LBL--15978

DE83 015014

ANNUAL ENVIRONMENTAL MONITORING REPORT

OF THE

LAWRENCE BERKELEY LABORATORY

1982

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Editor: Gary E. Schleimer

This work was supported by the Assistant Secretary for Environment
Office of Environmental Compliance and Overview
Environmental Safety and Program Support Division
U.S Department of Energy under Contract No. DE-AC03-76SF00098

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ABSTRACT

The Environmental Monitoring Program of the Lawrence Berkeley Laboratory is described. Data for 1982 are presented and general trends are discussed.

1982 ENVIRONMENTAL MONITORING SUMMARY

In order to establish whether LBL research activities produces any impact on the population surrounding the Laboratory, a program of environmental air and water sampling and continuous radiation monitoring was carried on throughout the year.[1] For 1982, as in the previous several years, doses attributable to LBL radiological operations were a small fraction of the relevant radiation protection guidelines (RPG).[2]

We define the maximum dose equivalent delivered to a hypothetical member of the community as the maximum perimeter dose equivalent. That value was $\leq$ 24.0 mrem (the 1982 dose equivalent measured at the Building 88 monitoring station B-13A, about 5% of the RPG). The total population dose equivalent attributable to LBL operations during 1982 was $\leq$ 16 man-rem, about 0.002% of the RPG of 170 mrem/person to a suitable sample of the population. (The total population dose equivalent is defined as the sum of the doses delivered to all individuals within a 80 km radius of the Laboratory.)

INTRODUCTION

Lawrence Berkeley Laboratory (LBL) is a large, multifaceted research laboratory that conducts programs of pure and applied research in the physical, biological, and environmental sciences. LBL, birthplace of the the cyclotron, was founded by the late Nobel Laureate Ernest Orlando Lawrence 51 years ago.

The Laboratory is located on the western slopes of the hills east of the Berkeley campus of the University of California, between elevations of 350 and 1000 feet. The site (Figs. 1 and 2) enjoys a Mediterranean type climate, with an annual rainfall of 25.0 inches (24-year average), prevailing northwesterly winds during the traditionally dry summers, and southwesterly winds during winter storms. LBL straddles two canyons that contain the headwaters of Strawberry and Blackberry Creeks. The population within a 50-mile (80-km) radius of the Laboratory is approximately 4.6 million (1970 census); this includes most of the residents of the greater metropolitan San Francisco Bay Area.

LBL research facilities include: four large accelerators, several small accelerators, a number of radiochemical laboratories, and a

tritium (^3H) labeling laboratory. The Bevatron (Building 51 in Fig. 1) is the most massive of LBL's accelerators. Originally designed as a 6-GeV proton synchrotron, it is presently capable of accelerating ions up to ^{40}Ca from 20 MeV/nucleon to 2.1 GeV/nucleon, and ions up to uranium to 1 GeV/nucleon, when using the SuperHILAC as an injector (this combination is called the Bevalac). The SuperHILAC (Building 71), a heavy ion accelerator, is a multiprogrammable research accelerator in its own right, and produces ion beams of energies up to 8.5 MeV/nucleon. The 88-Inch Variable Energy Sector-Focused Cyclotron (Building 88) routinely produces intense beams of energies of protons up to about 60 MeV, alpha particles to 140 MeV and heavy ions to mass 40 to energies of 350 MeV. The 184-Inch Cyclotron (Building 6) provides alpha particle beams with energies up to approximately 1 GeV. The first three of these accelerators provide beams around the clock; the 184-Inch Cyclotron is only run for brief periods each week, mostly for tumor therapy.

The Tritium Facility located in Building 75 was designed to handle kilocurie quantities of tritium used as a labeling agent for a variety of molecules subsequently employed in chemical and biomedical research. Radiochemical and radiobiological studies performed in many laboratories at LBL typically use millicurie quantities of a variety of radionuclides. The workplaces and effluent release points of all installations at LBL where significant quantities of radionuclides are handled are continuously sampled.

ENVIRONMENTAL MONITORING RESULTS

ACCELERATOR-PRODUCED RADIATION

To determine the radiological impact of LBL accelerator operations, we maintain permanent monitoring stations at four points about LBL's perimeter (see Fig. 1 and Table 1).

Table 1. Location of LBL monitoring stations (MS).

Building No. (see Fig. 1)	Name
B-13A	Building 88 Environmental MS
B-13B	Building 90 Environmental MS
B-13C	Panoramic Environmental MS
B-13C	Olympus Gate Environmental MS

Each station contains sensitive neutron and gamma pulse counters. The neutron detectors are ~500 cm^3 cylindrical BF_3 chambers housed in 2.5 inch thick cylindrical paraffin moderators. The gamma detectors are energy-compensated Geiger-Muller chambers. The output pulses from each of the eight detectors (one of each type is installed at each monitoring station) are prescaled and telemetered to registers in Building 75.[4] Each LBL accelerator building contains at least one somewhat smaller moderated BF_3 neutron detector whose output pulses are also prescaled and telemetered to Building 75. Operational checks of the system are performed daily, and detectors are calibrated semiannually. Typical dose per register-pulse value for a perimeter monitoring station neutron detector is 0.43 μrem/pulse. A gamma register-pulse is about 1.3 μR.

