ANNUAL ENVIRONMENTAL MONITORING REPORT

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Introduction

The Stanford Linear Accelerator Center (SLAC) is located two miles west of the Stanford Campus in San Mateo County, California. Its boundaries include Sand Hill Road on the north and San Francisquito Creek on the south. The land slopes to the south toward San Francisquito Creek. The total length of the accelerator and experimental areas is approximately 3 miles and is oriented almost east-west. Figures 1 and 2 locate SLAC with respect to the surrounding vicinity.

SLAC is a large research laboratory devoted to theoretical and experimental research in high energy physics and to the development of new techniques in high energy accelerator and particle detectors. The main tool of the laboratory is a 2 mile long linear accelerator. This accelerator produces beams of electrons with energies up to 22 billion electron volts (22 GeV). It can also accelerate positrons, the "anti-particles" of the electrons, up to 12 GeV.

SLAC was conceived, designed, built and is being operated by Stanford University. It is a national facility in that it is available to physicists not only from Stanford but also from all over the United States and the world. The work is carried out under the sponsorship and financial support of the U. S. Atomic Energy Commission.

Authorization of the project was given by the U. S. Congress in 1961. Construction of the accelerator started in 1962 and was completed in 1966. Research consisting of numerous and varied experiments has been under way since late 1966.

Summary

The SLAC regional surveillance program is intended to assess the contribution from SLAC operations, if any, to the existing radiation environment typically known as "background radiation." The term background radiation includes naturally occurring radioactive elements and man-made radioelements usually from past atmospheric weapons' testing. Accordingly, samples of soil, vegetation, ground water, surface water, sanitary and storm sewers are periodically collected and activity levels determined. Airborne radioactivity is measured and recorded continuously at the release point. Continuous physical radiation measurements of neutron and gamma dose is also provided near the

site boundary. Environmental and physical radiation monitoring locations are indicated on Fig. 3.

Monitoring Techniques and Standards

Concentration Guides for Liquid Effluent

The CG's for unidentified radionuclides that may be produced in water at SLAC and released to the environment is 3×10^{-6} μCi/ml. This is true because the following isotopes are not produced at SLAC: ^{90}Sr, ^{125}I, ^{126}I, ^{129}I, ^{131}I, ^{210}Pb, ^{210}Po, ^{211}At, ^{223}Ra, ^{224}Ra, ^{226}Ra, ^{227}Ac, ^{228}Ra, ^{230}Th, ^{231}Pa, ^{232}Th, ^{248}Cm, ^{254}Cf, ^{256}Fm and natural thorium.[1]

Sample Analysis

All water samples collected are analyzed for gross beta activity and tritium by an independent laboratory. Analysis for alpha emitting radioelements is not performed because we do not produce nor possess in unsealed form significant quantities of this type of radioactivity at SLAC.[2] In addition to routine gross beta analysis, SLAC will examine aliquots of selected specimens by gamma spectroscopy, if necessary.

Sample Preparation

When environmental water samples exhibit large amounts of insoluble solids, the solid fraction and filtrate activities are determined separately.

The total volume of each sample is measured and filtered through tarred filters. The original sample bottle is rinsed with the filtrate and the activity in each fraction is determined separately.

For the solid fraction, the filter paper and solid are dried at ~100°C and weighed after cooling. A 300 to 500 mg aliquot is counted. If required, self-absorption measurements are made on the dried samples.

The filtrate and water samples exhibiting low solid content are treated the same. An ~200 cc volume is taken from each 500 cc sample and evaporated to a smaller volume in a beaker. It is then transferred to a tarred planchet with dilute acid and water rinses. The sample is evaporated gently, weighed and counted.

Vegetation and soil samples are treated by similar techniques, except that the soil samples are not ashed unless the samples have a high organic content. An aliquot is dried and ashed and a 300-500 mg sample is transferred into a

tarred planchet, slurried with water and gently evaporated to dryness. The sample is then cooled, weighed and counted.

