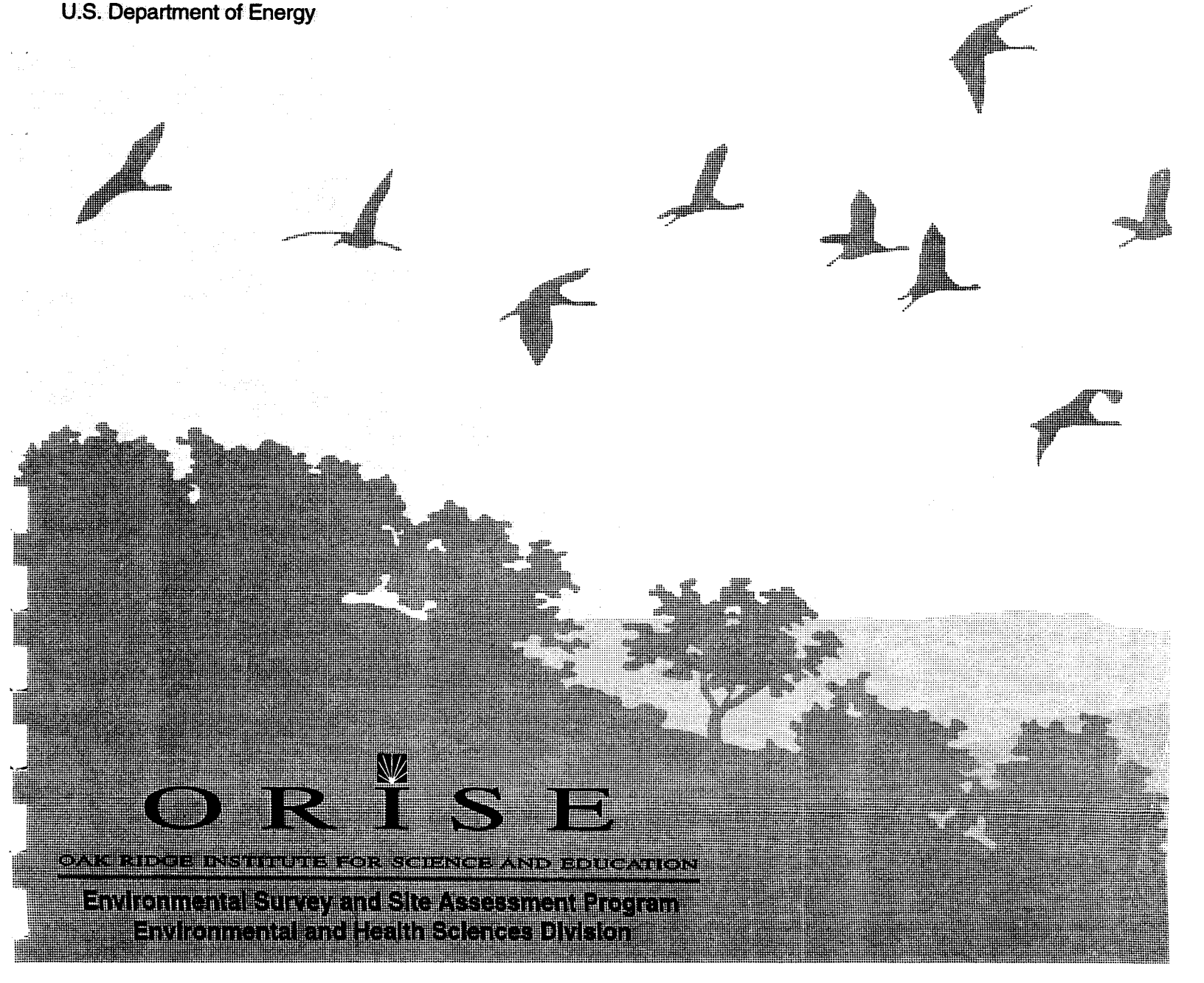
VERIFICATION SURVEY OF THE INTERIM STORAGE FACILITY (T654) SANTA SUSANA FIELD LABORATORY ROCKWELL INTERNATIONAL VENTURA COUNTY, CALIFORNIA

T. J. VITKUS

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



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Prepared by

T. J. Vitkus

Environmental Survey and Site Assessment Program
Environmental and Health Sciences Division
Oak Ridge Institute for Science and Education
Oak Ridge, Tennessee 37831-0117

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VERIFICATION SURVEY
OF THE
INTERIM STORAGE FACILITY (T654)
SANTA SUSANA FIELD LABORATORY
ROCKWELL INTERNATIONAL
VENTURA COUNTY, CALIFORNIA

Prepared by: _____ Date: 11/20/97
T. J. Vitkus, Survey Projects Manager
Environmental Survey and Site Assessment Program

Reviewed by: _____ Date: 12/1/97
R. D. Condra, Technical Resource Manager
Environmental Survey and Site Assessment Program

Reviewed by: _____ Date: 11/24/97
A. T. Payne, Quality Assurance/Safety Manager
Environmental Survey and Site Assessment Program

Reviewed by: _____ Date: 11/25/97
E. W. Abelquist, Assistant Program Director
Environmental Survey and Site Assessment Program

Reviewed by: _____ Date: 12/2/97
W. L. Beck, Program Director
Environmental Survey and Site Assessment Program

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FIELD STAFF

T. D. Herrera
J. R. Morton

LABORATORY STAFF

R. D. Condra
J. S. Cox
M. J. Laudeman

CLERICAL STAFF

D. K. Herrera
K. E. Waters

ILLUSTRATOR

T. D. Herrera

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ABBREVIATIONS AND ACRONYMS

μR/h	microroentgens per hour
AEC	Atomic Energy Commission
ASME	American Society of Mechanical Engineers
cm	centimeter
DOE	U.S. Department of Energy
EML	Environmental Measurements Laboratory
EPA	Environmental Protection Agency
ERDA	Energy Research and Development Administration
ESSAP	Environmental Survey and Site Assessment Program
ETEC	Energy Technology Engineering Center
GM	Geiger Mueller
ha	hectare
ISF	Interim Storage Facility
kg	kilograms
km	kilometer
M&O	Management and Operating
MDC	minimum detectable concentration
NaI	sodium iodide
NIST	National Institute of Standards and Technology
NRC	U.S. Nuclear Regulatory Commission
ORISE	Oak Ridge Institute for Science and Education
pCi/g	picocuries per gram
PIC	pressurized ionization chamber
SSFL	Santa Susana Field Laboratory
SNAP	Systems for Nuclear and Auxiliary Power
SRE	Sodium Reactor Experiment

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SANTA SUSANA FIELD LABORATORY
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INTRODUCTION AND SITE HISTORY

Rockwell International's Rocketdyne Division, now known as Rocketdyne/Boeing, operates the Santa Susana Field Laboratory (SSFL). The Energy Technology Engineering Center (ETEC) is that portion of the SSFL, operated for the Department of Energy (DOE), where nuclear energy research and development programs were performed. 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 engineering, developing, testing, and manufacturing operations for nuclear reactor systems and components. Other SSFL activities have also been conducted for the National Aeronautics and Space Administration, the Department of Defense, and other government related or affiliated organizations and agencies. Some activities have been licensed by the Nuclear Regulatory Commission and by the State of California Radiological Health Branch of the Department of Health Services.

