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1983 ENVIRONMENTAL MONITORING REPORT

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SAFETY AND ENVIRONMENTAL PROTECTION DIVISION

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BROOKHAVEN NATIONAL LABORATORY
ENVIRONMENTAL MONITORING REPORT

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1.0 INTRODUCTION

1.1 Background:

The primary purpose of Brookhaven National Laboratory's (BNL) environmental monitoring program is to determine whether:

1) facility operations, waste treatment, and control systems have functioned as designed and planned from the standpoint of containment of radioactivity, and

2) the applicable environmental radiation and radioactivity standards and effluent control requirements have been met.

The Laboratory's environmental monitoring program is designed and developed to accomplish these two primary objectives. While this annual report for calendar year 1983 generally follows the recommendations given in DOE/EP-0023, "A Guide for Environmental Radiological Surveillance at U.S. DOE Installations" (2), the suggested scope has been modified to meet the BNL site-specific environmental monitoring needs. The Laboratory's environmental surveillance program includes the sampling and analysis of nonradiological pollutants, and indices of water quality. These latter aspects reflect the local interest about environmental quality, particularly with regard to the preservation of the purity of the aquifer underlying Long Island (3).

1.2 Site Characteristics:

Brookhaven National Laboratory is a multidisciplinary scientific research center. It is situated close to the geographical center of Suffolk County on Long Island, about 97 km east of New York City. Its location with regard to surrounding communities is shown in Figure 1. About 1.29 million people live in Suffolk County (4) and about 0.37 million people in Brookhaven Township, within which the Laboratory is situated. The principal nearby population centers are located in shoreline communities. Table 1 gives the resident population distribution within 80 km of the BNL site. Although much of the land area within a 16 km radius is either forested or under cultivation, there has been some development of suburban housing in proximity to the Laboratory during recent years.

The Laboratory site is shown in Figure 2. It consists of some 2130 hectares (ha), most of which is wooded, except for a developed area of about 655 ha. The site terrain is gently rolling, with elevations varying between 36.6 and 13.3 m above sea level. The land lies on the western rim of the shallow Peconic River watershed, with a principal tributary of the river rising in marshy areas in the northern and eastern sections of the site.

In terms of meteorology, the Laboratory can be characterized as a well-ventilated site. In common with most of the eastern seaboard, its prevailing ground level winds are from the southwest during the summer, from the northwest during the winter, and about equally from these two directions during the spring and fall (5).

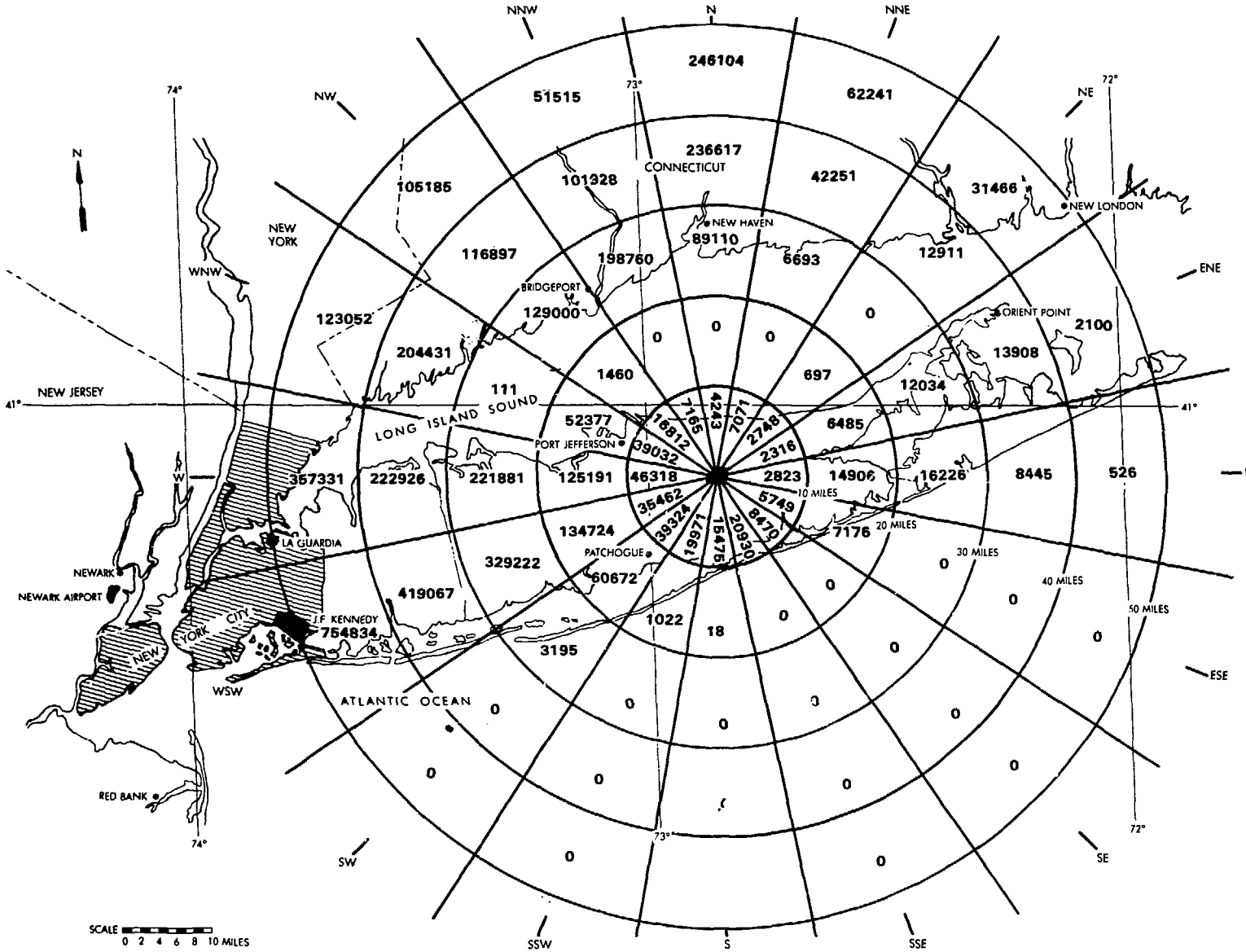


Figure 1. Resident population 1982 within a 50 mile radius of BNL.

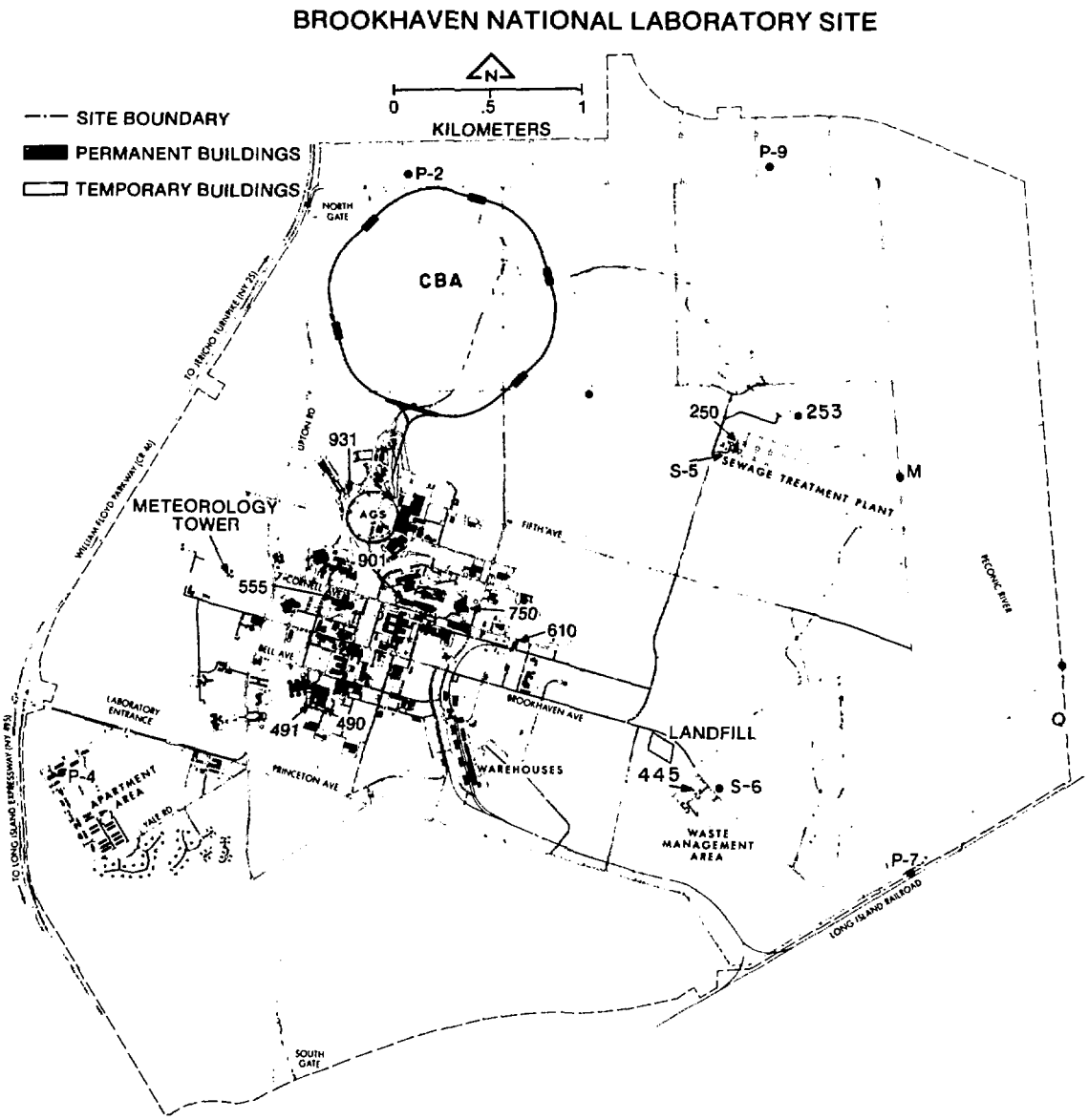
Table 1

1983 BNL Environmental Monitoring

1983 Resident Population Distribution[a] Within 80 Km Radius of BNL

Sector	0-16 Km (10 mi)	16-32 Km (20 mi)	32-48 Km (30 mi)	48-64 Km (40 mi)	64-80 Km (50 mi)	Total	Remarks
SSW	19,971	1,022	0	0	0	20,993	Beyond 32 Km - Atlantic Ocean
SW	39,324	60,672	3,195	0	0	103,191	Beyond 48 Km - Atlantic Ocean
WSW	35,462	134,724	329,222	419,067	754,834	1,673,309	Beyond 80 Km - Part of New York City
W	46,318	125,191	221,881	222,926	357,331	973,647	Beyond 80 Km - New York City
WNW	39,032	54,377	111	204,431	123,052	421,003	Beyond 32 Km and 48 Km - Long Island Sound; Beyond 48 Km - Connecticut and New York
NW	16,812	1,460	129,000	116,897	105,185	369,354	Same as WNW
NNW	7,165	0	198,760	101,928	51,515	359,368	Between 16 Km and 32 Km - Long Island Sound; Beyond 32 Km- Connecticut
N	4,243	0	89,110	236,617	246,104	576,074	Same as NNW
NNE	7,071	0	6,693	42,251	62,241	118,256	Same as NNW
NE	2,748	697	0	12,911	31,466	47,822	Between 32 Km and 48 Km - Long Island Sound; Beyond 48 Km - Connecticut
ENE	2,316	6,485	12,034	13,908	2,100	36,843	North Fork of Long Island
E	2,823	14,906	16,226	8,445	526	42,926	South Fork of Long Island and Atlantic Ocean
ESE	5,749	7,176	0	0	0	12,925	Long Island; Beyond 32 Km - Atlantic Ocean
SE	8,470	0	0	0	0	8,470	Beyond 16 Km - Atlantic Ocean
SSE	20,930	0	0	0	0	20,930	Same as SE
S	15,475	18	0	0	0	15,493	Beyond 32 Km - Atlantic Ocean
Total	273,909	406,728	1,006,232	1,379,381	1,734,354	4,800,604	

(a) Population estimated from data supplied by the Long Island Regional Planning Board and the Long Island Lighting Company (4).



ENVIRONMENTAL MONITORING STATIONS		DESIGNATION	EFFLUENT RELEASE POINT
AIR		250	SAND FILTER BEDS
P-2	NORTHWEST PERIMETER	253	PECONIC R. STREAM BED
P-4	SOUTHWEST PERIMETER	254	SITE BOUNDARY
P-7	SOUTHEAST PERIMETER	490	MRC STACK
P-9	NORTHEAST PERIMETER	491	MRR STACK
S-5	SEWAGE TREATMENT AREA	555	CHEMISTRY STACK
S-6	WASTE MANAGEMENT AREA	750	HFBR STACK
S-13	SW CORNER, ECOLOGY FIELD	901	VAN DE GRAAFF STACK
WATER		931	BLIP STACK
250	SEWAGE TREATMENT PLANT	445	WASTE MANAGEMENT AREA
253	PECONIC RIVER STREAM BED	610	STEAM PLANT
M	PECONIC RIVER, 0.5 MI. DOWNSTREAM FROM TREATMENT PLANT		
Q	SITE BOUNDARY		

Figure 2. Location of emission points and monitoring stations.

Studies of Long Island hydrology and geology [6-8] in the vicinity of the Laboratory indicate that the uppermost Pleistocene deposits, which are between 31-61 m thick, are generally sandy and highly permeable. Water penetrates them readily and there is little direct run-off into surface streams, except during periods of intense precipitation. The annual total for 1983 was 128 cm, which was close to the average annual precipitation of 122 cm. About half of this precipitation is lost to the atmosphere through evapotranspiration and the other half percolates to recharge groundwater. The groundwater in the vicinity of the Laboratory moves predominantly in a horizontal direction to the Great South Bay [6]. It takes a more easterly direction in the Peconic River watershed portions of the site. The estimated rate of movement at the groundwater surface is about 16.2 cm d^{-1} [6].

1.3 Existing Facilities:

A wide variety of scientific programs are conducted at Brookhaven, including research and development in the following areas:

1) the fundamental structure and properties of matter,

2) the interactions of radiation, particles and atoms with other atoms and molecules,

3) the physical, chemical and biological effects of radiation, and of other energy-related environmental pollutants,

4) the production of special radionuclides and their medical applications,

5) energy and nuclear related technology, and

6) the assessment of energy sources, transmission and uses, including their environmental and health effects.

The major scientific facilities which are operated at the Laboratory to carry out the above programs include the following:

1) The High Flux Beam Reactor (HFBR) is fueled with enriched uranium, moderated and cooled by heavy water, and operates at a routine power level of 60 MW(th).*

2) The Medical Research Reactor (MRR), an integral part of the Medical Research Center (MRC), is fueled with enriched uranium, moderated and cooled by light water, and is operated intermittently at power levels up to 3 MW(th).

3) The Alternating Gradient Synchrotron (AGS), a proton accelerator, operates at energies up to 33 GeV, and is used for high energy physics research.

*th = thermal

4) The 200 MeV Proton Linac serves as an injector for the AGS and also supplies a continuous beam of protons for radionuclide production by spallation reactions in the Brookhaven Linac Isotopes Production Facility (BLIP) and in the Chemistry Linac Irradiation Facility (CLIF).

5) The Tandem Van de Graaff, Vertical Accelerator, and Chemistry Van de Graaff are used in medium energy physics investigations, as well as for special nuclide production.

6) The National Synchrotron Light Source utilizes a linear accelerator and booster synchrotron as an injection system for two electron storage rings which operate at energies of 700 MeV vacuum ultraviolet (VUV) and 2.5 GeV (x-ray). It is used for VUV spectroscopy and for x-ray diffraction studies.

Additional programs involving irradiations and/or the use of radionuclides for scientific investigations are carried on at other Laboratory facilities including those at the Medical Research Center, the Biology Department, the Chemistry Department, and the Department of Applied Sciences (DAS). At the Hot Laboratory, special purpose radionuclides are developed and processed for on- and off-site use under the joint auspices of the DAS and the Medical Department. This facility also contains a radioactive waste treatment center, which includes an evaporator for volume reduction of liquid wastes.

Most of the airborne radioactive effluents at Brookhaven originate from the HFBR, BLIP and the research Van de Graaff, with lesser contributions from the Chemistry and Medical Research Centers. The first two contribute to the Laboratory's liquid radioactive wastes, with additional smaller contributions originating from the Medical Research Center, the Hot Laboratory complex, as well as from decontamination and laundry operations.

2.0 SUMMARY

The environmental levels of radioactivity and other pollutants found in the vicinity of BNL during 1983 are summarized in this report. As an aid in the interpretation of the data, the amounts of radioactivity and other pollutants released in airborne and liquid effluents from Laboratory facilities to the environment are also indicated. The environmental data includes external radiation levels; radioactivite air particulates; tritium concentrations; the amounts and concentrations of radioactivity in and the water quality of the stream into which liquid effluents are released; the concentrations of radioactivity in biota from the stream; the concentrations of radioactivity in and the water quality of ground waters underlying the Laboratory; and concentrations of radioactivity in milk samples obtained in the vicinity of the Laboratory.

The amounts of radioactivity released in airborne and liquid effluents from laboratory facilities to the environment were within allowable standards as stipulated in DOE Order 5480.1. Other pollutants, such as metals, organic compounds, etc., in the effluents released from the Laboratory were well below Federal, State and Local standards as applied to site specific conditions.

External Radiation:

Based on statistical analyses, the measured levels of external radiation at the site boundary were significantly different than the off-site monitoring stations. The net addition annual exposure that an individual, residing at the site boundary, would receive is 5.1 mrem.

Air and Rainfall - Radioactivity:

Other than tritium, there was no indication of BNL radioactive effluents in enviromental air and precipitation samples. The largest concentration of tritium in air at the site boundary, 9.6×10^2 pCi m^{-3} was 4.8% of the Radiation Concentration Guide (RCG). The largest average concentration of tritium in precipitation was 3.0×10^2 nCi/m^2. The total site wide deposition was 18.2 Ci.

Air - Nonradioactive:

At the central Steam Plant, stack testing conducted in 1983 indicated that SO_2 and NO_x emissions were reduced by 70% and 64%, respectively, when compared to the combustion of No. 6 oil. Calculations based on meterological parameters indicate that at the site boundary, the average concentrations of SO_2 and NO_x, resulting from the steam plant operations, were 0.04 µg m^{-3}, and 0.03 µg m^{-3} respectively. These values are approximately 1% of the applicable ambient air quality standards.

Liquid Effluent - Sewage Treatment Plant:

Of the sewage effluent released onto the sand filter beds of the Laboratory sewage treatment plant, 77% flowed directly into the Peconic River. The balance was assumed to have percolated into the ground water underlying the beds. The gross beta concentration of the output from them was 7.65 pCi l^{-1} (7.65×10^{-9} µCi ml^{-1}), or 0.3% of the Radiation Concentration Guide (RCG). The tritium concentration was 7.96 nCi l^{-1} (7.96×10^{-6} µCi ml^{-1}), or 0.3% of the RCG. The same concentration was assumed for the infiltration into groundwater.