Gross Beta

The prepared samples are counted in a low background proportional counter ($\leq$ 1.5 cpm). The results are compared to the efficiency of Cs^{137} for the counting system used.

Some environmental samples require ^{40}K corrections: the total amount of potassium in the sample is determined by flame photometry. The amount of ^{40}K activity can then be calculated based on the percent abundance of this naturally occurring radioelement. This correction is performed on all water samples whose gross beta activity is $> 1\times10^{-7}$ μCi/ml.

The data is reported as the midpoint of the single Poisson standard deviation of the counting error.

Tritium

A 2-3 ml aliquot of the filtered solution from the gross beta sample preparation is accurately transferred to a liquid scintillation sample vial. The sample vial is placed in a liquid scintillation counting system. The limit of sensitivity at the 95% confidence level is $\leq 3\times10^{-6}$ μCi/ml.

Concentration Guides for Airborne Radioactivity

The Concentration Guides (CG's) for airborne radioactivity appear in Reference 1. They were derived from dose standards which requires that no individual in the general population will be exposed to greater than 500 mrem in one year and that the average dose to a population of suitable size shall not exceed 170 mrem annually from project operations.

Airborne radioactivity produced as the result of accelerator operations are short-lived, i.e., the half-lives range from 2 minutes to 1.8 hours and are in gaseous form. These isotopes include the following:

Table 1

Gaseous Radioactivity Released to Atmosphere

Isotope	Half-Life	CG's
^{15}O	2.1 min	5×10^{-8} (a)
^{13}N	9.9 min	5×10^{-8} (a)
^{11}C	20.5 min	5×10^{-8} (a)
^{41}Ar	1.8 hr	4×10^{-8}

(a) Calculated from Reference 3.

Since we do not routinely release airborne radioactivity while the beam is on and routinely require a waiting period before turning on the exhausters, the only radioisotope routinely released is ^{41}Ar. By far the greater proportion of exposure, an individual may receive from the radioelements listed in Table 1, is from whole body immersion. Thus, for an individual to receive a whole body dose of 500 mrem annually requires an exposure to a cloud of ^{41}Ar whose average concentration is 4×10^{-8} μCi/cc for an entire year.

Analysis Techniques for Airborne Radioactivity

The accelerator and beam switchyard areas are vented by 12 fans: the discharge point is just slightly above roof elevation. The total exhaust rate for the accelerator is 130,000 CFM and the BSY is 85,000 CFM. The accelerator and BSY are not normally vented while the electron beam is on. If personnel entry has to be made during an operating cycle the area is vented for 10 minutes prior to entry and after the electron beam has been shut off. The release of any radioactivity is therefore not continuous and only for brief periods of from 30-60 minutes. The accelerator does not represent a significant source of gaseous or particulate radioactivity due to low activating potential.

Each ventilation fan is interlocked with a radioactive gas detector comprised of a Geiger-Mueller detector, power supply, rate-meter, strip chart recorder and air pump. The electronics are in continuous operation and the recorder and air pump are interlocked with the ventilation fan so that they operate only when the machine is being vented.

The gas monitors for the BSY have been modified to collect particulate samples during venting and have revealed negative results. During this report period, no particulate radioactivity above background levels were detected. This agrees with previous "grab" samples collected in the exhaust stream.

Radiation Monitoring Techniques

Seven Peripheral Monitoring Stations (PMS) serve to provide continuously recorded data concerning radiation levels (γ and n) near SLAC boundaries. Their positions are located in Fig. 3.

Radiation information is obtained with a Geiger tube and paraffin-moderated BF_3 neutron detector calibrated with a PuBe neutron source. The resultant sensitivites are such that a γ flux from ^{60}Co exposed to an average value of 1 mR/hr for one hour will be recorded as $\sim 10^4$ counts on the Geiger tube channel,

and a neutron flux having an average value for one hour of 1 mrem/hr will be read out as $\sim 10^5$ counts on the BF_3 channel. The hourly printout cycle of the Sodeco register is programmed by the two-clock motors with cam actuated switches and associated electronic circuitry. This programmer automatically interrupts data acquisition, generates a print command, resets the digits in parallel, and reverts to the normal condition of serial counting of incoming data pulses. Dead time per printout cycle is less than 20 seconds per hour.

