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ANNUAL ENVIRONMENTAL MONITORING REPORT OF THE LAWRENCE BERKELEY LABORATORY

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

March 1977

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DISCLAIMER

LBL-6405

ANNUAL ENVIRONMENTAL MONITORING REPORT OF THE LAWRENCE BERKELEY LABORATORY*

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

March 1977

Editor: Lloyd D. Stephens

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PREFACE

In 1976 we published the Annual Environmental Monitoring Report in two parts. Part One, LBL-4678, 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, 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.

Copies of LBL-4678 are available upon request from:

National Technical Information Services
U. S. Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22161
Price: Printed Copy $5.50; Microfiche $2.25

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ABSTRACT

The data obtained from the Environmental Monitoring Program of the Lawrence Berkeley Laboratory for the Calendar year 1976 are described and general trends are discussed.

1. ENVIRONMENTAL MONITORING DATA--1976

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 I.

There were no periods of time during which accelerator gamma levels were detectable above background variations during 1976.

Periods of data loss during the first half of 1976 were due to a remodeling shutdown and an interruption of primary power supplying the remotely located station. During 1976 we have attempted to produce a more accurate measurement of the environmental gamma background. It has been shown that the presently used Geiger-Muller detectors[1] did not accurately measure the environmental gamma radiation. In order to correctly measure the environmental gamma radiation we are in the process of operating the High Pressure Argon Ionization chambers developed by HASL[2] in each of the stations. The result of this work so far reveals we have been over-reporting our gamma contribution by ~36%. Therefore beginning with this report the corrected values will be used.

Table II summarizes the total dose equivalent at each station during 1976. In evaluating the annual dose equivalent due to photons, the data summarized in Table III were used. In evaluating the annual dose equivalent due to neutrons, the neutron detector calibration

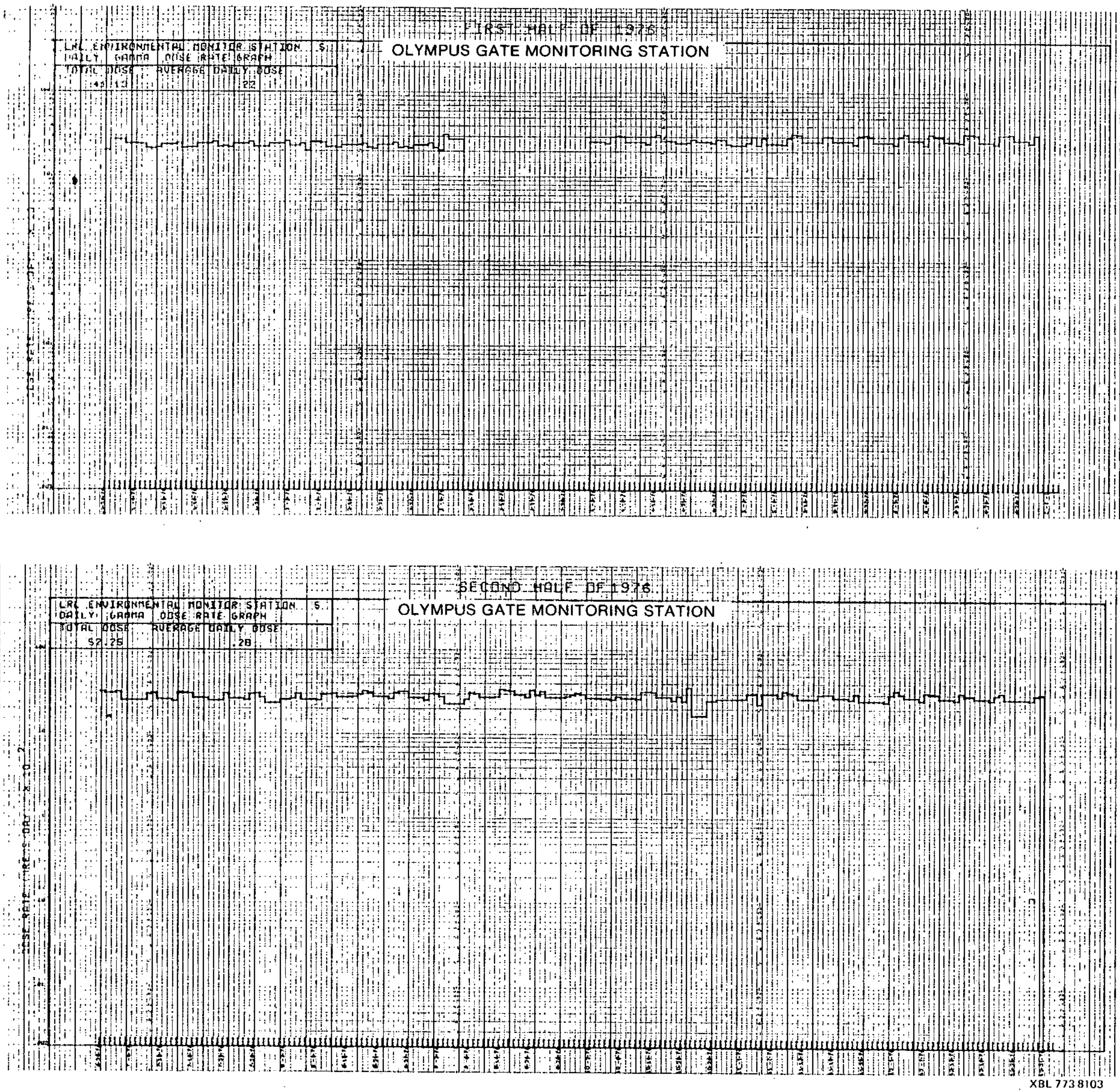
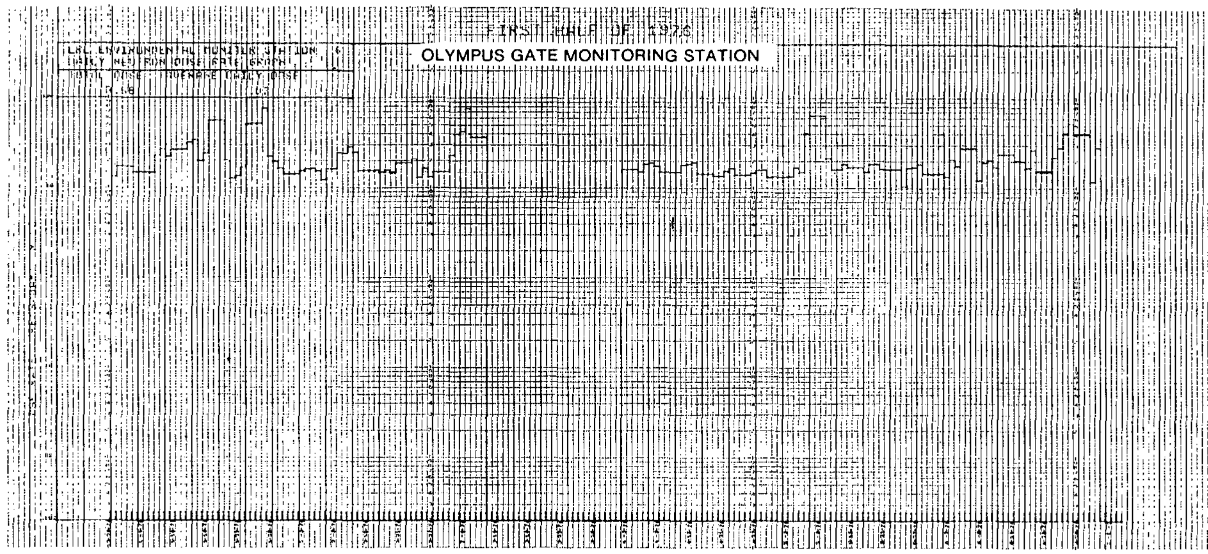
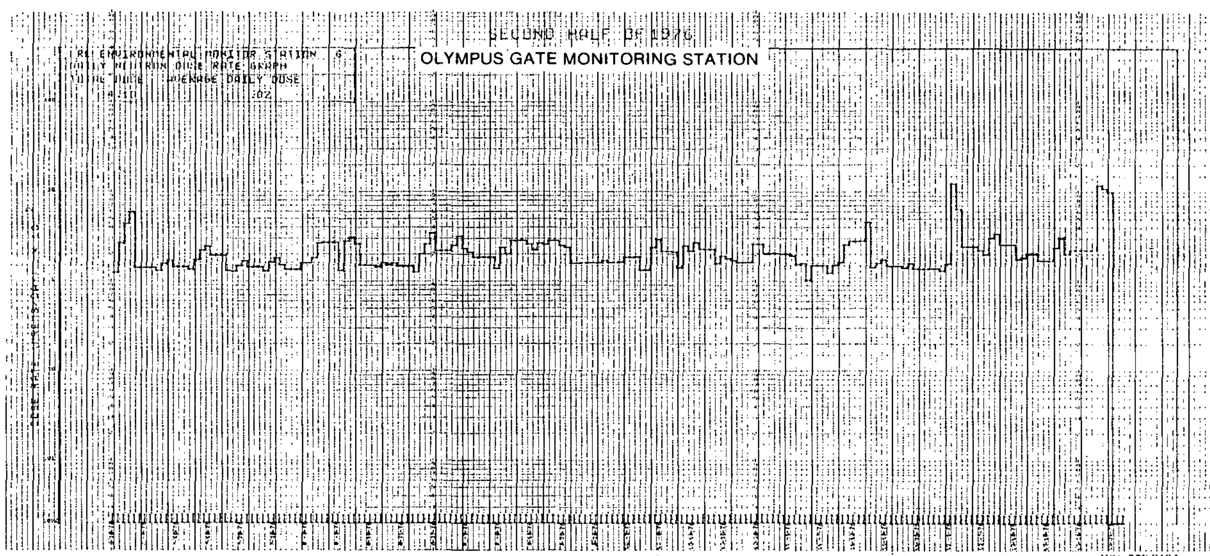

FIRST HALF OF 1976
OLYMPUS GATE MONITORING STATION
SECOND HALF OF 1976
OLYMPUS GATE MONITORING STATION
XBL 773 8103

Fig. 1.

