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1980 ENVIRONMENTAL MONITORING REPORT

J.R. Naidu and L.L. Olmer, Editors

April 1981

SAFETY AND ENVIRONMENTAL PROTECTION DIVISION

BROOKHAVEN NATIONAL LABORATORY
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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 a routine environmental monitoring program, according to DOE Manual Chapter 0513 (1), 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.

Brookhaven National Laboratory's (BNL) environmental monitoring program is designed and developed to accomplish these two primary objectives. While this annual report follows the recommendations given in ERDA 77-24, "A Guide for Environmental Radiological Surveillance at DOE's Installations" (2), considerable latitude has been exercised in tailoring the scope and methodology to meet the site's specific environmental monitoring needs. In addition, the Laboratory has extended its environmental surveillance program to include the sampling and analysis of nonradiological pollutants, such as heavy metals and organics. This latter program is being regularly enlarged to reflect the growing concern about nonradiological pollutants, particularly with regard to the preservation of the quality of the groundwater underlying Long Island (3).

1.2 Site Characteristics:

Brookhaven National Laboratory is a multidisciplinary scientific research center situated in 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 1.3 million people live in Suffolk County (4,5) and about 0.36 million people in Brookhaven Township, within which the Laboratory is situated. The principal nearby population centers are located in shore line communities. Table 1 gives the resident population distribution within 80 km of the BNL site. Though 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 the last decade.

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 itself 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 (6).

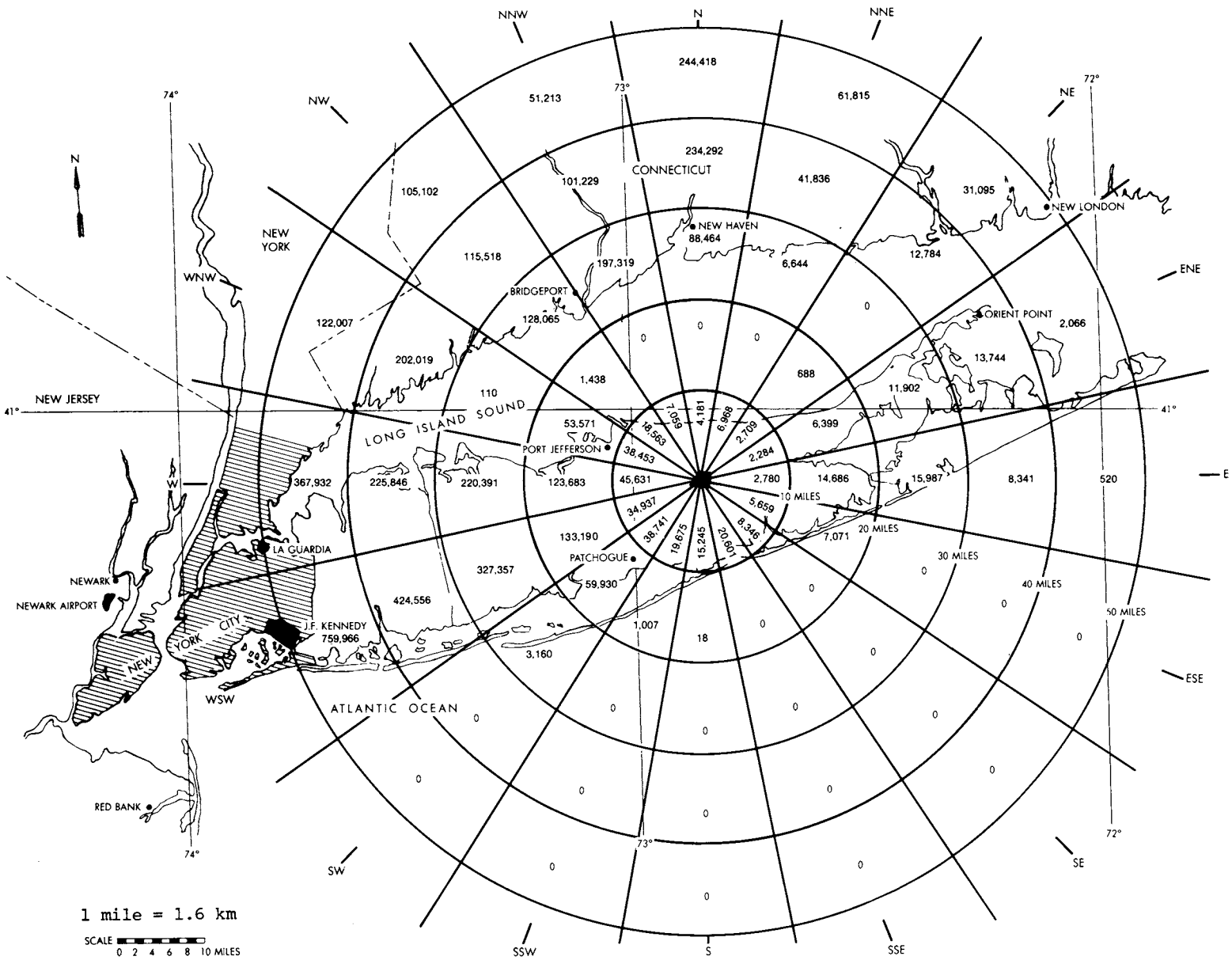


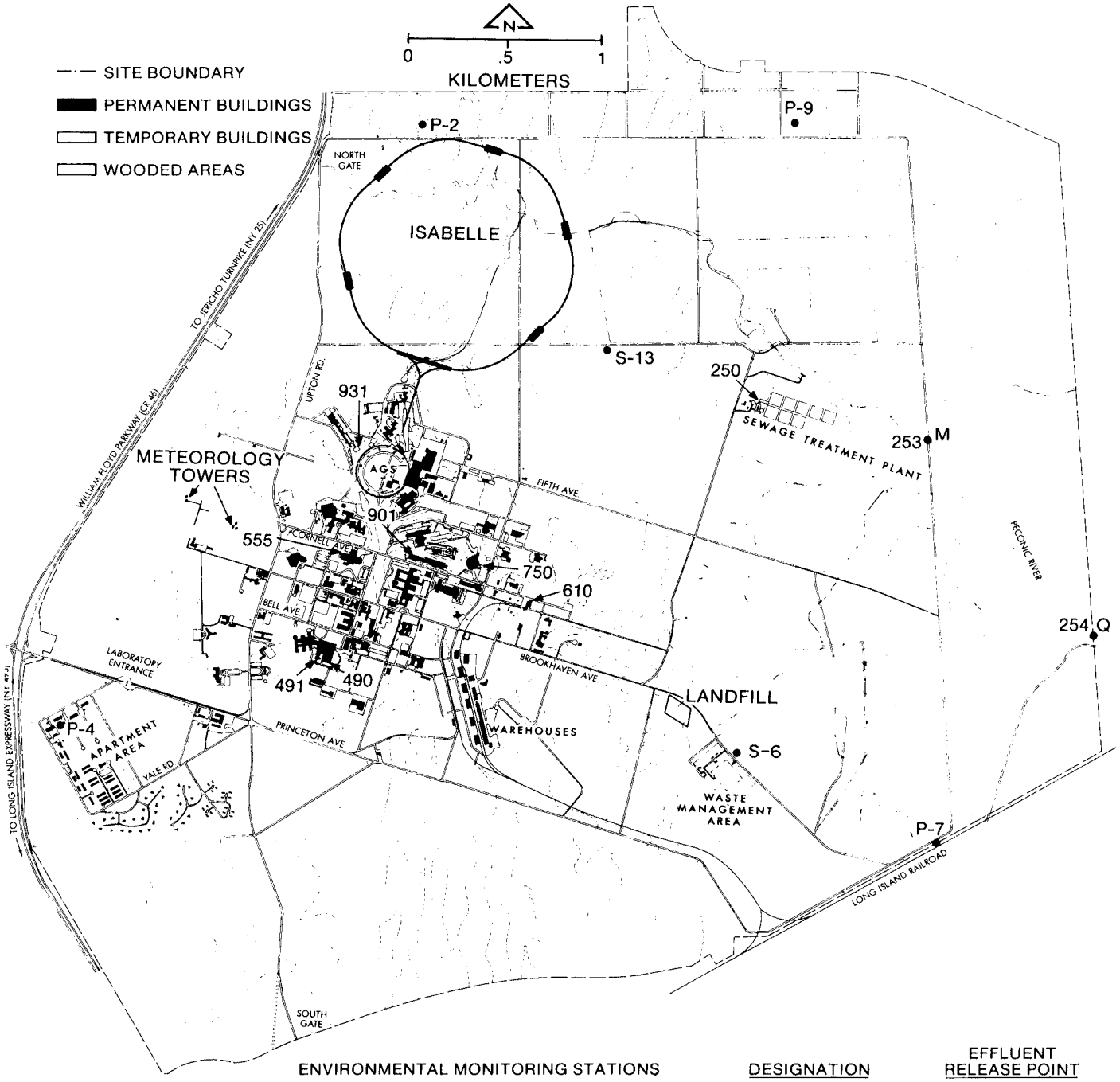
Figure 1. Map of the General Long Island Area Showing the Location of Brookhaven National Laboratory (BNL) and the Resident Population (1980) Within a 50 Mile (80 Km) Radius of BNL

TABLE 1

1980 BNL Environmental Monitoring
Resident Population (1980)[a] Distribution 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	19,675	1,007	0	0	0	20,682	Beyond 32 Km - Atlantic Ocean
SW	38,741	59,930	3,160	0	0	101,831	Beyond 48 Km - Atlantic Ocean
WSW	34,937	133,190	327,357	424,556	759,966	1,680,006	Beyond 80 Km - Part of New York City
W	45,631	123,683	220,391	225,846	367,932	983,483	Beyond 80 Km - New York City
WNW	38,453	53,571	110	202,019	122,007	416,160	Between 32 Km and 48 Km - Long Island Sound, beyond 48 Km - Connecticut and New York
NW	16,563	1,438	128,065	115,518	105,102	366,686	Same as WNW
NNW	7,059	0	197,319	101,229	51,213	356,820	Between 16 Km and 32 Km - Long Island Sound, beyond 20 Km - Connecticut
N	4,181	0	88,464	234,292	244,418	571,355	Same as NNW
NNE	6,968	0	6,644	41,836	61,815	117,263	Same as NNW
NE	2,709	688	0	12,784	31,095	47,276	Between 32 Km and 48 Km - Long Island Sound, beyond 48 Km - Connecticut
ENE	2,284	6,399	11,902	13,744	2,066	36,395	North Fork of Long Island
E	2,780	14,686	15,987	8,341	520	42,314	South Fork of Long Island and Atlantic Ocean
ESE	5,659	7,071	0	0	0	12,730	Long Island and beyond 32 Km - Atlantic Ocean
SE	8,346	0	0	0	0	8,346	Beyond 16 Km - Atlantic Ocean
SSE	20,601	0	0	0	0	20,601	Same as SE
S	15,245	18	0	0	0	15,263	Beyond 32 Km - Atlantic Ocean
Total	269,832	401,681	999,399	1,380,165	1,746,134	4,797,211	

[a]Population data estimated from information supplied by the Long Island Regional Planning Board (4,5).



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

Figure 2. Brookhaven National Laboratory Site

Studies of Long Island hydrology and geology [7-9] 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 average annual precipitation is 122 cm, however, the annual total for 1980 was only 89 cm. About half of this precipitation is lost to the atmosphere through evapotranspiration and the other half percolates to recharge ground water. The ground water in the vicinity of the Laboratory moves predominantly in a horizontal direction to the Great South Bay [7]. This is modified toward a more easterly direction in the Peconic River watershed portions of the site. The estimated rate of movement at the ground water surface is about 16.2 cm d^{-1} [7].

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,

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

Among the major scientific facilities operated at the Laboratory to carry out the above programs are:

1) the High Flux Beam Reactor (HFBR) which is fueled with enriched uranium, moderated and cooled by heavy water, and which operates at a routine power level of 40 MW(th). Recently, modifications to the primary water cooling system have been made to allow the power level to be raised to 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 natural water, and is operated intermittently at power levels up to 3 MW(th),

3) the Alternating Gradient Synchrotron (AGS), a proton accelerator which operates at energies up to 33 GeV,

4) the 200 MeV Proton Linac, which serves as an injector for the AGS, 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, which are used in medium energy physics investigations, as well as for special nuclide production,

6) the National Synchrotron Light Source project, soon to come on line, utilizes a linear accelerator and booster synchrotron as an injection system for two electron storage rings operating at energies of 700 MeV vacuum ultraviolet (VUV) and 2.5 GeV (x-ray). It will be used for spectroscopy in the VUV ring and for diffraction studies in x-ray ring,

7) an intersecting storage ring accelerator, "ISABELLE" is under construction. It will be a colliding-beam machine within which the collision of two proton beams of 400 GeV will make available effective energies up to 800 GeV to facilitate advanced studies in high energy physics. It is anticipated that it will be operational by 1983.

Additional programs involving irradiations and/or the use of radionuclides for scientific investigations are carried on at other Laboratory facilities including the Medical Research Center, the Biology Department, the Chemistry Department, and the Department of Energy and Environment (DEE). At the Hot Laboratory, special purpose radionuclides are developed and processed for on- and off-site use under the joint auspices of the DEE 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 also produce significant fractions of 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. Current environmental monitoring programs are being enhanced so as to permit the evaluation and impact of non-radiological pollutants being released to the environment.

2.0 SUMMARY

The environmental levels of radioactivity and other pollutants found in the vicinity of Brookhaven National Laboratory (BNL) during 1980 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; radioactive air particulates; tritium

and iodine 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 sediments and 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.

External Radiation:

At the boundary of the Laboratory, about 1.0 km northwest of the Alternating Gradient Synchrotron (AGS), the calculated dose due to skyshine (scattered neutron radiation) was about 0.36 mrem a^{-1}, or 0.07% of the Standard. This was too small to be measured. Due to their limited range, the external radiation from the AGS did not produce a measurable additive effect at off-site locations. As the ecology forest irradiation source has been discontinued, no increase in background radiation due to this source was seen at the north boundary of the site.

Air and Rainfall - Radioactivity:

Other than tritium, there was no indication of BNL radioactive effluents in environmental air and precipitation samples. The largest concentration of tritium in air at the site boundary, 5.6 pCi m^{-3} (5.6×10^{-12} μCi ml^{-1}) was <0.01% of the Radiation Concentration Guide (RCG). The largest average concentration of tritium in precipitation was at or below the Minimum Detection Limit (MDL) which was 200 pCi l^{-1} (2×10^{-7} μCi ml^{-1}). The MDL represents about 1% of the standard for drinking water.

Air - Nonradioactive:

At the Central Steam Plant, the most recent measurement of the stack emission of air particulates indicated that the average rate was 0.078 $lb/10^6$ Btu. A calculation based on meteorological parameters indicates that at the site boundary, their concentration was 0.31 μg m^{-3}, 0.4% of the yearly average ambient Air Quality Standard. At the site boundary the calculated concentrations of SO_2 and NO_x, resulting from the steam plant operations, were 0.8×10^{-3} ppm, and 5.6×10^{-4} ppm, respectively, which were about 3 and 1% of their respective 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 67% 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 25.4 pCi l^{-1} (2.54×10^{-8} μCi ml^{-1}), or < 1% of the Radiation Concentration Guide (RCG). The tritium concentration was 7.8 nCi l^{-1} (7.8×10^{-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 52 daily pH levels which were "out of limit" and a single instance of BOD_5 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 EPA under the National 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.

Peconic River - On-Site:

Downstream about 25% of the combined flow from the sand filter beds and from upstream of the Peconic River also percolated into the groundwater. This occurred between the sewage treatment plant outfall and the Laboratory perimeter, mostly during the latter half of the year. At the former site boundary (Station M), the gross beta concentration was 12.9 pCi l^{-1} (1.29×10^{-8} µCi ml^{-1}), or 0.4% of the RCG, and the tritium concentration was 6.5 nCi l^{-1} (6.5×10^{-6} µCi ml^{-1}), or 0.2% of the RCG. At the site boundary, the gross beta concentration was 10.1 pCi l^{-1} (1.01×10^{-8} µCi ml^{-1}), or 0.3% of the RCG, and the tritium concentration was 3.8 nCi l^{-1} (3.8×10^{-6} µCi ml^{-1}), or 0.1% of the RCG.

