

**VERIFICATION SURVEY
OF THE HOT CELL FACILITY SITE
GENERAL ATOMICS
SAN DIEGO, CALIFORNIA**

W.C. ADAMS

Prepared for the
Office of Site Closure
U.S. Department of Energy



OAK RIDGE INSTITUTE FOR SCIENCE AND EDUCATION

Environmental Survey and Site Assessment Program

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ABBREVIATIONS AND ACRONYMS

$\mu\text{R/h}$	microroentgens per hour
$\mu\text{rem/h}$	microrem per hour
ASME	American Society of Mechanical Engineers
BKG	background
cm	centimeter
D&D	decontamination and decommissioning
DOE	U.S. Department of Energy
EBOR	Experimental Beryllium Oxide Reactor
EML	Environmental Measurements Laboratory
ESSAP	Environmental Survey and Site Assessment Program
EDTA	ethylenediamine tetraacetate
GA	General Atomics
ha	hectare
HCF	Hot Cell Facility
HEPA	high efficiency particulate air (filter)
HLC	High Level Cell
HTGR	High Temperature Gas-Cooled Reactors
ITP	Intercomparison Test Program
kg	kilogram
km	kilometers
LLC	Low Level Cell
m	meter
m^2	square meter
MAPEP	Mixed Analyte Performance Evaluation Program
MDC	minimum detectable concentration
MeV	megaelectron volts
MGCR	Marine Gas-Cooled Reactor
mrem/yr	millirem per year
NaI	sodium iodide
NIST	National Institute of Standards and Technology
NRC	U.S. Nuclear Regulatory Commission
ORAU	Oak Ridge Associated Universities
ORISE	Oak Ridge Institute for Science and Education
pCi/g	picocuries per gram
RERTR	Reduced Enrichment Test Reactor
R&D	research and development
SNM	special nuclear material
TFE	thermionic fuel elements
TRIGA	Training, Research, Isotopes, General Atomics

**VERIFICATION SURVEY
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INTRODUCTION

General Atomics (GA) has maintained a fully-operational Hot Cell Facility (HCF) since 1958 in support of primarily government-funded nuclear research and development (R&D). The heavily-shielded remote-handling laboratory was used for a variety of radiologically hazardous and toxic experimental operations. GA operated the HCF under U.S. Nuclear Regulatory Commission (NRC) License/Docket Numbers SNM-696/70-734 and State of California Radioactive Material License/Docket Numbers 0145-80/121692-0145-80, both beginning in 1962.

The HCF housed three shielded cells—the High Level Cell (HLC), the Low Level Cell (LLC), and the Metallography Cell. The HLC was used to perform post-irradiation examinations on fuels and structural materials while the LLC was used as a staging area for samples being transferred in and out of the HLC. The Metallography Cell was utilized to prepare irradiated fuel and metal samples for the metallograph. Most of the projects served in the examination of irradiated fuel and graphite for High Temperature Gas-Cooled Reactors (HTGR) and the packaging of irradiated fuel for the Reduced Enrichment Test Reactor (RERTR). Earlier activities involved examinations of Hastelloy X-clad uranium oxide-beryllium oxide fuel for the Experimental Beryllium Oxide Reactor (EBOR) and its predecessor, the Marine Gas-Cooled Reactor (MGCR). The UO_2 -BeO fuel for the EBOR was manufactured in the area of the HCF that later served as the machine shop. Recently, the HCF was utilized for the examination of thermionic fuel elements (TFE) for space power application and fuel for GA's Training, Research, Isotopes, General Atomics (TRIGA) reactor.

In addition to activities conducted in the building's test cells, areas such as the Physical Test Lab, Hot Cell Yard, and the service gallery were used during operation. Since 1980, the Physical Test Lab was used for the Engineering Scale Tritium Extraction System project for the New Production Reactor program while the Hot Cell yard and service gallery were used for cask handling and maintenance activities, waste consolidation and packaging.

As usage of the Hot Cell dropped, and in conjunction with the continuing private industrial development around the site, GA decided that decontamination and decommissioning (D&D) of the facility and the surrounding area was necessary, for release for unrestricted use. GA, therefore, entered into a cost sharing agreement with the U.S. Department of Energy (DOE) to be the Prime Contractor and Site Manager of the GA Hot Cell D&D Project. Under DOE Contract No. DE-AC03-84SF11962, GA performed the characterization activities for the site. GA performed the decommissioning and final survey activities under DOE Contract No. DE-AE03-95SF20798 (GA 1998a).

Decommissioning activities have completely dismantled the HCF and a substantial portion of the building was disposed of as radioactive waste. Included in the waste disposal were the Cells Manipulator Repair Room and the machine shop. Although hot cell manipulators, a Kolmorgan periscope, hot cell windows, and portions of the high efficiency particulate air (HEPA) system were recycled and packaged for reuse by others, all remaining support equipment associated with the HCF, such as underground tanks, wells, and piping systems were excavated and disposed of accordingly. GA dismantled and performed final status surveys on those portions of the building that were not directly involved with the handling of radioactive materials such as offices, change rooms, and rest rooms. Also, paved surfaces (asphalt and concrete ground coverings) were surveyed and removed prior to the final surveys. Therefore, only open land area [approximately 8,300 square meters (m²)] are to be released (GA 2000a).

GA conducted characterization, remediation, and final status surveys of the HCF beginning in 1994 and completed the project in January 2000. The final radiological survey report has been provided to the DOE and NRC for review (GA 2000a).

DOE's Office of Site Closure, formerly the Office of Environmental Restoration, Northwest Area Programs, is responsible for oversight of the HCF remedial activities conducted at GA. It is the policy of the DOE to perform independent (third party) verification of remedial action activities conducted within the Office of Site Closure. The purpose of these independent verifications is to confirm that remedial actions have been effective in meeting established and site-specific guidelines and that the documentation accurately and adequately describes the radiological conditions at the

site. The DOE designated the Environmental Survey and Site Assessment Program (ESSAP) of the Oak Ridge Institute for Science and Education (ORISE) as the organization responsible for this task at GA. ESSAP was therefore requested to verify the final radiological status of the HCF. Verification activities were conducted during the periods of November 1, 1999 and March 21 through 22, 2000. These activities, which are the subject of this report, included reviews of pertinent documents and independent radiological measurement and sampling of remediated areas.

SITE DESCRIPTION

GA is a 48 hectares ([ha] 120 acres) facility located in the extreme western portion of San Diego County approximately 21 kilometers ([km] 13 miles) northwest of downtown San Diego, California and 1.6 km (1 mile) east of the Pacific Ocean (Figure 1). The facility is comprised of two contiguous sites referred to as the Main site and the Sorrento Valley site. The Hot Cell Facility site is located within the Main site, a 60 acre complex on the Torrey Pines Mesa, just southwest of the convergence of U.S. Interstate Highways 5 and 805.

The HCF is on the north side of the GA site—a plot plan indicating the location of the HCF in relation to other surrounding GA facilities is shown in Figure 2. The facility includes the former HCF structure (Building 23) location and the surrounding land areas that include the former radiation restricted area. The adjacent land areas which may have been impacted by HCF operations have been fenced in. This additional area is referred to as the extended footprint for the HCF (Figure 3). A fence was erected to delineate the HCF boundary with the exception of the north and west corners which are located on a steep hillside.

