ANNUAL ENVIRONMENTAL MONITORING REPORT OF THE LAWRENCE BERKELEY LABORATORY--1975

Prepared by the Staff of the
Engineering and Technical Services Division
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ABSTRACT

The data obtained from the Environmental Monitoring Program of the Lawrence Berkeley Laboratory for the calendar year 1975 are described and general trends are discussed.

1. Environmental Monitoring Data--1975

1.1. Accelerator-Produced Radiation

Figures 1 through 8 summarize the daily dose equivalent recorded at each environmental station due to photons and neutrons.

Inspection of these figures reveals particular conditions when radiation levels may be detected by the environmental stations. Examples may be seen during the period February 13-16, 1975, March 19, 1975, and April 22-24, 1975. A small increase in photon dose rate may be observed at both the Olympus Gate and Building 90 stations on February 13-14 during tuning of the SuperHILAC beam. Tuning of the SuperHILAC also produced the increase on March 19. The somewhat lesser increase on April 22-24 was due to Bevalac operation. Power failure on July 29, 1975 and power switching operations during the Christmas shut-down period produce artifacts in the computer plot which are no significance.

Table 1 summarizes the total dose equivalent at each station during 1975. In evaluating the annual dose equivalent due to photons, the data summarized in Table 2 were used. In evaluating the annual dose equivalent due to neutrons, the neutron detector calibration factors and neutron backgrounds at each monitor-in station are listed in Table 3. The net neutron count after background subtraction is converted to neutron fluence using the conversion factors of Table 3. 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

Fig. 1a

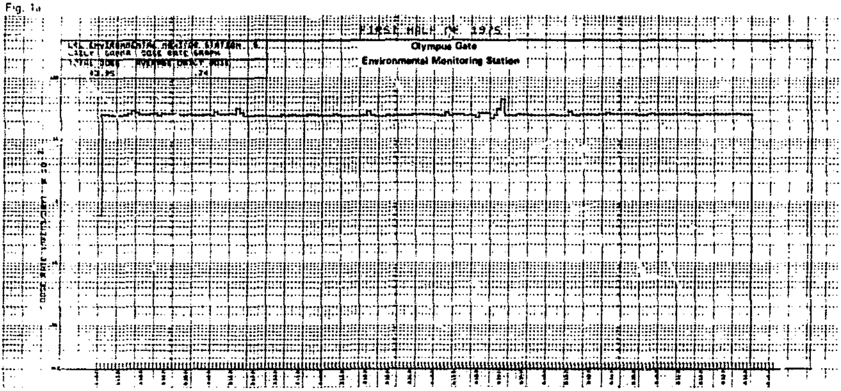
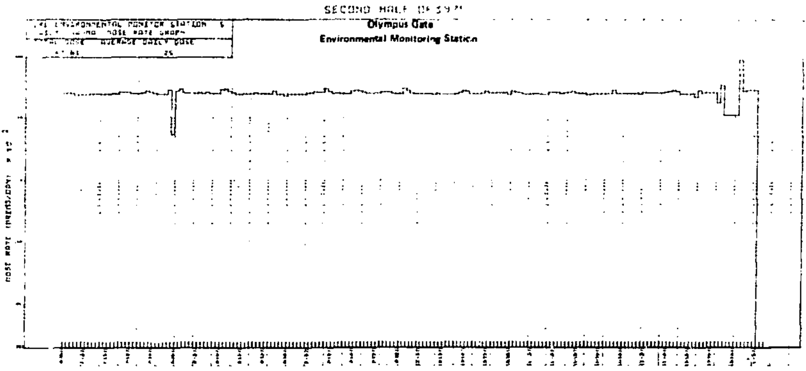


Fig. 1b



Figs. 1–8 Daily photon and neutron dose equivalents recorded at each environmental monitoring station. The data presented include natural background radiation.

XBL 764 1538

Fig. 2a

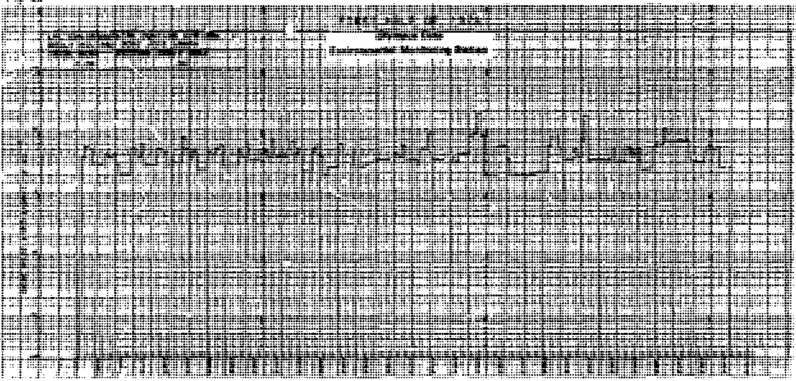
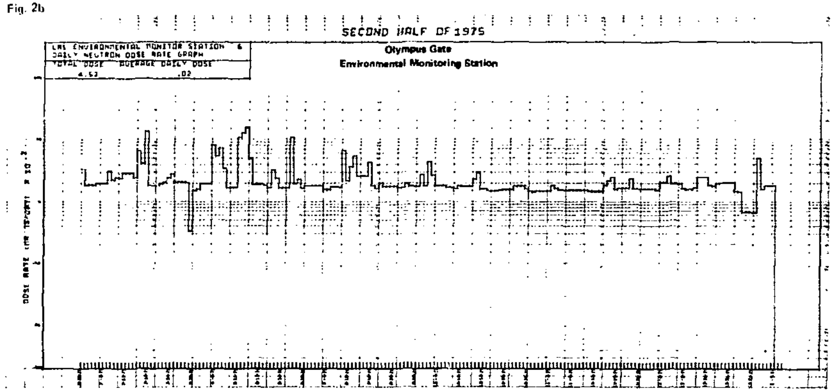