Peconic River - Off-Site:

Bimonthly 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 average gross beta concentration as established by bimonthly "grab" sampling was 4 pCi l^{-1} (4×10^{-9} µCi ml^{-1}), or 0.1% of the RCG and the tritium concentration was 0.93 nCi l^{-1} (0.93×10^{-6} µCi ml^{-1}), or 0.03% of the RCG. About 24 km downstream, at the river's mouth, the flow was about 22 times that at the Laboratory's site boundary (USGS-1980 data), the average concentration of gross beta activity being 4 pCi l^{-1} (4×10^{-9} µCi ml^{-1}) and that of tritium being 0.2 nCi l^{-1} (0.2×10^{-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 tributary additions which in turn have added fallout radionuclides that were present in the drainage area of the tributaries.

Peconic River - Aquatic Biological Studies:

Seasonal sampling of Peconic River bottom sediments, stream vegetation and fish were conducted at the site boundary. The data on fish obtained from the river at the site boundary suggested the presence of small amounts of radioactivity attributable to the Laboratory's past releases. The maximum concentration of ^{137}Cs in fish was about 1100 pCi kg^{-1}. This concentration would result in a dose commitment that was about 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 20 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, two times greater than that of the supply wells, and was less than 8% of the EPA Drinking Water Standard. The tritium concentrations were less than the MDL, which is about 1% of the EPA Drinking Water Standard.

Groundwater - Surveillance Wells:

Groundwater surveillance was conducted in a network of some 87 sampling wells installed adjacent to and downstream from identified areas where there is a potential for the percolation to 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 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 Drinking Water Standards. The largest average gross alpha concentration, 2.5 pCi l^{-1} (2.5×10^{-9} $\mu Ci\ ml^{-1}$) was 17% of the EPA Drinking Water Standard for unidentified mixtures containing alpha activity other than ^{226}Ra. It was not directly relatable to any known Laboratory effluent releases. The largest average gross beta concentration was 30.5 pCi l^{-1} (30.5×10^{-9} $\mu Ci\ ml^{-1}$). The largest average tritium concentration, 11.1 nCi l^{-1} (11.1×10^{-6} $\mu Ci\ ml^{-1}$) was 56% of the EPA Drinking Water Standard.

On-site, adjacent to the Solid Waste Management area, the landfill, the former open dump, and the decontamination facility storm sewer sump, above ambient background concentrations of gross beta activity, ^{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, 33 pCi l^{-1} (33×10^{-9} $\mu Ci\ ml^{-1}$), or 4 times the EPA Drinking Water Standard, was found in a well 175 m southeast of the area. This level reflects the effects of a known inadvertent injection into groundwater which occurred in 1960.

At the landfill, a gross alpha concentration of 9.6 pCi l^{-1} (9.6×10^{-9} $\mu Ci\ ml^{-1}$), or 1.5 times of the EPA Drinking Water Standard, a gross beta concentration of 103 pCi l^{-1} (103×10^{-9} $\mu Ci\ ml^{-1}$), or twice the compliance level based on the EPA Drinking Water Standard, and a tritium concentration of 43 nCi/ℓ (43×10^{-6} $\mu Ci/m\ell$) or two times the EPA Drinking Water Standard, were the largest found. They were found in wells between the landfill and locations 80 m south of the perimeter of the working area.

At the decontamination facility storm sewer sump, a ^{90}Sr concentration of 56.6 pCi l^{-1} (56.6 x 10^{-9} µCi ml^{-1}), 7 times the EPA Drinking Water Standard, was found in a surveillance well within a few meters of the sewer outfall into the sump.

Iron and zinc were found in excess of their respective standards (0.6 and 0.3 ppm for surface waters) 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 118 ppm and of zinc, 0.9 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 gross alpha, gross beta and ^{90}Sr radioactivity 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 gross alpha concentration, 1.4 pCi l^{-1} (1.4 x 10^{-9} µCi ml^{-1}) was 9% of the EPA Drinking Water Standard. However, this was not directly relatable to any known Laboratory effluent. The gross beta concentration was 13.2 pCi l^{-1} (13.2 x 10^{-9} µCi ml^{-1}), and the ^{90}Sr concentration was 1.2 pCi l^{-1} (1.2 x 10^{-9} µCi ml^{-1}). The latter was 15% of the EPA Drinking Water Standard.

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

Total Population Dose Resulting from Laboratory Sources:

The collective average dose-equivalent rate (total population dose) attributable to Laboratory sources, for the population up to a distance of 80 km, was calculated to be 2.7 rem a^{-1} (person-rem a^{-1}), as compared to a natural background dose-equivalent rate to the same population of about 307,307 rem a^{-1} (person-rem a^{-1}).

3.0 MONITORING DATA COLLECTION, ANALYSIS AND EVALUATION

3.1 External Radiation Monitoring:

Dose-equivalent rates at the site boundary, including natural background (as influenced by fallout) and the increments attributable to Laboratory activity, were routinely measured by the use of CaF_2:Dy thermoluminescent dosimeters (TLD) 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 dose-equivalent rates from external gamma radiation, as measured by thermoluminescent dosimeters (TLDs) [10], are given in Table 2. There was no measurable addition to the natural background attributable to Laboratory activities. The average external background radiation level at the site perimeter was 64 mrem a^{-1}. Fluctuations noted over the years [11] are within the realm of local variations of natural background levels and are regulated to a significant extent by climatic variations [12].

3.2 Airborne Effluents and Groundlevel Air Particulates, Tritium and Radioiodine Monitoring:

3.2.1 Facilities and Effluents:

The principal Laboratory facilities from which radioactive and nonradioactive effluents are released to the atmosphere are listed in Table 3. The location of these facilities 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 1980 are also shown in Table 3.

Considerable dilution with the ambient air occurs between the radioactivity release points to the atmosphere and the site boundary. Additionally, radioactive decay decreases the concentrations of shorter lived radionuclides during the transit time between the point of release and the site boundary. After dilution and decay, the concentrations of airborne radioactivity at the site boundary were reduced to such a level that no detectable increase in the dose equivalent rate (as resulting from the discharge of radioactive effluents to the atmosphere - Table 2) during 1980.

Oxygen-15 (^{15}O), Argon-41 (^{41}Ar) and Xenon-127 (^{127}Xe) are radioactive gases with relatively short half-lives. Thus, they have the potential of being environmentally significant as sources of increased external radiation in proximity to the point of release. Oxygen-15, which has a half-life of two minutes, is produced by the interaction of protons and water in the BLIP facility and generated at an estimated rate of 0.21 Ci μA^{-1} h^{-1}. When this facility is operated at the full beam current of 180 μA, the equilibrium activity of ^{15}O at the point of generation is 1.8 Ci. Argon-41, which has a half-life of 110 minutes, is produced by the interaction of neutrons and ventilating air in the Medical Reactor and released from its stack at a rate of 1 Ci $MW(th)^{-1}h^{-1}$ when it is operated at full power of 3 MW(th). Xenon-127, which has a half-life of 36.4 days, is produced at the BLIP facility and is processed at the Hot Laboratory for commercial uses. It is occasionally released unintentionally due to failures of the containment system. As indicated in the previous environmental monitoring reports [11] the radioactive gases released, except for ^{127}Xe, are a function of operational time and power level of the facility.

TABLE 2

1980 BNL Environmental Monitoring
External Dose-Equivalent Rates from Background and BNL Operations

	Location				
	P-2	P-4	P-7	Northeast Perimeter P-9	Average Background[a]
	mrem				
Minimum (Monthly)	4.56	4.76	4.80	5.12	4.73
Maximum (Monthly)	5.75	6.05	6.10	6.68	5.97
Average (Monthly)	5.18	5.37	5.47	5.89	5.34
Total (Annual)	62.15	64.45	65.59	70.7[b]	64.06

Locations of monitoring stations indicated on Figure 2.

(a) Average of P-2, P-4 and P-7. These monitoring stations are not affected by BNL on site radiations or effluents.

(b) Includes estimated value for September, as the TLD monitor was lost during that month.

TABLE 3

1980 BNL Environmental Monitoring
Gaseous Effluent Release Locations and Data on Effluent Pollutant
(Radionuclides, Particulate, SO_2 and NO_x) Concentrations

Building[a]	Facility and Release Point	Release Height[b] (m)	Principle Pollutant	On-Line Monitoring	Sampling Devices	Amount Released During 1980
490	Medical Research Center Roof Stack	13.7	Tritium (^3H)-	None	Dessicant for tritium vapor	1.5 Ci (vapor)
491	Medical Research Reactor - Stack	45.7	Argon-41 (^{41}Ar)	Moving tape for radio-particulates	Charcoal for radioiodines	255.8 Ci[c] ✓
555	Chemistry - Roof Stack	16.8	Tritium (^3H)	None	Dessicant for tritium vapor	16.4 Ci (vapor)
750	High Flux Beam Reactor	Stack 97.5	Tritium (^3H)	Kanne Chamber for Tritium (gas + vapor)	Dessicant for tritium vapor	178.8 Ci (vapor)
801	Hot Laboratory		^{127}Xe	None		1.6 Ci
			Gross Beta particulate	Beta scintillator for radioactive gases	Particulate filter for gross beta charcoal cartridge for radioiodines	7.8×10^{-5} Ci
901	Van de Graaff Accelerator	18.3	Tritium (^3H) (gas + vapor)	Kanne Chamber for tritium (gas + vapor)	Dessicant for tritium vapor	83.9 Ci (gas) 7.1 Ci (vapor)
931	Linac Isotope Facility	18.3	Tritium (^3H) vapor	G-M Detector for radiogases	Dessicant for tritium vapor	18.5×10^{-3} Ci(vapor)
			Oxygen-15 (^{15}O)			26015.0 Ci[d]
610	Central Steam Plant - Stack	19.8	Particulates	None	None	2.7×10^4 kg[e]
			SO_2			2.85×10^5 kg[e]
			NO_x			1.26×10^5 kg[e]

[a] Locations given in Figure 2.

[b] Above ground level.

[c] Calculated from reported operating time and "one-time" measured emission rate at 3 MW power level.

[d] Calculated from reported operating time and estimated production rate at 180 μamp full beam current.

[e] Estimated - based on amount of fuel consumed (See Table 4).

Tritium (^3H) has a half-life of 12.3 years, and is a very low energy beta emitter ($T_{\beta(max)}$ = 18.6 KeV). It is of principal environmental significance when in the form of tritiated water vapor (HTO), which is taken up and utilized by living systems as water. Of the 286 Ci of tritium released from the Laboratory facilities during 1980 (Table 3), 84 Ci (29%) were in gaseous form, and 202 Ci (71%) were released as tritiated water vapor (HTO).

The amount of tritium gas released at the Van de Graaf facility has been decreased following the employment of improved decontamination techniques such as scrubbing. The slight increase in tritium (as vapor) released from the HFBR resulted principally from the purging of the heat exchanger system during facility modifications to increase the power level from 40 MW to 60 MW.

Most of the heating requirements for the principal buildings at the Laboratory are supplied by a central steam plant (Figure 2). The amounts of conventional pollutants released from it are shown in Table 4. Those for sulfur dioxide (SO_2) and nitrogen oxides (NO_x) were estimated from reported emission factors for comparable plants [13], supplemented by analysis of the fuel oil for its sulfur content as utilized at the plant. The amount of particulates produced was based on the average concentration found in stack sampling of the steam boiler units in a series of tests conducted during 1977. At that time the average particulate emission rate was 0.78 lb $MBTU^{-1}$. This was below the emission limit of 0.1 lb $MBTU^{-1}$ for particulates as set forth by the New York State Department of Environmental Conservation (Part 227, Stationary Combustion Installations).

The emissions of SO_2, NO_x and particulates have decreased markedly since 1976 when the Laboratory initiated the utilization of alternate liquid fuels (ALF), such as mineral spirits, alcohol, jet fuel and reconstituted fuels. In 1980, the fraction of ALF relative to total fuel consumption, was 30%. These alternate fuels typically have a weighted average sulfur content of 0.5% or less when compared to the typical 1% sulfur content of the #6 oil and therefore contributes to the reduction of pollutants discharged to the atmosphere through the stack. Samples of ALF have been analyzed for cadmium (Cd), lead (Pb) and chlorinated hydrocarbons. The results indicated that the burning of ALF does not constitute a health hazard [15] (see also BNL Environmental Monitoring Report 1979 [11]).

3.2.2 Sampling and Analysis:

The Brookhaven environmental monitoring air sampling program is designed to identify and quantify airborne radioactivity attributable to natural sources, to activities remote from the Laboratory (e.g., above ground nuclear weapons tests) and to Laboratory activities. Most of the air concentrations of radioactivity detected during 1980 could be attributable to the first two sources.

3.2.3 Air Samples:

High volume (500 l min^{-1}) positive displacement air pumps (Gast 3040) were operated at a monitoring station southeast of the solid waste management areas (Fig. 2, S-6), and at the northeast and the southwest perimeter stations

TABLE 4

1980 BNL Environmental Monitoring
Emission of SO_2, NO_x and Particulates from Central Steam Plant
(Bldg. 610)

Effluent	Total kg	Calculated Stack Concentration	Average Boundary Concentration[a]	EPA Primary Air Quality Standard [15]
SO_2	2.85×10^5[b]	237 ppm	0.83×10^{-3} ppm	0.03 ppm
NO_x	1.26×10^5	137 ppm	5.56×10^{-4} ppm	0.05 ppm
Particulates	2.7×10^4[c]	0.08 g m^{-3}	0.31 µg m^{-3}	75 µg m^{-3}

(a) Based on average X/Q of 2.4×10^{-7} sec m^{-3} calculated by BNL Meteorology Group (1980).

(b) Based on average 1.0% sulfur content.

(c) Based on measured average value during February 1977 stack sampling conducted on main steam boiler unit (New York Testing Laboratories, Inc., Westbury, N.Y., 11590).

(P-9 and P-4). The air sampling media consisted of a 7.6 cm diameter air particulate filter (Gelman type G) followed by a 7.6 cm x 2.5 cm bed of petroleum-based charcoal (Columbia Grade LC 12/28 x mesh) for collection of radiohalogens. Parallel to this is a low volume filter system sampling at a flow rate of 56 ℓ min^{-1} and consists of a 7.6 cm diameter air particulate filter (Gelman type G) followed by a 250 cm^3 impregnated charcoal filter. The rationale for the latter sampling system is to assure collection of all species of radioiodines at a suitable flow rate. Short term fluctuations in airborne radioactive particulate concentrations are generally indicative of the presence of recent weapons test debris.

The air particulate samples were analyzed for gross beta activity using a 12.7 cm diameter beta scintillator. These data are shown in Table 5. No clear seasonal trend could be observed for gross beta activity in 1980. The gross beta activity increased at all monitoring stations during the last quarter. This could be attributed to the Chinese nuclear test of October 16, 1980.

In addition to the gross beta counts indicated above, analyses for gamma emitting nuclides were performed on a composite of all individual air particulate samples shortly after the end of each month. The charcoal samples, which were composited, were analyzed at one month post-collection to determine ^{131}I by decay. These data are reported in Table 5. Other fission product nuclides, such as ^{103}Ru, ^{106}Ru, ^{137}Cs, ^{141}Ce, and ^{144}Ce were at or below Minimum Detection Limit (MDL) for the counting system used (Table 17). Although detectable levels of ^{131}I have been noted during earlier Chinese nuclear tests, none were detected during 1980. Naturally occurring ^{7}Be was present in low but near uniform concentrations throughout the year.

Sampling for tritium vapor was performed at the air sampling stations by drawing a small side stream of air ($\sim$100 cm^3 min^{-1}) through silica gel cartridges. These were generally changed on a biweekly basis. The collected vapor was subsequently removed from the gel by heating, then condensed, collected and assayed by liquid scintillation counting. The tritium air concentration data obtained during 1980 is shown in Table 6. The measured yearly average concentration (including background) at the site boundary, was about 3.5 pCi m^{-3} (0.035 x 10^{-10} μCi cm^{-3}), or 0.002% of the applicable Radiation Concentration Guide (RCG).