Liquid Effluents - National Pollutant Discharge Elimination System Permit:

Except for 5 daily pH levels which were "out of limit" and one instance of biochemical oxygen demand (BOD) percent removal, all reportable non-radiological parameters of the Laboratory sewage effluent were within the limits set forth in the Laboratory's permit, issued by the New York State Department of Environmental Conservation under the State Pollution Discharge Elimination System. The average water quality of the sewage treatment plant effluent at the point of discharge was at or within water quality standards for the receiving body of water, in most instances, meeting drinking water quality standards.

Peconic River - On-Site:

At the former site boundary (Station M), the gross beta concentration was 7.23 pCi l^{-1} (7.23×10^{-9} µCi ml^{-1}), or 0.2% of the RCG, and the tritium concentration was 6.76 nCi l^{-1} (6.76×10^{-6} µCi ml^{-1}), or 0.2% of the RCG. At the

site boundary, the gross beta concentration was 4.9 pCi l^{-1} (0.49 x 10^{-8} µCi ml^{-1}), or 0.2% of the RCG, and the tritium concentration was 5.4 nCi l^{-1} (5.4 x 10^{-6} µCi ml^{-1}), or 0.2% of the RCG.

Peconic River - Off-Site:

Sampling of the Peconic River water downstream of the sewage treatment plant outfall has indicated a decrease of concentrations of radioactivity. At a location 4.8 km downstream, the annual average gross beta concentration was 2.3 pCi l^{-1} (2.3 x 10^{-9} µCi ml^{-1}), or 0.1% of the RCG. About 19.5 km downstream, the average concentration of gross beta activity was 1.9 pCi l^{-1} (1.9 x 10^{-9} µCi ml^{-1}); that of tritium being 0.72 nCi l^{-1} (0.72 x 10^{-6} µCi ml^{-1}). Based on total flow and activity per unit volume, the total gross beta activity in the river at that location exceeded that at the Laboratory's site boundary. This difference is attributed to the fact that the total flow at the river's mouth is increased due to the tributary additions which, in turn, have added fallout radionuclides that were present in the draining area of the tributaries.

Peconic River - Aquatic Biological Studies:

Fish were collected at Donahue's Pond (Peconic Lake) for radionuclide analysis. The maximum concentration of ^{137}Cs in fish was about 174 pCi kg^{-1}. This concentration would result in a dose commitment that was less than 1% of the RCG, based on an assumed ingestion of 50 g of fish per day.

Groundwater - Supply and Process Wells and Recharge Basins:

About 16 million liters of water per day obtained from on-site supply wells were used for "once through" cooling and returned to groundwater in on-site recharge basins. The concentration of gross beta activity at point of recharge was, on the average, 15% greater than that of the supply wells, and was about 5% of the EPA Drinking Water Compliance Level Standard. The tritium concentrations were near or at the MDL, which is about 1% of the EPA Drinking Water Standard.

Groundwater - Surveillance Wells:

Groundwater surveillance was conducted in a network of some 100 sampling wells installed adjacent to and downstream from identified areas where there is a potential for the percolation and migration of radioactivity and other contaminants in groundwater. With the aquifer underlying Long Island being classified as a "sole source" it was necessary to apply EPA and New York State (NYS) Drinking Water Standards to all activities concerning groundwater use or recharge.

a. On-Site Wells:

Immediately adjacent to the sand filter beds and to the Peconic River on-site and at the site boundary, gross beta, tritium and ^{90}Sr concentrations have been decreasing, when compared to those observed during previous years. This reflects the decrease in the concentrations due to decay and dilution. They were not more than a few percent of the EPA and NYS Drinking Water

Standards. The largest average gross alpha concentration, 1.3 pCi l^{-1} (1.3 x 10^{-9} µCi ml^{-1}) was 9% of the EPA Drinking Water Standard for unidentified mixtures containing alpha activity other than ^{226}Ra. It was not directly relatable to any known Laboratoty effluent releases. The largest average gross beta concentration was 4.6 pCi l^{-1} (4.6 x 10^{-9} µCi ml^{-1}); the largest average tritium concentration was 7.5 nCi l^{-1} (7.5 x 10^{-6} µCi ml^{-1}).

On-site, adjacent to the Solid Waste Management area, the current landfill, and the decontamination facility storm sewer sump, above ambient background concentrations of gross beta acitivity, ^{90}Sr, and tritium were found in a number of nearby groundwater surveillance wells. Much of the gross beta activity appeared to be related to ^{90}Sr.

At the Waste Management area, the largest ^{90}Sr concentration, 28.55 pCi l^{-1} (28.55 x 10^{-9} µCi ml^{-1}), or 4 times the EPA Drinking Water Standard, was found in a well at the Waste Management Area perimeter. This level reflects the effects of a known inadvertent injection into groundwater which occurred in 1960.

At the landfill, an average gross alpha concentration of 6.3 pCi l^{-1} (6.3 x 10^{-9} µCi ml^{-1}), or 0.4 times the EPA Drinking Water Standard, an average gross beta concentration of 30.0 pCi l^{-1} (30.0 x 10^{-9} µCi ml^{-1}), or 0.6 times the compliance level, and an average tritium concentration of 7.7 nCi l^{-1} (7.7 x 10^{-6} µCi ml^{-1}) or 0.4 times the EPA Drinking Water Standard, were the largest found.

At the decontamination facility storm sewer sump, a ^{90}Sr concentration of 79 pCi l^{-1} (79 x 10^{-9} µCi ml^{-1}), 10 times the EPA Drinking Water Standard, was found in a surveillance well within a few meters of the sewer outfall into a sump.

Iron and zinc were found in excess of their respective standards (0.6 and 0.3 ppm for drinking water) in numerous sampling wells on-site. However, this appears to be related to corrosion from the well casings and not to Laboratory effluents, except for a few wells adjacent to the Landfill. There, the largest concentration of iron was 76 ppm and of zinc, 6.1 ppm.

In all cases, the on-site levels of radioactivity or of other agents which were found in above ambient background in ground water appeared to be confined to within a hundred meters of their origin. They would require decades of travel before reaching the site boundary. Concentrations of radioactivity, and water quality parameters, in ground water from perimeter surveillance wells (other than those adjacent to the Peconic River) were at or near background and only a few percent of the EPA Drinking Water Standards.

b. Off-Site Wells:

Concentrations of tritium were found to be slightly higher in a sampling well about 0.35 km east of the site boundary than in wells at the boundary itself. The tritium concentration, 4.3 nCi l^{-1} (4.3 x 10^{-6} µCi ml^{-1}), was 22% of the EPA Drinking Water Standard. The gross beta concentration, 3.5 pCi l^{-1}

(3.9×10^{-9} μCi ml^{-1}), was 7% of the EPA Drinking Water Compliance Level Standard.

Except for pH levels slightly lower than the Water Quality Standard, but within the local natural variation, other indices of water quality in these surveillance wells were within the standards.

Total Population Dose Resulting from Laboratory Sources

During 1983, the collective (population) average dose equivalent attributable to Laboratory sources, for the population up to a distance of 80 km, was calculated to be 0.04 person-rem. This can be compared to a natural background dose-equivalent rate to the same population of about 303,000 rem a^{-1} (person-rem a^{-1}).

3.0 MONITORING DATA COLLECTION, ANALYSIS AND EVALUATION

3.1 External Radiation Monitoring:

Dose-equivalent rates from gamma radiation at the site boundary, including natural background (as influenced by fallout) and the increments attributable to Laboratory activity, were determined through the use of CaF_2:Dy thermoluminescent dosimeters (TLD) [9]. They were exposed for monthly periods at each of the four perimeter monitoring stations P-2, P-4, P-7, and P-9, the locations of which are shown in Figure 2. The observed rates, as measured by these TLDs at the site boundary, are given in Table 2. The dose-equivalent rate from external radiation at the site perimeter averaged 69.1 mrem a^{-1}.

Figure 3 shows the locations of the off-site TLDs with respect to the Laboratory (HFBR Stack, #750 as the center; Figure 2). The standard 16 sectors with sector #1 centering on true North have been used to locate the TLDs. The dose-equivalent rates observed are given in Table 3.

The 1983 site perimeter and off-site TLD data were evaluated through the use of a crossed, three-way factorial analysis of variance (ANOVA) for unbalanced data. The independent variables in the ANOVA were sector, season (defined by calendar quarter), and ring; with the model incorporoating all cross-products. The ring variable is an approximation of distance as TLDs were grouped in incremental rings defined as the site perimeter, site perimeter-5 km, 5-10 km, and greater than 10 km.

The overall model was highly significant ($p < 0.0005$), as were the following variables: sector ($p < 0.0001$), ring ($p < 0.0001$), season ($p < 0.001$), sector*ring ($p < 0.0001$), and ring*season ($p < 0.04$). The variable terms sector*season and sector*ring*season were not statistically significant ($p < 0.96$ and $p < 0.38$, respectively). These results suggested that there were significant differences due to seasonal, directional, and distance factors. The data was further evaluated using Duncan's Multiple Range test and Schaffe's test, the results indicating that the highest TLD exposure rates occur at the site boundary and decrease with distance from the site boundary ($p < 0.05$). The exposure rate at the site perimeter was significantly greater than the site perime-

Table ?

1983 BNL Environmental Monitoring

Site-Perimeter External Dose-Equivalent Rates from

Background and BNL Operations

Period	Location[a] Northwest Perimeter (P-2)	Southwest Perimeter (P-4)	Southeast Perimeter (P-7)	Northeast Perimeter (P-9)	Perimeter Average[b]
	mrem				
Minimum (Monthly)	5.0	5.2	5.0	5.1	5.1
Maximum (Monthly)	6.0	6.1	6.4	7.3	6.5
Average (Monthly)	5.5	5.7	5.8	6.1	5.8
Total (Annual)	66.3 ± 3.7	68.6 ± 3.4	69.0 ± 4.6	72.6 ± 7.1	69.1 ± 2.6

(a) Locations of monitoring stations are shown in Figure 2.

(b) Station P-9 lies on a bed of coal cinders which contain radium and thorium at concentrations larger than the foundation material used at other perimeter stations which may result in an artificially elevated reading.

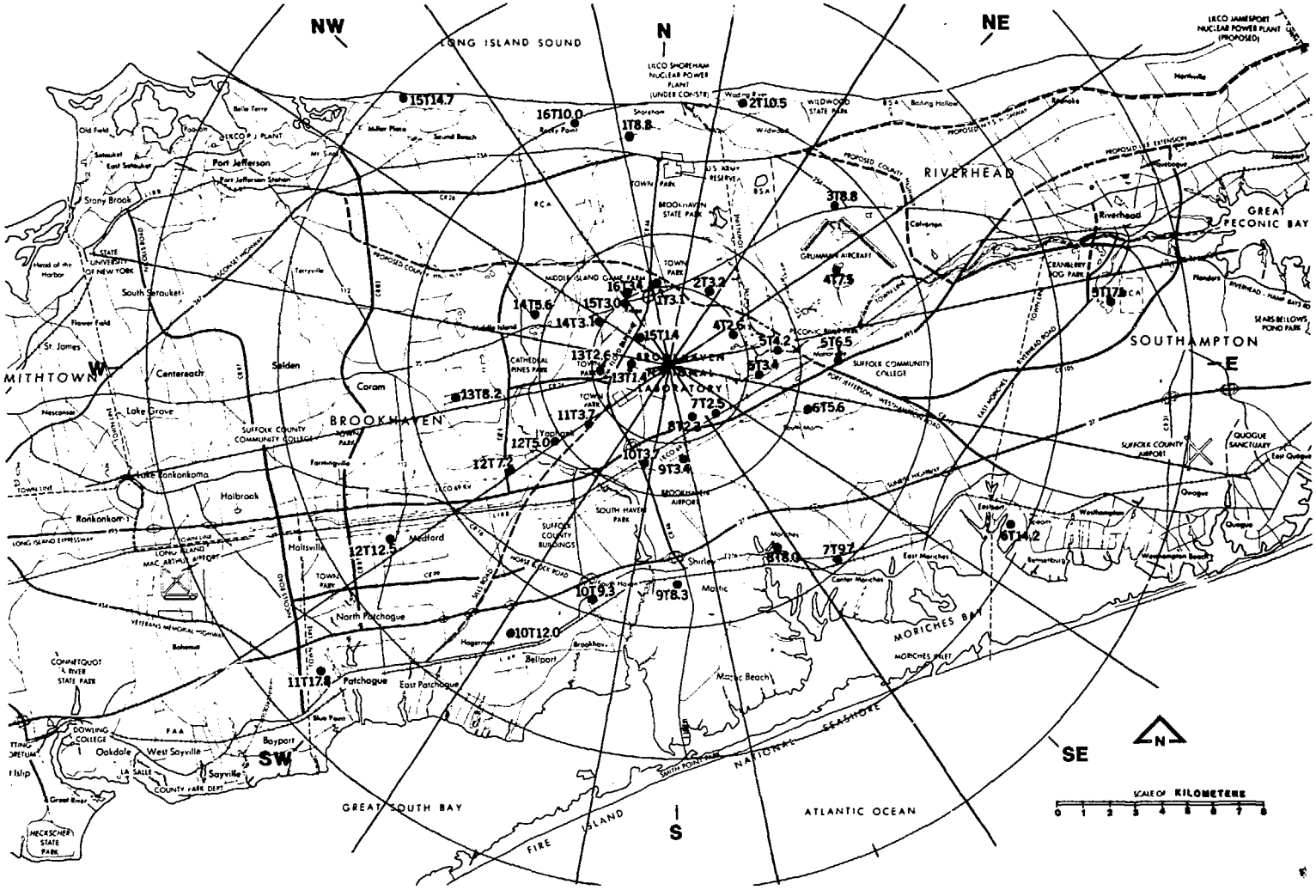


Figure 3. Location of off-site thermoluminescent dosimeters Brookhaven National Laboratory.

Table 3

1983 BNL Environmental Monitoring

Off-Site External Dose-Equivalent Rates

TLD No [a]	Compass Heading (degrees)	Distance From HFBR Stack (km)[b]	Annual Total[c] (mrem)
1T3.1	350	3.1	65.0
1T8.8	350	8.8	53.0
2T3.2	31	3.2	63.4
2T10.5	14	10.5	64.5
3T8.8	46	8.8	62.4
4T2.6	62	2.6	60.8
4T7.5	59	7.5	59.8
5T6.5	88	6.5	58.8
5T4.2	79	4.2	55.1
5T17.1	81	17.1	56.7
6T5.6	107	5.6	61.9
6T14.2	115	14.2	53.0
7T9.7	140	9.7	59.8
7T2.5	139	2.5	74.9
8T2.3	155	2.3	60.8
8T8.0	151	8.0	80.1
9T3.4	173	3.4	64.0
9T8.3	178	8.3	77.5
10T3.7	196	3.7	71.8
10T9.3	199	9.3	56.2
10T12.0	211	12.0	65.0
11T3.7	233	3.7	61.4
11T17.8	229	17.8	55.1
12T5.0	238	5.0	62.9
12T7.2	241	7.2	60.3
12T12.5	238	12.5	62.9
13T1.4	273	1.4	68.1
13T2.6	263	2.6	62.4
13T8.2	262	8.2	58.8
14T3.1	302	3.1	65.5
14T5.6	290	5.6	73.3
15T1.4	306	1.4	70.7
15T3.0	325	3.0	54.6
15T14.7	316	14.7	65.0
16T3.4	331	3.4	64.5
16T10.0	339	10.0	62.4
Shielded TLD[d]			19.8

(a) See Figure 3 for TLD locations.
(b) See Figure 2 for HFBR Stack (Bldg. 750) location.
(c) Estimate based upon time-weighted averages. The standard deviation of the measurement is approximately ± 10%.
(d) Represents background due to cosmic ray and is based upon twelve measurements.

ter-5 km and 5-10 km rings ($p < 0.05$). The site perimeter-5 km and 5-10 km rings were significantly greater than the 10-20 km ring mean exposure rate. The net additional annual exposure that a person residing at the site boundary would receive is 5.1 mrem.

In the analyses, four stations served to measure exposure rates at the site perimeter, as opposed to 32 stations at greater distances from the Laboratory. The grouping of the data into sectors may have masked any spatial autocorrelation in the data. If such autocorrelation is present, certain assumptions of the statistical tests employed would be violated, invalidating the analysis of variance results. Future analyses will incorporate the latitude-longitude coordinates of each sample station in an attempt to determine the presence of any spatial autocorrelation.

3.2 Airborne Effluents, Tritium and Radioiodine Monitoring:

3.2.1 Facilities and Effluents:

The principal Laboratory facilities from which radioactive effluents are released to the atmosphere are listed in Table 4. Their locations on the Laboratory site are shown in Figure 2. The installed on-line effluent monitors, sampling devices, and the types and amounts of effluents released during 1983 are indicated in Table 4. With the exception of tritium, there were no radionuclides detected at the site boundary which are attributed to Laboratory effluents.

Oxygen-15 and Argon-41 are radioactive gases with relatively short half-lives. Oxygen-15, which has a two minute half-life, is produced by the interaction of protons and water in the BLIP facility and generated at an estimated rate per unit beam current of 0.21 Ci μA^{-1} h^{-1}. When this facility is operated at the full beam current of 180 μA, the equilibrium ^{15}O activity is 1.8 Ci. Argon-41, which has a 110-minute half-life, is produced by the interaction of neutrons and ventilating air in the shield of the Medical Research Reactor. It is released from the stack at an estimated rate of 1 Ci $MW(th)^{-1}h^{-1}$.

Tritium (^3H) has a 12.3-year half-life, and is a very low energy beta emitter ($T_{\beta(max)}$ = 18.6 KeV). It's principal environmental significance is when it is in the form of tritiated water vapor (HTO), which is taken up and utilized by living systems as is ordinary water. Of the 408 Ci of tritium released from the Laboratory research facilities during 1983 (Table 4), 118 Ci (29%) were in gaseous form, and 290 Ci (71%) were released as HTO. Tritium releases remained at low levels during 1983 as the Laboratory continued to employ as low as reasonable achievable practices.

The Laboratory incinerates certain categories of waste in the Waste Management Incinerator. The individual radionuclides, their half-lives and total quantities in the incinerated waste material are shown in Table 5. Tritium was the largest in quantity, 260 mCi. Limits on the amount incinerated and meterological dispersion are utilized to assure that airborne concentrations at the site boundary are small fractions of the Radiation Concentration Guides (RCG).

Table 4
1983 BNL Environmental Monitoring
Atmospheric Effluent Release Locations and Radionuclide Activity

Building No.(a)	Facility and Release Point	Release Height(b) (m)	Principal Radionuclide	On-Line Monitoring	Fixed Sampling Devices	Amount Released During 1983
490	Medical Research Center Roof Stack	13.7	Tritium	None	Dessicant for tritium vapor	7.9×10^{0} Ci (vapor)
491	Medical Research Reactor Stack	45.7	Argon-41	Moving tape for radioparticulates	Charcoal for radioiodines	2.6×10^{2} Ci (c)
555	Chemistry Roof Stack	16.8	Tritium	None	Dessicant for tritium vapor	5.2×10^{-1} Ci (vapor)
750	High Flux Beam Reactor Stack	97.5	Tritium	None	Dessicant for tritium vapor	2.7×10^{2} Ci (vapor)
801	Hot Laboratory		Gross Beta Particulates	Beta Scintillator for radioactive gases	Particulate filter for gross beta; charcoal cartridge for radioiodines	1.0×10^{-5} Ci
901	Van de Graff Accelerator	18.3	Tritium	Kanne chamber for tritium (gas & vapor)	Dessicant for tritium vapor	1.2×10^{1} Ci (vapor) 1.3×10^{2} Ci (d) (gas & vapor)
931	Linac Isotope Facility	18.3	Oxygen-15 Tritium	G-M Detector for radioactive gases	Dessicant for tritium vapor	3.0×10^{4}Ci (e) 4.3×10^{-2}Ci (vapor)
445	Incinerator		See Table5	None	None	See Table 5

(a) Locations given in Figure 2.
(b) Above ground level.
(c) Calculated from reported operating time and "one-time" measured emission rate at 3MW power level.
(d) Gas and vapor value covers sampling period of 3/8/83 to 12/28/83. Data from 1/1/83 to 3/3/83 was not collected due to equipment malfunction.
(e) Calculated from reported operating and estimated production rate at 180 μamp full beam current.