Fig. 2b



XBL 764-1539

Fig. 3a

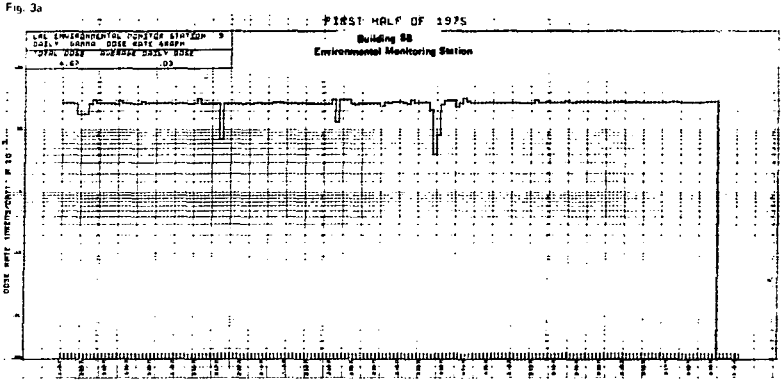
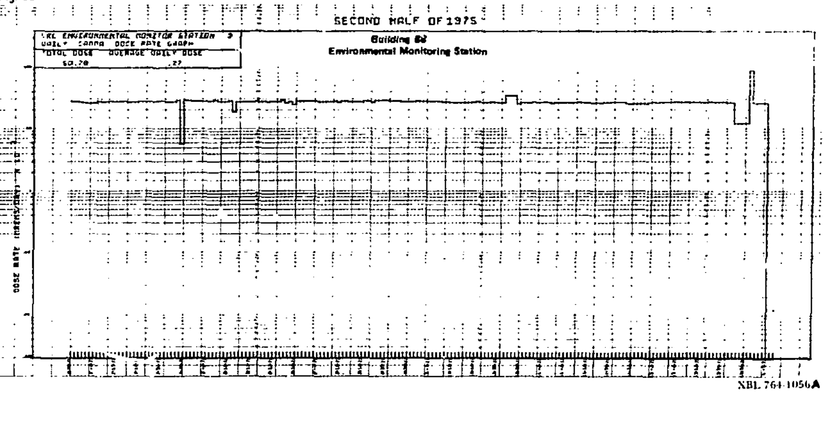


