1978 ENVIRONMENTAL MONITORING REPORT

J.R. NAIDU, Editor

April 1979

SAFETY AND ENVIRONMENTAL PROTECTION DIVISION

BROOKHAVEN NATIONAL LABORATORY

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SAFETY AND ENVIRONMENTAL PROTECTION DIVISION

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NOTICE

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BROOKHAVEN NATIONAL LABORATORY
ENVIRONMENTAL MONITORING REPORT

CONTENTS

CONTENTS (cont'd) Page

Page

FIGURES

TABLES

TABLES (cont'd) Page

TABLES (cont'd) Page

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 were functioning as designed and planned from the standpoint of containment of radioactivity, and

2) the applicable environmental radiation and radioactivity standards and effluent control requirements were being met.

The Brookhaven National Laboratory's (BNL) environmental monitoring program is designed and developed to meet the above two primary objectives and this annual report has closely followed the recommendations given in ERDA 77-24, "A Guide for Environmental Radiological Surveillance at DOE's Installations."[2] However, it must be recognized that considerable latitude was exercised in tailoring the scope and methodology to meet the site's specific environmental monitoring needs at BNL. In addition, the Laboratory has extended its surveillance program to include analysis of the environment for non-radiological components such as heavy metals and organics. This program is being constantly updated to reflect the growing concern over non-radiological pollutants.

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 1.2 million people live in Suffolk County, with principal nearby population centers located in shore line communities. Figure 2 and Table 1 give 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 is a definite transition towards development of suburban housing in proximity to the Laboratory.

The Laboratory site is shown in Figure 3. It consists of some 2130 ha, most of which is wooded, except for a central developed area of about 405 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 the river itself rising in marshy areas in the north and east 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 of the year, from the northwest during the winter, and about equally from these two directions during the spring and fall. This is reflected in the annual wind distribution at an elevation of 108 m, as observed by the BNL Meteorology Group, which is shown in Figure 4.

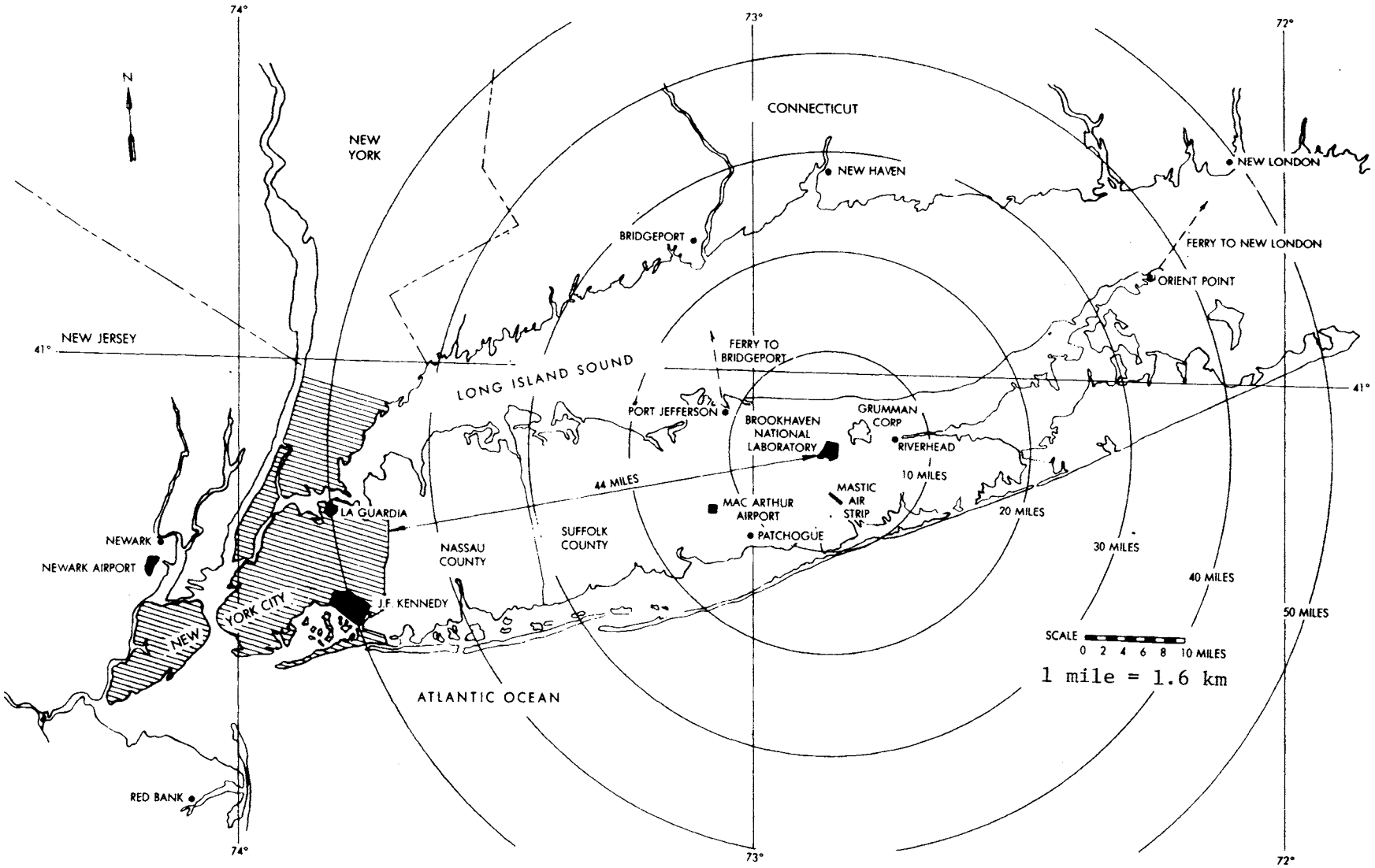


Figure 1. Map of the general Long Island area showing the location of Brookhaven National Laboratory.

TABLE 1

1978 BNL Environmental Monitoring Resident Population (1978)[a]
Distribution Within 80 km Radius of BNL

Sector	16 km	32 km	48 km	64 km	80 km	Total	Remarks
SSW	19,246	985	0	0	0	20,231	Beyond 32 km - Atlantic Ocean
SW	37,895	59,596	3,178	0	0	100,669	Beyond 48 km - Atlantic Ocean
WSW	34.175	132,460	328,244	427,331	765,700	1,687,910	Beyond 80 km - Part of New York City
W	44,636	121,342	220,622	227,300	370,300	984,200	Beyond 80 km - New York City
WNW	37,614	52,402	100	201,000	121,800	412,916	Between 32 km & 48 km - Long Island Sound and beyond 48 km - Connecticut and New York States.
NW	16,202	1,407	127,400	115,000	104,800	364,809	Same as WNW
NNW	6,905	0	196,500	101,300	51,300	356,005	Between 16 km and 32 km - Long Island Sound, beyond 20 km - Connecticut.
N	4,090	0	88,000	233,700	244,600	570,390	Same as NNW
NNE	6,841	0	6,500	41,700	61,800	116,841	Same as NNW
NE	2,677	683	0	12,600	30,900	46,860	Between 32 km and 48 km - Long Island Sound, beyond - Connecticut
ENE	2,275	6,404	11,720	13,304	2,000	35,703	North Fork of Long Island
E	2,744	14,301	15,485	7,984	485	40,999	South Fork of Long Island and Atlantic Ocean,
ESE	5,550	6,849	0	0	0	12,399	Long Island and Beyond 32 km - Atlantic Ocean.
SE	8,164	0	0	0	0	8,164	Beyond 18 km - Atlantic Ocean
SSE	20,152	0	0	0	0	20,152	Same as SE
S	14,913	18	0	0	0	14,931	Beyond 32 km - Atlantic Ocean
Total	264,079	396,447	997,749	1,381,219	1,753,685	4,793,179	

[a] Population data taken from DOE/EIS - 0003, August 1978 [3]
The above data is also shown in Figure 2.

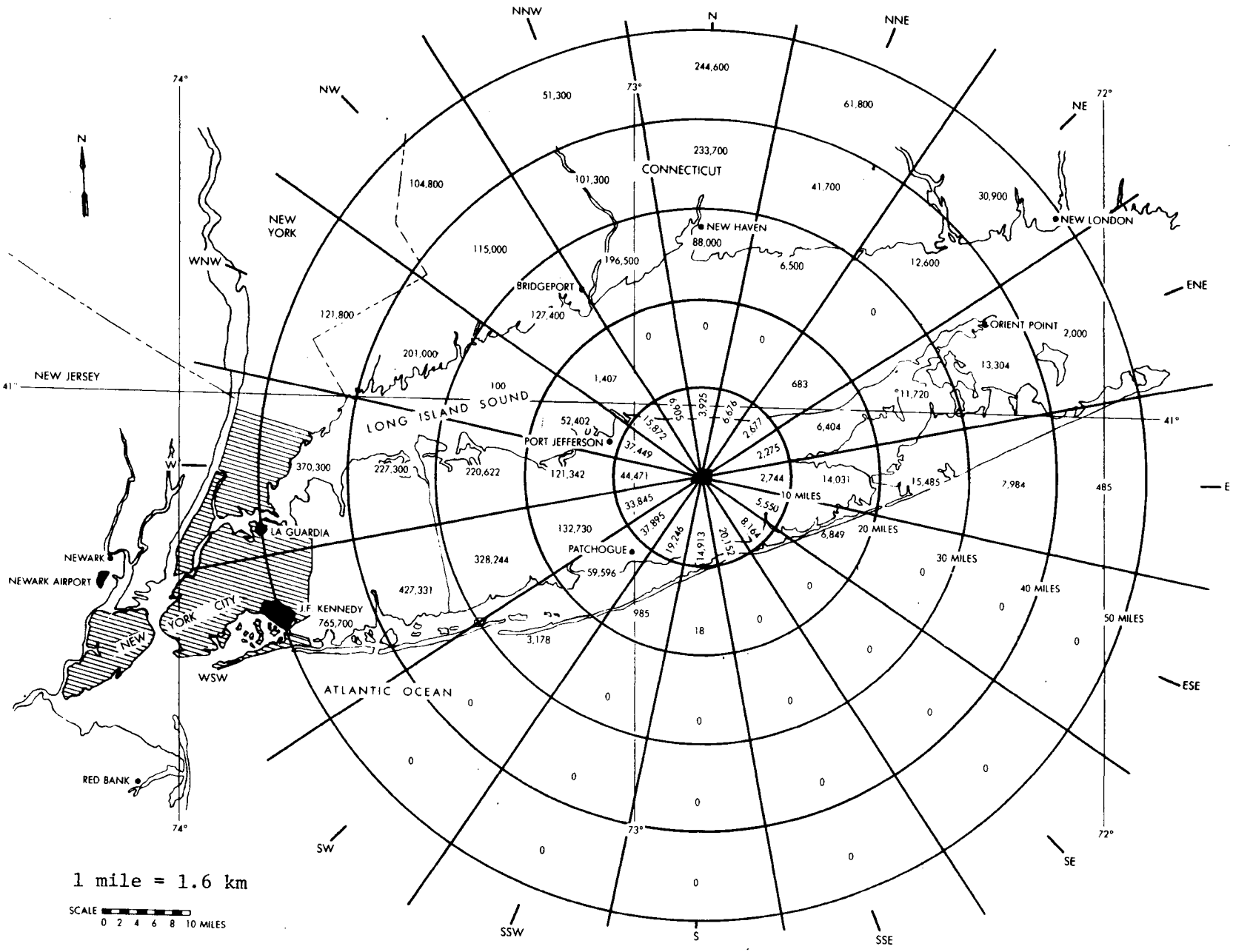
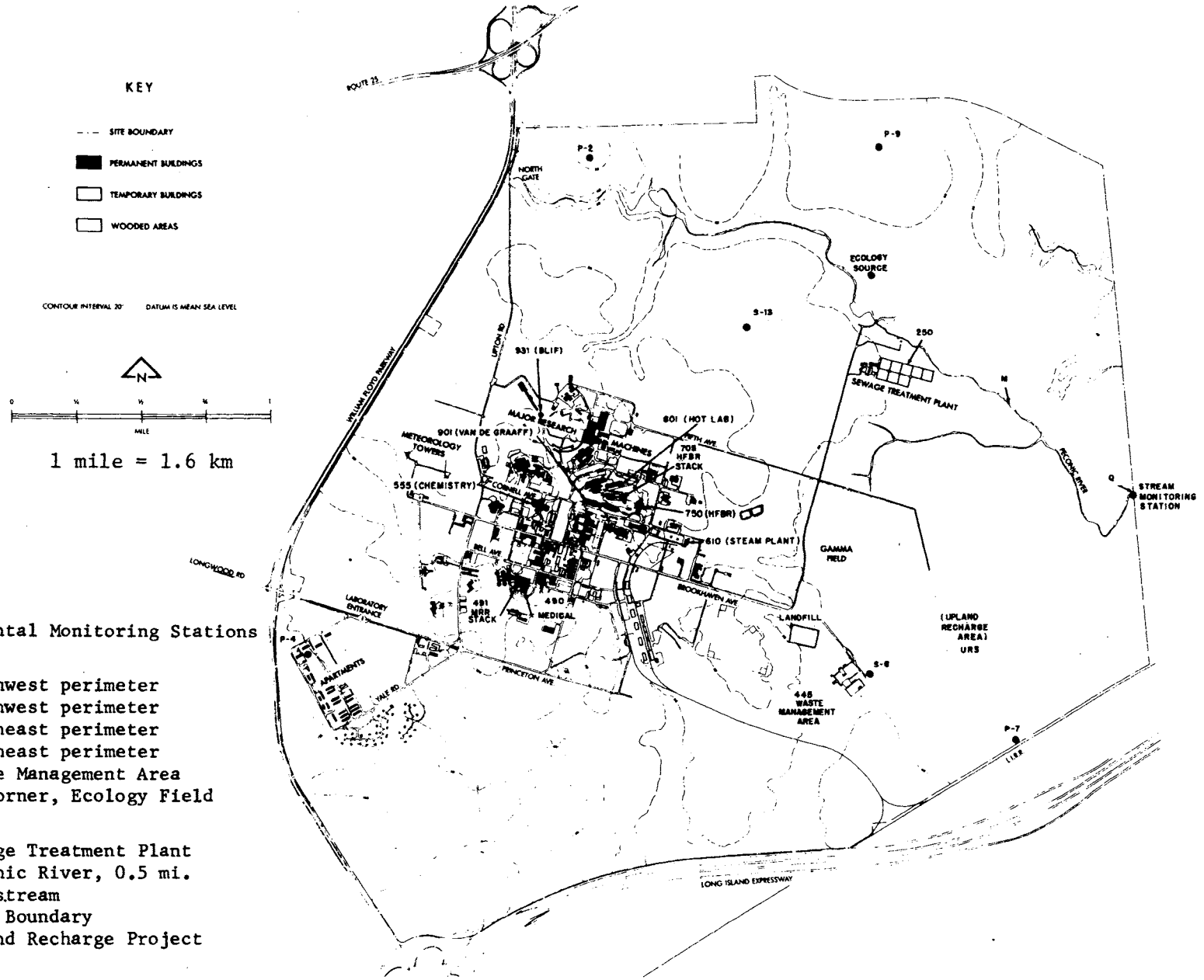


Figure 2. Resident population (1978) within a 80 km radius of BNL.



Environmental Monitoring Stations

Air

P-2	Northwest perimeter
P-4	Southwest perimeter
P-7	Southeast perimeter
P-9	Northeast perimeter
S-6	Waste Management Area
S-13	SW Corner, Ecology Field

Water

250	Sewage Treatment Plant
M	Peconic River, 0.5 mi. downstream
Q	Site Boundary
UR-3	Upland Recharge Project

Figure 3. Brookhaven National Laboratory site.

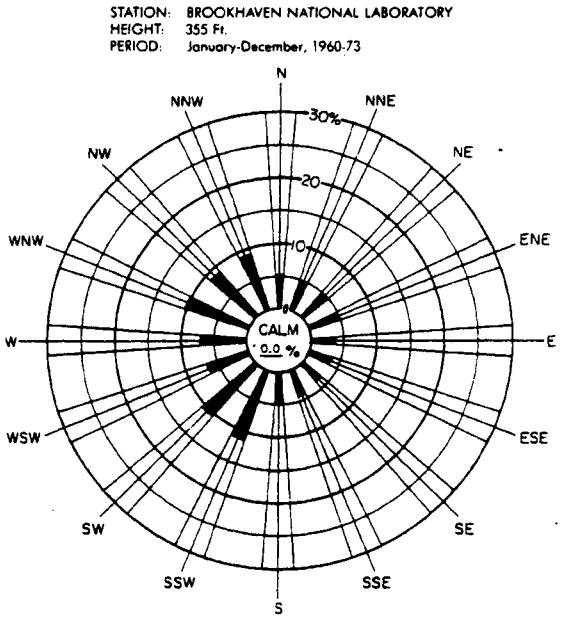


Figure 4. Annual wind rose. The wind rose also represents the period 1973-1978.

Studies of the hydrology and geology [4-6] of Long Island in the vicinity of the Laboratory indicate that the uppermost Pleistocene deposits, which are locally 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, the annual total for 1978 being 135.8 cm, of which about half is lost to the atmosphere through evapotranspiration and the other half percolates to recharge ground water. As indicated in Figure 5 [6], the ground water in the vicinity of the Laboratory moves predominantly in a horizontal direction to the Great South Bay. 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} [6].

1.3 Existing Facilities:

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

1) fundamental structure and properties of matter,

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

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

4) radionuclides and medical applications,

5) nuclear and energy-related technology,

6) energy sources, transmission and use including their environmental 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 operates at a routine power level of 40 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, but also supplies continuous currents of protons for radionuclide production by spallation reactions, in the Brookhaven Linac Isotopes Production Facility (BLIP) and the Chemistry Linac Irradiation Facility (CLIF),

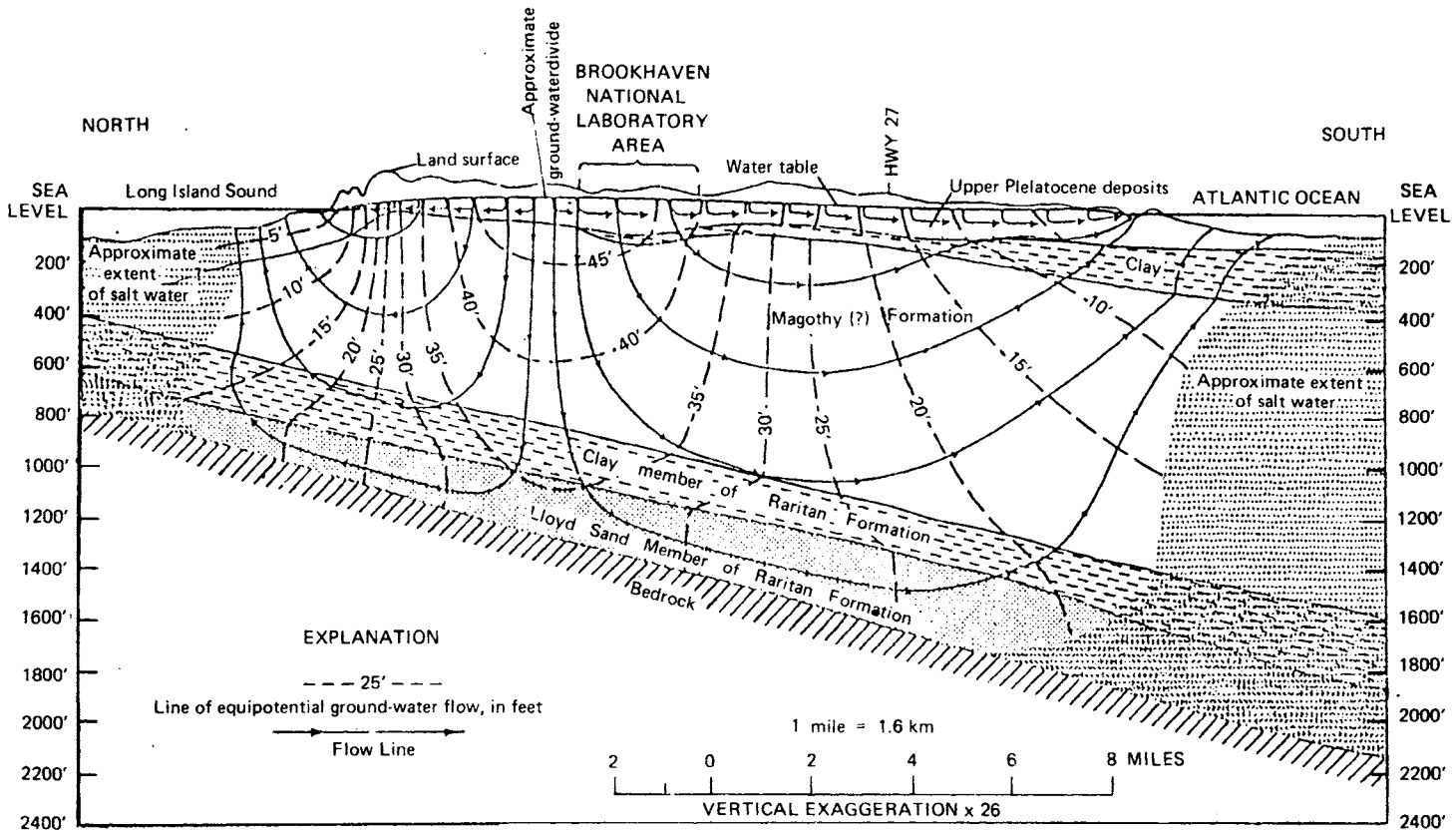


Figure 5. Schematic ground-water flow lines, central Upton area.

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

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 (including a high activity gamma irradiation source), the Chemistry Department, and the Department of Energy and Environment. The latter includes the Hot Laboratory, where special purpose radionuclides are developed and processed for on- and off-site use. 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 produce significant fractions of the Laboratory's liquid radioactive effluents, but additional significant contributions originate from the Medical Research Center, the Hot Laboratory complex, as well as from decontamination and laundry operations.

The Department of Energy and Environment conducts the Meadow-Marsh Project, wherein natural ecosystems are used to treat sewage and return clean water to the ground water aquifer. This experiment is conducted adjacent to a cultivated agricultural area previously established by the Biology Department in the southeast zone of the Laboratory site. It utilizes a portion of the flow from the sanitary waste treatment plant and therefore constitutes a potential route for the release of small amounts of radioactivity to ground water.

2.0 SUMMARY

The environmental levels of radioactivity and other pollutants found in the vicinity of Brookhaven National Laboratory (BNL) during 1978 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.

The external radiation dose for 1978 at the north boundary of the Laboratory attributable to an ecology forest irradiation source was 1.9 mRem a^{-1} (1.9×10^{-5} Sv a^{-1}) or 0.4% of the applicable Radiation Protection Standard [11].*

At the boundary of the Laboratory, about 1.0 km northwest of the Alternating Gradient Synchrotron (AGS), the calculated dose due to skyshine (scattered radiation) was about 0.82 mRem a^{-1} (0.82×10^{-5} Sv a^{-1}), or 0.15% of the Standard. This was too small to be measured. Due to their limited range, the external radiation from the AGS and those from the gamma forest source did not produce a measurable additive effect at off-site locations.

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, 35 pCi m^{-3} (3.5×10^{-12} μCi ml^{-1} or 1.3×10^{-5} Bq ml^{-1}) was 0.02% of the Radiation Concentration Guide (RCG). The largest average concentration of tritium in precipitation, <399 pCi l^{-1} (<3.99×10^{-7} μCi ml^{-1} or 14.7×10^{-3} Bq ml^{-1}) was 0.02% of the RCG for drinking water.

At the Central Steam Plant, the most recent (1977) 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, the concentration of air particulates was 0.31 μg m^{-3}, 0.48% of the yearly average ambient Air Quality Standard [12]. The calculated site boundary concentrations of SO_2 and NO_x emitted from the plant were 0.0012 and 0.0008 ppm, respectively, which were 4.7 and 1.6% of their respective ambient air quality standards.

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* The applicable Radiation Protection Standards and Radiation Concentration Guides for persons in uncontrolled areas are shown with the relevant tabulated data.

About 88% of the sewage effluent released onto the sand filter beds of the Laboratory sewage treatment plant 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 bed output was 24.73 pCi l^{-1} (2.47×10^{-8} μCi ml^{-1} or 9.15×10^{-4} Bq ml^{-1}), or 0.9% of the RCG. The tritium concentration was 3.5 nCi l^{-1} (3.5×10^{-6} μCi ml^{-1} or 1.3×10^{-1} Bq ml^{-1}), or 0.2% of the RCG.