Table 5
1983 BNL Environmental Monitoring
Estimated Radionuclide Content of Incinerated Materials (a)

Radionuclide(b)	Half-Life	Quantity (mCi)
^{3}H	12.2y	259.5
^{125}I	60.2d	1.7
^{14}C	5730y	8.4
^{103}Ru	40d	0.1
^{32}P	14.3d	0.1
^{35}S	87.9d	0.3
^{201}Tl	3.0d	0.1
^{7}Be	53.0d	1.1
^{113}Sn	118.0d	0.2
^{131}I	8.1d	0.1

y = year

d = day

(a) Incinerated in the Waste Management Incinerator.

(b) Radionuclides released in annual quantities of less than 0.1 mCi have not been included.

Table 6
1983 BNL Environmental Monitoring
HFBR Stack-Gamma Spectroscopy Data

Date	Total Flow (10^7 m^3)	^{75}Se	^{126}I	^{82}Br	^{131}I	^{137}Cs	^{60}Co	^{144}Ce	^{69}Ge	^{86}Rb	^{74}As	^{123}I	^{203}Hg
		pCi/m^3											
Jan.	1.14	--	--	140	0.086	--	0.0069	0.013	1.72	0.21	0.014	--	--
Feb.	1.14	--	0.015	37	0.043	0.0016	0.0019	0.011	--	0.0090	--	0.071	0.0015
March	1.26	0.00069	0.0030	0.20	0.012	0.0016	--	--	--	--	--	--	--
April	0.924	0.0056	0.17	8.5	0.21	0.024	--	--	--	--	--	--	--
May	0.65	0.0054	--	810	0.10	0.0025	0.0071	--	--	--	--	--	--
June	0.611	--	--	--	0.24	0.0063	--	--	--	--	--	--	--
July	0.493	0.0021	--	--	0.071	0.0022	--	--	--	--	--	--	--
Aug.	0.73	0.0057	--	--	0.23	0.0032	--	--	--	--	--	--	--
Sept.	1.22	--	--	360	1.5	0.0039	0.0043	0.035	--	--	--	--	--
Oct.	1.27	0.0047	--	--	0.78	--	--	--	--	--	--	--	--
Nov.	0.84	0.0072	--	--	--	0.0035	--	--	--	--	--	--	--
Dec.	1.23	0.0047	0.135	100	0.65	--	--	--	--	--	--	--	--
Monthly Average	0.96	0.0028	0.030	1.3	0.382	0.0037	0.0017	0.0061	0.17	0.022	0.0014	0.0070	0.00015
		μCi											
Annual Total	11.5	0.33	3.4	1.3×10^4	43.9	.426	.199	.70	19.6	2.5	16.0	81.0	0.017

- Indicates not detected.

Gamma emitting nuclides released from the HFBR stack are shown in Table 6. ^{126}I, ^{69}Ge, and resulting daughter products result from processing of targets in the Hot Laboratory. The remaining nuclides are presumed to be the result of experimental studies relating to ^{235}U fission.

Most of the heating requirements for the principal buildings at the Laboratory are supplied by the central steam plant (Figure 2). In 1976 the Laboratory initiated the utilization of light feed stock (LFS), such as mineral spirits, alcohol, solvents, jet fuel and reconstituted fuels. In 1983, the fraction of LFS relative to total fuel consumption, was 70%. These light stock fuels typically have a weighted average sulfur content of 0.5% or less as compared to the regulatory limit of 1% sulfur content in #6 oil. In 1983, the mean fuel combustion efficiency over the entire range of boiler loading capacities was determined to be 99.8% for No. 5 Boiler firing alternate liquid fuels (ALF) (27). Under typical operating conditions the combustion efficiency is higher, since the upper limits of the boiler loading capacity are rarely reached (29). Samples of LFS used in the preparation of ALF are analyzed for cadmium, chromium, lead, and chlorinated hydrocarbons to ensure that the burning of ALF does not constitute a potential environmental problem. In addition, stack testing conducted in 1983 demonstrated that SO_2 and NO_x emissions were reduced by 70% and 64%, respectively when compared to the combustion of No. 6 oil (30).

3.2.2 Sampling and Analysis:

The Brookhaven environmental air monitoring program is designed to identify and quantify airborne radioactivity attributable to natural sources, to activities remote from the Laboratory (e.g., above ground nuclear weapon tests) and to Laboratory activities. Most of the concentrations of radioactivity in air detected during 1983 were attributable to natural sources. The only detectable nuclide attributable to Laboratory activities, was tritium, as tritium vapor.

3.2.3 Air Samples:

During 1983, positive displacement air pumps were operated at a nominal flow rate of 15 ℓ min^{-1} at the monitoring station adjacent to the solid waste management area (S-6), and at the site boundary stations P-2, P-4, P-7 and P-9 (see Figure 2 for locations). The air sampling media consisted of a 5 cm diameter air particulate filter (Gelman type) followed by a 62.5 cm^3 bed of triethylene diamine (TEDA) impregnated charcoal for the collection of radiohalogens.

The air particulate samples were counted for gross beta activity using an anti-coincidence proportional counter. The data are shown in Table 7. A seasonal trend was not apparent for gross beta activity in 1983. In addition to counting for gross beta activity, analyses for gamma emitting nuclides were performed on charcoal filters and on a composite of all air particulate samples at the end of each month. No ^{131}I was detected in these samples during 1983. Much smaller concentrations of radionuclides attributable to the residue from past atmospheric weapons test were detected. The average annual air concentra

Table 7

1983 BNL Environmental Monitoring

Gross Alpha and Gross Beta Concentrations in Environmental Station Air Particulate Filters

Location[a]	Quarterly Period	No. of Samples	Gross Alpha			Gross Beta		
			Average	Minimum	Maximum	Average	Minimum	Maximum
			(pCi/m^3)					
P-2	First	12	0.00122	0.00028	0.0034	0.0223	0.0052	0.172
	Second	13	0.00116	0.00011	0.0026	0.0135	0.0060	0.0272
	Third	12	0.0012	0.000026	0.0047	0.0226	0.0001	0.0598
	Fourth	12	0.00074	0.000029	0.0017	0.0068	0.0017	0.0189
	Annual		0.0011	0.000026	0.0047	0.0167	0.0001	0.172
P-4	First	11	0.00109	0.000095	0.0026	0.0132	0.0071	0.0198
	Second	13	0.00127	0.00044	0.0029	0.0132	0.0019	0.0264
	Third	12	0.00142	0.00026	0.0025	0.0221	0.0089	0.0394
	Fourth	12	0.00070	0.000026	0.0017	0.0068	0.0017	0.0189
	Annual		0.0011	0.000026	0.0029	0.0139	0.0019	0.0394
P-7	First	12	0.00119	0.000095	0.0029	0.0139	0.0068	0.0181
	Second	13	0.00153	0.00089	0.0030	0.0170	0.0073	0.0357
	Third	11	0.0017	0.00073	0.0039	0.0276	0.0001	0.1010
	Fourth	13	0.0010	0.00021	0.0017	0.0146	0.0075	0.0232
	Annual		0.00135	0.000089	0.0039	0.0192	0.0001	0.1010
P-9	First	11	0.00052	0.000082	0.0013	0.0072	0.0024	0.0166
	Second	13	0.00089	0.00011	0.0024	0.0092	0.0023	0.0264
	Third	12	0.00154	0.000090	0.0039	0.0315	0.0001	0.139
	Fourth	13	0.00085	0.000028	0.0026	0.0126	0.0002	0.024
	Annual		0.00096	0.000082	0.0039	0.0151	0.0001	0.139

a: Locations of monitoring stations are shown in Figure 2.

tions of ^{137}Cs and ^{7}Be in the charcoal filter samples were 3.0×10^{-3} pCi/m^3 and 1.1×10^{-2} pCi/m^3, respectively. The average annual air concentrations of ^{137}Cs and ^{7}Be in the composite air particulate samples were 3.4×10^{-3} pCi/m^3 and 6.4×10^{-2} pCi/m^3, respectively. The data is consistent with the absence of any reported atmospheric nuclear tests during the year, as well as with operations at the Laboratory. The concentrations have been decreasing since the last such reported test in 1980.

Sampling for tritium vapor was also performed at each of the air sampling stations by drawing a small side stream of air ($\sim$200 cm^3 min^{-1}) through silica gel cartridges. These cartridges were normally changed on a weekly basis. The collected vapor was subsequently removed from the gel by heating; then condensed, collected, and assayed by liquid scintillation counting. The tritium vapor concentration data obtained in this manner during 1983 are shown in Table 8.

The highest quarterly average concentrations were observed during the first and third quarters at the southeast station (P-7). The highest annual average concentration, 4.9×10^{2} pCi/m^3, was observed at station P-7. This value was 2.5% of the Radiation Concentration Guide (RCG) (14). The yearly average concentrations at stations P-2 and P-4 were at or near the MDL.

The current Laboratory environmental monitoring program does not include routine air sampling for nonradioactive substances. Based upon 0.5% sulfur and 0.8% nitrogen content (12,33), the calculated annual average concentrations at the site boundary of the conventional pollutants released from the central steam plant were 0.04 $\mu g\ m^{-3}$ SO_2 and 0.03 $\mu g\ m^{-3}$ NO_x. These values are approximately 1% of the applicable ambient air quality standards (13).

3.2.4 Precipitation:

Two pot-type rain collectors are situated adjacent to the sewage treatment plant (see Figure 2). Routine collections were made whenever precipitation was observed. Part of each collection was evaporated for gross alpha and beta counting, a fraction was composited for monthly tritium analysis, and the balance was put through ion exchange columns for quarterly ^{90}Sr and gamma analyses. The data for 1983 are reported in Table 9. The observed concentrations are consistent with the absence of above-ground weapons testing.

3.2.5 Milk Samples

Milk samples were collected from two dairy farms in the vicinity of the site. Fallout radionuclide concentrations were not detected in these milk samples. The range of ^{40}K detected in these samples was 1.1×10^{-6} to 1.4×10^{-6} μCi/ml.

3.3 Liquid Effluent Monitoring:

The basic principle of liquid waste management at the Laboratory is confinement and concentration to minimize the volumes of liquids requiring decontamination prior to on-site release or processing into solid form for off-site

Table 8
1983 BNL Environmental Monitoring
Tritium Vapor Concentrations in Air
(pCi/m^3)

Quarterly Period	P-9 Northeast Perimeter[a] NNE (11.25-33.75°)	P-7 Southeast Perimeter[a] ESE (101.25-123.75°)	P-4 Southwest Perimeter[a] SW (168.75-258.75°)	P-2 Northwest Perimeter[a] NNW (326.25-348.75°)	Minimum Detection Limit[b]
First	4.7×10^0	9.6×10^2	2.6×10^0	1.7×10^0	
Second	9.1×10^1	1.6×10^2	4.0×10^0	3.6×10^0	
Third	1.5×10^2	8.1×10^2	5.1×10^0	5.1×10^0	$0.6 - 18 \times 10^0$
Fourth	1.6×10^1	6.3×10^0	6.2×10^0	7.5×10^0	
Average	6.6×10^1	4.9×10^2	4.3×10^0	4.4×10^0	
Radiation Concentration Guide (14)			2.0×10^5		

(a) See Figure 2 for location of monitoring stations.

(b) The variable range for the MDL results from the tritium determination procedure and is a function of counting efficiency, counting time, sample volume, and relative humidity.

Table 9
1983 BNL Environmental Monitoring
Quarterly Average Radionuclide Activity in Precipitation

Quarter	Rainfall (cm)	Gross α	Gross β	^{3}H	^{90}Sr	^{7}Be	^{137}Cs
		nCi/m^2					
First	35.3	0.26	0.65	270	0.012	16	0.020
Second	39.5	0.13	0.38	300	0.0021	No analysis	
Third	22.5	0.097	0.57	190	0.022	5.0	0.027
Fourth	30.5	0.077	0.33	95	0.012	6.7	a
Annual Total	127.8	0.56	1.93	855	0.048	27.7	0.057

(a) Below the minimum detection limit.

burial. Accordingly, liquid wastes are segregated at the point of origin on the basis of their anticipated concentrations of radioactivity or other potentially harmful agents.

Small volumes (up to a few liters) of concentrated liquid wastes containing radioactivity or other hazardous agents are withheld from the Laboratory waste systems. They are stored at their sources of generation in small containers, collected by the Laboratory waste management group, and subsequently packaged for off-site disposal (in the case of hazardous wastes as defined by DOE Order 5480.2).

Facilities which may routinely produce larger volumes (up to several hundred liters) of radioactive or otherwise contaminated waste liquids are provided with dual waste handling systems, one for "active" (D, probably contaminated) and one for "inactive" (F, probably uncontaminated) wastes. As shown in Figure 4, wastes placed into the "active" or D system are collected in holdup tanks. After sampling and analysis, they are either transferred by installed pipelines or by tank truck to storage tanks adjacent to the Laboratory liquid waste evaporator. At this facility, liquids are concentrated about a hundred fold and ultimately disposed of as solid wastes. If found to be of sufficiently low concentration [16], D wastes may be routed directly from holdup tanks to the Laboratory sanitary waste system.

Subject to the results of analysis, "inactive" wastes are routed directly to the Laboratory sanitary waste system, where they are mixed with large quantities (approaching 4,000,000 l d^{-1}) of cooling and other uncontaminated water routinely produced by diverse Laboratory operations. Sampling and analysis of the waste in facility holdup tanks is done to facilitate waste management while effluent sampling is performed at the sewage treatment plant to establish the concentration and amounts of environmental releases.

The amounts of low level radioactive waste effluents that may be routinely disposed of by release into the Laboratory sanitary waste system are established by administrative limits [16]. Within these limits, individual releases are kept as low as reasonably achievable.

3.3.1 State Pollutant Discharge Elimination System Permit:

The effluent from the Laboratory sewage treatment plant is subject to the conditions of the State Pollutant Discharge Elimination System Permit No. NY 000 5835, authorized by the New York State Department of Environmental Conservation (NYSDEC). Quarterly reports have been prepared in accordance with this permit. A yearly summary of the data requested by NYSDEC in 1983 is shown in Table 10. As required by the permit, chlorination of the effluent was discontinued in May, 1983. The Laboratory effluent was within all of the permit requirements, with the exception of five daily pH levels and one instance of BOD_5 percent removal. The effluent pH variations were within the local natural range of groundwater (pH 5.5-6.0). A Laboratory study has indicated that the low pH of rainfall (pH 2.5-4.9) on Long Island is a significant factor in lowering the pH of the Laboratory effluent as it passes through the sand filter beds.

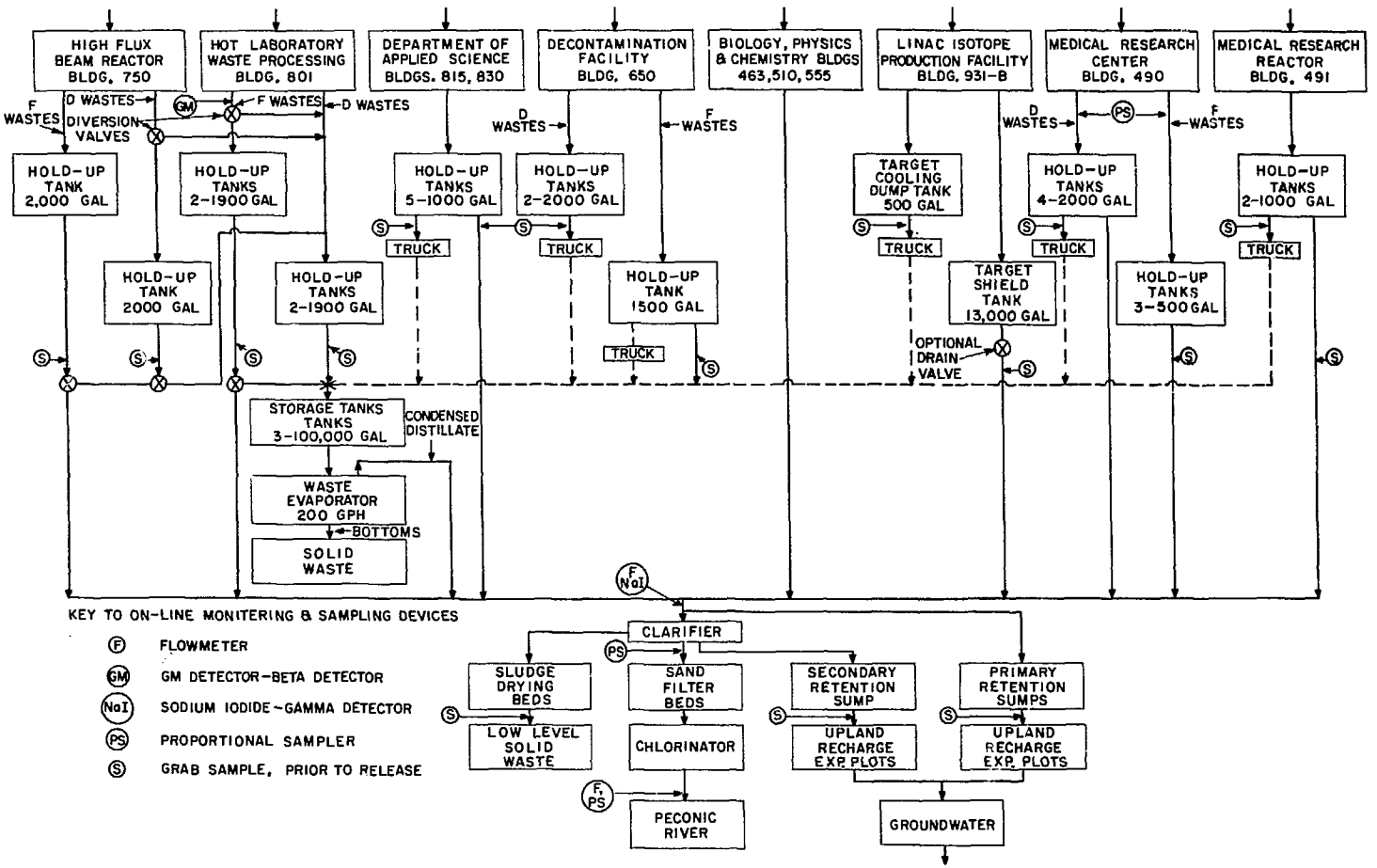


Figure 4. Liquid effluent systems Brookhaven National Laboratory.