The current Laboratory environmental monitoring program does not include air sampling for nonradioactive substances. The calculated annual average concentrations of the conventional pollutants released from the central steam plant at the site boundary are listed in Table 4. All were less than 3% of the EPA Primary Air Quality Standard for the reported constituents. As discussed earlier in this Section, the use of ALF with #6 fuel oil did not represent a significant impact on the environment.

TABLE 5

1980 BNL Environmental Monitoring
Gross Beta Concentrations in Air Particulate Filters,
and Gamma Emitting Nuclides in Charcoal Filters
(pCi/m^3)

Period	Location	Number of Samples	Gross Beta Average	Gross Beta Maximum	Gross Beta Minimum	^{7}Be (a)
January to March	S.W. Perimeter (P-4)	13	0.0484	0.0963	0.0110	0.1
	N.E. Perimeter (P-9)	8	0.0585	0.0787	0.0418	
April to June	S.W. Perimeter	14	0.0504	0.1340	0.0202	0.09
	N.E. Perimeter	7	0.0424	0.0547	0.0269	
July to September	S.W. Perimeter	11	0.0374	0.0698	0.0035	0.08
	N.E. Perimeter	13	0.0518	0.0815	0.0295	
October to December	S.W. Perimeter	12	0.0665	0.2750	0.0211	0.11
	N.E. Perimeter	13	0.0643	0.1210	0.0317	
Annual Total	S.W. Perimeter	50	0.0474	0.2750	0.0035	0.095
	N.E. Perimeter	41	0.0541	0.1210	0.0269	

Locations given in Figure 2.

(a) Sample - Composite of charcoal filters from all stations.

Applicable Standards - Table 17.

TABLE 6

1980 Environmental Monitoring

Tritium Vapor Concentration (Average) in Air

(pCi/m^3)

Period	Northeast Perimeter (P-9)	Southeast Perimeter (P-7)	Southwest Perimeter (P-4)	Minimum Detection Limit*
1/1 - 3/26	2.8	1.3	2.9	
3/27 - 6/30	2.4	2.3	4.9	1 - 5
7/1 - 9/5	<4.0	3.0	<5.5	
9/6 - 12/31	3.3	<1.7	5.6	
Average (Annual)	3.1	2.1	4.7	
Radiation Concentration Guide [14]		2×10^5		

* Range is based on the MDL for this particular tritium determination procedure, which is a function of counting efficiency, counting time, sample volume, and relative humidity.

About 225 kg of various pesticides, chiefly organo-phosphates, Thiodan, Diazinon, Carbaryl and Parathion, were applied on site during 1980, principally to protect crops which were grown for biological research purposes. All of these pesticides are considered biodegradable, with persistence times in the order of a week. Furthermore, they were applied with a "sticker" additive to minimize their subsequently becoming airborne.

3.2.4 Precipitation:

Two pot-type rain collectors, each with a surface area of 0.33 m^2, are situated adjacent to the sewage treatment plant (see Fig. 2). A routine collections was made from these whenever precipitation was observed during a previous 24 hour (or weekend) period. Another was made once a week (whether or not precipitation occurred) by washing down the rain collector with a known volume of water. Part of each collection was evaporated for gross beta counting, a small fraction was composited for monthly tritium analysis, and the balance was put through ion exchange columns for subsequent quarterly ^{90}Sr and gamma analyses. The data for 1980 (with the exception of tritium) are reported in Table 7. There was no detectable indication of Laboratory released airborne radioactivity in precipitation collected on site. The gross beta activity does reflect rainfall scavenging of radioactive fallout from the stratosphere which is most pronounced during the spring season. This is also true for the naturally produced gamma emitter ^{7}Be. Fission and activation products, such as ^{54}Mn, ^{65}Zn, ^{95}Zr-Nb and ^{131}I, were all below their MDL (Table 17). Strontium-90 deposition also parallels that of gross beta activity.

To obtain an indication of the washout of tritium from local airborne releases, small precipitation collectors were installed at the perimeter stations (P-2, P-4, P-7, P-9), at Blue Point, some 20 km southwest of the Laboratory site. The average tritium concentration were all reduced significantly when compared to previous years [11] and were at or below the MDL (Table 17). At the MDL, the average concentration (on site) would have been less than 1% of the EPA Drinking Water Standard [16].

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 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 agents, by an EPA licensed contractor).

TABLE 7

1980 BNL Environmental Monitoring
Monthly Average Gross Beta Concentration
Total Gross Beta and Radionuclide Activity in Precipitation

Month	Rainfall (cm)	Average Gβ (10^{-9} μCi/mℓ)	Gβ	^{7}Be	^{90}Sr
				(10^{-3} μCi/m^2)	
January	5.13	2.2	0.11		
February	3.00	12.6	0.38	26.0	0.114
March	18.29	12.4	2.27		
April	15.65	14.2	2.22		
May	3.86	11.6	0.45	32.0	0.091
June	9.14	8.4	0.77		
July	4.88	17.6	0.86		
August	3.96	1.2	0.05	12.5	0.035
September	2.49	6.4	0.16		
October	9.12	2.0	0.18		
November	10.67	8.2	0.87	10.6	0.029
December	2.69	9.6	0.26		
Total	88.88	-	8.58	81.1	0.269
Average	7.41	8.9	0.72	6.8	0.002
Radiation Concentration Guide [14]		3×10^3	3×10^3	8×10^2	8×10^1

Facilities which may produce larger volumes (up to several hundred liters/batch) 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 3a, 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 [17], 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 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 small 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 [17]. Within these limits, individual releases are kept as low as practicable.

3.3.1 National Pollutant Discharge Elimination System (NPDES) Permit:

As of January 31, 1975, the effluent from the Laboratory sewage treatment plant was subject to the conditions of The National Pollutant Discharge Elimination System (NPDES) Permit No. NY 000 5835. Quarterly reports have been prepared in accordance with this permit, using data obtained by the sewage treatment plant operators. A yearly summary of these data is shown in Table 8, which includes permit conditions. The Laboratory effluent was within all of these conditions, with the exception of some daily pH levels and a single instance of BOD_5 percent removal, which in this case was 80.7 as compared to the permit requirement of 85.

The pH levels were below the lower limit of 5.8 on 52 occasions. However, they were within the local natural range of ground water (pH 5.5-6.0). A 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. The percent removal of BOD_5 is determined by subtracting the BOD_5 level of the effluent from that of the influent. However, if the influent BOD_5 is itself very low, the percent removal may be less than 85%, even though the effluent level is very low. The single exception to the stipulated 85% removal was therefore the difference between two relatively small numbers.

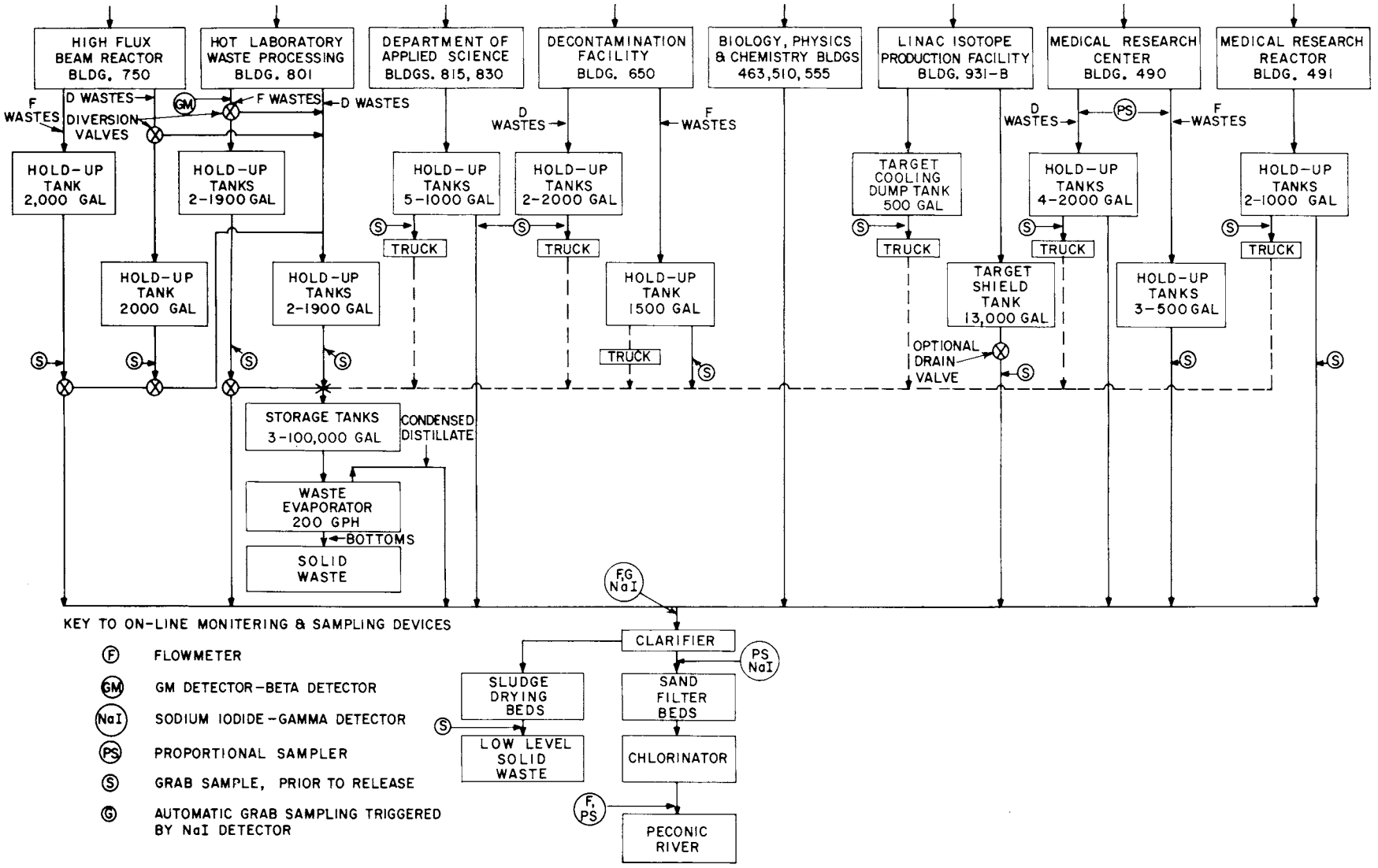


Figure 3a. BNL Liquid Effluent Systems

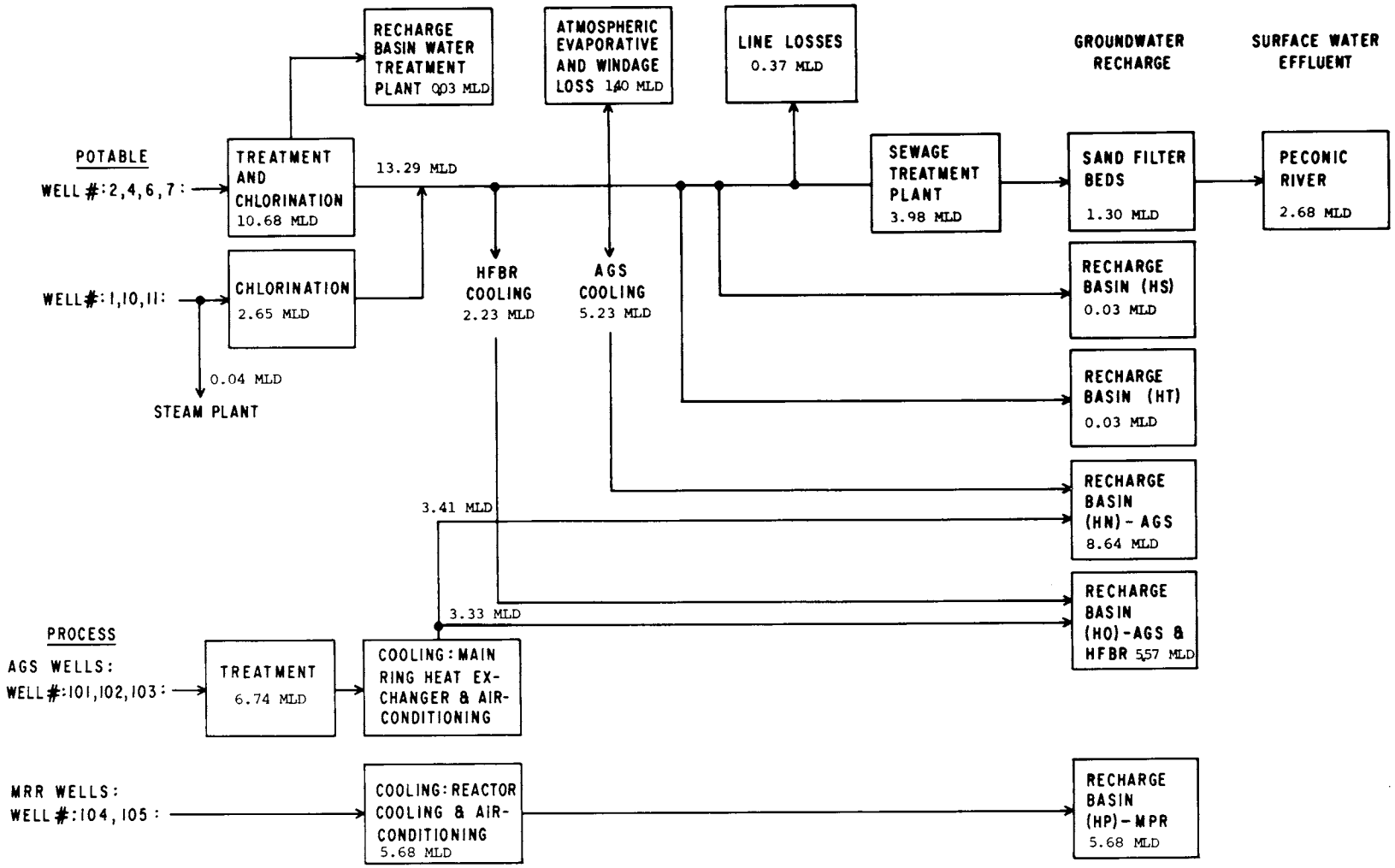


Figure 3b. Brookhaven National Laboratory: Schematic of Water Use and Flow

TABLE 8
1980 BNL Environmental Monitoring
National Pollution Discharge Elimination System
Summary of Data

Parameter	Status	Quantity					Concentration					Frequency of Analysis	Sample Type
		Minimum	Average	Maximum	Units	Number[(a)] of Exceptions	Minimum	Average	Maximum	Units	Number[(a)] of Exceptions		
Flow	Sample measurement	0.28	0.74	2.65	MGD	0	-	-	-	-	-	Cont.	NA
	Permit requirement	-	2.65	-			-	-	-			Cont.	NA
pH Influent	Sample measurement	6.1	6.8	7.9	STD.	-	-	-	-	-	-	5/7	GRAB
	Permit requirement	-	-	-	Units		-	-	-			Daily	GRAB
pH Effluent	Sample measurement	5.3	5.9	6.8	STD.	52	-	-	-	-	-	5/7	GRAB
	Permit requirement	5.8	5.9	9.0	Units		-	-	-			Daily	GRAB
BOD_5 Influent	Sample measurement	80.7	137.8	208.0	Kg/day	-	22.0	34.8	46.2	mg/ℓ	-	Weekly	8 hr.
	Permit requirement	-	-	-			-	-	-			Monthly	8 hr.
BOD_5 Effluent	Sample measurement	4.6	11.4	17.8	kg/day	0	0.7	3.4	6.9	mg/ℓ	0	Weekly	8 hr.
	Permit requirement	-	262.0	391.0			-	30.0	45.0			Monthly	8 hr.
Percent removal BOD_5	Sample measurement	-	-	-	-	-	80.6	91.2	96.6	%	1	Weekly	-
	Permit requirement	-	-	-			85.0	-	-			Monthly	-
Suspended solids, Influent	Sample measurement	80.7	187.1	394.6	kg/day	-	19.0	47.7	99.0	mg/ℓ	-	Biweekly	8 hr.
	Permit requirement	-	-	-			-	-	-			Monthly	8 hr.
Suspended solids, Effluent	Sample measurement	0.0	5.1	36.3	kg/day	0	0.0	1.8	13.5	mg/ℓ	0	Biweekly	8 hr.
	Permit requirement	-	262.0	391.0			-	30.0	45.0			Monthly	8 hr.
Percent removal Suspended solids	Sample measurement	-	-	-	-	-	91.0	98.3	100.0	%	0	Biweekly	-
	Permit requirement	-	-	-			85.0	-	-			Monthly	-
Settleable solids, Influent	Sample measurement	-	-	-	-	-	0.1	1.20	6.0	mℓ/ℓ	-	5/7	GRAB
	Permit requirement	-	-	-			-	-	-			Daily	GRAB
Settleable solids, Effluent	Sample measurement	-	-	-	-	-	0.0	0.0	0.0	mℓ/ℓ	-	5/7	GRAB
	Permit requirement	-	-	-			-	-	-			Daily	GRAB
Residual Chlorine Effluent	Sample measurement	-	-	-	-	-	0.4	0.9	2.0	mg/ℓ	-	5/7	GRAB
	Permit requirement	-	-	-			-	-	-			Daily	GRAB
Temperature, Effluent	Sample measurement	4.0	15.8	29.0	°C	-	-	-	-	-	-	5/7	GRAB
	Permit requirement	-	-	-			-	-	-			Daily	GRAB
Fecal Coliform, Effluent	Sample measurement	-	-	-	-	-	0.0	0.0	0.0	n/100 mℓ	0	Weekly	GRAB
	Permit requirement	-	-	-			-	200.0	400.0			Monthly	GRAB

- Indicates not required

(a) Total for the year

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 78% of the water has typically been recovered by an underlying tile field. This recovered water was chlorinated and then released into a small stream that forms one of the headwaters of the Peconic River.

