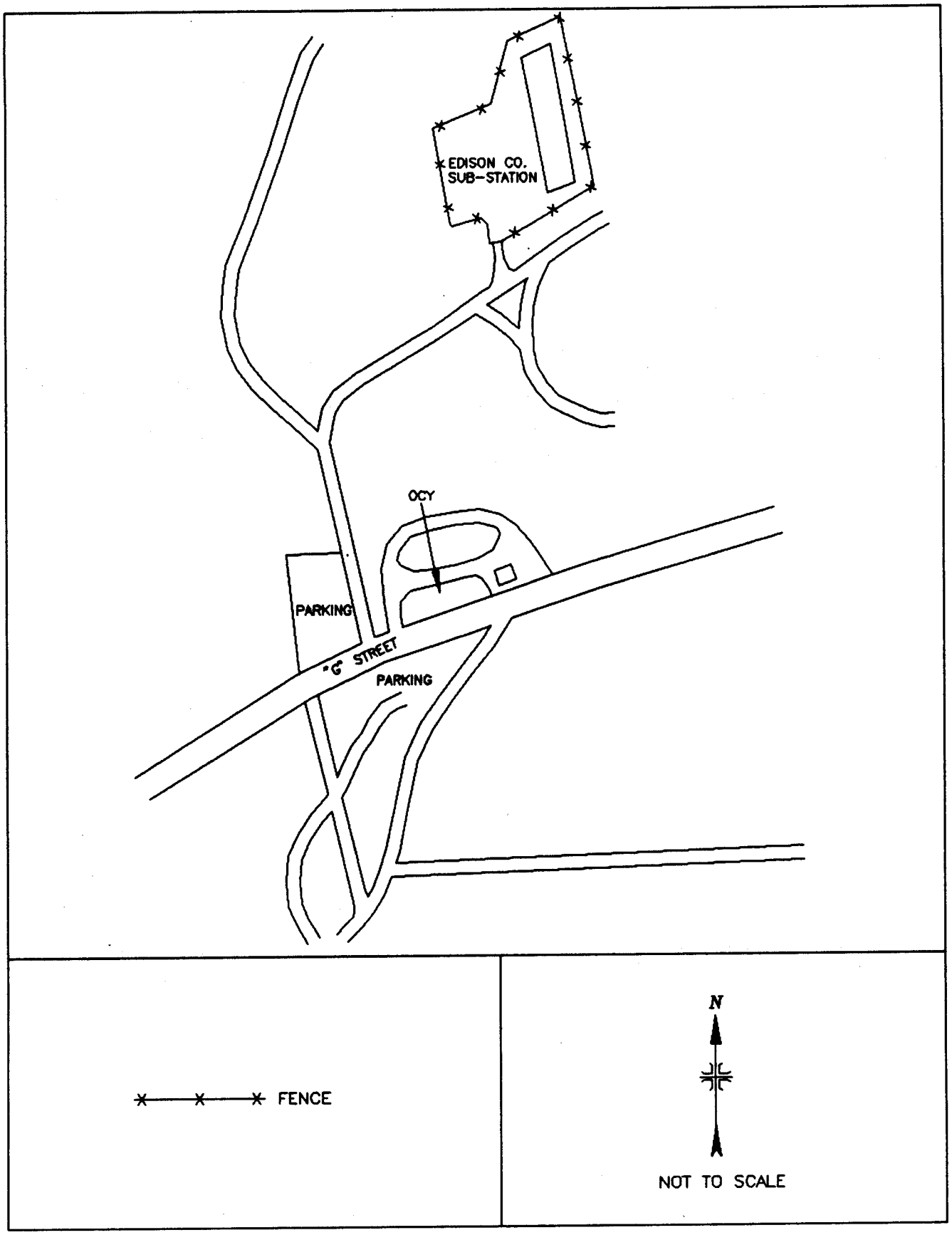

FIGURE 3: Location of the Old Conservation Yard

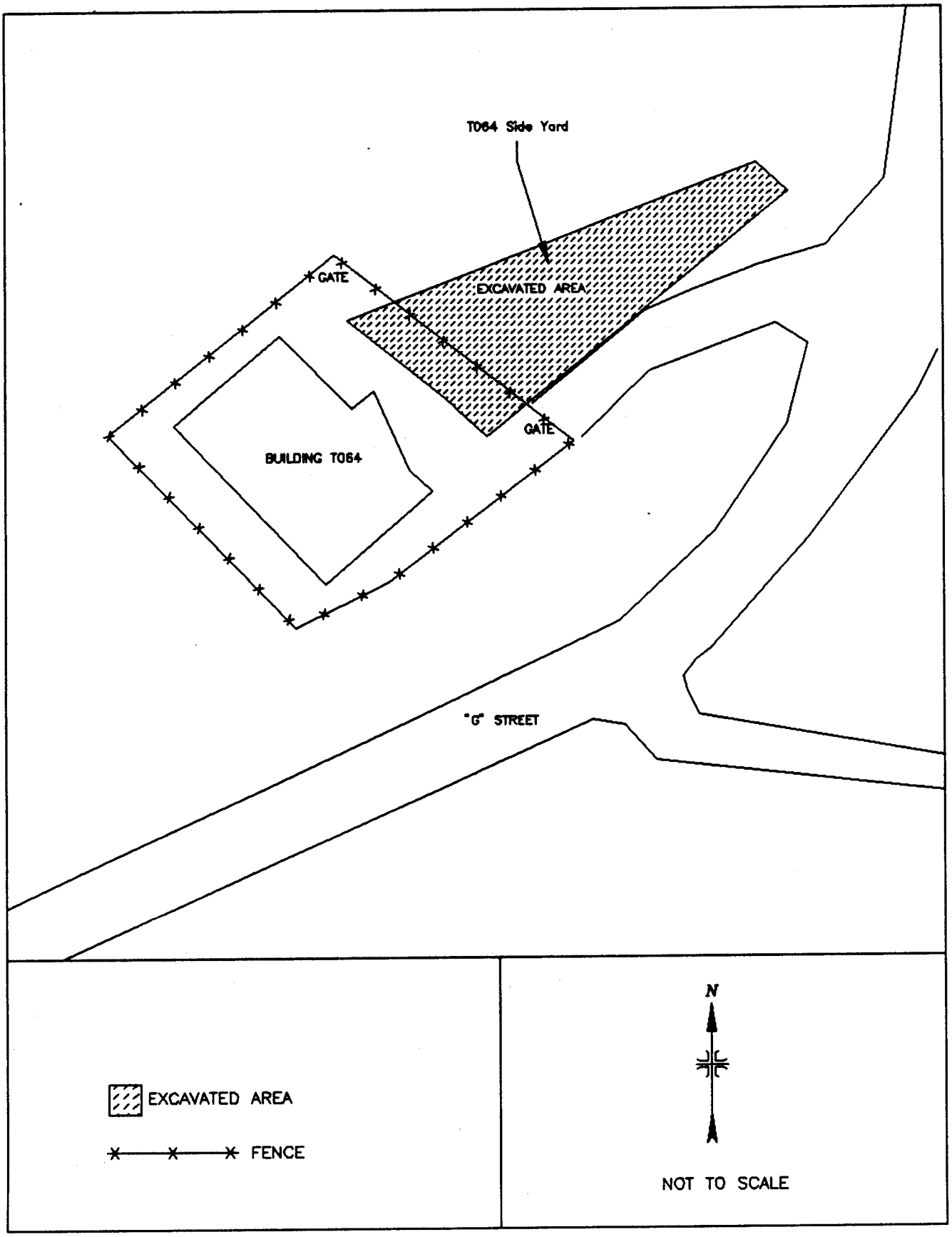