OBJECTIVES

The objectives of the verification survey were to confirm that remedial actions had been effective in meeting established guidelines and that documentation accurately described the post-remedial action radiological conditions of the property.

DOCUMENT REVIEW

ESSAP reviewed GA's characterization report, decommissioning plan, final survey plan, final radiological survey results and other supporting documentation concerning site decommissioning activities for the HCF (GA 1998a, b, c and 2000a). Information was evaluated to ensure that areas identified as exceeding site guidelines had been decontaminated and that residual soil concentration levels satisfied the established guidelines.

PROCEDURES

During the periods of November 1, 1999 and March 21 through 22, 2000, ESSAP performed verification surveys of the HCF grounds. The initial survey in November 1999 was performed on the open pits and trenches. Due to the approaching rainy season, GA had requested that the building footprint and associated trenches be verified prior to the project's completion to allow the area to be backfilled upon receipt of the final status survey sample analysis data demonstrating compliance with the release criteria. Therefore, ESSAP performed verification activities of the open pits and trenches concurrently with GA's final status survey. The results of this survey were submitted to the DOE in an interim letter report (ORISE 2000a). The March 2000 survey activities were performed on the remaining areas of the HCF. The surveys were performed in accordance with a site-specific survey plan, submitted to and approved by the DOE, and the ORISE/ESSAP Survey Procedures and Quality Assurance Manuals (ORISE 1999a, 1998a and b).

SURVEY PROCEDURES

The following procedures describe the site verification activities that were conducted.

Reference System

The 10 meter \times 10 meter (m) grid established by GA was used for referencing measurement and sampling locations (Figure 3).

Surface Scans

Gamma scans were conducted at one to two meter intervals over 100% of the HCF site (including the trenches and pits addressed during the November 1999 survey activities) using NaI scintillation detectors coupled to ratemeters with audible indicators. Locations of elevated radiation, suggesting the presence of surface or near surface contamination, were marked and identified for further investigation.

Exposure Rate Measurements

Background exposure rates were determined during a previous site survey—measurement locations are shown on Figure 4 (ORAU 1986). Exposure rates were measured at one meter above the surface at each soil sample location using a microrem meter. Measurement locations are shown on Figure 5.

Soil Sampling

Background soil samples collected at six locations outside of the GA facility during a previous site survey were used for comparison purposes (ORAU 1986). Figure 4 shows background soil sample locations. A total of 37 surface (0-15 cm) soil samples were collected from random locations within the HCF grounds (Figure 5). Twelve of the soil samples (sample locations 1 through 12) were collected from within the excavated areas (trenches and pits) with the remaining 25 soil samples (sample locations 13 through 37) collected from the open land areas. A soil sample was collected from one location of elevated radiation in Grid Block I2, that was identified by surface scans (sample location 13)—an additional four samples were collected from this grid block for averaging purposes (Figure 5). Additionally, ESSAP requested and received five soil samples, collected by GA, for confirmatory analysis.

SAMPLE ANALYSIS AND DATA INTERPRETATION

Samples and data were returned to the ORISE/ESSAP laboratory in Oak Ridge, Tennessee for analysis and interpretation. Sample analyses were in accordance with the ORISE/ESSAP Laboratory Procedures Manual (ORISE 1999b). Soil samples were analyzed by gamma spectroscopy for

uranium and mixed fission and activation products, primarily Cs-137, Cs-134, and Co-60. Spectra were also reviewed for other identifiable total absorption peaks. Seventeen of the samples were analyzed by wet chemistry methods for Sr-90. All soil sample results were reported in units of picocuries per gram (pCi/g). Exposure rates were reported in units of microrentgens per hour (μ R/h). Additional information concerning major instrumentation, sampling equipment, and analytical procedures is provided in Appendices A and B.

FINDINGS AND RESULTS

DOCUMENT REVIEW

ESSAP's review determined that the procedures, methods, and data submitted by GA were appropriate and adequately reflect the radiological status of the HCF. Comments identified during these reviews were submitted to the DOE (ORISE 1998c and 2000b). GA provided satisfactory written responses to ESSAP's comments (GA 2000b and c).

SURFACE SCANS

Gamma surface scans did not identify any areas of elevated direct radiation from within the excavations (trenches and pits) and only one location of slightly elevated activity was detected in the remaining open land areas (Grid Block I2).

EXPOSURE RATES

Background exposure rates, presented in Table 1, ranged from 7 to 13 μ R/h and averaged 10 μ R/h (ORAU 1986). Site exposure rates are summarized in Tables 2 and 3, and ranged from 9 to 20 μ R/h.

RADIONUCLIDE CONCENTRATIONS IN SOIL

Background Soil Samples

The radionuclide concentrations in background soil samples are presented in Table 1. Concentration ranges were as follows: less than 0.1 pCi/g for Co-60; less than 0.1 to 0.2 pCi/g for Cs-137; 1.3 to 3.2 pCi/g for total thorium (Th-228 + Th-232); less than 0.2 to 0.7 pCi/g for U-235; less than 1.1 to 1.6 pCi/g for U-238; and less than 3.4 pCi/g for total uranium.

Excavated (Trenches and Pits) Area Soil Samples

Twelve soil samples were collected from the excavated areas and the analytical results are summarized in Table 2. The radionuclide concentrations for Cs-134, Eu-152, Eu-154, Eu-155, Nb-94, Sb-125, and U-235 were generally less than the respective minimum detectable concentrations for each radionuclide. Detectable radionuclide concentrations were as follows: less than 0.1 to 0.3 pCi/g for Co-60; less than 0.1 to 1.4 pCi/g for Cs-137; 0.12 to 2.69 pCi/g for Sr-90; 0.9 to 2.7 pCi/g for U-238; 1.2 to 1.9 pCi/g for Th-232; and, 1.2 to 2.1 pCi/g for Th-228. Total thorium concentrations ranged from 2.5 to 3.8 pCi/g and total uranium concentrations were less than 4.4 pCi/g.

Remaining Open Land Area Soil Samples

The analytical results for soil samples collected from the remaining open land areas are summarized in Table 3. The radionuclide concentrations for Cs-134, Eu-152, Eu-154, Eu-155, Nb-94, Sb-125, and U-235 were generally less than the respective minimum detectable concentrations for each radionuclide. Detectable radionuclide concentrations were as follows: less than 0.1 to 0.4 pCi/g for Co-60; less than 0.1 to 2.4 pCi/g for Cs-137; 0.25 to 2.85 pCi/g for Sr-90; 0.3 to 3.2 pCi/g for U-238; less than 0.4 to 2.0 pCi/g for Th-232; and, 0.9 to 2.1 pCi/g for Th-228. Total thorium concentrations ranged from less than 1.3 to 4.0 pCi/g and total uranium concentrations were less than 6.8 pCi/g.

Confirmatory Soil Sample Analyses

The five soil samples submitted by GA were analyzed by ESSAP and the results were directly compared to GA's results (Table 4). The radionuclide concentrations for Co-60, Cs-137, Th-228, Th-232, and U-235 were generally in agreement—there were some discrepancies with the U-238 results. For example, the U-238 results for samples 23S-98-144 and -145 were different by a factor of greater than 2. A review of the gamma spectroscopy data reporting procedures indicated that the cause for the discrepancy was the use of different total absorption peaks to quantify the U-238 concentrations.

