LBL-7530
Addendum-3/16/78

ADDENDUM
TO THE ANNUAL ENVIRONMENTAL MONITORING REPORT
OF THE LAWRENCE BERKELEY LABORATORY
1977

Occasionally during the year, a power failure will occur and produce a noticeable effect in the telemetered data from one or more of the Environmental Monitoring Stations. Such an event will cause the daily readings from the station to appear below the "normal background" for a period of time.

Two stations were effected this way during 1977. The Olympus Gate Station was effected on 19 September 1977, and 22-28 November 1977, during the Thanksgiving Holiday period. The Building 90 Station had a telemetry loss during 23-26 September 1977. See Figs. 4 and 6.

There is no statistically significant change in the reported values shown in Table 2 as a result of these events.

LBL 7530

UC-41

TID-4500-R66

ANNUAL ENVIRONMENTAL MONITORING REPORT OF THE LAWRENCE BERKELEY LABORATORY 1977

Prepared by the Staff of the
Engineering and Technical Services Division
Lawrence Berkeley Laboratory

March 1978

Editor: Lloyd D. Stephens

The following staff of the Environmental Health and Safety Department of the Engineering and Technical Services Division have contributed to the preparation of this report.

H. P. Cantelow

G. E. Schleimer

A. R. Smith

L. D [illegible]ephens

R. H. Thomas

J. Young

TABLE OF CONTENTS

ABSTRACT

The data obtained from the Environmental Monitoring Program of the Lawrence Berkeley Laboratory for the Calendar year 1977 are described and general trends are discussed.

PREFACE

In 1976 we published the Annual Environmental Monitoring Report in two parts. Part One, LBL-4678,[1] discussed in detail the modeling used to determine the population dose equivalent due to Laboratory operations. This volume also described natural radiation background, geological features, climate and meterology, and the environmental surveillance program of the Lawrence Berkeley Laboratory. Part Two, LBL-4827,[2] included the results of the sampling and measuring programs and the other necessary data to derive the environmental impact of Laboratory operations for 1975.

This year we will only reference LBL-4678, thereby reducing the Annual Environmental Report to the essential details.

1. Environmental Monitoring Data -- 1977

1.1. Accelerator-Produced Radiation

Figures 1 through 8 summarize the daily dose equivalent recorded for each environmental monitoring station due to photons and neutrons. These figures include natural background with the fluctuations due primarily to statistical variations.

There are some identifiable periods of accelerator operation that produced environmental radiation. These are listed in Table 1.

TABLE I.

Inclusive Dates	Accelerator	Beam	Environmental Monitoring Station*
3/25-28/77	Bevatron	p^+,33%; C,36%; Ne,31%	OGEMS, 90EMS
5/18-25/77	Bevatron	p^+,27%; C,73%	OGEMS, 88EMS
7/29-8/3/77	Bevatron	p^+	OGEMS, 88EMS 90EMS, PANEMS
1/7-14/77	88-Inch Cyclotron	120 MeV α	88EMS
3/10-15/77	88-Inch Cyclotron	80 MeV ^3He	88EMS
5/28-6/2/77	88-Inch Cyclotron	90 MeV α	88EMS
9/22-30/77	88-Inch Cyclotron	35 MeV d	88EMS, 90EMS
12/7/77	88-Inch Cyclotron	$^9Be^{4+}$	PANEMS, OGEMS 88EMS, 90EMS neutron and gamma
5/26-6/6/77	SuperHilac		OGEMS

* OGEMS - Olympus Gate Environmental Monitoring Station
90EMS - Building 90 Environmental Monitoring Station
88EMS - Building 88 Environmental Monitoring Station
PANEMS - Panoramic Way Environmental Monitoring Station