FIGURE 4: Location of Building T064 Side Yard

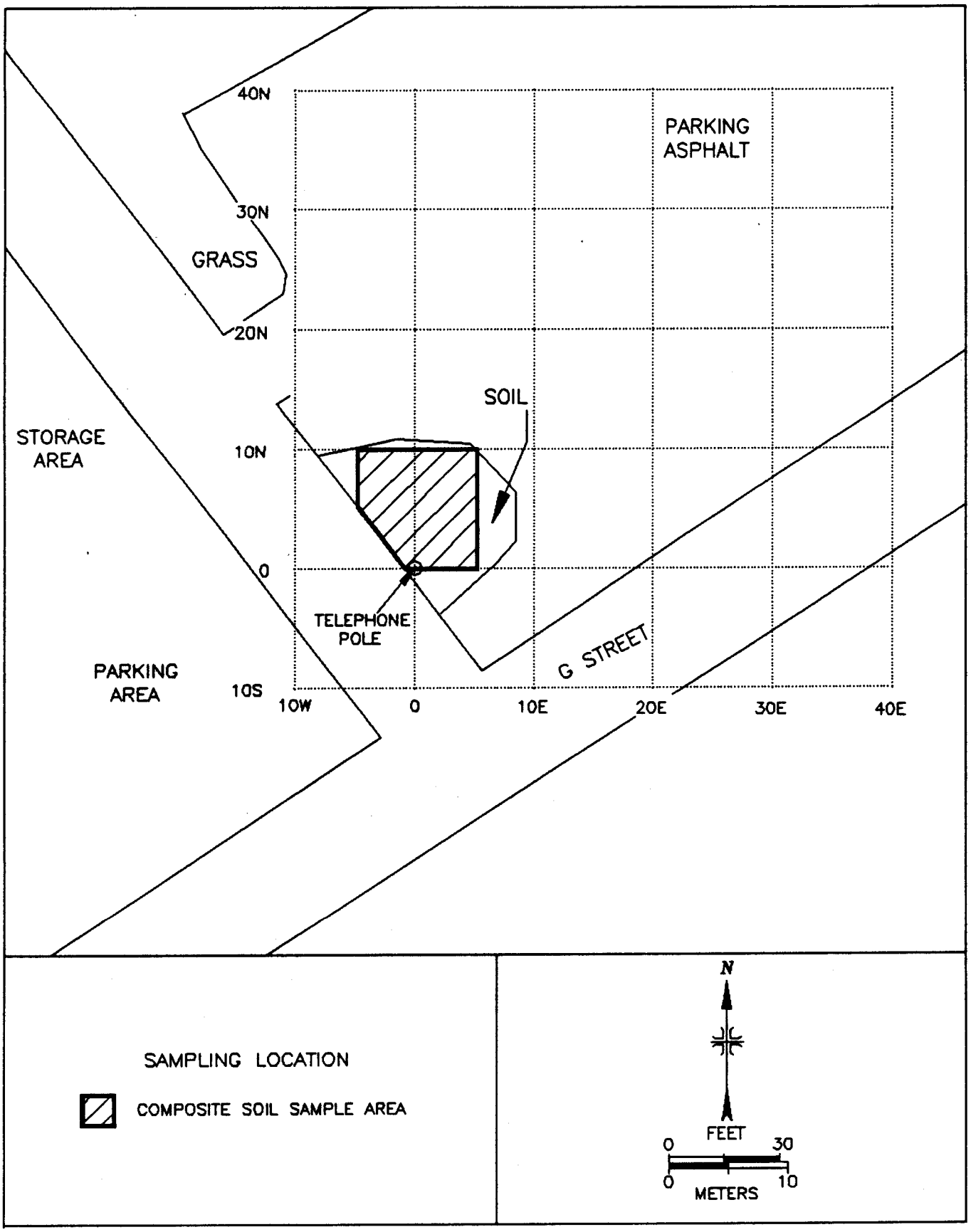

FIGURE 5: Old Conservation Yard – Reference Grid