Fig. 3b



XBL 764-1056A

Fig. 4a

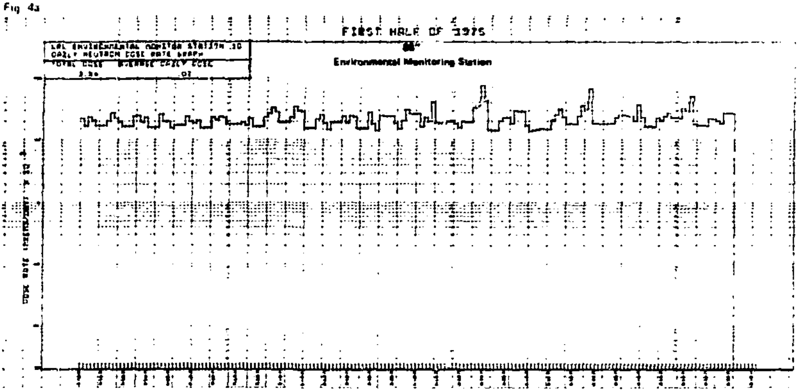

FIRST HALF OF 1975
Environmental Monitoring Station

Fig. 4b

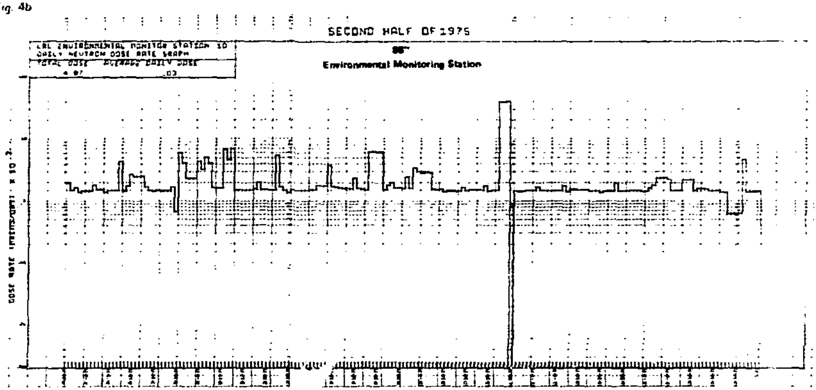

SECOND HALF OF 1975
Environmental Monitoring Station

Fig. 5a

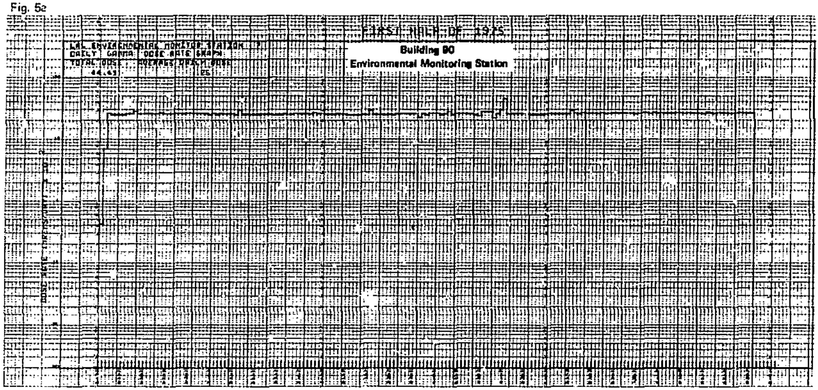
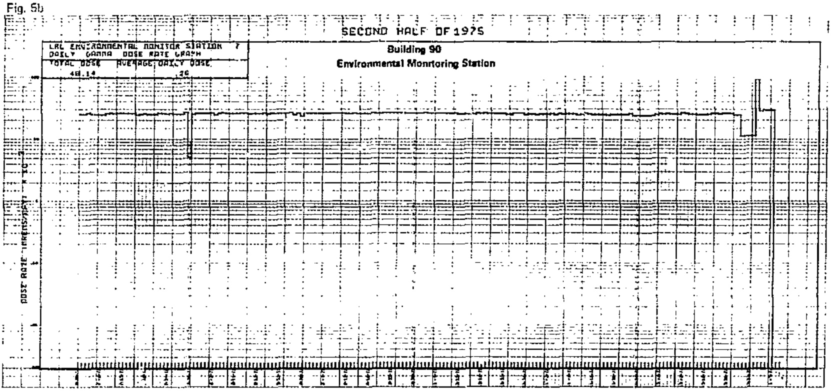


Fig. 5b



XBL 764-1541

Fig. 6a

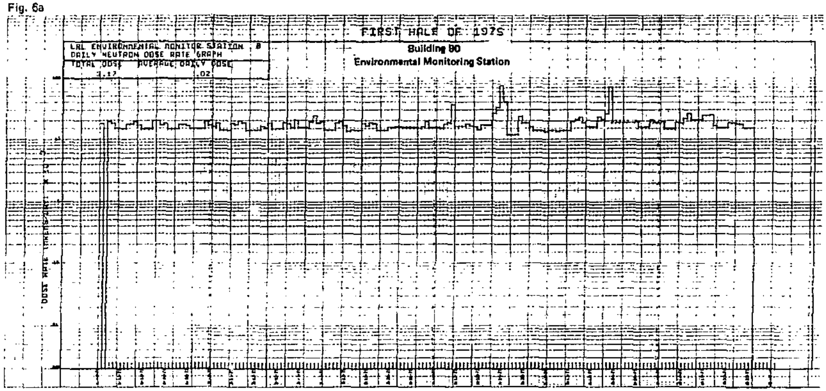
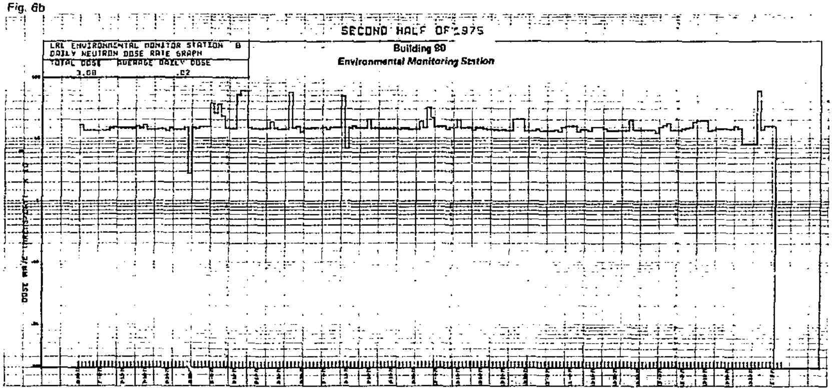