A schematic of the sewage treatment plant and its related sampling arrangements are illustrated in Figure 4. In addition to the inplant flow measurement and sampling instrumentation, totalizing flowmeters (Leopold and Stevens TP 61-2), with provision for taking a sample for each 7576 liters of flow are installed in combination with positive action battery operated samplers (Brailsford DU-1), at the chlorine house, at the former site boundary which is 0.8 km downstream on the Peconic River, and at the site boundary, 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 chlorine house outfall 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, alpha, and for 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 monthly minimum, maximum and average flow, the gross beta activity and that of the principal individual nuclides at the clarifier (input to the filter beds), the chlorine house (output from the beds), the former perimeter and the site perimeter are shown in Table 9. Yearly totals and average concentrations are also indicated. During 1980, about 67% of the total flow into the clarifier appeared in the output at the chlorine house after passing through the sand filter beds. The balance was assumed to have percolated to the ground water flow under the beds. This loss to ground water was greater than during recent years (11). Calibration checks made could only account for about 2-3% of the losses. Other causes such as loss of efficiency of filter beds, lowering of the water table due to lack of adequate precipitation, could account for the larger than usual losses. Estimates of the amount of radioactivity released to the ground water in this manner during 1980 are shown in Table 9. These were calculated on the additional assumption that the average concentrations of the contained nuclides corresponded to those in the output from the beds, as observed at the chlorine house.

An analysis of the radionuclide concentrations at the chlorine house 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. During 1980, other radionuclides such as ^{22}Na, ^{51}Cr, ^{54}Mn, ^{57}Co, ^{58}Co, ^{65}Zn, ^{95}Zr-Nb, ^{125}Sb, ^{140}Ba-La and ^{144}Ce, which have been detected in

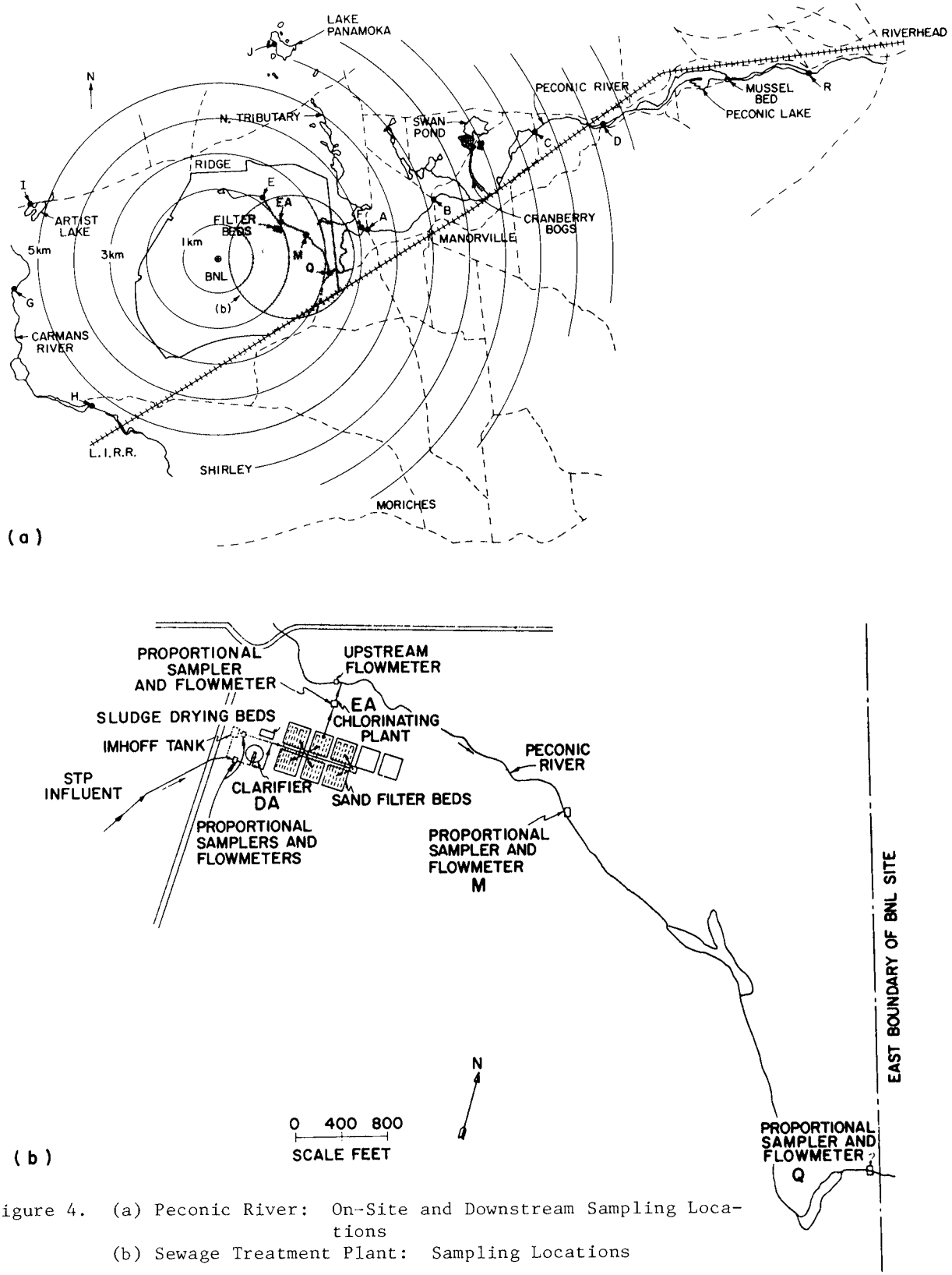


Figure 4. (a) Peconic River: On-Site and Downstream Sampling Locations
(b) Sewage Treatment Plant: Sampling Locations

TABLE 9

1980 BNL Environmental Monitoring
Total Activities and Concentrations of Identifiable Nuclides in Liquid Effluents
from the Sewage Treatment Plant and in the Peconic River

	Flow x 10^{10} mℓ	Gα	Gβ	^{3}H	^{7}Be	^{60}Co	^{90}Sr	^{131}I	^{134}Cs	^{137}Cs
					Clarifier (mCi)					
Monthly (Minimum)	9.48	0.11	1.80	500	ND	ND	<0.01	ND	ND	ND
Monthly (Maximum)	15.38	0.20	6.60	1552	1.40	1.10	0.14	1.80	0.05	0.14
Average (Monthly)	12.10	0.15	3.30	952	0.30	0.17	0.03	1.07	0.01	0.05
Total (Annual)	145.28	1.84	39.10	11426	1.50	1.73	0.41	2.14	0.07	0.33
Average Concentration (10^{-9} µCi/mℓ)	-	1.27	26.90	7864	1.03	1.19	0.28	1.47	0.05	0.23
					Groundwater (Sand-Filter Beds) (mCi)					
Total (Annual)	47.48	0.57	12.04	3683	0.48	0.31	0.23	0.04	1.69	3.46
Average Concentration (10^{-9} µCi/mℓ)	-	1.20	25.36	7756	1.02	0.65	0.49	0.08	3.56	7.29
					Chlorine House (mCi)					
Monthly (Minimum)	1.03	0.05	1.10	72	ND	ND	0.01	ND	ND	ND
Monthly (Maximum)	8.80	0.14	5.80	1022	0.75	0.30	0.09	0.08	2.80	4.90
Average (Monthly)	5.70	0.10	2.10	632	0.13	0.06	0.04	0.08	0.44	0.71
Total (Annual)	97.80	1.17	24.80	7585	1.00	0.64	0.48	0.08	3.52	7.13
Average Concentration (10^{-9} µCi/mℓ)	-	1.20	25.36	7756	1.02	0.65	0.49	0.08	3.56	7.29
					Former Perimeter (mCi)					
Quarterly (Minimum)	4.30	0.06	0.70	139	ND	ND	0.04	ND	ND	ND
Quarterly (Maximum)	17.30	0.22	2.10	1717	0.16	0.19	0.22	1.80	0.15	0.22
Average (Monthly)	10.50	0.13	1.40	682	0.08	0.04	0.04	1.10	0.09	0.14
Total (Annual)	126.50	1.55	16.40	8189	0.50	0.31	0.48	2.14	0.68	1.39
Average Concentration (10^{-9} µCi/mℓ)	-	1.22	12.90	6474	0.40	0.24	0.38	1.69	0.54	1.10
					Groundwater (Stream Bed) (mCi)					
Total (Annual)	29.66	0.36	3.84	1920	0.12	0.70	0.03	0.50	0.16	0.32
Average Concentration (10^{-9} µCi/mℓ)	-	1.21	12.94	6473	0.40	2.36	0.38	1.68	0.54	1.08
					Site Perimeter (mCi)					
Quarterly (Minimum)	0.38	0.01	0.07	11	ND	ND	0.08	ND	ND	ND
Quarterly (Maximum)	34.64	0.47	3.20	1369	0.08	0.02	0.64	ND	0.15	0.33
Average (Monthly)	16.18	0.20	1.64	610	0.03	0.01	0.10	-	0.04	0.12
Total (Annual)	145.63	1.79	14.77	5488	0.23	0.06	0.94	-	0.35	0.97
Average Concentration (10^{-9} µCi/mℓ)	-	1.22	10.14	3768	0.16	0.04	0.64	(a)	0.24	0.67
Radiation Concentration Guide (14) (10^{-9} µCi/mℓ)			$3x10^{3}$ (c)	$3x10^{6}$ ($2x10^{4}$) (b)	$2x10^{6}$	$5x10^{4}$	$3x10^{2}$ (8) (b)	$3x10^{2}$	$9x10^{3}$	$2x10^{4}$

ND = Not determinable as concentration of radionuclide in sample was at or below Minimum Detection Limit (MDL).

(a) Below the MDL of the system used in estimating the activity. Other nuclides such as ^{22}Na, ^{51}Cr, ^{54}Mn, ^{57}Co, ^{58}Co, ^{65}Zn, ^{95}Zr-Nb, ^{125}Sb, ^{140}Ba-La, ^{144}Ce, were all at or below the MDL.

(b) EPA Drinking Water Regulations apply to groundwater on Long Island [24].

(c) For mixtures of radionuclides containing < 10% ^{90}Sr, $^{125-133}I$, or long lived alpha emitters. The concentration guides for unknown mixtures depend, within the range given, or whether certain radionuclides are known to be present in concentrations less than 0.1 of their RCGs', and the sum of the fractions of the RCGs' for all such radionuclides is less than 0.25.

previous years, were all at or below MDL (Table 17) and as such were not reported in the Table 9. As a result of the As Low As Reasonably Achievable (ALARA) approach, the Laboratory releases of radionuclides have been on the decrease over the years.

Flow and activity concentration data for the former site boundary sampling location, 0.8 km downstream (see Fig. 4), and at the present site boundary are shown in Table 9. Climatic conditions during 1980 resulted in decreased flows when compared to previous years due to below average rainfall (89 cm). This resulted in a markedly decreased flow at the site perimeter, which was essentially zero during the last quarter of the year. This resulted in a loss of about 25% between the former perimeter and the present site boundary during 1980. Upper limit estimates of the activity that may have percolated to the underlying aquifier are also shown in Table 9. These are based on the decrease in total flow between the former site boundary and the perimeter during the period August to December.

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, 2% of the annual total activity (excluding tritium) consisted of ^{90}Sr and that no appreciable amounts of long-lived radioactive iodine or other bone-seeking nuclides such as radium were present. Under these circumstances, the applicable Radiation Concentration Guide (RCG) was 300 pCi l^{-1} (0.3×10^{-6} μCi ml^{-1}). The gross beta concentration in the portion which is assumed to have percolated to ground water was 12.9 pCi l^{-1} (1.29×10^{-8} μCi ml^{-1}) or 26% of the EPA Drinking Water Standard [16].

At the Laboratory perimeter (2.6 km downstream from the chlorine house), 5% of the annual total activity was ^{90}Sr. 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]. The observed gross beta concentration of the water released downstream was 10.1 pCi l^{-1} (1.01×10^{-8} μCi ml^{-1}) or <1% of the RCG [14].

The Safety and Environmental Protection Division also performs routine water quality measurements on samples of the filter beds effluent, of the Peconic River upstream of the effluent discharge point, of the river at the former perimeter of the Laboratory (0.8 km downstream) and of the river at the present Laboratory perimeter (2.6 km downstream). A summary of these data for 1980 is shown in Table 10. In general, that portion of the Peconic River within the Laboratory site showed compliance with the NYS DEC Water Quality Standards [18]. Although occasionally below the standard [19], the effluent pH was within the range of local ambient levels. After mixing with the upstream flow, the temperature increment was within the standard [20] at the Laboratory perimeter. Yearly average concentrations of metals for which analyses were made were all at or within the standard for the receiving body of water [15,19], except for iron (Fe) and zinc (Zn).