and Sampling Locations

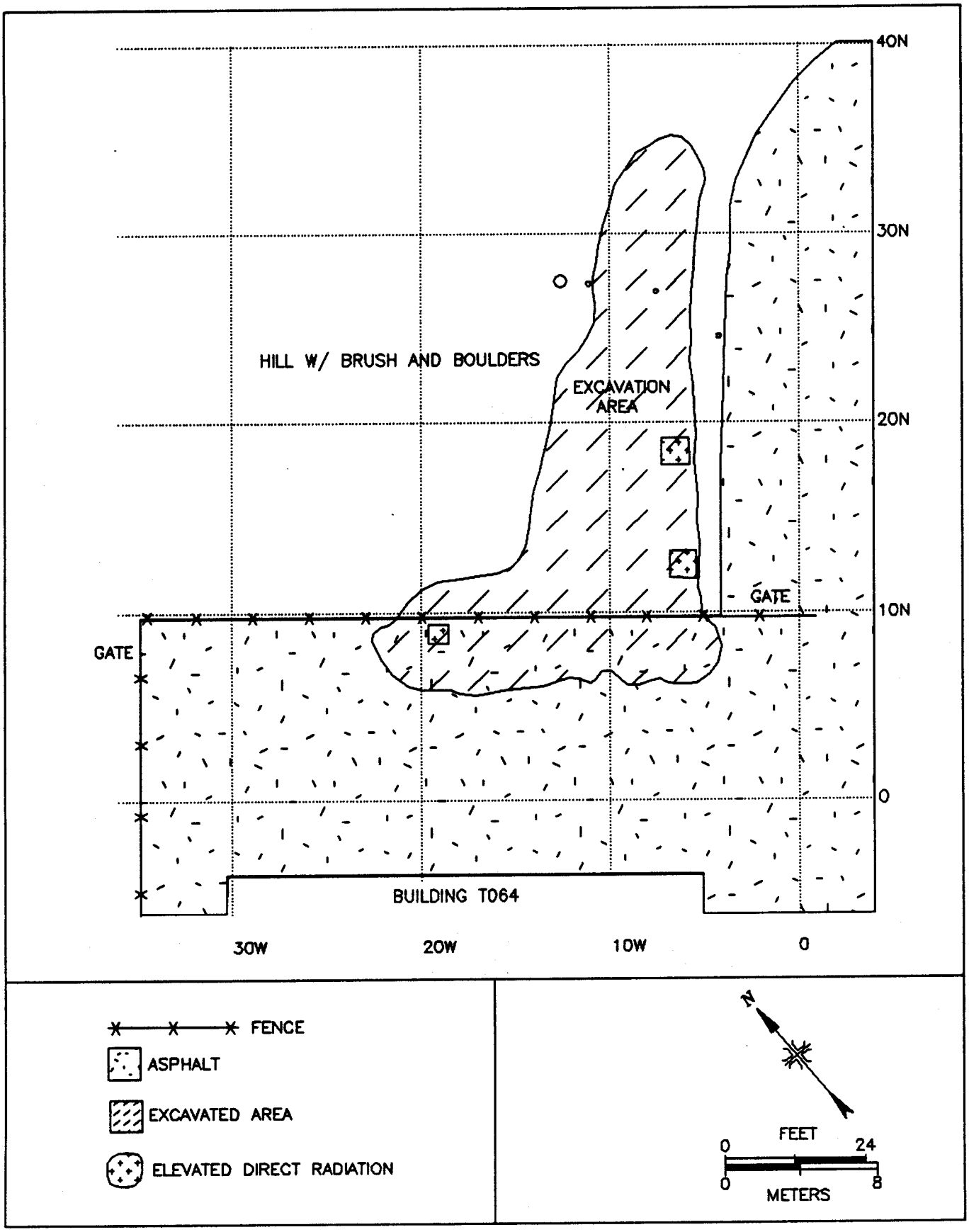

FIGURE 6: Building T064 Side Yard – Locations of Elevated Direct Radiation