0 0 0 0 4 8 0 1 4 1 6





XBL 773 8104

Fig. 2.

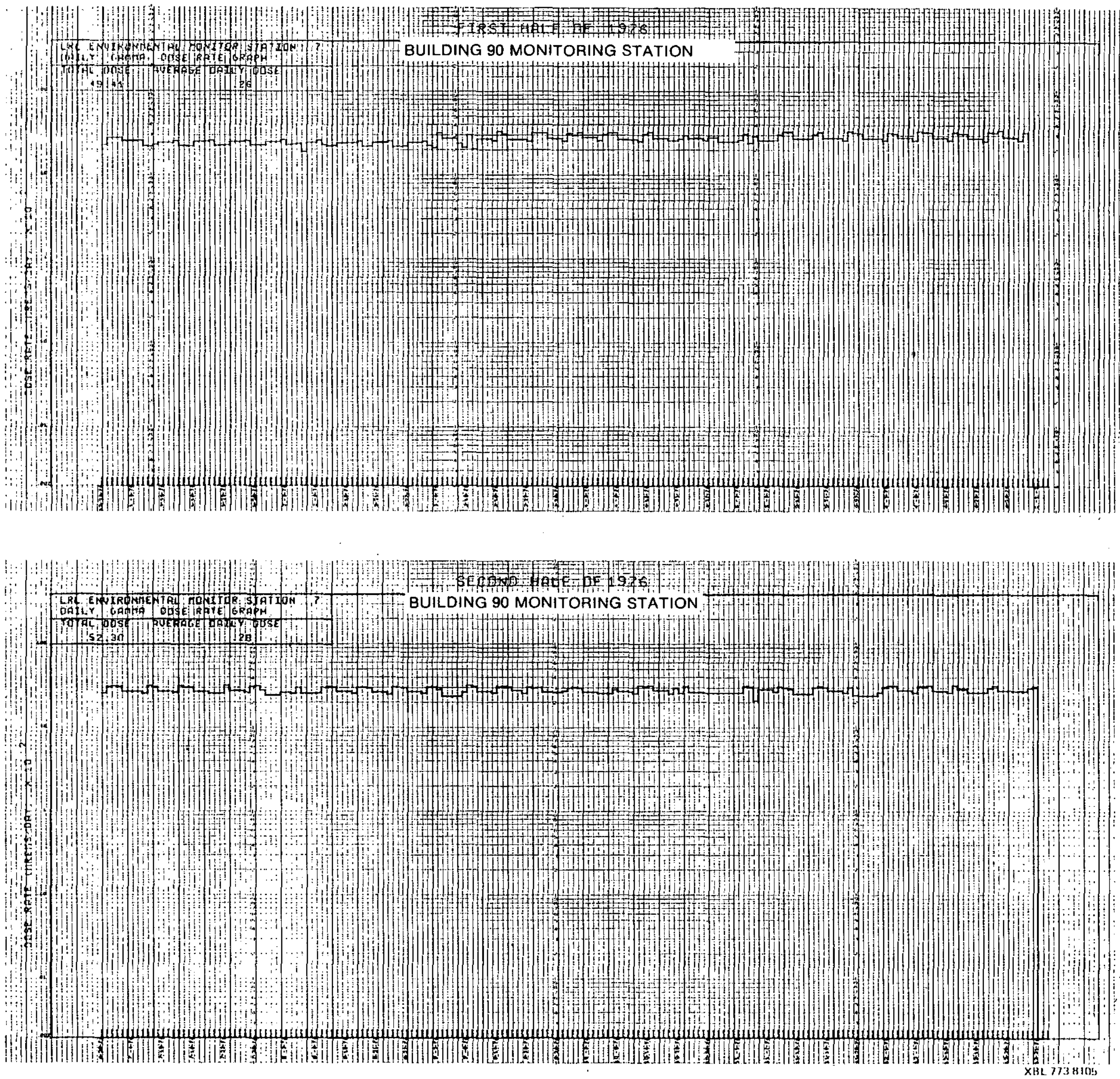

BUILDING 90 MONITORING STATION
TOTAL DOSE AVERAGE DAILY DOSE
.26
LRL ENVIRONMENTAL MONITOR STATION 7
DAILY GAMMA DOSE RATE GRAPH
TOTAL DOSE AVERAGE DAILY DOSE
52.30 .28
BUILDING 90 MONITORING STATION
XBL 773 8105

Fig. 3.

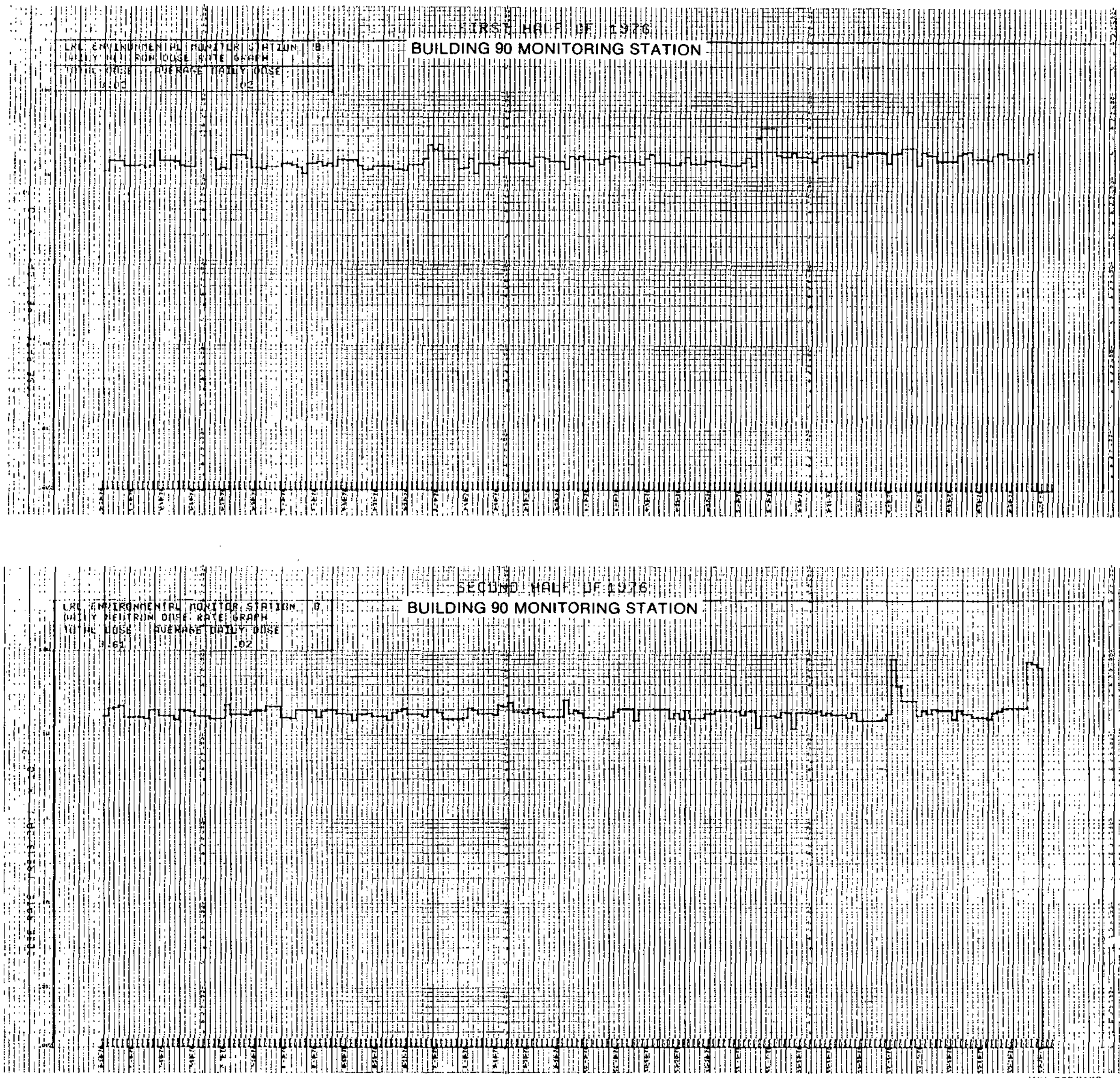
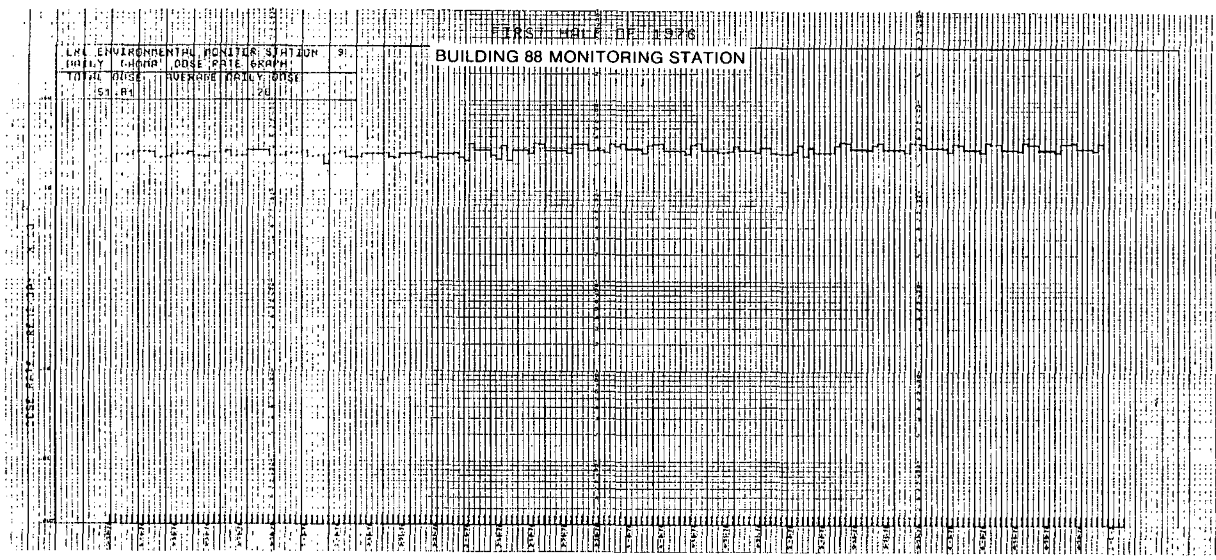