Table 10
1983 BNL Environmental Monitoring
State Pollutant Discharge Elimination System
Effluent Data Summary[a]

Parameter	Status	Minimum	Mean	Maximum	Units	Number of Exceptions [b]	Frequency of Analysis	Sample Type
Temperative	Sample measurements	7.0	17.0	24.0	°C	--	Daily	Grab
	Permit requirement	----------c----------					Daily	Grab
pH	Sample measurements	5.6	--	7.0	SU	5	Daily	Grab
	Permit requirement	5.8	--	9.0			Daily	Grab
Settleable Solids	Sample measurements	0	0	0	ml/l	--	Daily	Grab
	Permit requirement	----------c----------					Daily	Grab
Residual Chlorine[d]	Sample measurements	0	0.2	.97	mg/l	--	Daily	Grab
	Permit requirement	----------c----------					Daily	Grab
Flow	Sample measurements			1.2	MGD[e]	0	Continuous	Metered
	Permit requirement	--	--	2.3			Continuous	Metered
Suspended Solids, Concentration	Sample measurements	0	1.2	9.0	mg/l	0	2/month	8 Hr. C
	Permit requirement	--	30.0	45.0			Monthly	8 Hr. C
Suspended Solids, Stream loading	Sample measurements	1.9	8.0	57.8	lbs/day	0	2/month	8 Hr. C
	Permit requirement	--	575.0	863.0			Monthly	8 Hr. C
BOD_5, Concentration	Sample measurements	--	3.0	6.6	mg/l	0	3/month	8 Hr. C
	Permit requirement	--	30.0	45.0			Monthly	8 Hr. C
BOD_5, Stream Loading	Sample measurements		20.1	45.6	lbs/day	0	3/month	8 Hr. C
	Permit requirement		575.0	863.0			Monthly	8 Hr. C
Percent removal BOD_5	Sample measurements	84.2	--	--	%	1	3/month	--
	Permit requirement	85.0	--	--			Monthly	--
Fecal coliform	Sample measurements	--	85	800	n/100ml	8	Daily	Grab
	Permit requirement	--	200	400			Monthly	Grab

(a) Additional effluent data is shown in Tables 11A, 11B, 11C, and 12.
(b) Total for the year.
(c) Monitoring is required -- no limits.
(d) Chlorination at the outfall was discontinued 5-1-83.
(e) Million gallons per day.

3.3.2 Peconic River:

Primary treatment of the liquid stream collected by the sanitary waste system to remove suspended solids is provided by a 950,000 liter clarifier. The liquid effluent from it flows onto sand filter beds, from which about 77% of the water was recovered by an underlying tile field. This recovered water was then released into a small stream that forms one of the headwaters of the Peconic River. The balance was assumed to have percolated to the groundwater under the beds and/or removed through evaporation.

A schematic of the sewage treatment plant and its related sampling arrangements is shown in Figure 5A. In addition to the inplant flow measurement and sampling instrumentation, totalizing flowmeters (Leopold and Stevens TP 61-2) capable of taking a sample for each 7576 liters of flow are installed in combination with positive action battery operated samplers (Brailsford DU-1). These are operated at the flow measuring weir for the effluent outfall (EA), at the former site boundary (M) which is 0.8 km downstream on the Peconic River, and at the site boundary (Q), 2.6 km downstream.

An aliquot of each daily (or weekend) sample of the input to the sand filter beds and of their output to the Peconic River was evaporated for the analysis of gross alpha and gross beta activity. Another aliquot was counted directly for tritium. Samples from the two downstream locations were obtained three times a week. Aliquots of each were analyzed for gross beta, gross alpha, and tritium. Another aliquot, proportional to the measured flow during the sampling period, was passed through ion exchange columns for subsequent analysis as an integrated sample. Unless the gross beta count at a given location indicated the need for immediate radionuclide identification, one set of these columns was analyzed directly on a monthly or quarterly basis for gamma emitting nuclides and the other was eluted for radiochemical processing for ^{90}Sr analysis. The average radionuclide concentrations at the clarifier (input to the filter beds) and at the outfall (output from the beds) are shown in Tables 11A and 11B. Yearly totals are also indicated. During 1983, about 77% of the total flow into the clarifier appeared in the output at the chlorine house after passing through the sand filter beds.

An analysis of the radionuclide concentrations at the outfall over the past several years has indicated a time lag between input and output from the sand filter beds. This lag appears to be greater for ^{134}Cs and ^{137}Cs than for ^{90}Sr, which explains why larger amounts of the latter were found in the effluent relative to those in the influent.

Radionuclide concentration data for the former site boundary sampling location (M) and at the present site boundary (Q) are also shown in Tables 11A and 11B. Stream flow at station M was measured using a v-notch weir. Proportional stream sampling was conducted based on stream flow measurements. From June to October, accurate flow measurements were not possible due to equipment failure and flow rates which exceeded the measurement capability of the v-notch weir. During this period, grab samples and non-proportional continuous samples were collected at this station. Total activity values listed in Tables 11A and 11B were calculated using the activity concentration measurements from the available

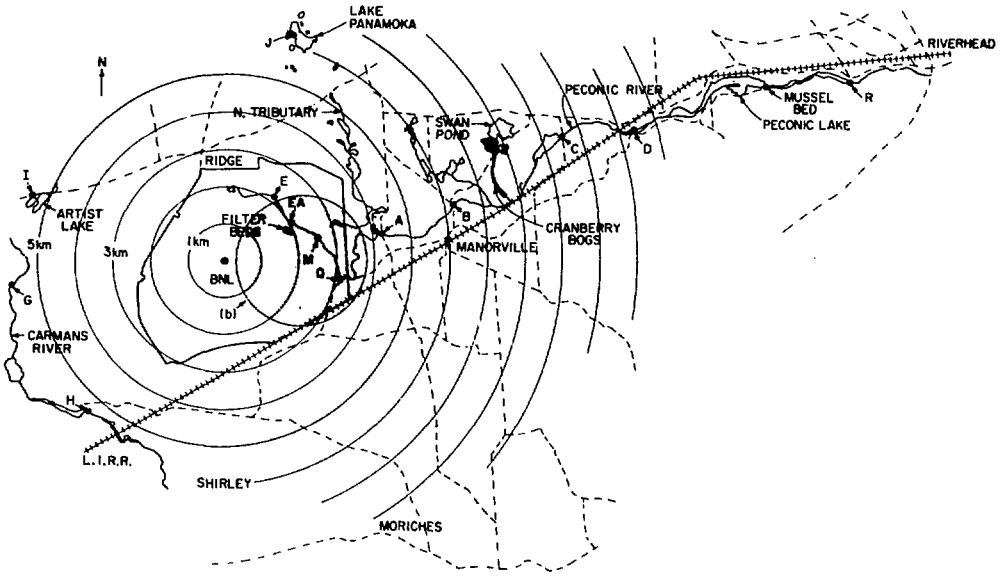


Figure 5. (a) Peconic River: On-site and downstream sampling locations.

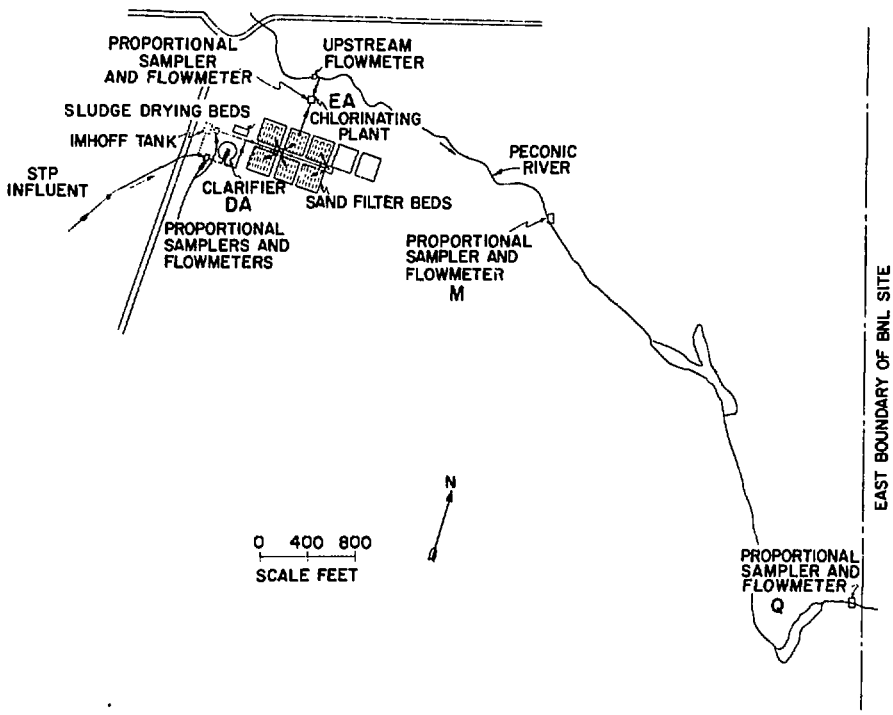


Figure 5. (b) Sewage treatment plant: Sampling locations.

Table 11A
1983 BNL Environmental Monitoring
Sewage Treatment Plant and Peconic River
Average Radionuclide Data

Month	Location[a]	Gross α [b]	Gross β [c]	^{90}Sr[d]	^{3}H[e]	Location[a]	Gross α [b]	Gross β [c]	^{90}Sr[d]	^{3}H[e]
		(pCi/l)			(nCi/l)		(pCi/l)			(nCi/l)
Jan.	Sewage	1.96	11.81	0.64	4.42	Sewage	1.49	8.80	g	4.73
Feb.	Treatment	1.55	7.53	0.81	6.46	Treatment	1.68	6.59	0.28	5.88
Mar.	Plant	1.54	7.02	0.65	2.26	Plant	1.51	6.42	0.82	1.92
April	Influent	1.35	8.69	0.12	1.47	Effluent	1.44	8.30	0.65	1.30
May	(DA)	1.65	9.13	0.15	2.41	(EA)	1.51	7.07	0.47	2.08
June		1.44	6.82	0.12	5.34		1.47	6.40	0.60	4.70
July		1.67	16.61	0.18	16.06		1.47	10.06	0.16	20.42
Aug.		1.38	12.35	0.17	10.47		1.56	12.39	0.34	12.09
Sept.		1.29	6.58	0.56	21.08		1.33	6.40	0.61	20.06
Oct.		1.38	10.82	0.22	4.55		1.35	8.26	0.46	7.79
Nov.		1.26	10.32	2.91	6.63		1.17	4.20	0.29	7.49
Dec.		1.33	5.55	0.67	2.01		1.32	4.83	1.84	2.22
Annual Average		1.47	9.58	0.57	7.41		1.44	7.65	0.59	7.96
			mCi					mCi		
Total		1.85	12.1	0.72	9,340		1.39	7.39	0.57	7,690
Jan.	Former Site	1.42	7.73	f	6.33	Site	g	g	g	g
Feb.	Perimeter[h]	1.58	5.40	f	5.59	Boundary[i]	1.47	5.59	f	4.21
Mar.	(M)	1.44	5.75	0.61	1.49	(Q)	1.50	4.62	f	1.10
April		1.20	4.67	f	0.94		1.32	3.18	f	0.88
May		1.46	4.00	f	0.83		1.56	3.41	f	1.06
June		1.47	4.12	0.51	2.45		1.37	3.62	0.51	2.03
July		1.52	6.78	f	4.69		1.59	6.70	f	12.78
Aug.		1.51	9.05	f	6.12		1.61	7.89	f	6.43
Sept.		1.36	8.20	0.41	29.92		1.43	5.74	0.41	15.81
Oct.		1.35	16.23	f	4.91		1.33	9.94	f	7.19
Nov.		1.22	3.93	f	6.14		1.24	4.24	f	6.19
Dec.		1.41	4.26	0.60	1.43		1.37	3.92	0.60	7.25
Annual Average		1.43	7.23	0.51	6.76		1.32	4.90	0.51	5.40
			mCi					mCi		
Total		1.96	9.98	0.71	9,290		2.72	10.1	1.05	11,200

Month	Plant Influent	Plant Effluent	Former Perimeter
	Flow		
	(1×10^7 l)	(1×10^7 l)	(1×10^7 l)
Jan.	7.66	6.86	6.03
Feb.	7.88	7.31	7.46
Mar.	9.82	8.54	10.71
April	10.75	8.57	6.39
May	10.54	5.83	11.40
June	10.13	8.03	h
July	10.95	9.52	h
Aug.	15.04	10.15	h
Sept.	12.30	7.99	h
Oct.	11.54	8.45	h
Nov.	10.38	7.31	5.48
Dec.	9.10	8.02	10.0

(a) Locations shown in Figure 5.
(b) Counting error is ≤ 40%.
(c) Counting error is ≤ 25%.
(d) Counting error is ≤ 10%.
(e) Counting error is ≤ 20%.
(f) Below the minimum detection limit (0.09 pCi/l).
(g) No sample analyzed.
(h) For the June-October period, calculations were based on average monthly flow (1973-81) of 1.6×10^8 liters.
(i) All calculations based on average monthly flow (1973-81) 1.7×10^9 liters.
Applicable Standards - See Table 17

Table 11B
1983 Environmental Monitoring
Sewage Treatment Plant and Peconic River
Gamma Spectroscopy Data

Location[a]	Month	^{51}Cr	^{60}Co	^{65}Zn	^{137}Cs	^{7}Be	^{83}Rd	^{84}Rb
		(pCi/l)						
Sewage Treatment Plant Influent (DA)	Jan.	2.6	6.0	2.4	0.55	b	b	b
	Feb.	b	1.3	0.20	0.41	0.87	b	b
	Mar.	0.29	1.5	1.1	0.77	0.31	b	b
	April	0.84	1.5	0.77	0.16	0.51	b	b
	May	b	1.2	0.37	0.28	0.93	b	b
	June	b	1.0	0.20	0.11	0.62	0.26	0.41
	July	0.57	1.5	0.017	0.096	0.50	0.22	1.4
	Aug.	1.2	1.4	0.11	0.15	0.27	0.77	0.38
	Sept.	0.42	0.60	b	0.19	0.60	0.11	0.068
	Oct.	0.25	1.4	0.18	0.18	0.58	b	b
	Nov.	0.97	0.44	0.095	0.51	0.38	0.094	b
	Dec.	b	0.71	0.070	0.37	1.6	b	b
Annual Average		0.59	1.44	0.40	0.29	0.58	0.15	0.21
		mCi						
Annual Total		0.74	1.8	0.51	0.37	0.74	0.19	0.26
		pCi/l						
Sewage Treatment Plant Effluent (EA)	Jan.	0.49	1.2	0.90	0.92	b	b	b
	Feb.	b	0.33	0.67	1.6	b	b	b
	Mar	b	0.44	0.66	1.3	b	b	b
	April	0.50	0.84	0.54	1.4	b	b	b
	May	b	b	b	0.040	b	b	b
	June	0.42	0.70	0.16	1.4	b	b	b
	July	b	1.1	0.18	1.7	b	1.1	0.57
	Aug.	b	1.1	0.079	1.3	b	0.57	0.27
	Sept.	b	0.71	0.25	2.4	b	1.1	0.38
	Oct.	b	0.47	0.17	1.2	b	b	b
	Nov.	b	0.22	0.083	0.57	b	0.034	b
	Dec.	b	0.27	0.12	0.57	b	b	b
Annual Average		0.12	0.65	0.31	1.24	b	0.26	0.12
		mCi						
Annual Total		0.12	0.62	0.30	1.20	b	0.25	0.11
		pCi/l						
Former Site Perimeter (M)[c]	Jan.	b	0.78	0.76	0.96	b	b	b
	Feb.	b	0.38	0.54	1.2	b	b	b
	Mar.	b	0.71	0.34	0.85	0.62	b	b
	April	no sample						
	May	b	0.74	b	0.63	b	b	b
	June	b	0.81	b	0.83	b	b	b
	July	b	1.0	b	1.4	b	0.68	b
	Aug.	b	3.7	b	2.7	b	1.4	b
	Sept.	b	2.8	b	2.6	b	0.87	b
	Oct.	no sample						
	Nov.	b	0.27	b	0.60	b	b	b
	Dec.	b	0.68	b	0.63	b	b	b
Annual Average		b	1.2	0.089	1.2	0.049	0.35	b
		mCi						
Annual Total		b	1.6	0.12	1.6	0.066	0.47	b
		pCi/l						
Site Boundary (Q)[d]	Jan.	no sample						
	Feb.	no sample						
	Mar.	no sample						
	April	no sample						
	May	b	0.44	b	0.65	b	b	b
	June	b	0.57	b	1.0	b	b	b
	July	b	0.93	b	1.5	b	b	b
	Aug.	b	2.0	b	2.7	b	b	b
	Sept.	no sample						
	Oct.	b	0.47	0.2	0.97	b	b	b
	Nov.	b	0.25	0.054	0.40	b	b	0.047
	Dec.	no sample						
Annual Average		b	0.39	0.022	0.60	b	b	0.0039
		mCi						
Annual Total		b	0.80	0.045	1.24	b	b	0.0081

(a) Locations are shown in Figure 5. Plant influent and effluent flows are shown in Table 11.A

(b) Below the Minimum Detection Limit. See Appendix B

(c) Calculations based on average monthly flow (1973-81 data) of 1.6×10^8 liters for the June-October period.

(d) All calculations based on average monthly flow (1973-81 data) of 1.7×10^9 liters.

Applicable Standards - See Table 17

sampling regimes and an average monthly flow estimated from data collected between 1973 and 1981.

At station Q, obstructions in the stream beyond the site perimeter raised the water level on the down side of the v-notch weir to a point where this measuring device is no longer effective at measuring the flow of the Peconic River. Consequently, all samples collected at this station were either grab or non-proportional continuous samples. Total activity released at the site boundary were calculated using the activity concentrations measured from the available sampling regimes and the average monthly flow as determined from the period 1973 to 1981.

Analysis of monthly composite samples of the Peconic River at the former site boundary (0.8 km downstream from the chlorine house) during this period showed that, on the average, <1% of the annual total activity (excluding tritium) consisted of ^{90}Sr and that no appreciable amounts of long-lived radioactive iodine or bone-seeking nuclides such as radium were present. At the Laboratory perimeter (2.6 km downstream from the chlorine house), where flows were calculated from the nine year average, the average concentration of ^{90}Sr was 1.05 pCi ℓ^{-1}. Since the Peconic is not a direct source of drinking water, the applicable RCG was 300 pCi l^{-1} (0.3×10^{-6} μCi ml^{-1}) (14).

Radionuclide measurements were also performed on samples of water collected from the Peconic River upstream of the effluent discharge point, the north tributary to the Peconic, and at downstream sampling stations. As shown in Figure 5A, the specific sampling locations were as follows:

Off-Site (Peconic River, proceeding downstream)

A - Peconic River at Schultz Road, 4.85 km downstream,

R - Peconic River at Riverhead, 19.35 km downstream,

Controls

E - Peconic River, upstream from the Laboratory effluent outfall,

F - Peconic River, north tributary (independent of the Laboratory drainage area),

H - Carmans River, outfall of Yaphank Lake,

A summary of the radiological data for 1983 is shown in Table 11C. From the table it is seen that the concentrations remained well below the applicable RCG.