The neutron background attributable to cosmic rays measured at LBL exhibits small fluctuations about a mean value of 3.3 mrem/year.[3] Table 2 lists the fence-post dose equivalents measured at each environmental monitoring station during 1982.

The fence-post neutron fluence and gamma ray flux attributable to LBL accelerator operation in 1982 is characterized as follows.

1. The 184-Inch Cyclotron produced no dose discernible above background as measured at the Panoramic Monitoring Station.

2. The SuperHILAC and Bevatron contributed equally to the dose equivalent measured at the Olympus Gate Monitoring Station, a dose distributed rather uniformly from mid-March to mid-June, and mid-July through year's end.

3. The 88-Inch Cyclotron dose equivalent was distributed rather uniformly throughout the year and was 24.5 mrem. The 24.0 mrem is the sum of a 22.5 mrem neutron component and a 1.5 mrem gamma component.

4. The Building 90 Monitoring Station dose equivalent is correlated with and attributed to 88-Inch Cyclotron operations.

The continuous gamma measurements telemetered from the Building 90, Olympus Gate, and Panoramic Monitoring Stations showed no significant correlation with the operation of any of the LBL accelerators and were background for 1982. The mean value of gamma background was 77 $\pm$ 5 mrem for the year.

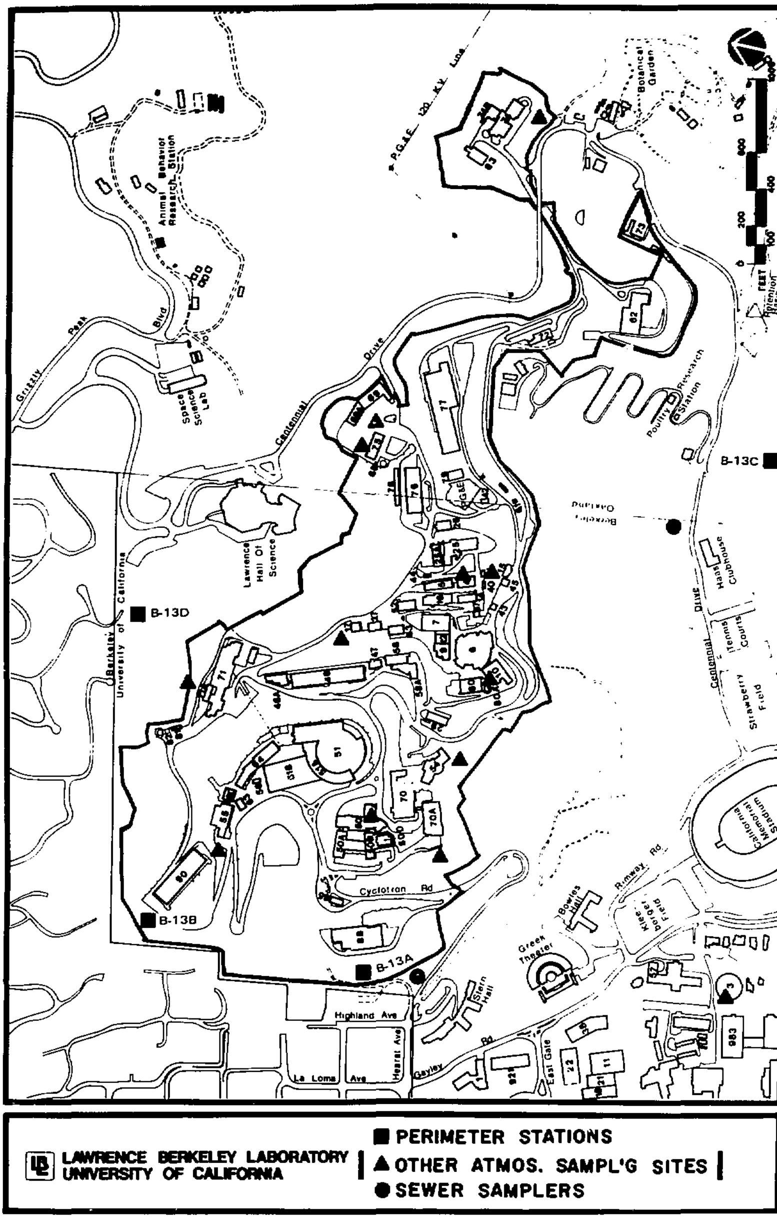
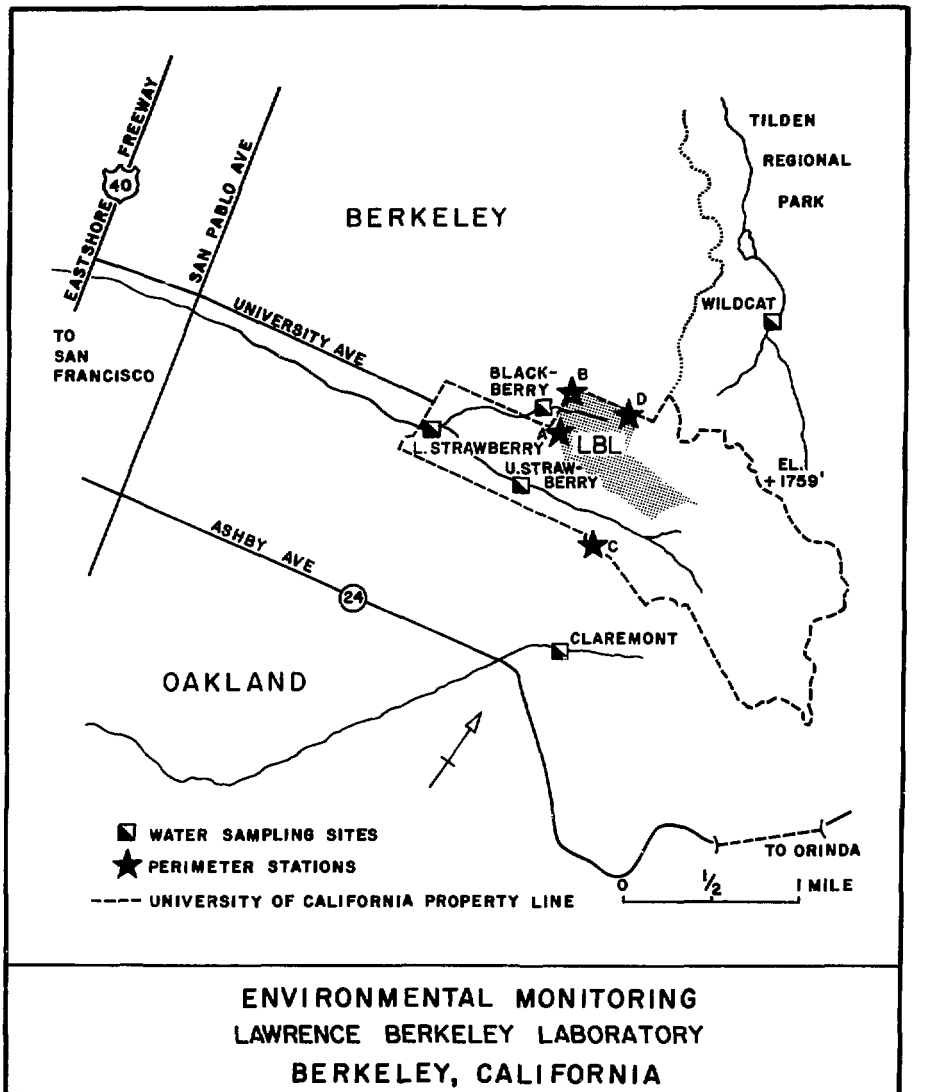