BUILDING 90 MONITORING STATION
SECOND HALF OF 1976
BUILDING 90 MONITORING STATION
LRL ENVIRONMENTAL MONITOR STATION
DAILY NEUTRON DOSE RATE GRAPH
AVERAGE DAILY DOSE
.02
XBL 7738106

Fig. 4.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LRL ENVIRONMENTAL MONITOR STATION 9
DAILY GAMMA DOSE RATE GRAPH
TOTAL DOSE AVERAGE DAILY DOSE
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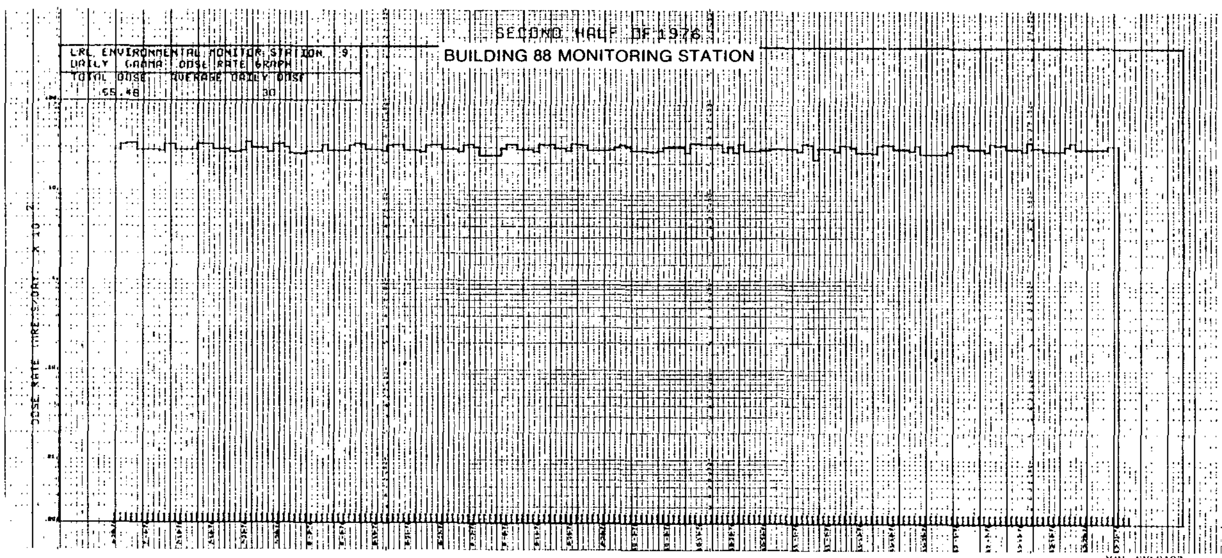
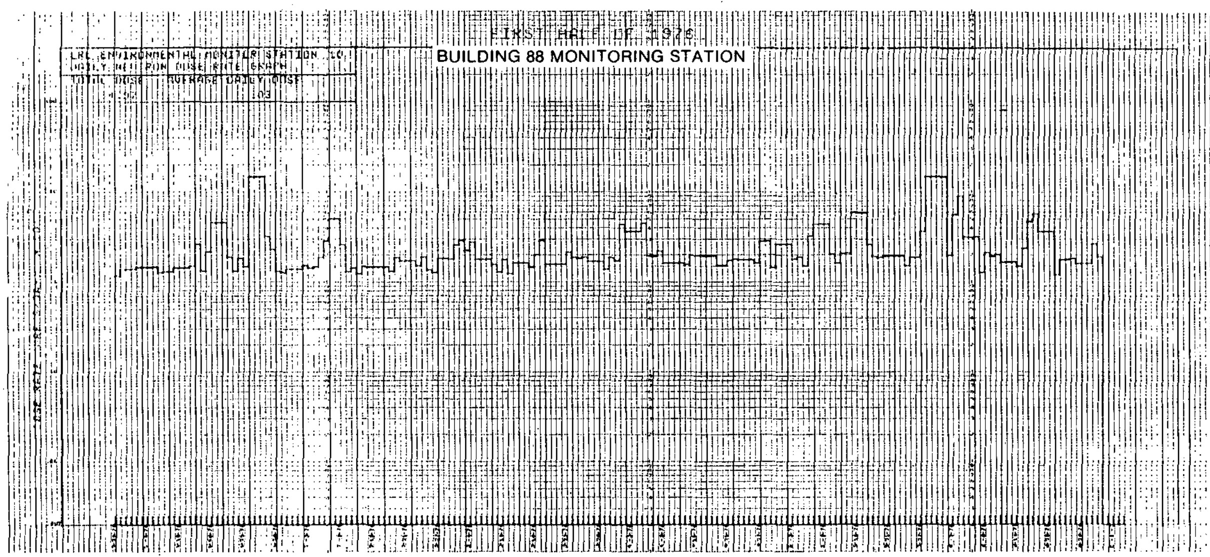
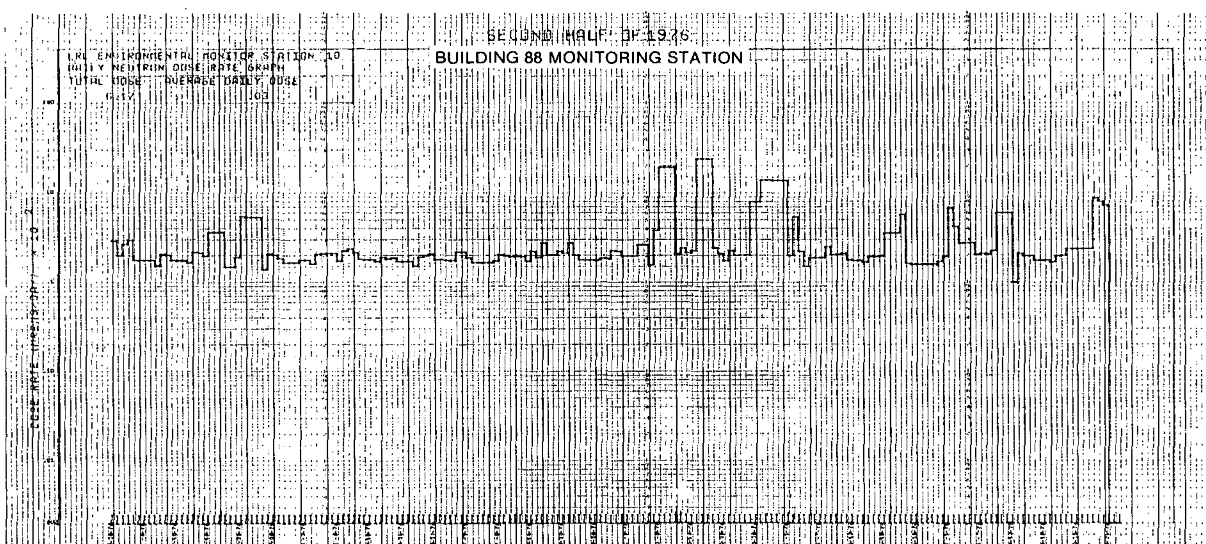

SECOND HALF OF 1976
BUILDING 88 MONITORING STATION
LRL ENVIRONMENTAL MONITOR STATION 9
DAILY GAMMA DOSE RATE GRAPH
TOTAL DOSE AVERAGE DAILY DOSE
55.48 .30
XBL 773 8107

Fig. 5.

0 0 0 0 4 8 0 1 4 1 8





XBL 773 8108

Fig. 6.