Fig. 6b



XBL 764-1542

Fig. 7a

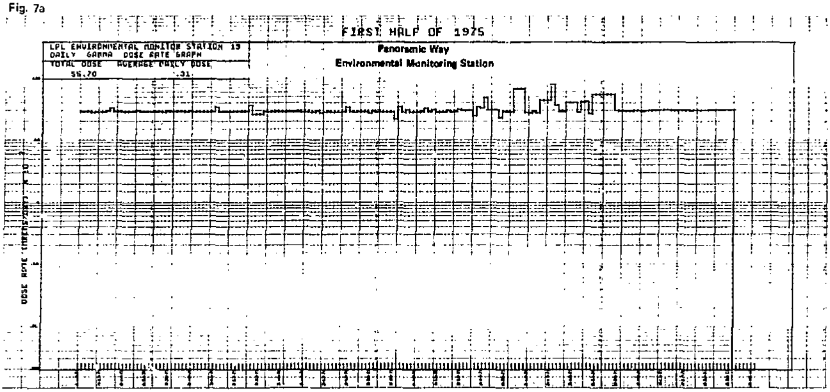
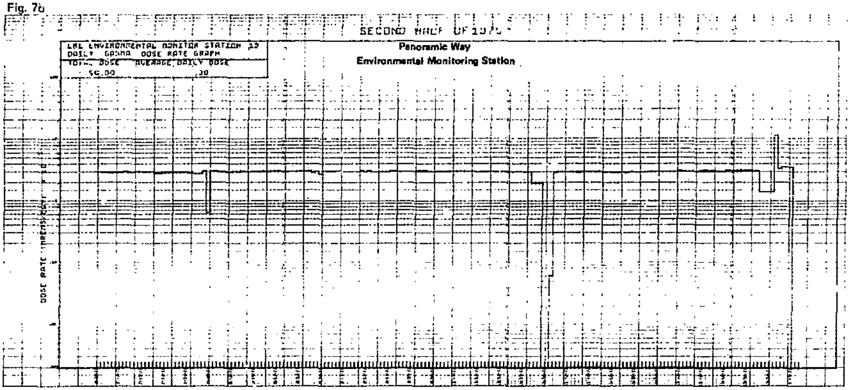


Fig. 7b



XBL 764-1543

Fig. 8a

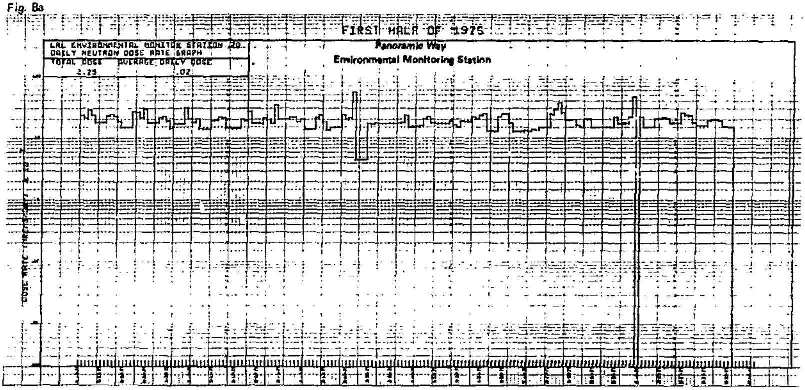
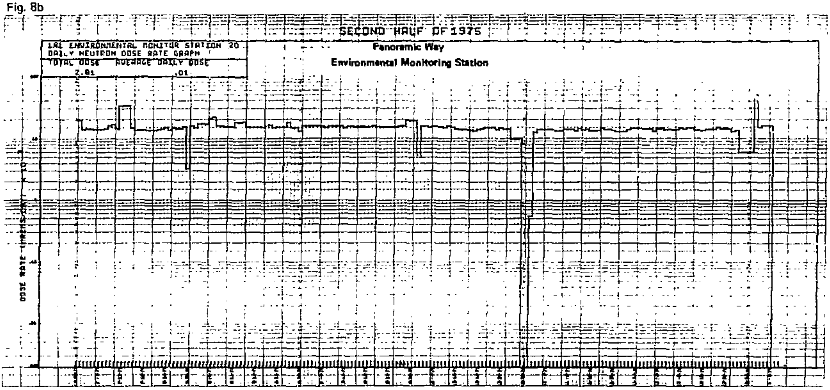


Fig. 8b



XBL 764-1537

Table 1. Radiation Levels at the LBL Site Boundary Due to Accelerator Operation--1975.

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*	3.5	3.5
88-Inch Cyclotron	0	1.6	1.6
Building 90	0*	1.4	1.4
Panoramic Way	0	0.8	0.8
Standard for Comparison			500[3]

*The difference between the measured total photon dose equivalent and natural background falls within the normal variation of background values and is, therefore, considered to be zero in the evaluation of total dose equivalent due to Laboratory operation.

Table 2. 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	73	1.94
88-Inch Cyclotron	102	1.77
Building 90	89	1.81
Panoramic Way	109	2.01

*Except neutrons.

Table 3. 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	14.5	26.9
88-Inch Cyclotron	15.3	25.5
Building 90	14.2	23.9
Panoramic Way	14.9	22.9

Bevatron.[1] 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 $n^{-1}cm^{2}$.[2]

1.2. Radionuclide Measurements and Release

1.2.1. Atmospheric Sampling

The total quantities of radionuclides discharged into the atmosphere are summarized in Table 4. With the exception of tritium, releases for 1975 were extremely small, coming very close to our goal of "zero release."

Table 4. Total Quantities Discharged into the Atmosphere (1975).

Nuclide(s)	Quantity Discharged
Alpha Emitters	$<1\times10^{-8}$ Ci
Unidentified Beta-Gamma Emitters	8×10^{-5} Ci
Carbon-14	0.15 Ci
Tritium	23 Ci

During 1975 there were no releases that could have resulted in concentrations greater than 1% of the relevant radiation protection standard.[3] Tables 5 and 6, which summarize the general and special air sampling data, provide confirmation of this assertion. The general air sampling program gave data all of which are within the range of normal background. The special air sampling program for ^{14}C and ^{3}H

Table 5. Summary of Air Samples (1975).