Monthly "grab" water samples were obtained at on- and off-site locations along the Peconic River. A battery operated fixed flow sampler was operated at Riverhead, (at the mouth of the Peconic River), between March and December. Reference "grab" samples were obtained from other nearby streams and bodies of

TABLE 10

BNL Environmental Monitoring
Sewage Treatment Plant, Peconic River and Offsite Locations
Average Radionuclide, Metals and Water Quality Data

Location	Gross α (pCi/ℓ)	Gross β (pCi/ℓ)	Tritium (nCi/ℓ)	^{90}Sr (pCi/ℓ)	Ag	Cd	Cr	Cu	Fe	Pb	Zn	Dissolved Oxygen	Chlorides	Nitrate-Nitrogen	Total Phosphoros	Dissolved Solids	Conductivity (μmhos/cm)	Temperature ^{o}C	pH	Coliform - Fecal #/100 mℓ	Coliform - Total #/100 mℓ
Peconic River					ppm																
Sewage Treatment Plant Influent (DA)	1.27	26.9	7.864	0.279	0.004	0.0007	0.006	0.080	0.362	0.015	0.106	ND	ND	0.01	1.3	ND	ND	21	6.8	ND	ND
Sewage Treatment Plant Effluent (EA)	1.20	25.4	7.76	0.49	0.002	0.0015	0.004	0.058	0.099	0.006	0.221	8.2	26.9	4.2	0.93	120	154	16	5.8	3	2
Former Perimeter (M)	1.22	12.9	6.474	0.376	0.001	0.0006	0.002	0.038	0.780	0.003	0.080	8.5	22.6	2.7	0.66	104	131	13	6.0	42	334
Site Perimeter (Q)	1.22	10.14	3.768	0.644	0.001	0.0006	0.003	0.029	0.504	0.003	0.100	6.8	20.7	1.38	0.44	90	125	12	6.2	43	254
A	0.24	4.06	0.93	NOT DONE								6.7	8.2	0.38	0.27	57	59	13	6.2	119	668
R	0.25	4.05	0.21	0.41	0.001	0.0006	0.002	0.004	0.663	0.003	0.005	8.6	12.4	0.37	0.07	67	96	18	6.8	69	154
Control																					
Upstream of Laboratory Outfall (E)	0.37	5.92	1.31	NOT DONE																	
F-North Tributary into Peconic River	0.25	2.66	0.19	NOT DONE								6.4	6.9	0.31	0.05	55	51	16	5.9	42	193
H-Carmen's River	0.21	1.58	0.19	NOT DONE								9.9	9.7	0.92	0.01	75	102	14	6.7	19	88
I-Artist's Lake	0.20	3.70	0.19	NOT DONE								10.1	20.4	0.08	0.01	82	103	14	7.3	65	133
J-Lake Panamoka	0.22	2.61	0.19	NOT DONE								10.5	8.7	0.19	0.01	44	65	14	6.9	7	50
Radiation Concentration Guide [14]	$6x10^{2}$	$1x10^{2}$	$3x10^{3}$	$3x10^{2}$																	
New York State Water Quality Standard [18,19]					0.1	0.2	0.1	0.2	0.6	0.1	0.3	-	500	20	-	1000	-	-	-	-	4#

ND - Not Done

Applicable Standards - Table 17.

water outside the Laboratory drainage area. As shown in Figure 4, the sampling locations were as follows:

Off-Site (Peconic River, proceeding downstream)

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

B - Peconic River at Wading River-Manorville Road, 7.04 km downstream,

C - Peconic River at Manorville, 10.67 km downstream,

D - Peconic River at Calverton, 14.23 km downstream,

R - Peconic River at Riverhead, 19.35 km downstream,

Controls (Not in the Laboratory drainage area)

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

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

H - Carman Rivers, outfall of Yaphank Lake,

I - Northeast corner of Artist Lake on Route 25,

J - Lake Panamoka.

Yearly average gross beta, tritium and ^{90}Sr concentrations at downstream (A and R) and control locations (E,F) are shown in Table 10. A comparison with the on-site and perimeter concentrations, as shown in Table 10, indicated that downstream of the outfall the concentrations of the nuclides in the Laboratory effluent in the Peconic River, diminished rapidly to near background levels at the more distant sampling locations. Considering the concentrations of radioactivity near the mouth of the Peconic River at Riverhead, where the flow was about 22 times that at the Laboratory perimeter (USGS-1980 data), it was evident that the estimated total amount of radioactivity there was greater than that released into the Peconic River at the Laboratory perimeter. This could represent radioactivity from tributaries and wash out from drainage areas, in addition to contributions from groundwater.

During 1980, measurements of selected water quality and purity parameters were initiated at downstream locations on the Peconic River and at control locations were initiated in order to provide a comparison with the same parameters in the Laboratory effluent (as reported in Table 10). These limited "grab" sample data are shown in Table 10. The effect of somewhat elevated levels of some of the parameters downstream is attributed to other sources, residential and industrial, along the length of the Peconic River, based on the observation that the increased levels are not uniform but seem to be localized. Other control locations (H,I, and J as indicated in Figure 4), were also monitored for the same

parameters. The results indicate, (Table 10) that in general, the levels are comparable to on-site releases.

3.3.3 Recharge Basin:

After use in "once through" heat exchangers and process cooling, about 20 million 1 d^{-1} (MLD) of water was returned to the aquifer through on-site recharge basins; about 8.6 MLD to basin N located about 610 m northeast of the AGS; about 5.5 MLD to basin O about 670 m east of the HFBR; and about 5.7 MLD to basin P located 305 m south of the MRR (see Fig. 3b and 5). A polyelectrolyte and dispersant (Drewsperse 738 and 744) is added to the AGS cooling and process water supply, to establish a phosphate concentration of about 2 ppm in order to maintain the ambient iron in solution. Of the total AGS pumpage, about 3.4 MLD was discharged to the N basin, and 3.3 MLD to the O basin. The HFBR secondary cooling system water recirculates through mechanical cooling towers and is treated to control corrosion and deposition of solids. Blowdown from this system, about 2.2 MLD, which contains about 6-8 ppm inorganic polyphosphate and 3-4 ppm mercaptobenzothiozone is also discharged to the O sump. The untreated MRR-MRC "once through" coolant, which amounts to 5.7 MLD, is discharged to the P basin. Concentrations of radioactivity and other constituents in the water discharged into these basins are monitored by routine weekly grab sampling. The average gross beta and tritium activity concentrations are shown in Table 11. The average gross beta activity concentrations in the sumps were slightly above background. The N sump receives water that has been used to cool the LINAC beam stops at the AGS. This results in the formation of activation products that contribute to the increase of activity of the N sump. The average gross beta activity was 5-10% of the EPA Drinking Water Standard (16). At the U sump east of the steam plant, the gross beta activity showed levels approaching 30% of the EPA Drinking Water Standard (16). However, they decreased by 35% from the 1979 levels. During 1980 it was ascertained that the steam plant boiler washings were being discharged into this sump, resulting in unusually high levels of radioactivity and water quality parameters. The discharge was rerouted to the sanitary waste system. Since then, all the measured parameters have decreased considerably. In general, the average concentration of gross beta and tritium activity in the other basins increased slightly above those in the Laboratory supply wells and were about 5% of the applicable EPA Drinking Water Standards (16).

Water quality data obtained during 1980 from periodic (approximately monthly) analyses of "grab" samples from the recharge basins and from a culvert which conducts some air conditioning tower blowdown, and from storm sewer influents from the southeast Laboratory building complex to a sump (S) south of the warehouse area (about 1.2 km south of Building 610, see Fig. 2) are shown in Table 11. All results were within established standards for ground water quality. Excess metal concentrations, such as for Cd, Cr, Cu, Fe, Pb and Zn, indicate effects of chemical treatment for keeping iron in solution in the cooling water systems.

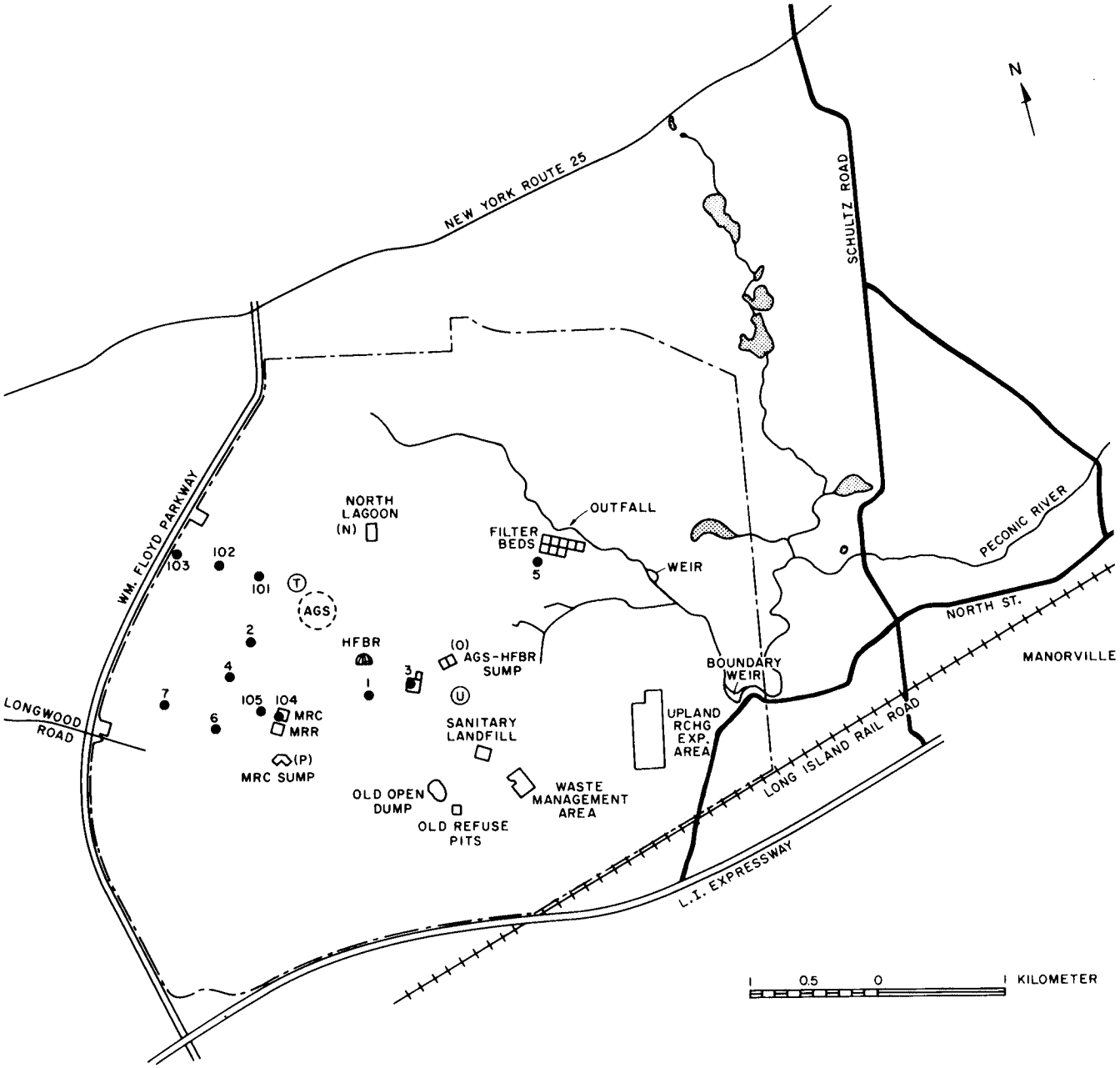


Figure 5. On-Site: Potable and Supply Wells and Recharge Sumps

TABLE 11

1980 BNL Environmental Monitoring
Recharge Basins - Average Radionuclide, Metals and Water Quality Data

Location [a]	# of Samples		Gross α (pCi/ℓ)	Gross β (pCi/ℓ)	Tritium (nCi/ℓ)	Ag	Cd	Cr	Cu	Fe	Pb	Zn	Dissolved Oxygen	Chlorides	Nitrate-Nitrogen	Total Phosphoros	Dissolved Solids	Conductivity (μmhos/cm)	Temperature °C	pH	Coliform - Fecal #/100 ml	Coliform - Total #/100 ml
						ppm																
N (North of AGS)	34	Minimum	0.20	1.18	0.18																	
		Maximum	0.41	12.66	1.55																	
		Average	0.36	5.16	0.58	0.001	0.0006	0.002	0.036	1.795	0.003	0.021	9.2	16.5	0.33	0.40	68	94	16	6.9	16	127
O (East of HFBR)	38	Minimum	0.21	1.81	0.18																	
		Maximum	0.52	8.18	4.42																	
		Average	0.32	3.97	1.10	0.001	0.0006	0.002	0.016	1.366	0.003	0.050	9.6	19.7	0.35	0.32	91	111	18	6.9	0	7
P (South of MRR)	27	Minimum	0.18	1.84	0.18																	
		Maximum	0.67	13.79	1.55																	
		Average	0.37	3.77	0.44	0.001	0.0006	0.002	0.015	1.152	0.005	0.007	5.4	25.8	1.45	0.45	135	186	15	6.9	0	0
T (North of Linac)	41	Minimum	0.13	1.18	0.18																	
		Maximum	0.38	11.73	2.18																	
		Average	0.23	2.38	0.80	0.001	0.0007	0.002	0.033	0.205	0.003	0.014	9.3	24.9	0.42	0.08	99	120	17	7.2	0	0
U (East of Steam Plant)	22	Minimum	0.17	4.86	0.46																	
		Maximum	0.57	27.09	1.41																	
		Average	0.29	15.15	1.02	0.001	0.0006	0.002	0.088	0.180	0.015	0.034	8.3	78.3	1.06	0.26	322	408	16	9.8	0	0
S (South of Warehouse)		Minimum																				
		Maximum	—— NOT DONE ——																			
		Average				0.001	0.0017	0.003	0.096	0.487	0.031	0.286	9.1	22.8	0.91	0.31	212	130	16	7.1	151	412
EPA Drinking Water Standard [16]			15	50	20	0.05	0.01	0.05	-	-	0.05	-	-	-	10	-	-	-	-	-	-	-

[a] Locations of Recharge Basins given in Figure 5.

Recharge Basin - East of Steam Plant (U) - ^{90}Sr: 0.95 pCi/ℓ (one sample).

Applicable Standards - Table 17.

3.3.4 Aquatic Biological Studies:

Samples of sediment, vegetation, and fish were collected at Station Q (Site Boundary) and were analyzed for gamma emitters and ^{90}Sr. The data is shown in Table 12 and is restricted to ^{90}Sr and ^{137}Cs as these radionuclides were found in detectable concentrations above the MDL and can be considered as principal contributors to body burden estimates in man. Other nuclides such as ^{60}Co, which are specifically attributable to Laboratory effluents, if present, were either less than or equal to the MDL for the counting system used (Table 17 and Appendix B). This table also summarizes corresponding data from the previous years [11] in order to indicate the change in radioactivity with time in the different ecological compartments.

Looking at the concentration factors on a unit weight basis for ^{90}Sr and ^{137}Cs at Station Q, it is noted that there is an increase across the food chain: water-vegetation-fish. For ^{90}Sr, the concentration factor for fish ranges from 80 to 110 in flesh. For ^{137}Cs, the concentration factor for fish ranged from 930-1630. These results are in accordance with other observations in aquatic environments [21,22]. Using an assumed intake of 1.36 kg/yr [23] of fish flesh (edible portions) by adults and the indicated range of concentrations of ^{90}Sr and ^{137}Cs in fish flesh (edible portions), one can compute body burdens for these radionuclides in man to be ranging from 0.05% to 0.20% respectively of the upper limit of the doses permissible to the general public under the DOE Standard [14].

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 5, these wells are located generally west to northwest of the Laboratory's principal facilities and 'upstream' of the local ground water flow pattern. An average of about 25.8 MLD was pumped from them in 1980.

Quarterly grab samples were obtained from these wells. These were analyzed for gross alpha, gross beta and tritium and the results are shown in Table 13. All gross alpha concentrations were <1 pCi/liter ($<1 \times 10^{-9}$ μCi ml^{-1}), and almost all tritium concentrations were <1.0 nCi/liter ($<10^{-6}$ μCi/ml). There are some differences in the gross beta concentrations among these wells. Since, these differences are not corroborated by tritium concentrations, the sources of gross beta do not appear to be related to Laboratory activities. In general, these values have been consistent over many years.

3.3.5.2 Ground Water Surveillance:

Samples of ground water were obtained from a network of shallow surveillance wells previously installed in the vicinity of several areas where a potential has existed for the percolation of radioactivity from the surface downward into the saturated zone of ground water. These include areas adjacent to the

TABLE 12

1980 BNL Environmental Monitoring
Concentration of ^{90}Sr and ^{137}Cs in Water, Sediment, Vegetation
and Fish Obtained from the Peconic River at the
Site Perimeter as Observed During 1974-1980

	Water		Sediment		Vegetation		Fish	
	^{90}Sr	^{137}Cs	^{90}Sr	^{137}Cs	^{90}Sr	^{137}Cs	^{90}Sr	^{137}Cs
Year	(pCi/ℓ)		(pCi/Kg-wet) [a]		(pCi/Kg-wet) [a]		Flesh (pCi/Kg-wet) [a]	Flesh
1974	1.23	1.13	-	306	-	220	-	112-326
1975	1.74	4.46	-	525	-	1010	-	397
1976	1.37	1.86	-	440	-	257	-	700
1977	1.09	1.60	-	1656	-	1128	25-30	772-3400
1978	1.11	0.79	-	920	-	990	27-34	536-1192
1979	0.58	0.87	19	188	86	585	40-60	1036-1113
1980	0.64	0.67	67	214	76	727	54-72	626-1094

[a] Original results given in dry weight; the results shown are corrected to wet weight to facilitate estimation of concentration factors.