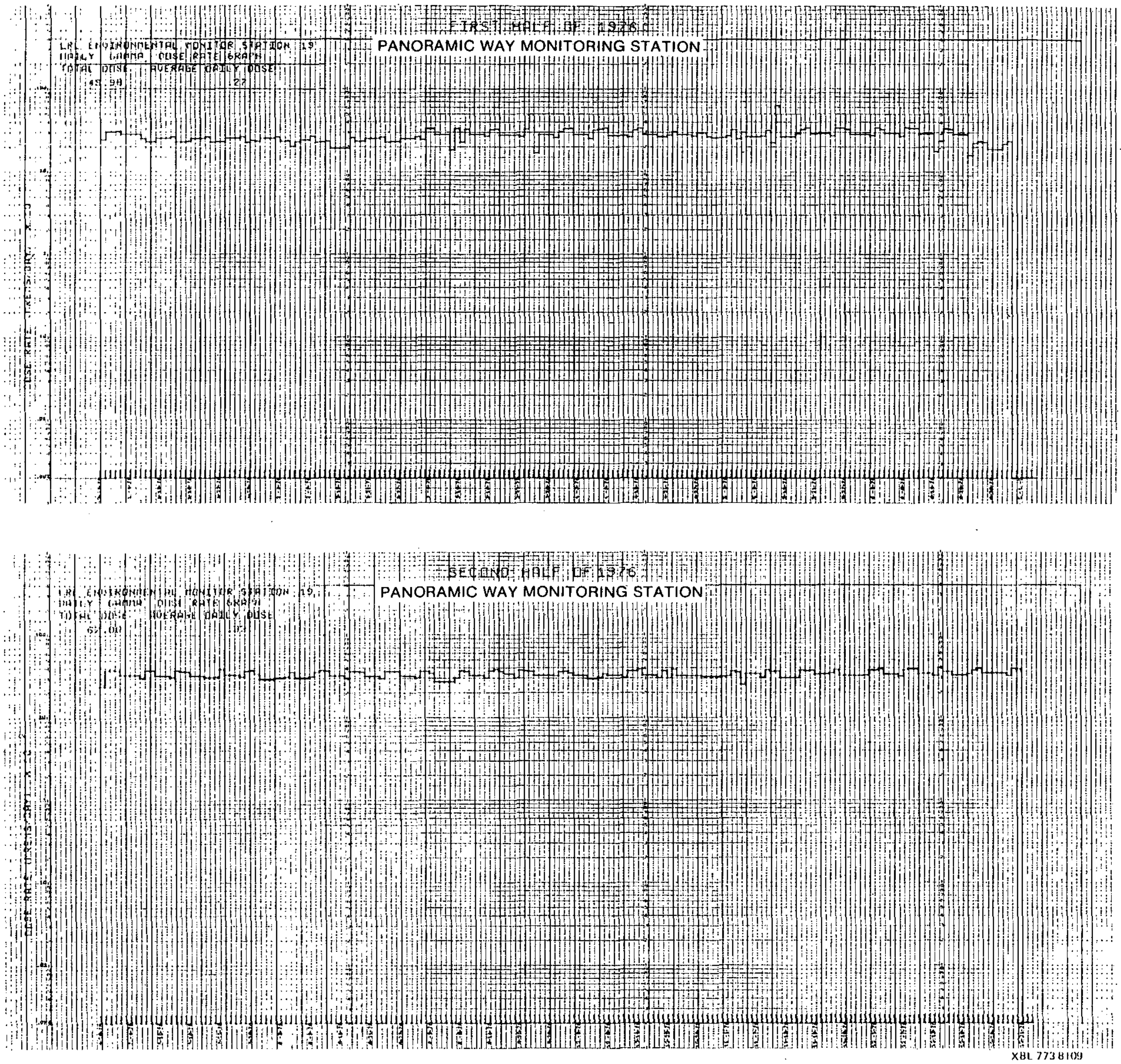

FIRST HALF OF 1976
PANORAMIC WAY MONITORING STATION
SECOND HALF OF 1976
PANORAMIC WAY MONITORING STATION
XBL 773 8109

Fig. 7.

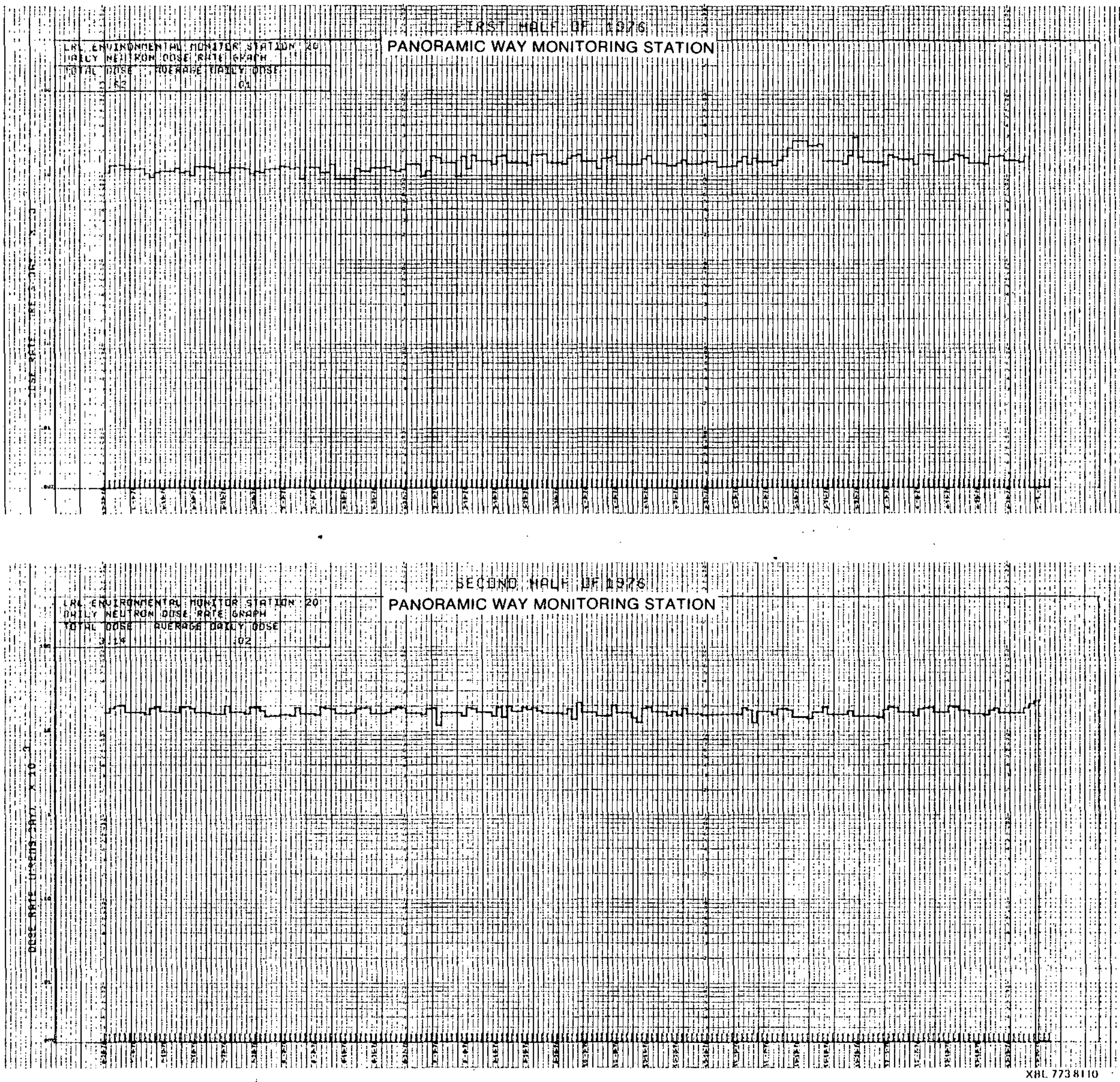

FIRST HALF OF 1976
PANORAMIC WAY MONITORING STATION
SECOND HALF OF 1976
PANORAMIC WAY MONITORING STATION
XBL 773 8110

Fig. 8.

Table I.

Inclusive Dates	Accelerator	Beam	Environmental Monitoring Station
1/23/76 to 1/26/76	88-Inch Cyclotron	110 MeV, ^{4}He	88 EMS
5/19/76 to 5/22/76	88-Inch Cyclotron	315 MeV, ^{16}O	88 EMS
7/21/76 to 7/25/76	88-Inch Cyclotron	90 MeV, ^{3}He	88 EMS
10/8/76 to 10/11/76	88-Inch Cyclotron	90 MeV, ^{3}He	88 EMS
10/15/76 to 10/18/76	88-Inch Cyclotron	55 MeV, d^+	88 EMS
10/27/76 to 10/31/76	88-Inch Cyclotron	110 MeV, α	88 EMS
10/31/76 to 11/3/76	88-Inch Cyclotron	250 MeV, ^{20}Ne	88 EMS
1/19/76 to 1/22/76	Bevatron	63% α, 21% p^+	OG EMS
3/1/76 to 3/5/76	Bevatron	46% p^+, 12% Ne, 11% α	OG EMS
5/6/76 to 5/10/76	Bevatron	43% p^+, 8% α	OG EMS

Table II. Radiation levels at the LBL site boundary due to accelerator operation--1976.

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	2.39±0.008*	2.39±0.008*
88-Inch Cyclotron	0	5.35±0.009	5.35±0.009
Building 90	0	0.44±0.008	0.44±0.009
Panoramic Way	0	0.78±0.007	0.78±0.007
Standard for Comparison			500[3]

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

Table III. 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	68	1.24
88-Inch Cyclotron	91	1.13
Building 90	83	1.16
Panoramic Way	94	1.11

*Except neutrons.

factors and neutron backgrounds at each monitoring station are listed in Table IV. The net neutron count after background subtraction is converted to neutron fluence using the conversion factors of Table IV. 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 $n^{-1} cm^{2}$.[4]

1.2. Radionuclide measurements and Release

1.2.1. Atmospheric Sampling

The total quantities of radionuclides discharged into the atmosphere are summarized in Table V. Although these amounts are greater than the amounts released in 1975, the quantities resulted in a small population dose equivalent (see Table XII).

During 1976 there were no releases that could have resulted in concentrations greater than 1% of the relevant radiation protection standard.[3] Tables VI and VII, which summarize the general and special air sampling data, provide confirmation of this assertion. The general air sampling program gave data all of which were within the range of normal background. The special air sampling program for ^{14}C and ^{3}H found detectable concentrations of these nuclides (Table 7). Average concentrations for the year were less than 1% of the radiation

Table IV. Neutron detector calibration factors and neutron backgrounds at each monitoring station.

	Neutron Detector Calibration Factor ncm^{-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

Table V. Total quantities discharged into the atmosphere (1976).

Nuclide(s)	Quantity Discharged
Alpha Emitters	1.4×10^{-7} Ci
Unidentified Beta-Gamma Emitters	4×10^{-4} Ci
Carbon-14	3.5×10^{-1} Ci
Tritium	26 Ci

Table VI. Summary of air samples (1976).

	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	518	0.46±0.10	<2	6	47±4	<80	800	2	0.5
Perimeter Stations									
Building 88	52	0.45±0.27	<2	3	46±12	<80	570	2	0.5
Building 90	52	0.55±0.28	<2	5	53±12	<80	630	3	0.5
Panoramic	44	0.79±0.32	<2	5	44±13	<80	570	4	0.4
Olympus Gate	48	0.52±0.29	<2	3	51±13	<80	630	3	0.5
Standard for Comparison		20			10,000				

Table VII. Summary of special air sampling (1976).