	No. of Samples	Concentration, 10^{-15} µCi/ml						% of Standard[3]	
		Alpha			Beta-Gamma			Alpha	Beta-Gamma
		Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Avg.
On Site Average of 10 Locations	486	0.3±0.1	<2	5	38±4	<80	300	2	0.4
Perimeter Stations									
Olympus Gate	51	<0.5	<2	2	41±12	<80	210	<3	0.4
88-Inch Cyclotron	50	0.7±0.3	<2	7	40±12	<80	240	4	0.4
Building 90	50	< 0.6	<2	4	40±12	<80	180	<3	0.4
Panoramic Way	49	< 0.5	<2	4	41±12	<80	190	<3	0.4
Standard for Comparison		20			10,000				

Table 6. Summary of Special Air Sampling (1975).

	No. of Samples	Concentration, 10^{-9} μCi/ml Avg.	Min.	Max.	% of Standard[5]
Samples for Tritium in Air					
On Site					
Bldg. 3 Roof	51	0.23±0.05	<0.3	2.4±0.3	0.1
Perimeter					
LHS	50	0.09±0.05	<0.3	0.9±0.3	0.05
B13D (Olympus)	51	0.03±0.05	<0.3	0.4±0.3	0.02
Standard for Comparison		200			
Samples for Carbon-14 in Air (as CO_2)					
On Site					
Bldg. 3 Roof	51	<0.04	<0.02	0.34±0.14	0.04
Standard for Comparison		100			

found levels within the range of normal background from ^{14}C but some detectable concentration of ^{3}H (Table 6). However, the highest ^{3}H concentration detected was 2.4×10^{-9} µCi/ml, while the average concentration for the year was a factor of ten lower, corresponding to 0.1% of the radiation protection standard.

The measurements of atmospheric deposition (Table 7) all lie within the range of normal background.

1.2.2. Water Sampling

Table 8 summarizes the 1975 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.

Table 9 summarizes the sewage sampling data for 1975. The Hearst sewer data are not significantly different from previous years' data, but the Strawberry sewer data are significantly higher. This increase is not because of releases from the Lawrence Berkeley Laboratory but from the Campus of the University of California which, during 1975, began to discharge radioactive waste into the Strawberry sewer above the point at which it is monitored by LBL. During 1975 it is estimated that 14 mCi of radioactive material were discharged by the University of California. Making this correction, both sewage concentrations were similar to previous years and less than 1% of the ERDA standard for discharge to sewers (See Table 9).[3]

Table 7. Summary of Atmospheric Deposition (1975).

	No. of Samples	Total Deposition, 10^{-3} $\mu Ci/m^2$ α Avg.	α Max.*	β Avg.	β Max.*
On Site					
(8 locations)	96	0.10	0.17±0.11	7.1	8.2±0.4
Perimeter					
(4 locations)	48	0.06	0.08±0.08	6.3	9.8±0.3

No standards for comparison have been established.

*Highest total for any one site.

Table 8. Surface Water and Tap Water Samples (1975).

	No. of Samples	Concentration, 10^{-9} μCi/ml				% of Standards	
		α		β			
		Avg.	Max.	Avg.	Max.	α	β
On Site Streams							
Blackberry	51	<0.1	2.7	2.4±0.1	16	<0.3	2.4
Lower Strawberry	51	<0.2	2.0	4.9±0.1	16	<0.7	4.9
Upper Strawberry	51	<0.2	2.4	2.5±0.1	8	<0.7	2.5
Average		<0.1		3.3±0.1		<0.3	3.3
Off Site Streams							
Claremont	51	<0.4	3.2	2.1±0.1	6	<1.3	2.1
Wildcat	51	<0.1	3.4	1.6±0.1	3	<0.3	1.6
Average		<0.2		1.8±0.1		<0.7	1.8
Tap Water	51	<0.1	0.6	1.5±0.1	6	<0.3	1.5
Standard for Comparison		30		100			

Table 9. Summary of Sewage Sampling Data (1975).

Total Quantities Discharged

	Total Volume 10^6 Liters	Total α μCi	Total β-γ mCi
Hearst Sewer	241	<64	1.48±0.15
Strawberry Sewer	154	<69	17.52±0.17*
Total	395	<106	19.00±0.23*

Net Concentrations

	No. of Samples	Concentration, 10^{-9} μCi/ml α Avg.	α Max.	β-γ Avg.	β-γ Max.	% of Standard α	% of Standard β-γ
Hearst	40	<0.3	2.0±1.5	6.1±0.6	20±4	<0.1	0.2
Strawberry	46	<0.5	<14	113.7±1.1*	1308±15	<0.1	3.8*
Overall		<0.3		48.1±0.6*		<0.1	1.6*
Standard for Comparison		400		3,000			

*The Strawberry sewer is also used by others. Of the 17.52 mCi observed, an estimated 14 mCi was discharged by a non-LBL source. Thus the total beta-gamma activity discharged by LBL was 5 mCi, rather than 19. Net beta-gamma concentrations from LBL sources were, therefore, 22.9×10^{-9} μCi/ml (0.8% of the standard) in the Strawberry sewer, and 12.7×10^{-9} μCi/ml (0.4% of standard) overall.