TABLE 13

1980 BNL Environmental Monitoring
Potable and Cooling Water Wells - Average Radionuclide, Metals and Water Quality Data

Well # (a)	Gross α (pCi/ℓ)	Gross β (pCi/ℓ)	Tritium (nCi/ℓ)	Ag	Cd	Cr	Cu	Fe	Pb	Zn	Dissolved Oxygen	Chlorides	Nitrate-Nitrogen	Total Phosphoros	Dissolved Solids	Conductivity μmhos/cm	Temperature °C	pH
				ppm														
1	ND			.001	.0006	.002	.041	.018	.003	.011	9.5	13.4	0.84	0.01	79	118	12	5.8
3	ND										8.6	18.3	0.10	0.06	73	106	17	6.6
4	0.46	2.17	0.18	.001	.006	.002	.010	2.748	.003	.006	7.3	19.8	0.28	0.02	82	111	12	5.9
5	0.14	1.24	0.18	.001	.0006	.002	.006	0.712	.003	.090	10.0	7.2	0.04	0.01	39	46	12	6.0
6	0.49	1.85	0.19	.001	.0006	.002	.005	4.835	.003	.003	7.9	25.6	0.53	0.01	89	135	12	6.0
7	0.31	1.12	0.65	.001	.0006	.002	.014	2.677	.003	.010	7.1	16.3	0.17	0.02	63	99	11	5.8
102	0.99	4.07	0.18	.001	.0006	.002	.008	3.370	.003	.030	7.5	10.8	0.14	0.30	60	77	11	6.2
103	0.57	2.03	0.18	.001	.0006	.002	.011	4.485	.006	.033	4.4	16.5	0.35	0.22	69	90	11	6.0
104	0.38	2.03	0.19	.001	.0006	.002	.004	0.616	.003	.067	5.9	24.3	1.12	0.02	117	167	15	6.1
105	0.23	2.63	0.29	.001	.0006	.002	.025	0.646	.003	.004	6.6	26.1	1.69	0.01	131	166	14	5.8
EPA Drinking Water Standard [16]	15	50	20	0.05	0.01	0.05	-	-	0.05	-			10	-		-		
New York State Drinking Water Standard [24]											>4	250			500		<30	6.5-8.5

(a) Locations of Potable and Cooling Water Wells given in Figure 5.

ND - Not Done

Applicable Standards - Table 17.

on-site recharge basins, the sand filter beds, the Peconic River downstream, the solid waste management area, the former open dump, the sanitary landfill, the decontamination facility sump, and the Meadow-Marsh Project area. The locations of most of these ground water surveillance wells are shown in Figure 6. The locations of the several wells installed at the landfill and solid waste management area are shown in Figure 7.

For convenience in assessing the data, the wells have been divided into several groups. Yearly average gross alpha, gross beta, and tritium activity concentrations of the wells adjacent to the sand filter beds, and downstream on the Peconic River are summarized in Table 14. During the year, at least one sample from locations adjacent to the recharge basins and from locations immediately adjacent to the sand filter beds and the Peconic River were analyzed for ^{90}Sr and ^{137}Cs (by gamma analysis). Corresponding information for wells downstream (with reference to ground water movement) of the solid waste management area, the landfill and former dump zones, and the decontamination facility sump (about 1 km east of the HFBR) are also summarized in Table 14. It is to be noted the data in the table does not include all the wells. Only those wells that have been consistently showing higher than normal values over the years have been included. Since the aquifer underlying Nassau and Suffolk Counties has been designated as a "Sole Source" (24), the EPA Drinking Water Standards are applicable (16). The data, therefore, are evaluated in terms of the EPA standard and not the RCG's, as was done in previous years.

In analyzing the data over the past several years, it has been observed that the spread of radioactivity in the ground water from Laboratory operations has remained limited to within a few hundred meters of the identifiable foci. Above background concentrations of gross beta emitters, tritium and ^{90}Sr were found on-site adjacent to the sand filter beds and the Peconic River at about 10-25% for Gβ, 10-50% for ^{3}H and 10-100% ^{90}Sr of the Drinking Water Standards (16). In 1980, the activity concentrations were generally less than those noted in 1974 and 1975 (11), and had further decreased when compared to that during 1976-1979 (11), indicating that radionuclides had not moved significantly since 1976 and therefore had undergone dilution and decay. Wells XH and XZ, which had shown a significant increase in gross beta activity in 1978 over previous years (11) were reduced by more than 80% in 1980 and as such were not reported in the table. It must be noted, however, that these increases in 1978 were not accompanied by a similar increase in ^{90}Sr activity. Of the wells located adjacent to the Peconic River and the sand filter beds, in the direction of the ground water flow, only well XL showed a slight increase in gross beta activity over the 1979 values. Adjacent to the Peconic River at the site boundary all gross beta and tritium concentrations were less than or equal to 4% of the Drinking Water Standards. In 1978, samples of well water collected from homes (stations A, B, C and D - Figure 6) and well WS, all of which are downstream, with reference to ground water movement, of the Laboratory and the Peconic River had indicated ^{90}Sr concentrations approaching one to two $pCi\ell^{-1}$. In 1980, all showed a slight decrease and were $<1\ pCi\ell^{-1}$, as compared with the EPA drinking water limit of 8 $pCi\ell^{-1}$ (16). An extensive study of wells throughout Suffolk County in 1979 indicated that shallow wells generally contained larger concentrations of ^{90}Sr than deeper wells, regardless of their proximity to the Laboratory. This is attributed to fallout from past nuclear tests.