About 0.8% of the combined flow from the sand filter beds and from upstream of the Peconic River permeated into the groundwater. This percolation has occurred between the sewage treatment plant outfall and the Laboratory perimeter and seemed to take place mostly during the latter half of the year. As established at a midway stream sampling location, the gross beta concentration was 16.9 pCi l^{-1} (1.69×10^{-8} μCi ml^{-1} or 6.2×10^{-4} Bq ml^{-1}), or <1% of the RGG, and the tritium concentration was 2.1 nCi l^{-1} (2.1×10^{-6} μCi ml^{-1}), or < 0.1% of the RCG. At the site boundary, the gross beta concentration was 14.6 pCi l^{-1} (1.46×10^{-8} μCi ml^{-1} or 0.5×10^{-3} Bq ml^{-1}), or 0.5% of the RCG, and the tritium concentration was 1.9 nCi l^{-1} (1.9×10^{-6} μCi ml^{-1} or 0.7×10^{-1} Bq ml^{-1}), or 0.06% of the RCG.

About 2% of the total flow from the clarifier at the BNL sewage treatment plant was utilized by the Meadow-Marsh Project. The average gross beta concentration was 29.2 pCi l^{-1} (2.92×10^{-8} μCi ml^{-1} or 1.1×10^{-3} Bq ml^{-1}), or 0.8% of the RCG, and its tritium concentration 1.95 nCi l^{-1} (1.95×10^{-6} μCi ml^{-1} or 0.7×10^{-1} Bq ml^{-1}), or 0.04% of the RCG.

The sewage utilized by the Meadow-Marsh Project contained Cd in a concentration of 12 ppm or 1200 times the water quality standard; Cu in a concentration of 1.7 ppm, which is about four times the standard; Fe in a concentration of 7.4 ppm, which is 12 times the standard, and Zn in a concentration of 1.5 ppm, which is three times the applicable water quality standard [10]. However, there is no direct runoff of these effluents and the project is designed to assess the retention of agents commonly present in sewage by various plant systems.

Except for 67 daily pH levels which were "out of limit", all reportable 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 [12].

Bimonthly sampling of the Peconic River water has indicated a decrease of concentrations of radioactivity as one proceeds downstream of the sewage treatment plant outfall. At a location 4.8 km downstream, the average gross beta concentration as established by bimonthly "grab" sampling was 7.2 pCi l^{-1} (7.2×10^{-9} μCi ml^{-1} or 2.7×10^{-4} Bq ml^{-1}), or 0.20% of the RCG and the tritium concentration less than 0.43 pCi l^{-1} (<0.43×10^{-6} μCi ml^{-1} or <1.6×10^{-2} Bq ml^{-1}), or 0.01% of the RCG. About 24 km downstream, at the river's mouth, the flow was about 25 times that at the Laboratory's site boundary, the avearge concentration of gross beta activity being 9.2 pCi l^{-1} (9.2×10^{-9} μCi ml^{-1}

or 3.4×10^{-1} Bq ml^{-1}) and that of tritium being 0.2 nCi l^{-1} (2×10^{7} μCi ml^{-1} or 0.7×10^{-2} Bq ml^{-1}). Thus, it was apparent that 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.

Seasonal sampling of Peconic River bottom sediments, stream vegetation and of miscellaneous aquatic fauna was conducted. The data indicated that concentration of ^{51}Cr, ^{60}Co and ^{65}Zn, which can be attributed to the Laboratory's effluents, as well as ^{22}Na, ^{137}Cs and ^{144}Ce, which represent fallout contributions were below the Minimum Detection Limits (MDL) of the system used and as such were not reported. The data from a few fish obtained from the river at the former site boundary suggested the presence of small amounts of the Laboratory's releases in the past. The concentration of ^{137}Cs ranges from 536 to 1192 pCi kg^{-1} (2×10^{1} to 40 Bq kg^{-1}). This concentration was 0.07 to 0.02% of the RCG based on an assumed ingestion of 50 g d^{-1}.

About 19 million liters of water per day were used for "once through" cooling and returned to groundwater in on-site recharge basins. The concentration of gross beta activity was about five times greater than that of the supply wells and was less than 0.1% of the RCG. Tritium concentrations were less than the MDL,which is about 0.2% of the RCG.

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. 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 that observed during previous years and reflects the decrease in the concentrations. These were up to a few percent of the EPA Drinking Water Standards [13]. The largest gross alpha concentration, 2.0 pCi l^{-1} (2.0×10^{-9} μCi ml^{-1} or 0.7×10^{-4} Bq ml^{-1}) was 13% 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 128 pCi l^{-1} (12.8×10^{-8} μCi ml^{-1} or 4.7×10^{-3} Bq ml^{-1}). The largest average tritium concentration, 4.8 nCi l^{-1} (4.8×10^{-6} μCi ml^{-1} or 1.8×10^{-1} Bq ml^{-1}) was 31% of the EPA Drinking Water Standard.

Concentrations of gross alpha and 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, then those at the boundary itself. The gross alpha concentration, 1.8 pCi l^{-1} (1.8×10^{-9} μCi ml^{-1} or 6.7×10^{-6} Bq ml^{-1}) was 12% of the EPA Drinking Water Standard [13]. However, this was not directly relatable to any known recently discharged Laboratory effluent. The gross beta concentration was 13.1 pCi l^{-1} (13.1×10^{-9} μCi ml^{-1} or 4.9×10^{-4} Bq ml^{-1}), and the ^{90}Sr concentration was 2.1 pCi l^{-1} (2.1×10^{-9} μCi ml^{-1} or 0.8×10^{-4} Bq ml^{-1}). The latter was 25% of the EPA Drinking Water Standard [13].

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 survillance wells were within the standards. In a limited sampling of a few on-site wells immediately adjacent to the sand filter beds and to the Peconic River on-site, Fe and Zn were found up to ten times their respective water quality standards. These levels exceeded those found in recent Laboratory liquid effluents, and might be an artifact produced by the sampling well casing rather than being present in groundwater itself.

On-site, adjacent to the Solid Waste Management area, the landfill, the former open dump, the decontamination facility storm sewer sump, and at the Meadow-Marsh Project area, 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, 80 pCi l^{-1} (8.0×10^{-10} μCi ml^{-1} or 3.0×10^{-3} Bq ml^{-1}), or ten times the EPA Drinking Water Standard [13], was found in a well 152 m south 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 7.0 pCi l^{-1} (0.7×10^{-8} μCi ml^{-1} or 0.3×10^{-6} Bq ml^{-1}), or 50% of the EPA Drinking Water Standard [13], a gross beta concentration of 94.0 pCi l^{-1} (0.94×10^{-7} μCi ml^{-1} or 3.5×10^{-3} Bq ml^{-1}), or 5% of the RCG, and a tritium concentration of 197 nCi l^{-1} (1.97×10^{-6} μCi ml^{-1} or 0.7×10^{1} Bq ml^{-1}), or ten times the EPA Drinking Water Standard [13], were the largest found. They occurred in wells between the landfill and a location 61 m south of the boundary of the working area.

At the decontamination facility storm sewer sump, a ^{90}Sr concentration of 2.2 pCi l^{-1} (0.22×10^{-8} μCi ml^{-1} or 0.8×10^{-3} Bq ml^{-1}), or 25% of the EPA Drinking Water Standard [13], was found in a surveillance well about 46 m southeast of the sewer outfall into the sump.

With the exception of the presence of Fe and Zn in wells adjacent to the landfill area, all on-site water quality and purity parameters were within the established standards. Immediately adjacent to the landfill, the concentration of Fe was 131 ppm, or 230 times the standard, and that of Zn was 1.5 ppm, or 2.4 times the standard.

All of the above on-site levels of radioactivity or other agents above ambient background in ground water appeared to be confined to within a few hundred feet of their origin, and 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 [13].

Milk samples were obtained by the New York State Department of Environmental Conservation from two Suffolk County dairy farms, one 10 km southeast and one 40 km east of the Laboratory site, following the two Chinese nuclear tests conducted on March 14 and December 14. The fallout radionuclide concentrations in milk were at or below MDL. The data was within the variations of fallout radionuclide concentrations in milk samples for that period within New York State. This activity concentration was considerably lower than those of the previous year (1976) of about 200 pCi l^{-1} (7.4 Bq l^{-1}) of milk.

The collective average dose equivalent rate (total population dose), for the population up to a distance of 80 km, attributable to Laboratory sources, was calculated to be 10.69 rem a^{-1} (person-rem a^{-1}) as compared to a natural background dose equivalent rate to the same population of about 326,270 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 increments attributable to Laboratory activity, were measured by the use of CaF_2:Dy thermoluminescent dosimeters exposed for monthly periods at each of the four perimeter monitoring stations P-2, P-4, P-7, and P-9, as shown in Figure 3.

The observed monthly average dose equivalent rates resulting from gamma activity only [7, 8] are given in Table 2. There was no measurable addition to the natural background attributable to Laboratory activities, except at the northeast perimeter. At this location, the Ecology Forest irradiation source, which contained about 6020 curies (2.23×10^{14} Bq) of ^{137}Cs (as of 1/1/78), produced a dose equivalent rate of $1.9 \pm .01$ mRem a^{-1} ($1.9 \times 10^{-5} \pm 1 \times 10^{-7}$ Sv a^{-1}) or 0.5% of the Radiation Protection Standard for a hypothetical individual member of the general public at this location on the Laboratory perimeter. Background was 68.1 mRem a^{-1} (6.81×10^{-4} Sv a^{-1}). It is to be noted that the source radiation (photons) are less penetrating during winter months relative to the summer months as the density of air increases with the drop in temperature during winter [7, 8], which accounts for the increases in radiation levels noted during the summer months.

3.2 Airborne Effluents and Ground-Level Air Particulates, Tritium and Radioiodine Monitoring:

3.2.1 Facilities and Effluents

The principal Laboratory facilities that currently discharge radioactive effluents to the atmosphere are listed in Table 3. The installed on-line effluent monitoring and sampling devices are also indicated. The location of these facilities on the Laboratory site is shown in Figure 3. The types and amounts of these effluents released during 1978 are shown in Table 4.

Oxygen-15, Iodine-124, Iodine-126 and Xenon-127 are radioactive gases and have the potential of being environmentally significant as sources of increased external radiation at or near the point of generation. Calculations indicate that Oxygen-15, which has a half-life of two minutes, is evolved from the BLIP facility at an efficiency of 0.21 Ci μA^{-1} h^{-1} (7.8×10^{9} Bq μA h^{-1}). When the facility is operated at the full beam current of 180 μA, the equilibrium activity at the point of generation is 1.8 Ci (6.6×10^{10} Bq). ^{127}Xe is produced for commercial use. Argon-41, which has a half-life of 110 minutes, is released from the Medical Reactor Stack at an efficiency of 1 Ci MW $(th)^{-1}h^{-1}$ (3.7×10^{10} Bq MW $(th)^{-1}h^{-1}$) when it is operated at full power of 3 MW (th). Assuming equilibrium is attained, a conservative assumption, the equilibrium activity is 8 Ci (2.96×10^{11} Bq) at the reactor stack. In reviewing the data over the past five years (1974-1978),

TABLE 2

1978 BNL Environmental Monitoring
External Background and Dose Equivalent Rates
(mRem/week)

Month	P-2	P-4	P-7	Northeast Perimeter P-9	Source[a]	Average Background[b]
December/January (77) (78)	1.17	1.26	1.23	1.18	0.00	1.22
January/February	1.03	1.08	1.08	1.02	0.00	1.06
March/April	1.10	1.12	1.12	1.12	0.01	1.11
May	1.24	1.14	1.21	1.23	0.03	1.20
June	1.30	1.21	1.18	1.20	0.00	1.23
July	1.17	1.23	1.22	1.29	0.08	1.21
August/September	1.11	1.18	1.19	1.25	0.09	1.16
October	1.17	1.23	1.22	1.22	0.01	1.21
November	1.04	1.12	1.14	1.15	0.05	1.10
December/January (79)	1.11	1.16	1.17	1.11	0.00	1.15
Total (mRem/year) (59 weeks)	66.60	68.71	68.88	68.95	1.9 ± 0.5	68.17
Average (mRem/week)	1.13	1.16	1.17	1.17	0.03	1.15
Error $\pm$ 2 S.D.	0.11	0.13	0.13	0.11	0.01	0.09

Locations of monitoring stations indicated on Figure 3

[a] ^{137}Cs Ecology Forest Irradiation Source radiation level derived by subtracting average background at other stations from total measured level at northeast perimeter.

[b] Average of P-2, P-4 and P-7, unaffected by BNL on site radiations or effluents.

Data for this table supplied by J. Gilmartin (S&EP) using CaF_2 (Dy) environmental monitoring TLDs which were placed in the above locations by E. Hartmann (S&EP).

mRem = 0.00001 Sv.

TABLE 3

1978 BNL Environmental Monitoring Gaseous Effluent
Release Locations and On-Line Monitoring and Sampling Devices

Building[a]	Facility and release point radioactive effluents	Release height (m)	Principal nuclide(s)	On-Line monitoring	Sampling devices
490	Medical Research Center Roof Stack	13.7	Tritium (vapor)	None	Dessicant for tritium vapor
491	Medical Research Reactor	45.7	Argon-41	Moving tape for radio-particulates	Charcoal for radioiodines
555	Chemistry Building Roof	16.8	Tritium (vapor)	None	Dessicant for tritium vapor
750 801	High Flux Beam Reactor/ Hot Laboratory Stack	97.5	Tritium (vapor)	Beta scintillator for radioactive gases; Kanne chamber for tritium (gas+vapor)	Dessicant for tritium vapor; particulate filter for gross beta; charcoal cartridge for radioiodines
901	Van de Graaff Accelerator	18.3	Tritium (gas+ vapor)	Kanne chamber for tritium (gas+vapor)	Dessicant for tritium vapor
931	Linac Isotope Facility	18.3	Tritium (vapor) Oxygen-15	G-M detector for radiogases	Dessicant for tritium vapor
Steam Plant Effluents					
610	Central Steam Plant Stack	19.8	Particulates; SO_2; NO_x	None	None

[a]Locations given in Figure 3

TABLE 4

1978 BNL Environmental Monitoring Airborne Effluent Data
Radioactive Effluents

Building	Facility and release point	Elevation[a] (m)	Nuclide	Activity released (Ci)
491	Medical Research Reactor Stack	45.7	^{41}Ar	604[b]
490	Medical Research Center Stack	13.7	^{3}H (vapor)	0.43
555	Chemistry Building Stack	16.8	^{3}H (vapor)	11.28
750	High Flux Beam Reactor	97.5	^{3}H (vapor)	90
801	Hot Laboratory Stack		^{3}H (vapor)	42.15×10^{-3}
			Gross Beta (particulate)	2.15×10^{-3}
			^{127}Xe	4.22
901	Van de Graaff Accelerator	18.3	^{3}H (gas)	1263
			^{3}H (vapor)	3.04
931	Linac Isotope Production Facility	18.3	^{3}H (vapor)	130.46×10^{-3}
			^{15}O	61570[c]
			^{127}Xe	5.57

[a] Above ground level.

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

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

Ci = 3.7×10^{10} Bq.

it is to be observed that, except for ^{127}Xe, the radioactive gases released are a function of operational time and power level of the facility. In relation to the environment, it must be recognized that considerable dilution with the ambient air occurs between the point of generation of these sources of radioactivity and the site boundary. Additionally, radioactive decay decreases the air activity concentrations of these radionuclides during the transit time between the source and the site boundary. Both these factors, dilution and decay, reduce the air activity concentrations to a level at which no detectable increase in the dose equivalent rate at the site boundary occurs.

Tritium (^{3}H) has a half-life of 12.3 years, and is a very low energy beta emitter ($T\beta$ = 18.6 KeV). Its principal environmental significance is as tritiated water vapor (HTO), which is taken up and utilized by living systems as water. Of the 1368 Ci (5.1×10^{13} Bq) of tritium released from the Laboratory facilities during 1978, 1263 Ci (4.7×10^{13} Bq) (92%) was in gaseous form, and 105 Ci (3.9×10^{12} Bq) (8%) was released as tritiated water vapor (HTO). As Low as Reasonably Achievable (ALARA) practices at HRBR have reduced HTO releases by 70% since 1974. These include changing heavy water at frequent intervals (once a year) and an effective program to detect and prevent leaks.

The amounts of conventional pollutants released from the Central Steam Plant are shown in Table 5. Those for sulfur dioxide (SO_2) and nitrogen oxide (NO_x) are derived from reported emission factors for comparable plants [9], supplemented by analysis for sulfur content of the fuel oil utilized at the plant. The amount of particulates was based on the average concentration found in stack sampling of the steam boiler units in a series of tests conducted during 1977 by an Environmental Protection Agency (EPA) approved laboratory. Their results indicate the average emission rate of particulates, 0.078 lb/MBTU, was below the emission limit of 0.1 lb/MBTU as set forth by the New York State Department of Environmental Conservation (Part 227, Stationary Combustion Installations).

A review of the fuel consumption over the past five years (1974-1978) has indicated reductions in SO_2, NO_x and particulates. This is noticeable especially when compared to 1976 as the Laboratory has been burning alternate liquid fuels (ALF) such as mineral spirits, alcohol, jet fuel and reconsitututed fuels. The consumption of ALF has increased from zero in 1976 to 6% in 1977 and 23% in 1978. These alternate fuels have a weighted average sulfur content of 0.5% or less, as compared to the 1% sulfur content of the #6 oil. Thus, though the total volume of fuel consumed has gone up, the amount of fuel, if weighted to 1% sulfur content, has been reduced by 18% which, in turn, is reflected in the reduction of the pollutants. Recognizing the importance of fuel savings by burning ALF and because of the uncertainties in the potential releases to the environment resulting from the combustion of these fuels, analyses of the samples of these alternate fuels were done by an EPA approved laboratory. The analysis of a composite sample indicated a total mercury concentration of 5.0 ppm (salt and organo-Hg). At this concentration, it is not possible to exceed the EPA emission rate limit of 2.3 kg/day. In fact, if BNL burned 100% ALF in its boiler, the calculated emission rate at maximum feeding (1860 kg/hr) is only 0.22 kg/day. The current usage of ALF is as a mixture with #6 fuel oil. In 1977, BNL used 6,419,000 gallons of #6 fuel oil and 375,000 gallons of ALF (17:1).

TABLE 5

1978 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[12]
SO_2	4.0×10^5[b]	307 ppm	1.2×10^{-3} ppm	0.03 ppm
NO_x	1.9×10^5	198 ppm	8.02×10^{-4} ppm	0.05 ppm
Particulates	3.1×10^4[c]	0.08 g/m^3	0.31 $\mu g/m^3$	75 $\mu g/m^3$

[a]Based on average X/Q of 2.4×10^{-7} sec/m^3 calculated by BNL Meteorology Group (1978).

[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).

Table based on data supplied by Plant Engineering (E.E. Shelton).

In 1978, the usage was 6,318,300 gallons of #6 fuel oil and 1,464,200 gallons of ALF (4:1). Consequently, effluent emissions during 1977 and 1978 resulted in mercury discharge rates of 6.5×10^{-3} kg/day and 46.5×10^{-3} kg/day, approximately 400 to 100 times below the EPA limit. The analysis for chlorinated hydrocarbons was negative although small traces of chlorine were detected. Additionally, the low ash content (<20 ppm) indicated neglibible quantities of trace metals. Therefore, even if the most liberal estimates of usage are employed, the environmental consequences of burning these alternate fuels with #6 fuel oil do not represent a significant impact.

3.2.2 Sampling and Analysis

The Brookhaven environmental monitoring air sampling program is designed to distinguish between concentrations of airborne radioactivity attributable to natural sources and activities remote from the Laboratory (e.g., above ground nuclear weapons tests) from Laboratory activities. All of the detected air concentrations of radioactivity during 1978 could be attributable to the first two sources. Recent fallout from two Chinese nuclear tests detonated on March 14 and December 14, 1978 were also detected.

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. 3, S-6), and at the northeast and southwest perimeter stations (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. Short term fluctuations in airborne radioactive particulate concentrations are indicative of the presence of recent weapons tests debris. To distinguish between nuclear weapon test debris and that resulting from activities of the Waste Management operations, the air particulate filters at station S-6 were changed and counted on a daily basis during the work week. The air particulate filters at the other stations were changed and counted on a weekly basis.

After allowing several days for the decay of short lived natural radioactivity, gross alpha counts of air particulate samples from the Solid Waste Management area station were made, using a 12.7 cm diameter Zn-S coated detector with a photomultiplier tube. After allowing for decay, gross beta counts of air particulate samples from all locations were made using a 12.7 cm beta scintillator. These data are shown in Table 6. This table also includes data from a source point--the HFBR stack. The sampling point in the stack is located after the exhaust air from the Hot Lab (Bldg. 801) and the HFBR pass through absolute filters. The data should, therefore, represent the concentration at the HFBR stack. The seasonal trend of an early spring maximum, as observed for both gross alpha and gross beta activity in 1975, shifted toward late spring in 1976, early summer in 1977, and for 1978 has returned to an early spring maximum. An increase in gross beta and alpha activity observed during previous years has been slightly decreased. The early spring maximum parallels increased precipitation causing scavenging of beta, gamma emitting fallout radionuclides created during previous weapon tests. Significant differences between sampling locations were seen during the months of March, April, September and December. In general, the gross beta activity at the

Table 6

1978 BNL Environmental Monitoring Average Gross Alpha, and Gross Beta Concentrations, Air Particulate Filters (pCi/m^3 or 1.03E-12 $\mu Ci/cm^3$)

		ALPHA				BETA			
	LOCATION	NO.	AVERAGE	MAXIMUM	MINIMUM	NO.	AVERAGE	MAXIMUM	MINIMUM	TL FLOW(M3)
JANUARY	WASTE AREA	20	.0009	.0021	.0002	20	.1232	.2300	.0689	2.249E+04
	S.W. PERIM					5	.1388	.1950	.1080	1.475E+04
	N.E. PERIM					5	.1067	.1380	.0692	1.801E+04
	STACK					5	.0453	.1190	.0248	8.820E+02
FEBRUARY	WASTE AREA	14	.0007	.0014	.0001	15	.1238	.2290	.0118	1.466E+04
	S.W. PERIM					3	.1378	.1630	.1050	8.975E+03
	N.E. PERIM					4	.1475	.4060	.0612	1.334E+04
	STACK					4	.1350	.1780	.0777	7.932E+02
MARCH	WASTE AREA	23	.0009	.0020	.0001	23	.3596	2.7800	.0205	2.221E+04
	S.W. PERIM					4	.4498	.6790	.2150	1.169E+04
	N.E. PERIM					4	.3253	.9390	.1110	1.546E+04
	STACK					4	.0490	.0624	.0248	9.154E+02
APRIL	WASTE AREA	20	.0008	.0020	.0001	20	.2179	.7030	.0549	2.024E+04
	S.W. PERIM					4	.1910	.2330	.0968	1.717E+04
	N.E. PERIM					4	.2284	.3520	.0956	1.543E+04
	STACK					4	.0461	.0794	.0259	8.175E+02
MAY	WASTE AREA	22	.0006	.0022	.0001	22	.1472	.2850	.0608	2.372E+04
	S.W. PERIM					5	.1492	.2550	.0888	2.005E+04
	N.E. PERIM					5	.1383	.2370	.0906	1.783E+04
	STACK					4	.0579	.0792	.0447	6.365E+02
JUNE	WASTE AREA	22	.0009	.0028	.0003	23	.2561	.4580	.0254	1.912E+04
	S.W. PERIM					3	.2208	.2860	.1670	1.210E+04
	N.E. PERIM					4	.2338	.3030	.1800	1.560E+04
	STACK					4	.1238	.7480	.0283	9.217E+02
JULY	WASTE AREA	18	.0006	.0014	.0001	18	.1545	.2830	.0868	1.908E+04
	S.W. PERIM					5	.1928	.2630	.1070	1.641E+04
	N.E. PERIM					5	.1820	.2500	.1080	1.639E+04
	STACK					5	.0552	.0755	.0273	8.020E+02
AUGUST	WASTE AREA	23	.0009	.0080	.0000	23	.1030	.1520	.0686	1.992E+04
	S.W. PERIM					4	.1133	.1380	.0854	1.555E+04
	N.E. PERIM					4	.0955	.1260	.0832	1.581E+04
	STACK					4	.0364	.0638	.0253	7.082E+02
SEPTEMBER	WASTE AREA	19	.0008	.0028	.0001	19	.1106	.6020	.0435	1.838E+04
	S.W. PERIM					4	.0785	.0960	.0578	1.603E+04
	N.E. PERIM					4	.0739	.0930	.0509	1.571E+04
	STACK					5	.0541	.1540	.0373	7.505E+02
OCTOBER	WASTE AREA	22	.0006	.0018	.0000	22	.0641	.1370	.0105	2.071E+04
	S.W. PERIM					5	.0544	.0752	.0400	1.698E+04
	N.E. PERIM					5	.0500	.0745	.0280	1.672E+04
	STACK					3	.0641	.1770	.0254	5.934E+02
NOVEMBER	WASTE AREA	20	.0009	.0023	.0003	20	.0854	.2860	.0358	1.911E+04
	S.W. PERIM					4	.0581	.1100	.0466	1.505E+04
	N.E. PERIM					4	.0515	.0586	.0461	1.538E+04
	STACK					4	.1663	.3730	.0553	7.902E+02
DECEMBER	WASTE AREA	20	.0010	.0029	.0001	20	.1007	.1630	.0069	1.822E+04
	S.W. PERIM					20	.1222	.8670	.0804	1.867E+04
	N.E. PERIM					4	.1047	.1370	.0898	1.184E+04
	STACK					3	.3459	.5410	.0711	7.213E+02
YTD	WASTE AREA	243	.0008	.0080	.0000	245	.1582	2.7800	.0069	2.467E+05
	S.W. PERIM					66	.1513	.8670	.0400	1.834E+05
	N.E. PERIM					52	.1444	.9390	.0280	1.896E+05
	STACK					49	.0975	.7480	.0248	9.332E+03
FIRST QTR	WASTE AREA	57	.0009	.0021	.0001	58	.2079	2.7800	.0118	6.370E+04
	S.W. PERIM					12	.2412	.6790	.1050	3.541E+04
	N.E. PERIM					13	.1887	.9390	.0612	4.891E+04
	STACK					13	.0741	.1780	.0248	2.591E+03
SECND QTR	WASTE AREA	64	.0007	.0028	.0001	65	.2065	.7030	.0254	6.760E+04
	S.W. PERIM					12	.1813	.2860	.0888	4.932E+04
	N.E. PERIM					13	.1972	.3520	.0906	4.885E+04
	STACK					12	.0794	.7480	.0259	2.376E+03
THIRD QTR	WASTE AREA	60	.0008	.0080	.0000	60	.1226	.6020	.0435	5.739E+04
	S.W. PERIM					13	.1289	.2630	.0578	4.799E+04
	N.E. PERIM					13	.1180	.2500	.0509	4.792E+04
	STACK					14	.0489	.1540	.0253	2.261E+03
LAST QTR	WASTE AREA	62	.0008	.0029	.0000	62	.0826	.2860	.0069	5.804E+04
	S.W. PERIM					29	.0805	.8670	.0400	5.070E+04
	N.E. PERIM					13	.0653	.1370	.0280	4.395E+04
	STACK					10	.1991	.5410	.0254	2.105E+03

Reference Standards - Table 33

YTD = Total

Waste Management area was about three times that of the SW and NE Perimeter areas, the latter two being usually similar in value. These differences indicate the presence of Laboratory-produced radionuclides in air particulate samples. However, the gross beta activity showed a significant overall increase in March and to a slight extent in December following the nuclear tests conducted during the same months by the Chinese.