1.3. Population Dose Equivalent Resulting from 1975 LBL Operation

The maximum dose equivalent at the site boundary due to penetrating radiation produced by accelerator operation was 3.5 millirem (Table 1, Section 1.1). The corresponding population dose equivalent is 3.5 man rem.[4]

From the data given in Ref. 5, we may calculate that the population dose equivalent resulting from the release of 23 Ci of tritium, 0.15 Ci of ^{14}C, 8×10^{-5} Ci of unidentified β-γ emitters and $<10^{-8}$ Ci of unidentified alpha emitters (Table 4) were 0.3, 0.006, <0.02 and <0.0002 man rem respectively.

These values are summarized in Table 10.

1.4. Non-Radioactive Pollutants

The Laboratory does not carry out routine monitoring of non-radioactive pollutants.[2]

Table 10. Population Dose Equivalent--1975.

Source of Exposure	Population Dose (man rem)
Penetrating Radiation--	
Accelerator operation	3.5
Radionuclide Release:	
^{3}H	0.3
^{14}C	0.006
Unknown β,γ emitters	<0.02
Unknown α emitters	<0.0002
Total	3.8

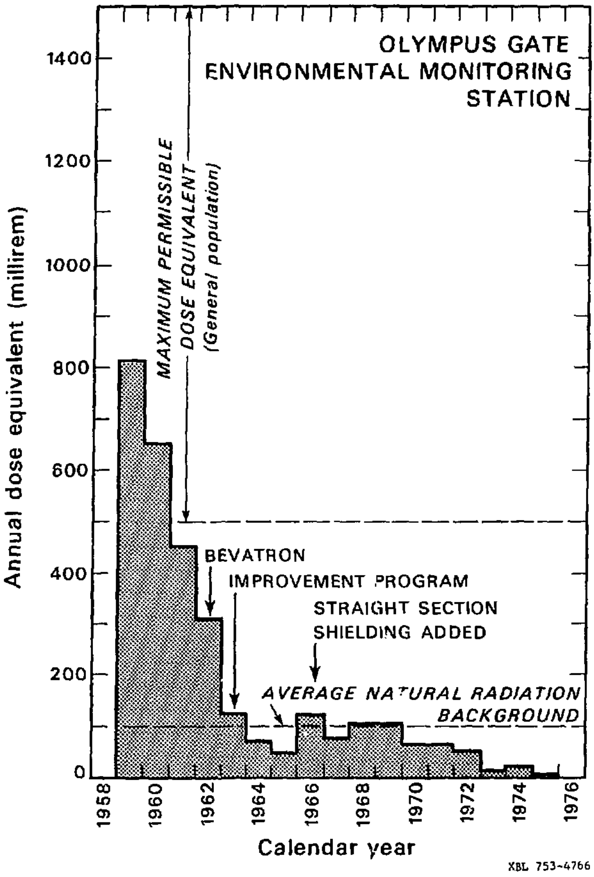
2. Summary of Environmental Monitoring Data and Trends

2.1. Accelerator Produced Penetrating Radiation

The general trend of decreasing radiation levels at our site boundary due to accelerator operation, which has occurred over the past several years, continued during 1975. Reported radiation levels for 1975 decreased by factors between 3 (Panoramic Way) and 8 (Olympus Gate) compared with the reported levels for 1974. These reductions are partly owing to improved accuracy in reporting environmental monitoring data (improved background data, neutron fluence to dose equivalent conversion, etc.), but is also because of reduced use of the Bevatron to accelerate protons, with a corresponding increase in its use to accelerate heavy ions (at intensities much smaller than the corresponding proton intensity). With the increasing intensity of heavy beams available from the Bevalac, this decreasing trend for radiation levels is not expected to continue and small increases in site boundary radiation levels are expected in the future.

Figures 9 through 12 show the reported 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. The Bevatron has a long history--having been in operation since 1954. During the past 20 years substantial changes have occurred in accelerator intensity, mode of operation, and shielding. Shielding studies have formed an integral part of particle accelerator development at the Lawrence Berkeley Laboratory. As accelerator intensities have increased, shielding has been installed to maintain radiation levels well below required radiation safety standards. The existing shielding for the accelerator proper was designed in 1961 and installed in 1962 as part of an extensive accelerator improvement program. The shielding design was predicated upon a proton intensity of 10^{13} protons per pulse, repetition frequency of 10 pulses per minute, and a maximum permissible dose equivalent rate at the Laboratory boundary of 500 millirem per year. It was recognized at that time that site boundary radiation levels due to leakage from the shielding roof, when thick targets were operated in the accelerator straight sections, would present a limiting operational condition on the accelerator. However, continuing improvements in accelerator operation--particularly with regard to beam extraction--and the addition of shielding above the accelerator straight sections have made significant reductions possible in site boundary radiation levels, despite increasing beam intensity. It is interesting to contrast the declining radiation levels observed at the Olympus Gate Station with the increasing intensities of the Bevatron (Fig. 13). Inspection of Fig. 13 shows that in the period 1959-1973, while the Bevatron intensity increased by a factor of 40, radiation levels reported at the Olympus Gate Station fell by a factor of about 20--an overall improvement of a factor of 800. During late 1962 and early 1963 the Bevatron underwent a substantial modification and was out of operation for a significant time. This shutdown was, however, only partially responsible for the falling radiation level recorded at that time. This falling trend continues



Figs. 9–12. Trends of dose equivalent measured at the environmental monitoring stations.