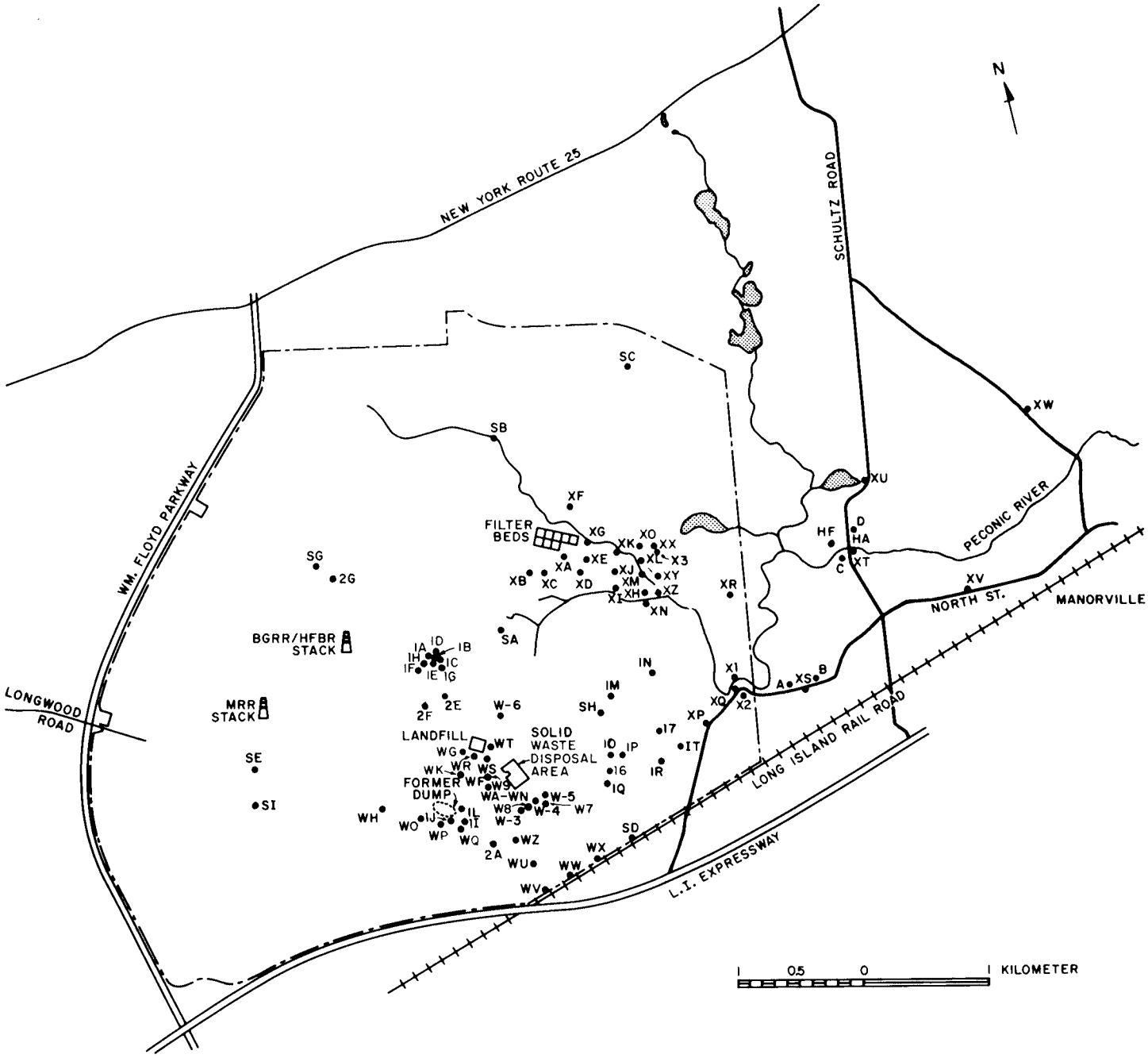


Figure 6. Location of Groundwater Surveillance Wells

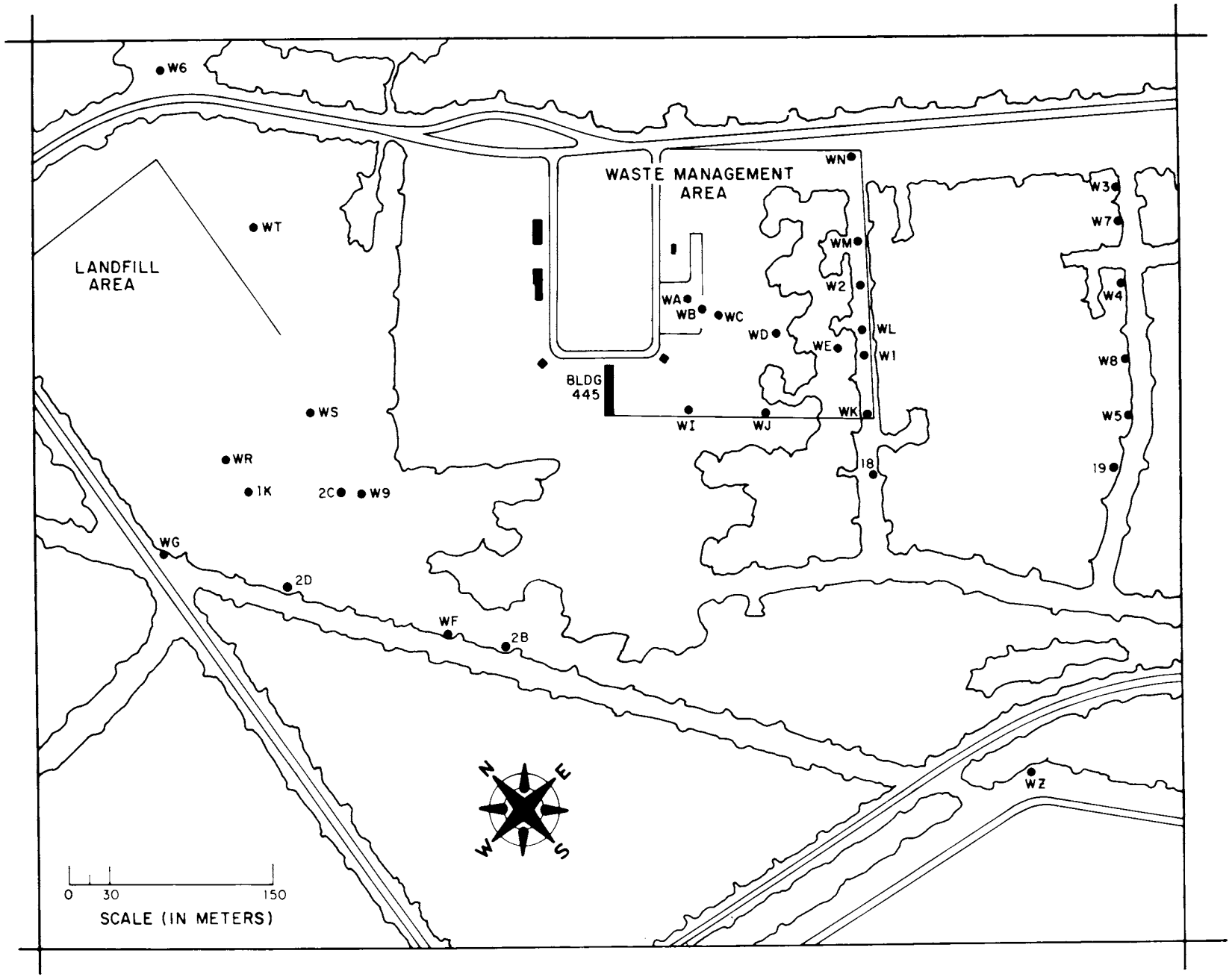


Figure 7. Landfill and Waste Management Area Surveillance Wells

TABLE 14

1980 BNL Environmental Monitoring
Groundwater Surveillance Wells - Average Radionuclide, Metals and Water Quality Data

Well #	# of Samples Analyzed	Gross α (pCi/ℓ)	Gross β (pCi/ℓ)	Tritium (nCi/ℓ)	^{90}Sr (pCi/ℓ)	Ag	Cd	Cr	Cu	Fe	Pb	Zn	Dissolved Oxygen	Chlorides	Nitrate Nitrogen	Total Phosphates	Dissolved Solids	Conductivity (μmhos/cm)	Temperature °C	pH
						ppm														
Sand Filter Bed and Peconic River Area																				
XA	4	0.55	11.61	11.10	2.59	0.001	0.0009	0.002	0.006	0.077	0.003	0.255	5.2	26.7	4.46	0.04	119	156	18	5.8
XC	1	0.39	4.25	0.2	1.13	0.001	0.0005	0.002	0.002	1.49	0.003	0.157	2.0	7.9	0.07	0.01	36	54	10	5.8
XF[a]	1	0.12	1.18	0.19	<0.09	0.001	0.0005	0.002	0.006	0.015	0.006	0.887	8.8	8.4	0.04	0.01	51	54	10	5.9
XG	4	0.69	7.57	0.91	0.86	0.001	0.0006	0.002	0.003	4.22	0.015	0.069	7.0	11.9	0.15	0.04	58	76	13	6.1
XJ	1	0.3	3.74	0.2	1.15	0.001	0.0005	0.002	0.002	1.18	0.003	0.283	2.0	6.0	0.02	0.01	33	45	8	4.8
XK	4	0.87	9.33	2.42	1.95	0.001	0.0006	0.002	0.008	1.02	0.003	0.572	2.2	13.2	0.18	0.04	79	105	12	6.1
XL	4	0.9	30.51	3.82	8.32 [5.87, 10.77]	0.001	0.0006	0.002	0.006	2.085	0.003	0.237	2.3	14.6	0.38	0.04	85	104	12	6.1
XM	3	2.51	12.02	5.64	1.67	0.001	0.0006	0.002	0.011	7.98	0.003	1.08	7.8	20.7	0.36	0.15	88	112	20	6.0
XN	2	0.37	8.94	1.45	1.41	0.001	0.0005	0.002	0.006	0.149	0.003	0.241	8.2	14.9	0.11	0.01	78	82	-	4.5
XQ	1	0.29	10.29	1.79	1.22	0.001	0.0006	0.002	0.005	6.42	0.003	0.144	1.6	25.9	0.03	0.01	88	136	13	6.3
XR	1	0.2	3.33	0.19	1.34	0.001	0.001	0.002	0.005	0.84	0.007	1.95	11.0	7.4	0.14	0.01	42	48	9	5.6
XS[b]	4	1.39	13.53	0.2	1.21	0.001	0.0006	0.002	0.015	2.43	0.003	0.166	8.9	14.3	0.27	0.01	81	117	12	5.8
XT[b]	1	0.22	1.47	0.18	0.20	0.001	0.0005	0.002	0.002	1.17	0.003	0.117	2.4	4.6	-	0.30	59	68	10	6.8
XW[b]	1	0.22	2.07	0.18	<0.09	0.001	0.0005	0.002	0.003	0.839	0.003	0.181	1.8	39.8	-	0.12	-	133	11	6.5
XX	4	0.61	9.69	1.81	2.96	NOT DONE							1.7	17.8	0.05	0.01	53	101	11	5.9
XY	1	0.24	6.16	1.54	2.13	0.001	0.0005	0.002	0.004	0.461	0.003	0.264	2.0	14.8	0.03	0.01	62	88	12	5.3
Miscellaneous on Site																				
SA[a]	1	0.24	1.34	0.22	1.06	0.001	0.0008	0.002	0.006	0.320	0.003	0.782	8.6	10.8	0.38	0.01	46	70	13	5.4
SC[a]	1	0.21	0.98	0.18	0.13	0.001	0.0006	0.014	0.011	0.256	0.015	2.14	7.7	4.0	0.11	0.11	40	43	11	6.0
SE[c]	2	0.22	2.73	0.19	<0.09	0.001	0.0006	0.002	0.004	1.43	0.003	0.05	7.1	27.3	1.45	0.01	110	167	15	6.6
SG	1	0.5	5.95	0.17	1.40	0.001	0.0006	0.002	0.003	1.83	0.003	0.115	7.0	16.8	0.78	0.01	70	88	14	5.8
2E	1	0.23	2.33	0.18	1.12	0.001	0.0006	0.002	0.003	0.209	0.003	0.005	7.0	13.3	0.43	0.03	129	197	15	6.3
2F	2	0.29	3.48	0.18	0.89	0.001	0.0006	0.002	0.004	1.555	0.003	0.005	8.5	16.7	0.91	0.01	56	94	15	6.2
2G	2	0.25	1.68	0.23	<0.09	0.001	0.0006	0.002	0.002	0.007	0.006	0.04	5.0	21.2	0.45	0.02	82	112	16	5.9
Waste Management Area																				
WB	2	0.08	0.83	14.7	17.72 [27.01, 8.43]	0.001	0.0006	0.002	0.007	0.1	0.006	0.543	6.8	10.3	2.49	0.01	140	129	15	5.2
WC	1	0.46	97.44	7.98	9.53	0.001	0.0006	0.008	0.008	0.303	0.003	0.402	6.0	5.4	3.41	0.18	108	130	15	5.2
WD	2	0.33	26.17	11.69	3.65 [1.84, 5.46]	0.001	0.0007	0.002	0.006	0.158	0.01	0.692	8.2	6.8	1.60	0.01	123	106	14	5.3
WE	1	0.38	15.86	12.4	4.14	0.001	0.0006	0.002	0.004	0.15	0.003	0.476	8.0	2.5	0.46	0.02	40	51	14	5.6
WK	2	0.29	61.21	32.4	27.58	0.001	0.0006	0.002	0.005	0.11	0.006	0.414	7.4	5.6	0.44	0.01	121	78	13	5.5
WL	2	0.24	51.5	23.8	24.99 [33.02, 16.97]	0.001	0.0006	0.002	0.005	0.208	0.003	0.399	9.0	2.6	0.36	0.01	121	67	13	5.6
WM	1	1.0	23.7	0.76	2.35	NOT DONE														
WZ	1	0.36	3.78	0.19	<0.09	0.001	0.0013	0.002	0.006	3.64	0.05	1.47	9.4	7.7	0.25	0.01	66	70	11	6.5
W1	2	0.25	8.54	1.27	2.76	0.001	0.0006	0.002	0.007	0.292	0.003	0.564	9.1	2.3	0.05	0.01	99	45	12	5.6
W5	2	0.21	5.22	0.2	0.17	0.001	0.0006	0.002	0.005	0.028	0.003	0.521	8.5	3.8	0.22	0.01	69	43	12	5.3
W8	2	0.25	1.54	0.19	<0.09	0.001	0.0006	0.002	0.003	0.131	0.023	1.38	8.3	4.6	0.40	0.01	43	52	12	5.4
Landfill Area																				
WR	2	4.49	57.89	10.81	2.00	0.003	0.0006	0.004	0.005	106.8	0.003	0.190	4.3	61.8	0.5	0.01	510	893	14	6.5
WS	2	3.58	41.03	24.55	2.92	0.003	0.0006	0.003	0.013	118.1	0.031	0.210	7.5	25.9	0.21	0.02	163	590	13	6.6
WT	2	0.6	1.66	0.24	<0.09	0.001	0.0006	0.002	0.005	1.35	0.003	0.930	4.5	10.7	0.26	0.01	54	80	12	5.4
W9	2	9.59	102.8	43.25	10.29	0.004	0.0006	0.004	0.008	64.2	0.003	0.130	3.1	29.5	0.44	0.01	455	941	12	6.6
1K	2	6.96	65.25	11.14	3.61	0.001	0.0006	0.003	0.005	52.9	0.003	0.149	1.3	30.0	0.32	0.01	427	861	14	6.5
2C	2	5.7	84.83	37.09	8.35	0.004	0.0006	0.002	0.007	19.7	0.003	0.022	3.3	4.6	0.43	0.11	702	1510	13	6.1
2D	1	5.92	49.58	0.3	<0.09	0.002	0.0006	0.011	0.015	20.9	0.003	0.005	2.4	25.6	1.04	0.01	343	-	13	6.6
650 Sump Area																				
1A	1	0.26	124.0	0.18	56.58	0.001	0.002	-	0.004	0.487	0.003	0.626	7.6	16.1	0.51	0.03	79	116	16	6.2
1B	1	0.18	0.97	0.18	-	NOT DONE														
Former Dump Area																				
WO	1	0.21	1.74	0.2	0.12	0.001	0.0009	0.002	0.058	1.130	0.003	0.010	12.0	3.6	0.05	0.01	40	46	11	5.7
WP	1	0.26	1.82	1.76	0.02	0.001	0.0013	0.002	0.004	1.540	0.003	0.007	7.2	11.5	1.07	0.02	61	86	12	5.3
WQ	1	0.48	1.32	0.2	<0.09	0.001	0.0006	0.002	0.003	0.380	0.003	0.003	11.0	8.9	0.06	0.01	40	57	11	5.6
EPA Drinking Water Standard [16]	15	50	20	8	0.05	0.01	0.05	-	-	0.05	-	-	-	10	-	-	-	-	-	

[a] Control

[b] Off-site

[c] Medical sump

Applicable Standards-Table 17.

In several wells adjacent to the solid waste management area, the gross beta, tritium and ^{90}Sr activity concentrations for 1980 showed a decrease when compared to 1979. Elevated ^{90}Sr activity concentrations, exceeding Drinking Water Standards, were found in wells WB, WC, WD, WE, WK and WL. They reflect the inadvertent injection in 1960 of approximately one Ci of aged fission products into ground water at well WA. The concentrations of ^{90}Sr in these wells decreased when compared to 1979. Such fluctuations appear to represent the complex interaction of ground water movement rates and distribution coefficients of the elements in the soil matrix. The gross beta and tritium activity concentrations decreased when compared to those of recent years in several wells immediately adjacent to the landfill area. This is attributable to the evident restrictions against the disposal of radioactive waste on the landfill, as well as movement and dilution through ground water. The gross beta and ^{90}Sr concentrations in well 1A, at the decontamination facility (Bldg. 650) sump, which had increased by a factor of two in 1978 [11] were lower in 1980. The concentrations of gross beta activity and tritium in other wells around this sump area have continued to decrease. The gross beta and ^{90}Sr concentrations in wells 1A, 1H and 1E exceeded the limits for groundwater of 50 $pCi\ell^{-1}$ and 8 $pCi\ell^{-1}$, respectively. However, calculations based on ground water 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 indicate travel times greater than two ^{90}Sr half-lives (approximately 60 years) to reach the site boundary. In addition, 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 inadvertent discharge of ^{90}Sr into well WA and at the 650 sump area could cause the concentrations of ^{90}Sr in any well off-site to exceed EPA drinking water limits.

Several water quality and purity parameters were also evaluated for most ground water surveillance wells. The data for those wells adjacent to on-site sumps, the sand filter beds, and downstream of the Peconic River on- and off-site, are also shown in Table 14. Similarly, the data for wells adjacent to the solid waste management area, the landfill, the dump area and the 650 sump, are also shown. Analyses for selected metals were conducted for a few wells immediately adjacent to the sand filter beds, to the Peconic River, to the waste management, landfill and former dump areas. These data are shown in Table 14.

In general, the data were comparable to that observed during 1974-1979. With the exception of pH, all analyzed water quality parameters were within New York State Water Quality Standards [18]. The somewhat 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 8). Concentrations of Fe and Zn in excess of water quality standards were found in some of the wells immediately adjacent to the sand filter beds, the Peconic River, landfill areas, and the 650 sump area. Since these results may be an artifact produced by the sampling well casings, or reflect the leaching of accumulations of these metals from past Laboratory releases, a program to compare effects of well casings was instituted in 1980. The results indicate that the effect is measurable. Tracing the levels of these elements in the ground water system by means of the Laboratory surveillance wells downstream in the direction of the ground water flow, has indicated significant decreases as one proceeds away from the Laboratory,

such as 60-70% along the Peconic River, 25 to 30% in the waste management area and 50-60% in the 650 sump area. Much lower levels of Zn were found in the Laboratory supply wells. Several contain Fe in excess of the standard, but most of this is removed prior to use. Zn and Fe are considered as nuisance elements and not as a health hazard.

The Industrial Hygiene Group of the Safety and Environmental Protection Division has instituted a program whereby purchases of chemical compounds that have the potential for polluting the river water are flagged and the user is notified of the proper disposal method. This program has helped the Safety and Environmental Protection Division to identify and advise the users of such compounds since 1978. In addition, a Laboratory wide notification program has been put into effect whereby permission is required from Safety and Environmental Protection Division before any chemical that is defined as toxic is discharged into the sanitary system.

The general rate and direction of ground water movement is 16.2 cm d^{-1} and predominantly in the southeast direction (7). It appears, therefore, that many years of travel time would be required for ground water containing radioactivity or other pollutants to reach an off-site well, during which considerable dilution by infiltration of precipitation would be anticipated. The data from all the surveillance wells are reviewed at frequent intervals in order to evaluate the monitoring program and appropriate action is taken, such as, rescheduling the sampling of wells and follow up analysis if required.

3.4 Unusual Occurrences:

3.4.1 Oil Spills:

During 1980, the Laboratory experienced one oil spill. This occurred at the motor vehicle diesel oil storage tank. The spill involved about 50-100 gallons of diesel oil and was caused by over filling of the storage tank. Reporting and clean-up procedures were instituted immediately. The absorbents used to clean up the spills were disposed of according to New York State Department of Environmental Conservation (NYSDEC) approved procedures. Since the spill occurred within the protective berm area the need for revegetation was not required.

3.4.2 Chinese Nuclear Tests:

The Chinese detonated an atmospheric nuclear test on October 16, 1980. As indicated in Section 3, slight increases in gross beta activity were noted in air samples and precipitation. Fallout radionuclide concentrations were at or below MDL in milk and grass samples collected from dairy farms in the vicinity of the site and as such are not reported here. Unlike the previous years, 1976 in particular, the 1980 values may be considered as insignificant in terms of Radiation Protection Guide Limits (14).

4.0 OFF SITE DOSE ESTIMATES

Increased levels of radiation and concentrations of radioactivity, in air and water, above ambient background, with resulting increased doses to people, are attributable to the following three Laboratory sources:

1. airborne radioactive effluents, primarily tritium,

2. radioactive liquid effluents,

3. skyshine from the Alternating Gradient Synchrotron (AGS).

These are discussed below, and the collective dose equivalent rate due to Laboratory operations during 1980 is calculated.

4.1 Annual Average Collective Dose-Equivalent Rate Due to Airborne Effluents:

As indicated in Table 3, a total of 286 Ci of tritium was released from various Laboratory facilities during 1980, making it the largest source of dose equivalent to persons off-site relative to other laboratory released radionuclides. It was conservatively assumed that all the tritium released was in the form of tritiated water vapor at the site boundary for the estimation of dose equivalent.

Air activity concentrations of tritium vapor at the site boundary were close to the MDL. Data given in Table 6 indicates an average concentration (including background) of 3.3 pCi m^{-3} at the site boundary ($\sim$2500 meters from the HFBR stack). Continuous exposure at the Radiation Concentration Guide (2 x 10^5 pCi m^{-3}) would result in a per capita annual average dose-equivalent rate of 500 mRem a^{-1}. Thus, the per capita annual average dose-equivalent rate, at this distance, attributable to Laboratory air effluent tritium vapor was (3.3 x 500)/(2 x 10^5) or <0.01 mRem a^{-1} or <0.002% of the Radiation Protection Standard [14]. Since the individual external background per capita dose-equivalent rate (Table 2) in this area was about 64.1 mRem a^{-1}, the tritium contribution amounts to an increase at the site boundary of about 0.01%, which is within the temporal and spatial variations of the background itself.

As was previously stated, the dose equivalents due to ^{41}Ar, ^{15}O and ^{127}Xe were not measurable and as such were not included in the final estimates.

Table 15 gives the doses to the general public due to BNL tritium releases. It indicates that beyond the site boundary, the dose rates due to tritium in air effluents from the Laboratory were very small, compared with background and variations in background. The parameter X/Q, tabulated in the second column, is the ratio of ground level concentration to rate of emission, i.e., concentration per unit emission rate, and is a function of meteorological conditions and distance from the source. The values have been calculated for the 97.5 m release height of the HFBR stack and are averages for a whole year and for all the sixteen tabulated directions. While their use may produce an underestimate at close-in distances for releases from shorter stacks, overall it results in some overestimation of population exposure, since X/Q values in the

TABLE 15

1980 Environmental Monitoring
Collective Annual Average Dose-Equivalent Rate Due to Airborne Effluents
From BNL Facilities in Comparison with Background

Distance from HFBR Stack (km)	X/Q [27] $sec\ m^{-3}$	Population [a]	HTO [b] Per Capita Dose Equivalent Rate $mrem\ Person^{-1}a^{-1}$	HTO [b] Collective Average Dose Equivalent Rate $rem\ a^{-1}$	Background Collective Average Dose Equivalent Rate $rem\ at^{-1}$
1.6- 3.2	2.4×10^{-7}	1,612	0.0095	0.015	103
3.2- 4.8	1.0×10^{-7}	5,590	0.004	0.022	358
4.8- 6.4	6.0×10^{-8}	11,698	0.0025	0.029	749
6.4- 8.0	3.9×10^{-8}	20,402	0.0015	0.031	1,307
8.0-16.1	1.7×10^{-8}	230,530	0.0005	0.115	14,767
16.1-24.2	8.0×10^{-9}	245,423	0.0005	0.123	15,722
24.2-32.2	5.5×10^{-9}	156,258	0.0005	0.078	10,010
32.2-48.4	3.8×10^{-9}	999,399	0.0005	0.499	64,021
48.4-64.5	2.7×10^{-9}	1,380,165	0.0005	0.69	88,413
64.5-80.6	2.1×10^{-9}	1,746,134	0.0005	0.873	111,857
1.6-80.6	-	4,797,211	-	2.475	307,307

[a] Population data estimated from information supplied by Long Island Regional Planning Board [5]. See Table 1 for estimated population distribution for 1980.