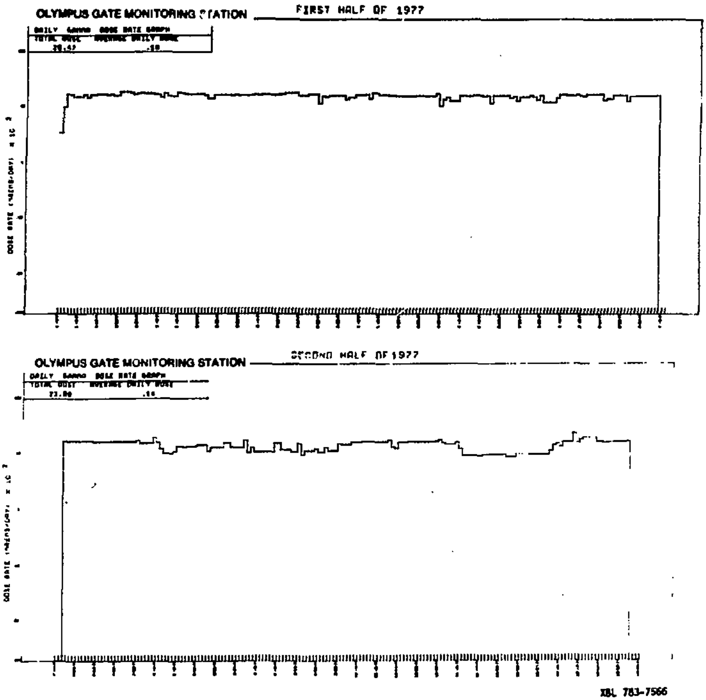

OLYMPUS GATE MONITORING STATION
FIRST HALF OF 1977
OLYMPUS GATE MONITORING STATION
SECOND HALF OF 1977
XBL 783-7566

Fig. 1

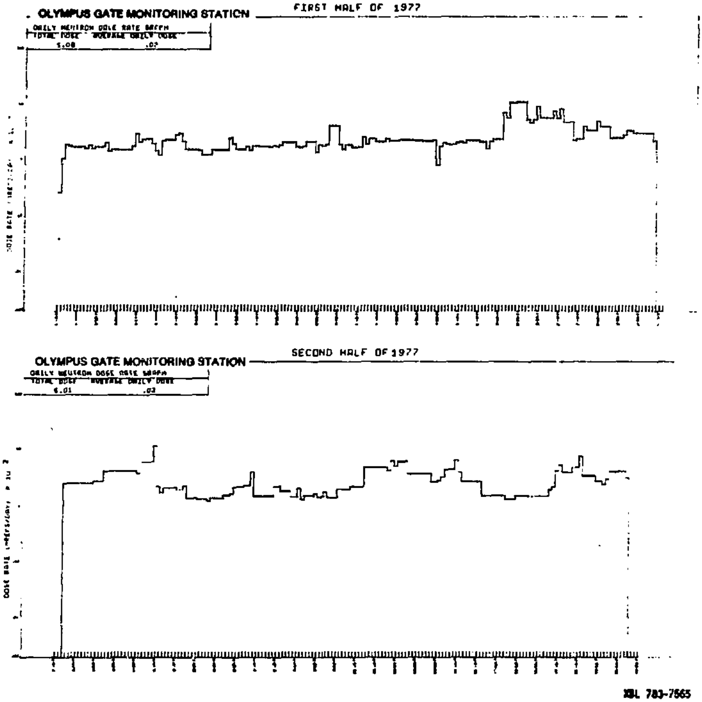
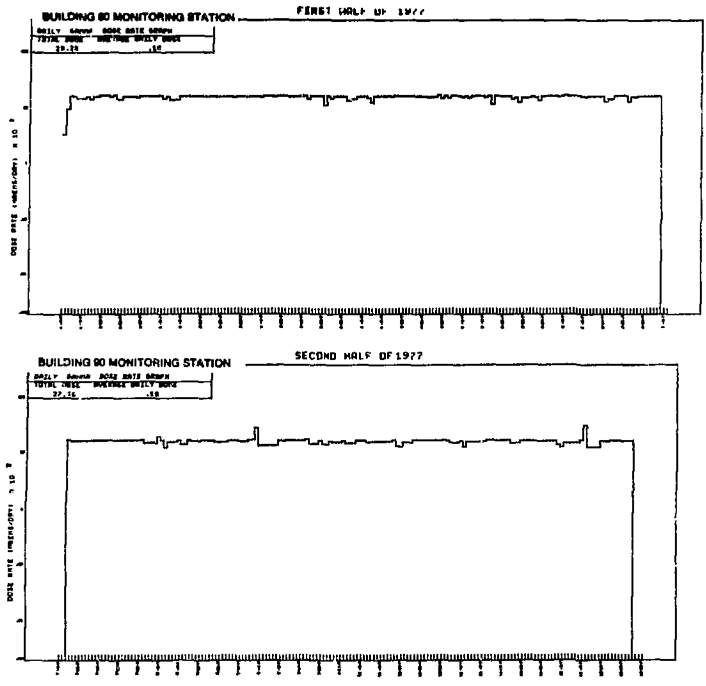