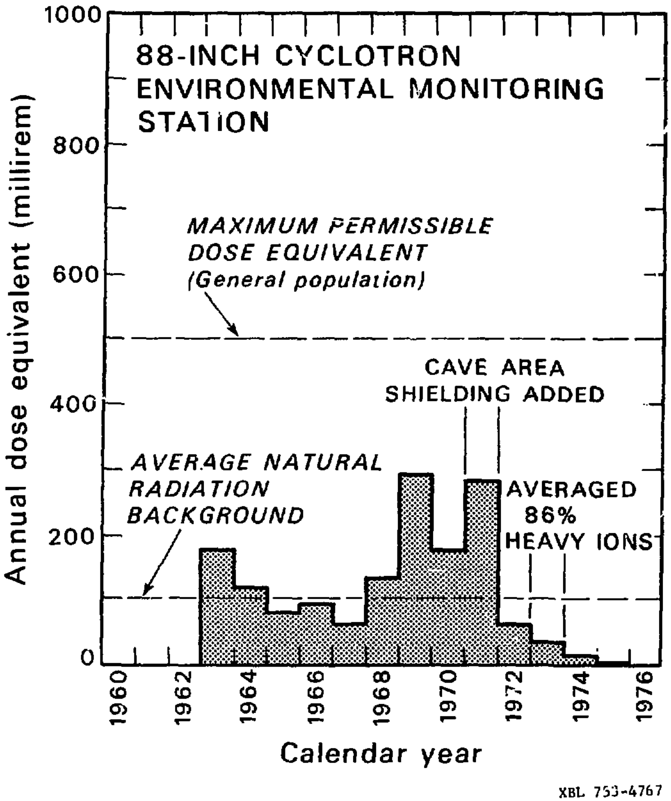

1000
800
600
400
200
0
88-INCH CYCLOTRON
ENVIRONMENTAL MONITORING
STATION
MAXIMUM PERMISSIBLE
DOSE EQUIVALENT
(General population)
CAVE AREA
SHIELDING ADDED
AVERAGE NATURAL
RADIATION
BACKGROUND
AVERAGED
86%
HEAVY IONS
1960
1962
1964
1966
1968
1970
1972
1974
1976
Annual dose equivalent (millirem)
Calendar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