Grizzly Peak Blvd
Space Science Lab
Animal Behavior Research Station
P.G.&E. 120 Kv Line
Botanical Garden
FEET
Retention Basin
Centennial Drive
Poultry Research Station
B-13C
Berkeley
Oakland
Lawrence Hall Of Science
B-13D
University of California (Berkeley)
Haas Clubhouse
Tennis Courts
Strawberry Field
California Memorial Stadium
Rimway Rd
Cyclotron Rd
B-13B
Bowles Hall
Kleeberger Field
Greek Theater
B-13A
Stern Hall
Highland Ave
Hearst Ave
La Loma Ave
Gayley Rd
East Gate
LAWRENCE BERKELEY LABORATORY
UNIVERSITY OF CALIFORNIA
PERIMETER STATIONS
OTHER ATMOS. SAMPL'G SITES
SEWER SAMPLERS

Figure 1.



ENVIRONMENTAL MONITORING
LAWRENCE BERKELEY LABORATORY
BERKELEY, CALIFORNIA

Figure 2.

Table 2. Radiation dose at the LBL boundary due to accelerator operation, 1982.

Station	Totals above background		
	Gamma (mrem)	n (mrem)	Total[a] (mrem)
Olympus Gate MS	Background	3.9 ± 0.3	3.9 ± 0.3
Building 90 MS	Background	1.0 ± 0.3	3.9 ± 0.3
Building 88 MS	1.5 ± 0.5	22.5 ± 0.5	24.5 ± 0.5
Panoramic MS	Background	Background	Background

[a]The errors shown are those associated with the actual counts. Dose conversion factors are not known to this accuracy.

[b]Source: Ref. 2.

AIRBORNE RADIONUCLIDES

Gross atmospheric beta and alpha activities are measured by air sampling at 14 points: Four perimeter environmental monitoring stations and 10 of the 12 "other atmospheric sampling sites" identified in Fig. 2. (The sites on the north side of Building 75 and the roof of Building 4 are rain collectors. The Building 3 site contains samplers for HTO (tritiated water) and $^{14}CO_2$.)

The gross beta and alpha sampling media are 4 x 6 inch cellulose-asbestos filters through which air is pumped at 4 cfm. Samples are removed weekly. Before they are counted, they are set aside for five days to enable short-lived radon and thorium daughters (naturally occurring airborne radionuclides) to decay. The filters are loaded into an automatic counter that determines their gross alpha activity by means of a large area 0.25-mil mylar window gas proportional counter. Gross beta is counted with Geiger-Muller detectors with 30 mg/cm^2 windows. The detection limit for alpha emitters is 2 x 10^{-15} μCi/ml. The detection limit for beta emitters is 80 x 10^{-15} μCi/ml.

To ensure accuracy of all counting results, each group of samples counted includes at least one radiation standard sample and a number of background samples.

