SLAC–363

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ENVIRONMENT AND SAFETY OFFICE
STANFORD LINEAR ACCELERATOR CENTER
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1.0 Introduction

1.1 General

The Stanford Linear Accelerator Center (SLAC) is a national facility operated by Stanford University under contract with the U.S. Department of Energy (DOE). It is located on the San Francisco Peninsula, about halfway between San Francisco and San Jose, California. The site area is in a belt of low rolling foothills, lying between the alluvial plain bordering San Francisco Bay on the east and the Santa Cruz Mountains on the west. The accelerator site varies in elevation from 53 to 114 meters (m) above sea level, whereas the alluvial plain to the east around the Bay lies less than 46 m above sea level; the mountains to the west rise abruptly to over 610 m. The SLAC site occupies 170 hectares of land owned by Stanford University and leased for fifty years in 1962 to the DOE (then AEC) for purposes of research in the basic properties of matter. The lands are part of Stanford's "academic reserve," and are located west of the University and the City of Palo Alto. The site is located in an unincorporated portion of San Mateo County. It is bordered on the north by Sand Hill Road and on the south by the San Francisquito Creek. The accelerator is sited on a roughly 300-meter-wide parcel, 3.2 kilometers (km) long, running in an east-west direction. The width of the parcel expands to about 910 m at the target (east) end to allow space for buildings and experimental facilities.

The SLAC staff currently numbers roughly 1,550 employees; there are about 1,200 full-time people, 200 part-time and 150 visiting scientists. Approximately one-quarter of the staff is professional, composed of physicists, engineers, programmers and other scientific-related personnel. The balance of the staff composition is support personnel including technicians, crafts personnel, lab assistants, clerical and administrative employees.

1.2 Accelerators in Perspective

Accelerators are simply tools of research enabling physicists to explore and understand the fundamental behavior of the subatomic environment. Some accelerators are linear, as is SLAC's; others are circular in geometry as are cyclotrons, synchrocyclotrons, betatrons and synchrotrons. All conventional accelerators accelerate subatomic particles (electrons, protons, positrons, alpha particles) to a high energy and bombard a target nucleus. Physicists then study the effects of the collisions in an attempt to understand precisely what happens and thereby understand the nature of the atomic nucleus. Because of the very strong forces which bind the nucleus and its constituents together, physicists need greater and greater energies in order to delve constantly deeper. Consequently, accelerators have grown in size and complexity.

One of the important components of the U.S. High Energy Physics Program is the 3.2 km-long electron accelerator at SLAC. This machine is now capable of accelerating electrons to 50 billion electron volts (GeV), and positrons will soon achieve the same energy. These particle beams are utilized by an array of experimental fixed target installations, two colliding beam storage rings and the Stanford Linear Collider (SLC).

The Positron Electron Project (PEP) storage ring is a special extension of the SLAC accelerator and poses no greater environmental problems than does the existing linac. The center-of-mass energy achieved by colliding beam particles together is vastly more efficient than having a single beam strike a stationary target. In a colliding-beam storage machine the beam particles are truly "recycled;" i.e., the same bunches of beam particles are brought into collision over and over again, rather than striking a target only once. For this reason, colliding-beam devices (in a fundamental way) produce very much less radiation and residual radioactivity than do conventional accelerators.

The PEP facility completed in 1980, is a large storage ring housed in an underground tunnel at depths varying from 6–30 m, in which beams of electrons and their antimatter equivalent (positrons) circulate in opposite directions at energies up to 15 GeV. The underground ring has a diameter of about 700 m and is located at the eastern extremity of the SLAC site.

When particles of matter and antimatter meet head-on at high velocity, both are completely converted into energy. According to the formulations of Albert Einstein, energy can be transformed into matter and vice versa. In the electron-positron collisions some of the resulting energy is immediately transformed back into matter, producing a variety of particles of immense interest to physicists. Many of the design details of the PEP facility are based on the design and experience of a small existing storage ring at SLAC called the Stanford Positron Electron Asymmetric Ring (SPEAR). The SPEAR facility came into operation and began performing colliding-beam experiments in 1972. The SPEAR machine is about one-eighth the size and capable of about one-quarter the energy of the PEP facility. Although the high energy physics usefulness of SPEAR has been fully exploited in the 1980's, its success has established the feasibility and served as a prototype for PEP. SPEAR also serves as a strong source of synchrotron light for the Stanford Synchrotron Radiation Laboratory (SSRL).

In addition to the aforementioned facilities, SLAC has built a new machine, the Stanford Linear Collider (SLC). The SLC project was proposed in 1980 and finished in 1987. When fully operational, SLC provides electron-positron collisions at 100 GeV center-of-mass energy.[1] This new project will not have any additional significant environmental impact. It is housed in a 3 km underground tunnel having a single interaction region at the eastern end of the site.

1.3 Local Climate

The climate in the SLAC area is Mediterranean. Winters are warm and moist, and summers are mostly cool and dry. Long-term weather data describing conditions in the area have been assembled from official and unofficial weather records at Palo Alto, 4.8 km to the east. The SLAC site is 60 to 120 m higher than the Palo Alto station and is free of the moderating influence of the city; temperatures therefore average about two degrees lower than those of Palo Alto. Daily mean temperatures are seldom below zero degrees Centigrade or above 30 degrees Centigrade.

Rainfall averages about 560 millimeters (mm) per year. The distribution of precipitation is highly seasonal. About 75% of the precipitation—including most of the major storms—occurs during the four-month period December through March. Most winter storm periods are from two days to as much as a week in duration. The storm centers are usually characterized by relatively heavy rainfall and high winds. The combination of topography and air movement produces short fluctuations in intensity which can be best characterized as a series of storm cells following one another so as to produce heavy precipitation for periods of five to fifteen minutes with lulls in between.

1.4 Site Geology

The SLAC site is underlain by sandstone and claystone with some basalt at the far eastern end of SLAC's boundary. In general, the bedrock on which the western half of the accelerator rests is of Eocene age (over 50 million years old) ,and that under the eastern half is of Miocene age (over ten million years old). On top of this bedrock at various places along the accelerator alignment are found alluvial deposits of sand and gravel, generally of Pleistocene age (one million years old). At the surface is a soil overburden of unconsolidated earth materials averaging from 0.1 to 1.5 m in depth.

1.5 Site Water Usage

Use of water by SLAC is about equally divided between accelerator and equipment cooling, and domestic uses (such as landscape irrigation, sanitary sewer and drinking water). The "pre-PEP" (circa 1979) consumption amounted to about 340,000 cubic meters per year (930 cubic meters per day, on the average).

Since half of the water is necessary for machine cooling, the daily consumption of this component varies directly with the accelerator running schedule, and hence also varies directly with electric power demand (the domestic water usage is relatively constant and is insensitive to the accelerator schedule). The relationship between power and water consumption can be appreciated if one considers that 85% of the power used in linac operation is finally dissipated by water evaporation, in the ratio of about 630 kilowatt–hours (kWh) per cubic meter of water. SLAC now employs five cooling water towers comprising a total cooling capacity of 79 MW to dissipate the heat generated by the linear accelerator and other experimental apparatus.

Power consuming devices are directly cooled by a recycling closed-loop system of low conductivity water (LCW). The LCW is piped from the accelerator (or other devices to be cooled) to the cooling towers, where the heat is exchanged from the closed system to the domestic water in the towers. A portion of the tower water is ultimately evaporated into the atmosphere. Because of this constant evaporation during operation, the mineral content of the remaining water gradually increases and eventually must be discarded as "blowdown."

The SLAC domestic water is furnished via the Menlo Park Municipal Water Department (MPWD) whose source is the City of San Francisco-operated Hetch Hetchy aqueduct system from reservoirs in the Sierra Nevada. SLAC and its neighboring Sharon Heights development, including the shopping center, receive water service from a separate independent system (called "Zone 3") within the MPWD. This separate system taps the Hetch Hetchy aqueduct and pumps water up to a 7600 cubic meter reservoir west on Sand Hill Road. The Zone 3 system was constructed in 1962 under special agreements between the City of Menlo Park, the developer of Sharon Heights, Stanford University, and the DOE. The cost of construction—including reservoir, pump station and transmission lines—was shared among the various parties; each party has a vested interest in, and is entitled to, certain capacity rights in accordance with these agreements.