Fig. 10

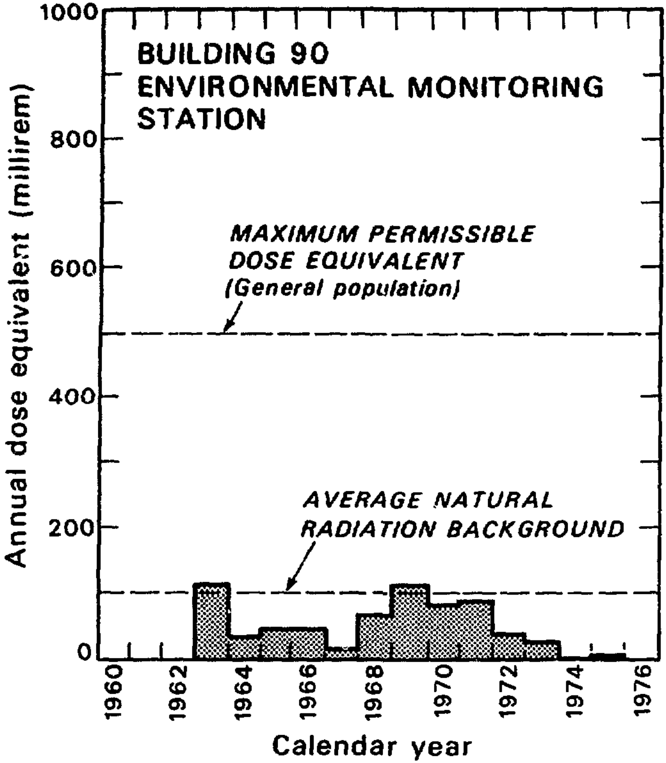


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Fig. 11

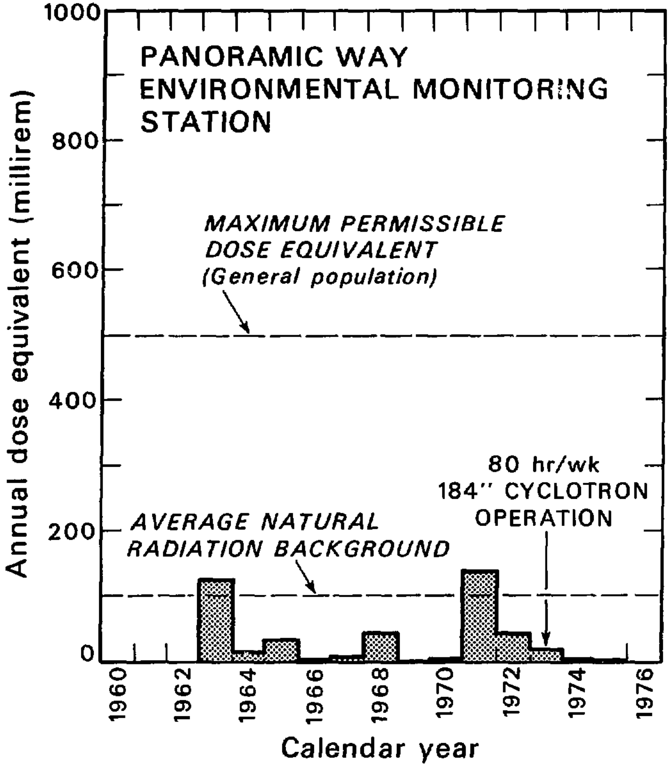

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Fig. 12

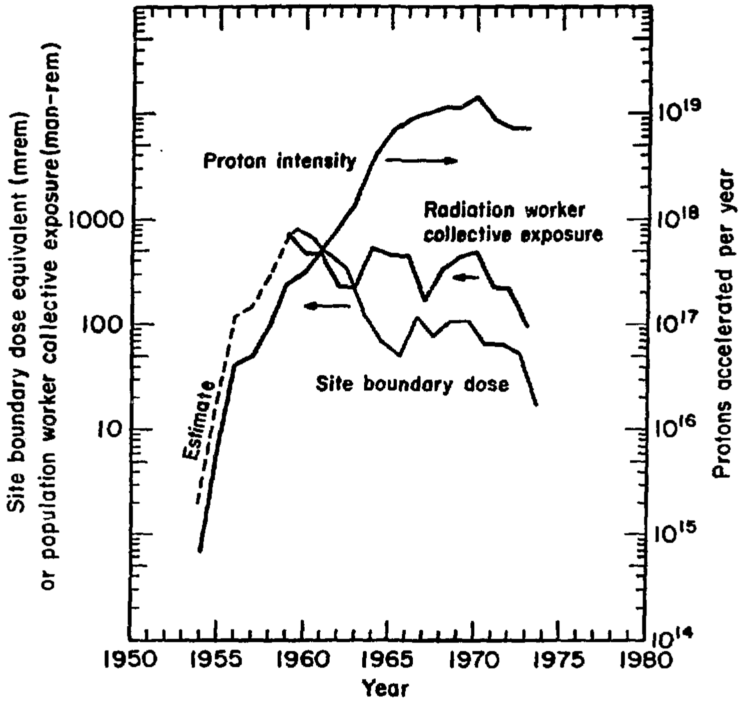

Fig. 13. Comparison between the increasing intensity of the Bevatron (right hand scale) and the decreasing radiation levels of the Laboratory's site boundary and decreasing radiation worker collective exposure since 1959 (left hand scale).

through 1964 and 1965 and is also due to the addition of shielding and improvements in accelerator operation--particularly the development of an extracted beam. Radiation levels through 1966 showed an increase because of increasing circulating proton beam intensity, but the decrease observed in 1967 was due to the installation of extra shielding to the straight sections of the Bevatron. Since 1970 radiation levels have declined as a result of increasing use of the Bevatron to accelerate heavy ions at low intensities.

The monitoring station adjacent to the 88-inch cyclotron responds to radiation from both the Bevatron and the 88-inch cyclotron. The 88-inch cyclotron was completed in 1961 and the first external beam obtained in 1962. During the period 1962-1966 the radiation levels observed at this station closely reflect the operation of the Bevatron (see Figs. 9 and 10). In 1967, however, increasing intensity at the 88-inch cyclotron is reflected in the higher radiation levels recorded at this station. The addition of new shielding to the cave roofs during the latter part of 1970 resulted in a dramatic reduction in the radiation levels for 1971, and the 88-inch cyclotron is now so well shielded that its adjacent monitoring station now principally responds to the Bevatron.

The station situated at Panoramic Way is in direct view only of the 184-inch cyclotron and responds principally to that accelerator. High readings at this station may usually be directly attributed to unusual experimental conditions at the 184-inch cyclotron. Reduced use of this accelerator will result in a decline in readings at this station. The residual levels measured will be largely due to indirect radiation from the Bevatron.

Radiation levels recorded at the Building 90 environmental monitoring station are principally from indirect radiation from the Bevatron and 88-inch cyclotron (compare Figs. 9 through 11).

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 waste program always yields results within the range of normal background. No changes are expected in these observations.

The new practice of the University of California in discharging radionuclides into the Strawberry sewer will complicate analysis of the sewer-sampling program data. Analysis will be particularly difficult in view of the fact that the quantity of material discharged by the University is several times (fourfold in 1975) greater than that discharged by the Laboratory, and that occurred in just 2 months. Trends in sanitary sewer monitoring data are, therefore, unpredictable, but University discharges are likely to be greater than quantities from the Laboratory, by about two orders of magnitude.

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2. Thomas, R. H. (ed), The Environmental Surveillance Program of the Lawrence Berkeley Laboratory, Lawrence Berkeley Laboratory Internal Report, LBL-4678, April 1976
3. United States Energy Research and Development Administration Manual, Chapter 0524-Standards for Radiation Protection.
4. Op cit, Ref. 2, Section 4.2.3.
5. Op cit, Ref. 2, Section 4.2.4.