OLYMPUS GATE MONITORING STATION
FIRST HALF OF 1977
SECOND HALF OF 1977
XBL 783-7565

Fig. 2



XBL 783-7564

Fig. 3

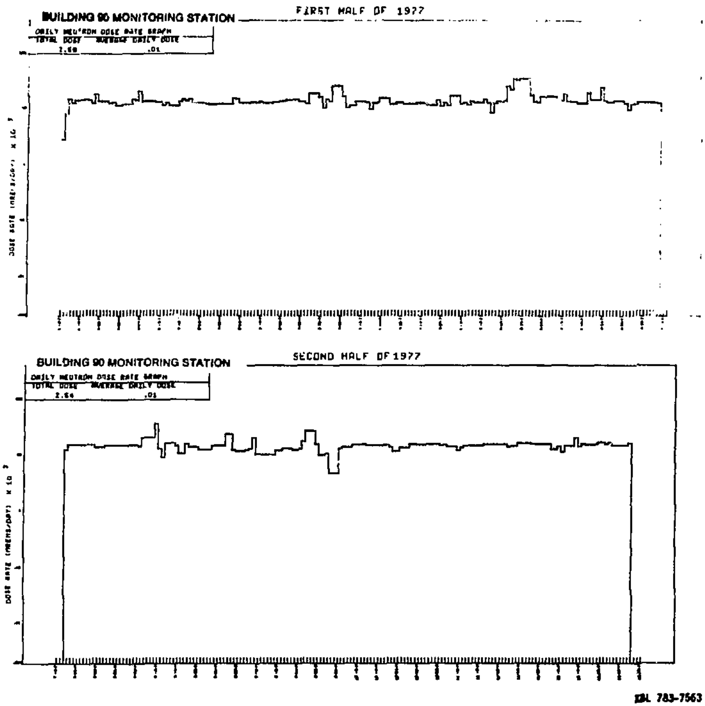
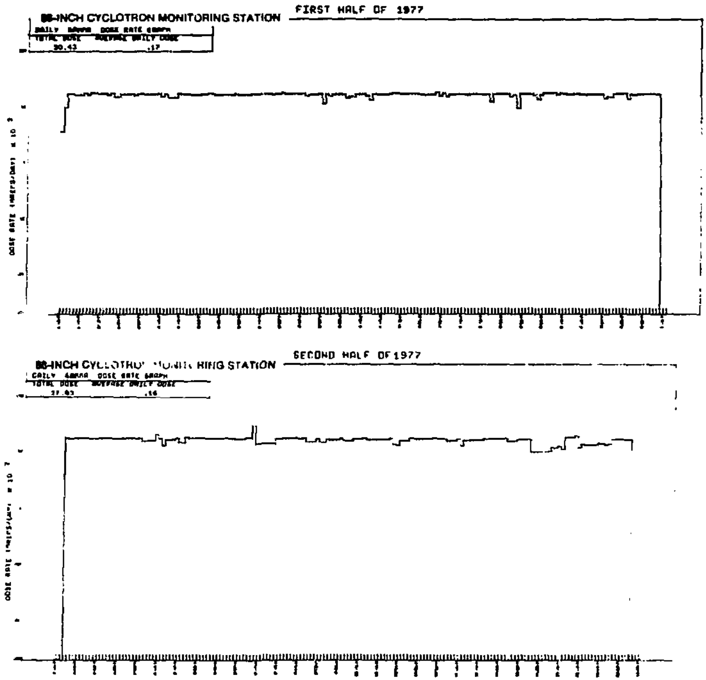
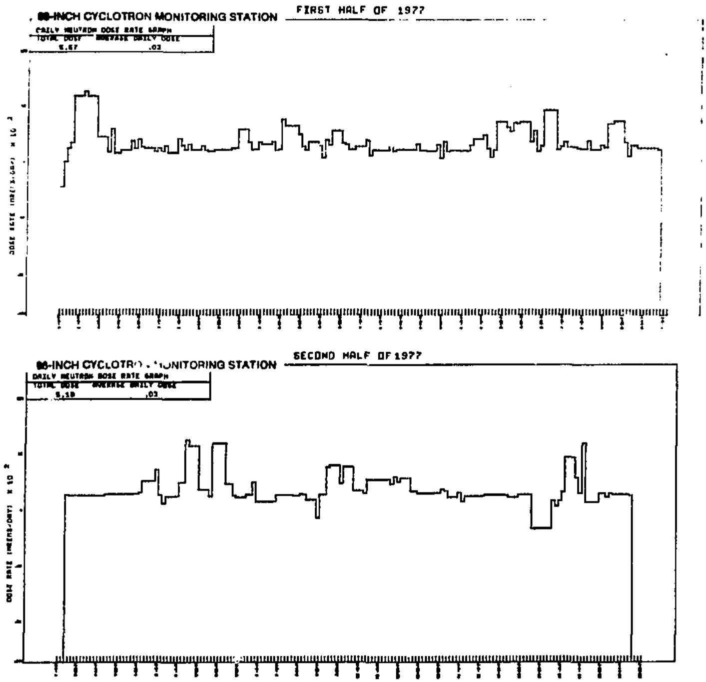