In addition to the gross beta counts indicated above, shortly after the end of each month, analyses for gamma emitting nuclides were performed on a monthly composite of all individual air particulate samples. Additional gamma analyses were also scheduled at six month and one year post-collection to facilitate the resolution of short and long lived nuclides with full energy peaks too close to be resolved by the NaI detection system employed. The charcoal samples were re-analyzed at one month post-collection to determine ^{131}I by decay in its full energy peak region during this time. Data are reported in Table 7. The increase in gross beta activity following the Chinese nuclear test in late 1976 began to decline in early 1977 but scavenging by heavy precipitation did result in activity approaching late 1976 levels. Furthermore, when compared to 1976 data, it seems that there is evidence of a spring maximum, as evident by the increase in activity in March to July 1978 following an initial increase of activity during October to November 1977 resulting from the Chinese nuclear test of September 1977. Part of the increase in March 1978 could be the result of the Chinese nuclear test in March 1978; however, only a very slight increase was noted in December 1978 following the Chinese nuclear test on December 14. (It is probable that we may see this activity in early 1979.) Fission product nuclides did not exhibit a similar trend; however, statistically significant levels of ^{131}I noted during the earlier Chinese nuclear tests in 1976 and 1977 were not detected. ^{140}Ba-La, however, was seen during March and December 1978. Other nuclides, such as ^{7}Be and ^{95}Zr-Nb, were at low levels but were uniform in activity throughout the year. 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. These data indicate the absence of Laboratory effluent contributions.

Sampling for tritium vapor was performed at the same air sampling stations by drawing a small side stream of air (~100 cm^3/min) through silica gel cartridges which were changed on a monthly basis. During colder months, the sampling cycle was lengthened as the low humidity permitted extending the sampling capacity of the silica gel. The collected vapor was subsequently removed from the gel by heating, then condensed and assayed by liquid scintillation counting. The tritium air concentration data obtained during 1978 is indicated in Table 8. The background concentration was inferred from that found in precipitation collected off site. It should be noted that the high tritium activity from May to August was due to contamination of the counting system. The measured yearly average concentration at the site boundary, about 35 pCi m^{-3} (0.35×10^{-10} μCi cm^{-3} or 1.30×10^{-6} Bq cm^{-3}), was 0.02% of the applicable Radiation Concentration Guide (RCG).

TABLE 7

1978 BNL Environmental Monitoring Monthly Average Concentrations of Gross Beta Activity and of Gamma Emitting Nuclides in Monthly Composite Air Particulate and Charcoal Filters

(pCi/m^3 or 10^{-12} $\mu Ci/ml$)

Month	Average Gross β	Sample Volume m^3	NUCLIDES			
			^{7}Be	^{95}Zr-Nb	^{106}Ru	^{140}Ba-La
January	0.121	56132	0.12	-	-	-
February	0.136	37868	0.21	0.07	0.007	-
March	0.364	50276	0.18	0.12	0.005	0.006
April	0.210	53658	0.19	0.05	-	-
May	0.144	62237	0.18	-	-	-
June	0.237	47742	0.14	0.09	-	-
July	0.174	52682	0.12	0.17	0.015	-
August	0.103	51988	0.12	0.18	0.010	-
September	0.103	50871	0.10	0.09	0.008	-
October	0.057	55500	0.09	0.11	-	-
November	0.068	50330	0.17	0.08	-	0.002
December	0.113	49451	0.19	0.10	-	-
Average	0.151					
Radiation Concentration Guide[11]	100		$4x10^4$	$2x10^3$	200	1000

Error on the counting of samples is estimated to be about 15%.

Radionuclides such as ^{131}I, ^{137}Cs, ^{144}Ce all below MDL.

See Figure 3 for location of sampling stations: P-2, P-4, P-7, P-9, S-6 and S-13.

$pCi = 3.7 \times 10^{-2}$ Bq.

TABLE 8

1978 BNL Environmental Monitoring Average Tritium Vapor Concentration in Air

(pCi/m^3 or 10^{-12} $\mu Ci/ml$)

Period	Waste Management Area	Southwest Perimeter	Northeast Perimeter	Background
January	74±8	<8	18±5	↑
February	105±7	15±7	11±6	
March	104±11	<10	<5[b]	
April	128±13	<9	39±9	
May[a]	145±18	<13	<17	1.8[c]
June[a]	203±45	35±10	125±31	
July	151±26	188±32	157±16	
August	163±30	32±19	<27	
September	104±29	30±15	<26	
October	60±14	17±11	<9[b]	
November	78±12	14±8	11±4[c]	
December	42±7	8±6[b]	<10[b]	↓
Average	113± 19	32± 12	37± 14	
Radiation Concentration Guide	. . . . . 2 x 10^5			

[a] Partial samples collected during periods of 4/28 to 5/12 and 6/15 to 6/27. Samples collected during 5/12 to 6/15 were contaminated during sample processing giving an erroneous value of ^3H concentration.

[b] Counted for a long time to explore sensitivity levels of counting.

[c] Calculated from concentration of tritium in precipitation collected off site. Assuming average temperature of 15°C and 50% relative humidity.

$\mu Ci = 3.7 \times 10^4$ Bq.

$pCi = 3.7 \times 10^{-2}$ Bq.

The current Laboratory environmental monitoring program does not include air sampling for nonradioactive substances. The calculated annual average concentrations at the site boundary of the conventional pollutants released from the Central Steam plant are indicated in Table 5. All were less than 2% of the EPA Primary Air Quality Standard for these constituents. As discussed earlier in this Section, the use of ALF with #6 fuel oil does not represent a significant impact on the environment.

About 250 kg of various pesticides, chiefly organo-phosphates, Thiodan, Diazinon, Carbaryl and Parathion, were applied [15] on site during 1978, 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 becoming airborne subsequently.

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. 3). Two routine collections were made from these, one whenever precipitation was observed during a previous 24 hour (or weekend) period, and the other 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 composited for monthly tritium analysis, and the balance put through ion exchange columns for subsequent quarterly ^{89}Sr, ^{90}Sr and gamma analyses. The data for 1978 (with the exception of tritium) are reported in Table 9. 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 two (March 14 and December 14) Chinese nuclear tests. The amounts of naturally produced gamma emitters, such as ^{7}Be and ^{22}Na, have been slightly higher each year since 1975, especially during 1977 and 1978. Fission and activation products, such as ^{54}Mn, ^{95}Zn-Nb, ^{131}I and ^{137}Cs, were all below their MDL despite the two Chinese nuclear tests. Measurements of ^{144}Ce indicated the presence of fallout from the two Chinese nuclear tests.

To obtain an indication of tritium washout, small precipitation collectors, in addition to the pot-type collectors, were established at the perimeter stations (P-2, P-4, P-7, P-9) and at Blue Point, some 20 km southwest of the Laboratory site. As indicated in Table 10, the average tritium concentration in the collectors located at station P-9 and at the sewage treatment plant (in the predominant downwind direction from Laboratory release locations) and at other collectors, were all reduced significantly when compared to 1974, 1975, 1976 and 1977. The levels detected are, however, at or below the MDL. The average concentration (on site) was less than 0.01% of the RCG for drinking water. The estimated total deposition of tritium on the Laboratory site during 1978 was less than 10 curies (3.7×10^{11} Bq) (using the yearly totals of on-site and perimeter concentrations). The washout of Laboratory effluent appears to have been less than 8 curies ($<3 \times 10^{11}$ Bq) or about 8% of the reported stack release of tritium vapor.

TABLE 9

1978 Monthly Average Gross Beta Concentration,
Total Gross Beta Activity and Individual Nuclide Activity in Precipitation[a]

Month	Rainfall (cm)	Average Gβ (pCi/liter or 10^{-9} μCi/ml)	(nCi/m^2) Gβ	^{7}Be	^{22}Na	^{65}Zn	^{90}Sr	^{131}I	^{137}Cs	^{144}Ce
January	27.2	14.7	4.0							
February	6.6	199.8	13.1	31.0	b	b	0.11	b	b	b
March	8.5	1450.0	122.6							
April	6.1	64.9	3.9							
May	16.4	33.5	5.5	35.1	b	0.81	0.31	b	b	2.44
June	2.1	58.2	1.2							
July	11.8	14.4	1.7							
August	13.3	11.9	1.6	50.5	0.79	0.28	0.21	b	b	0.81
September	10.8	19.1	2.1							
October	10.4	8.1	0.8							
November	7.1	45.3	3.2	51.3	1.07	0.56	0.07	b	b	2.79
December	15.5	9.4	1.5							
Total	135.8	1929.3	161.3	167.9	1.86	1.65	0.70	--	--	6.04
Average	11.3	160.8								
Radiation Concentration Guide[11]		$3x10^{3}$	$8x10^{2}$	$5x10^{5}$	$1x10^{4}$	$3x10^{4}$	$8x10^{1}$	$8x10^{1}$	$5x10^{3}$	$3x10^{3}$

nCi = 3.7×10^{1} Bq.

pCi = 3.7×10^{-2} Bq.

[a] There were two Chinese nuclear tests; one on March 14, 1978 and the other on December 14, 1978. Some fallout activity was detected at BNL as a result of the tests.

[b] Below the Minimum Detection Limit (MDL) of the system used in analyzing the sample.

TABLE 10

1978 BNL Environmental Monitoring Monthly Average Tritium Concentration in Precipitation (pCi/liter)

Period	P-2	P-4	P-7	P-9	BNL Sewage Treatment Plant	Off-Site (Blue Point)
January-March	<340	<340	<340	<340	No Sample	<340
April	<260	<375	<409	<580	<409	No Sample
May	<260	<260	<375	<648	<444	<260
June-July	<220	<385	<220	<220	<220	<220
August-September	<270	<270	<270	<270	<270	<270
October-December	No Sample	<260	<260	<341	No Sample	<260
Total (pCi/liter)	~~<1350~~	~~<1890~~	~~<1874~~	<2399	~~<1145~~	~~<1350~~
(nCi/m^2)	<366	<513	<508	<650	<310	<366
Average (pCi/liter)	<270	<315	<312	<399	<286	<270
Radiation Concentra-Guide[11](pCi/liter)	. . . . . 3×10^6					

There is an estimated error of 50% in the tritium values.

MDL for this table is based on 1.64 σ at 90% CL.

pCi = 3.7×10^{-2} Bq.

3.3 Liquid Effluent Monitoring:

To minimize the volumes of liquids that would have to be handled prior to on-site release of processing into solid form for off-site burial, the basic principle of liquid waste management at the Laboratory is confinement and containment. Accordingly, liquid wastes are segregated on the basis of their anticipated concentrations of radioactivity or other potentially harmful agents.

The primary water cooling systems of such facilities as the High Flux Beam Reactor, and the Medical Research Reactor, each of which contain multicurie (terabecquerel) amounts of radioactivity, are closed systems with no direct connection to any Laboratory waste system.

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 for pickup by the Laboratory's Waste Management group and subsequent packaging for off-site disposal (in the case of hazardous agents, by an EPA licensed contractor).

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 6, 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, D wastes may be routed directly from holdup tanks to the Laboratory sanitary waste system.

As shown in Figure 6, "inactive" or F wastes, depending on the results of analysis, are routed directly to the Laboratory sanitary waste system, where they are diluted by 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 are done to facilitate waste management; while effluent sampling is done 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's sanitary waste system are established by administrative limits [16], which correspond to those applicable to sewage systems. Within these limits, individual releases are kept as low as practicable.

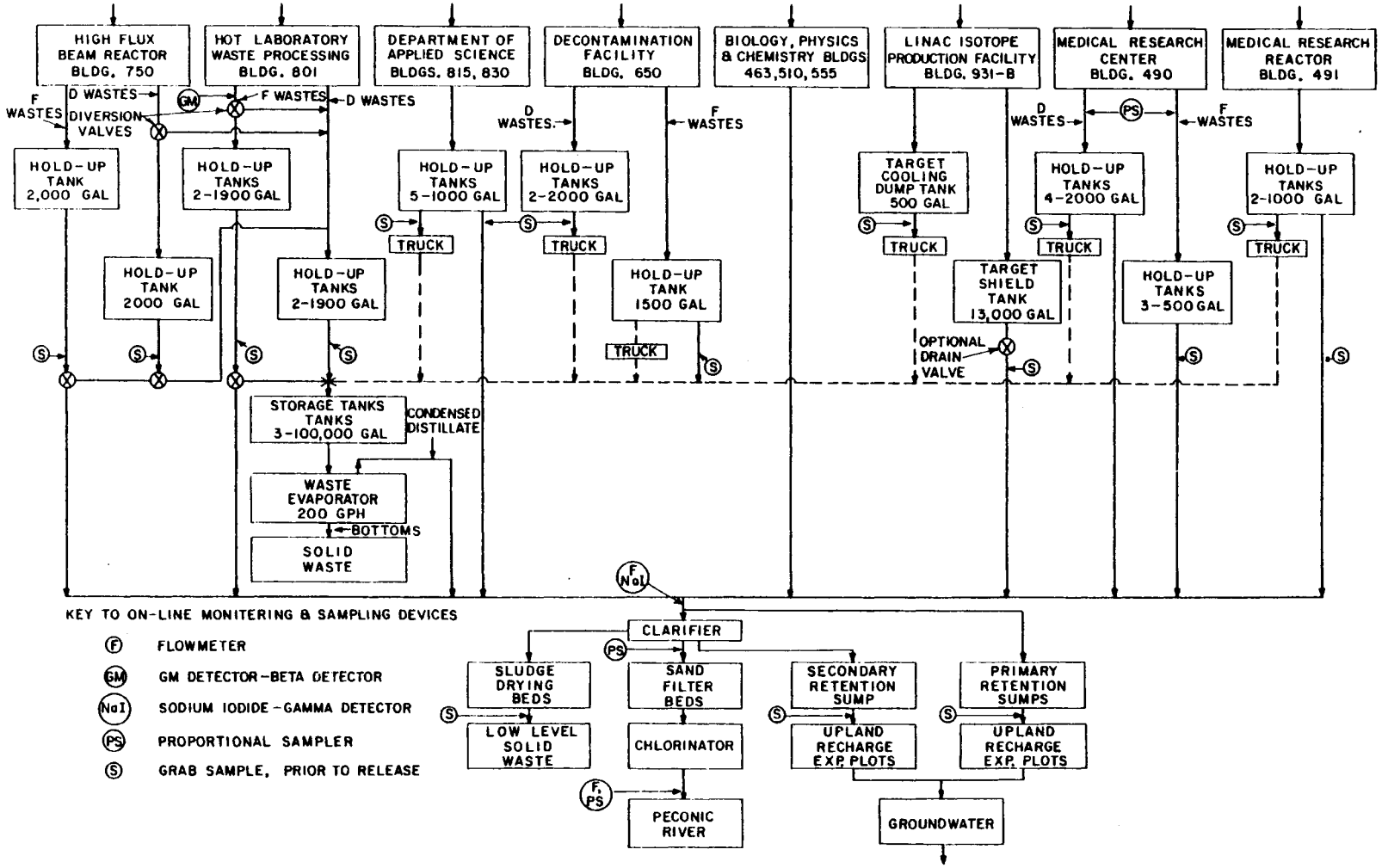

Figure 6. BNL liquid effluent systems.

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 were prepared in accordance with this permit using data obtained by the sewage treatment plant operators. A yearly summary of these data, which follows the same format as these quarterly reports, is shown in Table 11 which includes a specification of the permit conditions. The Laboratory effluent was within these conditions, with the exception of some daily pH levels which were "out of limit," as set by the permit.

The daily pH levels were below 5.8 on 67 occasions. However, these were only slightly below the lower level set forth in the permit and within the local natural range of ground water (pH 4.5-5.5). A study initiated to determine the causative factors behind such "out of limit" pH values 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 U.S. EPA is considering the possibility of lowering BNL's permit standard on this parameter (pH).

3.3.2 Meadow-Marsh Project

A small portion of the liquid effluent flow from the clarifier (2%) was diverted from the sand filter beds for application to the Meadow-Marsh experimental plots. A summary of the total flows and of the gross beta, tritium and ^{90}Sr total activities and activity concentrations is shown in Table 12.

Water quality parameters of the Laboratory's effluent used in the Meadow-Marsh Project were evaluated by BNL's Department of Energy and Environment [17]. These data are shown in Table 13. The effluents met the standards for ground surface discharge with the exception of the metals Cd and Fe, BOD_5, coliform, and suspended solids [10]. It should be noted that the purpose of this experiment is to determine the efficiency of natural ecosystems for the removal of pollutants in the applied effluents and was based on the premise that the "effluent" percolating to the saturated zone (3-4.5 m below the ground surface in the area) would be within ground water quality standards.

Because of the permeable nature of the local soils, there was no surface runoff from the experimental area, and hence no direct route by which these effluents might reach a surface stream.

3.3.3 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. Its liquid effluent then flows onto sand filter beds, from which about 88% of the water is recovered by an underlying tile field. This water is chlorinated and 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 shown in Figure 7. In addition to the inplant flow measurement and

TABLE 11

1978 BNL Environmental Monitoring National Pollution Discharge Elimination System
Summary of Monthly Report Data

Parameter	Status	Quantity					Concentration						
		Minimum	Average	Maximum	Units	No.[a] ex	Minimum	Average	Maximum	Units	No. ex	Frequency of analysis	Sample type
Flow	Reported	0.44	0.87	1.39	MGD		XX	XX	XX			Cont.	NA
	Permit condition	XX	2.30	XX		-	XX	XX	XX	-	-	Cont.	NA
pH Influent	Reported	5.90	6.85	7.60	Std.		XX	XX	XX			5/7	Grab
	Permit condition	XX	XX	XX	Units.	-	XX	XX	XX	-	-	Daily	Grab
pH Effluent	Reported	4.8	6.00	7.2	Std.	67	XX	XX	XX			5/7	Grab
	Permit condition	5.8	XX	9.0	Units.	-	XX	XX	XX	-	-	Daily	Grab
BOD_5 Influent	Reported	48.90	119.45	214.02	Kg/		14.40	29.43	41.70	mg/l		Weekly	8 hr.
	Permit condition	XX	XX	XX	day	-	XX	XX	XX		-	Monthly	8 hr.
BOD_5 Effluent	Reported	4.27	9.77	21.40	Kg/	0	1.20	2.94	6.50	mg/l	0	Weekly	8 hr.
	Permit condition	XX	262.00	391.00	day	-	XX	30.00	45.00		-	Monthly	8 hr.
Percent removal, BOD_5	Reported	XX	XX	XX			87.90	92.30	98.76		0	Weekly	-
	Permit condition	XX	XX	XX	-	-	85.00	XX	XX	%	-	Monthly	-
Suspended solids, Influent	Reported	42.19	105.98	224.72	Kg/		11.50	26.69	40.50	mg/l		Biweekly	8 hr.
	Permit condition	XX	XX	XX	day	-	XX	XX	XX		-	Monthly	8 hr.
Suspended solids, Effluent	Reported	0.00	1.60	5.70	Kg/	0	0.00	0.53	1.50		0	Biweekly	8 hr.
	Permit condition	XX	262.00	391.00	day	-	XX	30.00	45.00	mg/l	-	Monthly	8 hr.
Percent removal, Suspended solids	Reported	XX	XX	XX			91.30	97.67	100.00		0	Weekly	-
	Permit condition	XX	XX	XX	-	-	85.00	XX	XX	%	-	Monthly	-
Settleable solids, Influent	Reported	XX	XX	XX			0.30	1.50	8.00	ml/l		5/7	Grab
	Permit condition	XX	XX	XX	-	-	XX	XX	XX		-	Daily	Grab
Settleable solids Effluent	Reported	XX	XX	XX			0.00	0.13	1.00	ml/l		5/7	Grab
	Permit condition	XX	XX	XX	-	-	XX	XX	XX		-	Daily	Grab
Residual Chlorine, Effluent	Reported	XX	XX	XX			0.60	0.92	1.50	mg/l		5/7	Grab
	Permit condition	XX	XX	XX	-	-	XX	XX	XX		-	Daily	Grab
Temperature, Effluent	Reported	1.70	14.92	27.00	°C		XX	XX	XX			5/7	Grab
	Permit condition	XX	XX	XX		-	XX	XX	XX	-	-	Daily	Grab
Fecal coliform, Effluent	Reported	XX	XX	XX			0.00	0.00	0.00	n/100 ml	0	Weekly	Grab
	Permit condition	XX	XX	XX	--	-	XX	200.00	400.00		-	Monthly	Grab

XX Indicate not required.

[a] Total for the year.

Data collected by R. Richards (Sewage Treatment Plant) and forwarded by M. Haller (Plant Engineering) to Safety and Environmental Protection Division.

TABLE 12

1978 BNL Environmental Monitoring Gross Beta, ^{3}H (HTO) and ^{90}Sr in Effluent Applied to Meadow-Marsh Experimental Plots

Month	Flow $x10^{10}$ ml	Gross Beta[a] Concentration pCi/liter	Gross Beta[a] Total μCi	^{3}H (HTO) Concentration nCi/liter	^{3}H (HTO) Total mCi	^{90}Sr Concentration pCi/liter	^{90}Sr Total μCi
January	0.23	14.0	32.1	1.27	2.91		
February	0.21	34.4	72.3	0.88	2.02	0.36	2.41
March	0.23	26.7	61.3	2.00	4.60		
April	0.22	24.1	53.0	1.67	3.67		
May	0.23	48.9	112.6	1.21	2.79	1.33	8.91
June	0.22	47.6	104.6	1.37	3.02		
July	0.23	27.3	62.7	2.71	6.23		
August	0.23	26.9	61.9	2.27	5.22	1.61	10.95
September	0.22	27.3	60.1	2.12	4.67		
October	0.23	27.9	64.1	1.64	3.78		
November	0.22	26.8	58.9	1.87	4.12	0.57	3.88
December	0.23	18.2	1.8	4.33	9.95		
Total	2.70	--	785.4	--	52.98	--	26.15
Average	--	29.2	--	1.95	--	0.97	--
Radiation Concentration Guide[11]		3000[b]		3000		300	

[a] Does not include HTO.