During current operations, roughly 45% of the water consumed by the laboratory is rejected by evaporation from the four cooling towers. The remaining 55% is disposed of as follows:

- 26% is runoff to the San Francisquito Creek via the storm drains,
- 20% is waste domestic and process water discharged via the sanitary sewers connected to the Menlo Park Sanitary District, and
- 9% is absorbed into the ground from irrigation.

1.6 Land Use

San Mateo County has the ultimate planning responsibility with respect to University lands which are within the county, but not within an incorporated city. The San Mateo County General Plan is the primary land use regulatory tool with respect to such lands. Adherence will be made to all applicable federal, state and local regulations, including chemical and sanitary discharges which might (directly or indirectly) adversely affect the environmental quality.

The Board of Trustees of Stanford University has the responsibility of preserving and protecting Stanford's land endowment for the use of present and future generations of students and faculty. While financial and political influences on land use policy are taken into account, the dominant and prevailing consideration is the appropriateness of those policies in the furtherance of the University's academic mission. Board policies are designed to encourage land uses consistent with the institutional characteristics and purposes of Stanford, and to discourage those uses or claims which do not relate to or support the mainstream of the University. Certainly SLAC falls into the former category.

The purpose of the Stanford land endowment is to provide adequate land for facilities and space for the instructional and research activities of the University. The use of lands is planned in a manner consistent with the characteristics of Stanford as a residential teaching and research university, and provides flexibility for unanticipated changes in academic needs. Cooperation with adjoining communities is important and the concerns of neighboring jurisdictions are considered in the planning process.

1.7 Demography

Menlo Park is the closest incorporated city to SLAC. According to the 1980 census the City of Menlo Park has a land area of 43.8 km^2, a population of 26,369, and a population density of 602 persons per km^2. This population has decreased by 1.7% since the 1970 census.

In 1974 a population estimate within 1.6 km of SLAC was determined by aerial photographs and type of structures revealed. The populated area surrounding SLAC is a mix of offices, schools, condominiums, apartments, single family housing and pasture land. Occupancy factors of .1–1.0 were assumed, depending on the type of structure. The populated area is about 1.5 km^2 or (from the 1980 census population density) about 1,000 people . The total area including open lands^2 is 8 km^2.

2.0. General Summary

2.1 Unusual Events or Releases

On October 17, 1989, a 7.1 Richter scale earthquake shook the San Francisco Bay Area. Structural damage to buildings was minor. Some equipment and magnet supports in the linac and associated tunnels were damaged. The major upset was sloshing of the plating shop tanks onto the wet floor. A total of 22,750 gallons was eventually transported offsite for disposal from the mixing of the tanks and the washdown waters.

2.2 Notice of Violation

One Notice of Violation (NOV) was received by SLAC from the South Bayside System Authority (SBSA) in April 1989. This NOV was for exceeding the metal finishing pretreatment standard for cyanide. Operational and procedural changes were implemented and approved by SBSA in a letter received October 1989.

2.3 Radioactive and Nonradioactive Releases

There were no reportable radioactive or nonradioactive releases to the environment in 1989.

3.0 Compliance Summary

3.1 Background

The Stanford Linear Accelerator Center (SLAC) must operate in compliance with applicable Federal, State and local environmental regulations, as well as DOE Orders. SLAC's status with major environmental statutes are as follows:

Clean Air Act (CAA):

> SLAC has Permits-to-Operate for 33 point sources throughout the site and a site-wide permit for wipe-cleaning operations. These permits are regulated by the Bay Area Air Quality Management District (BAAQMD).

Clean Water Act (CWA):

> SLAC has a National Pollutant Discharge Elimination System (NPDES) Permit from the California Regional Water Quality Control Board (RWQCB), San Francisco Bay Region. SLAC also has a treatment facility that is regulated under the metal finishing pretreatment standards of the CWA. The discharge from the treatment facility and the total sanitary sewer effluent are regulated by two permits (joint authority) from the West Bay Sanitary District and the South Bayside System Authority.

Resource Conservation and Recovery Act (RCRA):

> SLAC is a generator of hazardous wastes and has 90 days to ship its wastes to Environmental Protection Agency (EPA)–approved treatment, storage or disposal facilities (TSDFs).

3.2 Current Issues and Actions

There are no serious environmental compliance issues at SLAC. The current activities include a replacement program for PCB transformers, and investigation and possible remediation of PCB soil contamination.

Potential Release from Earthquake

On October 17, 1989, a 7.1 Richter scale earthquake shook the San Francisco Bay Area. The epicenter of the Loma Prieta Earthquake was approximately 15 miles southwest of SLAC.

Structural damage to SLAC buildings was minor due to adherence to earthquake standards and further earthquake-proofing required by the SLAC Earthquake Committee. Equipment and magnet supports for the linac were damaged and require major repair. The major environmental effect was sloshing of plating shop tanks onto the wet floor. Two seismic valves also opened during the quake and flushed the wet floor with several hundreds of gallons of water. Several water makeup valves were dislodged and dumped water into rinse tanks until manually shut off. All of this wastewater was flushed through the line to the treatment facility. Controls at the treatment facility were lost due to power and air outage.

The volume of wastewater released to the sanitary sewer could not be determined. On October 18, 1989, the South Bayside System Authority (SBSA) was notified of a potential release and that the treatment facility had been set on closed-loop recirculation. Analyses of the wastewater for waste profiling and subsequent disposal were made. A total volume of 22,750 gallons of wastewater from the spilled tanks and washdown were disposed at a hazardous waste facility. No actions were taken by SBSA due to other upsets at the treatment facility from the earthquake.

Plating Shop NOV

In 1989 the major noncompliance item was a Notice of Violation (NOV) from SBSA for exceeding the metal finishing pretreatment standard for cyanide. Changes implemented to remedy the NOV included installation of chemical treatment feed pumps, a mixer, and a cyanide control system. These modifications were inspected by SBSA personnel in June 1989, and a memo was sent to the West Bay Sanitary District stating that the modifications should allow SLAC to continue to meet their discharge standard for the cyanide rinse waste stream.

Cleanup and Sampling Activities

SLAC has sampling and cleanup activities at the Master Substation. This area has stored mineral oil and PCB contaminated equipment that have leaked due to improper past practices. The first third of the Master Substation (which includes the main drainage way) has undergone cleanup activities that will continue until December 1990. Cleanup is to the State cleanup level of 5 ppm of PCBs.

The Environmental Survey Sampling Team performed sampling at various locations that were suspected of being contaminated. Sampling results confirmed PCB contamination at the Master Substation and at the area surrounding an IR-8 PCB transformer that had overpressurized. The area by the IR-8 transformer had been remediated, but not adequately. This area is scheduled for cleanup in 1990.

The Environmental Survey Sampling Team also found PCB contamination at the IR-6 and IR-8 separator drainage. Both drainage pathways carry storm runoff from areas where PCB transformers or equipment are located. The contamination is probably an accumulation from the beginning of SLAC's operation. This area is scheduled for remediation in 1990 as well.

Other areas identified by the Environment Survey Sampling Team will be resampled to confirm contamination. These areas include the hillside along Building 36 for PCB contamination and the IR-8 separator discharge for unusually high levels of metals (antimony, copper and zinc).

4.0 Environmental Nonradiological Program Information

4.1 Environmental Permits

SLAC has been issued the following permits:

- California Regional Water Quality Control Board
  San Francisco Bay Region
  NPDES Permit CA0028398
  Order 87–044
  Expiration date: April 30, 1990
  Waste Discharge Permit, Order 85-88

- West Bay Sanitary District and South Bayside System Authority
  Wastewater Discharge Permit No. WB860915–PTE
  Wastewater Discharge Permit No. WB860915–FNS
  Expiration dates: September 14, 1990

- Bay Area Air Quality Management District
  Plant No. 556
  34 permits.

- EPA Hazardous Waste Generator
  Identification No. CA8890016126

4.2 Environmental Monitoring Performance

Environmental monitoring is required by a variety of local, state and federal agencies. Routine monitoring includes:

National Pollutant Discharge Elimination System (NPDES) sampling:

> SLAC has five cooling towers that blowdown to San Francisquito Creek. Blowdown is regulated under the Clean Water Act as industrial waste waters with three discharge points to the creek. The conditions for monitoring under this permit (CA0028398, Order 87-044) are listed in Table IV-1. SLAC's present permit expires April 30, 1990.