Numerous buildings and land areas became radiologically contaminated as a result of the various activities which included operation of ten reactors and 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 and enriched isotopic abundances), plutonium, Am-241, fission products (primarily Cs-137 and Sr-90), activation products (H-3, Co-60, Eu-152, Eu-154, Ni-63, Pm-147, and Ta-182). Chemical contaminants, mainly chlorinated organic solvents, have also been identified in groundwater, primarily as a result of rocket engine testing.

Decontamination and decommissioning of contaminated facilities began in the late 1960's and continues as the remaining DOE program operations at ETEC have been terminated effective September 30, 1995. As part of this program, Rocketdyne/Boeing performed decommissioning and final status surveys of a number of facilities that supported the various nuclear related ETEC operations during the latter part of the 1950's and continuing through the 1980's. Environmental management of DOE contaminated properties continues under the termination clause of the existing Management and Operating (M&O) contract. Surplus sodium facilities have been included in the current DOE Environmental Restoration and Waste Management Program for stabilization and eventual cleanup.

The Interim Storage Facility (ISF), also referred to as DOE Facility 654, was constructed in 1958 to support the Sodium Reactor Experiment (SRE). The ISF was used to store dummy and irradiated fuel elements, shipping and storage casks, hot waste generated at the SRE, and items from the Organic Moderated Reactor Experiment and Systems for Nuclear Auxiliary Power (SNAP). The ISF consisted of a concrete pad with a trench containing eight 51-centimeter diameter galvanized steel cells extending 7.6 meters into the rock strata. While the ISF was in use, a number of the items stored there deteriorated and released low-level contamination to adjacent asphalt and concrete surfaces and soil areas. Decommissioning of the ISF began in 1984 and involved removal of contaminated surfaces, soil, and the storage cells. A radiological survey was performed; the area was backfilled and then returned to a natural state (Rockwell 1985). Due to limited subsurface soil data, Rocketdyne/Boeing performed further subsurface soil sampling on September 30, 1997 in order to supplement the original final status survey.

DOE's Office of Environmental Restoration, Northwestern Area Programs 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 purpose of these independent verifications is to confirm that remedial actions have been effective in meeting established and supplemental guidelines and that the documentation accurately and adequately describes the radiological conditions at the site. The Environmental Survey and Site Assessment Program (ESSAP) of the Oak Ridge Institute for Science and Education (ORISE) was designated as the

organization responsible for this task at SSFL and was requested by the DOE to perform verification surveys of the ISF. This report describes the results of the verification surveys.

SITE DESCRIPTION

The SSFL is located in the Simi Hills of southeastern Ventura County, California, approximately 47 kilometers (29 miles) northwest of downtown Los Angeles (Figure 1). The site is comprised of approximately 1,090 hectares (ha [2,700 acres]) and is divided into four administrative areas (Areas I through IV) and a Buffer Zone. DOE operations were conducted in Rockwell International-owned and DOE-owned facilities located within the 117 ha Area IV (Figure 2). The ETEC portion of Area IV consists of government-owned buildings that occupy 36 ha.

The ISF was located in the north-central portion of Area IV. The ISF was paved with a concrete berm containing the eight storage cells. The pavement, berms, and storage cells were removed during the decommissioning and the area was backfilled and graded. Total area of the ISF is approximately 1000 m^2. Figures 2 and 3 show the location and plot plan of the ISF.

OBJECTIVE

The objective of the verification surveys was to validate that cleanup procedures and survey methods used by Rocketdyne/Boeing were adequate. Perfomance of independent document reviews and evaluation of measurement and sampling data provide assurance that the post-remediation data were sufficient, accurate, and demonstrate that remedial actions were accomplished in accordance with appropriate standards and guidelines, and that authorized limits were met.

DOCUMENT REVIEW

ESSAP previously reviewed Rocketdyne/Boeing's supporting documentation concerning final status survey procedures and results for the ISF (Rockwell 1985). This documentation was judged to be inadequate under current practice to justify release of the facility for use without radiological restrictions. A supplemental survey plan was developed by Rocketdyne (Boeing 1997) for a cooperative soil sampling effort with ESSAP.

PROCEDURES

ESSAP personnel initially conducted independent measurement and sampling activities of the ISF during the period September 11 through 14, 1995, the results of which were initially provided in a 1996 report (ORISE 1996a). To address the lack of detailed analyses of subsurface soil, Rocketdyne/Boeing provided a drilling contractor to perform subsurface sampling at three locations within the ISF on September 30, 1997. At each borehole location, the contractor used mechanical augers to advance the borehole in 2.4-meter increments, at which point a split-spoon sampler was driven into the soil in order to obtain the sample for ESSAP. ESSAP's survey activities were performed in accordance with two site-specific survey plans (ORISE 1995a and 1997a), using procedures and instruments described in the ESSAP Survey Procedures and Quality Assurance Manuals which are summarized in Appendices A and B (ORISE 1995b and 1995c).

REFERENCE SYSTEM

Measurement and sampling locations were referenced to prominent site features during the initial survey and to Rocketdyne/Boeing's grid system during the subsurface investigations. Field data was recorded on representative area drawings.

SURFACE SCANS

Surface scans for gamma activity were performed over 100 percent of the ISF during the 1995 survey. The ISF was excavated to a depth of 7.5 to 9 meters when the storage cells were removed

and then backfilled to grade. As a result of backfilling, the original soil was inaccessible except by drilling; therefore, scans of the ISF were concentrated in the peripheral areas where contamination may have migrated. Surface scans were performed using NaI scintillation detectors coupled to ratemeters with audible indicators.

Each subsurface sample core was scanned with a GM detector for beta-gamma activity. After the completion of each borehole and the removal of the auger, the borehole was gamma logged at one meter intervals using a NaI scintillation detector enclosed within a lead collimator that had four slots at the detector midpoint.

EXPOSURE RATE MEASUREMENTS

Exposure rate measurements were performed at four locations in the ISF area. Figure 3 shows the measurement locations. Exterior background exposure rate measurements were made at six locations within 0.5 to 10 km of the site (Figure 4). Exposure rate measurements were performed at one meter above the surface using a pressurized ionization chamber (PIC).