Tritium, as HTO, is sampled by passing atmospheric air through a column containing silica gel. Adsorbed water is "exchanged" into distilled water and a aliquot (5 ml) is placed in a vial and counted in a scintillation counter. The detection limit for HTO in air is 700 x 10^{-15} μCi/ml.

As with gross alpha and beta samples, silica gel HTO samples are changed weekly. Each of the four perimeter environmental monitoring stations contains a tritium sampler, as does the Building 3 site. The stack from the tritium labeling facility is also monitored for tritium as described above.

The concentration of $^{14}CO_2$ in air is determined by air sampling with NaOH. Samples are changed weekly. Air is bubbled through a jar containing 30 ml of 0.2 M NaOH and thymol blue as a pH indicator. If acid fumes in the sampled air drop the pH of the sample to about 5, a color change results, and the sample is assumed to be invalid. An aliquot (5 ml) of the NaOH is added to scintillation cocktail and counted in a liquid scintillation counter. The detection limit for $^{14}CO_2$ is 200 x 10^{-12} µCi/ml.

The total quantities of radionuclides discharged into the atmosphere are summarized in Table 3. The figures are similar to those of last year, and the releases resulted in a small population dose equivalent (see Table 11).

Table 3. Total quantities discharged to the atmosphere, 1982.

Nuclide	Quantity (Ci)
Unidentified alpha emitters	$<1 \times 10^{-6}$
Unidentified beta emitters	8.3×10^{-5}
Carbon-14	0.16
Tritium	115
Iodine-125	2.3×10^{-4}
Iodine-131	5.4×10^{-4}

All data from the general air sampling program were within the range of normal background (Table 4). All measurements of atmospheric deposition at outlying perimeter stations lie within the range of normal background, however small amounts of tritium were detected in rainfall collected within the Laboratory boundary near the stack from the Building 75 tritium facility (Table 5).

The special air sampling program for ^{14}C and ^{3}H found detectable concentrations of these nuclides (Table 6). Essentially, 100% of the tritium released from LBL was discharged from the Building 75 stack.

Table 4. Summary of air samples, 1982.

	No. of samples	Concentration (10^{-15} µCi/ml)						Average as % of standard	
		Alpha			Beta			Alpha	Beta
		Ave.	Min.	Max.	Ave.	Min.	Max.		
On-site average of 10 locations	485	0.49 ± 0.08	<2	4 ± 2	10 ± 4	<80	140 ± 80	2.4	1
Perimeter Stations:									
Building 88	50	0.9 ± 0.3	<2	3 ± 2	<11	<80	<80	4	1
Building 90	49	1.1 ± 0.3	<2	4 ± 2	<11	<80	110 ± 100	6	1
Panoramic Way	48	0.8 ± 0.3	<2	4 ± 2	18 ± 12	<80	140 ± 100	4	2
Olympus Gate	50	0.8 ± 0.3	<2	3 ± 2	<12	<80	100 ± 80	4	1
Standard for comparison[a]		20			10,000				

[a]Source: Ref. 2.

Table 5. Summary of atmospheric deposition, 1982.

	Total deposition (10^{-3} µCi/m^2)						Tritium in rainfall (µCi/m^2) as HTO[a]		
	No. of samples	Alpha		Beta			No. of samples	Ave.	Max[b]
		Avg.	Max.[b]	Ave.	Min.	Max.[b]			
On-site (9 locations)	108	0.03	0.15	1.5	0.62	2.9	186	0.4 ± 0.1	4.6[c]
Perimeter (4 locations)	48	<0.01	0.017	1.9	0.18	5.2	36	<0.2	0.3
No standards for comparison have been established.									

[a] The on-site tritium in rainfall data are computed from the samples taken at 11 locations.

[b] Highest total for any one site.

[c] Although "on-site," this location is near the fence and representative of the area just outside the perimeter. The average tritium-in-rainfall concentration at this location (Building 75 collector) was 4.3 x 10^{-6} µCi/ml, 0.1% of the drinking water concentration guide (CG); the maximum observed concentration was 121 x 10^{-6} µCi/ml or [illegible] of the guideline (Ref. 2).

Table 6. Summary of special air sampling, 1982.

	No. of samples	Concentration (10^{-9} µCi/ml) Ave.	Min.	Max.	Average as % of standard
Samples for tritium as HTO					
On-site:					
Building 3 roof	51	0.3 ± 0.1	<0.7	2 ± 0.7	0.2
Perimeter:					
LHS	52	0.3 ± 0.1	<0.7	3 ± 0.8	0.2
B-13D (Olympus)	50	0.2 ± 0.1	<0.7	2 ± 0.7	0.1
Standard for comparison[a]		200			
Samples for carbon-14 as CO_2					
On-site:					
Building 3 roof	51	<0.04	<0.2	0.3 ± 0.2	0.004
Standard for comparison[a]		1000			

[a]Source: Ref. 2.

WATERBORNE RADIONUCLIDES

Rainwater, creek water, and sewage from LBL's two sewer outfalls are analyzed for gross beta and alpha emitters (see Fig. 1; the Strawberry sanitary sewer is the southern site, Hearst is the western sewer). Additionally, sewer effluent is analyzed for gross halogen (radioiodine) content. Rainwater is analyzed for tritium (the Building 75 tritium labeling facility does not release liquid effluent into the sewer or surface streams).