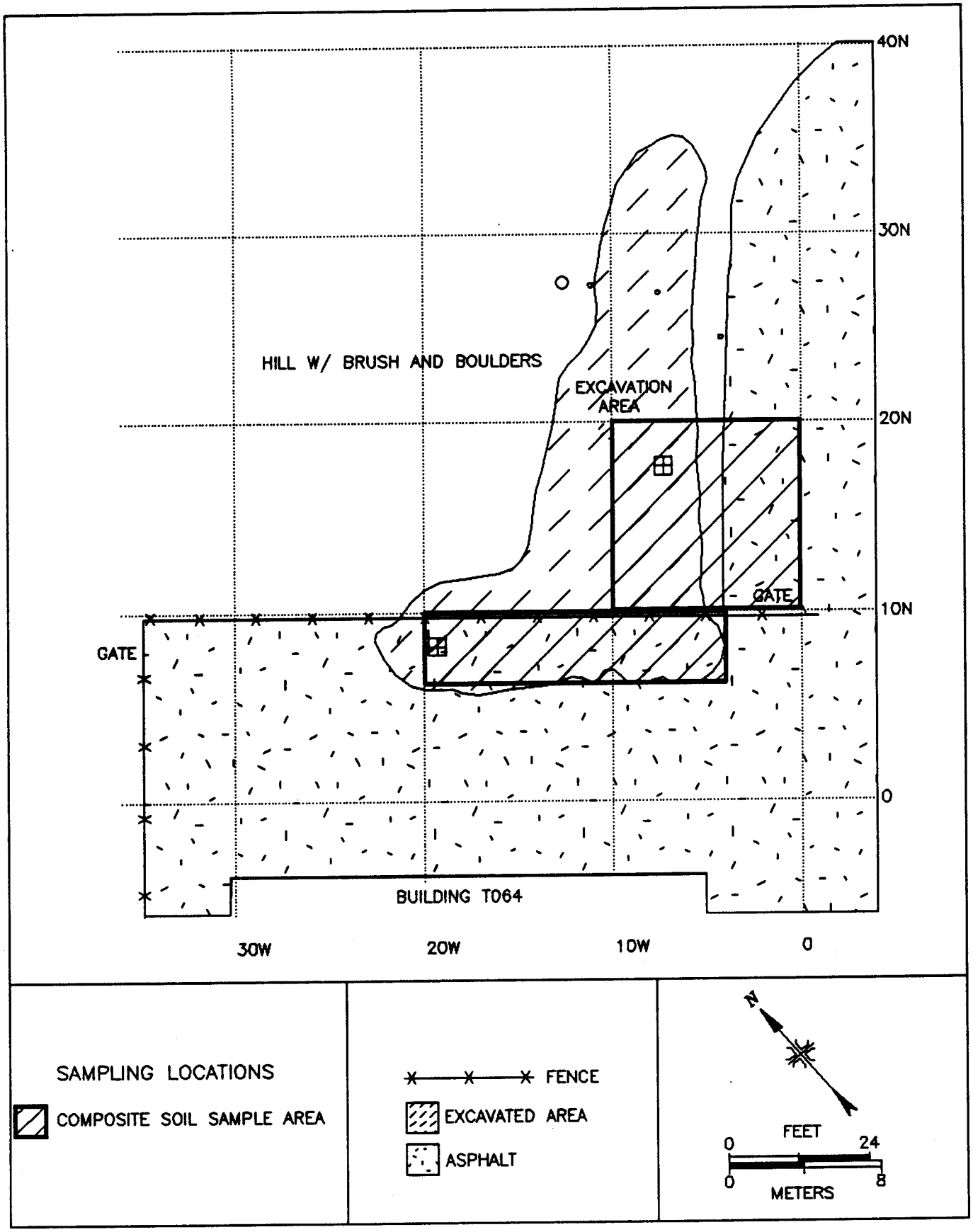

FIGURE 7: Building T064 Side Yard – Reference Grid and Measurement and Sampling Locations