It has been ESSAP's experience that whenever Th-232 and U-238 are both present within the soil samples, that the use of the 0.63 MeV total absorption peak, as opposed to the 0.93 MeV peak is a better choice for quantifying U-238 concentrations (from the Th-234 daughter) due to interference from the 0.93 MeV peak of Ac-228 in the thorium series. GA was notified of this and they subsequently re-evaluated the data for the confirmatory samples. ESSAP reviewed this revised data which is also provided in Table 4 and found the results to agree within the statistical deviation of the procedure (Table 4). Although uranium concentrations have been over-estimated, they are still below the site release criteria. GA's responses to ESSAP's comment letter adequately addressed these discrepancies (GA 2000b and c).

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 soil guidelines are provided in Table 5 and have been approved by both the DOE and the State of California. All quantified radionuclide concentrations were less than the respective guidelines. The DOE exposure rate guideline is 20 μ R/h above background—although GA's site-specific criteria are based on a maximum external exposure of 10 μ R/h above background (DOE 1990 and GA 1998c). All exposure rates were within this guideline.

SUMMARY

During the periods of November 1, 1999 and March 21 through 22, 2000, the Environmental Survey and Site Assessment Program performed verification surveys of General Atomics' Hot Cell Facility Site located in San Diego, California. Verification survey activities included document reviews, gamma surface scans, exposure rate measurements, and soil sampling.

Results of the verification surveys confirmed the results obtained by GA. Gamma surface scans identified only one area of elevated direct gamma radiation. Soil samples collected from this location did not contain elevated concentrations of any of the primary radionuclides of concern. This confirms that the elevated gamma levels were the result of suspected geometry factors influencing ambient gamma background levels. With the exception of Sr-90 results, all other soil samples had radionuclide concentrations that were either at background or less than the respective minimum detectable concentration levels. Sr-90 radionuclide concentrations, though above background levels, were well below the site-specific release criteria.

Additionally, for confirmatory analyses, ESSAP requested five soil samples from GA that had previously been analyzed by GA. The results indicated that there were discrepancies between ESSAP and GA in the reporting of U-238 gamma spectroscopy data for the same soil samples. ESSAP recommended that the specific radionuclides and gamma energies used to determine the soil concentrations of these radionuclides be identified and provided for review (ORISE 2000b). GA's response to this request addressed GA's use of different total absorption peaks than ESSAP to estimate the concentration of these radionuclides in the soil samples (GA 2000b and c).

After reviewing this additional data, it is ESSAP's opinion that GA's quantification of U-238 concentrations over-estimate the U-238 activity. Even though the U-238 results were over-estimated, all of GA's final survey soil sample results were below the site release criteria. Therefore, ESSAP concurs with GA's final survey results in that the site release criteria have been met. It is ESSAP's opinion that all concerns have been addressed and adequately resolved.