Measurements of selected water quality and purity parameters were performed at the Sewage Treatment Plant, at the monitoring stations on the Peconic River, and at control locations in order to provide a comparison with the same parameters in the Laboratory effluent. These limited "grab" sample data are shown in Table 12. The results indicate that, in general, the levels

Table 11C
1983 BNL Environmental Monitoring
Peconic River and Control Samples, Average Radionuclide Data

Location[a]	Quarter	No of Samples	Gross α	Gross β	3H	^{90}Sr	^{137}Cs	^{7}Be	^{60}Co	^{22}Na
			pCi/l		nCi/l	pCi/l				
HH	1st	0								
	2nd	1	0.24	1.51	0.18					
	3rd	1	0.32	0.59	0.19					
	4th	0								
	Annual Average		0.28	1.05	0.19	Analysis not done				
HE	1st	8	1.50	2.65	0.81					
	2nd	21	1.44	3.38	0.79					
	3rd	19	1.47	3.86	0.93					
	4th	23	1.28	4.44	0.77					
	Annual Average		1.40	3.77	0.82	Analysis not done				
HF	1st	0								
	2nd	1	0.30	1.20	0.18					
	3rd	1	0.34	1.57	0.19					
	4th	0								
	Annual Average		0.32	1.39	0.19	Analysis not done				
HA	1st	0								
	2nd	1	0.36	2.78	0.18					
	3rd	1	0.31	1.84	0.19					
	4th	0								
	Annual Average		0.33	2.31	0.19	Analysis not done				
HR	1st	0								
	2nd	6	0.28	1.93	0.93	0.37	0.29	1.4	b	b
	3rd	8	0.26	1.98	0.38	0.35	0.16	0.64	0.15	0.039
	4th	4	0.22	1.72	0.19	0.50	Analysis not done			
	Annual Average		0.27	1.93	0.72	0.41	0.23	1.02	0.15	0.039

(a) Locations shown in Figure 5.

(b) Below the minimum detection limit.

Table 12

1983 BNL Environmental Monitoring

Sewage Treatment Plant, Peconic River, and Off-site Locations[b]

Average Water Quality and Metals Data

Location	pH (SU)	Conductivity (μmhos/cm)	Dissolved Oxygen	Chlorides	Nitrate-Nitrogen	Total Phosphorous	Dissolved Solids	Ag	Cd	Cr	Cu	Fe	Pb	Zn
								mg/l						
Peconic River														
Sewage Treatment Plant Influent (DA)	5.6-8.9				a			<0.01	0.004	<0.03	0.095	0.418	0.01	0.108
Sewage Treatment Plant Effluent (EA)	5.6-7.0	165	8.8	29.7	3.07	0.70	183	<0.01	0.003	<0.03	0.084	0.151	<0.0004	0.275
Former Perimeter (M)	4.8-10.0	130	9.0	23.2	2.31	0.44	147	<0.01	0.003	<0.03	0.131	0.787	<0.004	0.065
Site Perimeter (Q)	5.1-7.2	115	5.5	22.4	0.99	0.45	89			a				
4.85 km Downstream (A)	6.3-6.5	58	3.2	8.5	0.49	0.14	57			a				
19.35 km Downstream (R)	5.7-7.2	85	9.3	13.1	0.43	0.04	86			a				
Control														
Upstream of Laboratory Outfall (E)	4.1-6.8	62	5.2	12.8	0.21	0.05	74			a				
North Tributary into Peconic River (F)	6.0-6.2	39	2.4	6.8	0.47	0.03	33			a				
Carmen's River (H)	7.1-7.2	94	9.8	8.8	1.05	0.04	86			a				

a: Analysis not done.

b: Locations shown in Figure 5.

decreased with distance from the treatment plant outfall to levels comparable with the control locations. Metal concentrations reflect ambient levels.

3.3.3 Recharge Basins:

After use in "once through" heat exchangers and process cooling, on the average 15.5 million 1 d^{-1} (MLD) of water was returned to the aquifer through on-site recharge basins; 6.64 MLD to basin N located about 610 m northeast of the AGS; 5.16 MLD to basin O about 670 m east of the HFBR; and 3.62 MLD to basin P located 305 m south of the MRR (see Figs. 6 and 7). A polyelectrolyte and dispersant is added to the AGS cooling and process water supply, to maintain a phosphate concentration of about 2 ppm in order to maintain the ambient iron in solution. Of the total AGS pumpage, on the average, 2.21 MLD was discharged to the N basin, and 2.92 MLD to the O basin. The HFBR secondary cooling system water recirculates through mechanical cooling towers and is treatd with inorganic polyphosphate and mercaptobenzothiozone to control corrosion and deposition of solids. Blowdown from this system, 2.24 MLD, which contained about 6-8 ppm inorganic polyphosphate and 3-4 ppm mercaptobenzothiozone, was also discharged to the O basin. The untreated MRR-MRC "once through" coolant (3.62 MLD), after adjustment to a neutral pH, was discharged to the P basin.

Concentrations of radioactivity and other constituents in the water discharged into these and other smaller basins are monitored by grab sampling. The average concentrations of gross beta and tritium activity, water quality parameters, and concentrations of heavy metals are given in Table 13. The average concentrations of gross beta activity in the basins were slightly above background. The N basin receives water that has been used to cool the LINAC beam stops at the AGS; the process results in the formation of short lived activation products that are released to the N basin. The average concentration of gross beta activity discharged to the N basin was about 10% of the EPA Drinking Water Compliance Level Standard [15]. In general, the average concentrations of gross beta and tritium activity in the other basins were slightly above those in the Laboratory supply wells and on the average, were about 5% of the applicable Drinking Water Standards [15,17].

In general, water quality results were within established standards for ground water. Elevated Fe and Cu concentrations indicate effects of chemical treatment in the cooling water systems. Recharge basin S receives storm water runoff. The slightly elevated levels of conductivity and chlorides apparently reflect the practice of road-salting during winter storm conditions.

3.3.4 Aquatic Biological Surveillance:

Fish were collected at Donahue's Pond (Peconic Lake) and were analyzed for gamma emitters. ^{137}Cs was the only radionuclide found in detectable concentrations above the MDL. The activity level of ^{137}Cs in edible flesh was 174 pCi/kg(wet).

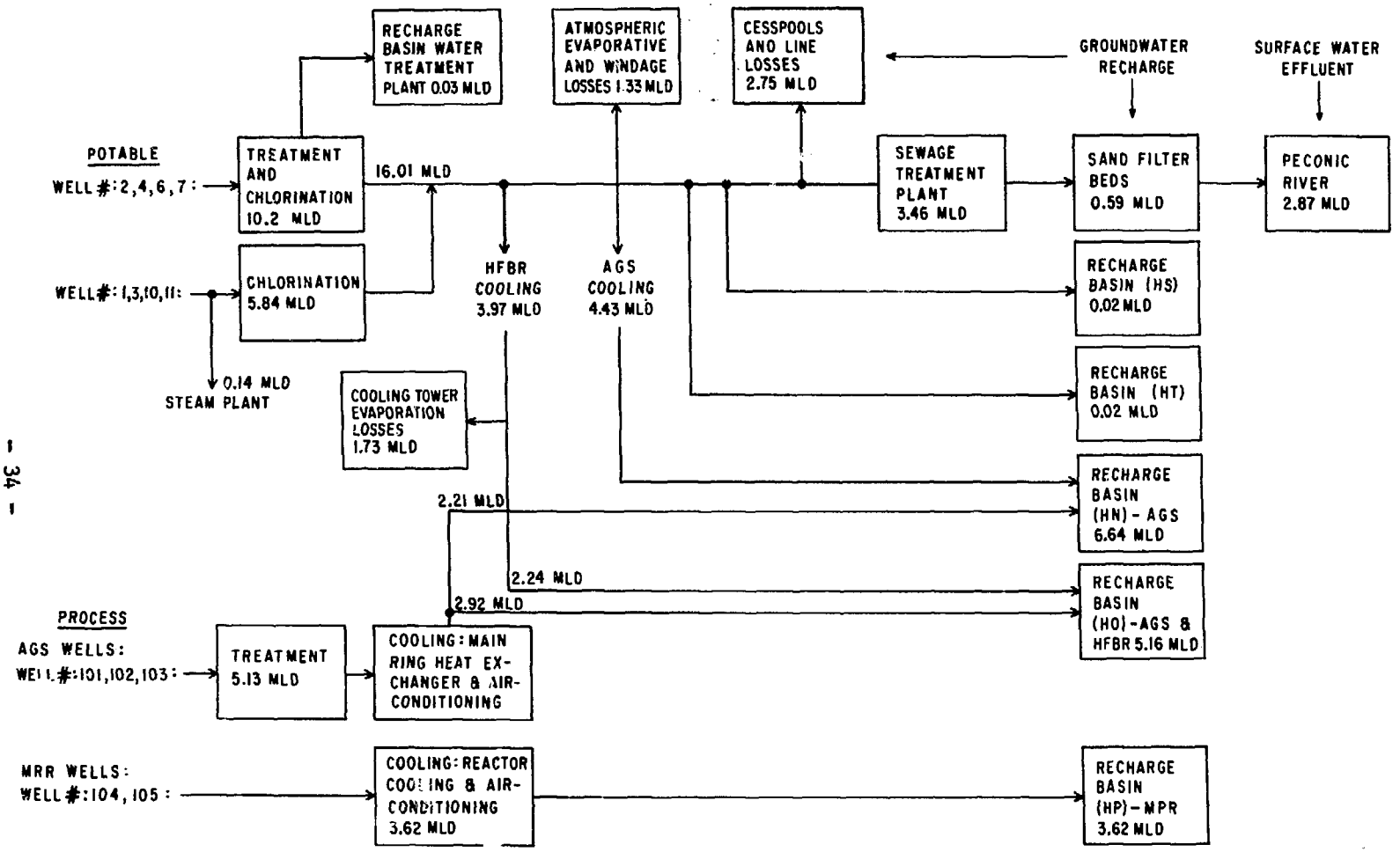


Figure 6. Brookhaven National Laboratory: schematic of water use and flow.

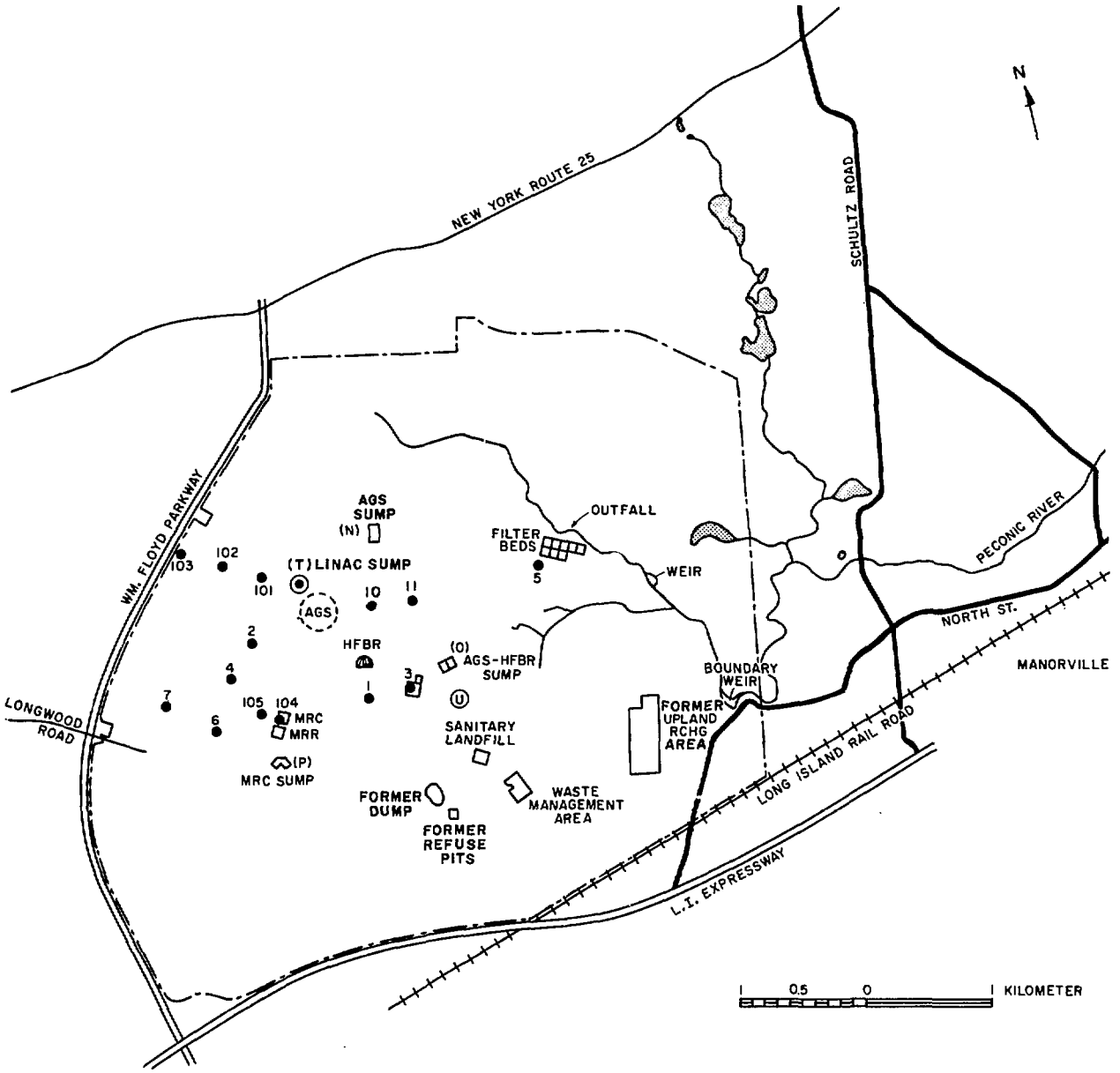


Figure 7. On-Site: Potable and supply wells and recharge sumps.

Table 13

1983 BNL Environmental Monitoring

Recharge Basins

Average Radionuclide, Water Quality, and Metals Data

Location[a]	No. of Samples[b]		Gross α (pCi/l)	Gross β (pCi/l)	^3H (pCi/l)	Tempera- (°C)	pH (SU)	Conductivity (μmhos/cm)	Dissolved Oxygen (mg/l)	Chlorides (mg/l)	Nitrates-Nitrogen (mg/l)	Total Phosphorous (mg/l)	Ag (mg/l)	Cd (mg/l)	Cr (mg/l)	Cu (mg/l)	Fe (mg/l)	Pb (mg/l)	Zn (mg/l)
		Minimum	<0.11	<0.30	<180	11	6.1	83	7.8	14.5	0.09	<0.01				<0.02	1.81		0.014
HN	9 (9,4)	Maximum	1.62	15.85	430	22	7.2	118	11.2	18.7	0.80	0.48				0.763	2.56		0.056
(North of AGS		Mean	0.50	4.95	200	15		96	10.0	16.9	0.33	0.15	<0.01	<0.006	<0.03	0.227	2.23	<0.005	0.034
		Minimum	<0.11	<0.30	<180	12	6.7	98	8.0	12.0	0.09	<0.01					0.58		<0.006
HO	8 (4,2)	Maximum	0.54	3.87	240	21	7.2	200	11.0	23.7	0.71	1.16					0.83		0.21
(East of HFBR)		Mean	0.35	2.23	190	18		158	9.5	17.3	0.50	0.53	<0.01	<0.006	<0.03	<0.02	0.71	<0.005	0.11
		Minimum	<0.11	<0.30	<180	1	6.2	142	3.5	2.5	0.59	<0.01					0.36		<0.006
HP	7 (7,3)	Maximum	0.37	2.06	380	2	7.4	200	7.9	27.8	1.64	0.03					1.36		0.008
(South of MRR)		Mean	0.25	1.28	230	15		166	6.0	20.6	1.18	0.01	<0.01	<0.006	<0.03	<0.02	0.85	<0.005	0.007
		Minimum	<0.11	<0.30	<180	11	5.0	95	7.8	17.5	0.21	<0.01				<0.02	0.09		<0.006
HT	9 (8,4)	Maximum	0.30	2.57	400	20	7.8	150	11.9	25.0	1.17	0.65				0.038	0.28		0.042
(North of Linac)		Mean	0.26	1.27	210	15		120	10.7	21.1	0.50	0.13	<0.01	<0.006	<0.03	0.027	0.16	<0.005	0.022
HS	(46)	Minimum				1	5.4	30	1.8	4.2	0.05	<0.01							
(South of		Maximum				22	8.3	475	15.6	81.1	3.19	4.20							
Warehouse)		Mean	---------- c ----------			13		164	9.8	27.3	0.88	0.42	---------- c ----------						
NYS Drinking Water Standard	(23)					--	6.5-8.5	--	--	250.0	10.0	--	0.05	0.01	0.05	1.0	0.30	0.025	5.0

a. Locations shown in Figure 7.

b. Numbers in parentheses indicate number of samples analyzed for water quality and metal parameters, respectively.

c. Analysis not done.

3.3.5 Surveillance Wells:

3.3.5.1 Potable Water and Process Supply Wells:

The Laboratory's potable water wells and cooling water supply wells are screened at a depth of about 30 m, about 15 m below the water table, in the Long Island surface layer of glacial outwash, sand and gravel. As shown in Figure 7, most of these wells are located west to north of the Laboratory's principal facilities which is 'upstream' of the local groundwater flow pattern. As indicated in Figure 6, about 25 MLD was pumped from them in 1983.

Grab samples were obtained from these wells. These were analyzed for radioactivity and water quality. The results are shown in Tables 14A and 14B. All gross alpha concentrations were <1 pCi/liter. With the exception of one well, all tritium concentrations were at or near the MDL. The tritium concentration at this well, 500 pCi/ℓ, was 2.5% of the Drinking Water Standard. There are some fluctuations in the gross beta concentrations among these wells but the variations are not considered significant. Concurrently, potable water is routinely tested for water quality as part of the Suffolk County Water Authority Compliance Assurance Program.

3.3.5.2 Groundwater Surveillance:

Samples of groundwater were obtained from a network of shallow surveillance wells which have been installed in the vicinity of several locations where a potential has existed for the percolation of radioactivity or other pollutants from the surface downward into the saturated zone of groundwater. These include areas adjacent to the on-site recharge basins, the sand filter beds, the Peconic River, the solid waste management area, the former landfill, the current landfill and the decontamination facility sump. The locations of most of these groundwater surveillance wells are shown in Figure 8, except for those installed at the landfill and solid waste management area which are shown in Figure 9.

For convenience in assessing the data, the wells have been divided into several groups. Yearly average radionuclide concentrations of the wells adjacent to the sand filter beds, and downstream on the Peconic River are summarized in Table 15A. Corresponding data for wells downstream (with reference to groundwater movement) of the solid waste management area, the current and former landfills, and the decontamination facility sump (about 1 km east of the HFBR) are summarized in Tables 15B and 15C. Since the aquifer underlying Nassau and Suffolk Counties has been designated as a "Sole Source" (23), the EPA and NYS Drinking Water Standards are applicable (15,17). The data, therefore, are evaluated in terms of these standards.