	No. of Samples	Concentration, 10^{-9} μCi/ml Avg.	Max.	% of Standard
Samples for Tritium in Air				
On Site				
Bldg. 3 Roof	52	0.5±0.1	3.7±0.7	0.3
Perimeter				
LHS	51	0.5±0.1	3.6±0.7	0.3
B13D (Olympus)	50	0.4±0.1	3.6±0.7	0.2
Standard for Comparison		200		
Samples for Carbon-14 in Air (as CO_2)				
On Site				
Bldg. 3 Roof	52	0.17±0.05	2.7±0.4	0.2
Standard for Comparison		100		

protection standards. The measurements of atmospheric deposition (Table VIII) all lie within the range of normal background, except during the period following the Chinese Weapons tests.

There were two Chinese Nuclear Weapons test in the atmosphere conducted during 1976, one on 26 September and one on 17 November 1976. Fallout from both tests was detected as increases in airborne radiation on our air samples. The activity was shown to be due to fission-products by using a NaI(Tl) γ-ray spectrometer (Fig. 9). Specific isotopes were identified by use of our high resolution GeLi gamma spectrometer (Fig. 10). This detector also gave a measure of the relative level of deposition (Fig. 11).

Figure 12 is a graph of the weekly atmospheric sampling results during 1976. The incremental increases shown in the last quarter of 1976 are attributed to these tests.

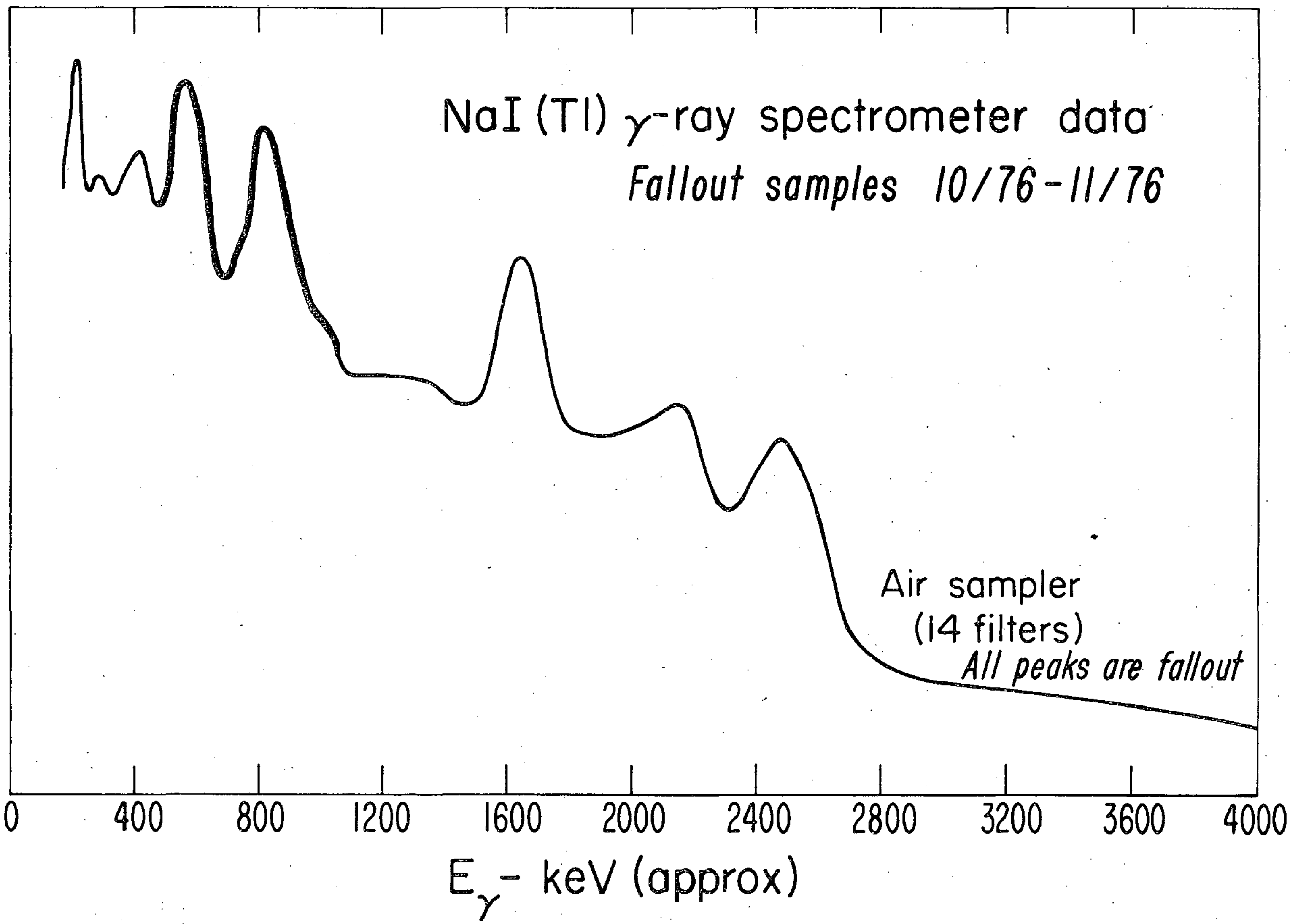
Table IX lists the isotopes identified as weapons tests related. An estimate of the relative importance of these isotopes compared to natural terrestrial background levels can be obtained as follows. The radionuclide ^{7}Be, a "natural fallout" radionuclide was also detected in the samples. The ^{7}Be peak intensity was seen to be approximately the same as the intensities of the fission product fallout peaks (Fig. 11). Thus, the fallout radionuclides must be similar in activity to the ^{7}Be γ activity. If ^{7}Be is uniformally deposited on the surface, it normally cannot be detected in field γ-ray measurements even when using high-resolution GeLi spectrometry at outdoor sites. We therefore expect the increment due to fission products to be undetectable in circumstances where uniform deposition

Table VIII. Summary of atmospheric deposition (1976).

	No. of Samples	Total Deposition, 10^{-3} $\mu Ci/m^2$ α Avg.	α Max.*	β Avg.	β Max.*
On Site					
(8 locations)	108	0.02	0.08±0.05	1.0	1.5±0.2
Perimeter					
(4 locations)	46	0.04	0.07±0.04	1.8	4.3±0.2

No standards for comparison have been established.

*Highest total for any one site.



XBL 774-687

Fig. 9.

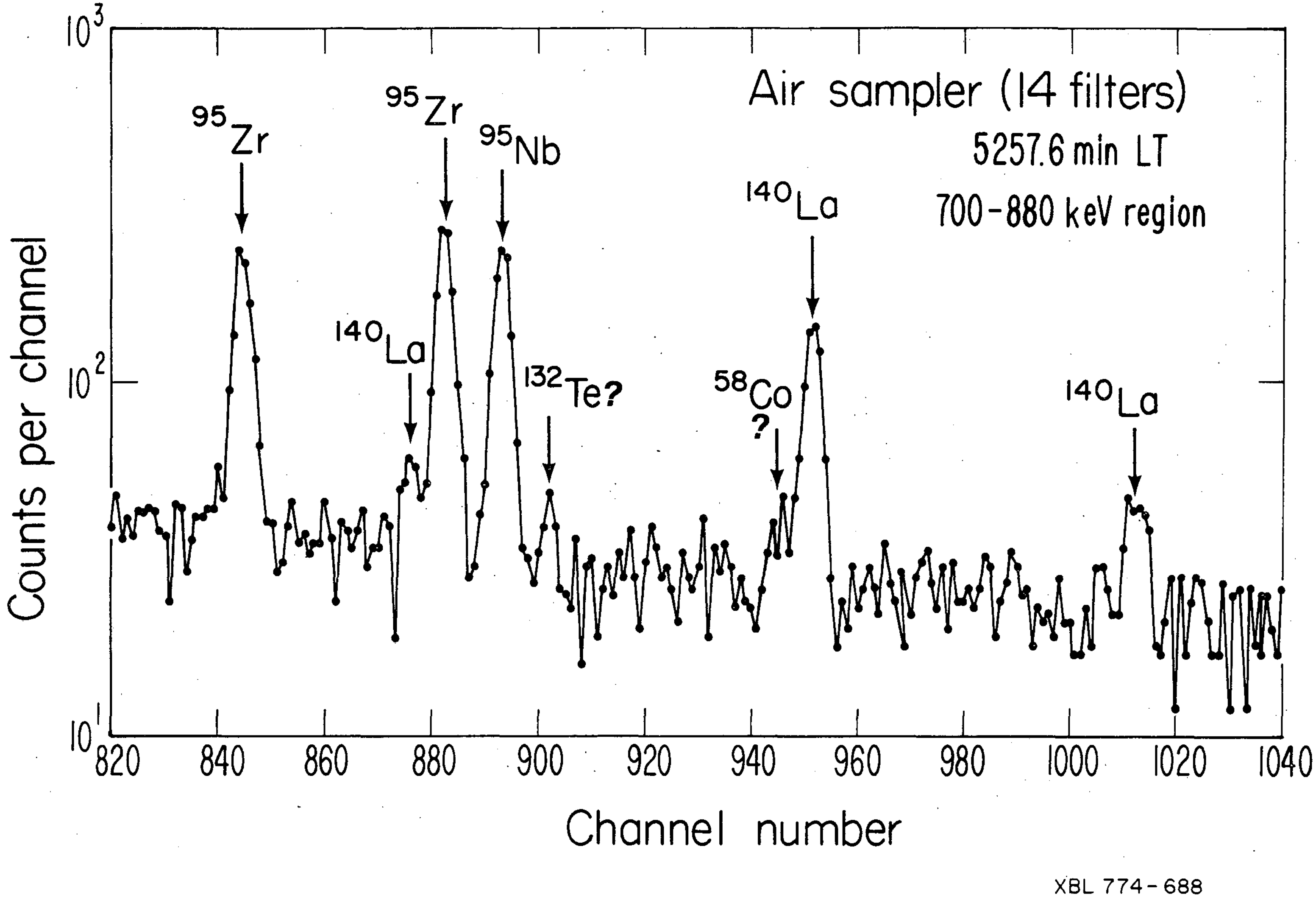
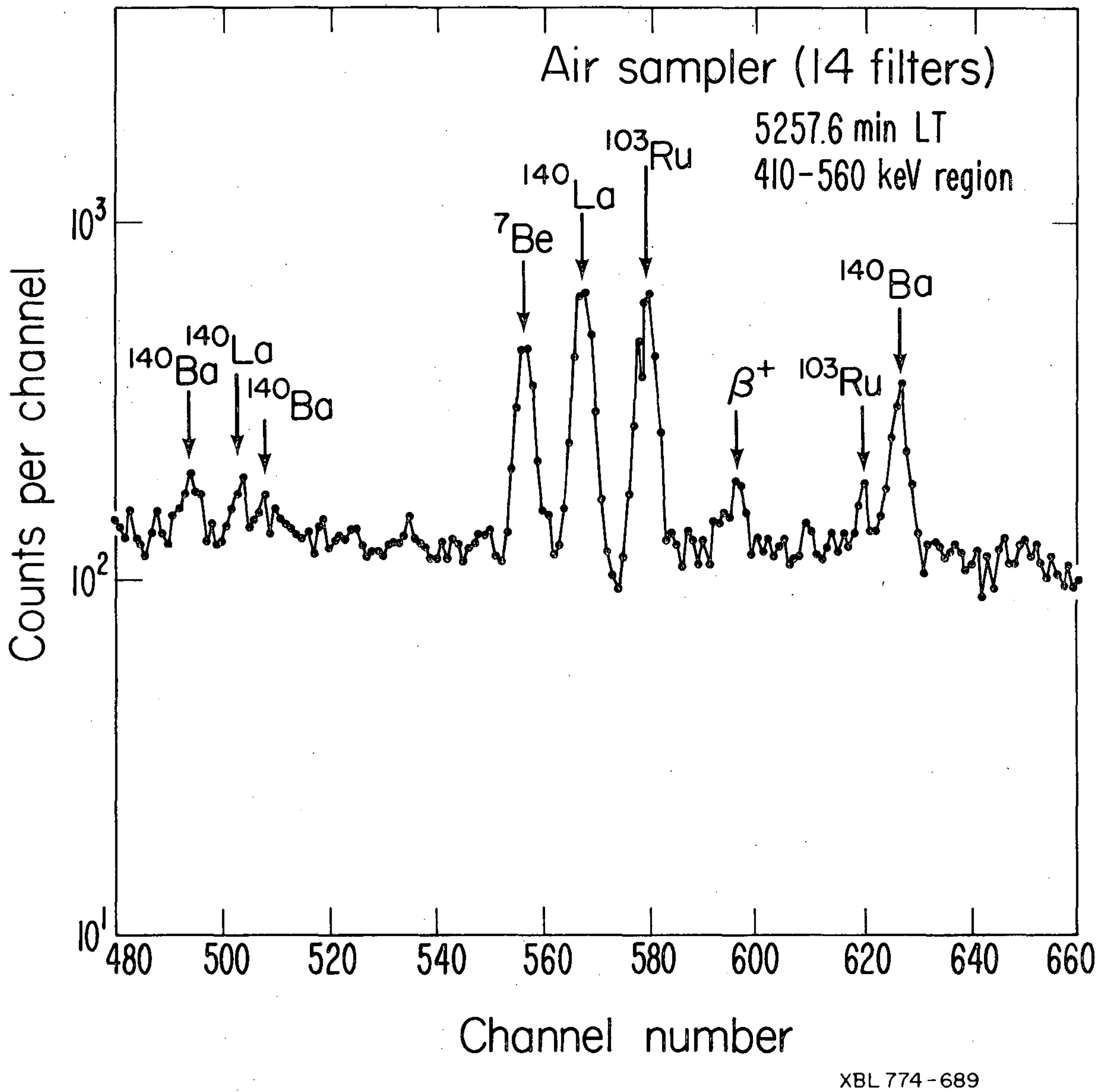