[b] For mixtures of radionuclides containing $\leq$ 10% ^{90}Sr, $^{125\text{-}131}I$, or long lived alpha emitters.

μCi = 3.7×10^{4} Bq.

nCi = 3.7×10^{1} Bq.

pCi = 3.7×10^{-2} Bq.

TABLE 13

1978 Meadow-Marsh Project Water Quality and Purity - Average Values

Parameter	Units	Station A Sewage Influent	Station C Meadow-Marsh Effluent	Station D Marsh Effluent	Station 6D[a] Combined Effluent from Stations C & D	Water Quality Standard[14]
Temperature	°C	c	c	c	14.0	Tmax<30
pH	c	7.0	7.0	7.4	7.1	6.5-8.5[b]
Dissolved Oxygen	ppm	c	c	c	6.7	>4
Chlorides	ppm	25.7	21.8	23.4	21.9	250
BOD	ppm	304.0	17.0	24.0	c	30
Total Coliform	Geometric Mean #/100 ml	5225.0	785.0	642.0	544.0	4
Fecal Coliform	Geometric Mean #/100 ml	318.0	7.0	26.0	70.0	4
Total Phosphorous	ppm	10.7	1.9	3.4	2.2	--
Total Nitrogen	ppm	33.9	5.3	11.5	1.7	10
MBAS	ppm	0.06	0.05	0.05		0.5
Dissolved Solids	ppm	178.0	136.0	152.0	139.0	500
Suspended Solids	ppm	656.0	30.0	37.0	c	30
Conductivity	µmhos/cc	243.0	185.0	230.0	176.0	--
Cadmium (Cd)	ppm	12.4	0.8	0.5	↑	0.01
Copper (Cu)	ppm	1.7	0.1	0.05	|	0.40
Iron (Fe)	ppm	7.4	2.9	2.8	c	0.60
Manganese (Mn)	ppm	0.2	0.1	0.15	|	0.60
Nickel (Ni)	ppm	0.04	0.02	0.02		--
Zinc (Zn)	ppm	1.5	0.3	0.1	↓	0.60

[a] 6D: Sampled and analyzed by S&EP Division.

[b] Cr natural range.

[c] Not done.

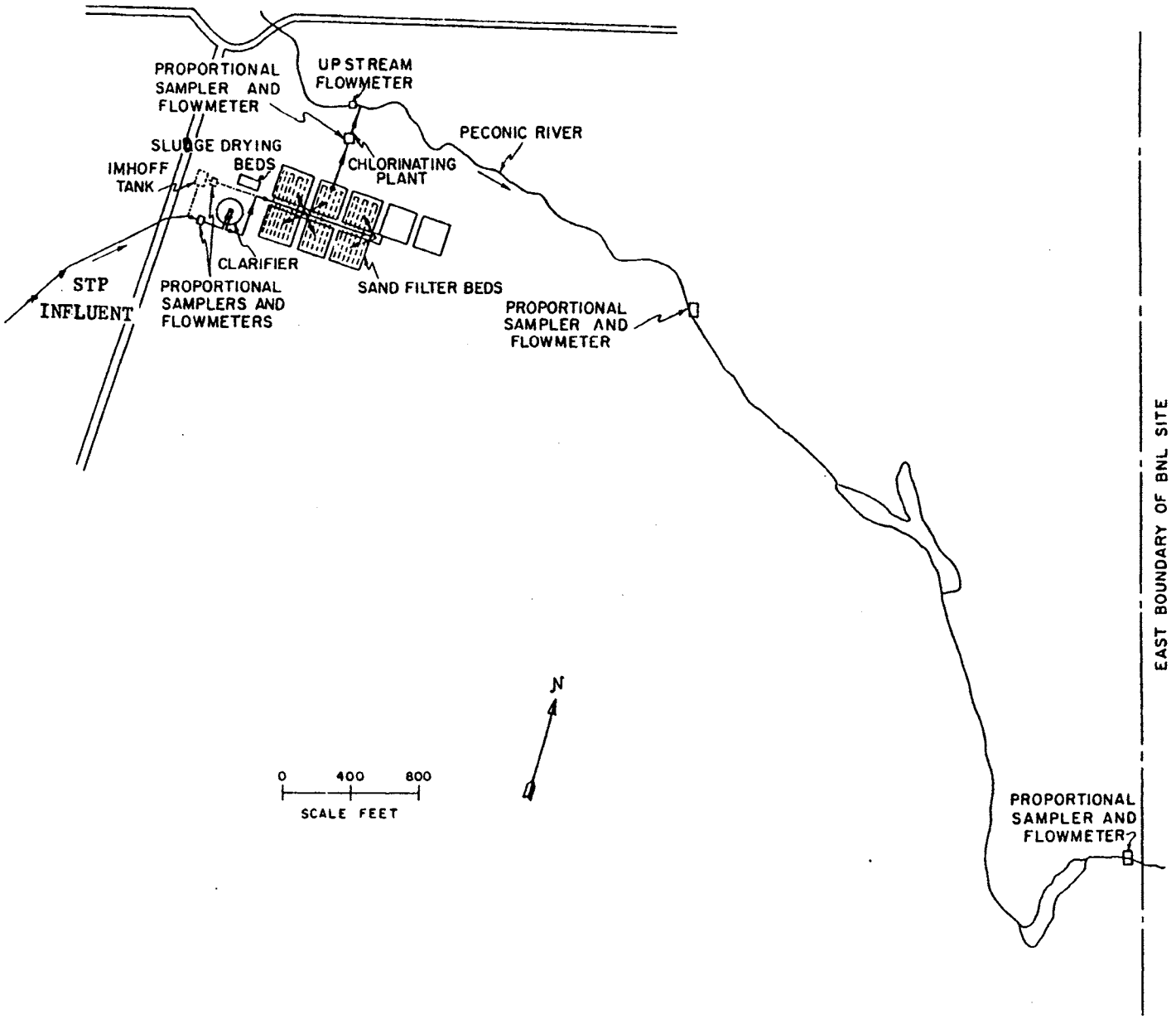

Figure 7. Sewage treatment plant.

sampling instrumentation, totalizing flowmeters (Leopold and Stevens TP 61-2), with provision for taking a sample for each 7576 liters of flow in combination with positive action battery operated samplers (Brailsford DU-1), are located 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 gross alpha and gross beta analysis, and another was counted directly for tritium analysis. Samples from the two downstream locations were obtained three times a week. Aliquots of each sample 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. If the gross beta count at each location did not indicate the need for immediate radionuclide identification, then 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 average flow and the monthly totals of gross beta and principal nuclide activities at the clarifier (input to the filter beds) and at the chlorine house (output from the beds) are shown in Table 14. Yearly totals and average concentrations are indicated. The average monthly flow at the clarifier which has been decreasing over the years (1976-1977) has shown a 14% increase over 1977 flows. The output at the chlorine house has shown a similar increase. The loss to ground water through the sand filter beds, however, has increased slightly when compared to 1977, even though the flow at the clarifier has increased. In 1978, of the total flow into the clarifier, 2% was utilized by the Meadow Marsh Project and about 88% of this total flow 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. Estimates of the amount of radioactivity released to the ground water in this manner during 1978 are shown in Table 14. 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.

Radionuclide concentrations at the chlorine house over the past five years, 1974-1978, have indicated fluctuations as a function of input into the sand filter beds. The activity concentrations in ground water are directly related to input levels for all radionuclides except for ^{3}H, ^{7}Be, ^{22}Na, ^{90}Sr, ^{134}Cs and ^{137}Cs. It is possible that the sand filter beds, which have over the years built up concentrations of radionuclides such as ^{22}Na, ^{90}Sr, ^{134}Cs and ^{137}Cs, could have released these nuclides. A review of the data over the past five years (1974-1978) indicates that a time lag between input and output from the sand filter beds is evident. The time lag appears to be greater for ^{134}Cs and ^{137}Cs than for ^{90}Sr. Radionuclides, such as ^{51}Cr, ^{65}Zn, ^{95}Zr-Nb, ^{125}Sb, ^{131}I and ^{144}Ce, which were detected in previous years were all at or below MDL (see Appendix B) and as such were not reported in the table. The Laboratory releases of radionuclides have been on the decrease over the years as a result of the ALARA approach. Fallout fission products in general are on the decrease

TABLE 14

1978 BNL Environmental Monitoring Total Activities and Concentrations of Identifiable Nuclides in Liquid Effluents
Sewage Treatment Plant

Month	Flow x 10^{10} ml	GB	GB + γ only[a]	^{3}H	^{7}Be	^{22}Na	^{54}Mn	^{57}Co	^{58}Co	^{60}Co	^{90}Sr	^{134}Cs	^{137}Cs
						Clarifier (mCi)							
January	10.46	2.94	4.27	195	0.85	0.85	0.48	b	b	0.22	0.030	0.07	0.09
February	8.85	12.81	14.26	104	0.91	b	0.54	b	1.10	0.14	0.016	b	0.10
March	9.69	2.47	3.55	254	0.96	b	0.12	b	0.58	0.28	0.033	b	b
April	8.91	3.11	3.86	330	0.56	b	0.08	0.11	b	0.33	0.014	b	b
May	12.20	2.51	2.94	343	0.23	b	b	0.20	b	0.14	0.150	0.11	b
June	13.01	4.40	4.59	556	0.19	0.44	b	b	b	0.09	0.337	b	b
July	14.99	3.30	3.62	646	0.32	b	b	b	b	0.11	0.180	b	0.11
August	17.08	7.25	7.62	823	0.37	b	b	b	b	0.20	0.275	0.22	b
September	13.47	3.91	4.35	383	0.44	b	b	b	b	0.50	0.156	b	b
October	14.15	5.37	5.90	903	0.41	b	0.12	b	b	0.64	0.050	b	b
November	11.75	8.53	8.81	808	0.28	b	b	b	b	0.18	0.056	b	0.22
December	10.40	3.24	3.98	826	0.74	b	b	b	b	0.05	0.019	b	b
Total	144.96	59.84	67.75	6171	6.26	1.29	1.34	0.31	1.68	2.88	1.316	0.40	0.52
						Average concentration (pCi/liter or 10^{-9} μCi/ml)							
		41.28	46.73	4257	4.32	0.89	0.92	0.21	1.16	1.99	0.907	0.28	0.36
						Groundwater (Sand Filter Beds) (mCi)							
Total	15.95	3.94	4.38	556	0.38	0.41	0.07	-	-	0.03	0.23	0.30	0.49
						Average concentration (pCi/liter or 10^{-9} μCi/ml)							
		24.73	27.48	3487	2.39	2.54	0.45	-	-	0.18	1.487	1.91	3.00
						Chlorine House (mCi)							
January	8.59	1.22	2.34	119	1.12	1.42	b			b	0.092	0.38	0.31
February	7.42	1.25	1.77	124	0.48	0.42	0.04			b	0.075	0.22	0.38
March	5.39	1.15	1.53	118	0.32	0.31	0.06			b	0.029	0.21	0.34
April	7.56	1.79	2.28	395	0.38	0.36	0.11			0.05	0.047	0.31	0.32
May	11.67	5.40	5.59	285	b	b	0.19			0.06	0.072	0.19	0.41
June	13.45	2.48	2.56	234	b	0.11	0.08			0.07	0.743	0.21	0.48
July	11.58	2.22	2.24	453	b	0.03	0.02	b	b	0.01	0.461	0.13	0.28
August	12.62	3.64	3.68	617	0.19	b	0.04			b	0.295	0.11	0.28
September	14.21	4.68	4.71	347	b	0.06	0.03			b	0.226	0.14	0.25
October	15.37	3.53	3.53	601	b	0.05	b			0.04	0.192	0.15	0.32
November	8.23	2.18	2.47	609	0.29	0.21	b			b	0.075	0.18	0.14
December	10.22	1.70	2.01	502	0.31	0.26	b			b	0.072	0.18	0.28
Total	126.31	31.24	34.71	4404	3.02	3.21	0.57	-	-	0.23	1.879	2.41	3.79
						Average concentration (pCi/liter or 10^{-9} μCi/ml)							
		24.73	27.48	3487	2.39	2.54	0.45	-	-	0.18	1.487	1.91	3.00
						Meadow Marsh (mCi)							
Total	2.70	0.58	1.20	50	0.62	0.04	-	-	-	0.04	0.03	-	-
						Average concentration (pCi/liter or 10^{-9} μCi/ml)							
		0.22	4.43	185	2.27	0.15	b	b	b	0.14	0.10	b	b
EPA-Drinking Water Regulations[13] and Radiation Concentration Guides[11] (pCi/liter or 10^{-9} μCi/ml)			$3x10^{3}$[c]		$2x10^{4}$	$2x10^{6}$	$4x10^{4}$	$1x10^{5}$	$5x10^{5}$	$1x10^{5}$	$5x10^{4}$	8	$9x10^{3}$	$2x10^{4}$

[a] Includes gamma (only) emitters but excludes tritium.

[b] Below the Minimum Detection Limit (MDL) of the system used in estimating the activity. Other radionuclides such as ^{51}Cr, ^{65}Zn, $^{95}ZrNb$, ^{125}Sb, ^{131}I, $^{140}BaLa$, ^{144}Ce were all below MDL.

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

mCi = 3.7×10^{7} Bq.

μCi = 3.7×10^{4} Bq.

pCi = 3.7×10^{-2} Bq.

in world-wide fallout and is reflected, in spite of recent Chinese nuclear tests, in the reduced concentrations in the effluent sampled at the chlorine house. It must be remembered that rainfall, with its radionuclide burden of fallout fission products, does contribute to the flow at the chlorine house and further downstream through tributaries which drain offsite areas.

Flow and activity concentration information at the former site boundary sampling location, 0.8 km downstream (see Fig. 7), and at the present site boundary are shown in Table 15. Climatic conditions in 1977 which had resulted in decreased flows when compared to previous years were reversed in 1978. Above average rainfall (136 cm) has caused the flow at the site perimeter to increase by six times over that recorded in 1977. Such changes in flow do affect the amount of water that percolates into the ground water system; for example, 16% of the flow between the former perimeter and the present site boundary was lost to the ground water in 1975, 30% in 1976, 60% in 1977 and less than 1% in 1978. Such fluctuations can result in changes in radionuclide activity concentrations between the former and present site boundary but this is related to total flow since the total activity essentially remains almost constant. This is true for radionuclides, such as ^{7}Be, ^{22}Na, and ^{137}Cs, which have remained in solution and therefore have not significantly precipitated out of the water body. Upper limit estimates of the total activity that may have percolated to the underlying water is also shown in Table 15. These are based on the decrease in total activity between the former site boundary and the perimeter during October and November.

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, 7% of the total activity consisted of ^{90}Sr and that no appreciable amounts of long-lived radioactive iodine or other bone-seeking nuclides such as radium were present. It must be noted that the 7% indicated above would decrease if other radionuclides were present.

Under these circumstances, the applicable RCG was 3000 pCi l^{-1} (3.0×10^{-6} μCi ml^{-1} or 1.1×10^{-1} Bq ml^{-1}). The gross beta concentration in the portion which percolated to ground water was 16.9 pCi l^{-1} (1.69×10^{-8} μCi ml^{-1} or 6.25×10^{-4} Bq ml^{-1}) or <1% of the RCG.

At the Laboratory perimeter (2.6 km downstream from the chlorine house), 6% of the yearly activity was ^{90}Sr. The applicable RCG was also 3000 pCi l^{-1} (1.1×10^{-1} Bq ml^{-1}). The observed gross beta concentration of the water released downstream was 14.6 pCi l^{-1} (1.46×10^{-8} μCi ml^{-1} or 5.4×10^{-4} Bq ml^{-1}) or <1% of the RCG.

In addition to the above measurements, the Safety and Environmental Protection Division conducts routine measurements of water quality and purity of the filter beds effluent, upstream of the Peconic River, at the former perimeter of the Laboratory (0.8 km downstream) and at the present Laboratory perimeter (2.6 km downstream). A summary of these data for 1978 is shown in Table 16. The outflow from the sand filter beds (EA) into the Peconic River was considerably above water quality standards for minimum dissolved oxygen (DO) [10, 18], except at upstream of the outfall (HE) and at the perimeter (HM).

TABLE 15

1978 BNL Environmental Monitoring Total Activities and Concentrations of Identifiable Nuclides in Liquid Effluents
Peconic River

Month	Flow x 10^{10} ml	GB	GB + γ only[a]	^{3}H	^{7}Be	^{22}Na	^{54}Mn	^{57}Co	^{58}Co	^{60}Co	^{90}Sr	^{134}Cs	^{137}Cs
Former Perimeter (mCi)													
January	19.39	2.12	Same as GB as no only γ emitters were detected.	219	↑	↑	↑	↑	↑	↑	}	b	0.10
February	9.27	0.91		109							0.34	0.12	0.18
March	20.24	5.10		251								0.11	0.30
April	20.54	3.32		418							}	0.18	0.18
May	21.86	4.54		309							1.63	0.14	0.06
June	19.87	4.79		182							}	b	b
July	20.54	2.46		424	b	b	b	b	b	b		b	0.05
August	22.24	3.01		632							} 0.65	0.09	b
September	15.54	1.86		289								0.08	0.05
October	13.88	2.65		441							}	0.07	0.05
November	10.31	2.49		545							0.27	0.07	0.05
December	11.29	1.37		578	↓	↓	↓	↓	↓	↓	}	0.10	0.08
Total	204.97	34.62	-	4397	-	-	-	-	-	-	2.89	0.96	1.10
Average Concentration (pCi/liter or 10^{-9} μCi/ml)													
		16.89	-	2145	-	-	-	-	-	-	1.41	0.47	0.54
Ground Water (Stream Bed) mCi)													
Total	1.70	0.29	-	36.46	-	-	-	-	-	-	0.02	0.008	0.009
Average Concentration (pCi/liter or 10^{-9} μCi/ml)													
		16.89	-	2145	-	-	-	-	-	-	1.41	0.47	0.54
Site Boundary (mCi)													
January	30.03	3.63	Same as GB as no only γ emitters were detected.	350	↑	↑	↑	↑	↑	↑	}	0.04	0.22
February	33.88	3.83		602							0.64	0.12	0.20
March	39.16	9.85		605						b		0.11	0.28
April	35.11	4.55		516							}	0.09	0.24
May	42.59	7.10		676							1.74	0.14	0.25
June	39.75	3.61		454						↓	}	0.17	0.18
July	29.22	3.03		499	b	b	b	b		0.03		0.19	0.19
August	27.68	5.23		753					b	0.02	} 1.01	0.10	0.20
September	16.46	1.93		321						↑		0.07	0.30
October	13.32	1.84		513							}	0.12	0.17
November	9.17	2.44		401						b	0.31	0.10	0.22
December	15.97	1.68		777	↓	↓	↓	↓	↓	↓	}	0.11	0.20
Total	333.44	48.72		6467	-	-	-	-	-	0.05	3.70	1.36	2.65
Average concentration (pCi/liter or 10^{-9} mCi/ml)													
		14.61	-	1939	-	-	-	-	-	0.01	1.11	0.41	0.79
Radiation Concentration[11] Guide and EPA-Drinking Water Regulations[13] (pCi/liter or 10^{-9} μCi/ml)				$3x10^{3}$[c]		$2x10^{4}$	$2x10^{6}$	$4x10^{4}$	$1x10^{5}$	$5x10^{5}$	$1x10^{5}$	$5x10^{4}$	8	$9x10^{3}$	$2x10^{4}$

[a] Includes gamma (only) emitters but excludes tritium.

[b] Below the Minimum Detection Limit (MDL) of the system used in estimating the activity. Other radionuclides such as ^{51}Cr, ^{65}Zn, $^{95}ZrNb$, ^{125}Sb, ^{131}I, $^{140}BaLa$, ^{144}Ce were all below MDL.

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

mCi = 3.7×10^{7} Bq.

μCi = 3.7×10^{4} Bq.

pCi = 3.7×10^{-2} Bq.

Table 16

1978 BNL Environmental Monitoring Liquid Effluent Water Quality and Purity

LOCATION	SAMPLE	TEMPERATURE	PH	DISSOLVED OXYGEN (PPM)	CHLORIDES (PPM)	NITRATE NITROGEN (PPM)	TOTAL PHOSPHOROUS (PPM)	DISSOLVED SOLIDS (PPM)	CONDUCTIVITY MICROMHO/CM	COLIFORM FECAL (/100 ML)	COLIFORM TOTAL (/100 ML)
EA	MEAN	15	5.8	8.1	25.3	3.69	0.80	107	154	0	1
	MINIMUM	0	4.7	4.5	0.0	0.05	0.40	62	69	0	0
	MAXIMUM	25	7.0	13.0	37.0	6.40	1.17	144	270	32	106
	NUMBER	238	235	226	57	51	52	8	238	228	235
HE	MEAN	10	5.5	6.5	7.6	0.17	0.05	43	47	18	66
	MINIMUM	0	4.1	2.4	3.6	0.03	0.01	6	38	0	0
	MAXIMUM	22	7.3	10.2	12.4	0.30	0.20	58	68	424	870
	NUMBER	97	95	96	12	14	13	9	97	92	85
HM	MEAN	13	5.8	9.3	17.4	1.60	0.36	70	101	12	81
	MINIMUM	0	4.6	5.0	6.0	0.33	0.10	58	62	0	0
	MAXIMUM	24	6.8	15.0	29.5	3.50	0.71	87	178	170	600
	NUMBER	133	134	133	51	51	51	8	134	135	109
HQ	MEAN	12	6.4	6.5	16.5	0.97	0.58	75	101	25	98
	MINIMUM	0	5.5	2.0	5.0	0.29	0.14	68	62	0	0
	MAXIMUM	25	9.8	12.2	27.0	2.81	13.50	82	210	234	870
	NUMBER	142	140	132	51	50	51	7	143	142	113

		METALS (IN PPM)							
		AG	CD	CR	CU	FE	HG	PB	ZN
EA	MEAN	.004	.0013	.006	.078	.114	.0013	.004	.266
	MINIMUM	.002	.0008	.003	.038	.046	.0004	.001	.163
	MAXIMUM	.006	.0020	.011	.137	.345	.0039	.013	.378
	EXCEPTION	2	0	3	0	0	0	9	0
	NUMBER	12	11	11	12	12	9	12	12
HE	MEAN	.001	.0005	.002	.002	.493		.004	.017
	MINIMUM	.001	.0004	.001	.001	.378		.003	.010
	MAXIMUM	.001	.0005	.003	.003	.608		.005	.024
	EXCEPTION	2	2	2	0	0	0	1	0
	NUMBER	2	2	2	2	2	0	2	2
HM	MEAN	.002	.0009	.007	.044	.232	.0007	.004	.128
	MINIMUM	.001	.0004	.001	.021	.104	.0001	.001	.058
	MAXIMUM	.006	.0013	.025	.099	.476	.0026	.015	.225
	EXCEPTION	4	0	4	0	0	0	9	0
	NUMBER	11	12	11	12	12	9	12	12

Table 16 (Continued)

1978 BNL Environmental Monitoring Sewage Influent Water Quality and Purity-Metals

		METALS (IN PPM)						
		AG	CD	CR	CU	FE	PB	ZN
DA	MEAN	.006	.0019	.019	.104	.396	.009	.229
	MINIMUM	.003	.0012	.009	.041	.150	.001	.082
	MAXIMUM	.009	.0034	.087	.153	.927	.022	.859
	EXCEPTION	1	0	1	0	0	3	0
	NUMBER	12	12	10	12	12	12	12

Reference Standards - Table 32

Table 16 (Continued)

1978 BNL Environmental Monitoring Precipitation Water Quality and Purity

LOCATION	SAMPLE	TEMPERATURE	PH	DISSOLVED OXYGEN (PPM)	CHLORIDES (PPM)	NITRATE NITROGEN (PPM)	TOTAL PHOSPHOROUS (PPM)	DISSOLVED SOLIDS (PPM)	CONDUCTIVITY MICROMHO/CM	COLIFORM FECAL (/100 ML)	COLIFORM TOTAL (/100 ML)
GD	MEAN		4.5								
	MINIMUM		3.3								
	MAXIMUM		6.2								
	NUMBER	0	44	0	0	0	0	0	0	0	0

Reference Standards - Table 32

EA: Sand filter beds
HE: Upstream of outfall
HM: Former site boundary
HQ: Site boundary
DA: Sewage Effluent
GD: Precipitation

Exception: Below Minimum Detection Limit (MDL)

The severe winter of 1977/1978 and heavy snowfall resulted in heavy decomposition of vegetation in the Peconic River drainage area. Consequently, the river water exhibited a high content of humic acid which in turn increased the biological oxygen demand and thereby a reduction in dissolved oxygen content was noticed [19]. Although occasionally below the standard, the 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 were, before dilution, at or within the standard for the receiving body of water [10, 18] for most of the metals except iron (Fe) and occasionally copper (Cu), zinc (Zn) and lead (Pb). Fe, from past studies, seems to be ubiquitous at the levels seen in the ground water system, and since the Laboratory derives all of its water from the aquifer under the Laboratory the presence of Fe in our effluents is not surprising. The high value of Zn upstream of the outfall confirms the presence of humic acid which is known to chelate and concentrate transition metals from the water [19].