SOIL SAMPLING

Individual surface soil samples were collected from four locations in the ISF area. Four samples were collected from each of the three boreholes at depth intervals of 2.4 meters. Sampling locations are shown on Figure 3. Soil samples were collected from the six background exposure rate measurement locations (Figure 4).

SAMPLE ANALYSIS AND DATA INTERPRETATION

Samples and data were returned to ORISE's ESSAP laboratory in Oak Ridge, Tennessee for analysis and interpretation. Sample analysis was in accordance with the ORISE/ESSAP Laboratory Procedures Manuals (ORISE 1995d and 1997b). Soil samples were analyzed by solid-state gamma spectrometry. Spectra were reviewed for U-238, U-235, Th-232, Cs-137, Co-60 and any other identifiable photopeaks, particularly longer-lived activation and fission products. Four

composite samples were analysed for Sr-90 by wet chemistry methods. The composite samples were prepared from equal aliquots of the samples collected from each borehole at the respective depth interval. Soil analytical results were reported in picocuries per gram (pCi/g). Exposure rates were reported in microroentgens per hour (μR/h).

FINDINGS AND RESULTS

DOCUMENT REVIEW

Based on the review of the initial 1985 project document, it was ESSAP's opinion that the documentation was inadequate to satisfactorily demonstrate that the ISF met the DOE guidelines for release for unrestricted use. Overall, the documentation did not provide a clear description of the sequence of events necessary for demonstrating compliance with the DOE guidelines. That is, the specification of contaminants present, selection of the appropriate guidelines, development of a sampling and analysis plan that provided adequate data for guideline interpretation, and presentation of the data in a manner that could be directly compared with the guidelines were not adequately identified. The types of deficiencies noted included the following: all potential contaminants were not identified, final surveys were not designed to identify residual contamination of all suspected radionuclides, radionuclide-specific sample analyses were not performed (i.e., gross beta analysis of soil samples was performed and the data used for demonstrating compliance), and appropriate guidelines were not always cited or unapproved site-specific guidelines were used. Comments on the documentation were provided to the DOE (ORISE 1996b). Rocketdyne/Boeing responded to these comments for the ISF by developing and implementing additional survey activities for the ISF that would address each of the deficiencies (Boeing 1997).

Surface Scans

Gamma surface scans and borehole logging did not identify any locations of elevated direct radiation indicative of residual contamination. Beta-gamma scans of the extracted sample cores also did not identify any elevated direct radiation.

Exposure Rates

Exposure rates are summarized in Table 1. Exposure rates for the ISF were 15 μR/h. Exterior background exposure rates ranged from 12 to 16 μR/h, and averaged 14 μR/h.

Radionuclide Concentrations in Soil

Radionuclide concentrations in soil samples are summarized in Table 2. Background concentration ranges for the naturally occurring radionuclides were less than 0.20 to 1.19 pCi/g for Ra-226, 0.56 to 1.72 pCi/g for Th-232, less than 0.13 pCi/g for U-235, and less than 2.15 to 2.54 pCi/g for U-238. Background concentrations of activation and fission products and Am-241 were all less than the respective minimum detectable concentration (MDC)—the maximum MDC was 1.09 pCi/g for Cr-51—with the exception of Cs-137 which ranged from less than 0.07 to 0.24 pCi/g. Radionuclide concentrations in the samples collected from the ISF ranged from less than 0.61 to 1.25 pCi/g for Ra-226, 0.67 to 1.94 pCi/g for Th-232, less than 0.84 pCi/g for U-235, and less than 2.35 pCi/g for U-238. All activation and fission products were less than the maximum MDC of 1.50 pCi/g for Cr-51. Only Cs-137 was detected above the MDC, as found with the background samples, with a concentration range of less than 0.22 to 0.43 pCi/g. The four borehole composite samples that were analyzed for Sr-90 were less than the MDCs, which ranged from 0.39 to 0.55 pCi/g. All MDCs were well below the associated authorized release limits.

COMPARISON OF RESULTS WITH GUIDELINES

The primary contaminants of concern for this site are uranium and mixed fission and activation products. The applicable site-specific guidelines are provided in Table 3 and have been approved by both the DOE (DOE 1996), in accordance with DOE Order 5400.5 which is summarized in Appendix C (DOE 1990), and the State of California (State of California 1996). All quantified radionuclide concentrations were less than the respective guideline.

The DOE's exposure rate guideline is 20 μR/h above background (DOE 1990), although Rocketdyne/Boeing has elected to use a more restrictive guideline of 5 μR/h above background. Exposure rates at one meter above the surface were within this guideline.

SUMMARY

The Environmental Survey and Site Assessment Program of the Oak Ridge Institute for Science and Education conducted verification activities for the ISF at the Santa Susana Field Laboratory in Ventura County, California. Verification activities included document reviews and during the period September 9 through 12, 1995 and September 30, 1997, ESSAP personnel visited the site and performed independent surface scans, surface activity measurements, exposure rate measurements, and soil sampling.

ESSAP's review identified a number of deficiencies in the ISF's final status documentation for the survey performed by Rocketdyne in 1984-1985. The deficiencies were addressed by Rocketdyne/Boeing through additional site investigations and by providing subsurface soil sampling for this verification survey. ESSAP's verification survey results for the area showed that exposure rates and radionuclide concentration levels in soil were comparable to background concentrations and correspondingly less than the guidelines for release for unrestricted use.