FIGURES

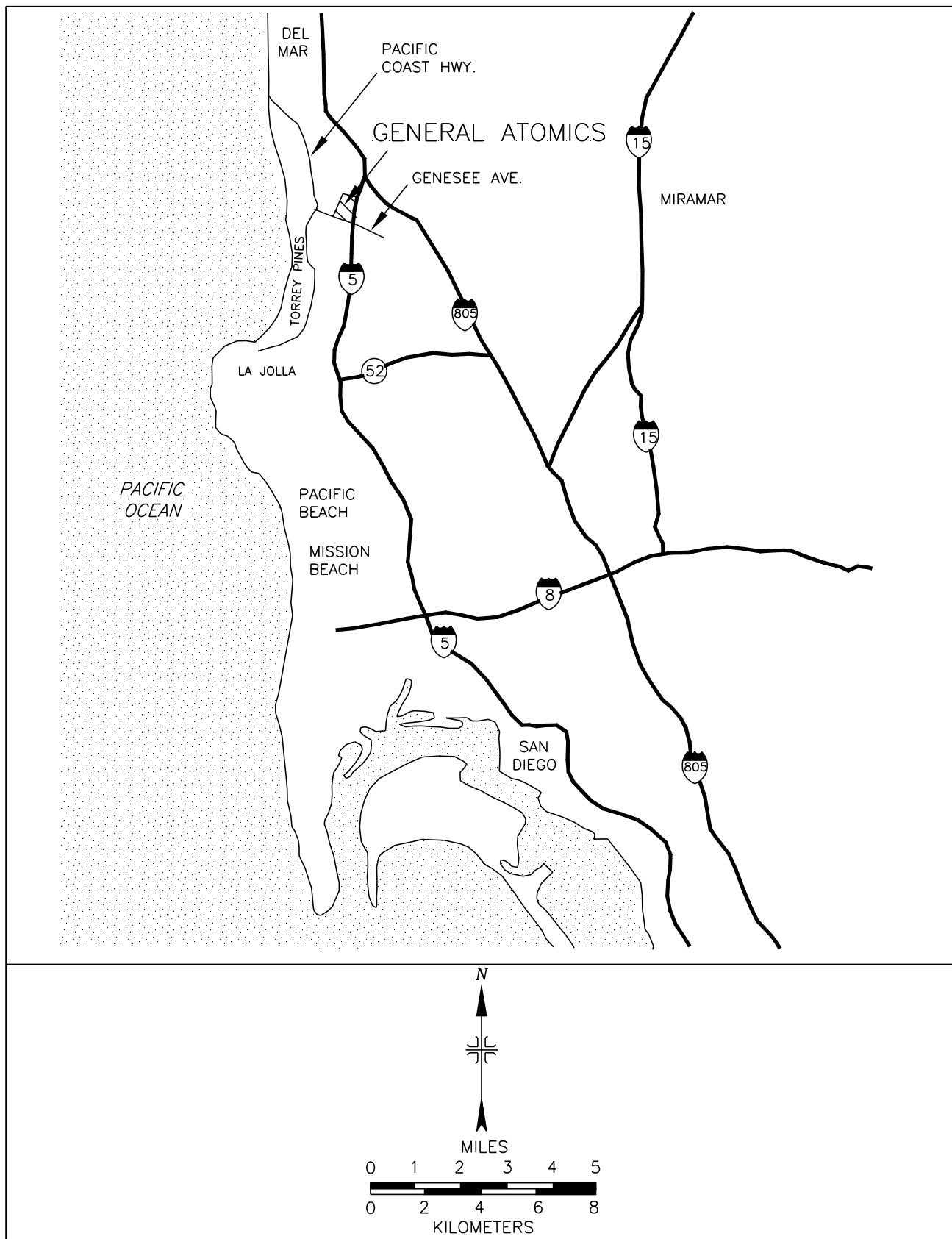


FIGURE 1: Location of General Atomics Facility – San Diego, California

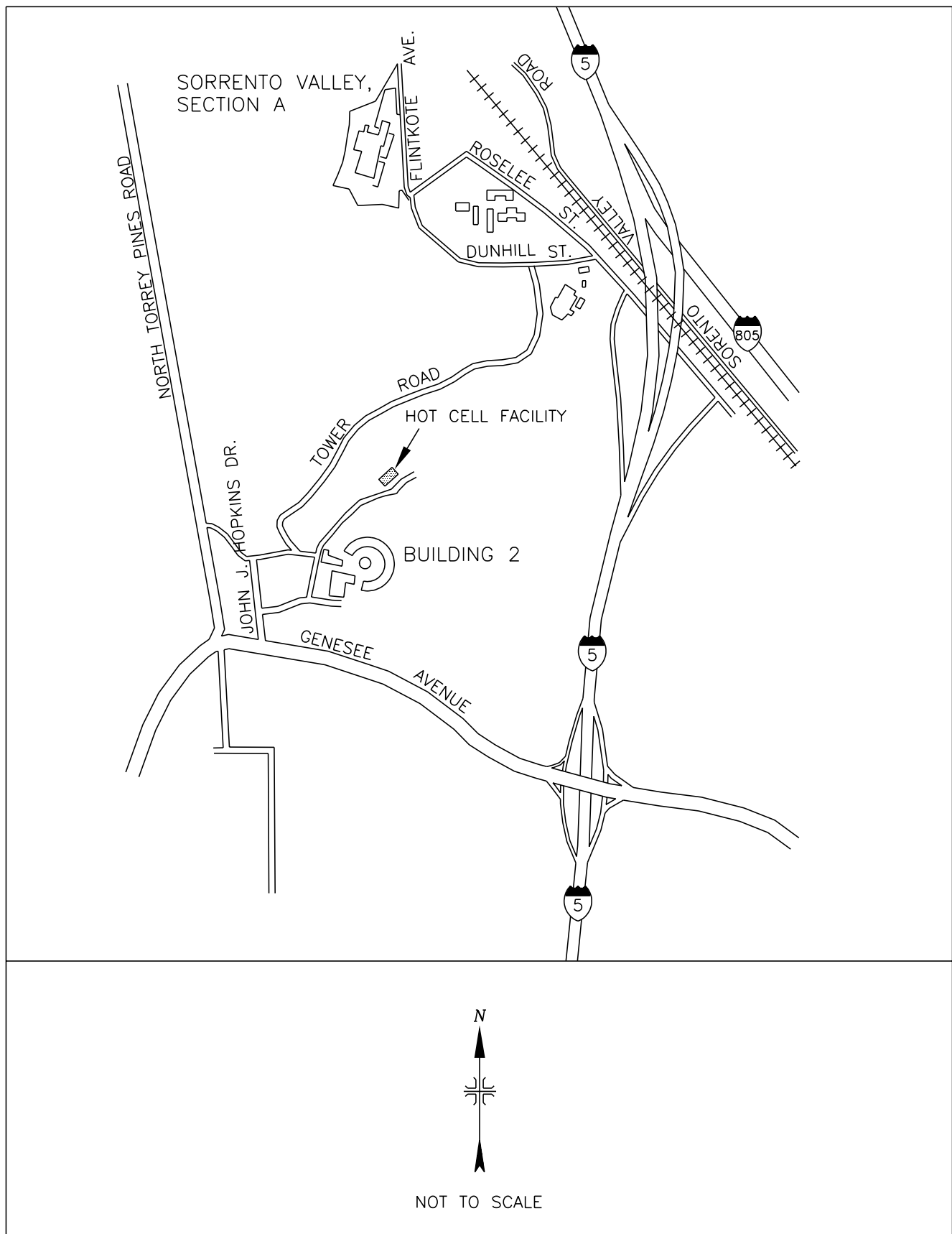


FIGURE 2: General Atomics Facility Indicating Location of Hot Cell Facility

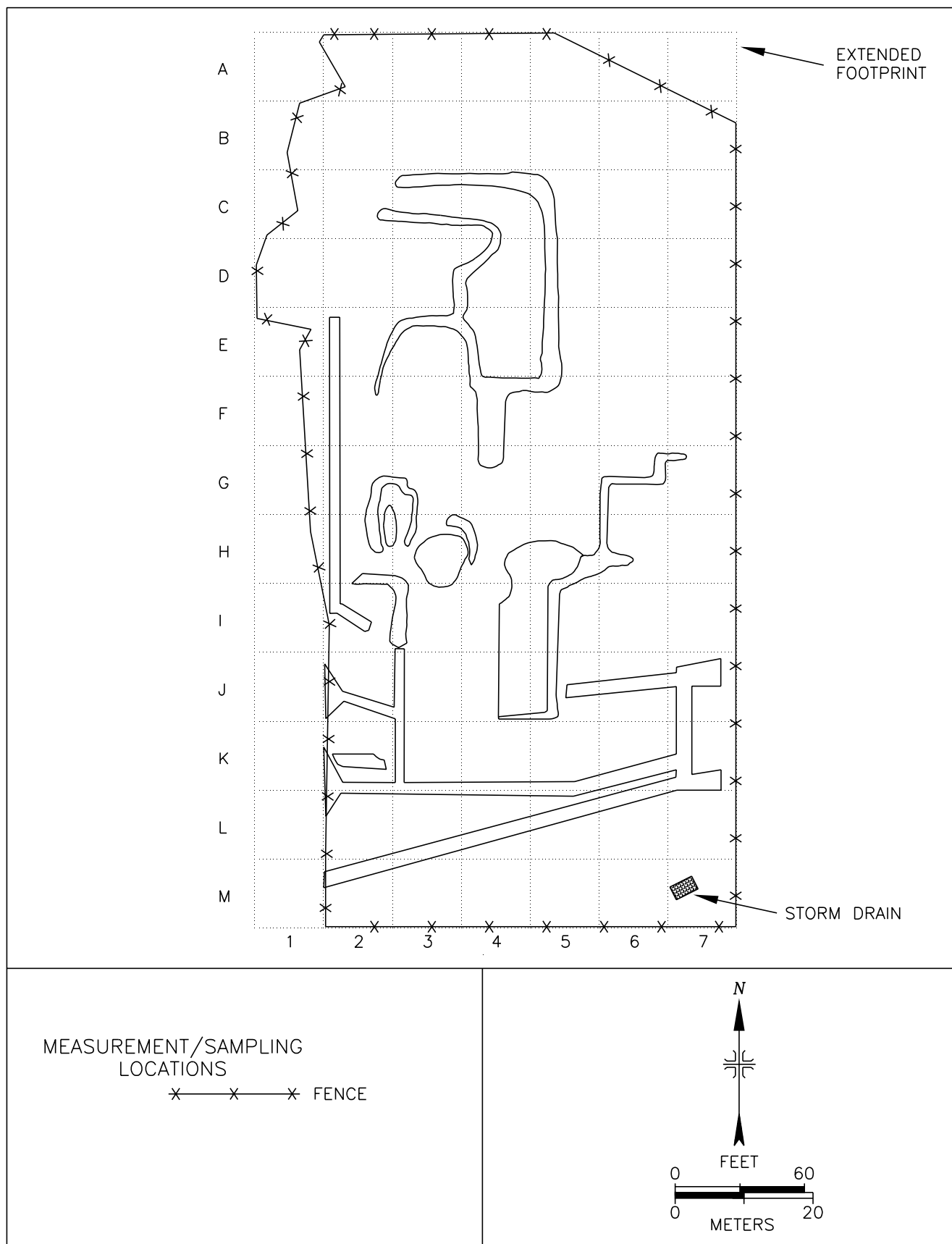


FIGURE 3: Plot Plan of the Hot Cell Facility Site

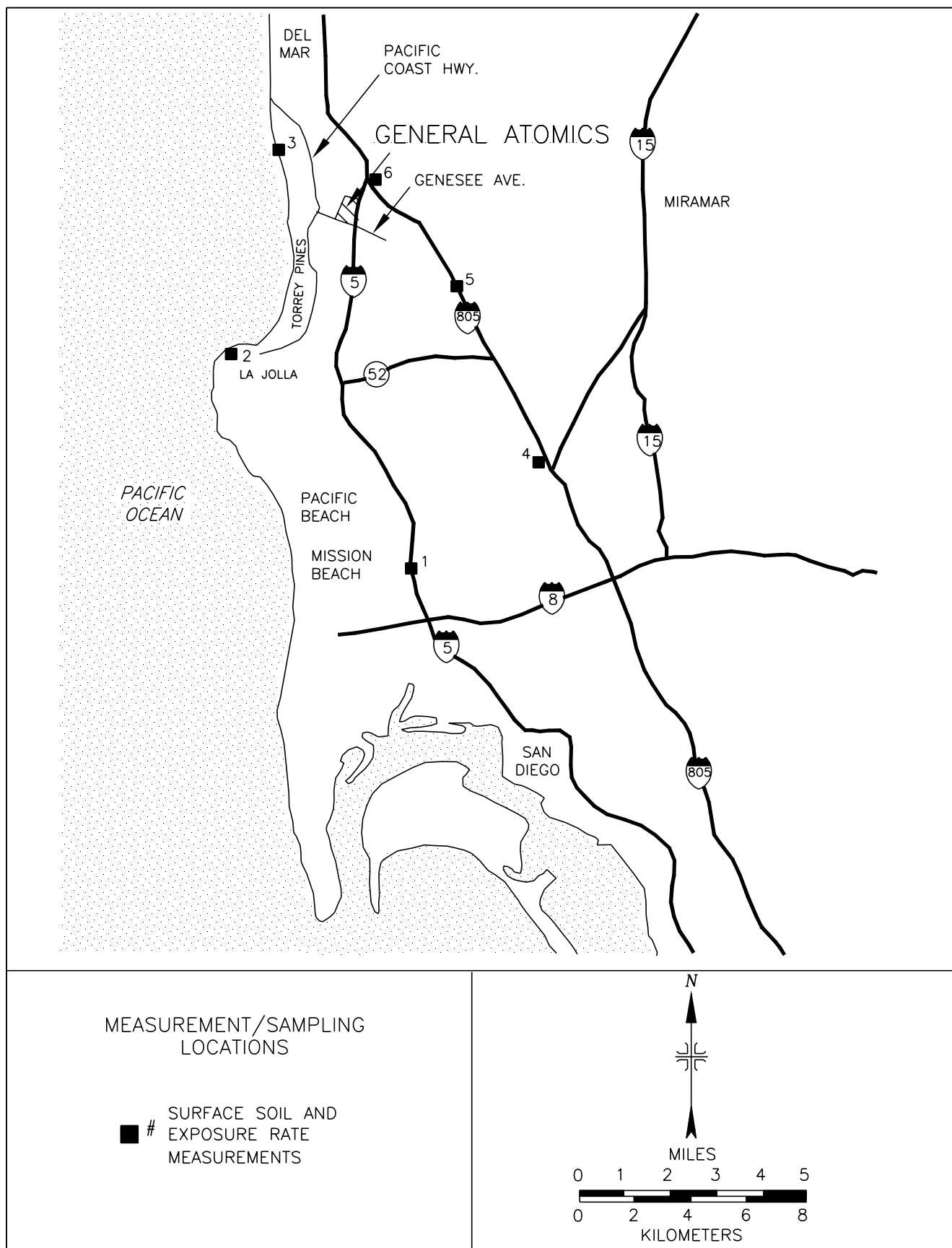


FIGURE 4: Background Measurement and Sampling Locations

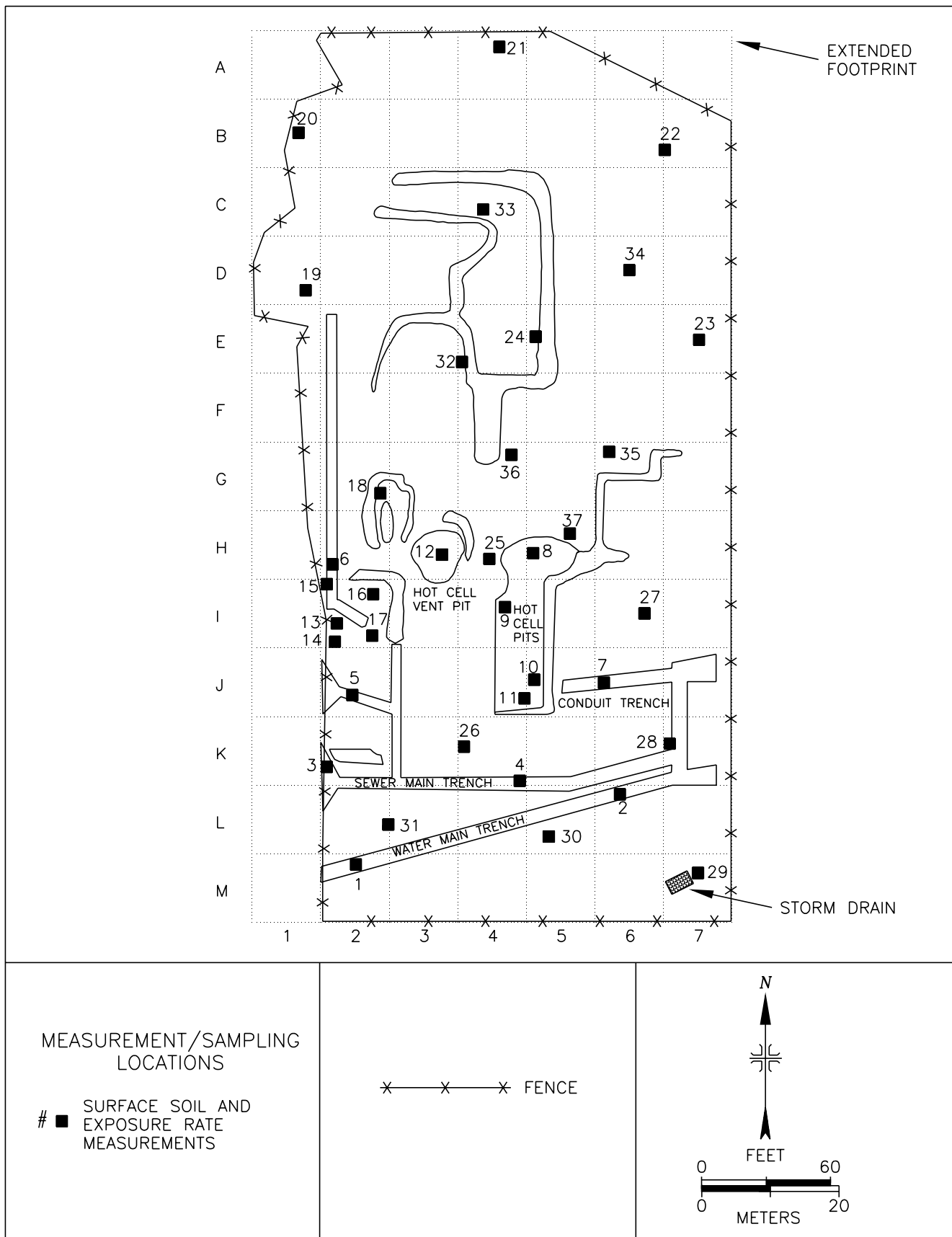


FIGURE 5: Hot Cell Facility Site – Measurement and Sampling Locations

TABLES

TABLE 1

**BACKGROUND EXPOSURE RATES AND
RADIONUCLIDE CONCENTRATIONS IN SOIL
GENERAL ATOMICS
SAN DIEGO, CALIFORNIA**

Location ^a	Exposure Rate	Radionuclide Concentrations (pCi/g)					
		Co-60	Cs-137	Total Th ^b	U-235	U-238	Total U ^c
1	7	<0.1	<0.1	1.3 ± 0.5 ^d	<0.2	1.6 ± 1.2	<3.4
2	8	<0.1	0.2 ± 0.1	2.0 ± 0.9	<0.2	1.6 ± 1.5	<3.4
3	7	<0.1	<0.1	2.2 ± 0.6	0.4 ± 0.2	1.1 ± 0.5	2.6
4	10	<0.1	<0.1	3.1 ± 0.8	<0.3	<1.1	<2.5
5	13	<0.1	<0.1	3.2 ± 0.8	0.7 ± 0.6	1.3 ± 0.6	3.3
6	13	<0.1	<0.1	1.9 ± 0.8	<0.2	1.0 ± 0.9	<2.2
Range	7 to 13	<0.1	<0.1 to 0.2	1.3 to 3.2	<0.2 to 0.7	1.0 to 1.6	<3.4
Average	10	<0.1	<0.1	2.93	<0.3	1.3	<2.9

^aRefer to Figure 4.

^bTotal thorium concentration were calculated by summing the Th-228 and Th-232 concentrations.