Table IV–1

National Pollutant Discharge Elimination System (NPDES)
Sampling Requirements(a)

Sampling Stations	E-001,	E-002,	E-003	C-R, C-1 (b)	Limit
Type of sample	Observation	Continuous	Grab	Grab	
Flow rate (gal/day)		M			
Settleable matter (ml/l/hr)			W (c)	W (c)	0.1
Oil and grease (mg/l)			2/W	W (c)	5
Total phosphate (mg/l)			2/W	2/W	<20
Total suspended solids (mg/l)			2/W	2/W	
Total dissolved solids (mg/l)			2/W	2/W	
pH (units)			M	M	6.5–8.5
Temperature (°C)			M	M	
Toxicity (% survival)			M (c)		90
All applicable standard observations	M				
Cooling water chemicals (type and lbs/mo added)	M				

(a) Frequency of Sampling:
W = once each week
2/W = twice each week
M = once each month
Q = once each quarter

(b) San Francisquito Creek upstream and downstream of discharge points.

(c) To be sampled on days coincident with effluent sampling.

Pretreatment standards for metal finishing operations:

SLAC has a facility for treating plating shop rinse waters before discharge to a publicly-owned treatment works (POTW). The South Bayside System Authority (SBSA) monitors the effluent from the treatment facility for compliance with the metal finishing pretreatment standards under the Clean Water Act. SBSA also monitors the total sanitary sewer discharge for compliance with SLAC's permit standards with the West Bay Sanitary District (WBSD). The standards for metal finishing pretreatment (Wastewater Discharge Permit No. WB860915-PTE) and SLAC's total sanitary sewer discharge limits (Wastewater Discharge Permit No. WB860915-FNS) are listed in Table IV-2 and IV-3. Both permits are renewable yearly with the present permits expiring September 14, 1990.

Air monitoring:

No air monitoring for nonradioactive species are required at this time. A list of the current BAAQMD permits is shown in Table IV-4.

Environmental deadlines that were met in 1989 include submission of the Air Toxics Inventory to the Bay Area Air Quality Management District (BAAQMD) and SLAC's Environmental Protection and Implementation Plan under DOE Order 5400.1 to SAN.

Table IV–2

Standards for Treatment Facility

Wastewater Discharge Permit No. WB860915=-PTE

Monitoring Location: Pretreatment effluent outfall uncombined with other waste streams

Constituent	Allowable Maximum	Monitoring Frequency	Sample Type
Oil and grease	100 mg/l (a)	—	—
pH (minimum–maximum)	6.0–12.5 (b)	Continuous	Grab or composite
Temperature	150°F	—	—
Arsenic	0.1 mg/l	—	—
Cadmium	0.62 mg/l	Quarterly (c)	Composite
Chromium (total)	2.77 mg/l	Quarterly (c)	Composite
Copper	3.38 mg/l	Quarterly (c)	Composite
Lead	0.69 mg/l	Quarterly (c)	Composite
Nickel	3.38 mg/l	Quarterly (c)	Composite
Silver	0.43 mg/l	—	—
Zinc	2.61 mg/l	Quarterly (c)	Composite
Cyanide (total)	1.20 mg/l (d)	Quarterly (c)	Grab
Phenols	1.0 mg/l	—	—
Toxic organics	2.13 mg/l (e)	Semiannual (c)	Grab

(a) Oil and grease of mineral or petroleum origin.

(b) pH of pretreatment effluent continuously monitored by industrial discharger.

(c) Sampling and analysis by SBSA.

(d) Cyanide samples will be collected at the plating shop pretreatment tank uncombined with other waste streams.

(e) Compliance with toxic organics limit will be based on all compounds detected by EPA Analytical Methods 601 and 602.

Table IV–3

Sanitary Sewer Standards

Wastewater Discharge Permit No. WB860915–FNS

Monitoring Location: Flowmeter station adjacent to Sand Hill Road

Constituent	Allowable Maximum	Monitoring Frequency	Sample Type
Daily flow	64,375 gal		
Oil and grease	100 mg/l (a)	–	–
pH (Minimum-Maximum)	6.0–12.5	–	Grab or composite
Temperature	150°F	–	–
Arsenic	0.1 mg/l	–	–
Cadmium	0.2 mg/l	Quarterly (b)	Composite
Chromium (total)	0.5 mg/l	Quarterly (b)	Composite
Copper	2.0 mg/l	Quarterly (b)	Composite
Lead	1.0 mg/l	Quarterly (b)	Composite
Mercury	0.01 mg/l	–	–
Nickel	1.0 mg/l	Quarterly (b)	Composite
Silver	4.0 mg/l	–	–
Zinc	3.0 mg/l	Quarterly (b)	Composite
Cyanide (total)	1.0 mg/l	–	–
Phenols	1.0 mg/l	–	–

(a) Oil and grease of mineral or petroleum origin.
(b) Sampling and analysis by SBSA.

Table IV–4

Bay Area Air Quality Management District (BAAQMD) Permits and Emissions

		Annual Average (lbs/day)[(a)]				
S#	Source Description	Particulates	Organics	NO_x	SO_2	CO
1	Boiler	-	-	20	7	5
2	Boiler	-	-	7	2	2
3	Degreaser	-	9	-	-	-
4	Degreaser	-	28	-	-	-
5	Spray booth		7	-	-	-
6	Boiler	-	-	4	16	1
7	Sandblasting booth	-	-	-	-	-
8	Sandblast room	-	-	-	-	-
9	Degreaser	-	4	-	-	-
10	Woodworking operations	-	-	-	-	-
11	Metal cutting operations	-	-	-	-	-
13	Metal grinding operations	-	-	-	-	-
14	Sandblast booth	-	-	-	-	-
16	Sandblast booth	-	-	-	-	-
17	Metal and epoxy glass grinding	-	-	-	-	-
18	Refrigerated vapor degreaser	-	3	-	-	-
19	Fume hood	-	-	-	-	-
20	Printed circuit board etchant	-	-	-	-	-
21	Anodizing, pickling and bright dip operations	-	-	-	-	-
22	Vapor degreaser	-	2	-	-	-
23	Cold cleaner	-	-	-	-	-
24	Cold cleaner	-	-	-	-	-
25	Cold cleaner	-	-	-	-	-
26	Cold cleaner	-	-	-	-	-
27	Cold cleaner	-	-	-	-	-
28	Cold cleaner	-	-	-	-	-
29	Cold cleaner	-	-	-	-	-
30	Sludge dryer	-	-	-	-	-
31	Cold cleaner	-	-	-	-	-
32	Cold cleaner	-	-	-	-	-
33	Cold cleaner	-	-	-	-	-
34	Cold cleaner	-	-	-	-	-
35	Cold cleaner	-	-	-	-	-
36	Wipe cleaning	-	-	-	-	-

(a) NO_x = Nitrogen oxides; SO_2 = Sulfur dioxide; CO = Carbon monoxide

5.0 Environmental Radiological Program Information

5.1 Airborne Monitoring

Airborne radionuclides are produced in the air volume surrounding major electron beam absorbers such as beam dumps, collimators and targets. The degree of activation is dependent upon the beam power absorbed and the composition of the parent elements. The composition of air is well known, consisting of nitrogen, oxygen, and trace quantities of carbon dioxide and argon. Induced radioactivity produced at high energies are short-lived, such as oxygen-15 and carbon-11 with half-lives of 2 minutes and 20 minutes, respectively. Nitrogen-13 with a half-life of 10 minutes is also produced, but in much lower concentrations. As a consequence of water cooling and concrete shielding both containing large quantities of hydrogen, the thermal neutron reaction with stable argon produces argon-41, which has a half-life of 1.8 hours.

We have not detected any other radionuclides including particulates in the airborne effluent exhausted from SLAC.

The accelerator, PEP, SPEAR and experimental areas are designed to transport (not absorb) high-energy electrons and positrons. Radioactive gas concentrations are therefore not produced in measurable quantities. The Beam Switch Yard (BSY), Positron Source (PS) and e^-/e^+ beam dumps in the Final Focus System (FFS) represent the only portion of SLAC designed to absorb high-energy particles and are the only sources of detectable gaseous radioactive emissions. These areas are not vented continuously. They are vented only for emergencies and at the end of each experimental cycle for brief periods of one hour or less.

The Derived Concentration Guides (DCG's) for airborne radioactivity appear in Ref. 3. They were derived from dose standards which require that no individual in the general population be exposed to greater than 10 mrem in one year.