Sewer outfalls are sampled continuously, sample-to-flow ratios are designed to be between 10 and 20 ppm, and composite samples are taken weekly. The five creek sample points indicated in Fig. 2 are sampled weekly. A one-quart grab sample is taken from each site and analyzed for gross alpha and beta emitters only.

The four perimeter environmental monitoring stations have 18-inch diameter cylindrical rainfall collectors on their roofs. During rainy months (generally October through May) rainwater is picked up monthly and analyzed for gross alpha and beta activities and for tritium. During the dry California summer, each collector is rinsed with a quart of tap water and the rinse is analyzed for "dry deposition." The 10 other atmospheric sampling sites alluded to in the air sampling section of this report each contain an 18-inch diameter combination rain/dry deposition collector, which is sampled on a monthly basis in the same manner as the four perimeter environmental monitoring stations.

Rain that falls into the collector on the north side of Building 75 is analyzed on a storm-by-storm basis for tritium, gross alpha and beta activities. Tritium analysis of water samples is accomplished by liquid scintillation counting. Water samples are prepared for gross alpha and beta analysis by acidification (HNO_3) and evaporation into 2-inch stainless steel planchettes. Organic residue not wet-washed by the nitric acid treatment are oxidized by flaming the planchettes.

Since radioiodine is driven out of the water samples when they are acidified, aliquots of the sewer effluent samples are preserved for radioiodine analysis. The iodine contained in the samples is precipitated with silver using stable KI as a carrier. The iodine aliquots are filtered, and the filtrate is processed in the same manner as the acid (HNO_3) samples described earlier. After flaming the filtrate planchette, the filter containing any precipitated radioiodine is placed in the planchette and counted.

The prepared planchettes are weighed (the tare weight of each planchette is first determined) and counted in a thin window low background gas proportional counter for both gross alpha and beta activities. Since the samples are thick, self absorption is computed based on areal sample density, which is the sample weight divided by the area of the planchette (20.26 cm^2), assuming an alpha energy of 5.2 MeV and a beta energy of 1 MeV.

Table 7 summarizes the 1982 data from the surface water and tap water sampling programs. These results are similar to those obtained in past years, and all lie within the normal range of background activity. There is no reason to suspect that any of the observed radioactivity

originated from LBL.

Table 8 summarizes the sewage sampling data for 1982. The average and maximum values listed for sewer beta concentrations reflect the weekly activity found in the hotter of the acid or radioiodine planchettes. LBL's historical release practices were maintained during 1982, and the Hearst sewage average beta concentration was about 0.8% of the DOE standard for beta discharges into sewers.[2] The campus of the University of California discharges radioactive waste into the Strawberry sewer above the point at which LBL monitors it. While the average Strawberry beta concentration for 1982 was significantly higher than the Hearst value, the amount is well below historical values, and is about 2% of the standard (1979 average Strawberry beta concentration was 86% of the standard).

NONRADIOACTIVE POLLUTANTS

The Laboratory does not carry out routine monitoring of airborne nonradioactive pollutants, although sewer sampling is carried out for heavy metals.

Samples were analyzed for heavy metals by the atomic absorption method at Lawrence Livermore National Laboratory.

Table 9 summarizes the sewer sampling data for heavy metals.

POPULATION DOSE RESULTING FROM LBL OPERATIONS

ACCELERATOR-PRODUCED RADIATION

The LBL model developed by Thomas[3] for determining population dose equivalent from the maximum measured value of perimeter (fence post) dose assumes that the fence-post dose rate changes are uncorrelated with fluctuations in population. During 1982 the maximum fence-post dose was measured at the Building 88 monitoring station and was 24.0 mrem for the year (Table 2). The 88-Inch Cyclotron operated continuously five days a week during 1982 except for weekly maintenance periods, a summer shutdown from June 26 to July 26, and a Christmas shutdown from December 18 to the end of the year. Dose spikes attributable to short intense light-ion runs were distributed throughout the operational year. Although the shutdown periods occurred when student/faculty populations were low (summer and Christmas vacations) and the shutdown time represents about 12% of the year, the model's assumptions should not be seriously compromised by ignoring these nonuniformities.

The model's expression relating population dose-equivalent M (in man-rem) to maximum measured fence-post dose H_o (in rem) is

$$M < 10^3 \times H_o(1.0 - 0.56f) \qquad (1)$$

where f = the fraction of the fence-post dose contributed by the 88 Inch Cyclotron and/or the SuperHILAC. [Note that the Thomas model does not include the population dose-equivalent attributable to LBL-produced

Table 7. Surface water and tap water samples, 1982.

		Concentration (10^{-9} µCi/ml)						Average as % of standard	
		Alpha			Beta				
	No. of samples	Ave.	Min.	Max.	Ave.	Min.	Max.	Alpha	Beta
On-site streams:									
Blackberry	51	<0.3	<1	3 ± 2	1.5 ± 0.1	<0.6	2.5 ± 0.9	<1	1.5
Lower Strawberry	51	<0.2	<0.6	<2	1.8 ± 0.1	<0.8	3.6 ± 0.8	<0.7	1.8
Upper Strawberry	51	<0.3	<1	<2	1.7 ± 0.1	<0.8	4.9 ± 1.0	<1	1.7
Average		<0.3						<1	
Off-site streams:									
Claremont	50	<0.3	<1	5 ± 3	1.7 ± 0.1	<0.8	6 ± 1	<1	1.7
Wildcat	51	<0.2	<1	<3	1.2 ± 0.1	<0.6	3 ± 0.8	<0.7	1.2
Tap water	51	<0.1	<0.2	1.1 ± 0.5	0.9 ± 0.09	<0.6	2.2 ± 0.8	<0.3	0.9
Standard of comparison			30			100			

[a]Source: Ref. 2.