^cTotal uranium concentrations were calculated by multiplying the U-238 concentration by 2 and adding the U-235 concentration.

^dUncertainties represent the 95% confidence levels based only on counting statistics. Additional uncertainties of ± 6 to 10% have not been propagated into this data.

TABLE 2

EXCAVATED AREAS (TRENCHES AND PITS)

EXPOSURE RATES AND RADIONUCLIDE CONCENTRATIONS IN SOIL

HOT CELL FACILITY SITE

GENERAL ATOMICS

SAN DIEGO, CALIFORNIA

Location ^a	Exposure Rate (μ R/h)	Radionuclide Concentrations (pCi/g)														
		Co-60	Cs-137	Cs-134	Eu-152	Eu-154	Eu-155	Nb-94	Sb-125	Sr-90 ^c	Th-232	Th-228	Total ^d Th	U-238	U-235	Total U ^e
1	14	<0.1	0.1 \pm 0.1 ^b	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	0.12 \pm 0.48	1.2 \pm 0.2	1.4 \pm 0.4	2.6	1.3 \pm 0.7	<0.3	<2.9
2	13	<0.1	0.1 \pm 0.1	<0.1	<0.1	<0.2	0.1 \pm 0.1	<0.1	<0.1	0.42 \pm 0.48	1.2 \pm 0.3	1.6 \pm 0.2	2.8	2.1 \pm 1.0	<0.2	<4.4
3	16	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	0.34 \pm 0.48	1.6 \pm 0.3	1.6 \pm 0.2	3.2	1.1 \pm 0.8	<0.3	<2.5
4	10	<0.1	<0.1	<0.1	<0.1	<0.1	0.1 \pm 0.1	<0.1	<0.1	0.50 \pm 0.47	1.3 \pm 0.2	1.2 \pm 0.1	2.5	1.2 \pm 0.5	<0.1	<2.5
5	17	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	0.62 \pm 0.48	1.2 \pm 0.2	1.3 \pm 0.1	2.5	1.0 \pm 0.6	<0.2	<2.2