FIGURES

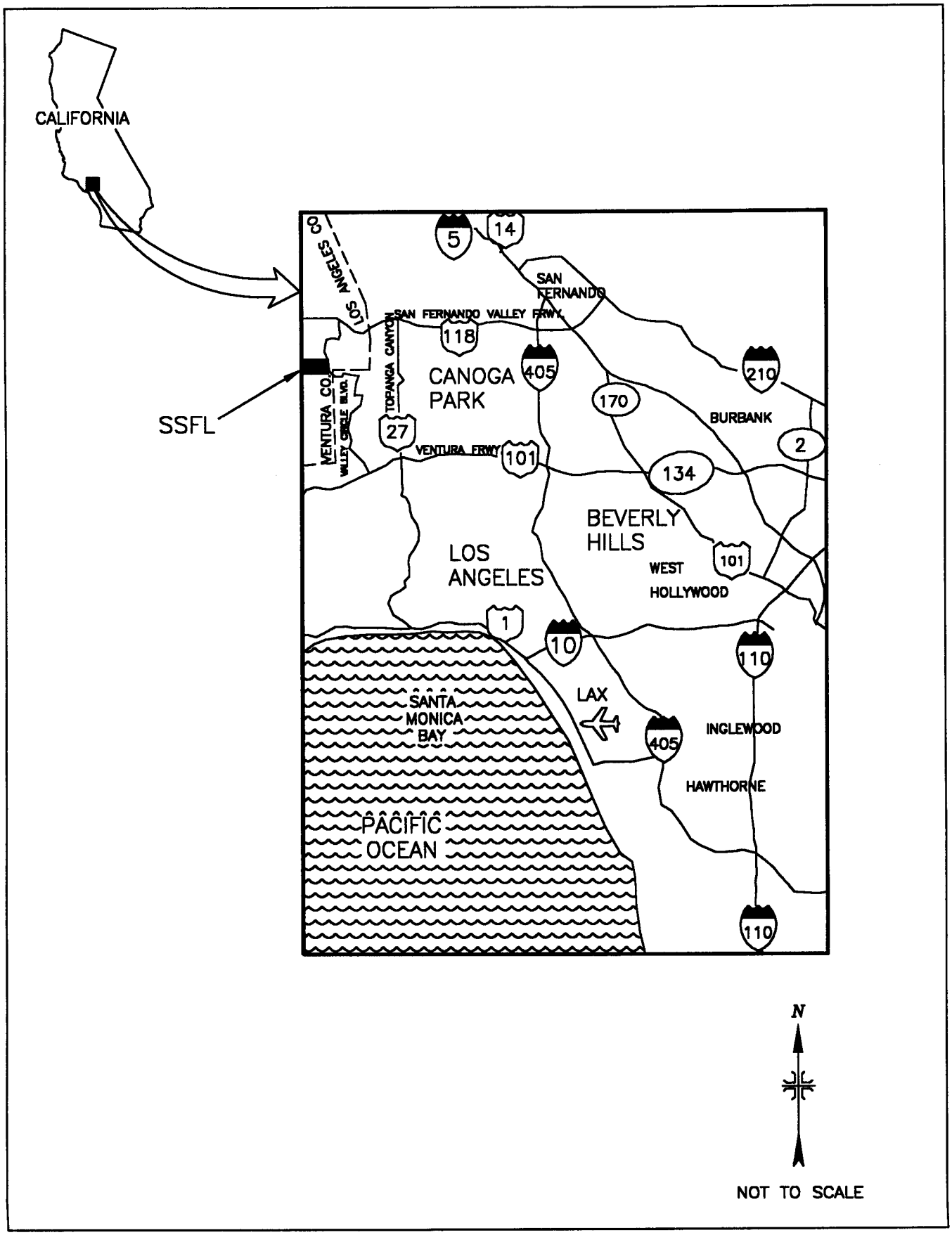

FIGURE 1: Los Angeles, California Area – Location of the Santa Susana Field Laboratory Site

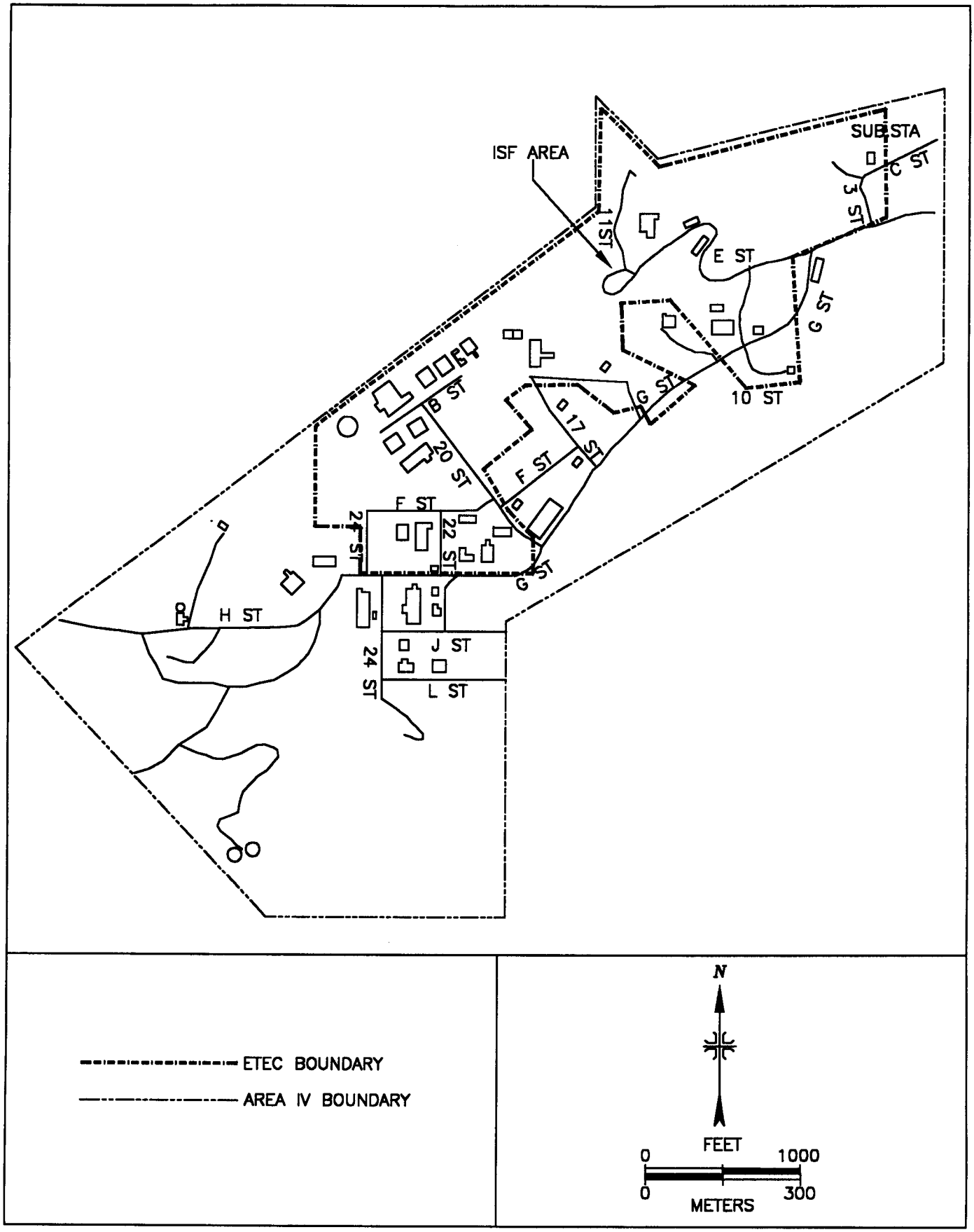

FIGURE 2: Santa Susana Field Laboratory Area IV, Plot Plan – Location of the Interim Storage Facility (T654)