BUILDING 90 MONITORING STATION
FIRST HALF OF 1977
BUILDING 90 MONITORING STATION
SECOND HALF OF 1977
XBL 783-7563

Fig. 4



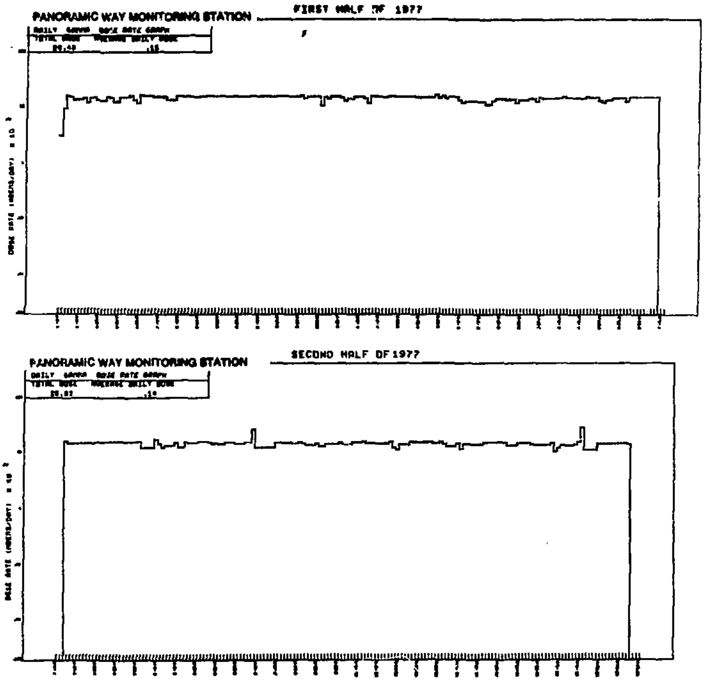
XBL 783-7562

Fig. 5



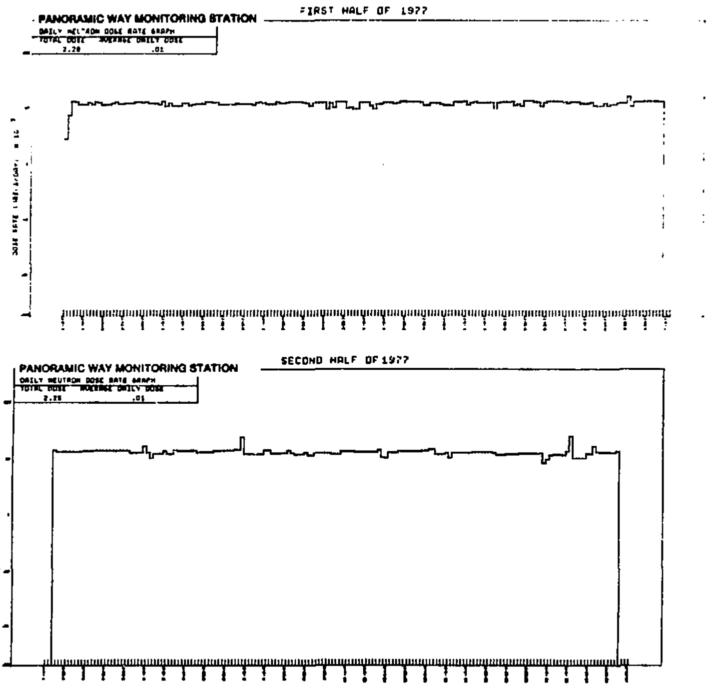
XBL 783-7561

Fig. 6



XBL 783-7560

Fig. 7



XBL 783-7559

Fig. 8

Table 2 summarizes the total dose equivalent at each station during 1977. In evaluating the annual dose equivalent due to photons, the data summarized in Table 3 were used. In evaluating the annual dose equivalent due to neutrons, the neutron detector calibration factors and neutron backgrounds at each monitoring station are listed in Table 4. The net neutron count after background subtraction is converted to neutron fluence using the conversion factors of Table 4. Because the neutron detectors do not respond over the entire energy spectrum, this measured fluence must be increased. Studies of the leakage neutron spectrum from accelerator shields at LBL show that the measured neutron fluence should be increased by a factor of 2.0 if the neutron spectrum at the environmental monitoring station is similar to that around the Bevatron.(3) Although this is probably a somewhat conservative assumption, it is at present adopted for our environmental radiation monitoring. The corrected fluence is converted to dose equivalent using a value of 1.86×10^{-8} rem $n^{-1} cm^2$.(5)

Table 2

Radiation Levels at the LBL Site Boundary Due to Accelerator Operation--1977

Location	Total Dose Equivalent from Photons (millirem) Jan.-Dec. (Background Subtracted)	Total Dose Equivalent from Neutrons (millirem) Jan.-Dec. (Background Subtracted)	Total Dose Equivalent (millirem) Jan.-Dec. (Background Subtracted)
Olympus Gate	0	4.5±0.01*	4.5±0.01*
88-Inch Cyclotron	0	5.3±0.01	5.3±0.01
Building 90	0	0	0
Panoramic Way	0	0.23±0.01	0.23±0.01
Standard for Comparison(4)			500 millirem

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

Table 3

Data Used in Evaluation of Annual Dose Equivalent Due to Photons

Location	Annual Background Radiation Due to Photons and Cosmic Rays* (millirem)	Calibration of Detector μR/Register Count
Olympus Gate	76	1.24
88-Inch Cyclotron	105	1.13
Building 90	92	1.16
Panoramic Way	112	1.11

*Except neutrons.

The annual background reported here was based on dry conditions of soil moisture and weather. 1977 was not an average year, due to the drought. There was one period during which gamma levels were detectable above background variations. This was during an 88-Inch Cyclotron beam development run on December 7, 1977.

Table 4

Neutron Detector Calibration Factors and Neutron Backgrounds at each Monitoring Station.

Location	Neutron Detector Calibration Factor n cm^{-2}/count	Background (Counts/Day)
Olympus Gate	16.3	26.9
88-Inch Cyclotron	15.6	27.5
Building 90	13.1	31.3
Panoramic Way	13.5	24.7

1.2. Radionuclide Measurements and Release

1.2.1. Atmospheric Sampling

The total quantities of radionuclides discharged into the atmosphere are summarized in Table 5. Although these amounts are greater than the amounts released in 1976 the quantities resulted in a small population dose equivalent (see Table 12).