Monthly "grab" water samples were obtained at on- and off-site locations along the upper tributary of the Peconic River, into which the Laboratory routinely discharges low level radioactive liquids within administrative limits [16]. Reference "grab" samples were obtained from other nearby streams and bodies of water outside the Laboratory's drainage area. The sampling locations, as shown in Figure 8, were as follows:

Off-Site (Peconic River, proceeding downstream)

A - Peconic River at Schultz Road, 4.85 km downstream (HA),

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

C - Peconic River at Manorville, 10.67 km downstream (HC),

D - Peconic River at Calverton, 14.23 km downstream (HD),

R - Peconic River at Riverhead, 19.35 km downstream (HR),

Controls (Not in the Laboratory drainage)

E - Peconic River, upstream from the Laboratory effluent outfall (HE),

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

H - Carman River, outfall of Yaphank Lake (HH),

I - Northeast corner of Artist Lake on Route 25 (HI).

Individual monthly and yearly average gross beta, tritium and ^{90}Sr concentrations at downstream and control locations are shown in Table 17. A comparison with the on-site and perimeter concentrations shown in Table 15 suggests that the concentrations of Laboratory effluents in the Peconic River,

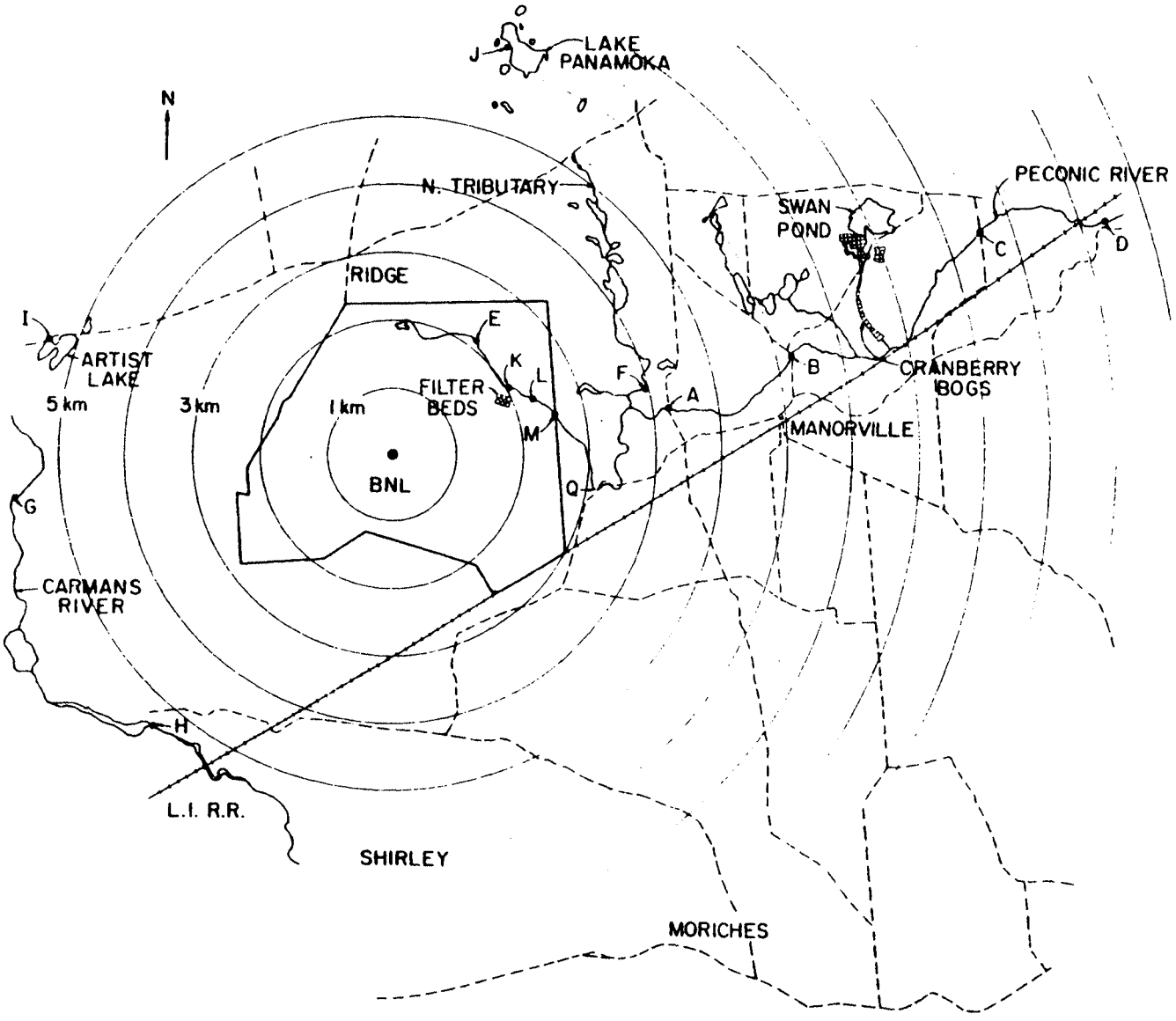

Figure 8. Peconic River, on-site and downstream sampling locations.

TABLE 17

1978 BNL Environmental Monitoring Downstream and Control Water Samples

	Downstream locations					Control locations		
Month	A	B	C	D	R[a]	E	F	H
	Gross Beta (pCi/liter)							
January	5.8	5.3	5.0	4.8	4.8	7.5	5.9	3.9
February	--	--	--	--	--	--	--	--
March	5.1	4.9	5.5	7.0	6.6	5.0	7.2	4.0
April	--	--	--	--	22.8	--	--	--
May	--	--	--	--	15.4	--	--	--
June	--	--	--	--	11.8	--	--	--
July	10.7	7.6	5.2	4.7	11.2	5.8	8.8	2.9
August	--	--	--	--	b	--	--	--
September	6.9	3.8	4.2	4.9	7.5	2.1	3.0	2.4
October	--	--	--	--	8.4	--	--	--
November	--	--	--	--	6.5	--	--	--
December	7.6	3.7	4.6	5.7	5.4	2.8	1.2	4.7
Average	7.2	5.0	4.9	5.4	10.0	4.6	5.2	3.6
	Tritium (HTO) nCi/liter)							
January	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
February	--	--	--	--	<0.23	--	--	--
March	<0.27	<0.23	<0.27	<0.23	<0.23	<0.23	<0.23	<0.23
April	--	--	--	--	<0.22	--	--	--
May	--	--	--	--	<0.24	--	--	--
June	--	--	--	--	<0.23	--	--	--
July	<1.2	<1.2	<1.2	<1.2	<0.22	<0.86	<1.2	<0.86
August	--	--	--	--	0.22	--	--	--
September	<0.23	<0.23	<0.23	<0.23	<0.18	<0.23	<0.23	<0.23
October	--	--	--	--	0.22	--	--	--
November	--	--	--	--	0.21	--	--	--
December	<0.27	<0.27	<0.27	<0.27	<0.27	<0.27	<0.27	<0.27
Average	<0.43	<0.43	<0.43	<0.43	0.22	<0.36	<0.43	<0.36
	^{90}Sr (pCi/liter)							
	2.1	0.69	1.2	--	0.85(3)	--	0.73	--

Radiation Concentration Guide : Gross β: 3000 pCi/liter for mixtures of radionuclides containing <10% ^{90}Sr, $^{125\text{-}133}$I and long lived alpha emitters.
HTO: 3000 nCi/liter.
^{90}Sr: 300 pCi/liter.

[a] Continuous sampling at R except in February (no sample) and March (grab sample).

[b] Contaminated sample

nCi = 3.7×10^{1} Bq.

pCi = 3.7×10^{-2} Bq.

downstream of the outfall, diminish 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 over the years has been about 25 times that at the Laboratory perimeter, it was evident that the total amounts of radioactivity at this location was much greater than those released into the Peconic River at the Laboratory perimeter. This probably represents tributary additions from rainfall and subsequent washout from drainage areas other than that of the Laboratory. During 1978, measurements of selected water quality and purity parameters at downstream locations on the Peconic River and at control locations were initiated in order to provide some perspective on the same parameters in the Laboratory effluent (as reported in Table 16). These limited "grab" sample data are shown in Table 18. The effect of somewhat elevated levels of some of the parameters downstream results from other activities both residential and industrial along the length of the Peconic River. This is based on the observation that the increased levels are not uniform but localized.

3.3.4 Recharge Basin

After use in "once through" heat exchangers and process cooling, about 18 million 1 d^{-1} (MLD) was returned to ground water in on-site recharge basins: about 6.6 MLD to basin N located about 610 m northeast of the AGS; about 5.8 MLD to basin O about 670 m east of the HFBR; and about 6.4 MLD to basin P 305 m south of the MRR (see Figure 9). An organic phosphate is added to the AGS cooling and process water supply, which is independent of the Laboratory's potable supply, to establish a PO_4 concentration of about 2 ppm in order to maintain the ambient iron in solution. Of the total AGS pumpage, about 5.4 MLD was discharged to the N basin, and 2.9 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 0.4 MLD, which contains about 10 ppm PO_4 and 3-4 ppm benzotriazole is also discharged to the O sump. The MRR-MRC "once through" coolant is not routinely treated and is discharged to the P basin. Concentrations of radioactivity and other agents in these basins are monitored by routine weekly grab sampling. The average gross beta and tritium activity concentrations are shown in Table 19. The average gross beta activity concentration in the sump north of the AGS (N) and LINAC (T) are slightly above background due to the beam stops and was 0.4 to 1% of the applicable RCG. However, in the case of the sump east of the Steam Plant (U), there were, during August and October, levels which approached within 3 to 10% of the RCG. However, wells monitoring these sumps have not shown any increase in gross beta activity. Sampling frequency of these wells will be increased in 1979 to observe ground water contamination, if any. In general, the average gross beta and tritium activity concentrations in the other basins were slightly increased above those in the Laboratory supply wells and were about 0.1% of the applicable RCG for unidentified gross beta emitters and tritium.

Water quality data obtained during 1978 from periodic (approximately monthly) analyses of "grab" samples from the recharge basins, from a culvert which conducts some air conditioning tower blowdown and storm sewer influents from the southeast Laboratory building complex to a natural sump south of the warehouse area (about 1.2 km south of Building 610, see Fig. 3) is shown in

Table 18

1978 BNL Environmental Monitoring Downstream and Control Water Quality and Purity

LOCATION	SAMPLE	TEMPERATURE	PH	DISSOLVED OXYGEN (PPM)	CHLORIDES (PPM)	NITRATE NITROGEN (PPM)	TOTAL PHOSPHOROUS (PPM)	DISSOLVED SOLIDS (PPM)	CONDUC-TIVITY MICROMHO/CM	COLIFORM FECAL (/100 ML)	COLIFORM TOTAL (/100 ML)
HA	MEAN	9	5.4	7.7	8.9	0.31	0.09	61	51	61	70
	MINIMUM	0	5.1	1.6	5.5	0.16	0.02	52	39	0	5
	MAXIMUM	24	5.8	14.6	11.2	0.47	0.26	80	60	288	200
	NUMBER	5	5	5	5	5	5	5	5	5	4
HB	MEAN	9	5.6	6.4	8.3	0.44	0.08	53	51	65	189
	MINIMUM	0	5.1	1.2	5.5	0.23	0.02	45	34	0	10
	MAXIMUM	25	6.2	9.6	10.7	0.78	0.19	66	59	280	728
	NUMBER	5	5	5	5	5	5	5	5	5	5
HC	MEAN	10	6.1	9.0	8.6	0.22	0.04	61	54	24	78
	MINIMUM	0	5.4	5.4	7.5	0.13	0.02	30	48	0	6
	MAXIMUM	27	6.7	13.1	10.2	0.29	0.08	132	59	98	192
	NUMBER	5	5	5	5	5	5	5	5	5	5
HD	MEAN	10	6.3	10.3	9.4	0.37	0.04	53	60	61	101
	MINIMUM	0	5.9	6.8	7.5	0.21	0.02	35	47	1	10
	MAXIMUM	27	6.6	12.6	11.2	0.80	0.09	76	69	160	176
	NUMBER	5	5	5	5	5	5	5	5	4	4
HF	MEAN	9	4.8	5.5	9.0	0.37	0.02	39	57	43	145
	MINIMUM	0	3.5	2.0	4.5	0.18	0.01	23	32	0	10
	MAXIMUM	25	5.5	7.0	16.0	0.52	0.04	47	124	160	440
	NUMBER	5	5	5	5	5	5	5	5	5	5
HH	MEAN	10	6.8	10.8	17.3	1.01	0.02	80	112	29	76
	MINIMUM	0	6.3	7.8	9.0	0.80	0.01	60	84	1	21
	MAXIMUM	21	7.1	12.7	46.0	1.35	0.06	133	200	96	146
	NUMBER	5	5	5	5	5	5	5	5	5	5
HI	MEAN	9	7.0	10.4	17.3	0.12	0.03	56	79	63	157
	MINIMUM	0	6.7	7.0	2.5	0.03	0.02	17	21	1	14
	MAXIMUM	22	7.1	12.8	22.5	0.19	0.05	70	99	198	400
	NUMBER	5	5	5	5	5	5	5	5	4	4
HL	MEAN	11	5.6	8.0	16.8	1.20	0.24	70	92	1	43
	MINIMUM	0	5.0	5.5	13.5	0.48	0.05	53	76	0	10
	MAXIMUM	21	6.1	11.4	23.5	2.17	0.48	91	124	1	96
	NUMBER	4	4	4	5	5	5	5	4	4	4
HR	MEAN	16	6.8	9.1	13.1	0.39	0.11	66	80	44	126
	MINIMUM	0	6.2	6.4	10.5	0.13	0.05	54	9	0	14
	MAXIMUM	27	7.2	12.6	19.6	0.86	0.26	79	96	260	760
	NUMBER	18	17	18	12	12	12	10	18	17	16

Reference Standards - Table 32

Table 18 (Continued)

1978 BNL Environmental Monitoring Downstream and Control Water Quality and Purity-Metals

		METALS (IN PPM)						
		AG	CD	CR	CU	FE	PB	ZN
HA	MEAN	.001	.0005	.002	.005	1.315	.004	.015
	MINIMUM	.001	.0004	.001	.004	.350	.002	.006
	MAXIMUM	.001	.0005	.003	.006	2.870	.005	.022
	EXCEPTION	3	3	2	0	0	2	0
	NUMBER	3	3	3	3	3	3	3
HB	MEAN	.001	.0005	.002	.004	2.753	.004	.015
	MINIMUM	.001	.0004	.001	.003	.530	.001	.007
	MAXIMUM	.001	.0005	.003	.005	6.290	.005	.021
	EXCEPTION	3	3	2	0	0	3	0
	NUMBER	3	3	3	3	3	3	3
HC	MEAN	.001	.0005	.002	.002	1.113	.004	.008
	MINIMUM	.001	.0004	.001	.002	.473	.002	.004
	MAXIMUM	.001	.0005	.003	.003	2.080	.005	.015
	EXCEPTION	3	3	2	0	0	2	0
	NUMBER	3	3	3	3	3	3	3
HD	MEAN	.001	.0005	.002	.002	.873	.004	.009
	MINIMUM	.000	.0004	.001	.001	.501	.003	.004
	MAXIMUM	.001	.0005	.003	.003	1.600	.005	.014
	EXCEPTION	3	3	3	0	0	3	0
	NUMBER	3	3	3	3	3	3	3
HF	MEAN	.001	.0005	.003	.002	1.618	.004	.008
	MINIMUM	.001	.0004	.002	.001	.654	.001	.003
	MAXIMUM	.001	.0005	.003	.003	2.590	.005	.016
	EXCEPTION	3	3	2	1	0	2	0
	NUMBER	3	3	3	3	3	3	3
HH	MEAN	.001	.0005	.003		.220	.004	.007
	MINIMUM	.001	.0004	.002		.138	.003	.004
	MAXIMUM	.001	.0005	.003		.303	.005	.009
	EXCEPTION	2	2	1	0	0	2	0
	NUMBER	2	2	2	0	2	2	2
HI	MEAN	.001	.0005	.002	.003	.276	.030	.010
	MINIMUM	.001	.0004	.001	.002	.161	.004	.002
	MAXIMUM	.001	.0005	.003	.004	.392	.057	.017
	EXCEPTION	2	2	2	0	0	0	1
	NUMBER	2	2	2	2	2	2	2
HL	MEAN	.001	.0004	.015	.027	.224	.003	.079
	MINIMUM	.001	.0004	.015	.027	.224	.003	.079
	MAXIMUM	.001	.0004	.015	.027	.224	.003	.079
	EXCEPTION	1	1	0	0	0	1	0
	NUMBER	1	1	1	1	1	1	1

Reference Standards - Table 32

TABLE 19

1978 BNL Environemntal Monitoring Monthly Sump Samples
Gross Beta and ^{3}H (HTO) Concentrations

	N			O			P			U			T		
	North of AGS			East of HIRDL			Medical			East of Steam Plant			Linac		
	No. Samples	Gross β pCi/liter	HTO nCi/liter	No. Samples	Gross β pCi/liter	HTO nCi/liter	No. Samples	Gross β pCi/liter	HTO nCi/liter	No. Samples	Gross β pCi/liter	HTO nCi/liter	No. Samples	Gross β pCi/liter	HTO nCi/liter
January	4	2.9	1.1	3	3.2	1.1	4	2.8	1.1	3	10.8	1.4	4	2.3	1.3
February	2	2.2	0.8	1	6.1	0.7	0	-	-	3	7.9	1.1	2	2.3	0.9
March	5	5.6	1.0	2	35.9	1.1	2	3.3	1.0	2	8.9	1.1	5	11.9	1.1
April	5	9.3	1.4	4	5.7	1.2	3	1.6	1.1	4	10.7	1.2	4	3.9	1.2
May	4	15.1	1.1	4	2.9	1.1	4	4.1	1.1	4	14.7	1.1	4	2.6	1.1
June	5	4.8	1.2	5	2.2	1.2	5	3.0	1.2	5	15.1	1.2	5	6.1	1.2
July	3	8.1	1.1	4	6.7	1.1	4	4.7	1.1	4	17.8	1.1	4	5.1	1.1
August	4	3.0	1.2	4	4.4	1.3	4	1.9	1.2	4	281.6	1.2	4	2.1	1.2
September	3	2.2	1.2	3	3.6	1.2	3	2.4	1.2	3	23.9	1.2	3	1.6	1.2
October	5	7.9	1.1	5	2.8	1.1	5	2.3	1.3	5	112.3	1.3	5	3.2	1.3
November	4	35.6	1.2	4	1.8	1.3	4	2.6	1.4	4	7.7	1.2	4	3.4	1.5
December	3	8.6	1.6	3	1.6	1.2	1	2.0	1.7	3	6.2	1.5	3	1.9	1.7
Total	46			42			39			42			47		
Average		9.0	1.2		5.1	1.2		2.9	1.2		50.4	1.2		4.2	1.2
Radiation Concentration Guide [11]				Gross β	3000 pCi/liter										
				HTO	3000 nCi/liter										

μCi = 3.7×10^{1} Bq.

pCi = 3.7×10^{-2} Bq.

Table 20. All were within established standards for ground water quality except in cases where washout from recharging of ion exchange resins (used in softening water) increased the concentrations of cations and anions, thereby increasing conductivity. Excess metal concentrations, such as Fe, Pb, indicate effects of chemical treatment for keeping iron in solution and steam plant condensates and boiler washings (Pb from pipes).

3.3.5 Aquatic Biological Studies

During the summers of 1977 and 1978, an intensive program aimed at understanding the effect of the Laboratory's effluent on the Peconic River system over the years was initiated. This study, which is expected to take three to four years, will be phased in gradually. In 1977 and 1978, the program was exploratory, wherein sampling stations, sampling techniques and analytical procedures and limitations were tried out. The results so obtained will be used to develop an adequate program to be implemented in 1979 and in 1980 when it is hoped that the data so obtained would be amenable to modeling for predictive purposes. Additional data from previous years will also be used.

Figure 8 indicates some of the sampling locations. These are:

E - Reference point-headwaters of the Peconic River-Control Station,

K - 0.045 km, no vegetation, significant influence of chlorine,

L - 0.106 km,

M - 0.798 km, referred to as the former site boundary,

Q - 2.11 km, the present site boundary, fish collected from here,

A - 4.85 km,

S - 7.05 km,

T -10.82 km,

U -14.23 km,

W -18.18 km, mussel bed,

Y -22.21 km, salt water meets fresh water.

These locations were sampled for sediment and vegetation common to most of the sites. A significant departure from previous sediment sampling techniques was the use of coring to collect river bottom sediments. This procedure will enable determination of both vertical and horizontal migration of radionuclides in the bottom sediments. Fish samples were restricted to Station Q because of availability. Mussel samples were available only from Stations T and W. Intensive sampling of the above parameters will be done in 1979.