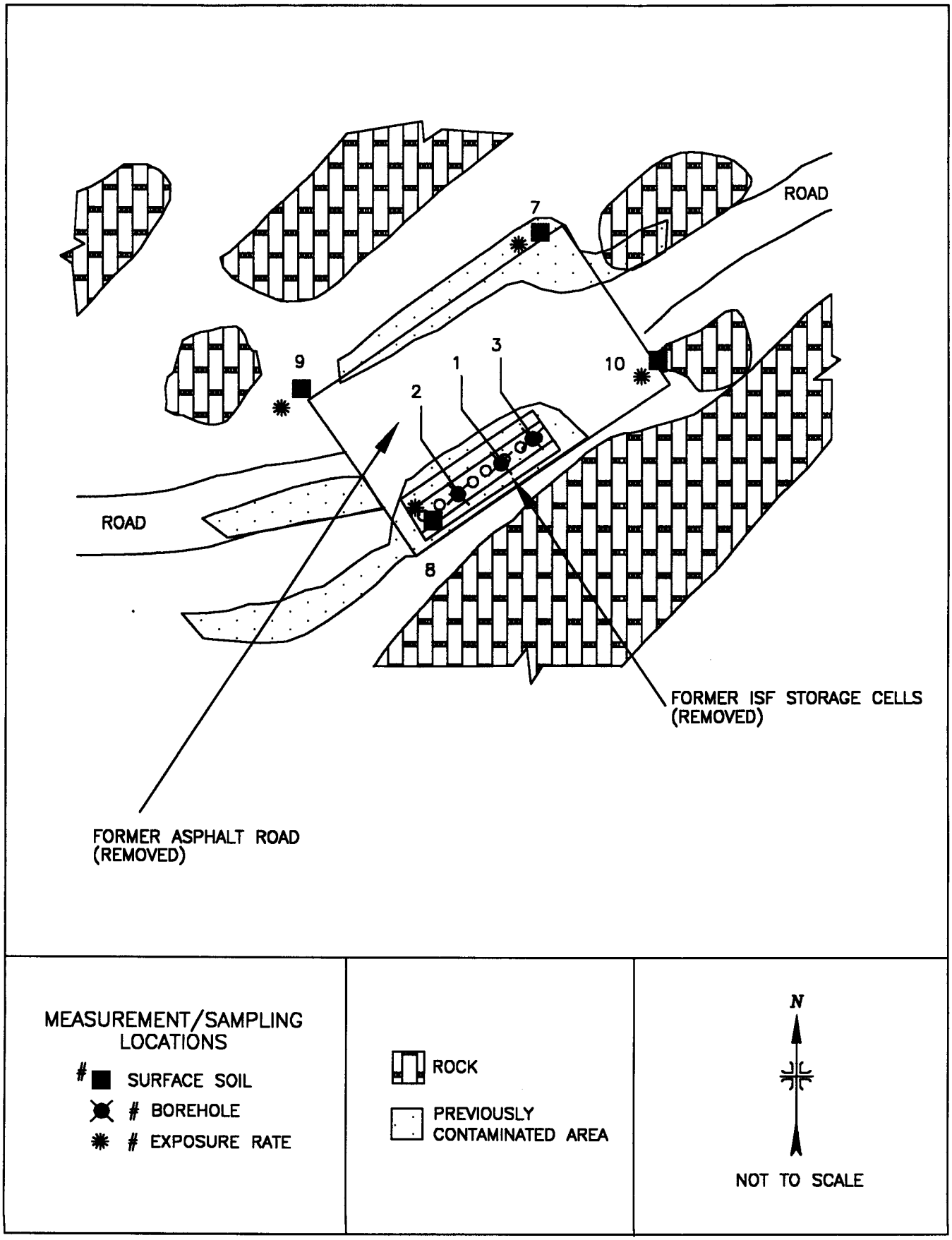

FIGURE 3: Interim Storage Facility – Plot Plan and Measurement and Sampling Locations