Air sampler (14 filters)
5257.6 min LT
700-880 keV region
^{95}Zr
^{95}Zr
^{95}Nb
^{140}La
^{140}La
^{132}Te?
^{58}Co ?
^{140}La
Counts per channel
Channel number
10^3
10^2
10^1
820
840
860
880
900
920
940
960
980
1000
1020
1040
XBL 774-688

Fig. 10.


Air sampler (14 filters)
5257.6 min LT
410-560 keV region
Counts per channel
Channel number
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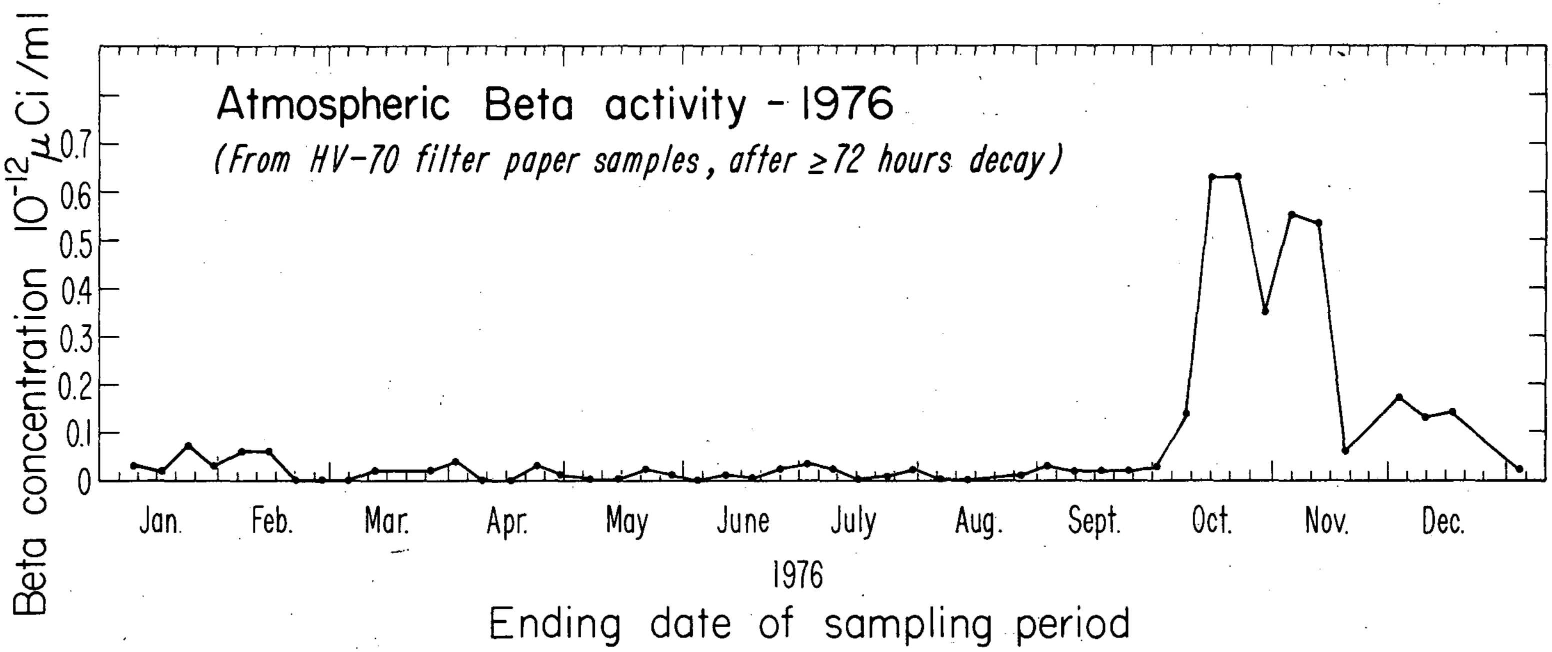
140La
140Ba
7Be
140La
103Ru
β+
103Ru
140Ba
XBL 774-689

Fig. 11



XBL 773-605

Fig. 12

Table IX. Fission product radionuclides identified with Chinese atmospheric weapons test fallout--Sept. to Dec. 1976.

Radionuclide	Identification E_γ (keV)
^{95}Nb	766
^{95}Zr	724, 757
^{103}Ru	497, 610
^{131}I	364
^{140}La	329, 433, 487, 752, 816, 1596
^{140}Ba	163, 305, 424, 438, 537
^{141}Ce	145

occurs. As a fact, the outdoor surveys we made during this time with a portable NaI(Tl) crystal instrument failed to show any increase above expected natural environmental levels.

1.2.2. Water Sampling

Table X summarizes the 1976 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.

1.2.3. Sewer Sampling

Table XI summarizes the sewage sampling data for 1976. 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 discharges radioactive waste into the Strawberry sewer above the point at which it is monitored by LBL. The Lawrence Berkeley Laboratory release practices have not changed during 1976 and are the same as 1975. The Hearst sewer concentration was less than 1% of the ERDA standard for discharge to sewers, however the Strawberry sewer was 33% of the standard[5] (see Table XI).

1.3. Population Dose Equivalent Resulting from 1976 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.[6] During 1976 the 88-Inch Cyclotron contributed a major portion of the measured radiation at

Table X. Surface water and tap water samples 1976.

	No. of Samples	Concentration, 10^{-9} μCi/ml				% of Standards	
		α		β			
		Avg.	Max.	Avg.	Max.	α	β
On Site Streams							
Blackberry	52	<0.3	2.6	1.9±0.2	10	<1.0	1.9
Lower Strawberry	52	<0.2	2.9	6.2±0.2	14	<0.7	6.2
Upper Strawberry	52	<0.2	2.7	2.2±0.2	4	<0.7	2.2
Average		<0.1		3.4±0.1		<0.3	3.4
Off Site Streams							
Claremont	52	<0.3	3.0	1.6±0.1	5	<1.0	1.6
Wildcat	52	<0.3	2.1	3.8±0.2	138	<1.0	3.8
Average		<0.2		2.7±0.1		<0.7	2.7
Tap Water	51	<0.1	2.1	1.1±0.2	6	<0.3	1.1
Standard for Comparison		30		100			

Table XI. Summary of sewage sampling data.