Table 8a. Summary of sewage sampling data, 1982.

Total quantities discharged	Total volume (10^6 liters)	Alpha (μCi)	Beta (mCi)
Hearst sewer	297	13	6.4
Strawberry sewer	180	81	10.3

Table 8b. Summary of sewage sampling data, 1982 (continued).

Net concentrations		Concentration (10^{-9} Ci/ml)						Average as % of standard	
	No. of	Alpha			Beta				
	samples	Ave.	Min.	Max.	Ave.	Min.	Max.	Alpha	Beta
Hearst	42	0.05	<0.4	1.1	23	<1	460 ± 20	0.01	0.8
Strawberry	29	0.5	<0.4	17 ± 12	57	<1.3	640 ± 40	0.1	2
Overall	71	0.2			35			0.05	1.2
Standard for comparison[a]			400			3000			

[a]Source: Ref. 2.

Table 9. Summary of sewer sampling for heavy metals, 1982.

		No. of samples	Metals detected (mg/liter)							
			Chromium	Copper	Zinc	Silver	Cadmium	Nickel	Iron	Lead
Standard for comparison: EBMUD[a] limitation on discharge			2	5	5	1	1	5	100	2
Hearst sewer	Max		24.5	2.35	1.95	0.75	0.07	0.20	23.15	0.85
	Ave	16	0.06	0.81	0.27	0.10	0.03	0.11	1.04	0.41
	Min		0.02	0.34	0.13	<0.04	<0.02	<0.08	0.47	<0.24
Average as a % of standard			3	16	5	10	3	2	1	20
Strawberry sewer	Max		3.10	42.2	10.0	0.15	0.40	1.04	92.0	8.00
	Ave	38	0.77	7.87	4.04	0.06	0.10	0.36	13.87	1.88
	Min		0.25	2.00	0.37	<0.03	<0.02	0.12	0.75	<0.33
Average as a % of standard			38	160	81	6	10	7	14	94

[a]East Bay Municipal Water District

gamma exposure as measured at the LBL boundary. However, since gamma rays are more rapidly attenuated by the atmosphere than the neutrons they "accompany," simply adding the gamma fence post exposure to the neutron component of H_o will produce a conservative overestimate of population dose-equivalent.]

Figure 1 shows that the Bevatron is equidistant from the Olympus Gate and Building 88 environmental monitoring stations. It is reasonable to assume that the fence-post dose attributable to the Bevatron as measured at the Olympus Gate station would be the same dose measured at the Building 88 station if both stations were within line of sight of the Bevatron. However, the topography blocks such line of sight from the Bevatron to the Building 88 monitoring station. At large distances from a high energy accelerator half of the dose equivalent is attributable to the line of sight neutron exposure and the other half is due to scattered skyshine neutrons. Because the Bevatron contributed ~2.0 mrem to the fence-post dose at the Olympus Gate station (half of the 3.9 mrem measured at that station), we establish the value of f in Eq. (1) in the following manner.

Let A = the dose measured at the 88-Inch Cyclotron Monitoring Station = 24.0 mrem.
B = the dose measured at the above station attributable to Bevatron skyshine, approximately 1.0 rem.
C = the dose expected from the Bevatron if it were line-of-sight from the 88-Inch Cyclotron Monitoring Station = 2.0 rem.

Then

$$f = \frac{A - B}{A - B + C} = \frac{24.0 - 1.0}{24.0 - 1.0 + 2.0} = 0.92 \qquad (2)$$

Substituting this value of f in Eq. (1) and using the H_o measured at the Building 88 monitoring station, we find the population dose attributable to acceleration operation to be

$$M < 10^3 \times 0.024[1.0 - 0.56(0.92)]$$

$$M < 12 \text{ man-rem for 1982.}$$

AIRBORNE RADIONUCLIDES

The population dose equivalent resulting from airborne releases of radioactive nuclides can be determined from the model developed by Cantelow.[3] To provide more consistent reporting of these data, new values have been calculated for the constant R (man-rem per curie released). These values, shown in Table 10, are based on maximum permissible concentration (MPC) data listed in Ref. 2. These values replace those listed in Ref. 3, Table 16. Table 11 of this report summarizes the total population dose-equivalent due to LBL operations.

Table 10. Population dose equivalent resulting from the release of 1 Ci of radionuclides.

Nuclide	MPC[a] (μCi/ml)	R[b] (rem m^3 Ci^{-1} s^{-1})	α_R (man-rem/Ci)
Unidentified α emitters	2×10^{-14}	7.9×10^{5}	7×10^{5}
Unidentified β emitters	1×10^{-11}	1.6×10^{3}	7×10^{2}
^{3}H	2×10^{-7}	7.9×10^{-2}	3×10^{-2}
^{14}C	1×10^{-6}	1.6×10^{-2}	7×10^{-2}
^{125}I	8×10^{-11}	2.0×10^{2}	80
^{131}I	1×10^{-10}	1.6×10^{2}	70

[a]Source: Ref. 2.