In connection with the pulse pair resolution limitation of the Sodeco register mentioned above, an important feature of this system involves the pulser which drives the register. It is of the nonparalyzable type. This means that if the instantaneous counting rate (20 counts/sec) is ever exceeded the register will merely not count the pulses in excess of its maximum rate. It can count at this maximum rate continuously (72,000 counts/hr).

Results of Environmental Monitoring

Results of the environmental analysis for radioactivity found in water, soil and vegetation appear in Table 2 and are reported in μCi/ml or μCi/gm for gross beta nonvolatile radioactivity. Analysis of tritium is performed on all water samples but is not reported because all environmental samples analyzed exhibited a tritium content less than the minimum detectable level of 3×10^{-6} μCi/ml.

Some of the peripheral wells (ground water) exhibit higher than normal concentrations of gross beta radioactivity and solids. This activity is due to naturally occurring radioactive potassium-40 and has been verified by flame photometry and gamma spectral analysis. The ^{40}K content in samples from W-1 are typically about 2×10^{-7} μCi/ml accounting for approximately 90% of the gross beta activity present. Only those samples whose concentrations are above 1×10^{-7} μCi/ml are corrected for ^{40}K. One well has exhibited some naturally occurring radioactive daughters of uranium. During dry seasons the concentration has approached 1×10^{-7} μCi/ml.

In addition to the ground and surface water sampling stations previously reported, two composite water sampling stations have been added; these samples are from the sanitary and storm sewers whose daily effluent averages approximately 55,000 and 70,000 gallons respectively. The sampling rate is fixed at 5 ml/min and represents a sampling fraction of approximately 3×10^{-5} of the total effluent volume. At the end of each calendar quarter an aliquot is collected and analyzed for gross beta and tritium radioactivity. Results for 1971 appear in Table 2. There has been no significant increase of radioactivity in water, soil or vegetation since SLAC operations began in 1966.

Table 2

Measured Radioactivity Content of Environmental Samples
Collected at SLAC from January through December, 1971

Sample	Total Samples	Gross Beta Activity[a]		
		Minimum	Maximum	Average
Well Water, μCi/ml	64	5×10^{-9}	1.0×10^{-7}	2.5×10^{-8}
Surface Water, μCi/ml	4	$\leq 5\times10^{-9}$	9×10^{-9}	9×10^{-9}
Sanitary Sewer, μCi/ml	4	(b)	(b)	2.2×10^{-8}
Storm Sewer, μCi/ml	4	(b)	(b)	1.3×10^{-8}
Stream Silt as Soil, μCi/gm	2	3.2×10^{-5}	3.6×10^{-5}	
Vegetation, μCi/gm,	2	3.1×10^{-5}	3.6×10^{-5}	

(a) Includes ^{40}K.
(b) Composite Sample.

Results of Airborne Monitoring

During 1971, SLAC released 5.2 Ci of short-lived gaseous radioactivity during a total venting period of 18 hours. The total volume equaled 5.6×10^{5} m^3 for an average on site concentration of 9.3×10^{-6} Ci/m^3 during the 18 hour release period and scattered throughout the year. The average off-site concentration would therefore be <0.5% of the standard ^{41}Ar.[4]

Results of Radiation Monitoring

The annual total dose from gamma and neutron radiation near SLAC's boundary appear in Table 3. Note that the maximum measured dose above background was only 4.4% of the annual individual standard of 500 mrem.

Table 3

Annual Dose Measured at SLAC's Peripheral Monitoring Stations during 1971

PMS No.	Dose, mrem (gamma and neutron)*	% of Standard
1	110 (104)	0.83
2	81 (88)	0
3	80 (68)	2.4
4	92 (70)	4.4
5	115 (100)	3.0
6	82 (100)	0
8	90 (86)	0.8

*Value includes background radiation, numbers in parenthesis indicate annual background measurement at each station from 1968 data.