Airborne radioactivity produced as the result of operations is short-lived; i.e., the half-lives range from 2.1 minutes to 1.8 hours and are in gaseous (not particulate) form. These isotopes include the following:

Table V–1

Radioactive Gases Released to Atmosphere

Isotope	Half–Life	μCi/cm^3
^{15}0	2.1 minutes	1.7×10^{-9} (a)
^{13}N	9.9 minutes	1.7×10^{-9} (a)
^{11}C	20.5 minutes	1.7×10^{-9} (a)
^{41}Ar	1.8 hours	1.7×10^{-9}

(a) Calculated from Ref. 5, assuming total submersion.

Since we do not routinely release airborne radioactivity while the beam is on and require a waiting period before turning on the exhaustors, the only radioisotope released is argon-41. By far the greater proportion of exposure an individual may receive under any circumstances from the radioelements listed in Table V–1 is from whole-body immersion. Thus for an individual to receive a whole-body dose of 10 mrem annually, it would require continuous exposure to a large cloud with average concentration equal to 1.7×10^{-9} μCi/cm^3 (Ci/m^3) for an entire year.

The BSY areas are vented by a total of five fans; the discharge point is just slightly above roof elevation. The total exhaust rate for the accelerator is 60 m^3/min, and for the BSY it is 40 m^3/min. Venting of PEP and its Interaction Regions (IR's) is accomplished by a total of 14 exhaust fans which vent just above grade level, with a total exhaust rate of 50 m^3/min. PEP is the only facility that is vented while the beam is on.

Each BSY ventilation fan is provided with a radioactive gas detector. A Geiger–Mueller (GM) detector, power supply, rate meter, strip chart recorder, and air pump are interlocked with the ventilation fan so that they operate only when the machine is vented.

The gas monitors for the BSY collect particulate samples during venting and have revealed negative results: during this monitoring period particulate radioactivity above background was not detected.

The effluent for the PS and FFS areas are also monitored continuously while the exhausters are running. The same type of air monitoring is used as described above for the BSY.

There were no measurable releases of radioactive gases from the BSY during 1989. However, the National Emission Standards for Hazardous Air Pollutants (NESHAP) requires a compliance report. The results of these calculations appear in Appendix C. They were derived by calculating the saturation activity for oxygen-15, carbon-11, nitrogen-13 and argon-41 and then releasing the radionuclides without applying decay factors.

The compliance report was generated by the required computer program, EPA Airdose–PC, Version 3.0. The results show that the annual effective dose equivalent (EDE) was less than 2.4% of the NESHAP standard.

5.2 Wastewater Monitoring

Wastewater containing radioactivity is not routinely released from the site. The only possible sources of liquid radioactive effluents are from primary cooling water systems in the BSY. In the event of leaks from the systems, water is collected in stainless-steel-lined sumps sized to contain the entire water volume. When necessary, the contents of the sumps are pumped to a mobile holding tank. The tank is then moved to the nearest sanitary sewer inlet and drained into the sewer after analysis is completed.

The only source of induced radioactivity is where the electron/positron beam is absorbed. Since water is composed of hydrogen and oxygen, the only radioisotopes produced are the short-lived oxygen-15 and carbon-11, beryllium-7 (54d), and tritium (12.3y). Oxygen-15 and carbon-11 are too short-lived to present an environmental problem, and the beryllium-7 is removed by the resin beds required to maintain the electrical conductivity of the water at a low level; therefore tritium is the only radioactive element present in the water that is of environmental importance.

Water that leaks from these systems is disposed of via the sanitary sewer. The concentration of tritium released is less than the Concentration Guides specified by DOE Order 5400.6, "Requirements for Radiation Protection for Public," without using the sewer effluent for dilution. SLAC is also bound by the provisions in a contract for service with the West Bay Sanitary District (Permit No. WB860915-FNS). There were no releases of water containing radioactivity during 1990.

5.3 Peripheral Monitoring Stations

Six Peripheral Monitoring Stations (PMS) provide continuously recorded data from radiation monitors located near SLAC boundaries. Their positions are located in Fig. 3. Five PMS have not been operational for the past three years due to SLC construction and commissioning of the new machine. One station has been operating the entire period. This station (PMS No. 01) has historically been in the most sensitive position and since 1966 has shown the highest dose of any of these stations.

The 1989 annual penetrating radiation dose at SLAC boundaries is shown in Table V–2. The summary of annual effective dose equivalents due to 1989 laboratory operations is shown in Table V-3. The measured annual dose to the general population coming from accelerator operations is almost entirely from fast neutrons and is characterized as skyshine from SLAC's research area. Estimates of individual and general population whole-body doses can be calculated from the PMS data, based on estimates of distance and population density near SLAC. From demographic information and the measured radiation dose near the site boundary, we can estimate both the average individual dose and the population dose from SLAC operations. From 1974 data, we used a population of 2,040 persons who are included in the pool exposed to 1 mrem or more for any calendar year. A shift in the experimental program to low-intensity experiments (including storage ring experiments) is the primary reason for the decrease in site boundary measurements, calculated population dose, and population number.

Table V–2

1989 Annual Penetrating Radiation Dose Measured Near SLAC Boundaries

PMS	Gamma (mrem)			Neutron (mrem)		
No.	Total	Background	Net	Total	Background	Net
1	OS	OS		10.4	11.6	1.2
2	OS	OS		OS	OS	
3	OS	OS		OS	OS	
4	OS	OS		OS	OS	
5	OS	OS		OS	OS	
6	OS	OS		OS	OS	

OS = Out of service.

Table V–3

Summary of Annual Effective Dose Equivalents Due to 1989 Laboratory Operations

	Maximum Dose to Laboratory Boundary[a]	Maximum Dose to an Individual[b]	Collective Dose to Population within 1.6 kM of Laboratory
Dose	1.2 mrem	0.12 mrem	1.2 person-rem
Location	Boundary south of Sandhill Road	Residence north of Sandhill Road	—
DOE radiation protection standard	—	100 mrem	—
Percentage of radiation protection standard	—	0.12%	—
Background	100 mrem	100 mrem	100 person-rem
Percentage of background	1.2%	0.1%	1.2%

[a] Maximum boundary dose is the dose to a hypothetical individual at the Laboratory boundary where the highest dose rate occurs, with no correction for shielding. It assumes that the hypothetical individual is at the Laboratory boundary continuously, 24 hours/day, 365 days/year.

[b] Maximum individual dose is to an individual at or outside the Laboratory where the highest dose rate occurs and where there is a person, but where calculations take into account occupancy (the fraction of time a person is actually at that location).

Radiation information is obtained with a GM tube for the ionizing component and a paraffin-moderated BF_3 neutron detector calibrated with a Pu-Be neutron source. The resultant sensitivities are such that a gamma exposure of 1 mR from a radioactive ^{60}Co source would be recorded as 10^4 counts on the GM tube channel and a neutron dose-equivalent of 1 mrem would be recorded as 10^5 counts on the BF_3 channel.

The hourly printout cycle of the Sodeco register is programmed by 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 so that the related corrections would be negligible and are not made.

6.0 Groundwater Protection Monitoring Plan

The hydrogeology at SLAC is highly complex due to folding and faulting of the geology. There is an extensive volume of information from past hydrogeological studies, primarily from the construction of tunnels and storage rings. This information has been reviewed and has confirmed that characterization of groundwater movement at SLAC would require extensive drilling and well installation.

Review of available information, both from SLAC and non-SLAC sources, indicates a perched groundwater system with high total dissolved solids and poor recharge. Poor interconnection between water-bearing units in the SLAC area are indicated by poor correlation of water fluctuations in wells.

The section of San Francisquito Creek closest to SLAC is a nonrecharge area. Closest wells using groundwater are about 0.5 miles from SLAC and are located close to the north side of San Francisquito Creek. There are presently eight monitoring wells surrounding a site that has been contaminated by a leaking solvent tank. Slug tests indicate hydraulic conductivities typical for silt and sandy clays, between 10^{-6} to 5 x 10^{-5} cm/sec.

The primary purpose of the Groundwater Protection Monitoring Plan will be to monitor areas where groundwater may have been contaminated or may have a high potential for contamination. It is proposed that further monitoring wells be installed in several areas at SLAC. This work is scheduled to begin in June 1990, dependent on the release of funding.