[b]Source: Ref. 3.

Table 11. Population dose equivalent, 1982.

Contributing factor	Population dose (man-rem)
Penetrating radiation from accelerator operation	12
Radionuclide release:	
^{3}H	3.4
^{14}C	0.001
^{125}I	0.02
^{131}I	0.04
Unidentified alpha emitters	<0.3
Unidentified beta emitters	0.06
TOTAL	16

For 1982, the population dose attributable to natural background sources for the population within 80 km of LBL was approximately 4.6×10^{6} persons x 0.080 rem/person-yr = 370,000 man-rem.

TRENDS--LBL ENVIRONMENTAL IMPACT

ACCELERATOR-PRODUCED PENETRATING RADIATION

Figures 3-6 show the annual accelerator-produced equivalent reported by the four perimeter environmental monitoring stations from the year they were established to date. During the past several years, the LBL accelerators have run heavy ions during a significant fraction of their operating schedules. Successful work in beam development has served to increase beam currents in recent years. and has increased the dose equivalent at the Building 88 Environmental MS somewhat. While the maximum perimeter dose equivalent (Fig. 5.) remains a fraction of the radiation protection guidelines,[2] work on improvements in accelerator beam optics is being directed toward reversing the recent upward trend.

AIRBORNE AND WATERBORNE RADIONUCLIDES

With the exception of occasional known releases, the atmospheric sampling program has yielded data over the past few years that are within the range of normal background. The surface water program always yields results within the range of normal background. Because no substantial changes in the quantities of radionuclides used are anticipated, no changes are expected in these observations. Under the terms of its license, the University of California Berkeley campus has historically discharged radionuclides into the Strawberry sewer, complicating the analysis of LBL sewer sampling data. This University discharge practice, which was sharply curtailed during 1979, is expected to remain so in the future.

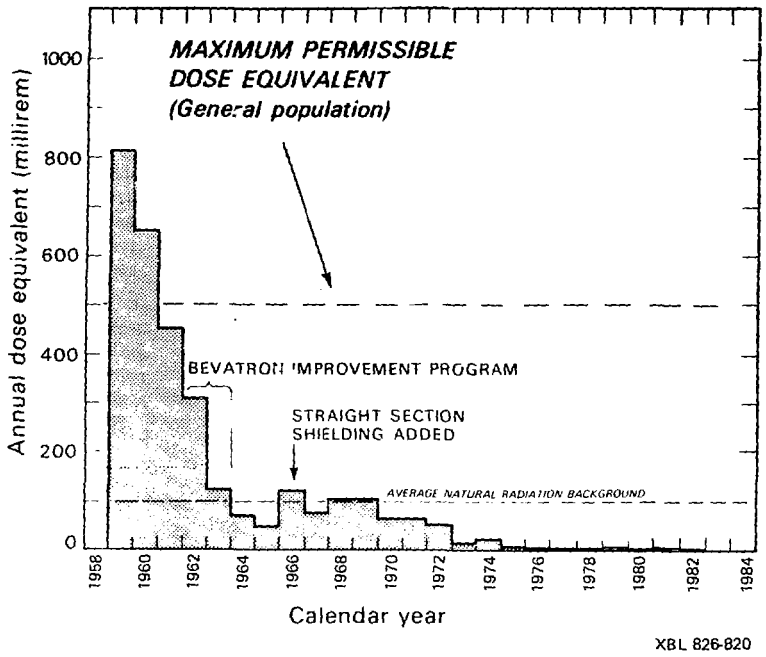


Figure 3. Annual accelerator-produced dose equivalent reported by the Olympus Gate Environmental Monitoring Station. Maximum Permissible Dose (General Population) is the maximum permissible dose equivalent to any single individual in the general non-Laboratory population. The maximum permissible average dose to the general population is 170 mrem/year.

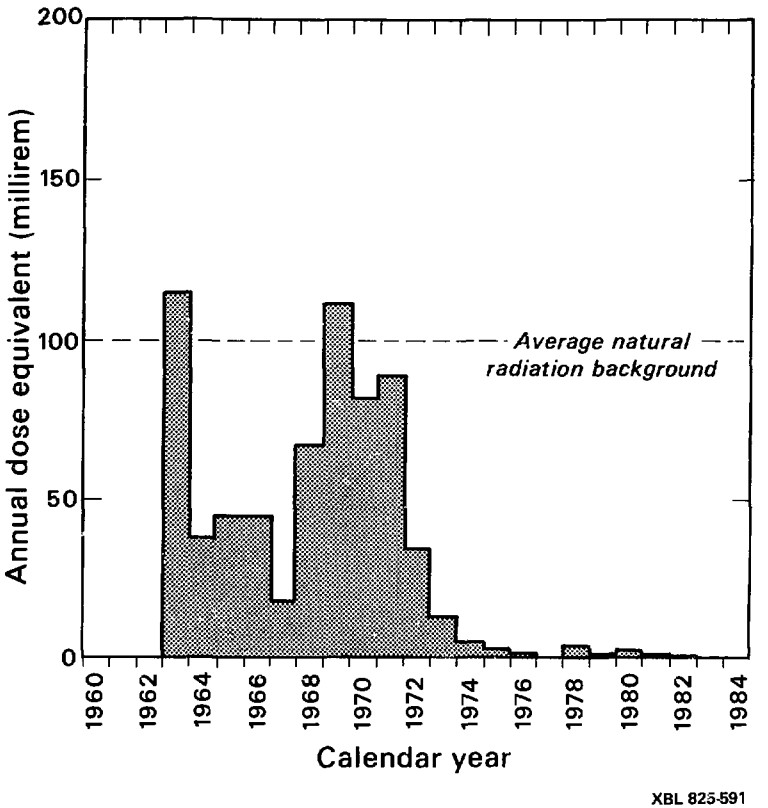


Figure 4. Annual accelerator-produced dose equivalent reported by the Building 90 Environmental Monitoring Station.