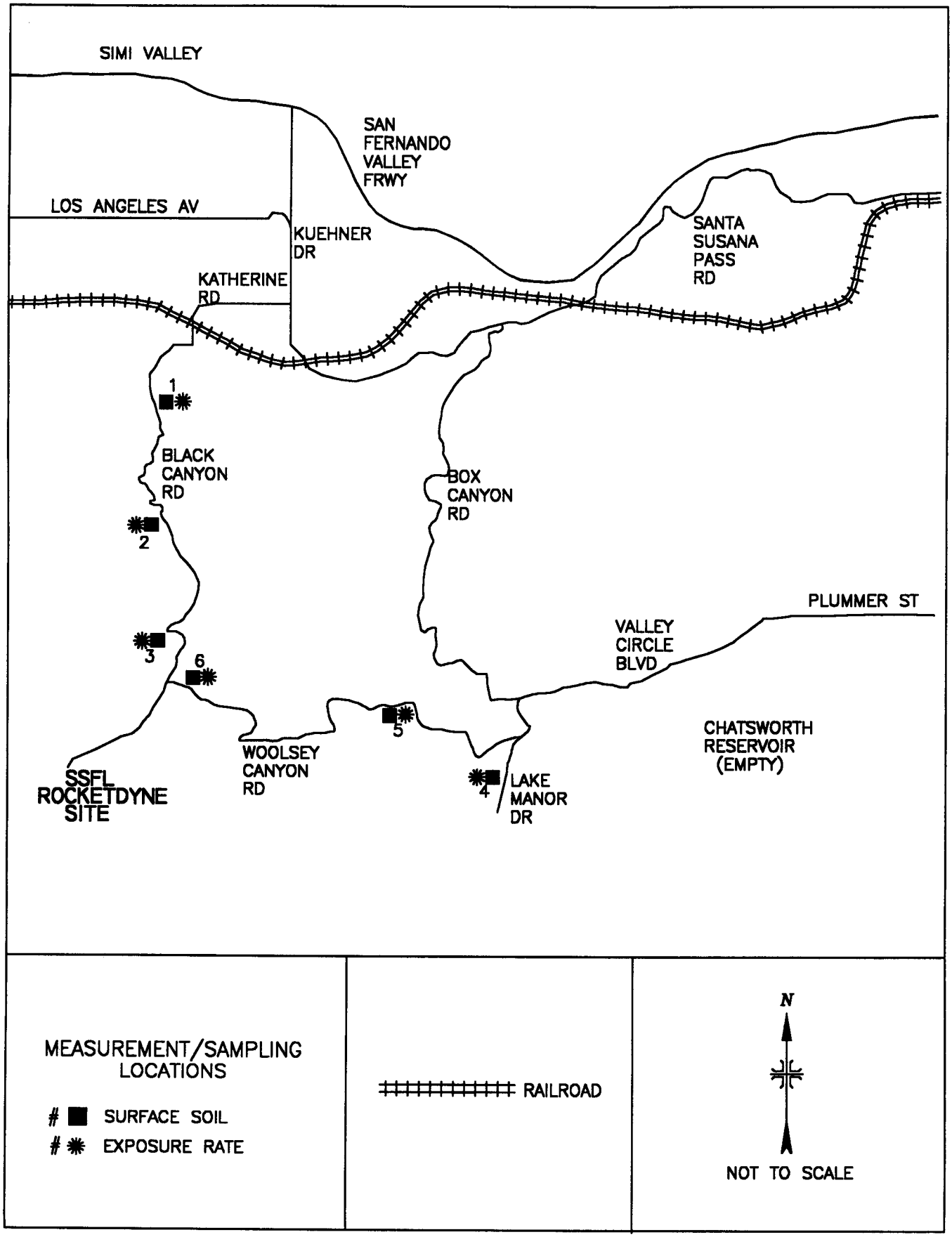

FIGURE 4: Santa Susana Field Laboratory, Ventura County, California – Background Measurement and Sampling Locations

TABLES

TABLE 1

BACKGROUND AND INTERIM STORAGE FACILITY EXPOSURE RATES SANTA SUSANA FIELD LABORATORY ROCKWELL INTERNATIONAL VENTURA COUNTY, CALIFORNIA

Location[a]	Exposure Rate at 1 m above Surface (μR/h)
Backgrounds	
#1 Gaston Road	13
#2 Black Canyon Road	16
#3 Black Canyon Road	14
#4 Valley Circle Road	15
#5 Woolsey Canyon Road	12
#6 Woolsey Canyon Road	14
Interim Storage Facility	
#7	15
#8	15
#9	15
#10	15

[a]Refer to Figures 3 and 4.

TABLE 2

RADIONUCLIDE CONCENTRATIONS IN SOIL
FORMER INTERIM STORAGE FACILITY (T654)
SANTA SUSANA FIELD LABORATORY
ROCKWELL INTERNATIONAL
VENTURA COUNTY, CALIFORNIA

Location[a]	Radionuclide Concentration (pCi/g)														
	Am-241	Co-57	Co-58	Co-60	Cr-51	Cs-137	Eu-152	Fe-59	Mn-54	Ra-226	Sb-124	Th-232	U-235	U-238	Zn-65
Borehole #1															
2.4m	<0.13	<0.04	<0.07	<0.09	<0.54	0.11 ± 0.09	<0.17	<0.15	<0.07	0.80 ± 0.18	<0.08	1.37 ± 0.39	<0.35	<1.44	<0.23
4.9m	<0.12	<0.04	<0.06	<0.09	<0.42	<0.08	<0.14	<0.14	<0.06	0.58 ± 0.13	<0.06	1.13 ± 0.31	<0.28	1.92 ± 1.20	<0.16
7.3m	<0.11	<0.03	<0.05	<0.09	<0.40	<0.05	<0.12	<0.14	<0.06	0.65 ± 0.13	<0.05	1.31 ± 0.30	<0.28	<1.17	<0.14
9.8m	<0.22	<0.06	<0.11	<0.15	<0.94	<0.11	<0.25	<0.32	<0.12	0.73 ± 0.22	<0.04	1.15 ± 0.43	<0.62	1.13 ± 1.49	<0.29
Borehole #2															
2.4m	<0.10	<0.04	<0.08	<0.12	<0.59	<0.08	<0.19	<0.21	<0.08	0.51 ± 0.15	<0.10	0.67 ± 0.39	<0.30	1.40 ± 1.05	<0.21
4.9m	<0.10	<0.04	<0.08	<0.12	<0.59	<0.08	<0.19	<0.21	<0.08	0.51 ± 0.15	<0.06	0.79 ± 0.37	<0.33	0.67 ± 0.78	<0.20
7.3m	<0.12	<0.04	<0.09	<0.12	<0.64	<0.10	<0.20	<0.20	<0.09	0.52 ± 0.15	<0.07	1.25 ± 0.36	<0.37	1.95 ± 1.07	<0.17
9.8m	<0.21	<0.06	<0.10	<0.13	<0.73	<0.08	<0.26	<0.25	<0.11	0.59 ± 0.18	<0.08	1.15 ± 0.41	<0.52	<2.35	<0.23
Borehole #3															
2.4m	<0.11	<0.03	<0.06	<0.09	<0.45	<0.06	<0.15	<0.14	<0.06	0.64 ± 0.14	<0.09	1.39 ± 0.35	<0.29	1.23 ± 1.39	<0.16
4.9m	<0.11	<0.04	<0.07	<0.09	<0.48	0.24 ± 0.10	<0.17	<0.15	<0.06	0.75 ± 0.17	<0.05	1.18 ± 0.37	<0.33	0.89 ± 0.95	<0.15
7.3m	<0.13	<0.04	<0.05	<0.10	<0.42	0.36 ± 0.06	<0.14	<0.12	<0.06	0.86 ± 0.14	<0.05	1.23 ± 0.30	<0.28	<1.21	<0.16
9.8m	<0.27	<0.09	<0.20	<0.22	<1.50	<0.22	<0.48	<0.50	<0.23	<0.61	<0.04	1.94 ± 0.78	<0.84	0.60 ± 1.61	<0.42

TABLE 2 (Continued)

RADIONUCLIDE CONCENTRATIONS IN SOIL
FORMER INTERIM STORAGE FACILITY (T654)
SANTA SUSANA FIELD LABORATORY
ROCKWELL INTERNATIONAL
VENTURA COUNTY, CALIFORNIA