In analyzing the data over the past decade, it is apparent that the spread of radioactivity in the groundwater from Laboratory operations has remained within a few hundred meters of the identifiable foci. Above background concentrations of gross beta emitters, tritium, and ^{90}Sr have been found on-site adjacent to the sand filter beds and the Peconic River. In 1983, they ranged from 1-9% for gross alpha, 1-11% for gross beta, 1-40% for ^{3}H, and 1-56% for ^{90}Sr of the Drinking Water Standards (15,17). Adjacent to the Peconic River at

Table 14A
1983 BNL Environmental Monitoring
Potable and Cooling Water Wells
Average Radionuclide Data

Well ID[a]	No. of Samples	Gross α	Gross β	^{3}H
		pCi/l		
1	2	0.32	6.33	500
2	2	0.69	1.45	210
3	2	0.28	2.86	<200
4	2	0.43	1.19	<200
5	2	0.48	1.06	<200
6	2	0.46	1.33	<200
7	2	0.50	1.22	<200
102	2	0.31	1.65	<200
105	1	<0.33	1.69	<200
NYS Drinking Water Standard (15)		15	50[b]	20,000

(a) Locations of Potable and Cooling Water Wells are shown in Figure 7.

(b) Compliance level.

Table 14B

1983 BNL Environmental Monitoring

Potable and Cooling Water Wells,

Average Water Quality and Metal Data

Well ID [a]	No. of Samples	Temperature (°C)	pH (SU)	Conductivity (μmhos/cm)	Dissolved Oxygen	Chlorides	Nitrate-Nitrogen	Total Phosophorous	Dissolved Solids	Ag	Cd	Cr	Cu	Fe	Pb	Zn
										mg/l						
1	2	13	5.8-5.9	107	7.2	14.8	0.98	<0.01	113	<0.001	<0.0006	<0.003	0.012	0.07	<0.004	0.035
2	2	14	5.6-6.1	111	6.9	18.6	1.07	0.02	123	<0.001	<0.0006	<0.003	0.117	0.26	<0.004	0.013
3	2	15	6.0-6.7	95	7.0	17.6	0.34	0.06	108	<0.001	<0.0006	<0.003	0.056	0.06	<0.004	0.008
4	2	11	5.7-6.0	83	6.5	16.8	0.43	<0.01	94	<0.001	<0.0006	<0.003	0.006	2.22	<0.004	0.003
5	2	13	5.3-6.8	43	7.8	5.3	0.13	<0.01	54	<0.001	<0.0006	<0.003	0.007	0.11	<0.004	0.080
6	2	12	5.3-6.0	124	6.0	26.6	0.82	<0.01	124	<0.001	<0.0006	<0.003	0.004	4.43	<0.004	0.003
7	2	12	6.0-6.0	69	5.7	12.6	0.12	0.03	84	<0.001	<0.0006	<0.003	0.011	1.14	<0.004	0.008
10	2	12	6.1-6.1	94	7.4	17.2	0.17	<0.01	b	<0.001	<0.0006	<0.003	0.008	0.006	<0.004	0.006
11	2	11	5.8-6.1	83	6.7	11.4	0.38	<0.01	95	<0.001	<0.0006	<0.003	0.006	0.027	<0.004	0.005
102	2	11	5.6-5.9	69	6.5	14.1	0.32	0.37	86	<0.001	<0.0006	<0.003	0.013	3.33	<0.004	0.020
105	1	13	6.0	145	5.9	24.2	0.59	<0.01	b	<0.001	<0.0006	<0.003	0.012	0.64	<0.004	0.005
Tap Water[c]	50	b	b	b	b	18.7	0.62	<0.01	b	--	--	--	b	b	b	b
EPA Drinking Water Standard (13)		--	--	--	--	--	10.0	--	--	0.050	0.010	0.050	--	--	0.050	--
NYS Drinking Water Standard (15)		--	6.5-8.5	--	--	250.0	10.0	--	500	0.050	0.010	0.050	1.0	0.3	0.025	5.0

(a) Locations of Potable and Cooling Water Wells are shown in Figure 7.

(b) No analysis done.

(c) Tap Water from Building 535.

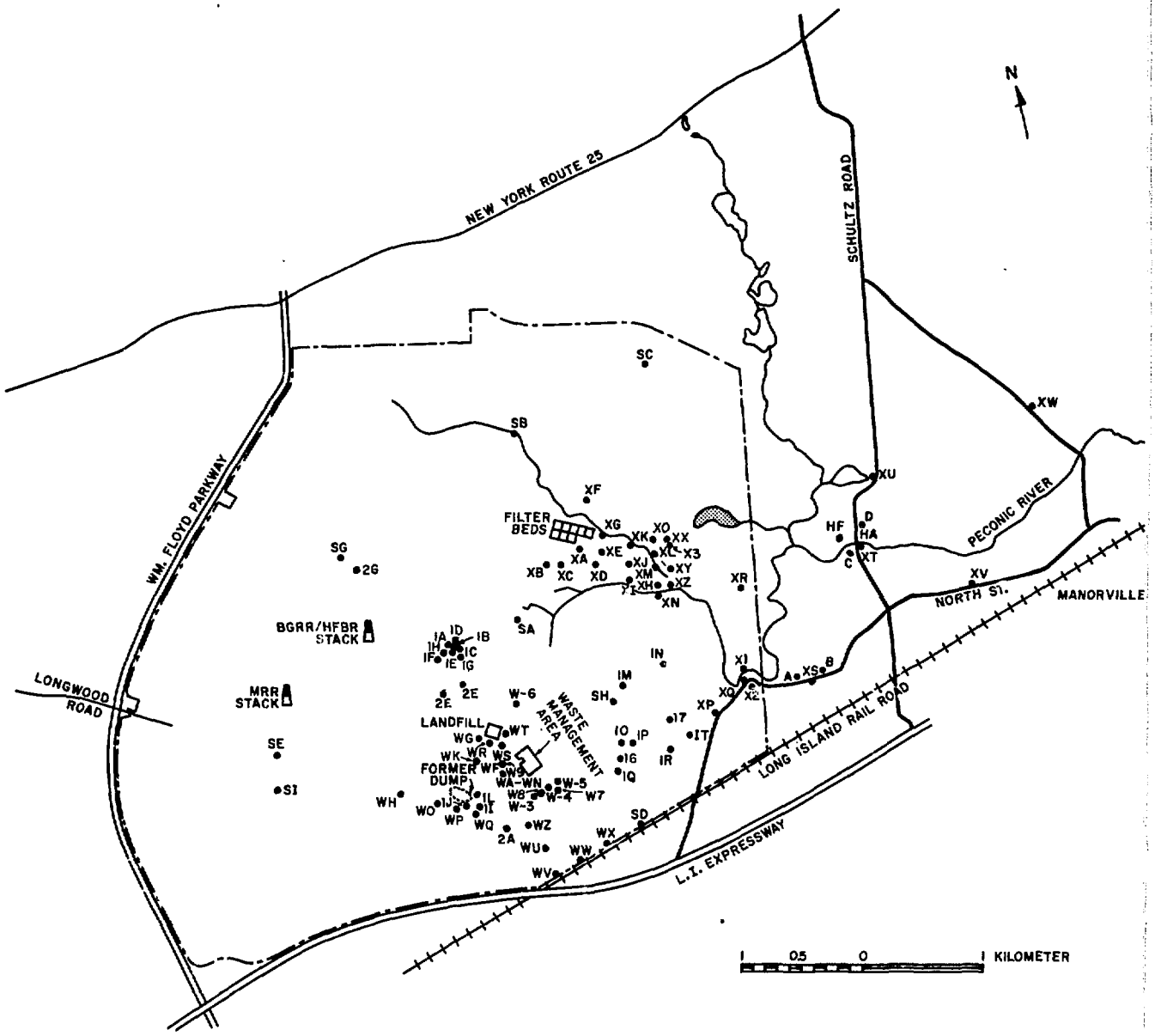


Figure 8. Location of groundwater surveillance wells.

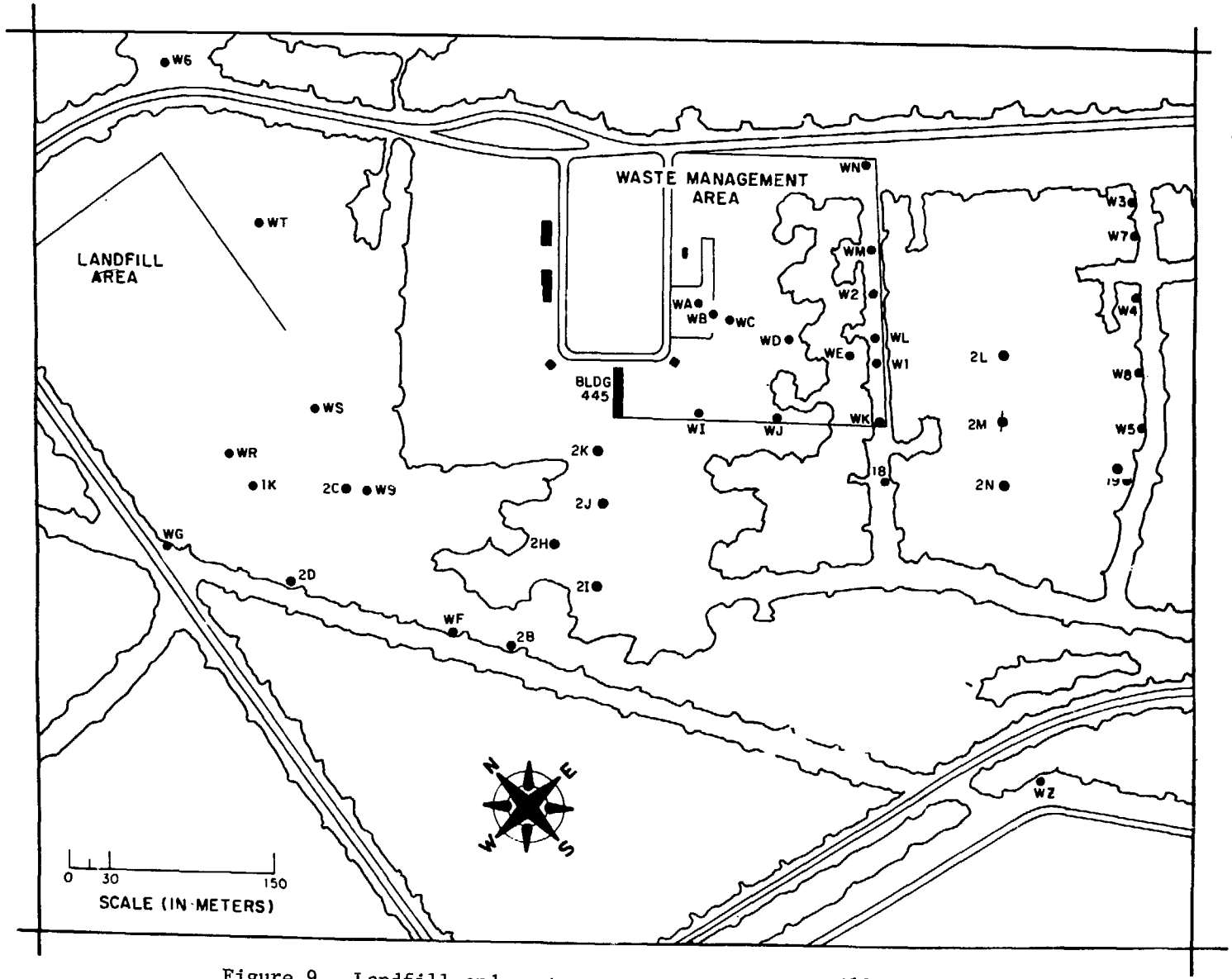


Figure 9. Landfill and waste management area surveillance wells.

Table 15A
1983 BNL Environmental Monitoring
Sand Filter Beds and Peconic River
Ground Water Surveillance Wells, Average Radionuclide Data

Well ID	No. of Samples Analyzed	Gross α	Gross β	^{3}H	^{90}Sr	^{60}Co	^{137}Cs
		pCi/l					
XB	1	0.31	2.6	210	0.25	a	a
XC	1	1.3	3.3	240	1.94	a	a
XA	2	0.45	3.7	7500	1.22	0.98	a
XD	2	0.18	0.49	180	<0.10	a	a
XE	2	0.28	0.98	180	0.51	a	a
XJ	2	0.29	0.87	180	0.93	a	a
XI	2	0.23	1.3	180	<0.10	a	a
XM	2	0.18	1.3	7900	0.81	a	2.7
XZ	1	0.40	1.8	890	b	a	a
XN	2	0.82	3.8	190	0.31	a	a
XF	2	0.19	0.62	230	<0.10	a	a
XK	1	0.23	4.60	3200	b	b	b
XO	1	0.11	0.30	200	2.45	0.41	a
XL	2	0.90	5.3	6200	4.44	a	a
XX	2	0.36	1.4	360	b	a	a
X3	2	0.38	1.4	190	1.53	a	a
XY	2	0.32	2.0	610	2.85	a	a
X1	2	0.25	1.3	180	b	b	b
X2	2	0.18	0.68	720	b	b	b
XS	1	0.27	3.5	4300	b	a	a
XT	1	0.18	1.1	190	1.20	a	a
XW	1	0.31	0.96	190	0.24	a	a
NYS Drinking Water Standards		15.0	50.0(c)	20,000	8.0		

(a) Below the minimum detection limit.
(b) Indicates no sample analyzed.
(c) Compliance level.

Applicable standards - See Appendix B

Table 15B
1983 BNL Environmental Monitoring
Waste Management Area
Ground Water Surveillance Wells, Average Radionuclide Data

Well ID	No. of Samples Analyzed	Gross α	Gross β	^{3}H	^{90}Sr	^{137}Cs	^{60}Co	^{22}Na	^{65}Zn
		pCi/l							
WI	2	0.16	2.2	220	0.12	a	a	a	a
WJ	2	0.24	4.2	1,900	0.79	0.05	a	0.083	a
WB	4	0.83	23.0	600	5.18	2.0	0.48	a	a
WC	4	1.4	16.0	760	3.38	0.36	0.10	0.81	a
WD	3	0.51	13.0	8,300	10.10	0.11	a	a	a
WE	4	0.34	14.0	560	6.20	0.06	a	a	a
W1	4	0.59	34.0	1,300	17.20	0.045	a	4.9	a
WK	4	0.64	39.0	6,500	28.55	a	0.055	4.3	a
WL	4	0.73	44.0	51,000	26.58	0.093	0.068	0.43	0.3
W2	3	1.5	39.0	1,900	20.70	a	a	0.21	a
WN	2	0.74	2.7	540	0.19	a	a	a	a
2L	2	0.20	0.57	190	0.11	0.18	a	a	a
2M	2	0.19	0.63	14,000	<0.09	a	a	a	a
2N	2	0.39	0.83	460	<0.09	a	a	a	a
W3	1	0.23	0.96	190	0.28	a	a	a	a
W7	1	0.11	0.30	180	0.10	a	a	a	a
W4	1	0.11	0.30	180	0.13	a	a	a	a
W8	1	0.11	0.30	180	<0.10	a	a	a	a
W5	1	0.11	0.30	180	<0.09	a	a	a	a
19	1	0.36	3.2	180	0.46	a	a	a	a
WU[b]	1	0.33	1.2	180	<0.10	a	a	a	a
WV[b]	1	0.50	3.6	180	0.09	a	a	a	a
WW[b]	1	0.11	0.30	180	0.20	a	a	a	a
NYS Drinking Water Standards		15.0	50.0[c]	20,000	8.0				

(a) Below the minimum detection limit. See Table 18.

(b) Wells are downgradient of Waste Management, Current Landfill, and Former Landfill.

(c) Compliance level.

Applicable standards - See Appendix B

Table 15C
1983 BNL Environmental Monitoring
Landfill Areas
Ground Water Surveillance Wells, Average Radionuclide Data

Well ID	No. of Samples Analyzed	Gross α	Gross β	^{3}H	^{90}Sr	^{137}Cs	^{60}Co	^{22}Na	^{65}Zn
		pCi/l							
Current Landfill									
W6	5	0.51	3.5	200	0.38	0.14	a	a	a
WT	4	1.3	1.3	200	0.23	0.15	a	a	a
WR	4	2.8	21.0	4,200	2.87	0.37	a	0.15	a
WS	4	3.9	26.0	7,700	2.42	a	a	2.0	a
1K	4	3.8	21.0	2,700	2.07	1.1	a	a	a
2C	4	3.0	30.0	7,800	5.89	a	a	0.38	a
W9	4	3.6	20.0	5,300	3.08	a	a	0.34	a
2D	1	6.3	25.0	250	2.82		no sample		
2H	2	0.33	4.5	910	2.38	a	a	0.46	a
2J	2	0.28	7.0	2,400	7.02	a	a	0.87	a
2K	2	0.37	8.6	1,100	2.83	a	a	0.42	0.17
2I	2	0.58	6.8	1,200	3.27	a	a	0.45	a
2B	2	0.20	0,99	180	0.36	a	a	a	a
2A	1	0.11	0.30	180	0.60	a	a	a	a
Former Landfill									
1I	1	0.23	1.0	190	<0.10	a	a	a	a
WP	1	0.28	1.7	190	0.46	a	a	a	a
IJ	1	0.23	0.53	190	<0.10	a	a	a	a
WQ	1	0.29	0.57	310	<0.20	a	a	a	a
WO	1	0.23	0.42	190	0.21	a	a	a	a
650 Sump									
1F	1	0.33	1.7	190	0.28	a	a	a	a
1A	2	0.52	71.0	180	53.9	a	a	a	a
1B	2	0.45	2.5	190	--		no sample		
1H	2	0.50	79.0	190	80.1	a	a	a	a
1D	2	0.27	1.6	180	0.44	a	1.0	a	a
1C	2	0.21	3.0	240	0.23	a	1.1	a	a
1E	2	0.35	41.0	190	46.5	a	a	a	a
1G	1	0.28	1.6	400	--	a	a	a	a
Miscellaneous Wells									
SE	1	0.67	8.49	190			no sample		
SG	1	0.29	0.70	250			no sample		
SI	1	0.29	1.42	190			no sample		
2F	1	0.29	4.83	250			no sample		
2G	1	0.36	1.32	190			no sample		
NYS Drinking Water Standards		15.0	50.0(b)	20,000	8.0				

(a) Below the minimum detection limit.
(b) Compliance level.

the site boundary (wells X1 and X2), the maximum gross beta and tritium concentrations were less than or equal to 3% and 4%, respectively, of the Drinking Water Standards. In 1978, samples of well water collected from homes and well XS (all of which are downstream with reference to groundwater movement of the Laboratory and the Peconic River) had indicated ^{90}Sr concentrations approaching one to two $pCi\ell^{-1}$. In 1982, all were <1 $pCi\ell^{-1}$, less than the EPA drinking water limit of 8 $pCi\ell^{-1}$ (15). An extensive study of wells throughout Suffolk County in 1979 indicated that, on the average, shallow wells contained greater concentrations of ^{90}Sr than deeper wells, regardless of their proximity to the Laboratory. This observation is attributed to fallout from past nuclear tests during the 1950's and early 1960's. In 1983, the maximum value observed for ^{90}Sr was 0.4 pCi/ℓ. The average ^{90}Sr concentration for the nine private wells adjacent to the Peconic River was 0.1 pCi/ℓ which indicates a continuing decline.

At the former landfill area, radionuclide concentrations ranged from nondetectable to background levels.

In several wells adjacent to the Waste Management area (Table 15B), the concentrations of gross beta activity, tritium and ^{90}Sr activity concentrations for 1983 showed some decline. However, several wells which had shown elevated levels of gross β and ^{90}Sr had increased in concentration for these radionuclides. When compared to 1982, wells W1, WK, WL, and W2 had higher gross β concentrations with W1, WK, and WL also exhibiting elevated ^{90}Sr concentrations. Wells W1 and WK also exhibited increases in tritium levels. Wells WD, W1, WK, WL, and W2 exceed the drinking water standards for ^{90}Sr and reflect the inadvertent injection of approximately one Ci of aged fission products into groundwater at well WA. Similarly, ^{137}Cs and certain activation products were detected in several wells downgradient of the injection point. The tritium levels observed in wells WL and 2M apparently indicate the migration of tritium from an as yet unidentified source at the Waste Management Area. The tritium concentration measured in well WL is a factor of 2.6 greater than the drinking water standard.