SLAC instituted a groundwater monitoring program for radioactive species in 1965. Some of the wells used to define geological formations for construction purposes were sampled to establish a background level. Since that time many of these wells have been abandoned. Three wells near major beam absorbers have been maintained to document that induced radioactivity or leakage of radioactive water is not a problem. Because of SLC machine testing at low power, samples were not analyzed during 1989. We have not been able to resume sampling because of SLC schedule changes. In any case, the high energy e^-/e^+ beam was not run in these areas during 1989.

7.0 Quality Assurance

All nonradioactive laboratory analyses are performed offsite by state or EPA certified laboratories. These lab oratories maintain their own quality assurance and quality control (QA/QC) programs as required by their certification. EPA or state approved methods are specified for each analyses. A chain-of-custody is maintained by SLAC and the laboratories.

Appendix A

Atmospheric Dispersion Model

In 1966 an independent evaluation of meteorological regimes at SLAC was performed.[6] From this study an empirical mathematical model was developed. The model that is used predicts the centerline concentration very well, but overestimates the total dosage values.

$$\frac{\chi P}{Q} = \frac{G}{u} \left(\frac{X}{X_0} \right)^{-1.75+[b(1-c)/u]}$$

where

$\chi P =$ centerline concentration ($\mathrm{Ci/m^3}$)
$Q =$ source strength (Ci/s)
$G =$ 8 $\mathrm{m^{-2}}$
$u =$ mean wind speed (m/s)
$X =$ distance from source (m)
$X_0 =$ 2 m
$C =$ fraction of sky covered by low clouds
$b =$ 0.5 m/s day and quad $b = -1.2$ m/s night .

Figure 4 summarizes peak concentration per unit source strength as a function of wind speed and atmospheric stability at a fixed distance of 400 m (roughly the distance from the source to SLAC's boundaries). To characterize atmospheric stability, the degree of cloud cover is indicated for day and night time regimes. This method is based upon Pasquill's data for cloud expansion for various stability categories.

For a wind speed of 2 m/s atmospheric dilution factors—for determining centerline concentrations—range between 2×10^{-5} and 1.5×10^{-3} $\mathrm{sec/m^3}$. For purposes of estimating radiation dose at the site boundary, neutral conditions are assumed and a generally conservative dilution factor of 4.5×10^{-4} $\mathrm{sec/m^3}$ is used to calculate average concentration at the site boundary (see Fig. 4, curve 1.0).

Because of recent regulatory requirements, DOE has required the use of a computer program called AIRDOSE for calculating population dose from airborne radioactive emissions. The results are tabulated in Appendix C, and the EPA Clean Air Act Compliance Report is also reproduced in this Appendix.

Appendix B

Model For Potential Dose Assessment

According to Department of Energy orders, an assessment of whole-body man-rem dose to the general population near SLAC is required where appropriate. Our site boundary dose due to accelerator operation has generally been less than 10 mrem per year from penetrating radiation. We have estimated the population size to include individual annual doses down to 1 mrem, which corresponds to a distance of approximately 1.6 km from a central point representative of the source of neutrons. The 1 mrem value is approximately 1% of the total natural background dose and is 1% of the technical standards for the general population (DOE Order 5480.11).

There are three major pathways leading to human exposure from ionizing radiation: (1) airborne, (2) food chain and (3) direct exposure to penetrating radiation. Of these three major pathways, only direct exposure to penetrating radiation is of any measurable significance from SLAC operations. The source of this exposure is from neutrons resulting from the absorption of high-energy electrons and photons in the experimental areas creating energetic particles, some of which escape from the heavily shielded enclosures.

In order to make an accurate and realistic assessment of radiation exposure to the public at low doses, it is necessary that exposure from the natural radiation environment be known. This is true because the instruments used respond to natural radiation sources as well as man-made sources, and the portion due to natural radiation must be subtracted from the total measurement. The population exposure assessments appearing in this document are in all cases overstatements of the true impact; hence the resulting values are representative of an upper limit of the possible range.

While the annual neutron dose from accelerator operations at the site boundary has generally been measurable, it has always amounted to less than 10% of the total annual individual dose from natural background radiation. According to an EPA report, the average dose from cosmic, terrestrial and internal radiation in California is 125 mrem. For purposes of comparison, we have rounded this number to 100 mrem.[7]

Another quantity of interest is the population dose in units of man-rem. This is simply the product of average individual dose and the total population exposed. For example, if 1,000 people are exposed to an average annual background dose of 0.1 rem (100 mrem), then the population dose is 0.1×1000 or 100 man-rem from natural background radiation. The annual variation of exposure to natural background radiation may vary by $\pm 20\%$, largely caused by the difference of naturally occurring uranium, thorium , and potassium present in the ground and in building materials where people live and work.

Two major problems associated with this dose assessment affect overall accuracy of the measurement. First, the conversion of neutron flux to dose requires that the spectrum of neutrons at the measurement point be known, because the quality factor (QF) is a function of neutron energy. Because of the very low neutron fluences at the SLAC boundary and beyond, it is impossible to measure the energy spectrum; therefore, we have selected a QF of ten as a conservative choice. We feel that this choice leads to an overestimate of the neutron dose-equivalent by a factor of approximately two. Until a useful experiment can be performed with neutron yields of sufficient intensity, the quality factor cannot be determined with any better precision.

A second problem is the behavior of neutrons at large distances. Most of the high energy accelerator laboratories have made measurements. They are unique to each facility because of design differences, type of machine, and surrounding topography. Here again we have chosen a conservative formula for calculating the dose at distances other than the point of measurement. Lindenbaum[8] gave a method for evaluating skyshine neutrons which was later verified by Ladu et al.[9] using Monte Carlo techniques. Lindenbaum approximated the falloff by $(e^{-}R/\lambda)/R$ where R is distance in meters from the source and $\lambda = 250$ m. This equation fits the SLAC data fairly well, and is the one used to predict doses beyond our measuring station (see Fig. 4). We feel that the methods used and reported in this document may overestimate the true population dose by at least an additional factor of two.

The population activity close to SLAC, i.e., within 1.6 km, is a mixture of commerce and residential dwellings. The occupancy factor—the proportion of time throughout the year that these structures are occupied—is assumed to be 1/4 for business activities, and

1.0 for private dwellings. The number of people is estimated for each type of structure, multiplied by the occupancy factor and summed to estimate the total population that might be continuously present.

According to the 1980 census the City of Menlo Park has an average population density of 602 persons per square kilometer (km^2). The populated area impacted by this source term is 1.5 km^2. Therefore the population total is 920 people. Previous estimates have resulted in a larger number by a factor of two, which is a function of the analytical model used. For purposes of estimating the population dose, we have rounded the calculated number to 1,000 people.

Appendix C

Clean Air Act Compliance Report

(Version 3.0 November 1989)

40 CFR Part 61
National Emission Standards
for Hazardous Air Pollutants

Facility: Stanford Linear Accelerator Center

Address: Stanford University
Stanford , CA. 94309
Annual Assessment for Year: 1989
Date Submitted: 4/28/90

Comments:

Prepared By:

Name: Richard Donahue
Title: Health Physicist
Phone #: (415) 926-4300

Prepared for:
U.S. Environmental Protection Agency
Office of Radiation Programs
Washington, D.C. 20460

CLEAN AIR ACT COMPLIANCE REPORT 4/28/90 7:54 AM

Facility: Stanford Linear Accelerator Center
Address: Stanford University City: Stanford State: CA
Comments:
Year: 1989

	Dose Equivalent Rates to Nearby Individuals (mrem/year)
Effective Dose Equivalent	0.0024
Highest Organ Dose is to GONADS	0.0027

------------------------EMISSION INFORMATION------------------------

Radio-nuclide	Class	Amad	Stack #1 (Ci/y)
C-11	D	1.0	1.0E-01
N-13	D	1.0	1.0E-01
O-15	D	1.0	6.0E-01
Stack Height (m)			0.00
Stack Diameter (m)			0.00
Buoyant (cal/s)			0.0E-01

------------------------SITE INFORMATION------------------------

Wind Data	SFO1122.WND	Temperature (C)	20
Food Source	LOCAL	Rainfall (cm/y)	100
Distance to Individuals (m)	400	Lid Height (m)	1000

*NOTE: The results of this computer model are dose estimates. They are only to be used for the purpose of determining compliance and reporting per 40 CFR 61.93 and 40 CFR 61.94.