Total Quantities Discharged

	Total Volume 10^6 Liters	Total α μCi	Total β-γ mCi
Hearst Sewer	304	213±97	5.9±0.2
Strawberry Sewer	175	<130	175±1
Total	479	255±131	181±1

Net Concentrations

		Concentration, 10^{-9} μCi/ml				% of Standard	
		α		β-γ			
	No. of Samples	Avg.	Max.	Avg.	Max.	α	β-γ
Hearst	49	0.7±0.3	20	19.5±0.6	410	0.2	0.7
Strawberry	45	<0.7	7	1000±3	20500	<0.2	33
Overall		0.5±0.3		378±1			
Standard for Comparison		400		3,000			

the site boundary, 68%. The Bevatron accounted for about 32% of the detectable radiation. SuperHILAC and 184-Inch operations were not significant during 1976. From Eq. (15),[6] the corrected population dose equivalent, M, will be:

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

$$M = 1000\ H_0 [0.62]$$

where f is the fraction of the time that the 88-Inch Cyclotron produced detectable radiation.

The maximum dose equivalent at the site boundary due to penetrating radiation produced by accelerator operation was 5.35 millirem (Table I, Section 1.1). The corresponding population dose equivalent is 3.32 man rem. Reasons for this decrease from 1975 (3.5 man rem) are due primarily to a shift in operations at all accelerators. The changes include more operation of the 88-Inch Cyclotron with light ions and larger heavy ion beam current as compared to 1975. Bevatron operation was primarily with heavy ions. However, the proton runs produced some measurable radiation at the site boundary. The SuperHILAC has had improved shielding and beam control since 1975, thereby reducing stray radiation levels. The 184-Inch Cycontron ran only alpha particles on a very reduced schedule.

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 ^{3}H, ^{14}C and unknown β-γ and α emitters can be determined from the model described in Ref. 8, Section 4.3.

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

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 XIII summarizes the sewer sampling data for heavy metals.

Table XII. Population dose equivalent--1976.

Source of Exposure	Population Dose (man rem)
Penetrating Radiation--	
Accelerator operation	5.35
Radionuclide Release:	
^{3}H	0.31
^{14}C	0.014
Unknown β,γ emitters	0.09
Unknown α emitters	0.002
Total	5.77

Table XIII. Summary of sewer sampling data for heavy metals--1976.

	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
Strawberry Sewer								
Average (mg/l)	1.8	5.0	5.4	0.01	0.08	0.9	7.9	0.2
% of Standard	95	100	108	1	8	18	8	9
Hearst Sewer								
Average (mg/l)	1.1	0.5	0.09	0.02	0	0	0.09	0
% of Standard	57	11	2	2	0	0	<1	0

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 operations during past years has leveled off during 1976 and in some areas shows a slight increase as predicted in last year's summary. There was an increase in some lighter ion beams used at the 88-Inch Cyclotron causing an increase in neutron levels at one monitoring station.

The gamma levels are once again reported as zero. There is no detectable gamma radiation due to accelerator operation.

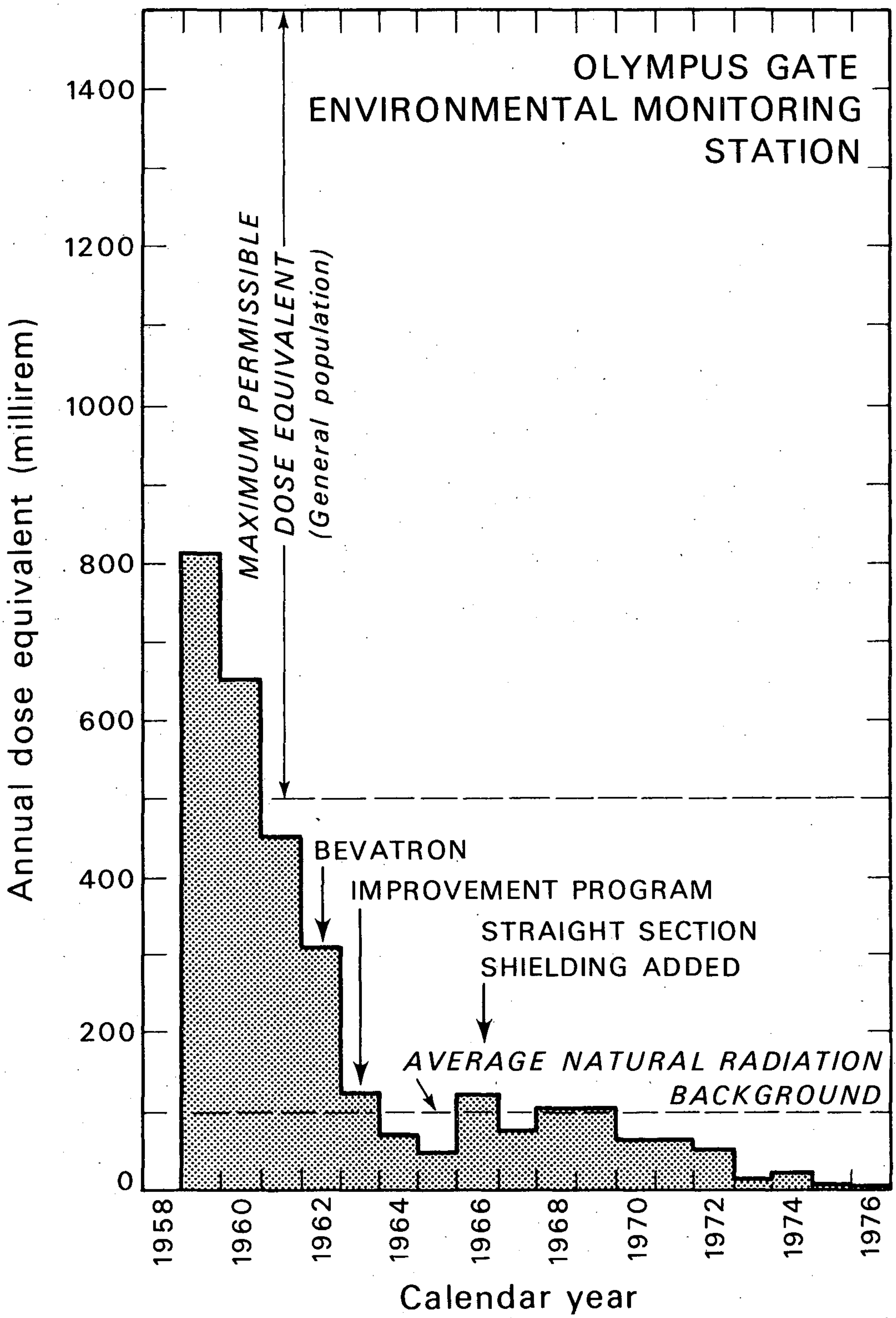
Figures 13 through 16 show the annual dose equivalent reported from the environmental monitoring stations since they have been established.

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

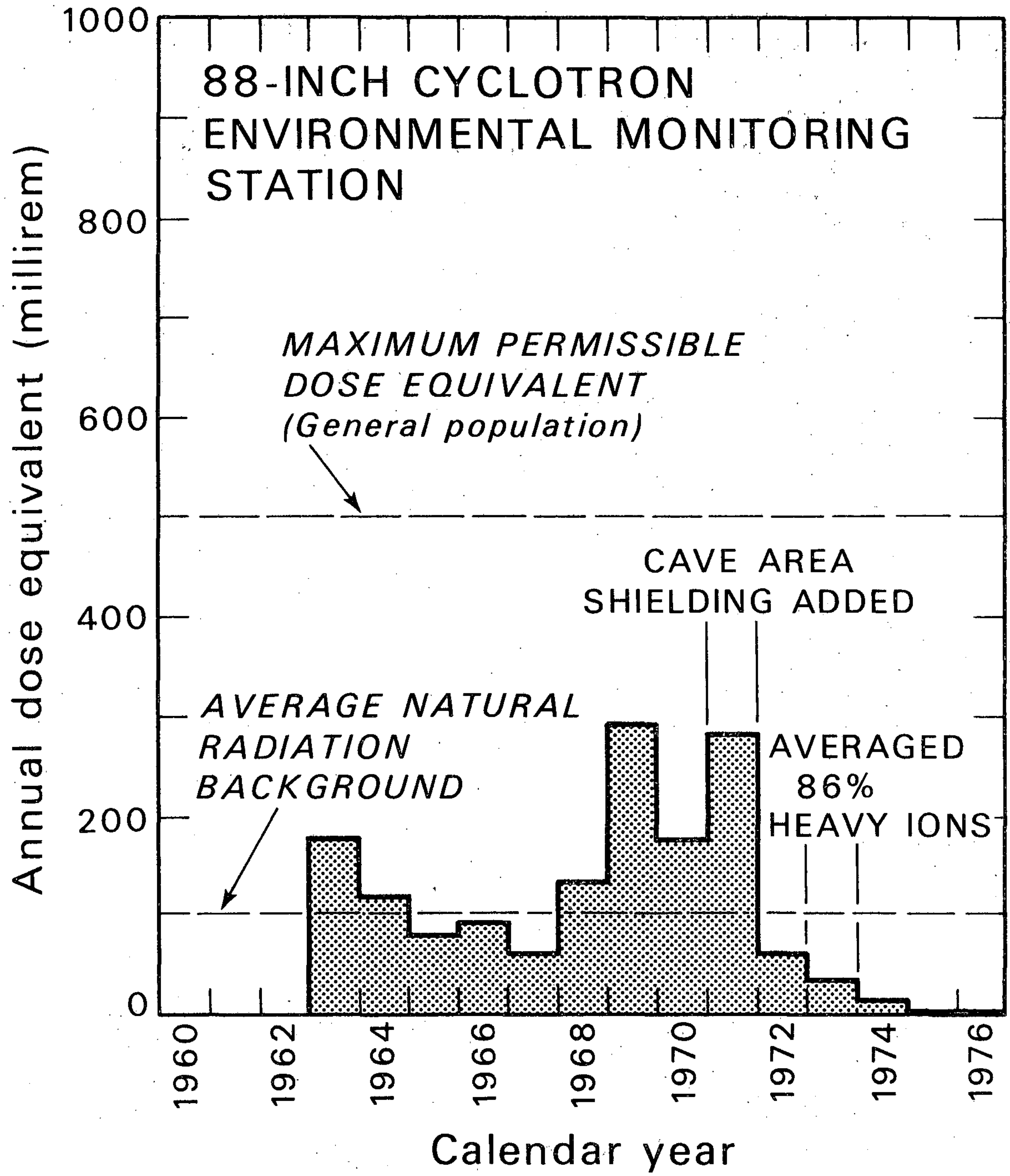
Over the past several years the atmospheric sampling program has, with the exception of occasional known releases, yielded data which are within the range of normal background. The surface water program always yields results within the range of normal background. No changes are expected in these observations.