Table 20

1978 BNL Environmental Monitoring Recharge Basins
Water Quality and Purity

LOCATION	SAMPLE	TEMPERATURE	PH	DISSOLVED OXYGEN (PPM)	CHLORIDES (PPM)	NITRATE NITROGEN (PPM)	TOTAL PHOSPHOROUS (PPM)	DISSOLVED SOLIDS (PPM)	CONDUCTIVITY MICROMHO/CM	COLIFORM FECAL (/100 ML)	COLIFORM TOTAL (/100 ML)
HN	MEAN	17	6.9	9.3	18.9	0.26	0.32	72	101	8	25
	MINIMUM	8	6.0	7.4	14.5	0.01	0.06	1	83	0	1
	MAXIMUM	25	9.8	12.4	30.8	0.54	0.57	101	142	29	54
	NUMBER	47	46	47	12	12	12	12	47	5	5
HO	MEAN	18	7.1	10.4	17.6	0.36	0.64	77	98	0	16
	MINIMUM	10	5.0	7.4	11.5	0.03	0.24	57	9	0	0
	MAXIMUM	25	9.4	15.0	21.0	1.54	1.38	89	150	2	62
	NUMBER	42	41	36	13	14	13	11	42	6	6
HP	MEAN	14	6.6	5.8	25.9	1.38	0.03	113	164	2	24
	MINIMUM	11	5.2	4.0	16.5	0.10	0.01	75	148	0	0
	MAXIMUM	22	8.2	8.2	30.5	1.82	0.05	133	285	10	106
	NUMBER	38	37	37	12	12	12	12	38	5	5
HS	MEAN	16	7.3	9.3	25.3	0.83	0.27	67	139	49	55
	MINIMUM	0	6.0	6.2	1.5	0.16	0.01	0	11	0	0
	MAXIMUM	25	9.0	12.0	155.1	3.64	2.69	117	500	461	600
	NUMBER	49	49	49	49	49	48	14	45	46	35
HT	MEAN	20	7.2	8.5	19.8	0.52	0.03	87	117	7	0
	MINIMUM	14	6.3	7.0	12.5	0.05	0.01	61	88	0	0
	MAXIMUM	26	8.3	10.4	28.5	1.25	0.05	106	157	47	0
	NUMBER	47	46	46	12	12	12	12	47	7	6
HU	MEAN	21	9.0	7.1	51.0	1.09	0.51	239	589	4	12
	MINIMUM	12	6.0	3.8	18.0	0.24	0.08	65	110	0	0
	MAXIMUM	31	10.6	9.8	156.0	1.85	1.36	620	8000	19	60
	NUMBER	42	41	36	11	11	11	11	42	6	6

Reference Standards - Table 32

Table 20 (Continued)

1978 BNL Environmental Monitoring Recharge Basins
Water Quality and Purity-Metals

		METALS (IN PPM)						
		AG	CD	CR	CU	FE	PB	ZN
HN	MEAN	.001	.0004	.002	.021	1.180	.001	.015
	MINIMUM	.001	.0004	.002	.021	1.180	.001	.015
	MAXIMUM	.001	.0004	.002	.021	1.180	.001	.015
	EXCEPTION	1	1	0	0	0	1	0
	NUMBER	1	1	1	1	1	1	1
HO	MEAN	.001	.0009	.010	.023	2.003	.004	.043
	MINIMUM	.001	.0005	.003	.012	1.030	.002	.017
	MAXIMUM	.001	.0020	.030	.030	3.710	.005	.116
	EXCEPTION	3	4	4	0	0	4	0
	NUMBER	3	4	4	4	4	4	4
HP	MEAN	.001	.0004	.010	.003	.421	.001	.002
	MINIMUM	.001	.0004	.010	.003	.421	.001	.002
	MAXIMUM	.001	.0004	.010	.003	.421	.001	.002
	EXCEPTION	1	1	0	0	0	1	1
	NUMBER	1	1	1	1	1	1	1
HT	MEAN	.001	.0004	.002	.022	.087	.005	.009
	MINIMUM	.001	.0004	.002	.022	.087	.005	.009
	MAXIMUM	.001	.0004	.002	.022	.087	.005	.009
	EXCEPTION	1	1	0	0	0	0	0
	NUMBER	1	1	1	1	1	1	1
HU	MEAN	.004	.0012	.014	.232	.995	.783	.253
	MINIMUM	.004	.0012	.014	.232	.995	.783	.253
	MAXIMUM	.004	.0012	.014	.232	.995	.783	.253
	EXCEPTION	0	0	0	0	0	0	0
	NUMBER	1	1	1	1	1	1	1

Reference Standards - Table 32

HN: North of AGS
HO: East of HFBR
HP: South of MRR
HS: South of Warehouse
HT: North of LINAC
HU: East of Steam Plant

Exception: Below Minimum Detection Limit (MDL)

The data in Table 21 is restricted to ^{90}Sr and ^{137}Cs. These radionuclides occur in significant quantities above the MDL and are principal contributors to body burden estimates in man. Other nuclides such as ^{60}Co, which is attributable to Laboratory effluents, did occur but were either less than or equal to the MDL for the counting system used (see Appendix B). In analyzing the data, it was noted that beyond Station Q, most of the radionuclides were at or below MDL. Also, Station Q represents the site boundary and a proper documentation of all releases is critical for the evaluation of Laboratory releases. The table, therefore, is also restricted to Station Q on the above basis.

Looking at the concentration factors for ^{90}Sr and ^{137}Cs at Station Q, it is noted that there is indeed biological magnification across the food chain: water-vegetation-fish. For ^{90}Sr, the concentration factor for fish ranges from 23 to 31 in flesh and from 36 to 45 in bone. In the case of ^{137}Cs, the vegetation-to-water ratio ranges from 200 to 1250 and the concentration factor for fish ranged from 100 to 2100. These results are in accordance with observations in aquatic environments [21, 22]. Using the range of concentrations of ^{90}Sr and ^{137}Cs in fish flesh (edible portions), one can compute, on an assumed intake of 50 grams per day, body burdens in man to be ranging from 0.2 to 0.5% of the Radiation Concentration Guide.

3.3.6 Surveillance Wells

3.3.6.1 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, or about 15 m below the water table, in the Long Island surface layer of glacial outwash, sand and gravel. As apparent from Figure 9, these wells are located generally west to northwest of the Laboratory's principal facilities in the local ground water flow pattern. An average of about 2.94×10^4 m^3 d^{-1} was pumped from them.

Bimonthly grab samples were obtained from these wells. These were analyzed for gross alpha, gross beta and tritium. All gross alpha concentrations were <1 pCi/liter (<1×10^{-9} μCi ml^{-1} or 3.7×10^{-5} Bq ml^{-1}), and almost all tritium concentrations were <1.0 nCi/liter (<10^{-6} μCi/ml or 3.7×10^{-2} Bq ml^{-1}). The gross beta and tritium results are set forth in Table 22. There were no significant differences in the gross beta concentrations among these wells which might be attributed to Laboratory effluents. These values have been consistent over many years. However, well #3 has been showing an increase in gross beta values indicating possible leakage in the well casing. This well, which was used as a source of potable water, has been discontinued.

3.3.6.2 Ground Water Surveillance

Samples of ground water were obtained from a network of shallow wells previously installed in the vicinity of several areas where there existed a potential for the percolation of radioactivity from the surface downward into the saturated zone of ground water. They included areas which were adjacent

TABLE 21

1978 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 1974-1978

Year	Water Concentration pCi/l ^{90}Sr	Water Total mCi	Water Concentration pCi/l ^{137}Cs	Water Total mCi	Sediment Concentration pCi/Kg-wet[a] ^{137}Cs	Vegetation Concentration pCi/Kg-wet[a] ^{137}Cs	Fish Concentration pCi/Kg-wet[a] ^{90}Sr flesh	Fish ^{90}Sr bone	Fish ^{137}Cs flesh
1974	1.23	1.88	1.13	1.69	306	220	-	-	112-326
1975	1.74	2.75	4.46	7.25	525	1010	-	-	397
1976	1.37	0.83	1.86	3.17	440	257	-	-	700
1977	1.09	2.04	1.60	2.94	1656	1128	25-30	-	772-3400
1978	1.11	3.70	0.79	2.65	920	990	27-34	40-50	536-1192

[a] Original results given in dry weight; the results shown in Table are corrected to wet weight as consumption of food is measured in terms of wet weight.

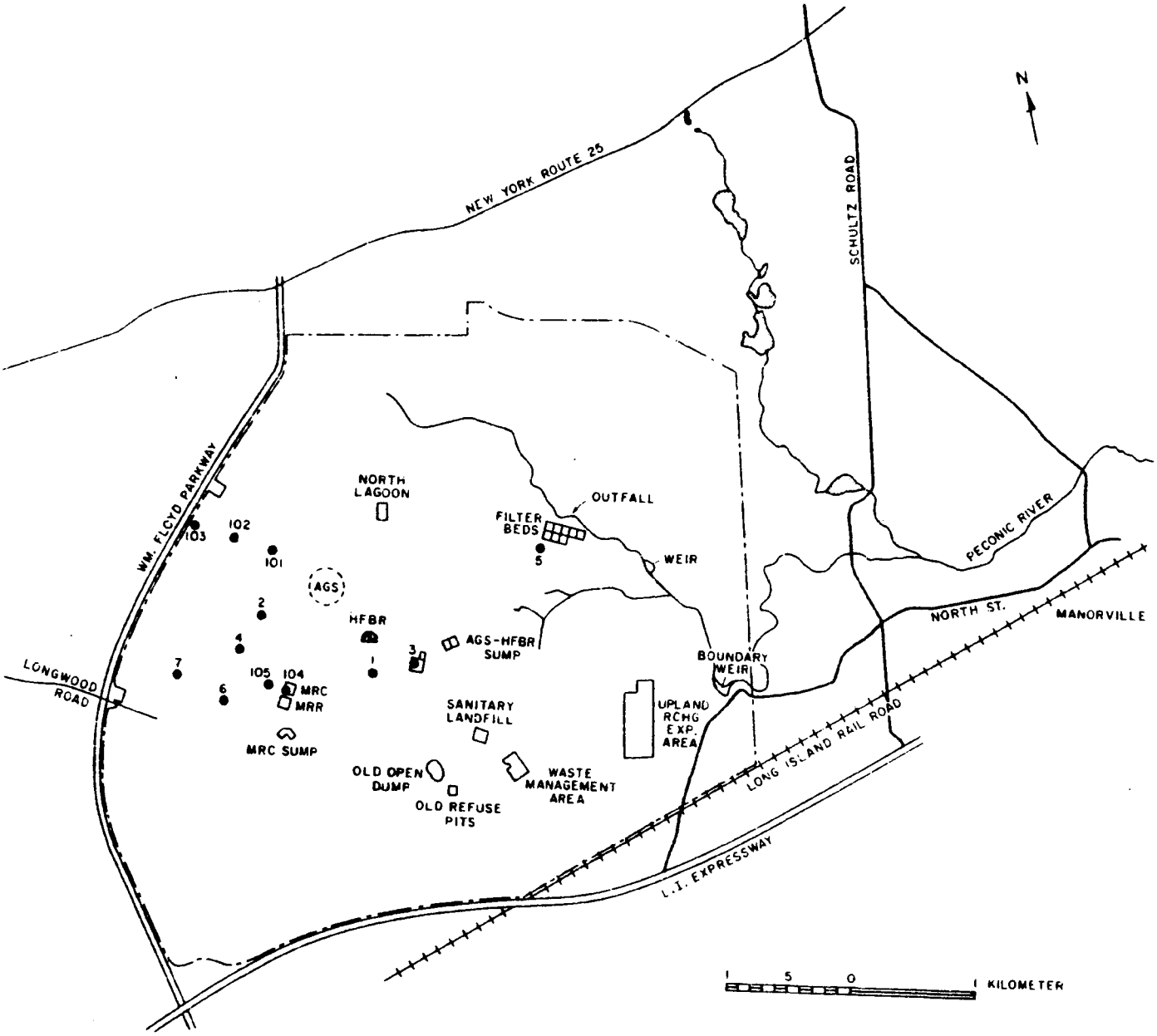

Figure 9. On-site potable and supply wells.

TABLE 22

1978 BNL Environmental Monitoring Gross Beta and Tritium Concentrations in Potable Water and Cooling Water Supply Wells

Month	Wells 1	2	3	4	5	6	7	101	102	103	104	105
Gross Beta (pCi/liter)												
March	3.2±1.2	<10.3	-	<1.6								2.1±1.2
April	2.3±1.1	-	14.0±1.5		<1.6	<1.6	1.8±1.1				3.4±1.3	
August	7.5±1.1	4.5±1.0	10.8±1.4	2.1±0.9	1.5±0.9	1.6±0.9	1.4±0.9		1.9±0.9	1.5±0.9	3.3±1.0	1.2±0.9
September	2.5±0.9	-	-	1.2±0.8	3.1±0.9	2.5±0.9	0.8					
December		2.9±0.9						3.3±0.9	1.6±0.8	1.2±0.8		2.4±.09
EPA-Drinking Water[13] and Radiation Concentration Guides[11]	3000 pCi/liter for unidentified nuclides in the absence of ^{90}Sr, ^{228}Ra or ^{129}I; 15 pCi/liter in the presence of ^{90}Sr, ^{228}Ra or ^{129}I.											
Tritium Concentration	(nCi/liter)											
March	<0.24	<0.88		<0.24								<0.24
April	0.33±0.23		<0.22		<0.23	<0.23	<0.23					
August	0.45±0.23	<0.23	<0.25	<0.21	<0.25	<0.22	<0.22		<0.22	<0.22	0.37±0.24	0.36±0.22
September	0.31±0.18	<0.25		<0.18	<0.25	<0.18	<0.18					
December								<0.25	<0.25	<0.25	<0.24	<0.24
EPA-Drinking Water[13] and Radiation Concentration Guides[11]	20 nCi/liter											

nCi = 3.7×10^{1} Bq.
pCi = 3.7×10^{-2} Bq.

to on-site recharge basins, to sand filter beds, to downstream Peconic River, to solid waste management area, to former open dump, to sanitary landfill, to decontamination facility sump, and to the Meadow-Marsh Project area. The locations of most of these ground water surveillance wells are shown in Figure 10. The locations of the several wells installed at the landfill and solid waste management area are shown in Figure 11.

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 23. 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) and are included in the table. 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) is summarized in Table 24. Since the aquifer underlying the Nassau and Suffolk Counties has been designated as a "Sole Source" [14], the EPA Drinking Water Standard is applicable. The data, therefore, is evaluated in terms of the new standard and not the RCG's, as done in previous years.

In analyzing the data over the last five years (1974-1978), it has been observed that the spread of radioactivity in the ground water from Laboratory operations remained limited to within a few hundred meters of the identifiable foci. Above background activity concentrations of gross beta emitters, tritium and ^{90}Sr were found on-site adjacent to the sand filter beds and to the Peconic River at small fractions of the Drinking Water Standards. In 1978, the activity concentrations were generally less than those noted in 1974 and 1975, but were similar to that of 1976 and 1977, indicating that radionuclides had not moved significantly since 1976. However, wells XH and XZ have shown a significant increase in gross beta activity. This situation is being examined and these wells will be sampled at frequent intervals in 1979. Adjacent to the Peconic River at the site boundary all activity concentrations were less than or equal to 4% of the Drinking Water Standards. Samples of well water collected from homes (Stations A, B, C and D - Figure 10) and well WS downstream (with reference to ground water movement) of the Laboratory and the Peconic River have indicated concentrations approaching one to two pCi/liter. Whether the ^{90}Sr present in these wells result from Laboratory operations or not, the above values confirm that the EPA drinking water limit of 8 pCi/liter [13] has not been exceeded.

Compared with the values detected in 1974-1977, the gross beta, tritium and ^{90}Sr activity concentrations for 1978 had, in most cases, decreased to 50% of the values in 1977 in several wells adjacent to the Solid Waste Management area.

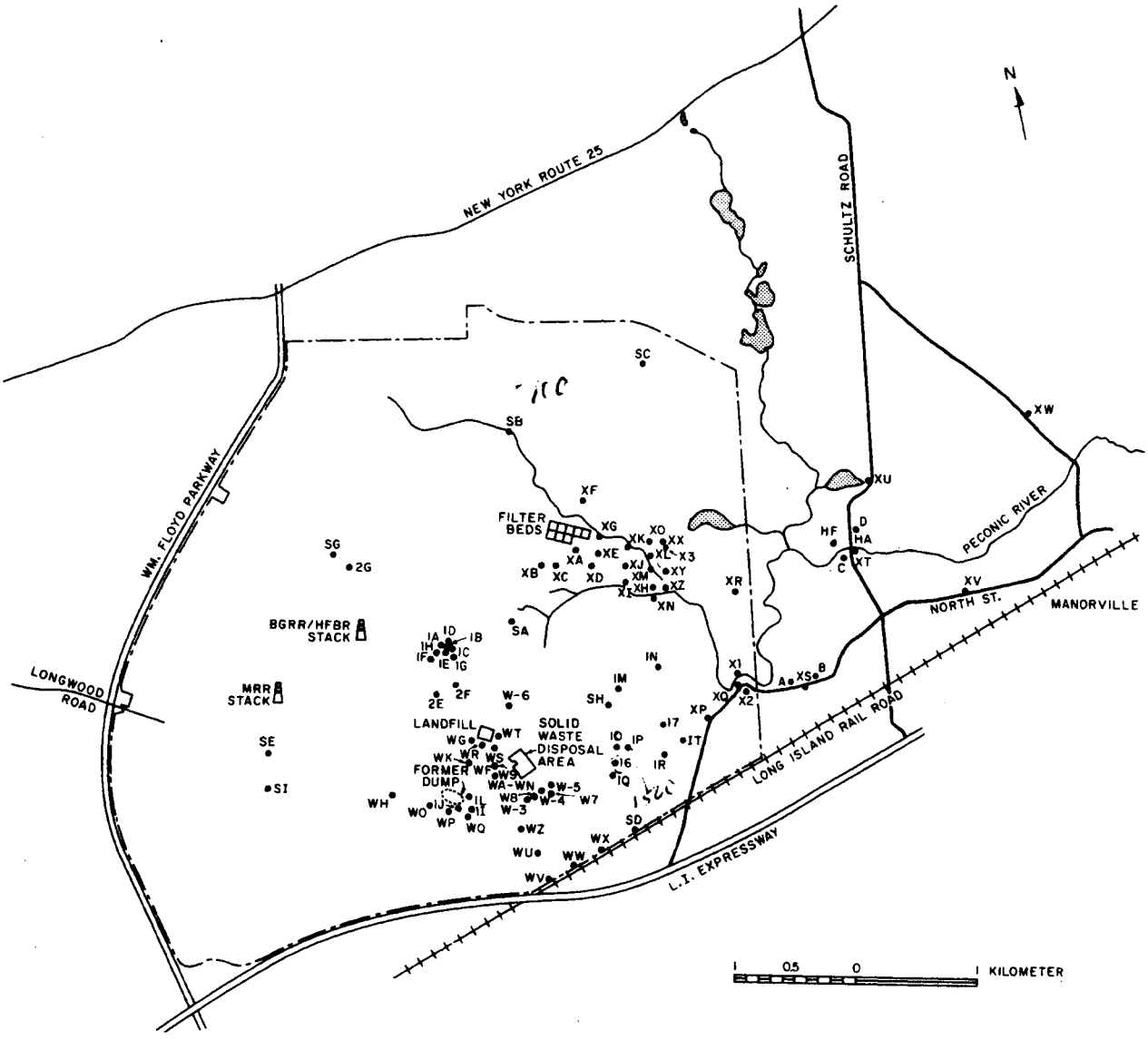

Figure 10. Location of groundwater surveillance wells.

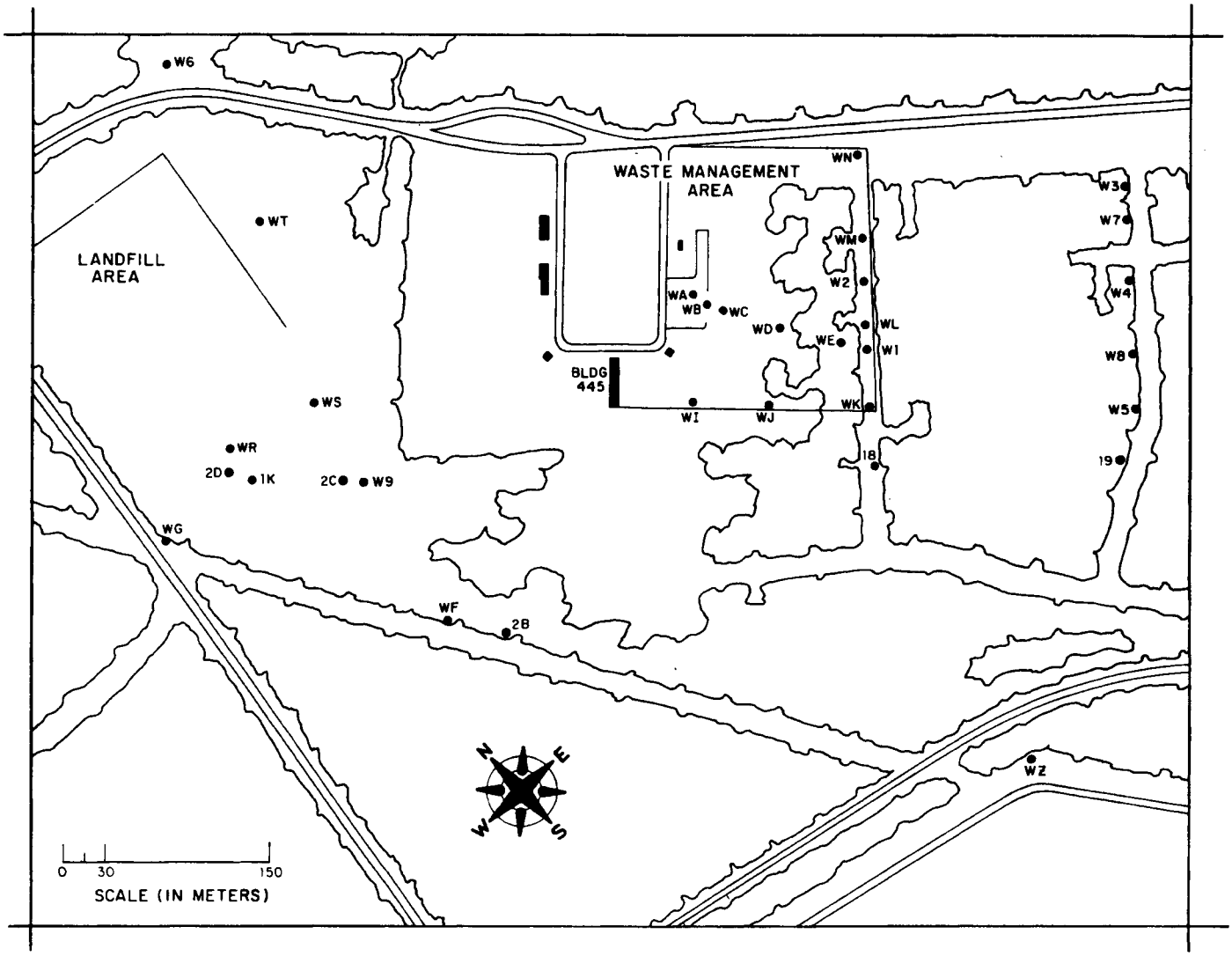

Figure 11. Landfill and waste management area surveillance wells.

TABLE 23

1978 Environmental Monitoring Sand Filter Bed, Peconic River Area and Miscellaneous On-Site Surveillance Wells Gross Alpha, Gross Beta, Tritium (HTO), ^{90}Sr and Other Nuclides Average Concentrations

Well	No. Samples	Gross α pCi/liter	Gross β pCi/liter	HTO nCi/liter	^{90}Sr pCi/liter	Other Radionuclides (pCi/liter)
			Sand Filter Bed and Peconic River Area			
XA	7	1.18±0.31	24.0±0.7	3.5±0.1	3.45±.24	^{22}Na:2.1±0.6 ^{60}Co:0.8±0.3
XB	1	<0.3	3.0±1.2	<0.2	--	
XC	1	0.8±0.4	7.4±1.3	<0.2	--	
XD	1	<0.4	<2.7	<0.2	--	
XE	1	<0.3	1.7±0.8	<0.2	--	
XF	1	<0.3	<1.2	<0.2	--	
XG	1	1.3±0.4	7.9±0.4	0.23±0.07	1.25±.18	
XH	2	0.9±0.4	57.3±2.6	0.7±0.2	--	
XI	2	0.5±0.2	4.2±0.9	0.21±0.15	--	
XJ	1	<0.3	3.8±0.9	<0.2	--	^{22}Na:0.9±0.3
XK	1	0.6±0.1	11.9±0.4	4.8±0.1	2.85±.19	
XL	6	1.9±0.3	19.0±0.7	2.3±0.1	5.05±.28	
XM	1	2.0±0.3	15.3±0.5	2.7±0.1	1.35±.17	
XN	1	1.0±0.4	2.9±0.9	<0.2	--	
XQ	1	0.5±0.1	9.3±0.4	3.2±0.9	1.25±.15	
XR	1	1.0±0.5	5.6±2.0	<0.2		
XS	9	1.8±0.2	13.1±0.5	0.23±0.08	2.10±.18	
XT	1	<0.1	<1.2	<0.2	--	
XW	1	0.36±0.27	<1.6	<0.2	--	
XX	9	0.57±0.12	9.3±4.4	3.3±0.1		
XY	2	0.25±0.17	5.7±0.8	1.5±0.2	--	
XZ	1	1.4±0.7	128.0±5.5	<0.2	--	
X1	1	<0.3	<2.6	<0.2	--	
X2	1	<0.4	<1.5	1.0±0.2	--	
X3	1	0.7±0.5	3.6±1.9	<0.2	--	
			Miscellaneous on Site			
16	1	0.37±0.23	5.0±1.0	1.5±0.3	--	
17	1	<0.3	1.7±1.1	<0.2	--	
2E	1	<0.2	15.0±1.6	0.3±0.2	--	
2F	1	<0.3	3.1±1.0	<0.2	--	
2G	1	<0.2	3.4±1.0	0.4±0.2	--	
SA	1	0.4±0.3	2.4±1.0	<0.2	--	
SB	1	<0.2	1.6±0.9	0.7±0.2	--	
SC	1	<0.3	<1.6	<0.2	--	
SD	1	<0.3	1.6±0.8	<0.2	--	
SE	3	0.3±0.2	7.0±0.7	<0.2	0.80±.21 (0.47±.13 / 1.13±.17)	
SG	1	<0.2	1.7±0.8	0.27±0.22	--	
SI	1	<0.2	1.9±0.9	<0.2	--	
EPA - Drinking Water Regulations[13] and Radiation Concentration Guides[11]		15	3000[a]	20	8	^{22}Na:4 x 10^4; ^{60}Co:5 x 10^4; ^{7}Be:2 x 10^6

[a] If $^{125\text{-}133}I$ and ^{90}Sr not present.

nCi = 3.7 x 10^1 Bq.

pCi = 3.7 x 10^{-2} Bq.