References

1. U. S. Atomic Energy Commission Manual, Chapter 0524, Standards for Radiation Protection.
2. W. R. Nelson, "Radioactive Ground Water Produced in the Vicinity of Beam Dumps," Report No. SLAC-TN-65-16 (July 1965).
3. Recommendations of the International Commission on Radiological Protection, Publication 2 (1959) (Pergamon Press, London).
4. J. A. Murray, L. M. Vaughan and R. W. McMullen, Atmospheric Transport and Diffusion Characteristics for Selected Daytime Meterological Regimes at SLAC, Memorandum Report No. 326-1, Metronics Aerosol Laboratory, 21 December 1967.

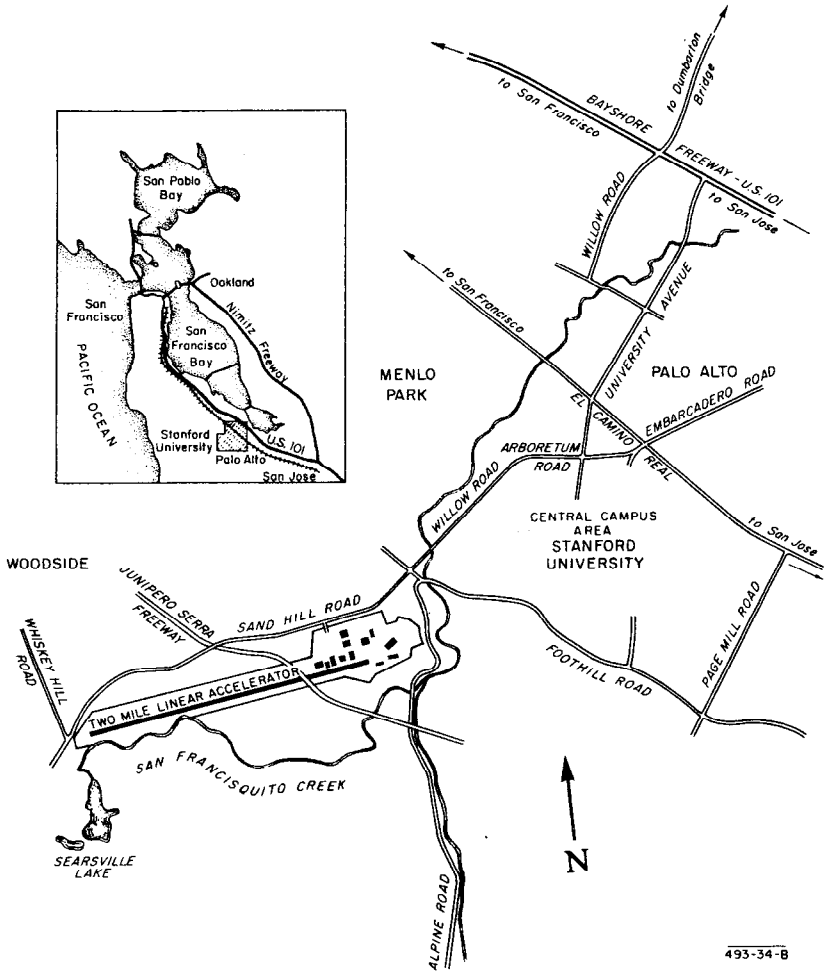
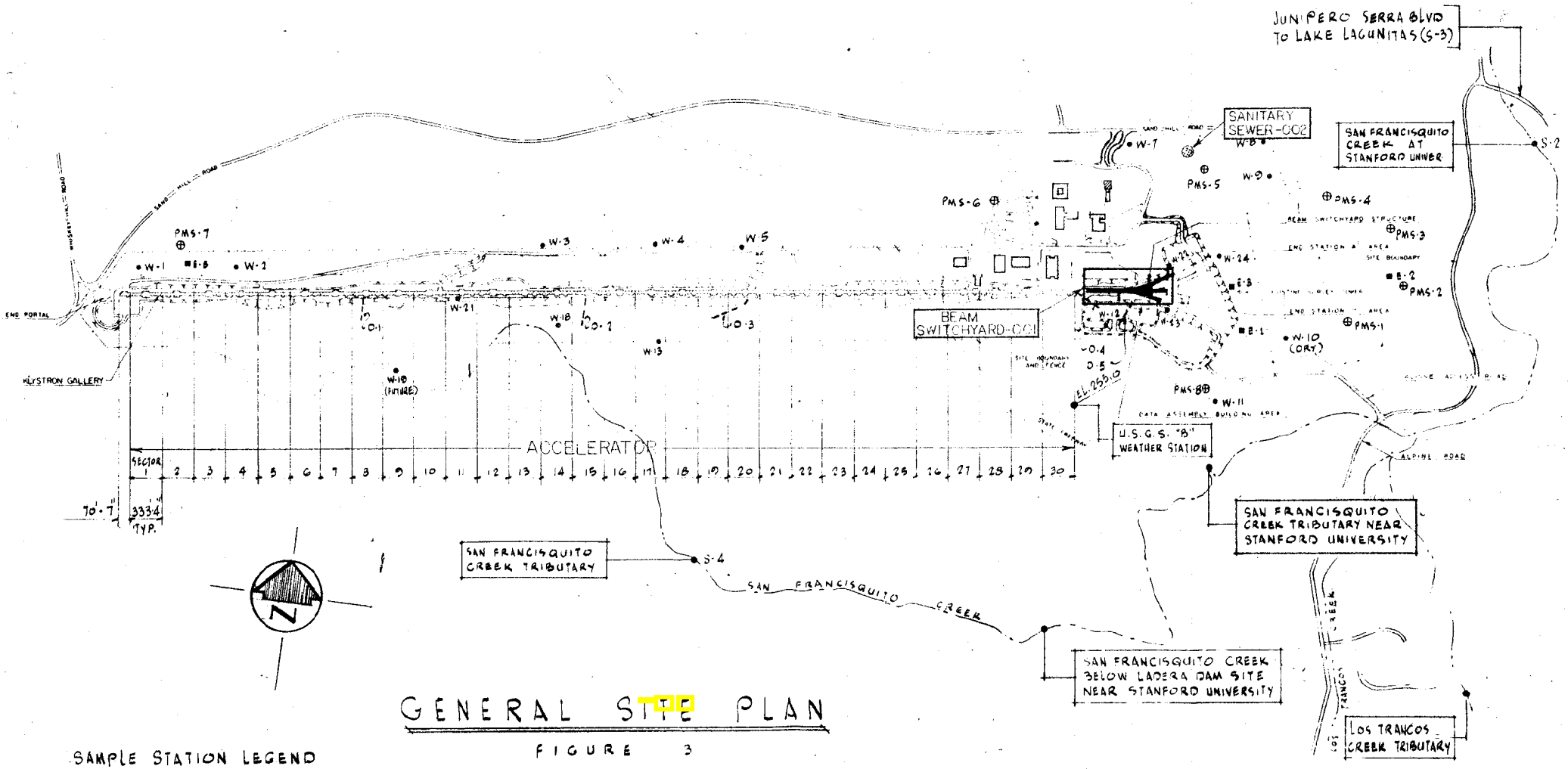


FIG. 1--Site location relative to Stanford University and surrounding communities.

FIG. 2--Air view of SLAC site showing the two-mile accelerator, the research facility, and the principal laboratories and shops.



GENERAL SITE PLAN

FIGURE 3

SAMPLE STATION LEGEND

- ●W PERIPHERAL WELLS
- ●S SURFACE WATER
- ■E ENVIRONMENTAL PLOTS
- ⊕PMS PERIPHERAL MONITORING STATIONS
- ---D SUBDRAINS

GRAPHIC SCALE

1000' 0 1000' 2000'

SCALE: 1" = 1000'