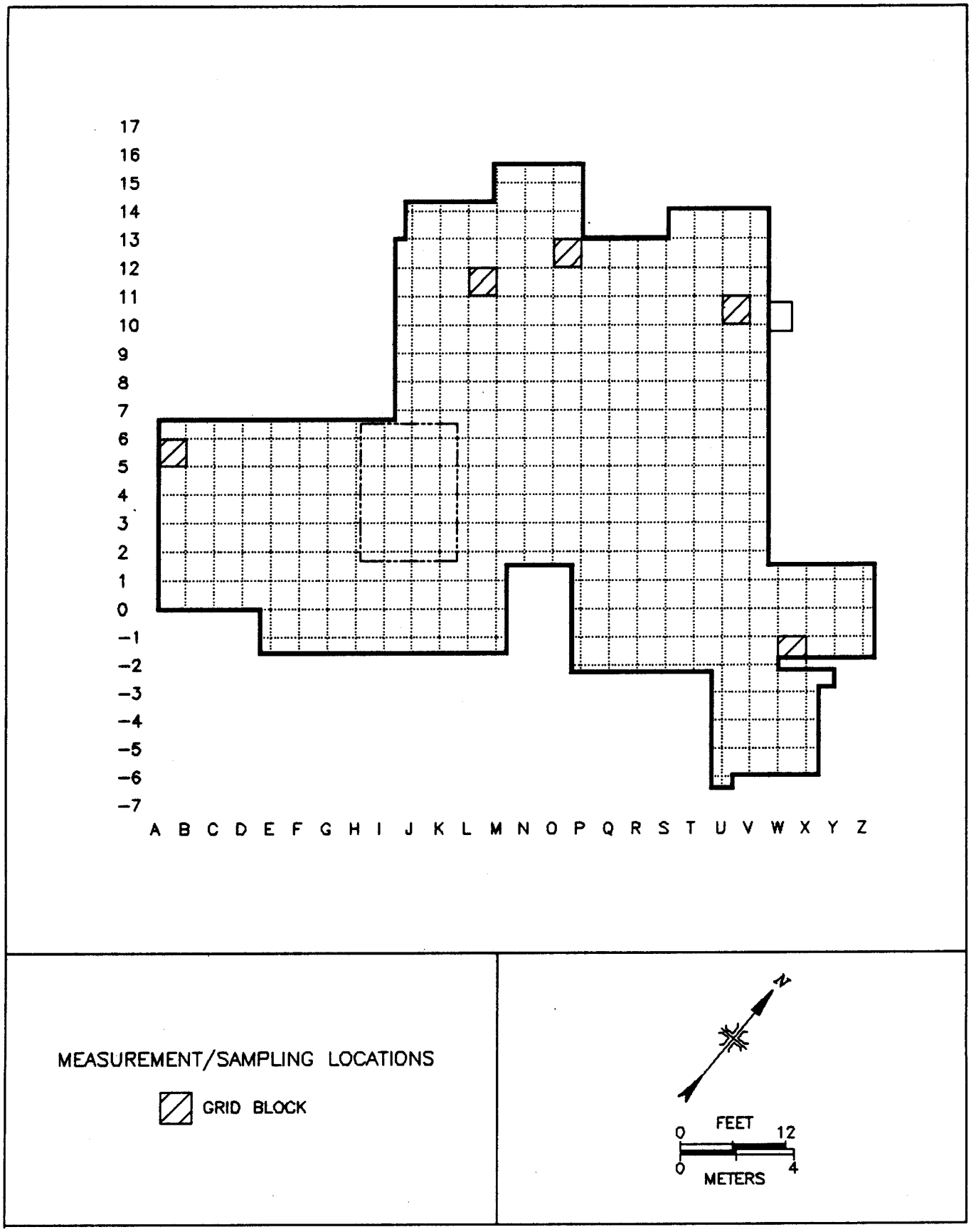

FIGURE 8: Building T028 Above Grade Pad – Reference Grid and Measurement and Sampling Locations

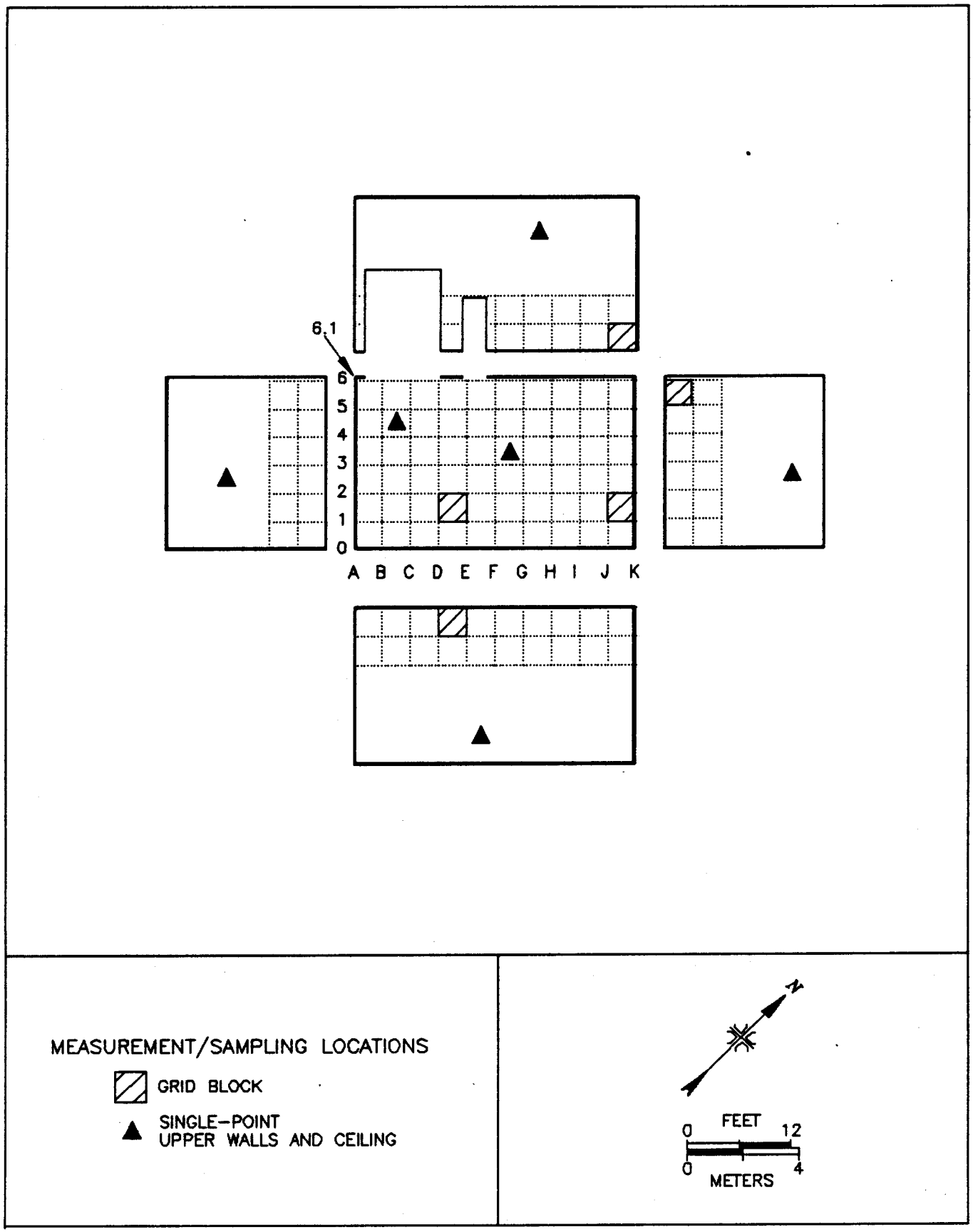

FIGURE 9: Building T028 Vault – Reference Grid and Measurement and Sampling Locations