6	17	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	0.50 \pm 0.50	1.9 \pm 0.3	1.9 \pm 0.2	3.8	0.9 \pm 0.6	<0.2	<2.0
7	15	<0.1	0.1 \pm 0.1	<0.1	<0.1	<0.1	0.1 \pm 0.1	<0.1	<0.1	0.60 \pm 0.48	1.3 \pm 0.2	1.2 \pm 0.1	2.5	0.9 \pm 0.5	<0.1	<1.9
8	20	0.3 \pm 0.1	1.4 \pm 0.1	<0.1	<0.2	<0.3	<0.2	<0.1	<0.2	2.69 \pm 0.62	1.7 \pm 0.3	1.9 \pm 0.5	3.6	1.6 \pm 0.7	<0.4	<3.6
9	20	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	0.89 \pm 0.53	1.7 \pm 0.3	1.7 \pm 0.2	3.4	2.4 \pm 0.9	<0.2	<5.0
10	20	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.26 \pm 0.48	1.6 \pm 0.2	1.5 \pm 0.1	3.1	1.5 \pm 0.7	<0.2	<3.2
11	18	<0.1	<0.1	<0.1	<0.2	<0.3	0.1 \pm 0.1	<0.1	<0.2	1.05 \pm 0.54	1.8 \pm 0.3	1.9 \pm 0.5	3.7	1.4 \pm 0.8	<0.3	<3.1
12	20	<0.1	0.1 \pm 0.1	<0.1	<0.2	<0.3	<0.2	<0.1	<0.2	0.68 \pm 0.50	1.7 \pm 0.3	2.1 \pm 0.6	3.8	2.7 \pm 0.9	<0.4	<5.8

^aRefer to Figure 5.

^bUncertainties are total propagated uncertainties, at the 95% confidence level.

^cWet chemistry results.

^dTotal thorium concentrations were calculated by summing the Th-228 and Th-232 concentrations.

^eTotal uranium concentrations were calculated by multiplying the U-238 concentration by 2 and adding the U-235 concentration.