Gross beta concentrations were observed to decrease in several wells immediately adjacent to the landfill, i.e., WS, 1K, W9, and 2C. This is attributed both to the discontinuation of the disposal of radioactive waste on the landfill in 1976, as well as the movement and dilution of radioactivity in the ground water adjacent to it. Compared to 1982, data from wells downgradient of the current landfill indicated that ^{90}Sr levels have remained relatively constant or decreased in wells immediately adjacent to it. Tritium concentrations decreased in wells W9, 2H, and 2B. However, concentrations increased in wells 1K, 2C, 2D, 2J and 2K, indicating migration of ground water away from the landfill. The measured concentrations did not exceed the drinking water standards in any of the landfill monitoring wells.

At the decontamination facility (Bldg. 650) sump, radionuclide levels varied from those observed over the years. Gross beta and ^{90}Sr levels substantially declined in well 1H, but increased in wells 1A and 1E. The ^{90}Sr levels in these wells exceeded the EPA limits of 8 $pCi\ell^{-1}$. However, calculations done using groundwater travel times of 16.2 cm d^{-1} (7), the ^{90}Sr distribution coefficient for ion exchange, and distance to the nearest potential user of drinking water, lead to predicted travel times of about 60 years for ^{90}Sr from this loca-

tion to reach the site boundary. In addition to physical decay (covering a period of two ^{90}Sr half-lives), considerable dilution by infiltration of precipitation would also be anticipated. Based on the existing levels in the above wells, the Laboratory does not foresee that this could cause the concentrations of ^{90}Sr in any well off-site to exceed EPA drinking water limits. The Laboratory will continue monitoring in these areas as part of the ongoing program of ground water evaluation.

The groundwater surveillance also included the evaluation of several water quality and metal parameters. The data for wells adjacent to the sand filter beds and downstream of the Peconic River on- and off-site, are shown in Tables 15D and 15E. The data for wells adjacent to the solid waste management area (Tables 15F and G), the current and former landfill (Tables 15H and 15I), and the 650 sump and miscellaneous wells (Tables 15J and 15K) are also shown.

In general, the data for samples obtained from wells adjacent to the sand filter beds and the Peconic River were comparable to those observed during previous years. All analyzed water quality parameters were within New York State Water Quality Standards (17), with some exceptions for pH and Fe. The occasional lower pH levels appear to reflect natural ambient levels, since higher pH levels were present in the input to and output from the sewage treatment plant (see Table 10). Concentrations of Fe and Zn in excess of water quality standards were found in several wells throughout the site. The detection of Zn apparently reflects a well-casing effect, i.e., leaching of Zn from the galvanized pipe. The elevated levels of Fe in the current landfill monitoring wells are believed to reflect the practice of landfilling the Fe flocculant from the water treatment plant. It should be noted that high Fe concentration is indigenous to groundwater in this region. Zn and Fe are nuisance elements and do not pose significant health hazards. Consumer taste preference and staining of plumbing fixtures were the criteria used in the formulation of regulatory limits (34).

The general rate and direction of groundwater movement is 16.2 cm d^{-1} and predominantly in the southeast direction (6-8). It appears, therefore, that many years of travel time would be required for groundwater from on-site locations that contain small concentrations of radioactivity or other pollutants to reach an off-site well. Considerable dilution and decay will reduce the concentrations to levels significantly below the drinking water standards.

3.4 Unusual Occurrences:

3.4.1 Oil Spills:

During 1983, five minor oil spills (10-50 gallons) occurred on site. Clean-up procedures were instituted immediately, to interdict potential groundwater contamination. The absorbents used to clean up the spills were disposed of according to New York State Department of Environmental Conservation recommendations. Spills are reported to NYSDEC in accordance with the requirements set forth in the Laboratory's Spill Prevention, Control, and Countermeasures Plan.

Table 15D

1983 BNL Environmental Monitoring

Sand Filter Beds and Peconic River

Ground Water Surveillance Wells, Average Water Quality Data

Well ID	No. of Samples	Temperature (°C)	pH (SU)	Dissolved Oxygen	Chlorides	Nitrate-Nitrogen	Total Phosphorous	Dissolved Solids	Conductivity
				mg/l					(μmhos/cm)
XB	1	10	a	3.9	5.0	0.49	<0.01	a	65
XC	1	10	a	4.6	6.5	0.52	<0.01	a	44
XA	2	16	5.6-5.7	7.0	37.5	5.47	<0.01	173	180
XE	3	11	4.8-5.7	7.6	5.5	0.19	0.14	82	69
XD	2	10	5.4-5.6	5.1	3.3	0.11	0.03	38	40
XJ	2	11	4.8-5.3	5.7	5.8	0.21	0.02	47	38
XI	2	10	4.8-5.2	6.4	6.8	0.18	0.48	45	43
XM	2	15	5.8-6.6	8.4	23.2	0.08	0.06	a	124
XZ	1	9	5.3	3.8	13.5	0.11	<0.01	66	65
XN	2	11	5.2-5.6	2.3	7.1	0.86	0.02	115	54
XF	2	11	6.3-6.4	5.2	6.6	0.24	0.02	61	54
XK	1	9	6.1	7.2	25.0	0.13	0.02	a	140
XO	1	11	5.0	8.8	7.1	0.03	<0.01	a	44
XL	2	12	5.8-6.4	3.4	22.4	0.21	0.02	a	149
XX	2	10	5.7-6.0	4.2	12.4	0.05	<0.01	66	74
X3	1	13	4.6	5.8	6.1	0.04	<0.01	a	57
XY	2	12	5.1-5.4	3.8	8.8	0.05	<0.01	61	68
X1	1	9	5.3	10.7	3.1	<0.01	<0.01	a	38
X2	2	12	5.2-58	5.0	14.3	0.31	<0.01	a	74
XS	1	12	6.3	3.1	25.0	0.05	<0.01	a	128
XT	1	10	6.5	2.5	5.1	0.42	<0.01	a	a
XW	1	11	5.2	4.6	15.2	0.30	<0.01	a	155
NYS Drinking Water Standards		--	6.5-8.5	--	250.0	10.0	--	--	--

a: No analysis done.

Table 15E

1983 BNL Environmental Monitoring

Sand Filter Beds and Peconic River

Ground Water Surveillance Wells, Average Metals Data

Well ID	No. of Samples	Ag	Cd	Cr	Cu	Fe	Pb	Zn	Hg
		mg/l							
XB	1	<0.001	<0.0006	<0.003	0.005	2.18	0.014	4.140	<0.00003
XC	1	<0.001	<0.0006	<0.003	0.010	4.87	<0.004	0.900	a
XA	2	<0.01	<0.006	<0.03	<0.02	0.124	<0.005	0.317	a
XE	3	<0.01	<0.002	<0.01	<0.02	0.210	<0.005	1.082	a
XD	2	<0.01	<0.006	<0.03	<0.03	0.059	<0.005	0.239	a
XJ	2	<0.01	<0.006	<0.03	<0.03	0.474	<0.005	0.248	a
XI	2	<0.01	<0.006	<0.03	0.013	0.046	<0.005	0.254	a
XM	2	<0.01	<0.006	<0.03	0.033	17.1	0.028	1.890	<0.00005
XZ	1	<0.001	<0.0006	<0.003	<0.003	0.042	<0.004	0.297	a
XN	2	<0.01	<0.006	<0.03	0.011	4.695	<0.005	1.330	<0.00005
XF	2	<0.01	<0.006	<0.03	0.017	0.286	0.045	2.410	<0.00005
XK	1	<0.001	<0.0006	<0.003	0.005	2.700	<0.004	0.162	<0.00003
XO	1	<0.001	<0.0006	<0.03	<0.02	<0.03	<0.005	0.260	a
XL	2	<0.01	<0.006	<0.03	0.017	2.165	<0.005	0.210	<0.00004
XX	2	<0.01	<0.006	<0.03	0.011	6.905	<0.005	0.156	a
X3	1	<0.01	<0.006	<0.03	<0.02	<0.03	0.008	<0.006	a
XY	2	<0.01	<0.006	<0.03	0.012	0.140	<0.005	0.516	<0.00005
X1	1	<0.001	<0.0006	<0.003	<0.003	0.014	<0.004	0.750	a
X2	2	<0.01	<0.006	<0.03	<0.02	<0.03	0.005	0.151	<0.00004
XS	1	<0.001	<0.0006	<0.003	0.009	0.372	<0.004	0.040	a
XT	1	<0.01	<0.006	<0.03	<0.02	1.590	<0.005	0.140	<0.00005
XW	1	<0.01	<0.006	<0.03	<0.02	0.550	<0.005	0.170	a
NYS Drinking Water Standard		0.05	0.01	0.05	1.0	0.30	0.025	5.0	0.002

a: Analysis not done.

Table 15F

1983 BNL Environmental Monitoring

Waste Management Area

Ground Water Surveillance Wells, Average Water Quality Data

Well ID	No.of Samples	Temperature (°C)	pH (SU)	Dissolved Oxygen	Chlorides	Nitrate-Nitrogen	Total Phosphorous	Dissolved Solids	Conductivity (µmhos/cm)
				mg/l					
WB	4	13	5.0-5.8	6.0	10.1	1.26	<0.01	67	70
WC	4	12	4.5-5.7	5.1	9.1	0.93	<0.01	72	71
WD	3	12	5.4-6.1	9.5	10.6	1.41	<0.01	137	118
WE	4	11	5.6-6.0	10.0	3.4	0.16	<0.01	56	41
WI	4	11	5.6-5.8	9.7	4.3	0.33	<0.01	72	51
WJ	2	11	5.1-5.4	7.5	7.1	0.55	<0.01	79	64
WK	4	11	5.5-5.8	9.1	6.4	0.66	<0.01	88	79
18	1	10	5.2	3.8	9.0	0.46	<0.01	96	70
WL	4	11	5.7-6.1	9.6	7.5	1.04	<0.01	83	85
W2	3	11	6.0	8.4	10.0	1.53	<0.01	135	145
WN	2	11	5.8-6.0	8.0	8.9	0.29	<0.01	106	113
WI	2	11	5.2-5.8	6.4	5.9	0.11	<0.01	71	51
2L	2	10	5.0-5.5	4.3	14.1	1.16	<0.01	98	105
2M	2	10	4.3-5.6	2.5	7.7	0.84	<0.01	70	68
2N	2	10	4.5-5.7	2.9	13.8	0.28	<0.01	87	74
W3	1	10	5.1	8.0	5.1	1.94	<0.01	a	88
W7	1	10	6.4	7.5	14.6	0.38	<0.01	a	97
W4	1	10	6.2	9.8	6.6	0.05	<0.01	a	46
W8	1	12	6.5	10.4	8.1	0.04	<0.01	a	60
W5	1	10	6.2	9.5	a	a	a	a	a
19	1	9	5.7	10.9	9.1	0.03	<0.01	a	54
WU	1	11	6.7	7.8	12.6	0.03	<0.01	a	75
WV	1	13	6.8	7.6	13.6	<0.01	<0.01	a	108
WW	1	10	6.3	8.7	13.1	<0.01	<0.01	a	76
NYS Drinking Water Standards		--	6.5-8.5	--	250.0	10	--	--	--

a: No analysis done.

Table 15G

1983 BNL Environmental Monitoring

Waste Management Areas

Ground Water Surveillance Wells, Average Metals Data

Well ID	No. of Samples	Ag	Cd	Cr	Cu	Fe	Pb	Zn	Hg
		mg/l							
WI	2	<0.01	<0.006	<0.03	0.03	16.4	0.024	0.305	<0.00005
WJ	2	<0.01	<0.006	<0.03	0.017	0.692	0.024	0.422	<0.00005
WB	4	<0.01	<0.006	<0.03	<0.02	0.323	0.007	0.994	<0.00005
WC	4	<0.01	<0.006	<0.03	<0.02	0.488	<0.004	0.266	<0.00005
WD	3	<0.01	<0.006	<0.03	<0.02	0.147	0.013	1.15	<0.00005
WE	4	<0.01	<0.006	<0.03	<0.02	0.058	<0.005	0.382	0.00005
W1	4	<0.01	<0.006	<0.03	<0.02	0.055	<0.02	0.464	0.00006
WK	4	<0.01	<0.006	<0.03	<0.02	0.192	<0.005	0.359	0.00006
18	1	<0.001	<0.0006	<0.003	0.004	0.164	0.010	0.016	<0.00005
WL	4	<0.01	<0.006	<0.03	<0.02	0.141	0.008	0.506	0.00006
W2	3	<0.01	<0.006	<0.03	<0.02	0.513	0.055	0.773	<0.00005
WN	2	<0.01	<0.006	<0.03	0.012	0.176	0.037	0.110	<0.00005
2L	2	<0.01	<0.006	<0.03	0.022	1.106	<0.005	0.083	<0.00005
2M	2	<0.01	<0.006	<0.03	<0.03	0.274	<0.005	0.164	<0.00005
2N	2	<0.01	<0.006	<0.03	0.025	0.117	<0.005	0.090	<0.00005
W3	1	<0.01	<0.006	<0.03	<0.02	0.050	<0.005	0.640	a
W7	1	<0.01	<0.006	<0.03	<0.02	<0.03	0.009	0.510	<0.00005
W4	1	<0.01	<0.006	<0.03	<0.02	<0.03	0.009	0.510	<0.00005
W8	1	<0.01	<0.006	<0.03	<0.02	0.170	0.02	2.50	<0.00005
W5	1	<0.01	<0.006	<0.03	0.02	0.040	<0.005	0.390	<0.00005
19	1	<0.01	<0.006	<0.03	<0.02	<0.03	0.02	0.020	<0.00005
WU	1	<0.01	<0.00[illegible]	<0.03	<0.02	0.130	0.01	1.38	<0.00005
WV	1	<0.01	<0.006	<0.03	<0.02	0.150	0.01	6.87	<0.00005
WW	1	<0.01	<0.006	<0.03	<0.02	<0.03	0.01	1.34	a
NYS Drinking Water Standard		0.05	0.01	0.05	1.0	0.30	0.025	5.0	0.002

a: Analysis not done.

Table 15H

1983 BNL Environmental Monitoring

Landfill Areas

Ground Water Surveillance Wells, Average Water Quality Data

Well ID	No. of Samples	Temperature (°C)	pH (SU)	Dissolved Oxygen	Chlorides	Nitrate-Nitrogen	Total Phosphorous	Dissolved Solids	Conductivity (μ mhos/cm)
				mg/l					
Landfill Area									
WG	1	12	5.9	0.8	10.4	0.33	<0.01	a	215
WR	4	12	6.3-6.6	7.4	25.3	0.42	<0.01	372	635
WS	4	11	6.3-6.7	3.2	51.1	0.39	<0.01	372	695
WT	4	11	5.6-5.8	6.9	19.1	0.26	0.05	90	98
1K	4	11	6.3-6.6	5.3	23.2	0.35	0.03	344	585
2C	4	11	6.4-6.8	3.0	14.9	0.32	<0.01	392	634
2D	1	12	6.1	0.6	28.1	0.39	<0.01	a	600
W9	4	11	6.3-6.8	3.7	32.2	0.30	<0.01	324	545
2H	2	11	5.9-6.3	8.9	15.4	0.56	<0.01	75	81
2K	2	12	6.0-6.1	2.9	14.3	0.20	<0.01	81	97
2I	2	12	6.3-6.4	4.6	14.1	0.54	<0.01	80	99
2J	2	10	5.4-5.7	5.4	10.7	1.04	<0.01	67	77
2A	1	10	5.8	11.4	7.1	0.04	<0.01	a	49
W6	4	11	5.5-7.0	4.8	17.5	0.49	<0.01	265	295
Former Landfill Area									
1I	1	11	5.7	8.5	9.7	0.17	<0.01	a	65
WP	1	11	5.3	8.9	9.7	3.0	<0.01	a	75
1J	1	11	6.2	11.3	9.2	0.06	<0.01	a	42
WQ	1	11	5.6	10.0	8.7	0.34	<0.01	a	52
WO	1	10	5.7	11.8	7.1	<0.01	<0.01	a	48
NYS Drinking Water Standard		--	6.5-8.5	--	250.0	10.0	--	--	--

a: No analysis done.

Table 15I

1983 BNL Environmental Monitoring

Landfill Areas

Ground Water Surveillance Wells, Metals Data

Well ID	No. of Samples	Ag	Cd	Cr	Cu	Fe	Pb	Zn	Hg
		mg/l							
Current Landfill									
W6	4	<0.01	<0.006	<0.03	<0.03	0.288	<0.005	0.254	<0.00005
WG	1	<0.01	<0.006	<0.03	<0.03	47.2	<0.005	0.380	<0.00005
WR	4	<0.01	<0.006	<0.03	<0.03	71.5	<0.004	0.189	<0.00005
WS	4	<0.01	<0.006	<0.03	<0.03	77.4	<0.004	0.124	<0.00004
WT	4	<0.01	<0.006	<0.03	0.018	0.578	<0.004	1.89	<0.00004
1K	4	<0.01	<0.006	<0.03	<0.03	75.6	<0.004	0.168	<0.00005
2C	4	<0.01	<0.006	<0.03	<0.03	38.6	<0.004	0.019	<0.00005
2D	4	<0.01	<0.006	<0.03	<0.03	72.8	<0.005	0.007	<0.00005
W9	4	<0.01	<0.006	<0.03	<0.03	74.9	<0.004	0.133	<0.00004
2K	2	<0.01	<0.006	<0.03	0.022	2.35	0.010	1.80	<0.00005
2J	2	<0.01	<0.006	<0.03	<0.03	0.061	<0.005	0.072	<0.00005
2H	1	<0.01	<0.006	<0.03	<0.03	0.100	<0.005	0.160	<0.00005
2I	2	<0.01	<0.006	<0.03	0.017	0.819	<0.005	6.12	a
2B	2	<0.01	<0.006	<0.03	<0.03	0.038	0.008	0.006	<0.00005
2A[b]	1	<0.01	<0.006	<0.03	<0.02	0.070	0.010	0.280	<0.00005
Former Landfill									
1I	1	<0.001	0.001	<0.003	0.050	2.31	<0.004	<0.041	<0.002
WP	1	<0.001	0.002	<0.003	0.009	1.28	<0.004	0.012	a
1J	1	<0.001	<0.0006	<0.003	0.009	2.33	<0.004	0.030	<0.002
WQ	1	<0.001	<0.0006	<0.003	0.008	1.40	0.004	0.026	a
WO	1	<0.001	<0.0006	<0.003	0.008	1.43	<0.004	0.013	a
NYS Drinking Water Standards		0.05	0.01	0.05	1.0	0.30	0.025	5.0	0.002

a: Analysis not done.
b: Well 2A is downgradient of the current and former landfill

Table 15J

1983 BNL Environmental Monitoring

650 Sump Area and Miscellaneous On-site Areas

Ground Water Surveillance Wells, Average Water Quality Data

Well ID	No.of Samples	Temperature (°C)	pH (SU)	Dissolved Oxygen	Chlorides	Nitrate-Nitrogen	Total Phosphorous	Dissolved Solids	Conductivity
				mg/l					(µmhos/cm)
Miscellaneous Wells									
SE	1	13	6.7	9.6	27.1	1.39	<0.01	a	175
SG	1	14	5.7	6.4	19.8	0.26	<0.01	a	96
SI	1	12	6.7	9.9	33.3	0.26	<0.01	a	132
2F	1	14	5.9	9.9	17.7	0.68	<0.01	a	98
2G	1	17	6.6	4.0	20.5	0.16	<0.01	a	113
650 Sump									
1F	1	15	6.4	8.5	11.5	0.47	<0.0'	a	110
1A	2	14	5.7-8.7	10.7	4.2	2.62	0.06	a	111
1B	2	18	5.9-7.6	9.3	13.9	0.45	<0.01	52	75
1H	2	12	5.9-7.4	8.4	3.9	0.42	<0.01	22	80
1D	2	11	6.2-8.3	9.7	16.8	1.47	<0.01	a	110
1C	2	12	6.2-6.3	7.8	17.1	0.75	0.07	79	104
1E	2	13	6.1-7.0	9.8	6.0	0.45	<0.01	46	75
1G	1	12	6.4	6.5	16.5	1.30	0.24	97	110
NYS Drinking Water Standards		--	6.5-8.5	--	250.0	10.0	--	--	--

a: Analysis not done.