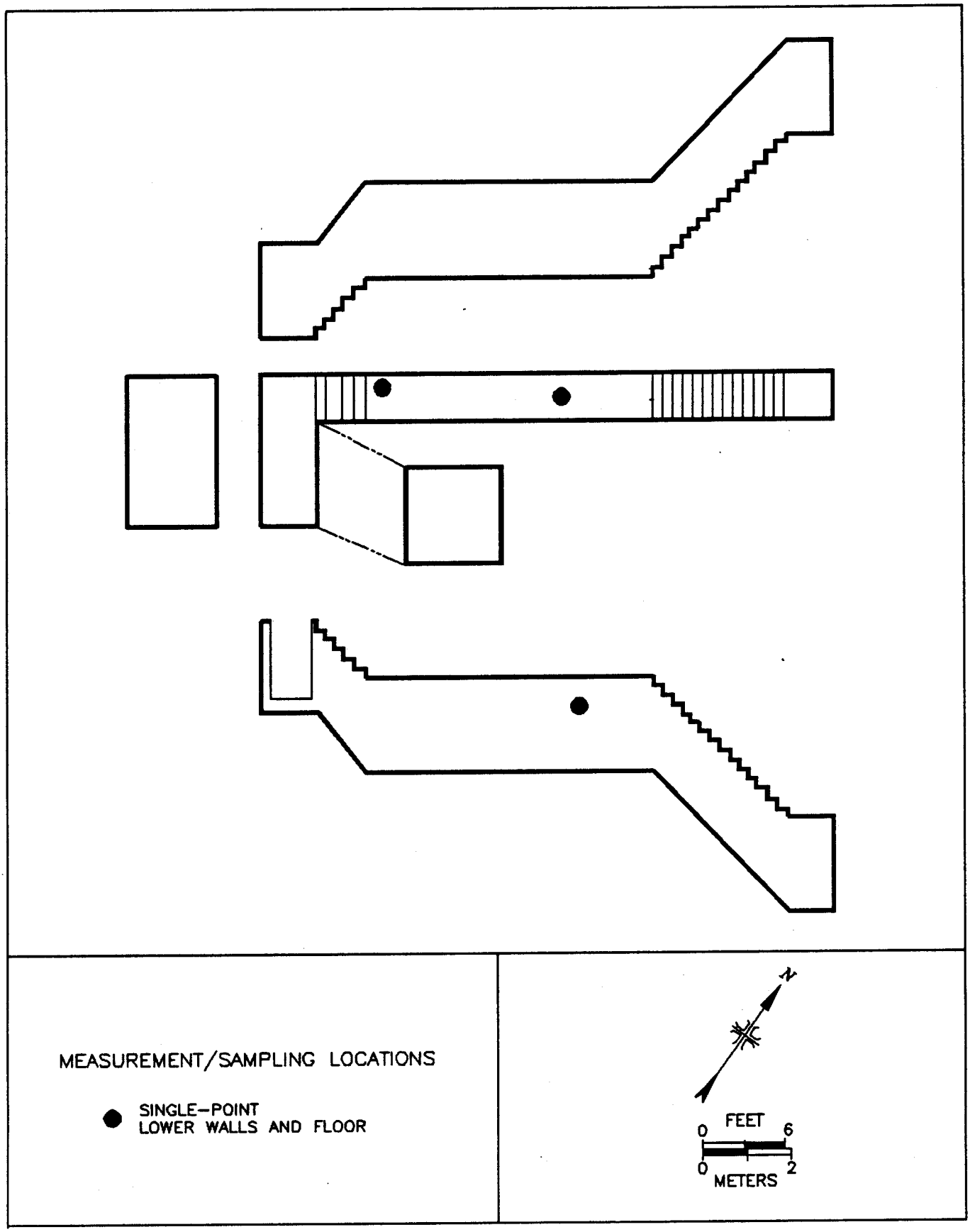

FIGURE 10: Building T028 Stairwell – Measurement and Sampling Locations

TABLE 1

RADIONUCLIDE CONCENTRATIONS IN SOIL
SANTA SUSANA FIELD LABORATORY
ROCKWELL INTERNATIONAL
CANOGA PARK, CALIFORNIA

Location[a]	Radionuclide Concentration (pCi/g)			
	Cs-137	Sr-90	U-235	U-238
OCY 0N, 5W[b]	0.6 ± 0.1[c]	<0.6	0.1 ± 0.1	1.4 ± 1.2
T064 Side Yard 0N, 20W[b]	7.5 ± 0.9	<0.5	<0.2	1.6 ± 1.2
10N, 10W[b]	27.7 ± 3.1	1.9 ± 1.0	0.4 ± 0.2	1.2 ± 1.2
9N, 19.5W[d]	35.1 ± 3.9	<0.4	0.3 ± 0.2	0.9 ± 1.2
19.5N, 8.5W[d]	210 ± 23	2.0 ± 0.3	0.3 ± 0.3	1.4 ± 2.8

[a]Refer to Figures 5 and 6.
[b]Radionuclide concentration levels presented are the averages for a composite sample representing a 100 m^2 area and include "hot-spots".
[c]Uncertainties represent the 95% confidence level, based only on counting statistics.
[d]Radionuclide concentration levels presented are those for a single "hot-spot" location.

TABLE 2

SUMMARY OF SURFACE ACTIVITY LEVELS
BUILDING T028
SANTA SUSANA FIELD LABORATORY
ROCKWELL INTERNATIONAL
CANOGA PARK, CALIFORNIA

Location[a]	Number of Measurement Locations		Range of Total Activity (dpm/100 cm²)				Range of Removable Activity (dpm/100 cm²)	
			Single Measurement		Grid Block Average			
	Single Pt.	Grid Blocks	Alpha	Beta	Alpha	Beta	Alpha	Beta
Foundation	N/A	5	<83-89	<860-1400	<83	<860-1200	<12	<15
Vault, Floor and Lower Wall	N/A	5	<83	<990-1000	<83	<990	<12	<15-25
Vault, Upper Wall and Ceiling	6	N/A	<83	<990	N/A	N/A	<12	<15
Vault, Stairwell	3	N/A	<83	<990-1000	N/A	N/A	<12	<15

[a]Refer to Figures 7, 8, and 9.