Table 5.

Total Quantities Discharged into the Atmosphere--1977

Nuclides(s)	Quantity Discharged
Alpha Emitters	$< 1 \times 10^{-6}$ Ci
Unidentified Beta-Gamma Emitters	4.1×10^{-5} Ci
Carbon-14	2.5×10^{-1} Ci
Tritium	78 Ci
Gallium-67	1.3×10^{-3} Ci
Iodine-125	4.6×10^{-4} Ci

The general air sampling program gave data all of which were within the range of normal background (Table 6). The special air sampling program for ^{14}C and ^{3}H found detectable concentrations of these nuclides (Table 7). Average concentrations of ^{3}H for the year were about equal to the radiation protection standards. The measurements of atmospheric deposition at perimeter stations all lie within the range of normal background, although small amounts of tritium were detected in rainfall collected within the Laboratory boundary. (Table 8)

Table 6

Summary of Air Samples--1977

		Concentration, 10^{-15} µCi/ml						% of Standard	
		Alpha			Beta-Gamma			Alpha	Beta-Gamma
	No. of Samples	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Avg.
On-Site Average of 10 Locations	504	0.35±0.10	<2	3	80±4	<80	520	2	0.8
Perimeter Stations									
Building 88	51	0.91±0.33	<2	4	84±13	<80	430	5	0.8
Building 90	49	0.86±0.34	<2	3	88±13	<80	350	4	0.9
Panoramic Way	50	0.84±0.33	<2	4	94±13	<80	450	4	0.9
Olympus Gate	51	1.09±0.34	<2	4	98±13	<80	440	4	1.0
Standard for Comparison[(4)]		20			10,000				

Table 7

Summary of Special Air Sampling--1977

	No. of Samples	Concentration 10^{-9} μCi/ml Avg.	Concentration 10^{-9} μCi/ml Max.	% of Standard
Samples for Tritium in Air				
On Site				
Bldg. 3 Roof	51	2.0±0.2	7±1	1.0
Perimeter				
LHS	50	1.8±0.2	8±1	0.9
B13D (Olympus)	50	1.5±0.2	8±1	0.8
Standard for Comparison		200		
Samples for Carbon-14 in Air (as CO_2)				
On Site				
Bldg. 3 Roof	51	0.02±0.02	.9±.2	0.02
Standard for Comparison		100		

Table 8

Summary of Atmospheric Deposition--1977

	Total Deposition, 10^3 $\mu Ci/m^2$					Tritium in Rainfall, $\mu Ci/m^2$		
	No. of Samples	α Avg.	α Max.*	β Avg.	β Max.*	No. of Samples	Avg.	Max.*
On Site								
(9 locations)	108	0.00	0.02±0.04	2.9	3.8±0.2	81	2.5	20.8±1.0
Perimeter								
(4 locations)	48	0.02	0.05±0.04	4.5	9.0±0.2	36	0.4	0.5±0.4

No standards for comparison have been established.

*Highest total for any one site.

1.2.2 Water Sampling

Table 9 summarizes the 1977 data from the surface water and tap water sampling program. 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 the Laboratory as shown in the table.

One unusually high concentration of ^{32}P was observed, but was very likely due to a cross-contamination problem in the analytical laboratory.

1.2.3. Sewer Sampling

Table 10 summarizes the sewage sampling data for 1977. The sewer data are not significantly different from the previous year's data. The campus of the University of California continued to discharge radioactive waste into the Strawberry sewer above the point at which it is monitored by LBL. LBL release practices have not changed during 1977 and are the same as in past years. The Hearst sewer concentration was less than 1% of the ERDA standard for discharge to sewers, however the Strawberry sewer was 14% of the standard[(4)] (see Table 11).

1.3 Population Dose Equivalent Resulting from 1977 LBL Operation

The population dose equivalent can be estimated as a function of the fence-post dose as a result of the various accelerator operating conditions and radionuclide releases.[(5),(6)] During 1977 the 88-Inch Cyclotron and SuperHILAC contributed a major portion of the measured radiation at the site boundary, 66%. The Bevatron accounted for about 34% of the detectable radiation. 184-Inch operations were not significant during 1977. From Eq. 15,[(5)] the corrected population dose equivalent, M, will be:

$$M = 1000\ H_0\ [1-0.56f]$$

where f is the fraction of the time that the 88-Inch Cyclotron produced detectable radiation; H_0, the measured fence-post dose equivalent substituting f = 0.66,

$$M = 1000\ H_0\ [0.63]$$

The maximum dose equivalent at the site boundary due to penetrating radiation produced by accelerator operation was 5.3 millirem (Table 2, Section 1.1). The corresponding population dose equivalent is 3.3 man rem. The slight change from 1976 is due to statistical variations rather than changes in accelerator operation. The Bevatron proton runs produced some measurable radiation at the site boundary. The SuperHILAC did produce some detectable radiation due to slightly higher beam currents. This is added to the 88-Inch Cyclotron contribution in our model.[5]

The highest site boundary dose equivalent was detected at the monitoring station located only ~100 meters from the 88-Inch Cyclotron.