ORGAN DOSE TO THE MAXIMALLY EXPOSED INDIVIDUAL

ORGAN	DOSE EQUIVALENT RATE TO THE ORGAN (mrem/y)
GONADS	2.7E-03
BREAST	2.6E-03
RED MARROW	2.1E-03
LUNGS	2.4E-03
THYROID	2.6E-03
ENDOSTEUM	2.4E-03
REMAINDER	2.1E-03
EFFECTIVE	2.4E-03

DOSE TO THE MAXIMALLY EXPOSED INDIVIDUAL BY PATHWAY FOR ALL RADIONUCLIDES

	EFFECTIVE DOSE EQUIVALENT (mrem/y)	DOSE EQUIVALENT TO THE ORGAN WITH THE HIGHEST DOSE GONADS (mrem/y)
INGESTION	3.1E-42	3.3E-43
INHALATION	5.1E-05	2.8E-06
AIR IMMERSION	2.3E-03	2.7E-03
GROUND SURFACE	2.9E-05	3.5E-05
TOTAL:	2.4E-03	2.7E-03

DOSE TO THE MAXIMALLY EXPOSED INDIVIDUAL BY RADIONUCLIDE FOR ALL PATHWAYS

RADIONUCLIDE	EFFECTIVE DOSE EQUIVALENT (mrem/y)	DOSE EQUIVALENT TO THE ORGAN WITH THE HIGHEST DOSE GONADS (mrem/y)
C-11	5.3E-04	6.0E-04
N-13	4.5E-04	5.2E-04
O-15	1.4E-03	1.6E-03
TOTAL :	2.4E-03	2.7E-03

Stanford Linear Accelerator Center

EFFECTIVE DOSE EQUIVALENT AS A FUNCTION OF DISTANCE IN THE DIRECTIONS OF THE MAXIMALLY EXPOSED INDIVIDUAL FOR ALL RADIONUCLIDES AND ALL PATHWAYS

DIRECTION : EAST-SOUTHEAST

DISTANCE (meters)	EFFECTIVE DOSE EQUIVALENT (mrem/y)
400	2.4E-03
1000	2.5E-04
3000	1.6E-05
10000	7.0E-07
80000	4.4E-11

EFFECTIVE DOSE EQUIVALENT AS A FUNCTION OF ALL DISTANCES AND ALL DIRECTIONS FOR ALL RADIONUCLIDES AND ALL PATHWAYS

DIRECTIONS: DISTANCE (METERS):	N	NNE	NE	ENE	E	ESE	SE	SSE
400	1.1E-03	5.4E-04	5.1E-04	7.1E-04	1.7E-03	2.4E-03	6.1E-04	1.7E-04
1000	9.8E-05	4.7E-05	4.5E-05	6.4E-05	1.8E-04	2.5E-04	6.0E-05	1.5E-05
3000	4.7E-06	2.4E-06	2.2E-06	3.3E-06	1.1E-05	1.6E-05	3.4E-06	7.6E-07
10000	1.6E-07	8.4E-08	7.7E-08	1.3E-07	5.4E-07	7.0E-07	1.4E-07	2.8E-08
80000	5.5E-12	2.1E-12	1.5E-12	2.6E-12	3.9E-11	4.4E-11	7.2E-12	9.6E-13

DISTANCE (METERS):	S	SSW	SW	WSW	W	WNW	NW	NNW
400	3.5E-04	1.9E-04	2.2E-04	2.5E-04	2.7E-04	3.8E-04	5.7E-04	5.9E-04
1000	3.3E-05	1.8E-05	2.0E-05	2.2E-05	2.5E-05	3.6E-05	5.1E-05	5.1E-05
3000	1.8E-06	9.4E-07	1.0E-06	1.1E-06	1.3E-06	1.9E-06	2.6E-06	2.5E-06
10000	7.1E-08	3.1E-08	3.2E-08	3.6E-08	4.0E-08	6.5E-08	9.4E-08	7.9E-08
80000	3.3E-12	5.1E-13	6.3E-13	5.8E-13	6.6E-13	9.5E-13	1.8E-12	1.2E-12

Appendix D

Calibration and Quality Assurance Procedures

The natural background radiation provides continuous verification that the monitoring equipment is connected and functioning properly. During accelerator downtime and any interrupted operation background radiation provides a calibration baseline as well.

A regular calibration procedure was initiated in 1984 using two small radioactive sources. The sources are placed at a measured distance to produce a known- dose equivalent rate. The equipment is kept in normal operation during these checks. The printer is marked so the calibration data is not confused with normal measurements. This procedure will be repeated twice each year, and following equipment repair or maintenance. Response to natural background radiation provides proof that the instruments are operating properly.

Airborne Radioactive Monitoring Equipment

Dose-equivalent from gaseous radioactivity reaching the site boundary (if large enough) would be detected by the PMS, which has its own quality assurance procedures.

The separate radioactive gas monitors for each ventilation fan are inspected and calibrated at the beginning of each accelerator cycle. They are calibrated with a small radioactive source. During operation the natural background radiation response assures that they are operating properly.

All water samples are analyzed by certified analytical laboratories, which have their own documented quality assurance procedures.

Appendix E

Compliance Assessment Summary

January 1990 to May 1990

Background

There are no serious environmental compliance issues at the Stanford Linear Accelerator Center (SLAC). The current activities include a replacement program for PCB transformers, and investigation and possible remediation of PCB soil contamination.

SLAC must operate in compliance with applicable Federal, State and local environmental regulations, as well as DOE Orders. SLAC's status with major environmental statutes are as follows:

Clean Air Act (CAA):

> SLAC has permits to operate 34 point sources and a site-wide permit for wipe cleaning operations. The permits are regulated by the Bay Area Air Quality Management District (BAAQMD).

Clean Water Act (CWA):

> SLAC has a National Pollutant Discharge Elimination System (NPDES) Permit from the California Regional Water Quality Control Board (RWQCB), San Francisco Bay Region. The RWQCB also has oversight of a Waste Discharge Permit for groundwater contamination. Two permits from the West Bay Sanitary District and South Bayside System Authority regulate the discharge from SLAC's treatment facility and the total sanitary sewer.

Resource Conservation and Recovery Act (RCRA):

> SLAC is a generator of hazardous wastes and has 90 days to ship its wastes to EPA approved treatment, storage or disposal facilities (TSDFs).

Current Issues and Actions

SLAC submitted a renewal for its NPDES Permit which expires April 30, 1990. Modifications have been requested for the discharge volumes at each cooling tower (due to increased loading with SLC operation) and the sampling procedures and schedules. The RWQCB engineer handling SLAC's permit has indicated that he will recommend an extension of the present permit pending review.

SLAC has received from the BAAQMD a Permit to Operate an additional solvent cold cleaner (Source No. 37).

Update of Low-Level Radioactive Wastes Activities

During 1987 SLAC's low-level radioactive wastes were prepared for shipment to a commercial licensed land burial site according to the then applicable regulations. Forty-three 55 gallon 17H drums had been prepared for shipment by an outside licensed contractor. Some of these drums contained irradiated lead which has now been defined as mixed hazardous waste (MHW)—the waste material is both chemically hazardous and radioactive. There is no disposal site that can legally accept MHW for permanent disposal.

DOE policy requires recycling where possible. The irradiated lead has been recovered. The previously packaged material was sorted by a licensed contractor. About 3000 lbs of irradiated lead was recovered from twenty-three drums of LLW.

Samples of lead were removed from each drum and analyzed for radioactive concentration by gamma spectroscopy. The maximum concentration was 60 pCi/gram. A total of 20 samples were analyzed by SLAC and five were sent to a commercial certified laboratory for confirmation of our results.

This lead will be melted and cast into forms usable for discrete shielding for personnel protection from induced radioactivity and to protect sensitive equipment from radiation damage. All irradiated lead will be recycled for this purpose.

SLAC is preparing a shipment of LLW for disposal at the DOE site at Hanford, Washington. SLAC is also in the process of qualifying our Quality Assurance Program for Radioactive Waste Management (RWM) in compliance with DOE Order 5820.2A, "Radioactive Waste Management" and Washington State requirements.

Peripheral Monitoring Stations (PMS)

For the past five years SLAC has been constructing and commissioning SLC. During this period all but one of the stations were out of service because of these activities. One station has been active throughout this period. PMS-1 is located in the most sensitive position; historically, it has measured the highest annual dose and it is the closest location to SLAC's offsite population.