REFERENCES

1. Argonne National Laboratory, "A Manual for Implementing Residual Radioactive Material Guidelines", DOE/CH/8901, June 1989.

2. Rockwell International, "Final Decontamination and Radiological Survey of the Old Conservation Yard," Document No. N704SRR990030, 1990.

3. Rockwell International, "Final Decontamination and Radiological Survey of the Building T064 Side Yard," Document No. N704SRR99031, 1990.

4. Rockwell International "Final Decontamination and Radiological Survey of Building T028," Document No. N704SRR990033, 1991.

5. Vitkus, T.J., Oak Ridge Associated Universities. Letter to Anthony Kluk, Ph.D, Director, San Francisco Operations, U.S. Department of Energy, June 5, 1992.

APPENDIX A

MAJOR INSTRUMENTATION

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The display of a specific product is not to be construed as an endorsement of the product or its manufacturer by the author or their employers.

DIRECT RADIATION MEASUREMENT INSTRUMENTATION

Instruments

Eberline Pulse Ratemeter
Model PRM-6
(Eberline, Santa Fe, NM)

Eberline "Rascal" Ratemeter-Scaler
Model PRS-1
(Eberline, Santa Fe, NM)

Detectors

Eberline GM Detector
Model HP-260
Effective Area, 15.5 cm^2
(Eberline, Santa Fe, NM)

Eberline ZnS Scintillation Detector
Model AC-3-7
Effective Area, 59 cm^2
(Eberline, Santa Fe, NM)

Victoreen NaI Scintillation Detector
Model 489-55
3.2 cm x 3.8 cm Crystal
(Victoreen, Cleveland, OH)

LABORATORY ANALYTICAL INSTRUMENTATION

High-Purity Germanium Detector
Model GMX-23195-S, 23% Eff.
(EG&G ORTEC, Oak Ridge, TN)
Used in conjunction with:
Lead Shield Model G-16
(Gamma Products, Palos Hills, IL) and
Multichannel Analyzer
3100 Vax Workstation
(Canberra, Meriden, CT)

Low Background Gas Proportional Counter
Model LB-5110
(Tennelec, Oak Ridge, TN)

APPENDIX B

SURVEY AND ANALYTICAL PROCEDURES

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SURVEY PROCEDURES

Surface Scans

Surface scans were performed by passing the probes slowly over the surface; the distance between the probe and the surface was maintained at a minimum—nominally about 1 cm. Surfaces were scanned using portable gamma scintillation and small area (15.5 cm^2 or 59 cm^2) hand-held detectors. Identification of elevated levels was based on increases in the audible signal from the recording and/or indicating instrument. Combinations of detectors and instruments used for the scans were:

Alpha	-	ZnS scintillation detector with ratemeter-scaler
Beta	-	GM detector with ratemeter-scaler
Gamma	-	NaI scintillation detector with ratemeter

Surface Activity Measurements

Measurements of total alpha and total beta activity levels were performed using ZnS scintillation and GM detectors with ratemeter-scalers. Count rates (cpm), which were integrated over 1 minute in a static position, were converted to activity levels (dpm/100 cm^2) by dividing the net rate by the instrumentations 4 π efficiency, determined at calibration, and correcting for the active area of the detector. The alpha activity background countrates for the ZnS scintillation detectors averaged approximately 1 cpm for each detector. The alpha efficiency factor was 0.19 for the ZnS scintillation detectors. The beta activity background count rate for the GM detectors averaged 52 cpm. Beta efficiency factors ranged from 0.24 to 0.27 for the GM detectors. The effective windows for the ZnS scintillation and GM detectors were 59 cm^2 and 15.5 cm^2, respectively.

Removable Activity Measurements

Removable activity levels were determined using numbered filter paper disks, 47 mm in diameter. Moderate pressure was applied to the smear and approximately 100 cm^2 of the surface was wiped. Smears were placed in labeled envelopes with the location and other pertinent information recorded.

Soil Sampling

Approximately 1 kg of soil was collected at each sample location. Collected samples were placed in a plastic bag, sealed, and labeled in accordance with ESSAP survey procedures.

ANALYTICAL PROCEDURES

Removable Activity

Smears were counted on a low background gas proportional system for gross alpha and gross beta activity.

Gamma Spectrometry

Soil Samples

Samples of soil were dried, mixed, crushed, and/or homogenized as necessary, and a portion sealed in 0.5-liter Marinelli beaker or other appropriate container. The quantity placed in the beaker was chosen to reproduce the calibrated counting geometry and ranged from 800 to 900 g of material. Net material weights were determined and the samples counted using intrinsic germanium detectors coupled to a pulse height analyzer system. Background and Compton stripping, peak search, peak identification, and concentration calculations were performed using the computer capabilities inherent in the analyzer system. Energy peaks used for determination of radionuclides of concern were:

Cs-137	0.662 MeV
U-235	0.143 MeV (or 0.186 MeV)
U-238	0.063 and 0.093 MeV from Th-234*
	(or 1.001 MeV from Pa-234 m)*

*Secular equilibrium assumed.

Spectra were also reviewed for other identifiable photopeaks.