TABLE 24

1978 Environmental Monitoring Waste Management, Landfill, Former Dump and 650 Area Surveillance Wells Gross Alpha, Gross Beta, Tritium (HTO) ^{90}Sr and Other Radionuclides Average Concentrations

Well	No. Samples	Gross α pCi/liter	Gross β pCi/liter	HTO nCi/liter	^{90}Sr pCi/liter	Other Radionuclides (pCi/liter)
			Waste Management Area			
18	1	<0.3	5.2±1.1	<0.2	0.64±.15	
19	1	0.5±0.3	2.8±1.0	<0.2	0.58±.15	
WB	1	<0.8	177.2±4.0	3.2±0.3	80.17±1.26	
WC	2	0.6±0.4	12.6±1.0	5.0±0.2	5.03±.34	(11.31±.26 / 4.87±.19)
WD	5	0.4±0.2	18.9±0.2	2.6±0.1	8.09±.53	
WE	2	0.4±0.2	18.0±1.1	1.7±0.2	12.76±.51	
WJ	1	<0.3	5.3±1.0	1.6±0.3	0.95±.19	
WK	5	1.4±0.2	101.4±1.4	2.8±0.1	62.25±1.80	(48.21±.36 / 124.5±.52)
WL	5	1.4±0.2	117.3±1.5	1.9±0.1	52.33±1.35	(33.79±.85 / 70.86±1.05)
WM	1	0.5±0.4	34.8±2.0	9.6±0.4	2.77±.26	
WN	1	<0.2	3.2±0.9	0.3±0.9	0.28±.15	
WU	1	<0.3	1.2±0.8	<0.2	0.09±.16[a]	
WV	1	<0.2	1.2±0.8	<0.2	0.08±.12[a]	
WW	1	<0.4	1.3±0.8	<0.2	0.47±.14	
WX	1	<0.3	2.7±0.9	<0.2	0.21±.13	
WZ	1	<0.2	3.6±1.1	<0.2	0.58±.15	
W1	5	0.6±0.2	27.1±0.8	0.5±0.1	10.40±.60	(5.83±.36 / 14.96±.48)
W3	1	<0.2	1.9±0.8	<0.2	0.67±.15	
W4	1	<0.2	4.0±0.9	<0.2	0.27±.12	
W5	1	<0.3	2.0±0.9	<0.2	0.2±.12	
W7	1	<0.2	1.7±0.8	<0.2	0.22±.13	
W8	1	<0.2	3.0±1.0	<0.2	0.2±.17	
			Land Fill Area			
2A	2	0.3±0.2	2.3±0.7	<0.2	--	
2B	2	0.3±0.2	3.3±0.7	<0.2	--	^{22}Na:0.5±.2;
2C	2	7.1±2.4	68.0±4.6	55.6±0.6	--	
2D	2	5.7±1.7	35.5±3.6	9.5±0.4	--	
WF	2	0.4±0.2	5.4±0.8	3.9±0.2	--	
WR	3	5.1±1.5	60.4±4.8	11.9±0.3	10.05±.44	^{22}Na:17±.4; ^{60}Co:0.8±.2;
WS	3	2.4±1.2	59.0±5.0	197.2±0.8	3.16±.27	^{7}Be:22.0±2.2;
WT	2	1.0±0.3	1.8±0.7	0.3±0.2	--	
W6	1	<0.3	6.2±1.2	<0.2	0.17±.12	
W9	3	5.1±1.8	93.6±5.7	42.3±0.4	27.50±.68	^{22}Na:0.8±.2; ^{60}Co:0.5±.2;
1K	3	6.2±2.8	66.8±5.6	18.6±0.3	8.72±.13	
			650 Sump Area			
1A	1	1.2±0.4	190.0±4.2	<0.2	83.62±1.29	
1C	1	<0.2	6.0±1.2	0.25±0.22	--	
1E	1	0.6±0.3	62.3±1.8	0.21±0.15	67.45±1.16	
1F	1	<0.3	1.5±0.9	<0.2	0.62±.16	
1H	1	1.5±0.5	149.4±3.8	<0.2	70.80±1.2	
1T	1	1.6±0.6	8.8±1.5	<0.2	--	
			Former Dump Area			
WH	1	<0.3	6.2±1.3	<0.2	0.67±.15	
WO	1	<0.2	<1.8	<0.2	<0.09	
WP	1	<0.3	<1.8	<0.2	<0.09	
WQ	1	<0.2	1.6±1.2	<0.2	<0.09	
1I	1	1.6±.6	8.8±1.5	<0.2	2.24±.25	
1J	1	<0.1	<1.6	<0.2	<0.09	
EPA-Drinking Water Regulations[13] and Radiation Concentration Guides[11]		15	3000[a]	20	8	^{22}Na:4 x 10^4; ^{60}Co:5 x 10^4; ^{7}Be:2 x 10^6

[a] If $^{125-133}I$ and ^{90}Sr not present.

nCi = 3.7 x 10^1 Bq.

pCi = 3.7 x 10^{-2} Bq.

Once again, movement of successive wavefronts from the source point is evident. The elevated ^{90}Sr activity concentrations, exceeding Drinking Water Standards, in wells WK, WL and WB continue to reflect the inadvertent release in 1960 of approximately 1 Ci (3.7×10^{10} Bq) of this nuclide to ground water at well WA. The concentrations in wells WK and WL have decreased by 20 to 30% but well WB, which is adjacent to WA, has increased by a factor of 2. Such fluctuations 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 which were increasing since 1974 decreased in several wells immediately adjacent to the landfill area and reflects movement and dilution through ground water. A further decrease in activity concentrations was apparent in wells adjacent to the former open dump when compared to the years 1974-1978. The gross beta and ^{90}Sr values in wells 1A and 1H, monitoring the decontamination facility (650) sump, have increased by a factor of two, while the other wells around this sump area have further decreased when compared to the concentrations during 1974-1977. In view of the new standards that are applicable to ground water systems, the gross beta and ^{90}Sr indeed exceed the limits. However, in the case of ^{90}Sr, calculations based on ground water travel times, ^{90}Sr distribution coefficient for ion-exchange and distance to potential user (as drinking water) indicate travel time greater than two ^{90}Sr half-lives (approximately 60 years) to reach areas where exposure can occur. Based on the existing levels in the above wells, the Laboratory does not foresee this inadvertent dumping of ^{90}Sr in well WA and the 650 sump area will cause the concentrations of ^{90}Sr in wells off-site to exceed EPA drinking water limits.

Several water quality and purity parameters were evaluated for all ground water surveillance wells. The data for those wells proximate to on-site sumps, the sand filter beds, and downstream of the Peconic River on- and off-site, are shown in Table 25. Similarly, the data for the solid waste management area, the landfill, the dump area and the 650 sump, are shown in Table 26. In addition, Table 27 presents similar data on potable and cooling water supply wells. This data is further compared with tap water, for a few of the parameters, in the same table. In all cases, the ground water quality parameters were within standard limits. 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 28. Results of trace element analyses for potable and cooling water supply wells, and tap water are given in Table 29.

In general, the data were comparable to that observed during 1974-1977. With the exception of pH, all analyzed water quality parameters were within New York State Water Quality Standards. 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 11). Concentrations of Fe, Zn and Pb 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. It is not clear to what extent they may be an artifact produced by the sampling well casings, or reflect the leaching of accumulations of these metals from past Laboratory releases. Tracing the levels of these elements in the ground water system by means of the

Table 25

1978 BNL Environmental Monitoring Sand Filter Beds and Peconic River Area Wells Water Quality and Purity

LOCATION	SAMPLE	TEMPERATURE	PH	DISSOLVED OXYGEN (PPM)	CHLORIDES (PPM)	NITRATE NITROGEN (PPM)	TOTAL PHOSPHOROUS (PPM)	DISSOLVED SOLIDS (PPM)	CONDUCTIVITY MICROMHO/CM	COLIFORM FECAL (/100 ML)	COLIFORM TOTAL (/100 ML)
XA	MEAN	17	5.8	4.7	27.2	4.09	0.06	123	168	0	1
	MINIMUM	15	5.3	2.6	25.0	2.67	0.01	108	152	0	0
	MAXIMUM	19	6.1	9.2	29.0	5.63	0.15	151	186	0	6
	NUMBER	8	8	5	8	8	5	7	8	7	7
XB	MEAN	9	6.2	7.4	5.0	0.10	0.02		62	43	0
	MINIMUM	9	6.2	7.4	5.0	0.10	0.02		62	43	0
	MAXIMUM	9	6.2	7.4	5.0	0.10	0.02		62	43	0
	NUMBER	1	1	1	1	1	1	0	1	1	1
XC	MEAN	8	6.0	1.5	4.5	0.10	0.02	38	47	0	0
	MINIMUM	8	6.0	1.5	4.5	0.10	0.02	38	47	0	0
	MAXIMUM	8	6.0	1.5	4.5	0.10	0.02	38	47	0	0
	NUMBER	1	1	1	1	1	1	1	1	1	1
XD	MEAN	10	5.1	6.0	9.5	0.05	0.05	47	54	0	0
	MINIMUM	10	5.1	6.0	9.5	0.05	0.05	47	54	0	0
	MAXIMUM	10	5.1	6.0	9.5	0.05	0.05	47	54	0	0
	NUMBER	1	1	1	1	1	1	1	1	1	1
XE	MEAN	13	5.5	6.2	7.9	0.12	0.05	44	45	0	0
	MINIMUM	13	5.5	6.2	7.9	0.12	0.05	44	45	0	0
	MAXIMUM	13	5.5	6.2	7.9	0.12	0.05	44	45	0	0
	NUMBER	1	1	1	1	1	1	1	1	1	1
XF	MEAN	11	6.2	6.4	6.4	0.05	0.05	48	45		
	MINIMUM	11	6.2	6.4	6.4	0.05	0.05	48	45		
	MAXIMUM	11	6.2	6.4	6.4	0.05	0.05	48	45		
	NUMBER	1	1	1	1	1	1	1	1	0	0
XG	MEAN	12	5.9	7.3	11.3	0.17	0.08	63	70	0	0
	MINIMUM	8	5.5	5.2	5.9	0.03	0.02	50	55	0	0
	MAXIMUM	17	6.3	9.0	21.1	0.31	0.23	80	92	0	1
	NUMBER	10	10	10	10	10	10	9	10	9	8
XH	MEAN	10	5.1	6.0	6.5	0.05	0.05	36	43	0	0
	MINIMUM	10	5.1	6.0	6.5	0.05	0.05	36	43	0	0
	MAXIMUM	10	5.1	6.0	6.5	0.05	0.05	36	43	0	0
	NUMBER	1	1	1	1	1	1	1	1	1	1
XI	MEAN	9	6.0	6.4	9.3	0.11	0.02	38	59	0	0
	MINIMUM	8	5.6	3.8	8.5	0.05	0.02	36	58	0	0
	MAXIMUM	10	6.4	9.0	10.0	0.17	0.02	40	59	0	0
	NUMBER	2	2	2	2	2	2	2	2	2	2
XJ	MEAN	12	5.4	2.8	19.3	0.14	0.43	79	101	0	0
	MINIMUM	12	5.4	2.8	19.3	0.14	0.43	79	101	0	0
	MAXIMUM	12	5.4	2.8	19.3	0.14	0.43	79	101	0	0
	NUMBER	1	1	1	1	1	1	1	1	1	1
XK	MEAN	12	6.2	1.6	22.0	0.17	0.06	113	137	0	0
	MINIMUM	8	6.0	1.1	13.5	0.03	0.01	99	123	0	0
	MAXIMUM	16	6.5	2.0	32.7	0.33	0.10	157	157	0	0
	NUMBER	10	10	10	10	10	10	10	10	10	10
XL	MEAN	15	6.1	2.7	24.2	0.28	0.04	104	127	0	0
	MINIMUM	10	5.7	1.1	18.3	0.14	0.01	85	109	0	0
	MAXIMUM	17	6.3	10.0	29.0	0.45	0.08	116	149	0	0
	NUMBER	6	6	6	6	6	6	6	6	3	3
XM	MEAN	16	6.0	7.0	21.2	0.97	0.07	87	113	0	0
	MINIMUM	12	5.2	4.2	15.5	0.10	0.01	71	83	0	0
	MAXIMUM	20	6.3	9.0	27.6	4.12	0.17	107	145	0	1
	NUMBER	9	9	9	10	10	10	10	9	9	9
XN	MEAN	10	5.6	2.0	9.9	0.81	2.38	50	57	0	4
	MINIMUM	10	5.6	2.0	9.9	0.81	2.38	50	57	0	4
	MAXIMUM	10	5.6	2.0	9.9	0.81	2.38	50	57	0	4
	NUMBER	1	1	1	1	1	1	1	1	1	1
XQ	MEAN	13	6.2	1.4	24.7	0.05	0.03	82	129	0	0
	MINIMUM	12	5.8	0.9	13.2	0.01	0.01	63	102	0	0
	MAXIMUM	14	6.6	2.4	36.1	0.10	0.07	106	155	0	0
	NUMBER	10	10	10	10	10	10	10	10	9	9
XR	MEAN	8	5.4	8.0	4.5		0.01	31	38	0	0
	MINIMUM	8	5.4	8.0	4.5		0.01	31	38	0	0
	MAXIMUM	8	5.4	8.0	4.5		0.01	31	38	0	0
	NUMBER	1	1	1	1	0	1	1	1	1	1
XS	MEAN	12	5.6	7.3	9.2	0.19	0.02	59	88	0	0
	MINIMUM	10	5.2	4.4	3.9	0.03	0.01	42	79	0	0
	MAXIMUM	13	6.1	10.0	13.0	0.94	0.04	72	98	0	0
	NUMBER	9	9	9	9	9	9	9	9	8	8

Reference Standards - Table 32

Table 25 (Continued)

1978 BNL Environmental Monitoring Sand Filter Beds and Peconic River Area Wells Water Quality and Purity

LOCATION	SAMPLE	TEMPERATURE	PH	DISSOLVED OXYGEN (PPM)	CHLORIDES (PPM)	NITRATE NITROGEN (PPM)	TOTAL PHOSPHOROUS (PPM)	DISSOLVED SOLIDS (PPM)	CONDUC-TIVITY MICROMHO/CM	COLIFORM FECAL (/100 ML)	COLIFORM TOTAL (/100 ML)
XT	MEAN	10	6.6	4.8	6.9	0.10	0.05	62	74	0	0
	MINIMUM	10	6.6	4.8	6.9	0.10	0.05	62	74	0	0
	MAXIMUM	10	6.6	4.8	6.9	0.10	0.05	62	74	0	0
	NUMBER	1	1	1	1	1	1	1	1	1	1
XW	MEAN	10	6.0	2.2	35.0	0.10	0.02	62	82	0	0
	MINIMUM	10	6.0	2.2	35.0	0.10	0.02	62	82	0	0
	MAXIMUM	10	6.0	2.2	35.0	0.10	0.02	62	82	0	0
	NUMBER	1	1	1	1	1	1	1	1	1	1
XX	MEAN	12	5.7	1.9	9.2	0.19	0.04	50	83	0	0
	MINIMUM	9	5.0	1.1	0.0	0.01	0.01	38	69	0	0
	MAXIMUM	14	6.2	2.8	14.8	0.91	0.17	59	111	0	0
	NUMBER	9	9	9	9	9	6	9	9	7	9
XY	MEAN	13	5.5	2.7	7.9	0.06	0.11	59	55	0	0
	MINIMUM	11	5.3	2.0	5.4	0.02	0.05	28	38	0	0
	MAXIMUM	14	5.6	3.4	10.3	0.10	0.18	89	72	0	0
	NUMBER	2	2	2	2	2	2	2	2	2	2
XZ	MEAN	10	5.2	6.4	4.0	1.46	0.10	40	44	0	0
	MINIMUM	10	5.2	6.4	4.0	1.46	0.10	40	44	0	0
	MAXIMUM	10	5.2	6.4	4.0	1.46	0.10	40	44	0	0

1978 BNL Environmental Monitoring Miscellaneous On Site Wells Water Quality and Purity

LOCATION	SAMPLE	TEMPERATURE	PH	DISSOLVED OXYGEN (PPM)	CHLORIDES (PPM)	NITRATE NITROGEN (PPM)	TOTAL PHOSPHOROUS (PPM)	DISSOLVED SOLIDS (PPM)	CONDUC-TIVITY MICROMHO/CM	COLIFORM FECAL (/100 ML)	COLIFORM TOTAL (/100 ML)
SA	MEAN	13	5.2	2.6	59.0	0.83	0.01	175	195	0	0
	MINIMUM	13	5.2	2.6	59.0	0.83	0.01	175	195	0	0
	MAXIMUM	13	5.2	2.6	59.0	0.83	0.01	175	195	0	0
	NUMBER	1	1	1	1	1	1	1	1	1	1
SB	MEAN	12	5.7	5.8	0.0	0.03	0.01	43	35	0	0
	MINIMUM	12	5.7	5.8	0.0	0.03	0.01	43	35	0	0
	MAXIMUM	12	5.7	5.8	0.0	0.03	0.01	43	35	0	0
	NUMBER	1	1	1	1	1	1	1	1	1	1
SC	MEAN	12	6.0	8.0		0.03	0.01	38	43	0	
	MINIMUM	12	6.0	8.0		0.03	0.01	38	43	0	
	MAXIMUM	12	6.0	8.0		0.03	0.01	38	43	0	
	NUMBER	1	1	1	0	1	1	1	1	1	0
SD	MEAN	10	6.0	6.0	6.0	0.33	0.01	38	40	0	7
	MINIMUM	10	6.0	6.0	6.0	0.33	0.01	38	40	0	7
	MAXIMUM	10	6.0	6.0	6.0	0.33	0.01	38	40	0	7
	NUMBER	1	1	1	1	1	1	1	1	1	1
SE	MEAN	14	6.4	7.9	20.5	1.38	0.03	113	160	0	0
	MINIMUM	14	6.3	7.6	12.7	1.12	0.01	110	157	0	0
	MAXIMUM	15	6.6	8.2	28.3	1.56	0.05	116	163	0	0
	NUMBER	3	3	3	3	3	3	2	2	3	2
SG	MEAN	11	5.9	5.8	19.0	0.38	0.02	99	111	0	0
	MINIMUM	11	5.9	5.8	19.0	0.38	0.02	99	111	0	0
	MAXIMUM	11	5.9	5.8	19.0	0.38	0.02	99	111	0	0
	NUMBER	1	1	1	1	1	1	1	1	1	1
SI	MEAN	12	5.8	8.2	26.5	1.22	0.02	99	140	0	2
	MINIMUM	12	5.8	8.2	26.5	1.22	0.02	99	140	0	2
	MAXIMUM	12	5.8	8.2	26.5	1.22	0.02	99	140	0	2
	NUMBER	1	1	1	1	1	1	1	1	1	1
16	MEAN	11	5.4	1.4	23.0	1.04	0.01	86	122	0	0
	MINIMUM	11	5.4	1.4	23.0	1.04	0.01	86	122	0	0
	MAXIMUM	11	5.4	1.4	23.0	1.04	0.01	86	122	0	0
	NUMBER	1	1	1	1	1	1	1	1	1	1
17	MEAN	11	5.8	8.4	2.0	0.03	0.01	22	19	0	0
	MINIMUM	11	5.8	8.4	2.0	0.03	0.01	22	19	0	0
	MAXIMUM	11	5.8	8.4	2.0	0.03	0.01	22	19	0	0
	NUMBER	1	1	1	1	1	1	1	1	1	1
2E	MEAN	18	6.2	1.6	44.5	0.14	0.07	198	275	0	11
	MINIMUM	18	6.2	1.6	44.5	0.14	0.07	198	275	0	11
	MAXIMUM	18	6.2	1.6	44.5	0.14	0.07	198	275	0	11
	NUMBER	1	1	1	1	1	1	1	1	1	1
2F	MEAN	15	6.1	8.6	20.1	0.50	0.01	85	109	0	0
	MINIMUM	15	6.1	8.6	20.1	0.50	0.01	85	109	0	0
	MAXIMUM	15	6.1	8.6	20.1	0.50	0.01	85	109	0	0
	NUMBER	1	1	1	1	1	1	1	1	1	1
2G	MEAN	23	6.0	2.0	18.0	0.19	0.04	84	111	0	0
	MINIMUM	23	6.0	2.0	18.0	0.19	0.04	84	111	0	0
	MAXIMUM	23	6.0	2.0	18.0	0.19	0.04	84	111	0	0
	NUMBER	1	1	1	1	1	1	1	1	1	1

Reference Standards - Table 32

Table 26

1978 BNL Environmental Monitoring Solid Waste Management Area Wells
Water Quality and Purity

LOCATION	SAMPLE	TEMPERATURE	PH	DISSOLVED OXYGEN (PPM)	CHLORIDES (PPM)	NITRATE NITROGEN (PPM)	TOTAL PHOSPHOROUS (PPM)	DISSOLVED SOLIDS (PPM)	CONDUCTIVITY MICROMHO/CM	COLIFORM FECAL (/100 ML)	COLIFORM TOTAL (/100 ML)
WB	MEAN	16	5.3	6.4	6.0	0.63	0.03	63	74		
	MINIMUM	16	5.3	6.4	6.0	0.63	0.03	63	74		
	MAXIMUM	16	5.3	6.4	6.0	0.63	0.03	63	74		
	NUMBER	1	1	1	1	1	1	1	1	0	0
WC	MEAN	14	5.4	4.8	8.3	0.80	0.02	67	71	0	0
	MINIMUM	13	5.3	3.6	5.5	0.43	0.02	64	67	0	0
	MAXIMUM	14	5.5	6.0	11.0	1.18	0.02	69	74	0	0
	NUMBER	2	2	2	2	2	2	2	2	2	2
WD	MEAN	12	5.5	8.0	3.0	0.57	0.01	56	73	0	0
	MINIMUM	10	5.3	6.4	0.0	0.07	0.01	38	44	0	0
	MAXIMUM	14	5.6	10.0	6.4	1.18	0.01	75	100	0	0
	NUMBER	5	5	5	5	5	2	5	5	3	3
WE	MEAN	13	6.1	8.1	4.5	0.36	0.02	46	50	0	0
	MINIMUM	12	6.0	7.6	4.0	0.01	0.02	46	42	0	0
	MAXIMUM	14	6.1	8.6	5.0	0.71	0.02	46	57	0	0
	NUMBER	2	2	2	2	2	2	1	2	2	2
WI	MEAN		6.5								
	MINIMUM		6.5								
	MAXIMUM		6.5								
	NUMBER	0	1	0	0	0	0	0	0	0	0
WJ	MEAN	12	6.0	5.0	8.5	0.59	0.06	58	84	0	0
	MINIMUM	12	6.0	5.0	8.5	0.59	0.06	58	84	0	0
	MAXIMUM	12	6.0	5.0	8.5	0.59	0.06	58	84	0	0
	NUMBER	1	1	1	1	1	1	1	1	1	1
WK	MEAN	11	5.4	7.2	8.0	0.60	0.02	70	87	0	0
	MINIMUM	10	4.8	5.8	4.6	0.04	0.01	60	79	0	0
	MAXIMUM	12	5.9	9.6	11.0	1.07	0.06	98	100	0	0
	NUMBER	5	5	5	5	5	5	5	5	4	4
WL	MEAN	11	5.6	8.6	3.9	1.68	0.02	63	84	0	0
	MINIMUM	10	5.3	7.0	2.6	0.50	0.01	36	57	0	0
	MAXIMUM	13	5.9	9.4	7.0	3.80	0.07	89	112	0	0
	NUMBER	5	5	5	5	5	5	5	5	2	2
WM	MEAN	13	6.5	5.3	7.5	1.55	0.01	99	132		
	MINIMUM	13	6.5	5.3	7.5	1.55	0.01	99	132		
	MAXIMUM	13	6.5	5.3	7.5	1.55	0.01	99	132		
	NUMBER	1	1	1	1	1	1	1	1	0	0
WN	MEAN	13	6.1	5.8	21.5	0.01	0.04		130	0	0
	MINIMUM	13	6.1	5.8	21.5	0.01	0.04		130	0	0
	MAXIMUM	13	6.1	5.8	21.5	0.01	0.04		130	0	0
	NUMBER	1	1	1	1	1	1	0	1	1	1
WV	MEAN	11	5.8	8.2	10.3	0.36	0.03	48	66	0	0
	MINIMUM	10	5.6	6.8	9.3	0.25	0.01	43	57	0	0
	MAXIMUM	11	5.9	9.5	11.3	0.47	0.04	53	75	0	0
	NUMBER	2	2	2	2	2	2	2	2	1	1
WX	MEAN	12	5.7	7.0	13.7	0.03	0.06	46	71	0	0
	MINIMUM	12	5.7	7.0	13.7	0.03	0.06	46	71	0	0
	MAXIMUM	12	5.7	7.0	13.7	0.03	0.06	46	71	0	0
	NUMBER	1	1	1	1	1	1	1	1	1	1
WZ	MEAN	11	6.2	6.4	7.8	0.03	0.03	57	92	0	0
	MINIMUM	11	6.2	6.4	7.8	0.03	0.03	57	92	0	0
	MAXIMUM	11	6.2	6.4	7.8	0.03	0.03	57	92	0	0
	NUMBER	1	1	1	1	1	1	1	1	1	1
W1	MEAN	11	5.5	8.4	5.2	0.44	0.01	45	51	0	0
	MINIMUM	10	5.2	7.4	2.1	0.11	0.01	31	47	0	0
	MAXIMUM	13	5.6	9.4	8.5	0.83	0.02	59	55	0	0
	NUMBER	5	5	5	5	5	5	5	5	2	2
W3	MEAN	11	5.8	4.6	10.0	1.88	0.01	70	100		
	MINIMUM	11	5.8	4.6	10.0	1.88	0.01	70	100		
	MAXIMUM	11	5.8	4.6	10.0	1.88	0.01	70	100		
	NUMBER	1	1	1	1	1	1	1	1	0	0
W4	MEAN	12	6.2	8.6	7.0	0.05	0.01	44	48	0	0
	MINIMUM	12	6.2	8.6	7.0	0.05	0.01	44	48	0	0
	MAXIMUM	12	6.2	8.6	7.0	0.05	0.01	44	48	0	0
	NUMBER	1	1	1	1	1	1	1	1	1	1
W5	MEAN	11	5.2	9.0	6.5	0.00	0.01	40	48	0	0
	MINIMUM	11	5.2	9.0	6.5	0.00	0.01	40	48	0	0
	MAXIMUM	11	5.2	9.0	6.5	0.00	0.01	40	48	0	0
	NUMBER	1	1	1	1	1	1	1	1	1	1
W6	MEAN	13	7.0	1.6	14.5	0.11	0.01	193	300		
	MINIMUM	13	7.0	1.6	14.5	0.11	0.01	193	300		
	MAXIMUM	13	7.0	1.6	14.5	0.11	0.01	193	300		
	NUMBER	1	1	1	1	1	1	1	1	0	0