Location[a]	Radionuclide Concentration (pCi/g)														
	Am-241	Co-57	Co-58	Co-60	Cr-51	Cs-137	Eu-152	Fe-59	Mn-54	Ra-226	Sb-124	Th-232	U-235	U-238	Zn-65
ISF Perimeter															
#7	<0.15	<0.04	<0.06	<0.11	<0.89	0.15 ± 0.10	<0.18	<0.19	<0.07	0.95 ± 0.16	<0.07	1.56 ± 0.31	<0.10	<1.48	<0.18
#8	<0.19	<0.06	<0.10	<0.13	<1.04	0.08 ± 0.10	<0.24	<0.27	<0.12	0.71 ± 0.20	<0.10	1.74 ± 0.39	<0.12	<2.04	<0.21
#9	<0.15	<0.05	<0.08	<0.09	<0.80	<0.08	<0.18	<0.22	<0.08	1.25 ± 0.18	<0.06	1.55 ± 0.35	<0.10	1.05 ± 1.50	<0.21
#10	<0.20	<0.06	<0.10	<0.14	<1.13	0.43 ± 0.08	<0.24	<0.25	<0.08	0.76 ± 0.19	<0.10	1.69 ± 0.36	<0.13	1.18 ± 1.28	<0.18
Backgrounds															
#1 Gaston Rd	<0.16	<0.05	<0.10	<0.10	<0.96	<0.07	<0.17	<0.21	<0.10	1.19 ± 0.21	<0.09	1.56 ± 0.37	<0.11	2.54 ± 1.59	<0.23
#2 Black Canyon Rd	<0.17	<0.06	<0.15	<0.15	<1.03	0.15 ± 0.10	<0.27	<0.24	<0.12	1.02 ± 0.22	<0.08	1.72 ± 0.32	<0.13	1.37 ± 1.49	<0.25
#3 Black Canyon Rd	<0.13	<0.04	<0.08	<0.11	<0.69	0.24 ± 0.10	<0.18	<0.28	<0.08	1.02 ± 0.16	<0.07	1.31 ± 0.30	<0.09	1.61 ± 1.15	<0.17
#4 Valley Circle Rd	<0.20	<0.06	<0.09	<0.13	<1.09	0.15 ± 0.06	<0.22	<0.27	<0.11	1.02 ± 0.22	<0.11	1.15 ± 0.40	<0.13	<2.15	<0.31
#5 Woolsey Canyon Rd	<0.13	<0.05	<0.09	<0.08	<0.71	<0.06	<0.15	<0.19	<0.07	0.88 ± 0.18	<0.05	1.24 ± 0.33	<0.09	2.08 ± 1.24	<0.19
#6 Woolsey Canyon Rd	<0.10	<0.03	<0.07	<0.07	<0.58	<0.06	<0.12	<0.15	<0.06	<0.20	<0.04	0.56 ± 0.29	<0.06	<1.02	<0.16

[a]Refer to Figures 3 and 4.
[b]Uncertainties represent the 95% confidence level, based only on counting statistics.

TABLE 3

SITE-WIDE LIMITS FOR SOIL AND WATER (REFERENCE N001SRR140127)[a] SANTA SUSANA FIELD LABORATORY ROCKWELL INTERNATIONAL VENTURA COUNTY, CALIFORNIA

Radionuclide	Soil Guidelines (pCi/g)	Water (pCi/l)
Am-241	5.44	1.5
Co-60	1.94	200
Cs-134	3.33	75
Cs-137	9.20	110
Eu-152	4.51	840
Eu-154	4.11	570
Fe-55	629,000	9,000
H-3	31,900	20,000[b]
K-40	27.6	290
Mn-54	6.11	2,000
Na-22	2.31	480
Ni-59	151,000	26,000
Ni-63	55,300	9,500
Pu-238	37.2	1.7
Pu-239	33.9	1.6
Pu-240	33.9	1.6
Pu-241	230	80
Pu-242	35.5	1.6
Ra-226	5[d] and 15[d]	4.1
Sr-90	36.0	8[b]
Th-228	5[d] and 15[d]	6.8

TABLE 3 (Continued)

SITE-WIDE LIMITS FOR SOIL AND WATER
(REFERENCE N001SRR140127)
SANTA SUSANA FIELD LABORATORY
ROCKWELL INTERNATIONAL
VENTURA COUNTY, CALIFORNIA

Radionuclide	Soil Guidelines (pCi/g)	Water (pCi/l)
Th-232	5[d] and 15[d]	2.0
U-234	30[c]	
U-235	30[c]	total uranium 20[b]
U-238	35[c]	
Gross alpha (not including radon and uranium	---	15[b]
Gross beta	---	50[b]

[a]Reference taken from Rocketdyne/Boeing 96ETEC-DRF-0374, Enclosure A, June 28, 1996
[b]State of California Maximum Contaminant Levels, CCR Title 22
[c]Generally more conservative NRC limits for uranium isotopes are proposed.
[d]DOE Order 5400.5 limits are proposed (5 pCi/g averaged over first 15 cm of soil depth and 15 pCi/g averaged over 15 cm layers below the top 15 cm).

REFERENCES

Energy Technology Engineering Center, Boeing North America, Inc. (Boeing). Building T654 Supplemental Final Radiological Survey Plan SSWA-0009. Canoga Park, CA; April 9, 1997.

Oak Ridge Institute for Science and Education (ORISE). Verification Survey Plan for the Interim Storage Facility; Buildings T030, T024, T019, T013; An Area Northwest of Buildings T019, T013, T012, and T059; and a Storage Yard West of Buildings T626 and T038; Santa Susana Field Laboratory, Rockwell International, Ventura County, California. Oak Ridge, TN; September 6, 1995a.

Oak Ridge Institute for Science and Education (ORISE). Survey Procedures Manual for the Energy/Environment Systems Division, Environmental Survey and Site Assessment Program, Revision 9. Oak Ridge, Tennessee; April 30, 1995b.

Oak Ridge Institute for Science and Education. Quality Assurance Manual for the Energy/Environment Systems Division, Environmental Survey and Site Assessment Program, Revision 9 and 10. Oak Ridge, Tennessee; January 31, 1995c and April 30, 1995c.

Oak Ridge Institute for Science and Education. Verification Survey of the Interim Storage Facility; Buildings T030, T641, and T013; An Area Northwest of Buildings T019, T013, T012, and T059; and a Storage yard West of Buildings T626 and T038, Santa Susana Field Laboratory, Rockwell International, Ventura County, California. Oak Ridge, TN; February 1996a.

Oak Ridge Institute for Science and Education. Comments on the Final Status Survey Documentation for the Interim Storage Facility; Building T013, T019, T024, T030, and T641; the Storage Yard West of Building T626 and T038; and the NW Area; Santa Susana Field Laboratory, Ventura County, California. Oak Ridge, TN; January 11, 1996b.

Oak Ridge Institute for Science and Education. Verification Survey Plan for Land Areas Formerly Supporting the Hot Laboratory (T020) and Interim Storage Facility (T654), Santa Susana Field Laboratory, Boeing North America, Inc., Ventura County, California. Oak Ridge, TN; September 25, 1997a.

Oak Ridge Institute for Science and Education. Laboratory Procedures Manual for the Energy/Environment Systems Division, Environmental Survey and Site Assessment Program, Revision 9. Oak Ridge, Tennessee; January 31, 1995d and April 30, 1997b.

Rockwell International. Interim Storage Facility Decommissioning Final Report. Ventura County, CA; March 15, 1985.

State of California, Department of Health Services. Authorized Sitewide Radiological Guidelines for Release of Unrestricted Use. August 9, 1996.