Strontium-90

Soil Samples

Soil samples were dried, mixed, crushed and then aliquots of the soil were dissolved using a potassium fluoride pyrosulfate fusion in which strontium was precipitated as a sulfate. Successive treatments with EDTA preferentially removed lead and excess calcium and returned the strontium to solution. Ferric and other insoluble hydroxides were precipitated at a pH of 12 to 14. Strontium was reprecipitated as a sulfate and barium was removed as a chromate using DTPA. The final precipitate of strontium carbonate was counted using a low-background gas proportional counter and the activity calculated using an in-house algorithm specifically designed for strontium analyses.

UNCERTAINTIES AND DETECTION LIMITS

The uncertainties associated with the analytical data presented in the tables of this report represent the 95% confidence level for that data. These uncertainties were calculated based on both the gross sample count levels and the associated background count levels. When the net sample count was less than 95% statistical deviation of the background count, the sample concentration was reported as less than the detection limit of the measurement procedures. Because of variations in background levels, measurement efficiencies, and contributions from other radionuclides in samples, the detection limits differ from sample to sample and instrument to instrument. Additional uncertainties, associated with sampling and measurement procedures, have not been propagated into the data presented in this report.

CALIBRATION AND QUALITY ASSURANCE

Analytical and field survey activities were conducted in accordance with procedures from the following documents:

-Survey Procedures Manual Revision 7 (June 1992)
-Laboratory Procedures Manual Revision 6 (April 1991)
-Quality Assurance Manual Revision 5 (June 1992)

The procedures contained in these manuals were developed to meet the requirements of DOE Order 5700.6B and 5700.6C for Quality Assurance and contain measures to assess processes during their performance.

Calibration of all field and laboratory instrumentation was based on standards/sources, traceable to NIST, when such standards/sources were available. In cases where they were not available, standards of an industry recognized organization were used.

Quality control procedures include:

- Daily instrument background and check-source measurements to confirm that equipment operation is within acceptable fluctuations.

- Participation in EPA and EML laboratory Quality Assurance Programs.

- Training and certification of all individuals performing procedures.

- Periodic internal and external audits.

APPENDIX C

RESIDUAL RADIOACTIVE MATERIAL GUIDELINES SUMMARIZED FROM DOE ORDER 5400.5

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RESIDUAL RADIOACTIVE MATERIAL GUIDELINES SUMMARIZED FROM DOE ORDER 5400.5

BASIC DOSE LIMITS

The basic limit for the annual radiation dose (excluding radon) received by an individual member of the general public is 100 mrem/yr. In implementing this limit, DOE applies as low as reasonable achievable principles to set site-specific guidelines.

STRUCTURE GUIDELINES

Surface Contamination Guidelines

Radionuclides[2]	Allowable Total Residual Surface Contamination (dpm/100 cm^2)[1] Average[3,4]	Maximum[4,5]	Removable[4,6]
Transuranics, I-125, I-129, Ra-226, Ac-227, Ra-228, Th-228, Th-230, Pa-231	Reserved	Reserved	Reserved
Th-Natural, Sr-90, I-126, I-131, I-133, Ra-223, Ra-224, U-232, Th-232	1,000	3,000	200
U-Natural, U-235, U-238, and associated decay product, alpha emitters	5,000α	15,000α	1,000α
Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above.[7]	5,000β-γ	15,000β-γ	1,000β-γ

External Gamma Radiation

The average level of gamma radiation inside a building or habitable structure on a site that has no radiological restriction on its use shall not exceed the background level by more than 20 μR/h and will comply with the basic dose limits when an appropriate-use scenario is considered.

SOIL GUIDELINES

Radionuclides	Soil Concentration (pCi/g) Above Background[8,9]
Cs-137 and Sr-90	Soil guidelines are calculated on a site-specific basis, using the DOE manual developed for this use.

[1] As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute measured by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

[2] Where surface contamination by both alpha- and beta-gamma-emitting radionuclides exists, the limits established for alpha- and beta-gamma-emitting radionuclides should apply independently.

[3] Measurements of average contamination should not be averaged over an area of more than 1 m^2. For objects of less surface area, the average should be derived for each such object.

[4] The average and maximum dose rates associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h and 1.0 mrad/h, respectively, at 1 cm.

[5] The maximum contamination level applies to an area of not more than 100 cm^2.

[6] The amount of removable material per 100 cm^2 of surface area should be determined by wiping an area of that size with dry filter or soft absorbent paper, applying moderate pressure, and measuring the amount of radioactive material on the wiping with an appropriate instrument of known efficiency. When removable contamination on objects of surface area less than 100 cm^2 is determined, the activity per unit area should be based on the actual area and the entire surface should be wiped. It is not necessary to use wiping techniques to measure removable contamination levels if direct scan surveys indicate that total residual surface contamination levels are within the limits for removable contamination.

[7] This category of radionuclides includes mixed fission products, including the Sr-90 which is present in them. It does not apply to Sr-90, which has been separated from the other fission products, or mixtures where the Sr-90 has been enriched.

[8] These guidelines represent allowable residual concentrations above background averaged across any 15-cm-thick layer to any depth and over any contiguous 100 m^2 surface area.

[9] If the average concentration in any surface or below-surface area, less than or equal to 25 m^2, exceeds the authorized limit of guideline by a factor of $(100/A)^{1/2}$, where A is the area or the elevated region in square meters, limits for "hot spots" shall also be applicable. Procedures for calculating these hot spot limits, which depend on the extent of the elevated local concentrations, are given in the DOE Manual for Implementing Residual Radioactive Materials Guidelines, DOE/CH/8901. In addition, every reasonable effort shall be made to remove any source of radionuclide that exceeds 30 times the appropriate limit for soil, irrespective of the average concentration in the soil.