The practice of the University of California in discharging radionuclides into the Strawberry sewer has complicated the analysis of the sewer-sampling program data. Analysis continues to be particularly difficult in view of the fact that the quantity of



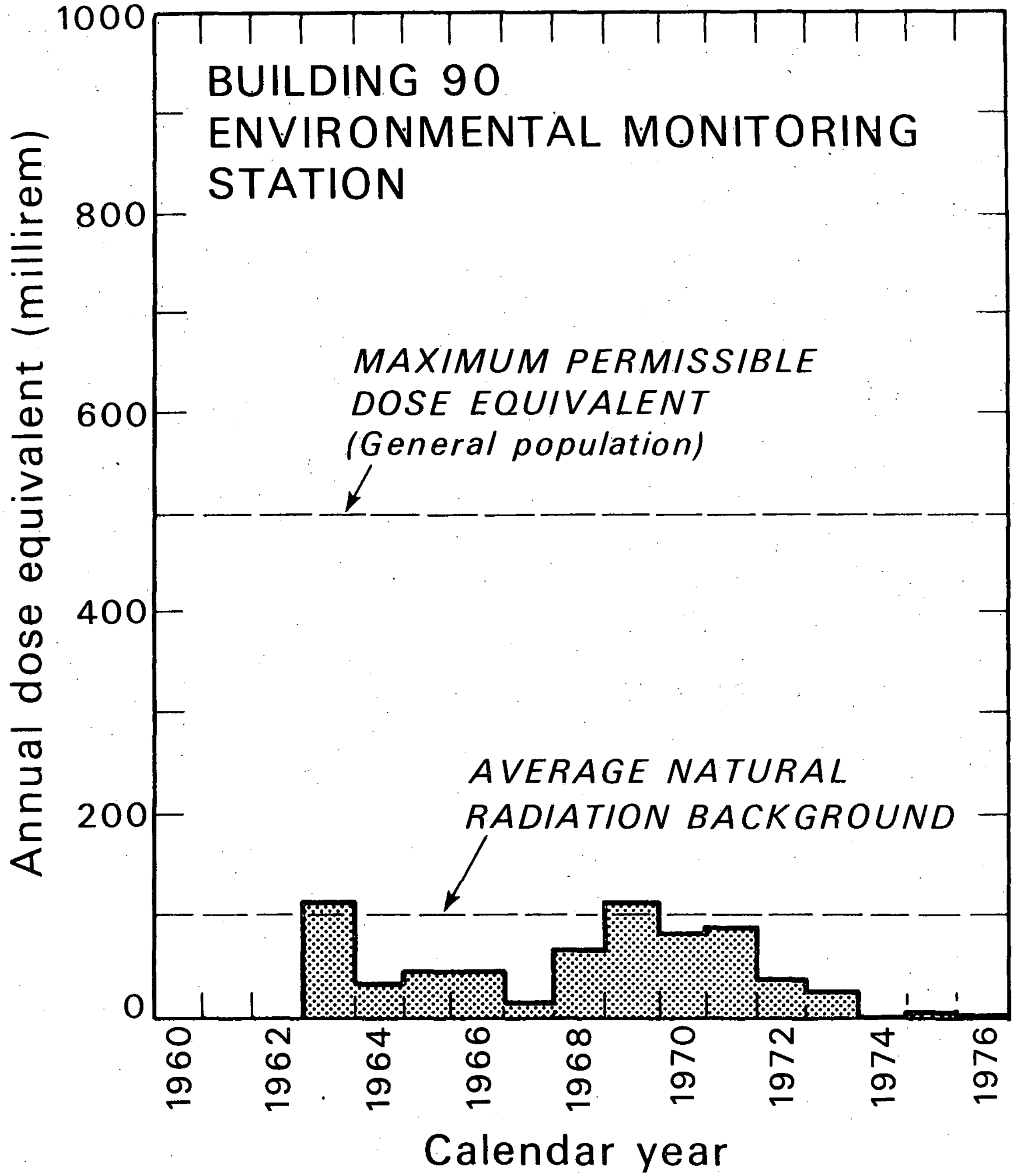
XBL 753-4766A

Fig. 13.



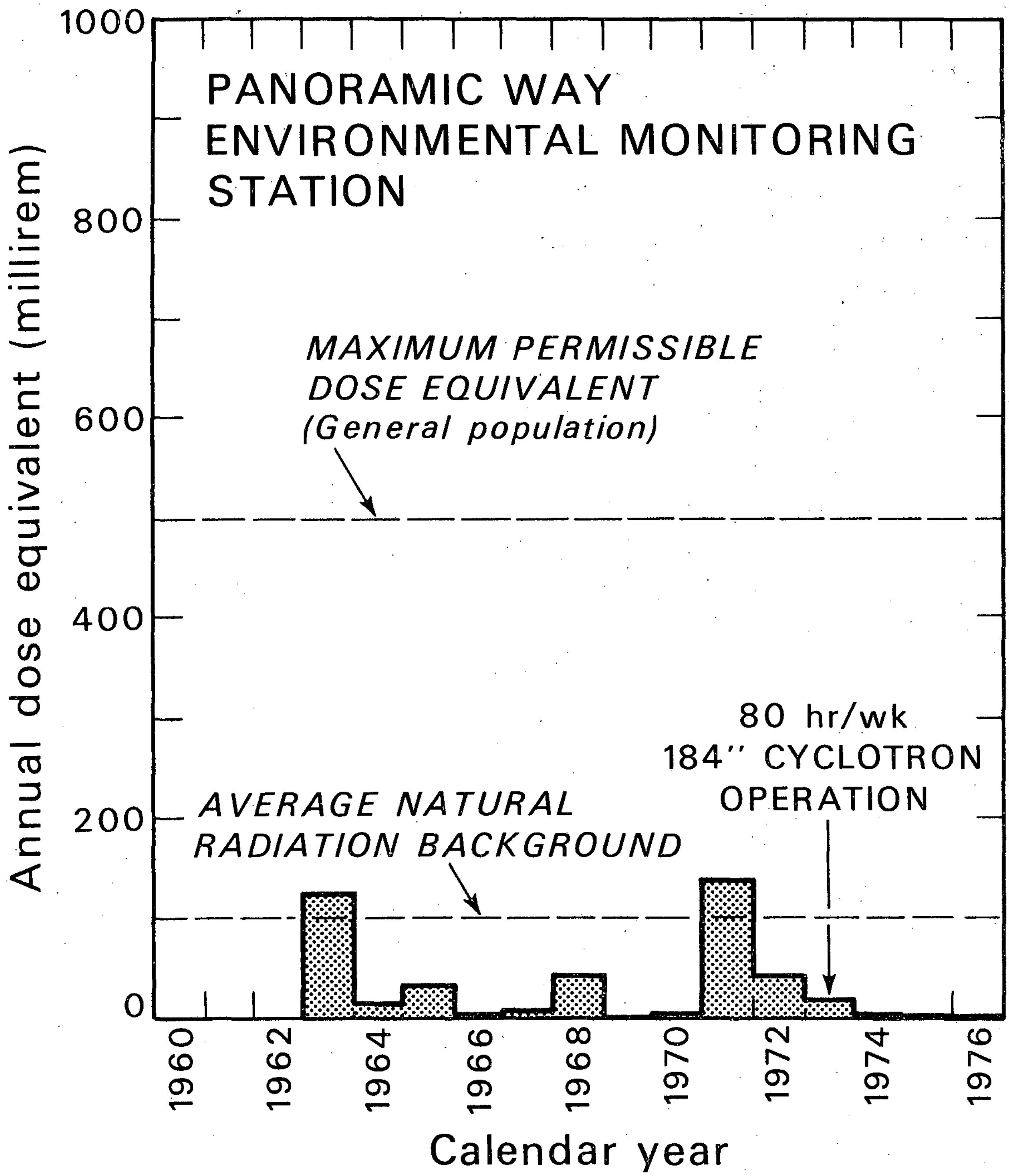
XBL 753-4767B

Fig. 14.



XBL 753-4768B

Fig. 15.



XBL 753-4769A

Fig. 16.

material discharged by the University is several times greater than that discharged by the Laboratory. 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.

REFERENCES

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1. A. R. Jones, Pulse Counters for γ-Dosimetry, Health Physics 1962. Vol. 8, pp. 1-9.
2. H. L. Beck, J. A. DeCampo, P. D. Raft, HASL-260, December 1972, Health and Safety Laboratory U. S. Atomic Energy Commission, New York, NY 10014.
3. W. S. Gilbert, et al., 1966, CERN-LRL-RHEL Shielding Experiment, Lawrence Radiation Laboratory Internal Report, UCRL-19794 (1968).
4. R. H. Thomas, ed., The Environmental Surveillance Program of the Lawrence Berkeley Laboratory, Lawrence Berkeley Laboratory Internal Report, LBL-4678, April 1976.
5. United States Energy Research and Development Administration Manual, Chapter 0524-Standards for Radiation Protection.
6. Op cit, Ref. 4. Section 4.2.3.
7. Op Cit, Ref. 4, Section 3.1.2.
8. Op Cit, Ref. 4, Section 4.2.4.
9. Op Cit, Ref. 4, Section 1.4.2.

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