Table 15K

1983 BNL Environmental Monitoring

650 Sump Area and Miscellaneous On-site Areas

Ground Water Surveillance Wells, Average Metals Data

Well ID	No. of Samples	Ag	Cd	Cr	Cu	Fe	Pb	Zn	Hg
		mg/l							
Miscellaneous Wells									
SE	1	<0.01	<0.006	<0.03	<0.03	2.93	<0.005	0.08	<0.00005
SG	1	<0.01	<0.006	<0.03	<0.03	2.30	<0.005	0.24	<0.00005
SI	1	<0.01	<0.006	<0.03	<0.03	5.18	<0.005	0.01	<0.00005
2F	1	<0.01	<0.006	<0.03	<0.03	2.22	<0.005	<0.006	<0.00005
2G	1	<0.01	<0.006	<0.03	<0.02	0.04	0.006	<0.006	<0.00005
650 Sump									
1F	1	<0.01	<0.006	<0.03	<0.02	10.2	<0.005	0.37	<0.00005
1A	2	<0.01	<0.006	<0.03	0.014	0.417	0.01	2.03	<0.00004
1B	2	<0.01	<0.006	<0.03	<0.02	5.92	0.04	3.52	a
1H	2	<0.01	<0.006	<0.03	<0.02	0.253	0.006	1.17	<0.00005
1D	2	<0.01	<0.006	<0.03	0.014	0.079	0.01	1.22	a
1C	2	<0.01	<0.006	<0.03	<0.02	1.73	0.006	1.76	a
1E	2	<0.01	<0.006	<0.03	0.02	0.156	0.01	2.13	<0.00005
1G	1	<0.001	<0.0006	<0.003	<0.001	<0.002	<0.004	0.946	a
NYS Drinking Water Standards		0.05	0.01	0.05	1.0	0.30	0.025	5.0	0.002

a: Analysis not done.

In September, a PCB spill of approximately 175 gallons occurred at the substation near Building 927. Clean-up procedures were rapidly implemented and involved excavation of the contaminated soil for ultimate off-site disposal at a licensed facility. Soil was removed to a depth of four feet (PCB concentration < 2 ppm) and a bentonite clay cap was installed to prevent infiltration of precipitation. All work and remedial action was approved by the NYSDEC.

4.0 OFF-SITE DOSE ESTIMATES

The doses to the public from the reported levels of radiation and concentrations of radioactivity in air and water, above ambient background, are principally attributable to the following Laboratory sources:

1. airborne radioactive effluents, primarily tritium, and

2. radioactive liquid effluents.

These are discussed below, and the collective dose-equivalent during 1983 due to these sources is calculated.

4.1 Collective Dose Equivalent Due to Airborne Effluents:

As indicated in Table 4, a total of 290 Ci of tritium vapor were released from various Laboratory facilities during 1983. It was the largest source of dose equivalent to persons off-site, relative to other airborne radionuclides in the BNL effluent streams. Data given in Table 8 indicates that the highest annual average site boundary concentration of tritium vapor was 4.9×10^{2} pCi m^{-3} at station P-7. The calculated maximum dose equivalent was 2.5×10^{-4} rem for the hypothetical individual residing at that location [32]. The dose equivalents due to ^{41}Ar, ^{15}O, and gaseous ^{3}H were not measurable. The calculated per capita annual average dose-equivalent rates for these radionuclides at the site boundary were 1.8×10^{-5} rem a^{-1}, 1.4×10^{-5} rem a^{-1}, and 1.1×10^{-9} rem a^{-1}, respectively. These are insignificant when compared to the tritium vapor contribution, and thus were not included in the final estimates.

The collective (population) dose equivalent was calculated for radionuclides released to the airborne environment using measured effluent release data and recorded BNL meterological parameters. Using actual source terms and meterological data at the given release point should yield the best projection of airborne concentrations, and thus dose to the general population. This approach also minimizes the effects of local micrometeorological conditions which may exist; resulting in differences between the measured and expected tritium concentrations at the perimeter monitoring stations. The magnitude of the variation between measured versus expected tritium concentrations at the site boundary varied during 1983 by factors of approximately 3 to 200. Dose equivalents are shown in Table 16. Methods used to calculate the dose equivalents are described in Appendix C. The collective dose-equivalent (total population dose due to the Laboratory tritium effluent and the incinerator releases) was 4.0×10^{-2} rem a^{-1}. This can be compared to the total population dose-equivalent due to natural background (63.1 mrem a^{-1} = the average off-site TLD

Table 16

1983 BNL Environmental Monitoring

Collective Annual Dose-Equivalent Rate Due to

Releases from BNL Facilities

Month	HFBR Stack	Waste Management Incinerator	Van de Graff Roof Vent Medical Roof Vent Chemistry Roof Vent	Sewage Treatment Plant Effluent
	Person-rems a^{-1}			
January	3.3×10^{-3}	3.5×10^{-5}	4.3×10^{-4}	1.4×10^{-6}
February	2.4×10^{-3}	3.5×10^{-6}	2.2×10^{-4}	1.8×10^{-6}
March	3.0×10^{-3}	1.4×10^{-5}	2.2×10^{-4}	8.3×10^{-7}
April	2.6×10^{-3}	5.8×10^{-7}	2.9×10^{-4}	3.1×10^{-6}
May	2.4×10^{-3}	4.5×10^{-7}	3.2×10^{-4}	5.3×10^{-7}
June	3.3×10^{-3}	1.7×10^{-4}	1.2×10^{-3}	3.3×10^{-6}
July	1.3×10^{-3}	1.0×10^{-5}	2.7×10^{-4}	6.9×10^{-6}
August	3.3×10^{-3}	1.7×10^{-4}	5.4×10^{-4}	1.0×10^{-5}
September	2.5×10^{-3}	3.7×10^{-7}	1.4×10^{-3}	7.7×10^{-6}
October	2.4×10^{-3}	5.8×10^{-5}	2.4×10^{-4}	3.9×10^{-6}
November	4.2×10^{-3}	2.6×10^{-5}	1.0×10^{-3}	3.4×10^{-6}
December	2.2×10^{-3}	2.0×10^{-5}	2.3×10^{-4}	4.5×10^{-7}
Annual Totals	3.3×10^{-2}	5.1×10^{-4}	6.4×10^{-3}	4.3×10^{-5}

Table 17
Maximum Permissible Levels of Radioactive
Contaminants in Air and Water

Contaminant		RCG Air (μCi/ml)	RCG Water (μCi/ml)	EPA and NYS Drinking Water Standard (μCi/ml)	NYS Standard Air (μCi/ml)
Gross α		1×10^{-13}	6×10^{-7}	1.5×10^{-8}	1×10^{-13}
Gross β		$\times 10^{-10}$	1×10^{-7}	5×10^{-8}*	1×10^{-10}
^{3}H		$\times 10^{-7}$	3×10^{-3}	2×10^{-5}	2×10^{-7}
^{90}Sr	S	3×10^{-11}	3×10^{-7}	8×10^{-9}	3×10^{-11}
	I	2×10^{-10}	4×10^{-5}		
Gamma Emitters					
^{7}Be	S	2×10^{-7}	2×10^{-3}	1.5×10^{-5}	2×10^{-7}
	I	4×10^{-8}	2×10^{-3}		
^{22}Na	S	6×10^{-9}	4×10^{-5}	4×10^{-5}	6×10^{-9}
	I	3×10^{-10}	3×10^{-5}		
^{51}Cr	S	4×10^{-7}	2×10^{-3}	4×10^{-7}	2×10^{-3}
	I	8×10^{-8}	2×10^{-3}		
^{54}Mn	S	1×10^{-8}	1×10^{-4}	7×10^{-7}	1×10^{-8}
	I	1×10^{-9}	1×10^{-4}		
^{57}Co	S	1×10^{-7}	5×10^{-4}	1×10^{-7}	5×10^{-4}
	I	6×10^{-9}	4×10^{-4}		
^{58}Co	S	3×10^{-8}	1×10^{-4}	3×10^{-8}	1×10^{-4}
	I	2×10^{-9}	9×10^{-5}		
^{59}Fe	S	5×10^{-9}	6×10^{-5}	5×10^{-9}	6×10^{-5}
	I	2×10^{-9}	5×10^{-5}		
^{60}Co	S	1×10^{-8}	5×10^{-5}	4×10^{-7}	1×10^{-8}
	I	3×10^{-10}	3×10^{-5}		
^{65}Zn	S	1×10^{-7}	3×10^{-3}	4×10^{-9}	1×10^{-4}
	I	6×10^{-8}	5×10^{-3}		
^{74}As	S	1×10^{-8}	5×10^{-5}	1×10^{-8}	5×10^{-5}
	I	4×10^{-9}	5×10^{-5}		
^{75}Se	S	4×10^{-8}	3×10^{-4}	4×10^{-9}	3×10^{-4}
	I	4×10^{-9}	3×10^{-4}		
^{82}Br	S	4×10^{-8}	3×10^{-4}	4×10^{-8}	3×10^{-4}
	I	6×10^{-9}	4×10^{-5}		
^{86}Rb	S	1×10^{-8}	7×10^{-5}	1×10^{-8}	7×10^{-5}
	I	2×10^{-9}	2×10^{-5}		
^{125}Sb	S	2×10^{-8}	1×10^{-4}	1.5×10^{-7}	2×10^{-8}
	I	9×10^{-10}	1×10^{-4}		
^{126}I	S	9×10^{-11}	3×10^{-7}	9×10^{-11}	3×10^{-7}
	I	1×10^{-8}	9×10^{-5}		
^{131}I	S	1×10^{-10}	3×10^{-7}	1.5×10^{-8}	1×10^{-10}
	I	1×10^{-8}	6×10^{-5}		
^{134}Cs	S	1×10^{-9}	9×10^{-6}	6.5×10^{-8}	1×10^{-9}
	I	4×10^{-10}	4×10^{-5}		
^{137}Cs	S	2×10^{-9}	2×10^{-5}	1.5×10^{-7}	2×10^{-9}
	I	5×10^{-10}	4×10^{-5}		
^{144}Ce	S	3×10^{-10}	1×10^{-5}	7×10^{-8}	3×10^{-10}
	I	2×10^{-10}	1×10^{-5}		
^{191}Os	S	4×10^{-8}	2×10^{-4}	4×10^{-8}	2×10^{-4}
	I	1×10^{-8}	2×10^{-4}		
^{203}Hg	S	2×10^{-9}	2×10^{-5}	2×10^{-9}	2×10^{-5}
	I	4×10^{-9}	1×10^{-4}		

S: Soluble
I: Insoluble
* EPA compliance level

value, Table 3) of 3.0×10^5 rem a^{-1}. The Laboratory releases contributed <0.00001% of the total dose due to natural background.

4.2 Collective Dose Equivalents Due to Liquid Effluents:

Since the Peconic River is not utilized as a drinking water supply, nor for irrigation, its waters do not constitute a direct pathway for the ingestion of radioactivity. However, the upper portions of the river are utilized for occasional recreational fishing by the local population.

Based on discussions with the New York State Department of Environmental Conservation regarding fish productivity in the Peconic River, it was assumed that: (a) the fish analyzed was the most frequently caught; (b) 100 fishermen caught 500 kg of fish in 1983 and that their families consumed all of these fish; (c) the distribution of adults and children (based on an average family of 2 adults and 2 children) was 370 adults and children above 12 years of age and 66 children below 12 years [4]. Thus, the estimated annual average fish consumption by the adult group was 1.36 kg/yr and for children below 12 years was 0.46 kg/yr (as compared to the USNRC Regulatory Guide [22] value of 21 kg/yr and 6.9 kg/yr respectively). Based on these values for consumption of fish and other relevant assumptions recommended in the NRC Regulatory Guide 1.109 [22], and the maximum observed concentration of ^{137}Cs in fish (174 pCi/kg(wet)), the collective dose equivalent to total body from this indirect pathway can be estimated to be 0.004 rem (0.011 mrem x 370 persons) for adults and 0.0002 rem (0.004 mrem x 66 persons) for infants.

4.3 Dose Equivalents Due to Alternating Gradient Synchrotron:

The AGS is located 1180 meters from the nearest site boundary. Although the machine is heavily shielded, some neutrons do penetrate the shield and others escape from areas where experiments are in progress. Some of these neutrons reach off-site areas either directly, or more likely by scattering from the air (which is called skyshine).

Neutron dose equivalents were measured at three Laboratory environmental monitoring stations P-2, P-4, and S-5. Dose equivalents at these locations were determined to be 0.44 mRem, 1.26 mRem, and 0.45 mRem, respectively, for the period October 22, 1982 to March 2, 1983. Using these data, an annual dose equivalent at the above environmental stations can be extrapolated to be 1.23 mRem, 3.51 mRem and 1.25 mRem respectively. These values correspond to typical dose-equivalent values due to cosmic sources [28]. Since the neutron dose due to AGS operations was not detectable, it has not been included in the final collective dose equivalent for BNL.

4.4 Collective (Population) Dose-Equivalent

The collective (population) dose-equivalent (total population dose) beyond the site boundary, within a radius of 80 km, attributed to Laboratory operations during 1983 is the sum of the values due to the three components discussed above, as shown below:

Pathway	Collective Dose-Equivalent (person-rem)
External	
AGS Skyshine	ND*
Airborne	
Tritium	0.04
Liquid	
Fish Consumption	0.004**

* ND: Not Detectable

** Infants 0.0002, Adults 0.004

The collective dose equivalent due to external radiation from natural background, to the population within a 80 km radius of the Laboratory, amounts to about 3.3×10^5 rem a^{-1}, to which about 9.7×10^4 rem a^{-1} (person-rem a^{-1}), should be added for internal radioactivity from natural sources.

APPENDIX A

QUALITY CONTROL

Radioactive Measurements:

Radiation measurement instruments were standardized with certified radioactive standards obtained from the National Bureau of Standards, U.S. Department of Commerce, are used to standardize radiation measurement instruments. These standards are certified to be within 5% of stated values. In some cases, certified standards, traceable to the National Bureau of Standards, were also obtained from Amersham/Searle for this purpose. Daily checks of instrument performances are made with these standards. Backgrounds are measured daily for gross alpha and beta counting systems. Backgrounds are measured weekly for gamma and alpha spectroscopy equipment. For tritium measurements a number of standards and blanks are included with each run of a liquid scintillator counter, which has a programmed automatic sample changer.

The Analytical Laboratory of BNL's Safety and Environmental Protection Division was a participant in an inter-laboratory comparison of samples of different matrices such as water, air filters, soil, vegetation and bone which contain a number of frequently encountered radionuclides. These samples were distributed, by the Department of Energy through its Environmental Measurements Laboratory on a semiannual basis. The radionuclides assayed were ^{3}H, ^{90}Sr, plutonium isotopes, and several gamma emitting nuclides. Most results were within the $\pm$20% acceptance criteria. Outlying results were examined and corrective action implemented.

Measurements of Water Quality Parameters:

The procedures utilized for the assay of nonradioactive contaminants were those presented in Standard Methods for the Examination of Water and Wastewater (14th edition, 1975).

APPENDIX B

Minimum Detectable Concentration for Gamma Emitting Radionuclides in Air and Water Samples

Medium	Air		Well Water		Surface Water	
*Detector	#1 & #2	#3	#1 & #2	#3	#1 & #2	#3
Units	← μCi/mℓ →		← μCi/mℓ →		← μCi/mℓ →	
Nuclide						
^{7}Be	1.1×10^{-14}	1.1×10^{-14}	1.3×10^{-9}	1.2×10^{-9}	2.5×10^{-9}	2.3×10^{-9}
^{54}Mn	2.0×10^{-15}	1.3×10^{-15}	2.3×10^{-10}	1.3×10^{-10}	4.3×10^{-10}	2.5×10^{-10}
^{60}Co	2.6×10^{-15}	2.0×10^{-15}	2.7×10^{-10}	2.0×10^{-10}	5.1×10^{-10}	3.8×10^{-10}
^{131}I	1.5×10^{-15}	1.4×10^{-15}	1.9×10^{-10}	1.6×10^{-10}	3.6×10^{-10}	3.0×10^{-1}
^{134}Cs	2.2×10^{-15}	1.5×10^{-15}	2.5×10^{-10}	1.6×10^{-10}	4.6×10^{-10}	3.0×10^{-1}
^{137}Cs	2.1×10^{-15}	1.3×10^{-15}	2.4×10^{-10}	1.5×10^{-10}	4.5×10^{-10}	2.8×10^{-1}
^{144}Ce	8.7×10^{-15}	7.3×10^{-15}	1.2×10^{-9}	9.3×10^{-10}	2.3×10^{-9}	1.8×10^{-9}

*Intrinsic Germanium

APPENDIX C

Methodology for Dose-Equivalent Calculations

Dispersion (χ/Q) was calculated for release elevations of 10 and 100 meters at each of the 16 directional sectors, and for 5 distance increments (1.6-16 km, 16-32 km, 32-48 km, 48-64 km, and 64-80 km) from the center of the site. The resulting dispersion values represent a monthly integral of the dispersion for a given distance and sector. The radionuclide specific release rates (μCi/sec) for a given month from the HFBR stack, the Chemistry Building roof vent, the Medical Building roof vent, the van de Graaff roof vent, the Hazardous Waste Management Incinerator stack, and for evaporation from the Sewage Treatment Plant were then used to estimate the air concentration at a given sector and distance. Air concentrations resulting from evaporation of sewage treatment plant effluent were estimated by assuming that 50% of the tritium was lost to the atmosphere; it was further assumed that this release dispersed in an identical manner to the 10 m roof-top releases. The air concentration, multiplied by the adult breathing rate (22.8 $m^3\ d^{-1}$), the number of days per month, the dose conversion factor for a given radionuclide (32), and the dispersion and population values for that sector and distance resulted in the monthly population nuclide-specific dose equivalent for each sector with distance. This procedure was conducted for each month, radionuclide, and release point. The dose equivalents were then summed to obtain the total population dose equivalent resulting from BNL operations.

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