The population dose equivalent resulting from airborne releases of radioactive nuclides can be determined from the model described in Ref. 6.

For the sake of providing more consistent reporting of these data, new values have been calculated for the constant "σR" (man-rem per curie released). The new values shown in Table 11 are based on MPC data listed in Chapter 0524 (Ref. 4). These values replace those listed in Ref. 1, Table 16.

Table 9

Surface Water and Tap Water Samples--1977

	No. of Samples	Concentration, 10^{-9} µCi/ml α Avg.	α Max.	β Avg.	β Max.	% of Standards α	β
On Site Streams							
Blackberry	51	<0.2	3.6	2.5±0.1	9	<0.7	2.5
Lower Strawberry	50	<0.3	3.1	11.5±0.2	208*	<1.0	11.5
Upper Strawberry	51	<0.7	4.7	2.6±0.1	5	<2.3	2.6
Average		<0.3		5.5±0.1		<1.0	5.5
Off Site Streams							
Claremont	51	<0.2	3.1	1.6±0.1	6	<0.7	1.6
Wildcat	50	<0.5	5.2	1.5±0.1	4	<1.7	1.5
Average		<0.3		1.53±0.04		<1.0	1.5
Tap Water	51	<0.1	8	1.1±0.1	2	<0.3	1.1
Standard of Comparison[4]		30		100			

*Identified as ^{32}P.

Table 10

Summary of Sewage Sampling Data--1977

Total Quantities Discharged

	Total Volume 10^6 Liters	Total α μCi	Total β-γ mCi
Hearst Sewer	244	44	3.5
Strawberry Sewer	228	52	95
TOTAL	472	96	98.5

Net Concentrations

		Concentration, 10^{-9} μCi/ml					
	No. or Samples	α Avg.	α Max.	β-γ Avg.	β-γ Max.	% of Standard α	% of Standard β-γ
Hearst	38	0.2	2.4	14.2	40	0.1	0.5
Strawberry	42	0.2	6.1	419	5280	0.1	14
Overall		0.2		209			
Standard for Comparison		400		3,000		-	

Table 11

Population Dose Equivalent Resulting from the Release of One Curie of Radionuclides

Nuclide	MPC (μCi/ml)	$R^{(6)}$ (Rem $m^3Ci^{-1}s^{-1}$)	$\alpha R^{(6)}$ (Man-rem/Ci)
Unidentified alpha emitters	$2x10^{-14}$	$7.9x10^5$	$3x10^5$
Unidentified beta emitters	$1x10^{-11}$	$1.6x10^3$	$7x10^2$
^3H	$2x10^{-7}$	.079	.03
^{14}C	$1x10^{-7}$	.16	.07
^{125}I	$8x10^{-11}$	200	80
^{67}Ga	$1x10^{-10}$	160	70

Table 12 summarizes the total population dose equivalent due to Laboratory operations.

Table 12

Population Dose Equivalent--1977

	Population Dose (man rem)
Penetrating Radiation--	
Accelerator operation	5.3
Radionuclide Release	
^3H	2.4
^{14}C	0.02
^{67}Ga	0.09
^{125}I	0.04
Unknown β,γ emitters	0.03
Unknown α emitters	<0.3
Total	8.

1.4 Non-Radioactive Pollutants

The Laboratory does not carry out routine monitoring of airborne non-radioactive pollutants, however, sewer sampling is carried out for heavy metals. The analysis is achieved by atomic absorption.

Table 13 summarizes the sewer sampling data for heavy metals.

2. Summary of Environmental Monitoring Data and Trends

2.1 Accelerator-Produced Penetrating Radiation

The general trend of decreasing radiation levels at our site boundary due to accelerator operation during past years has leveled off during 1977 and in some areas shows a slight but not statistically significant increase as predicted in last year's summary. There were changes in both ion beams as well as current which have resulted in shifts in maxima at the monitoring stations.

The gamma levels are once again reported as zero. There is only one period of detectable gamma radiation due to accelerator operation.

Figures 9 through 12 show the annual dose equivalent reported from the environmental monitoring stations since they have been established.

Radiation levels at the Olympus Gate Station have shown a steady decline since 1959 when estimates were first made. The Olympus Gate Station is in direct view of the Bevatron and most directly influenced by that accelerator.