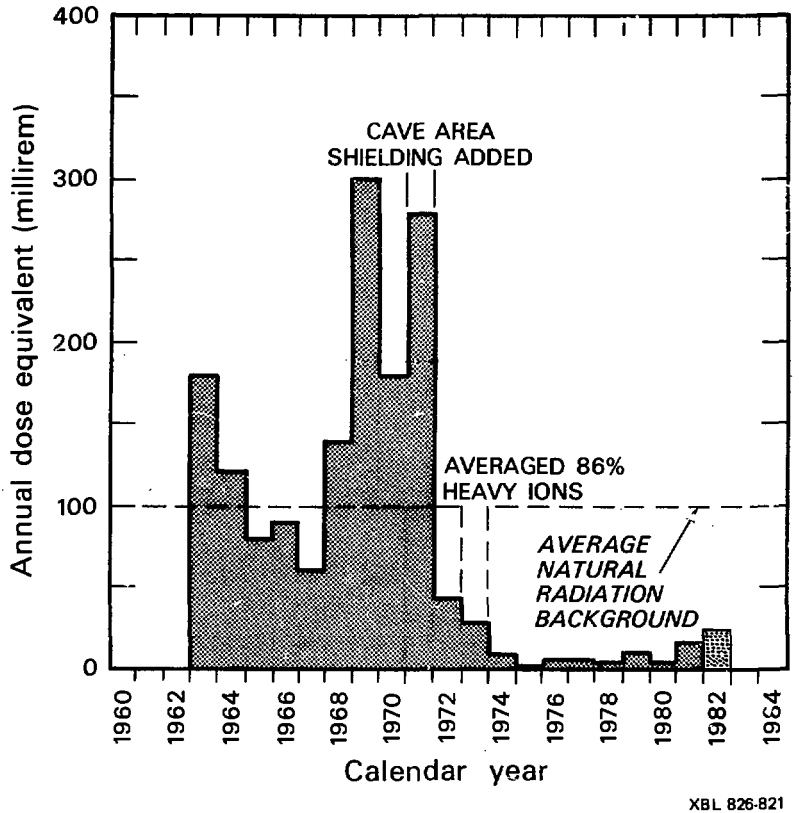


Figure 5. Annual accelerator-produced dose equivalent reported by the 88-Inch Cyclotron Environmental Monitoring Station.

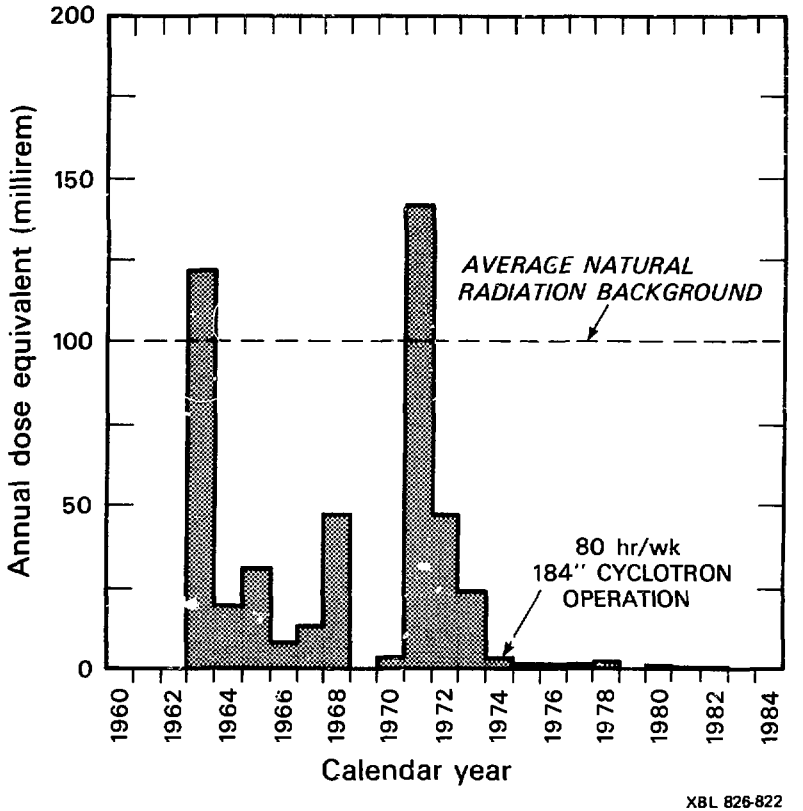


Figure 6. Annual accelerator-produced dose equivalent reported by the Panoramic Way Environmental Monitoring Station.

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