TABLE 3
REMAINING AREAS
EXPOSURE RATES AND RADIONUCLIDE CONCENTRATIONS IN SOIL
HOT CELL FACILITY SITE
GENERAL ATOMICS
SAN DIEGO, CALIFORNIA

Location ^a	Exposure Rate (μR/h)	Radionuclide Concentrations (pCi/g)														
		Co-60	Cs-137	Cs-134	Eu-152	Eu-154	Eu-155	Nb-94	Sb-125	Sr-90 ^b	Th-232	Th-228	Total ^c Th	U-238	U-235	Total U ^d
13	14	<0.1	<0.1	<0.1	<0.1	<0.2	<0.2	<0.1	<0.1	0.46 ± 0.51	1.5 ± 0.3	1.4 ± 0.2	2.9	1.4 ± 1.0	<0.3	<3.1
14	14	<0.1	0.1 ± 0.1 ^e	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	NA ^f	1.5 ± 0.3	1.3 ± 0.1	2.8	2.3 ± 0.8	<0.2	<4.8
15	13	<0.1	<0.1	<0.1	<0.2	<0.4	<0.3	<0.1	<0.2	NA	1.9 ± 0.4	2.1 ± 0.6	4.0	1.8 ± 1.0	<0.5	<4.1
16	12	<0.1	0.4 ± 0.1	<0.1	<0.2	<0.4	<0.2	<0.1	<0.2	NA	1.5 ± 0.3	1.2 ± 0.3	2.7	2.0 ± 1.0	<0.4	<4.4
17	11	0.1 ± 0.1	0.4 ± 0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	NA	1.6 ± 0.3	1.3 ± 0.1	2.9	1.7 ± 0.7	<0.2	<3.6
18	12	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	NA	1.0 ± 0.3	1.1 ± 0.1	2.1	2.0 ± 1.2	<0.2	<4.2
19	12	<0.1	0.2 ± 0.1	<0.1	<0.1	<0.2	<0.2	<0.1	<0	NA	1.5 ± 0.3	1.4 ± 0.2	2.9	2.4 ± 1.2	<0.3	<5.1
20	10	<0.1	0.3 ± 0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	NA	1.1 ± 0.2	1.1 ± 0.1	2.2	1.3 ± 0.7	<0.2	<2.8
21	9	<0.1	0.1 ± 0.1	<0.1	<0.2	<0.4	<0.2	<0.1	<0.2	NA	1.6 ± 0.4	1.6 ± 0.4	3.2	3.2 ± 1.3	<0.4	<6.8
22	9	<0.1	0.1 ± 0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	NA	1.5 ± 0.3	1.1 ± 0.1	2.6	1.4 ± 0.9	<0.2	<3.0
23	12	0.4 ± 0.1	2.4 ± 0.2	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	NA	1.2 ± 0.2	1.1 ± 0.1	2.3	0.7 ± 0.5	<0.2	<1.6
24	14	0.4 ± 0.1	0.6 ± 0.1	<0.1	<0.2	<0.3	<0.2	<0.1	<0.2	2.85 ± 0.65	1.7 ± 0.4	1.5 ± 0.2	3.2	1.5 ± 1.2	<0.3	<3.3
25	12	0.1 ± 0.1	0.5 ± 0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.2	0.57 ± 0.50	2.0 ± 0.3	1.8 ± 0.2	3.8	2.1 ± 1.1	<0.3	<4.5
26	9	<0.1	0.1 ± 0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	NA	1.1 ± 0.2	1.1 ± 0.1	2.2	1.0 ± 0.7	<0.2	<2.2
27	10	0.4 ± 0.1	2.4 ± 0.2	0.1 ± 0.1	<0.1	<0.2	<0.1	<0.1	<0.1	NA	0.9 ± 0.2	1.0 ± 0.1	1.9	0.5 ± 0.7	<0.2	<1.2
28	10	<0.1	0.1 ± 0.1	<0.1	<0.2	<0.3	<0.2	<0.1	<0.2	NA	1.0 ± 0.3	1.0 ± 0.3	2.0	0.3 ± 0.7	<0.4	<1.0
29	10	<0.1	0.2 ± 0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	NA	<0.4	0.9 ± 0.1	<1.3	1.3 ± 0.9	<0.2	<2.8

TABLE 3 (Continued)

**REMAINING AREAS
EXPOSURE RATES AND RADIONUCLIDE CONCENTRATIONS IN SOIL
HOT CELL FACILITY SITE
GENERAL ATOMICS
SAN DIEGO, CALIFORNIA**

Location ^a	Exposure Rate ($\mu\text{R/h}$)	Radionuclide Concentrations (pCi/g)														
		Co-60	Cs-137	Cs-134	Eu-152	Eu-154	Eu-155	Nb-94	Sb-125	Sr-90 ^c	Th-232	Th-228	Total ^d Th	U-238	U-235	Total U ^e
30	11	<0.1	<0.1	<0.1	<0.2	<0.3	<0.2	<0.1	<0.2	NA	1.8 ± 0.4	1.6 ± 0.2	3.4	1.4 ± 1.4	<0.4	<3.2
31	9	<0.1	0.1 ± 0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	NA	1.2 ± 0.3	0.9 ± 0.1	2.1	0.5 ± 0.9	<0.2	<1.2
32	11	<0.1	0.9 ± 0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	NA	1.1 ± 0.2	1.0 ± 0.1	2.1	1.5 ± 0.7	<0.2	<3.2
33	11	<0.1	0.9 ± 0.1	<0.1	<0.3	<0.4	<0.3	<0.1	<0.3	0.97 ± 0.51	1.3 ± 0.4	1.4 ± 0.4	2.7	2.1 ± 1.1	0.4 ± 0.4	<4.6
34	10	<0.1	0.4 ± 0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	NA	0.8 ± 0.2	0.9 ± 0.1	1.7	1.2 ± 0.6	<0.2	<2.6
35	11	<0.1	1.7 ± 0.1	<0.1	<0.1	<0.3	<0.2	<0.1	<0.2	NA	1.7 ± 0.3	1.5 ± 0.2	3.2	1.4 ± 1.1	<0.3	<3.1
36	12	0.3 ± 0.1	1.5 ± 0.1	<0.1	<0.2	<0.2	<0.1	<0.1	<0.1	NA	1.8 ± 0.3	1.8 ± 0.2	3.6	1.9 ± 0.9	<0.3	<4.1
37	12	<0.1	<0.1	<0.1	<0.2	<0.4	<0.3	<0.1	<0.2	0.25 ± 0.47	1.9 ± 0.4	1.9 ± 0.5	3.8	0.6 ± 1.3	<0.5	<1.7

^aRefer to Figure 5.^bWet chemistry results.^cTotal thorium concentrations were calculated by summing the Th-228 and Th-232 concentrations.^dTotal uranium concentrations were calculated by multiplying the U-238 concentration by 2 and adding the U-235 concentration.^eUncertainties are total propagated uncertainties at the 95% confidence level.^fNA = Not Analyzed.