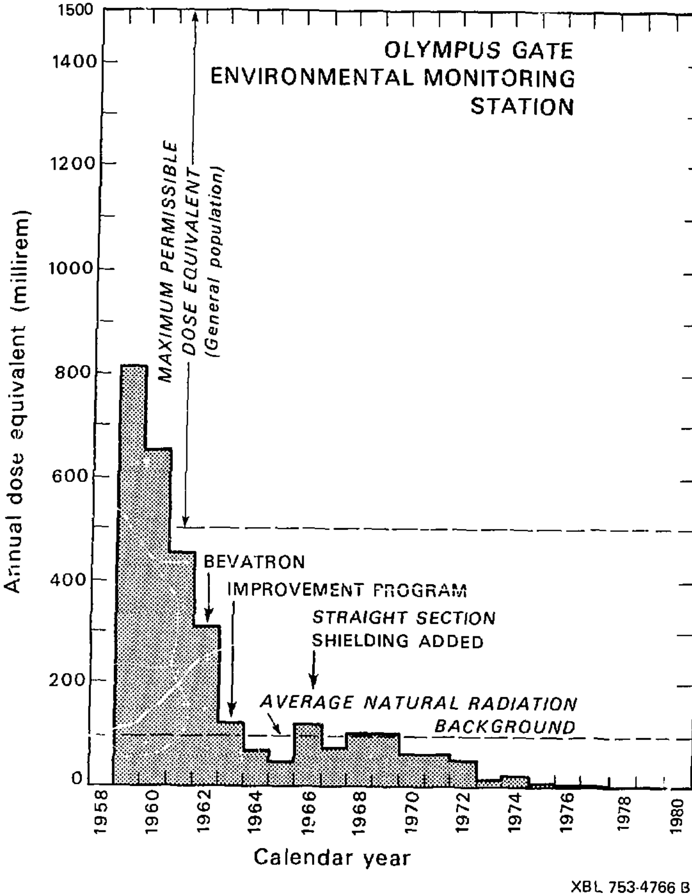
2.2 Release of Radionuclides

Over the past several years the atmospheric sampling program has, with the exception of occasional known releases, yielded data which are within the range of normal background. The surface water program always yields results within the range of normal background. As no substantial changes in the quantities of radionuclides used are anticipated, no changes are expected in these observations.

Table 13

Summary of Sewer Sampling Data for Heavy Metals--1977

	Metals Detected							
	Chromium	Copper	Zinc	Silver	Cadmium	Nickel	Iron	Lead
Standard for Comparison EBMUD Limitation on discharge (mg/l)	2	5	5	1	1	5	100	2
<u>Hearst Sewer</u>								
Average (mg/l)	0.52	0.67	0.39	<0.04	<0.02	<0.05	2.82	<0.06
% of Standard	26	13.4	7.8	4	2	1	2.8	3
<u>Strawberry Sewer</u>								
Average (mg/l)	1.12	4.5	2.98	<0.03	0.05	0.77	15.08	<0.31
% of Standard	56	90	59.6	3	5	15.4	15	15.5



OLYMPUS GATE
ENVIRONMENTAL MONITORING
STATION
MAXIMUM PERMISSIBLE
DOSE EQUIVALENT
(General population)
BEVATRON
IMPROVEMENT PROGRAM
STRAIGHT SECTION
SHIELDING ADDED
AVERAGE NATURAL RADIATION
BACKGROUND
Annual dose equivalent (millirem)
1500
1400
1200
1000
800
600
400
200
0
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
Calendar year
XBL 753-4766 B

Fig. 9

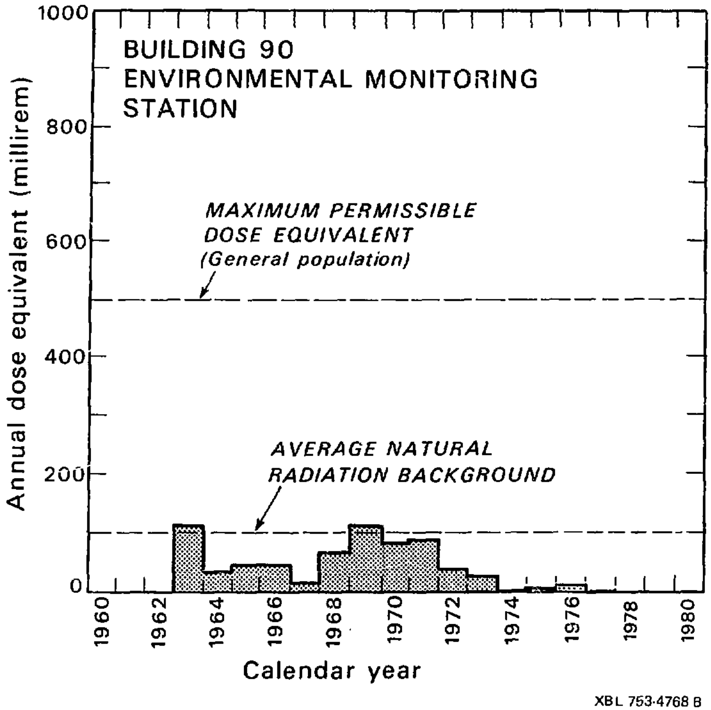

BUILDING 90
ENVIRONMENTAL MONITORING
STATION
MAXIMUM PERMISSIBLE
DOSE EQUIVALENT
(General population)
AVERAGE NATURAL
RADIATION BACKGROUND
Annual dose equivalent (millirem)
1000
800
600
400
200
0
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
Calendar year
XBL 753-4768 B