All PM stations have now been re-established. The response of each station is recorded in the VAX history buffer located in the Main Control Center. Every seven days this information is stored in SLAC's IBM mainframe computer. Each calendar quarter a plot of the average dose rate for each 24-hour period will be generated together with the total dose from neutron and gamma radiation for that quarter. Each station will record both accelerator and natural background radiation sources. The natural background radiation levels are known since we have been measuring this source for the past twenty years.

Environmental Permits

SLAC has been issued the following permits:

- California Regional Water Quality Control Board
  San Francisco Bay Region
  NPDES Permit CA0028398, Order 87–044
  Expiration date: April 30, 1990
  Waste Discharge Permit, Order 85-88
- West Bay Sanitary District and South Bayside System Authority
  Wastewater Discharge Permit No. WB860915–PTE
  Wastewater Discharge Permit No. WB860915–FNS
  Expiration dates: September 14, 1990
- Bay Area Air Quality Management District
  Plant No. 556, 35 permits
- EPA ID for Hazardous Waste Generator
  CA8890016126

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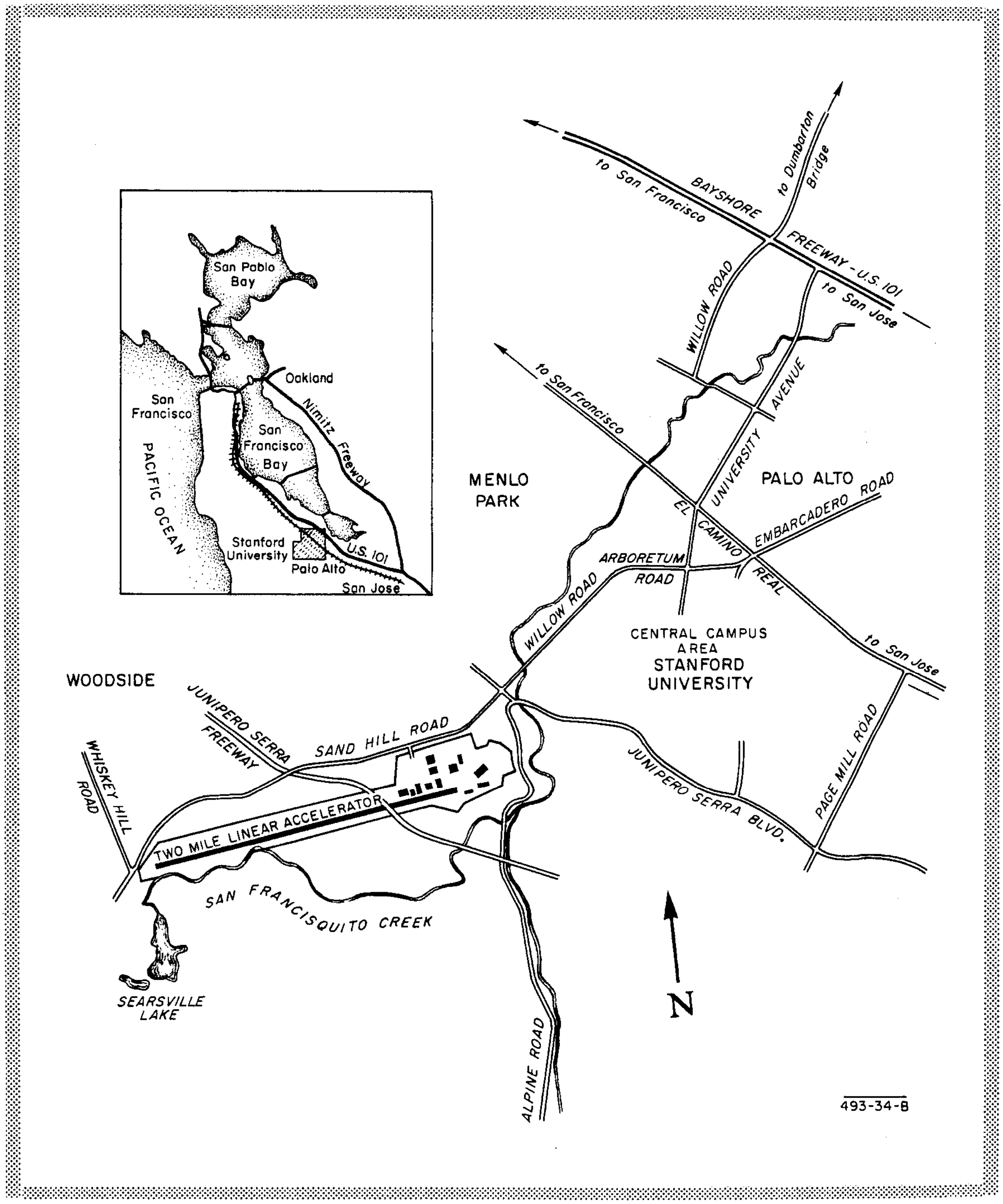

Figure 1. SLAC site location.

Figure 2. Air view of SLAC site showing the two-mile accelerator, the research facility, and the principal laboratories and shops. Also shown is the SLAC Linear Collider. The PEP Interaction Regions can be seen in the foreground, connected by the circumferential road.

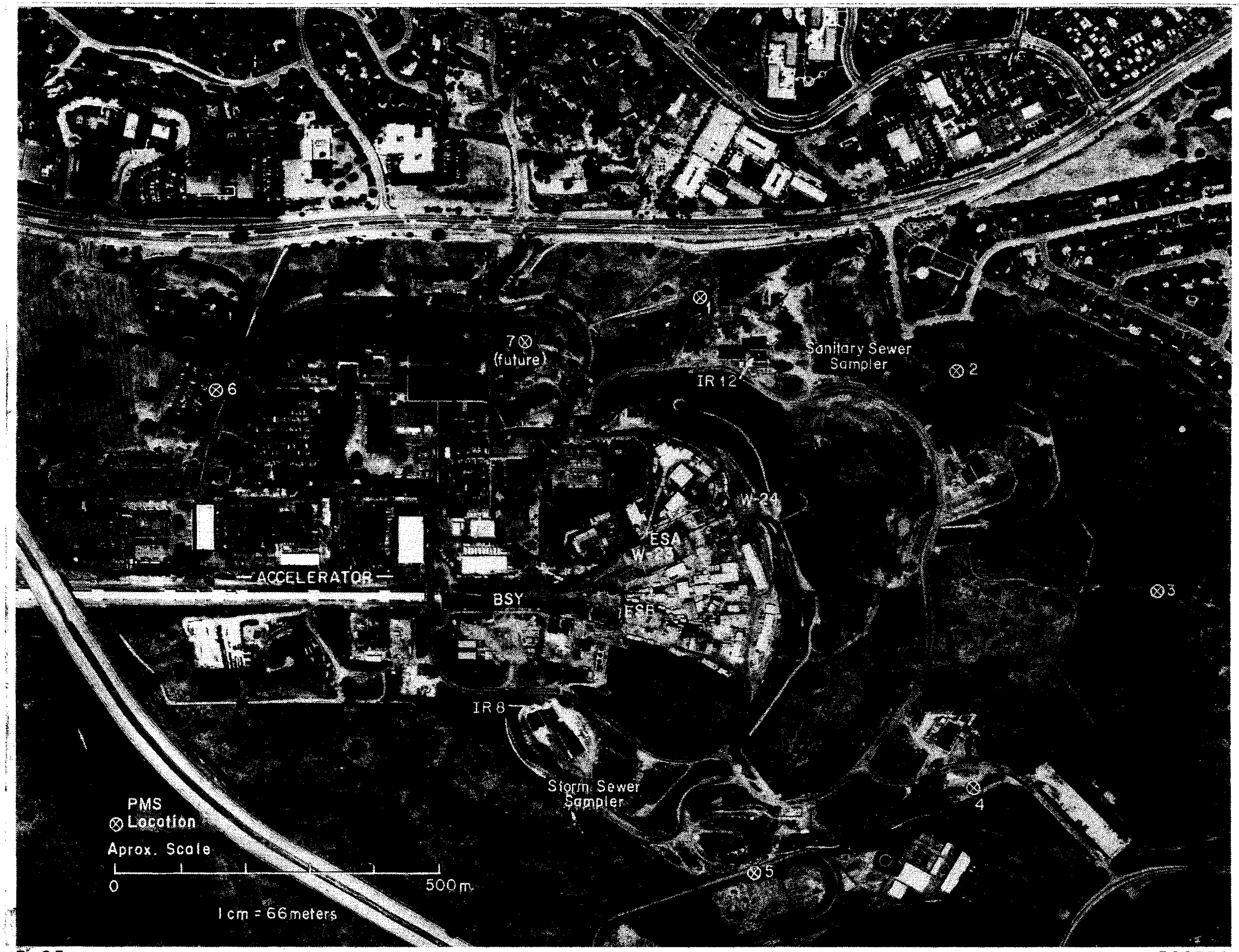

Figure 3. SLAC research yard and the surrounding community.