TABLE 4

CONFIRMATORY SAMPLE ANALYSES

GENERAL ATOMICS

SAN DIEGO, CALIFORNIA

Sample ID ^a	Radionuclide Concentrations (pCi/g)							
	Co-60	Cs-137	Th-228	Th-232	Total Thorium ^b	U-235	U-238	Total Uranium ^c
ESSAP Results								
23S-98-137	<0.1	<0.1	1.8 ± 0.3 ^d	2.0 ± 0.4	3.8	<0.3	2.7 ± 1.0	<5.7
23S-98-140	<0.1	<0.1	1.8 ± 0.2	1.5 ± 0.3	3.3	<0.2	1.6 ± 1.0	<3.4
23S-98-142	0.2 ± 0.1	0.5 ± 0.1	1.7 ± 0.2	1.6 ± 0.3	3.3	<0.2	2.1 ± 1.1	<4.4
23S-98-144	<0.1	<0.1	2.1 ± 0.2	2.0 ± 0.3	4.1	<0.2	2.3 ± 0.9	<4.8
23S-98-145	<0.1	<0.1	2.0 ± 0.2	1.9 ± 0.3	3.9	0.2 ± 0.2	2.0 ± 0.7	4.2
General Atomics Original Results								
23S-98-137	<0.1	<0.1	BKG ^e	BKG	BKG	BKG	BKG	BKG
23S-98-140	<0.1	0.11 ± 0.06	BKG	BKG	BKG	BKG	BKG	BKG
23S-98-142	0.24 ± 0.09	0.33 ± 0.13	BKG	BKG	BKG	BKG	BKG	BKG
23S-98-144	<0.1	<0.1	BKG	BKG	BKG	0.20	6.0	BKG
23S-98-145	<0.1	<0.1	BKG	BKG	BKG	0.15	5.7	BKG
General Atomics Revised Results^f								
23S-98-137	<0.1	<0.1	1.57 ± 0.15	1.60 ± 0.42	--- ^g	ND ^h	2.22 ± 1.91	---
23S-98-140	<0.1	0.11 ± 0.06	1.32 ± 0.14	1.57 ± 0.40	--- ^g	ND ^h	2.78 ± 1.65	---
23S-98-142	0.24 ± 0.09	0.33 ± 0.13	1.31 ± 0.16	1.55 ± 0.38	--- ^g	ND ^h	1.62 ± 1.56	---
23S-98-144	<0.1	<0.1	1.56 ± 0.15	1.45 ± 0.36	--- ^g	ND ^h	3.23 ± 1.89	---
23S-98-145	<0.1	<0.1	1.62 ± 0.16	2.00 ± 0.50	--- ^g	ND ^h	3.43 ± 2.00	---

^aSample identification used by General Atomics.

^bESSAP total thorium concentrations were calculated by summing the Th-228 and Th-232 concentrations.

^cESSAP total uranium concentrations were calculated by multiplying the U-238 concentration by 2 and adding the U-235 concentration.

^dESSAP uncertainties are total propagated uncertainties at the 95% confidence level.

^eGeneral Atomics analyses indicated that these samples contained background levels of the radionuclides. Average background levels were as follows: Th-228, 1.19 pCi/g; Th-232, 1.31 pCi/g; Total Thorium, 2.5 pCi/g; U-235, 0.14 pCi/g; U-238, 2.03 pCi/g.

^fGA revised results reported actual results for Th-228, Th-232, and U-238 (using 63keV peak).

^gNot calculated.

^hND means not detected.

TABLE 5
SOIL RELEASE CRITERIA¹
HOT CELL FACILITY SITE
GENERAL ATOMICS
SAN DIEGO, CALIFORNIA

Radionuclide²	Release Criteria Based on External Exposure Limits, in pCi/g	Release Criteria Based on Internal Exposure Limits, in pCi/g
Co-60	8 ³	
Cs-137	15 ³	
Cs-134	10	
Eu-152	11	
Eu-154	10	
Eu-155	635	
Nb-94	7.5	
Sb-125	37	
Sr-90		1800 ³
Natural Uranium		35 ⁴
Enriched Uranium (U-235, U-234, & U-238)		30 ⁴
Thorium (Th-232 & Th-228)		10 ⁴

¹The release criteria shown in this table without annotation by footnotes 2 or 3 were calculated by the licensee using RESRAD version 5.18 adhering to the same assumptions that were provided in the correspondence listed in note 2 below. This corresponds to conservative calculation of the homogenous concentration of an isotope in the soil that by itself would give approximately 10 μ R/h external exposure rate above background for the maximum year of exposure.

²If additional nuclides are encountered during the final survey activities, values identified in the previously approved GA Hot Cell Facility Decommissioning Plan and the GA Site Decommissioning Plan will be used.

³These release criteria are based upon precedent through NRC and State of California approved release limits for the GA site. See correspondence K. E. Asmussen to W. T. Crow, dated October 1, 1985, correspondence identification 696-8023, Subject: "Docket 70-734; Plan for Obtaining Release of Certain Areas to Unrestricted Use."

⁴These release criteria are based on past precedent established by NRC through NRC Policy Issue SECY-81-576, dated October 5, 1981, Subject "Disposal or on-site storage of residual thorium or uranium (either as natural ores or without daughters present) from past operations."

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

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)

Detectors

Bicron Micro-Rem Meter
(Bicron Corporation, Newburg, 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
Alpha Workstation
(Canberra, Meriden, CT)

High Purity Extended Range Intrinsic Detector
Model No. GMX-45200-5
(ORTEC)
used in conjunction with:
Lead Shield Model SPG-16-K8
(Nuclear Data)
Multichannel Analyzer
Alpha Workstation
(Canberra, Meriden, CT)

LABORATORY ANALYTICAL INSTRUMENTATION (continued)

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

Alpha 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 10 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

Exposure Rate Measurements

Measurements of dose equivalent rates ($\mu\text{rem/h}$) were performed at 1 m above the surface using a Bicon microrem meter. Although the instrument displays data in $\mu\text{rem/h}$, the $\mu\text{rem/h}$ to $\mu\text{R/h}$ conversion is essentially unity.

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 Spectroscopy

Samples of soil were dried, mixed, crushed, and/or homogenized as necessary, and a portion sealed in a 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 total absorption peaks associated with the radionuclides of concern were reviewed for consistency of activity. Energy peaks used for determining the activities of radionuclides of concern were:

Th-228	0.239 MeV from Pb-212*
Th-232	0.911 MeV from Ac-228*
U-235	0.143 MeV
U-238	0.063 MeV from Th-234* (or 1.001 MeV from Pa-234 m)*
Cs-137	0.662 MeV
Cs-134	0.795 MeV
Co-60	1.173 MeV
Eu-152	0.344 MeV
Eu-154	0.723 MeV
Eu-155	0.105 MeV
Nb-94	0.702 MeV
Sb-125	0.428 MeV

*Secular equilibrium assumed.

Spectra were also reviewed for other identifiable total absorption peaks (photopeaks).

Strontium-90 Analyses

Soil samples were dried, mixed, and crushed. An aliquot of ashed material was removed and dissolved using sequential molten salt fusions. The sample was then dissolved in a weak hydrochloric acid solution and strontium was precipitated with lead sulfate. Potential interferences were removed using EDTA and borium chromate. Strontium was precipitated as the carbonate and counted on a low background gas proportional counter. The count rate was corrected for yttrium ingrowth. The chemical yield was determined gravimetrically.

UNCERTAINTIES AND DETECTION LIMITS

The uncertainties associated with the analytical data presented in the tables of this report represent total propagated uncertainty at the 95% confidence level. These uncertainties were calculated based on both the gross sample count levels and the associated background count levels.

Detection limits, referred to as minimum detectable concentration (MDC), were based on 3 plus 4.65 times the standard deviation of the background count $[3 + (4.65\sqrt{\text{BKG}})]$. 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 standards/sources were available. In cases where they were not available, standards of an industry-recognized organization were used.

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, (January 1998)
- Laboratory Procedures Manual, (October 1999)
- Quality Assurance Manual, (May 1998)

The procedures contained in these manuals were developed to meet the requirements of DOE Order 414.1A and 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 EML, ITP, and MAPEP laboratory Quality Assurance Programs.
- Training and certification of all individuals performing procedures.
- Periodic internal and external audits.