[b] Tritiated water vapor.

direction of major population centers to the west of the Laboratory are lower than the 360° averages. Values of the dose rate due to tritium are derived by multiplying the measured values for the 1.6 to 3.2 km interval (0.0095 mrem a^{-1}) by the appropriate ratios of X/Q. The collective dose equivalent (total population dose) due to the Laboratory tritium effluent was 2.48 rem a^{-1}, and that due to natural background (64.1 mrem a^{-1}) was estimated to be 307,307 rem a^{-1}.

4.2 Doses 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.

Based on discussions with the New York State Department of Environmental Conservation, and the productivity of the Peconic River, an annual total catch of 500 kg of fish. It was also assumed that 100 fishermen caught the above amount of fish and that their families consumed all of these fish. Furthermore, it was assumed the breakdown of the adults and children (based on an average family of 2 adults and 2 children) was 364 adults and children above 12 years of age and 60 children below 12 years [4,5]. Thus the annual average consumption of fish by the adult group was estimated to be 1.36 kg/yr and children below 12 years was 0.46 kg/yr (as opposed to the USNRC Regulatory Guide [23] value of 21 kg/yr and 6.9 kg/yr), respectively. Using the above value for consumption of fish and other assumptions recommended in the NRC Regulatory Guide 1.109 [23] and the maximum observed concentration of ^{90}Sr and ^{137}Cs in fish (as shown in Table 12), the estimated maximum individual dose equivalent commitment is tabulated below.

Average Maximum Individual Dose-Equivalent Commitment for One Year of Ingestion (mrem a^{-1})

	^{90}Sr		^{137}Cs	
	Children below 12 yrs	Adults	Children below 12 yrs	Adults
Total Body	0.14	0.01	0.02	0.07
Bone	0.56	0.12	0.16	0.10

The collective average dose equivalent rate (total dose) from this indirect pathway, for the above population, can be estimated to be 0.11 rem a^{-1} (0.3 mrem x 364 persons) for adults and 0.05 rem a^{-1} (0.88 mrem x 60 persons) for infants.

Although not directly related to the Laboratory liquid effluents during 1980, a ^{90}Sr concentration of 1.21 pCi l^{-1} was found in off-site surveillance well (XS), about 0.35 km east of the Laboratory site boundary along the Peconic River. This level corresponds to 15% of the EPA Drinking Water Standard [16]. Assuming that during 1980 all of the 27 people [4,5] living in the vicinity of

this well obtained their drinking water from shallow water supply wells containing ^{90}Sr at the same concentration, then their collective dose equivalent does not exceed 0.02 rem (since 8 pCi/l corresponds to 4 mrem). Their collective average dose-equivalent commitment (total dose) from natural background (including internal radiation) would have been about 1.80 rem (person-rem) during 1980.

4.3 Doses Due to Alternating Gradient Synchrotron:

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

With the advent of the Isabelle project in 1978, the Safety and Environmental Protection Division has instituted an extensive program to evaluate different neutron detectors in the field and also to determine appropriate sampling locations. These studies should provide data on neutron dose distribution around the AGS and Isabelle facilities (when operational) and thus provide a basis for more accurate estimates of off-site doses. Preliminary results, derived by using a neutron monitor (Ludlum 55) at P2 (Figure 2), indicated an annual dose equivalent of 6.1 mrem resulting from neutrons other than those generated by the AGS facility. This dose-equivalent rate has been observed to be similar to levels at other accelerator facilities [25]. Since this study is still in the preliminary stage, it was decided to estimate the dose-equivalent rate from skyshine at the site boundary by comparing the total proton flux for 1977 to that for 1980 and to use this ratio to derive the 1980 dose-equivalent rates from the 1977 values (Table 31-1977 BNL-50813). As such, Table 16 gives the derived dose-equivalent rate (mrem a^{-1}) and the collective average dose-equivalent (average doses) rates for each population segment and for each distance from the source.

Since the dose-equivalent rate from this source decreases rapidly with distance, only population segments with radii of 1.6 to 3.2 and 3.2 to 4.8 kms were considered. The off-site derived collective average dose-equivalent rate (total dose) was 0.02 rem a^{-1} (person-rem a^{-1}) and applicable contributions were found only in the NW and NNW sectors.

4.4 Doses Due to the Gamma Forest ^{137}Cs Source:

A 5739 Ci ^{137}Cs source which was located in the northeast part of the Laboratory site, and about 1010 meters from the north boundary was decommissioned on September 28, 1979 and removed from the Ecology Forest area on October 29, 1979. Consequently there was no population dose resulting from this source.

4.5 Collective Average Dose Equivalent Rate (Total Population Dose):

The collective average dose-equivalent rate (total population dose) beyond the site boundary, within a radius of 80 km, due to Laboratory operations

during 1980 is the sum of the values due to the three components discussed above, as shown below:

Pathway		rem a^{-1} (person-rem a^{-1})
Airborne		
Tritium		2.48
Liquid Effluents		
Fish Consumption:	Adults	0.11
	Infants	0.05
Well water		0.02
AGS Skyshine		0.02
Total		2.68

The collective average dose equivalent (total annual dose) due to external radiation from natural background, to the population within a 80 km radius of the Laboratory, amounts to about 307,307 rem a^{-1}, to which about 94,601 rem a^{-1} (person-rem a^{-1}), should be added for internal radioactivity from natural sources.

TABLE 16

1980 BNL Environmental Monitoring
Off-Site Collective Annual Average Dose Equivalent Rate Due to
External Radiation Exposure from AGS Operations

Sector	Km	Population[(a)]	AGS		
			Distance (Km)	Dose Rate (mr a^{-1})	Person-rem
SSW	1.6-3.2	0	-	-	-
	3.2-4.8	265	4.4	7.14×10^{-5}	1.89×10^{-5}
SW	1.6-3.2	0	-	-	-
	3.2-4.8	99	4.3	8.92×10^{-5}	8.83×10^{-6}
WSW	1.6-3.2	0	-	-	-
	3.2-4.8	345	4.0	1.65×10^{-4}	5.69×10^{-5}
W	1.6-3.2	280	2.5	5.37×10^{-3}	1.50×10^{-3}
	3.2-4.8	874	3.9	2.32×10^{-4}	2.03×10^{-4}
WNW	1.6-3.2	270	2.1	1.25×10^{-2}	3.38×10^{-3}
	3.2-4.8	686	3.6	3.48×10^{-4}	2.39×10^{-4}
NW	1.6-3.2	206	2.0	2.10×10^{-2}	4.33×10^{-3}
	3.2-4.8	245	3.5	5.37×10^{-4}	1.32×10^{-4}
NNW	1.6-3.2	169	2.0	2.10×10^{-2}	3.55×10^{-3}
	3.2-4.8	79	3.5	5.37×10^{-4}	4.24×10^{-5}
N	1.6-3.2	218	2.3	8.05×10^{-3}	1.75×10^{-3}
	3.2-4.8	0	-	-	-
NNE	1.6-3.2	221	2.5	5.37×10^{-3}	1.19×10^{-3}
	3.2-4.8	388	3.6	3.48×10^{-4}	1.35×10^{-4}
NE	1.6-3.2	133	2.9	2.19×10^{-3}	2.91×10^{-4}
	3.2-4.8	199	3.5	3.48×10^{-4}	6.93×10^{-5}
ENE	1.6-3.2	0	-	-	-
	3.2-4.8	0	-	-	-
E	1.6-3.2	0	-	-	-
	3.2-4.8	354	4.0	1.61×10^{-4}	5.70×10^{-5}
ESE	1.6-3.2	0	-	-	-
	3.2-4.8	338	4.4	8.05×10^{-5}	2.72×10^{-5}
SE	1.6-3.2	0	-	-	-
	3.2-4.8	67	3.1	4.38×10^{-5}	2.93×10^{-6}
SSE	1.6-3.2	63	3.5	6.24×10^{-4}	3.93×10^{-5}
	3.2-4.8	716	4.5	5.37×10^{-5}	3.84×10^{-5}
S	1.6-3.2	51	3.3	8.05×10^{-4}	4.10×10^{-5}
	3.2-4.8	936	4.5	5.37×10^{-5}	5.03×10^{-5}
Total					0.017

(a) Population data estimated from information supplied by Long Island Regional Planning Board [5]. See Table 1 for estimated population distribution for 1980.

TABLE 17

Maximum Permissible Levels of Contaminants in Air and Water
With Their Detection Limits

Contaminant Radionuclide		DOE 0524 [14] Air	DOE 0524 [14] Water	EPA-Drinking Water [16] and NYS Drinking Water Standard [24] (a)	NYS Standard [18,26] Air	NYS Standard [18,26] Water	Detection Limit (b) Air	Detection Limit (b) Water
Gross α µCi/ml		1×10^{-13}	6×10^{-7}	1.5×10^{-8}	1×10^{-13}	6×10^{-7}	3×10^{-16}	3×10^{-10}
Gross β µCi/ml		1×10^{-10}	1×10^{-7}	5×10^{-8}*	1×10^{-10}	1×10^{-7}	1×10^{-15}	1×10^{-9}
^{7}Be µCi/ml	S	2×10^{-7}	2×10^{-3}	6×10^{-6}	4×10^{-8}	2×10^{-3}	1×10^{-12}	5×10^{-10}
	I	4×10^{-8}	2×10^{-3}	6×10^{-6}				
^{3}H µCi/ml		2×10^{-7}	3×10^{-3}	2×10^{-5}	2×10^{-7}	3×10^{-3}	2×10^{-12} (c)	2×10^{-7} (d)
^{60}Co µCi/ml	S	1×10^{-8}	5×10^{-5}	1×10^{-7}	3×10^{-10}	3×10^{-5}	1×10^{-14}	5×10^{-10}
	I	3×10^{-10}	3×10^{-5}	1×10^{-7}				
^{131}I µCi/ml	S	1×10^{-10}	3×10^{-7}	3×10^{-9}	1×10^{-8}	6×10^{-5}	1×10^{-14}	2×10^{-10}
	I	1×10^{-8}	6×10^{-5}					
^{137}Cs µCi/ml	S	2×10^{-9}	2×10^{-5}	2×10^{-7}	2×10^{-9}	2×10^{-5}	1×10^{-14}	3×10^{-10}
	I	5×10^{-10}	4×10^{-5}					
^{54}Mn µCi/ml	S	1×10^{-8}	1×10^{-4}	3×10^{-7}	1×10^{-8}	1×10^{-6}	1×10^{-14}	3×10^{-10}
	I	1×10^{-9}	1×10^{-4}	3×10^{-7}				
^{90}Sr µCi/ml	S	3×10^{-11}	3×10^{-7}	8×10^{-9}	3×10^{-11}	3×10^{-7}		1×10^{-10}
	I	2×10^{-10}	4×10^{-5}					
Non-Radioactive								
Temp C				T_{max} <30 $\Delta T \leq +_{-2.8}$				
pH				6.5-8.5				
Dissolved Oxygen ppm				>4.0				0.2
Chlorides ppm				250		500		0.1
Nitrogen-Nitrate ppm				10		20		0.05
Dissolved Solids ppm				500		1000		20.00
Coliform				Zero#/100ml		4#/100ml		0.00
Ag ppm				0.05		0.1		0.001
Cd				0.01		0.2		0.004
Cr				0.05		0.1		0.001
Cu				-		0.2		0.001
Fe				-		0.6		0.02
Hg				0.002		-		0.00007
Pb				0.05		0.1		0.005
Zn				-		0.3		0.002

(a) Aquifer under Long Island declared as "Sole Source" - Applicable Standard is EPA National Interim Primary Drinking Water Regulations [16].

(b) See Appendix B.

(c) As tritiated vapor

(d) For ^{3}H: 2×10^{-7} to 1×10^{-6} ∝ volume

S - Soluble

I - Insoluble

* EPA Annual Compliance Level

APPENDIX A

QUALITY CONTROL

Radioactive Measurements:

a. Alpha (α), Beta (β) and Gamma (γ):

Certified radioactive standards 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 were also obtained from Amersham/Searle and they are traceable to the National Bureau of Standards. Daily checks of instrument performances are made using the standards as well as backgrounds. In addition, some samples are counted both in the NaI system and the Ge(Li) system. The Ge(Li) system was calibrated using a new multi-gamma NBS Standard obtained in October 1977. The results from the NaI and Ge(Li) systems agree within 5%. 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 the Safety and Environmental Protection Division is a participant in the inter-laboratory comparisons of samples of different matrices of water, air filters, soil, vegetation and bone, which contain a number of frequently encountered radionuclides. These samples are distributed by the Department of Energy (DOE) through the Environmental Measurements Laboratory (EML), on a semiannual basis. The radionuclides assayed were ^{3}H, ^{90}Sr, plutonium isotopes and a number of gamma emitting nuclides. Our results agreed within 10% for water samples and within 15% for other sample matrices.

b. TLD Dosimeters:

The Dosimetry Services Group of the Safety and Environmental Protection Division participated in the Fourth International Intercomparison of Environmental Dosimeters conducted at Houston, Texas from mid February to mid May 1979. There were a total of 122 participants in this test.

The estimated field exposure, as measured by the BNL environmental monitoring TLD dosimeter, agreed within 0.8% of the value measured by a continuously operated recording pressurized ion chamber corrected for energy response. In the Laboratory exposure test, the BNL dosimeter agreed within 3.5% for the "high" ($\sim$50 mR exposure) and agreed within 6.4% for the "low" ($\sim$15 mR exposure).

The Dosimeter Services Group also participated in the Fifth International Intercomparison of Environmental Dosimeters conducted at Idaho Falls, Idaho from mid August to mid November 1980. Final results of this test are still pending and will be reported in the next annual report.

Measurements of Water Quality Parameters:

Procedures for nonradioactive contaminants are those presented in Standard Methods for the Examination of Water and Wastewater (14th edition, 1975). All standards are prepared from standard reference grade and analytical grade reagents in accordance with the requirements of standard methods. Standards are run with each set of samples analyzed and at least one duplicate and blank is run with each set.

APPENDIX B

Minimum Detectable Limit (MDL):

Some of the values in gamma scans by the NaI detector are not indicated in the tables as these values were at or below MDL. The MDL values are a function of Matrix (efficiency), Count Time (background), etc. Typical values for NaI and Ge(Li) systems are given below:

Units: 10^{-6} μCi
Detector: Two 4" NaI crystals
Geometry: Planchet and air particulates

Count Time (sec)	^{7}Be	^{144}Ce	^{57}Co	^{58}Co	^{60}Co
4,000	65.7	20.0	4.1	11.5	17.8
8,000	46.2	20.4	2.9	8.1	12.5
40,000	20.5	9.1	1.3	3.6	5.5
60,000	16.7	7.4	1.6	2.9	4.5

Count Time (sec)	^{134}Cs	^{137}Cs	^{59}Fe	^{131}I
4,000	15.9	7.1	3.9	6.0
8,000	11.2	5.0	2.7	4.2
40,000	5.0	2.2	1.2	1.9
60,000	4.0	1.8	1.0	1.5

Count Time (sec)	^{54}Mn	^{22}Na	^{125}Sb	^{65}Zn
4,000	7.0	22.3	30.7	15.9
8,000	4.9	15.6	21.6	11.2
40,000	2.2	6.9	9.2	4.9
60,000	1.8	5.6	7.8	4.0

Units: 10^{-6} μCi
Detector: 125 cc Ge(Li) Detector
Geometry: Filter paper

Count Time (sec)	^{7}Be	^{144}Ce	^{57}Co	^{58}Co	^{60}Co
4,000	18.5	8.2	2.0	4.6	6.2
50,000	7.5	4.1	0.5	1.0	2.0

Count Time (sec)	^{134}Cs	^{137}Cs	^{59}Fe	^{131}I
4,000	7.5	3.2	1.2	2.7
50,000	2.1	1.0	0.6	0.8

Count Time (sec)	^{54}Mn	^{22}Na	^{125}Sb	^{65}Zn
4,000	3.1	8.6	12.8	6.8
50,000	1.0	2.1	3.1	2.3

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