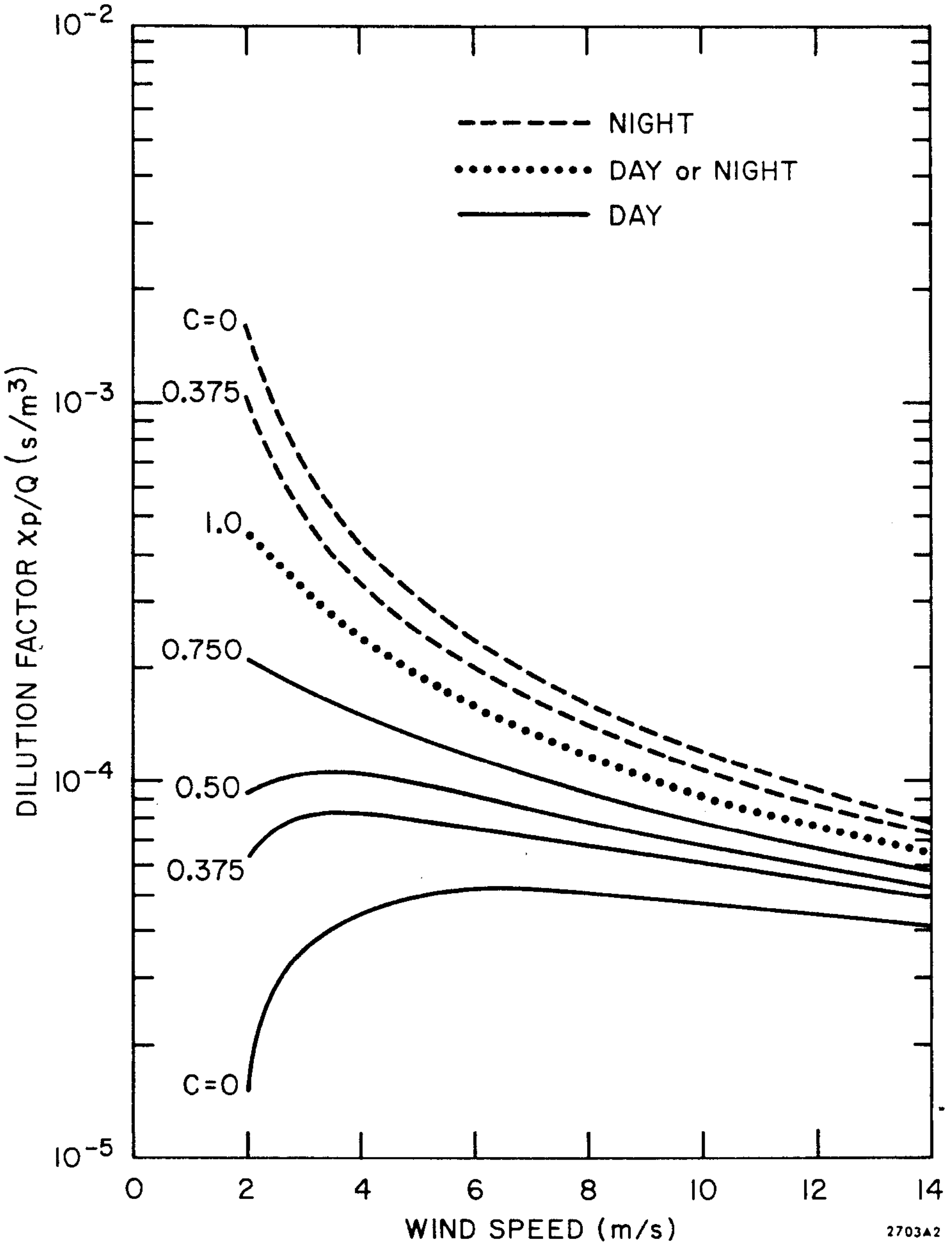

Figure. 4. Centerline dilution factor for various atmospheric conditions as a function of wind speed.

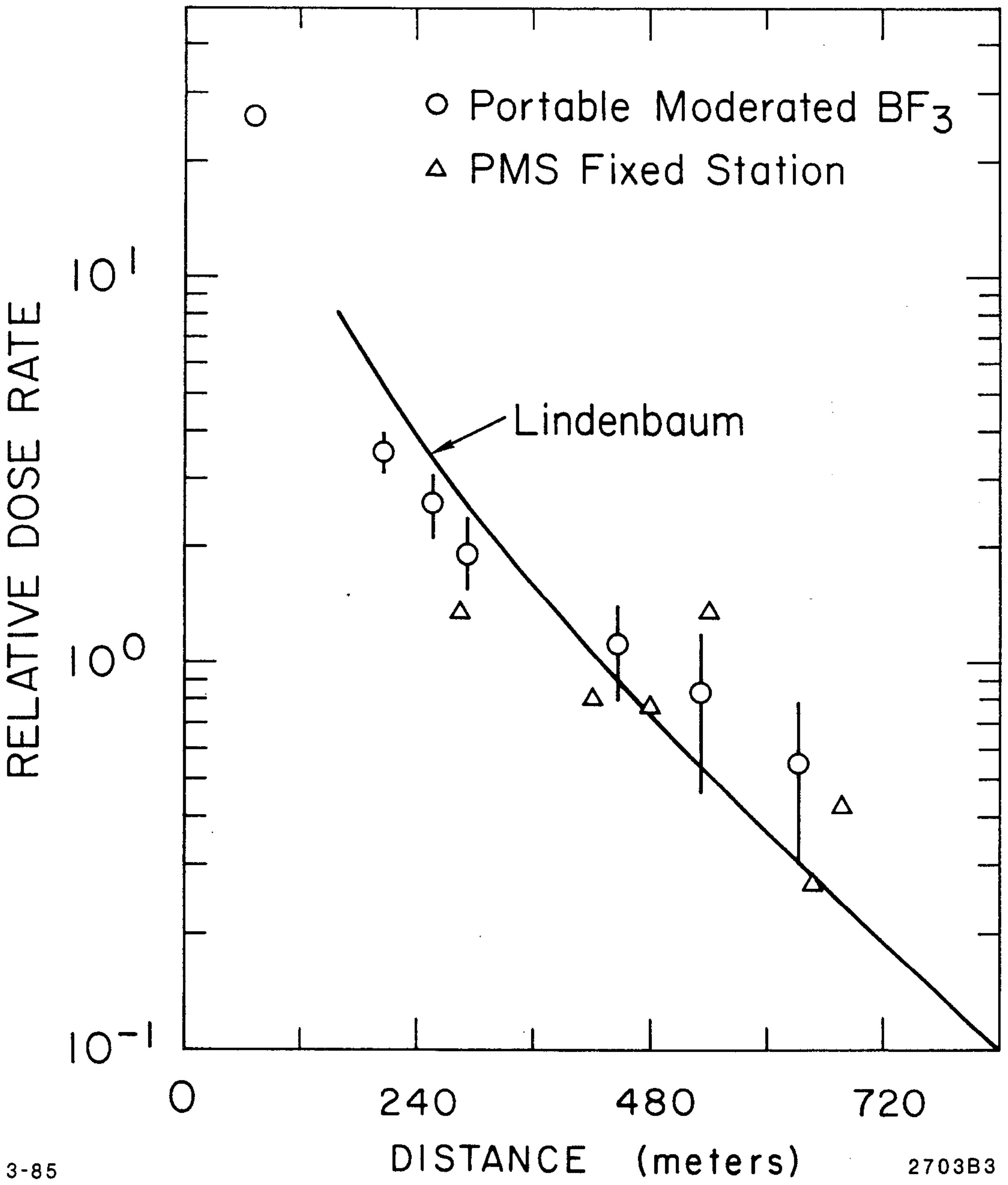

Fig. 5. Measurements made along a line between ESA and the site boundary.