REFERENCES (Continued)

U.S. Department of Energy (DOE). Radiation Protection of the Public and the Environment. Washington, DC: Doe Order 5400.5; February 1990.

U.S. Department of Energy. Memorandum from S. Robinson to R. Liddle, "Sitewide Limits for Release of Facilities Without Radiological Restrictions", September 17, 1996.

APPENDIX A

MAJOR INSTRUMENTATION

APPENDIX A

MAJOR INSTRUMENTATION

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

DIRECT RADIATION MEASUREMENT

Instruments

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

Ludlum Ratemeter-Scaler
Model 2200
(Ludlum Measurements, Inc.,
Sweetwater, TX)

Ludlum Ratemeter-Scaler
Model 2221
(Ludlum Measurements, Inc.,
Sweetwater, TX)

Detectors

Eberline GM Detector
Model HP-210
Effective Area, 20 cm^2
(Eberline, Santa Fe, NM)

Reuter-Stokes Pressurized Ionization Chamber
Model RSS-112
(Reuter-Stokes, Cleveland, OH)

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

LABORATORY ANALYTICAL INSTRUMENTATION

High Purity Extended Range Intrinsic Detectors
Model No: ERVDS30-25195
(Tennelec, Oak Ridge, TN)
Used in conjunction with:
Lead Shield Model G-11
(Nuclear Lead, Oak Ridge, TN) and
Multichannel Analyzer
3100 Vax Workstation
(Canberra, Meriden, CT)

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-5100-W
(Oxford, Oak Ridge, TN)

APPENDIX B

SURVEY AND ANALYTICAL PROCEDURES

APPENDIX B

SURVEY AND ANALYTICAL PROCEDURES

SURVEY PROCEDURES

Surface Scans

Surface scans were performed by passing the detectors slowly over the surface; the distance between the detector and the surface was maintained at a minimum—nominally about 1 cm. 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:

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

Exposure Rate Measurements

Measurements of gamma exposure rates were performed using a pressurized ionization chamber (PIC). The instrument was adjusted to one meter above the surface and allowed to stabilize. The measurement was read directly in μR/h.

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

Gamma Spectrometry

Soil samples 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. 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. All photopeaks associated with the radionuclides of concern were reviewed for consistency of activity. Energy peaks used for determining the activities of radionuclides of concern were:

Co-57	0.122 MeV
Co-58	0.811 MeV
Co-60	1.173 MeV
Cr-51	0.320 MeV
Cs-137	0.662 MeV
Eu-152	0.344 MeV
Eu-154*	0.723 MeV
Fe-59	1.099 MeV
Mn-54	0.835 MeV
Ra-226	0.351 MeV from Pb-214**
Sb-124	0.603 MeV
Th-228*	0.239 MeV from Pb-212**
Th-232	0.911 MeV from Ac-228**
U-235	0.143 MeV (or 0.186 MeV)
U-238	0.063 MeV from Th-234** (or 1.001 MeV from Pa-234 m)*
Zn-65	1.115 MeV

*Spectra reviewed for these radionuclides; however, unless anomalous concentrations identified, they were not included in the data table.

**Secular equilibrium assumed.
Spectra were also reviewed for other identifiable photopeaks.

Strontium-90

Soil samples were dried, mixed, crushed and then aliquots of the soil were dissolved using a potassium fluoride and pyrosulfate fusion. Strontium was dissolved in dilute hydrochloric acid and precipitated as lead sulfate. Lead and calcium were removed in EDTA. Barium was removed as barium chromate. Strontium carbonate was collected on a filter and counted using a low-background Tennelec gas proportional counter. Count rates were corrected for yttrium-90 ingrowth. Chemical yield was determined gravimetrically.

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. Additional uncertainties, associated with sampling and measurement procedures, have not been propagated into the data presented in this report.

Detection limits, referred to as minimum detectable concentration (MDC), were based on 2.71 plus 4.65 times the standard deviation of the background count [$2.71 + 4.65\sqrt{BKG}$]. When the activity was determined to be less than the MDC of the measurement procedure, the result was reported as less than MDC. 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.

CALIBRATION AND QUALITY ASSURANCE

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

Analytical and field survey activities were conducted in accordance with procedures from the following documents of the Environmental Survey and Site Assessment Program:

- Survey Procedures Manual, Revision 9 (April 1995)
- Laboratory Procedures Manual, Revisions 9 and 10 (January 1995 and April 1997)
- Quality Assurance Manual, Revision 7 (January 1995)

The procedures contained in these manuals were developed to meet the requirements of DOE Order 5700.6C and American Society of Mechanical Engineers (ASME) NQA-1 for Quality Assurance and contain measures to assess processes during their performance.

Quality control procedures include:

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

APPENDIX C

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 reasonably achievable principles to set site-specific guidelines.

STRUCTURE GUIDELINES

Indoor/Outdoor Structure Surface Contamination

	Allowable Total Residual Surface Contamination (dpm/100 cm^2)[b]		
Radionuclides[a]	**Average[c,d]**	**Maximum[d,e]**	**Removable[f]**
Transuranics, Ra-226, Ra-228, Th-230 Th-228, Pa-231, Ac-227, I-125, I-129 [g]	100	300	20
Th-Natural, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	1,000	3,000	200
U-Natural, U-235, U-238, and associated decay products	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 [h]	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[i,j,k]
Uranium and mixed fission and activation products	Soil guidelines are calculated on a site-specific basis, using the DOE manual developed for this use.

[a] 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.

[b] 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.

[c] 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.

[d] 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 a depth of 1 cm.

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

[f] The amount of removable radioactive 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 wipe 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.

[g] Guidelines for these radionuclides are not given in DOE Order 5400.5; however, these guidelines are considered applicable until guidance is provided.

[h] 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.

[i] These guidelines take into account ingrowth of radium-226 from thorium-230 or thorium-232 and radium-228 and assume secular equilibrium. If either Th-230 and Ra-226 or Th-232 and Ra-228 are both present, not in secular equilibrium, the guidelines apply to the higher concentration. If other mixtures of radionuclides occur, the concentrations of individual radionuclides shall be reduced so that (1) the dose for the mixtures will not exceed the basic dose limit, or (2) the sum of ratios of the soil concentration of each radionuclide to the allowable limit for that radionuclide will not exceed 1 ("unity").

[j] 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.

[k] 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 $(100/A)^{½}$, where A is the area of 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.

REFERENCES

"U.S. Department of Energy Guidelines for Residual Radioactive Material at Formerly Utilized Sites Remedial Action Program and Remote Surplus Facilities Management Program Sites," Revision 2, March 1987.

"DOE Order 5400.5, Radiation Protection of the Public and the Environment," February 1990.