Fig. 10

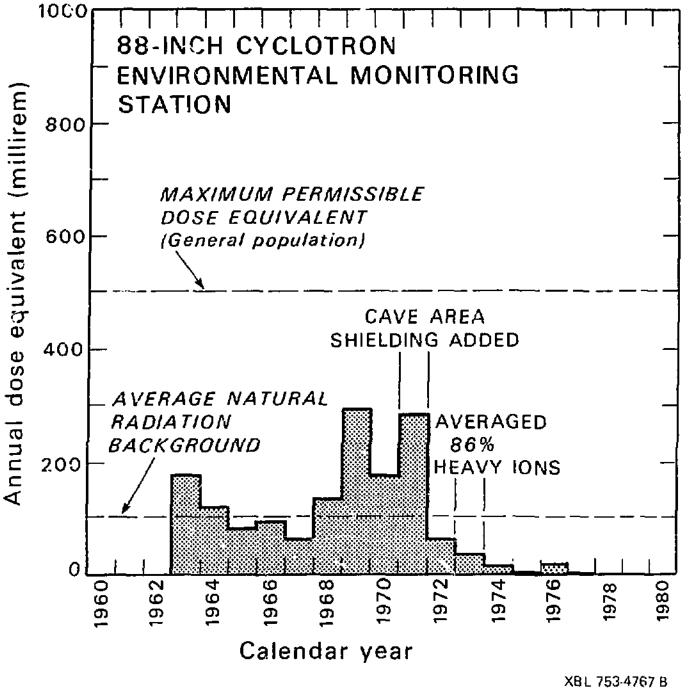

88-INCH CYCLOTRON
ENVIRONMENTAL MONITORING
STATION
MAXIMUM PERMISSIBLE
DOSE EQUIVALENT
(General population)
CAVE AREA
SHIELDING ADDED
AVERAGE NATURAL
RADIATION
BACKGROUND
AVERAGED
86%
HEAVY IONS
Annual dose equivalent (millirem)
1000
800
600
400
200
0
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
Calendar year
XBL 753-4767 B

Fig. 11

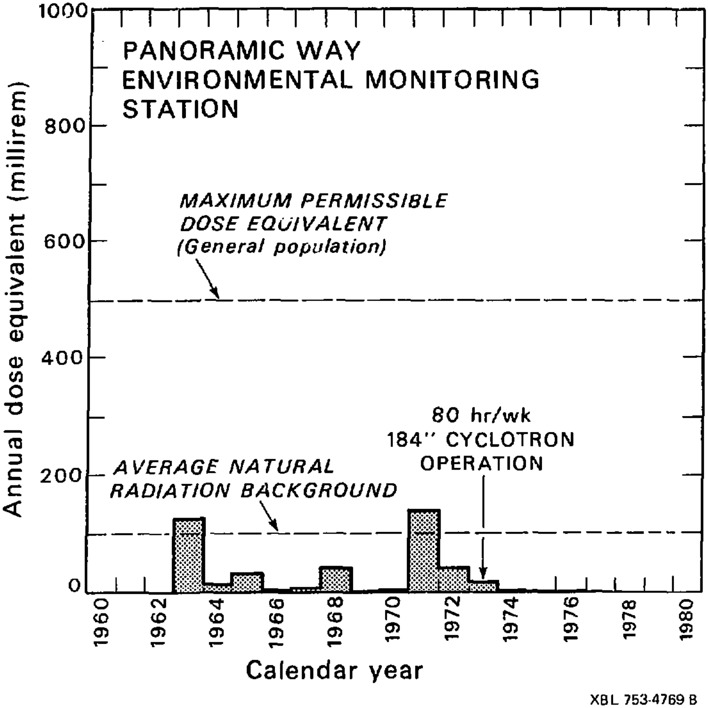

1000
800
600
400
200
0
PANORAMIC WAY
ENVIRONMENTAL MONITORING
STATION
MAXIMUM PERMISSIBLE
DOSE EQUIVALENT
(General population)
80 hr/wk
184'' CYCLOTRON
OPERATION
AVERAGE NATURAL
RADIATION BACKGROUND
Annual dose equivalent (millirem)
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
Calendar year
XBL 753-4769 B

Fig. 12

The practice of the University of California in discharging radionuclides in the Strawberry sewer continues to complicate the analysis of the sewer-sampling program data. Analysis also continues to be particularly difficult in view of the fact that the quantity of material discharged by the University is several times greater than that discharged by the Laboratory. Trends in sanitary sewer monitoring data are, therefore, unpredictable.

REFERENCES

*This work was done with support from the U.S. Department of Energy

1. R. H. Thomas, Ed., The Environmental Surveillance Program of the Lawrence Berkeley Laboratory, Lawrence Berkeley Laboratory Internal Report, LBL-4678, April 1976.

2. Staff Report, Engineering and Technical Services Division, Lawrence Berkeley Laboratory, Annual Environmental Monitoring Report of the Lawrence Berkeley Laboratory 1975, LBL 4827.

3. W. S. Gilbert, et al., 1966, CERN-LRL-RHEL Shielding Experiment, Lawrence Radiation Laboratory Internal Report, UCRL-19794 (1968).

4. United States Energy Research and Development Administration Manual, Chapter 0524-Standards for Radiation Protection.

5. Op Cit, Ref. 1 Section 4.2.3.

6. Op Cit, Ref. 1 Section 4.3.4.