Reference Standard - Table 32

Table 26 (Continued)

1978 BNL Environmental Monitoring Solid Waste Management Area Wells Water Quality and Purity

LOCATION	SAMPLE	TEMPERATURE	PH	DISSOLVED OXYGEN (PPM)	CHLORIDES (PPM)	NITRATE NITROGEN (PPM)	TOTAL PHOSPHOROUS (PPM)	DISSOLVED SOLIDS (PPM)	CONDUC-TIVITY MICROMHO/CM	COLIFORM FECAL (/100 ML)	COLIFORM TOTAL (/100 ML)
W7	MEAN	11	6.3	5.2	8.0	0.42	0.01	68	76	0	0
	MINIMUM	11	6.3	5.2	8.0	0.42	0.01	68	76	0	0
	MAXIMUM	11	6.3	5.2	8.0	0.42	0.01	68	76	0	0
	NUMBER	1	1	1	1	1	1	1	1	1	1
W8	MEAN	11	5.2	8.0	5.0	0.07	0.01	38	48	0	0
	MINIMUM	11	5.2	8.0	5.0	0.07	0.01	38	48	0	0
	MAXIMUM	11	5.2	8.0	5.0	0.07	0.01	38	48	0	0
	NUMBER	1	1	1	1	1	1	1	1	1	1
18	MEAN	11	5.5	9.4	5.9	0.03	0.02	52	65	0	0
	MINIMUM	11	5.5	9.4	5.9	0.03	0.02	52	65	0	0
	MAXIMUM	11	5.5	9.4	5.9	0.03	0.02	52	65	0	0
	NUMBER	1	1	1	1	1	1	1	1	1	1
19	MEAN	11	5.0	10.0	12.0	0.05	0.01	45	65	0	0
	MINIMUM	11	5.0	10.0	12.0	0.05	0.01	45	65	0	0
	MAXIMUM	11	5.0	10.0	12.0	0.05	0.01	45	65	0	0
	NUMBER	1	1	1	1	1	1	1	1	1	1

1978 BNL Environmental Monitoring Landfill Area Wells Water Quality and Purity

LOCATION	SAMPLE	TEMPERATURE	PH	DISSOLVED OXYGEN (PPM)	CHLORIDES (PPM)	NITRATE NITROGEN (PPM)	TOTAL PHOSPHOROUS (PPM)	DISSOLVED SOLIDS (PPM)	CONDUC-TIVITY MICROMHO/CM	COLIFORM FECAL (/100 ML)	COLIFORM TOTAL (/100 ML)
WF	MEAN	11	6.4	7.0	10.8	0.34	0.06	52	75	0	0
	MINIMUM	10	6.0	6.6	10.0	0.29	0.02	41	64	0	0
	MAXIMUM	12	6.7	7.4	11.5	0.39	0.09	63	85	0	0
	NUMBER	2	2	2	2	2	2	2	2	2	2
WR	MEAN	14	6.7	2.5	2.5	0.40	0.10	489	927	0	0
	MINIMUM	13	6.5	2.0	1.0	0.37	0.08	426	913	0	0
	MAXIMUM	14	6.8	3.0	4.0	0.42	0.11	552	941	0	0
	NUMBER	2	2	2	2	2	2	2	2	2	2
WS	MEAN	12	6.8	1.7	5.2	0.35	0.03	422	851	0	0
	MINIMUM	10	6.6	0.9	3.0	0.23	0.01	373	832	0	0
	MAXIMUM	14	7.0	3.0	7.1	0.47	0.08	492	862	0	0
	NUMBER	3	3	3	3	3	3	3	3	2	2
WT	MEAN	12	6.5	2.7	11.7	0.19	0.03	59	82	0	0
	MINIMUM	10	6.2	2.6	10.0	0.05	0.02	55	78	0	0
	MAXIMUM	13	6.7	2.8	13.4	0.32	0.04	63	86	0	0
	NUMBER	2	2	2	2	2	2	2	2	1	1
W9	MEAN	11	6.6	2.5	33.4	0.46	0.03	386	759	0	0
	MINIMUM	10	6.5	1.5	33.2	0.33	0.01	358	622	0	0
	MAXIMUM	12	6.7	4.0	33.5	0.68	0.08	442	940	0	0
	NUMBER	3	3	3	2	3	3	3	3	2	2
1K	MEAN	14	6.7	1.2	4.6	0.55	0.12	557	1087	0	0
	MINIMUM	12	6.5	0.6	1.0	0.50	0.01	540	1048	0	0
	MAXIMUM	15	7.0	2.0	9.7	0.61	0.23	588	1151	0	0
	NUMBER	3	3	3	3	3	3	3	3	1	1
2A	MEAN	10	5.9	9.2	6.8	0.10	0.03	45	50	0	0
	MINIMUM	10	5.6	9.0	4.1	0.03	0.01	33	46	0	0
	MAXIMUM	10	6.2	9.4	9.4	0.17	0.04	56	54	0	0
	NUMBER	2	2	2	2	2	2	2	2	2	2
2B	MEAN	10	5.5	9.7	7.5	0.09	0.01	52	67	0	0
	MINIMUM	10	5.5	9.0	3.6	0.03	0.01	43	66	0	0
	MAXIMUM	10	5.5	10.4	11.4	0.14	0.01	60	68	0	0
	NUMBER	1	1	2	2	2	2	2	2	1	1
2C	MEAN	12	6.7	2.1	4.0	0.57	0.02	569	1129	0	0
	MINIMUM	12	6.6	1.1	2.5	0.42	0.02	549	1040	0	0
	MAXIMUM	12	6.8	3.0	5.5	0.72	0.02	588	1218	0	0
	NUMBER	2	2	2	2	2	2	2	2	2	2
2D	MEAN	13	6.1	1.9	78.2	0.26	0.01	394	635	0	0
	MINIMUM	12	5.6	1.8	70.4	0.12	0.01	349	570	0	0
	MAXIMUM	13	6.5	2.0	86.0	0.40	0.01	438	700	0	0
	NUMBER	2	2	2	2	2	2	2	2	2	2

Reference Standards - Table 32

Table 26 (Continued)

1978 BNL Environmental Monitoring Former Dump Area Wells Water Quality and Purity

LOCATION	SAMPLE	TEMPERATURE	PH	DISSOLVED OXYGEN (PPM)	CHLORIDES (PPM)	NITRATE NITROGEN (PPM)	TOTAL PHOSPHOROUS (PPM)	DISSOLVED SOLIDS (PPM)	CONDUCTIVITY MICROMHO/CM	COLIFORM FECAL (/100 ML)	COLIFORM TOTAL (/100 ML)
WH	MEAN	12	5.3	8.0	4.1	0.44	0.01	64	78	0	0
	MINIMUM	12	5.3	8.0	4.1	0.44	0.01	64	78	0	0
	MAXIMUM	12	5.3	8.0	4.1	0.44	0.01	64	78	0	0
	NUMBER	1	1	1	1	1	1	1	1	1	1
WO	MEAN	10	6.5	11.6	2.0	0.05	0.01	48	53	0	0
	MINIMUM	10	6.5	11.6	2.0	0.05	0.01	48	53	0	0
	MAXIMUM	10	6.5	11.6	2.0	0.05	0.01	48	53	0	0
	NUMBER	1	1	1	1	1	1	1	1	1	1
WP	MEAN	10	5.8	8.2	3.4	0.21	0.01	44	58	0	0
	MINIMUM	10	5.8	8.2	3.4	0.21	0.01	44	58	0	0
	MAXIMUM	10	5.8	8.2	3.4	0.21	0.01	44	58	0	0
	NUMBER	1	1	1	1	1	1	1	1	1	1
WQ	MEAN	10	6.0	9.0	2.0	0.65	0.03	42	52	0	0
	MINIMUM	10	6.0	9.0	2.0	0.65	0.03	42	52	0	0
	MAXIMUM	10	6.0	9.0	2.0	0.65	0.03	42	52	0	0
	NUMBER	1	1	1	1	1	1	1	1	1	1
11	MEAN	12	5.2	9.2	8.8	11.72	0.01	122	133	0	0
	MINIMUM	12	5.2	9.2	8.8	11.72	0.01	122	133	0	0
	MAXIMUM	12	5.2	9.2	8.8	11.72	0.01	122	133	0	0
	NUMBER	1	1	1	1	1	1	1	1	1	1
1J	MEAN	12	6.1	10.6	3.9	0.05	0.01	32	37	0	0
	MINIMUM	12	6.1	10.6	3.9	0.05	0.01	32	37	0	0
	MAXIMUM	12	6.1	10.6	3.9	0.05	0.01	32	37	0	0
	NUMBER	1	1	1	1	1	1	1	1	1	1

1978 BNL Environmental Monitoring Building 650 Sump Area Wells Water Quality and Purity

LOCATION	SAMPLE	TEMPERATURE	PH	DISSOLVED OXYGEN (PPM)	CHLORIDES (PPM)	NITRATE NITROGEN (PPM)	TOTAL PHOSPHOROUS (PPM)	DISSOLVED SOLIDS (PPM)	CONDUCTIVITY MICROMHO/CM	COLIFORM FECAL (/100 ML)	COLIFORM TOTAL (/100 ML)
1A	MEAN	15	5.9	7.6	10.8	0.13	0.07	66	82		
	MINIMUM	15	5.9	7.6	10.8	0.13	0.07	66	82		
	MAXIMUM	15	5.9	7.6	10.8	0.13	0.07	66	82		
	NUMBER	1	1	1	1	1	1	1	1	0	0
1C	MEAN	14	6.4	7.6	10.8	0.42	0.22	85	91	0	0
	MINIMUM	14	6.4	7.6	10.8	0.42	0.22	85	91	0	0
	MAXIMUM	14	6.4	7.6	10.8	0.42	0.22	85	91	0	0
	NUMBER	1	1	1	1	1	1	1	1	1	1
1D	MEAN	12	6.7	7.8	15.7	0.21	0.08	74	99	0	0
	MINIMUM	12	6.7	7.8	15.7	0.21	0.08	74	99	0	0
	MAXIMUM	12	6.7	7.8	15.7	0.21	0.08	74	99	0	0
	NUMBER	1	1	1	1	1	1	1	1	1	1
1E	MEAN	15	5.8	8.4	4.9	0.79	0.09	52	66	0	0
	MINIMUM	15	5.8	8.4	4.9	0.79	0.09	52	66	0	0
	MAXIMUM	15	5.8	8.4	4.9	0.79	0.09	52	66	0	0
	NUMBER	1	1	1	1	1	1	1	1	1	1
1F	MEAN	16	6.3	9.0	15.7	0.44	0.01	78	99	0	
	MINIMUM	16	6.3	9.0	15.7	0.44	0.01	78	99	0	
	MAXIMUM	16	6.3	9.0	15.7	0.44	0.01	78	99	0	
	NUMBER	1	1	1	1	1	1	1	1	1	0
1H	MEAN	16	5.5	5.0	6.4	1.29	0.01	82	114		
	MINIMUM	16	5.5	5.0	6.4	1.29	0.01	82	114		
	MAXIMUM	16	5.5	5.0	6.4	1.29	0.01	82	114		
	NUMBER	1	1	1	1	1	1	1	1	0	0

Reference Standards - Table 32

Table 27

1978 BNL Environmental Monitoring Cooling Water Wells
Water Quality and Purity

LOCATION	SAMPLE	TEMPERATURE	PH	DISSOLVED OXYGEN (PPM)	CHLORIDES (PPM)	NITRATE NITROGEN (PPM)	TOTAL PHOSPHOROUS (PPM)	DISSOLVED SOLIDS (PPM)	CONDUC-TIVITY MICROMHO/CM	COLIFORM FECAL (/100 ML)	COLIFORM TOTAL (/100 ML)
FH	MEAN	11	6.6	7.2	11.5	0.05	0.03	64	85	0	0
	MINIMUM	11	6.6	7.2	11.5	0.05	0.03	64	85	0	0
	MAXIMUM	11	6.6	7.2	11.5	0.05	0.03	64	85	0	0
	NUMBER	1	1	1	1	1	1	1	1	1	1
FI	MEAN	10	6.3	7.7	12.7	0.03	1.01	65	82	0	0
	MINIMUM	10	6.1	6.8	12.3	0.03	0.01	60	75	0	0
	MAXIMUM	10	6.5	8.6	13.0	0.03	2.00	70	89	0	0
	NUMBER	2	2	2	2	2	2	2	2	2	2
FJ	MEAN	10	6.1	4.3	15.9	0.45	1.07	102	88	0	3
	MINIMUM	10	5.8	3.8	13.8	0.21	0.04	78	86	0	0
	MAXIMUM	10	6.3	4.8	18.0	0.69	2.10	126	89	0	6
	NUMBER	2	2	2	2	2	2	2	2	2	2
FK	MEAN	12	6.6	5.4	18.8	1.25	0.03	109	153	0	0
	MINIMUM	10	6.5	5.4	15.5	1.22	0.01	108	150	0	0
	MAXIMUM	13	6.7	5.4	22.0	1.27	0.05	109	156	0	0
	NUMBER	2	2	2	2	2	2	2	2	2	2
FL	MEAN	13	6.0	7.9	29.1	1.50	0.04	104	165	0	0
	MINIMUM	12	5.7	6.6	26.5	1.34	0.02	71	162	0	0
	MAXIMUM	13	6.4	9.2	30.8	1.58	0.05	121	166	0	0
	NUMBER	3	3	3	3	3	3	3	3	3	3

1978 BNL Environmental Monitoring Tap Water
Water Quality and Purity

LOCATION	SAMPLE	TEMPERATURE	PH	DISSOLVED OXYGEN (PPM)	CHLORIDES (PPM)	NITRATE NITROGEN (PPM)	TOTAL PHOSPHOROUS (PPM)	DISSOLVED SOLIDS (PPM)	CONDUC-TIVITY MICROMHO/CM	COLIFORM FECAL (/100 ML)	COLIFORM TOTAL (/100 ML)
FN	MEAN				18.6	0.51	0.05	80			
	MINIMUM				10.4	0.05	0.01	45			
	MAXIMUM				23.5	0.91	0.34	100			
	NUMBER	0	0	0	51	51	50	12	0	0	0

Reference Standards - Table 32
Locations indicated on Fig. 9 and identified as:

Potable		Cooling	
FA:	1	FH:	101
FB:	2	FI:	102
FC:	3	FJ:	103
FD:	4	FK:	104
FE:	5	FL:	105
FF:	6		
FG:	7		

Table 27 (Continued)

1978 BNL Environmental Monitoring Potable Supply Wells
Water Quality and Purity

LOCATION	SAMPLE	TEMPERATURE	PH	DISSOLVED OXYGEN (PPM)	CHLORIDES (PPM)	NITRATE NITROGEN (PPM)	TOTAL PHOSPHOROUS (PPM)	DISSOLVED SOLIDS (PPM)	CONDUC-TIVITY MICROMHO/CM	COLIFORM FECAL (/100 ML)	COLIFORM TOTAL (/100 ML)
FA	MEAN	12	6.0	9.2	17.7	0.77	0.02	81	114	0	0
	MINIMUM	12	5.7	8.8	17.4	0.66	0.01	74	110	0	0
	MAXIMUM	13	6.4	10.0	18.5	0.91	0.05	95	116	0	0
	NUMBER	4	4	3	4	4	4	4	4	2	2
FB	MEAN	13	6.2	7.1	18.3	0.74	0.01	78	132	0	0
	MINIMUM	12	6.0	6.6	15.0	0.69	0.01	42	122	0	0
	MAXIMUM	14	6.4	7.6	23.0	0.80	0.02	100	142	0	0
	NUMBER	3	3	3	3	3	3	3	3	3	3
FC	MEAN	16	6.4	7.7	19.8	0.68	0.09	75	115	0	0
	MINIMUM	16	6.2	7.2	19.5	0.65	0.08	69	112	0	0
	MAXIMUM	16	6.6	8.2	20.0	0.71	0.09	80	118	0	0
	NUMBER	2	2	2	2	2	2	2	2	2	2
FD	MEAN	12	6.0	7.5	11.5	0.32	0.04	61	78	0	0
	MINIMUM	11	5.8	5.4	10.3	0.10	0.02	52	73	0	0
	MAXIMUM	12	6.2	9.4	12.8	0.46	0.05	67	81	0	0
	NUMBER	3	3	3	3	3	3	3	3	2	2
FE	MEAN	11	6.2	10.4	4.4	1.27	0.01	42	82	0	0
	MINIMUM	9	5.6	9.4	1.0	0.03	0.01	41	43	0	0
	MAXIMUM	12	6.7	11.8	6.2	3.30	0.02	44	148	0	0
	NUMBER	3	3	3	3	3	3	3	3	3	3
FF	MEAN	12	6.2	8.3	16.0	0.68	0.05	81	125	0	0
	MINIMUM	11	6.1	7.4	9.5	0.50	0.02	74	110	0	0
	MAXIMUM	12	6.4	10.0	22.0	0.85	0.10	87	142	0	0
	NUMBER	3	3	3	3	3	3	3	3	2	2
FG	MEAN	11	6.2	8.0	7.9	0.11	0.02	54	70	0	0
	MINIMUM	10	6.0	7.6	2.5	0.05	0.01	50	66	0	0
	MAXIMUM	12	6.6	8.6	11.2	0.22	0.03	57	74	0	0
	NUMBER	3	3	3	3	3	3	3	3	2	2

Reference Standards - Table 32

Locations indicated on Fig. 9 and identified as:

Potable	Cooling	Tap Water
FA: 1	FH: 101	FN: Bldg. #535
FB: 2	FI: 102	
FC: 3	FJ: 103	
FD: 4	FK: 104	
FE: 5	FL: 105	
FF: 6		
FG: 7		

Table 28

1978 BNL Environmental Monitoring Sand Filter Beds and Peconic River Area Wells Water Quality and Purity-Metals

		METALS (IN PPM)						
		AG	CD	CR	CU	FE	PB	ZN
XA	MEAN	.001	.0008	.015	.005	.091	.005	.254
	MINIMUM	.001	.0005	.003	.005	.085	.005	.241
	MAXIMUM	.001	.0010	.026	.006	.097	.005	.267
	EXCEPTION	2	1	1	0	0	2	0
	NUMBER	2	2	2	2	2	2	2
XG	MEAN	.001	.0005	.013	.003	5.960	.096	.069
	MINIMUM	.001	.0004	.003	.003	3.550	.003	.069
	MAXIMUM	.001	.0005	.034	.004	7.890	.183	.069
	EXCEPTION	3	3	2	0	0	1	0
	NUMBER	3	3	3	3	3	3	1
XI	MEAN	.001	.0005	.003	.010	.086	.009	.591
	MINIMUM	.001	.0005	.003	.010	.086	.009	.591
	MAXIMUM	.001	.0005	.003	.010	.086	.009	.591
	EXCEPTION	1	1	1	0	0	0	0
	NUMBER	1	1	1	1	1	1	1
XK	MEAN	.001	.0005	.004	.005	1.777	.004	1.026
	MINIMUM	.001	.0004	.003	.004	1.550	.003	.726
	MAXIMUM	.001	.0005	.004	.007	1.890	.005	1.610
	EXCEPTION	3	3	1	0	0	3	0
	NUMBER	3	3	3	3	3	3	3
XL	MEAN	.001	.0005	.004	.004	1.610	.005	.668
	MINIMUM	.001	.0005	.003	.003	1.250	.005	.467
	MAXIMUM	.001	.0005	.005	.004	1.970	.005	.869
	EXCEPTION	2	2	1	0	0	2	0
	NUMBER	2	2	2	2	2	2	2
XM	MEAN	.001	.0005	.011	.016	1.159	.005	.683
	MINIMUM	.001	.0005	.003	.016	.927	.005	.517
	MAXIMUM	.001	.0005	.018	.016	1.390	.005	.849
	EXCEPTION	0	2	1	0	0	2	0
	NUMBER	2	2	2	1	2	2	2
XQ	MEAN	.001	.0005	.007	.046	14.600	.005	.443
	MINIMUM	.001	.0005	.003	.002	14.600	.005	.284
	MAXIMUM	.001	.0005	.011	.090	14.600	.005	.601
	EXCEPTION	1	2	1	0	0	2	0
	NUMBER	2	2	2	2	1	2	2
XS	MEAN	.001	.0005	.003	.017	3.610	.005	.160
	MINIMUM	.001	.0005	.003	.010	2.380	.005	.135
	MAXIMUM	.001	.0005	.003	.024	4.840	.005	.186
	EXCEPTION	2	2	2	0	0	2	0
	NUMBER	2	2	2	2	2	2	2
XX	MEAN	.001	.0005	.003	.002	7.860	.005	.159
	MINIMUM	.001	.0005	.003	.002	7.770	.005	.155
	MAXIMUM	.001	.0005	.003	.003	7.950	.005	.162
	EXCEPTION	2	2	2	0	0	2	0
	NUMBER	2	2	2	2	2	2	2

Reference Standards - Table 32

Table 28 (Continued)

1978 BNL Environmental Monitoring Miscellaneous On Site Wells
Water Quality and Purity-Metals

		METALS (IN PPM)						
		AG	CD	CR	CU	FE	PB	ZN
SA	MEAN	.001	.0016	.008	.005	.274	.013	1.160
	MINIMUM	.001	.0016	.008	.005	.274	.013	1.160
	MAXIMUM	.001	.0016	.008	.005	.274	.013	1.160
	EXCEPTION	1	0	0	0	0	0	0
	NUMBER	1	1	1	1	1	1	1
SB	MEAN	.001	.0004	.003	.001	.241	.001	.600
	MINIMUM	.001	.0004	.003	.001	.241	.001	.600
	MAXIMUM	.001	.0004	.003	.001	.241	.001	.600
	EXCEPTION	1	1	0	1	0	1	0
	NUMBER	1	1	1	1	1	1	1
SC	MEAN	.001	.0006	.003	.006	.108	.007	.870
	MINIMUM	.001	.0006	.003	.006	.108	.007	.870
	MAXIMUM	.001	.0006	.003	.006	.108	.007	.870
	EXCEPTION	1	0	1	0	0	0	0
	NUMBER	1	1	1	1	1	1	1
SD	MEAN	.001	.0009	.023	.003	.529	.015	.505
	MINIMUM	.001	.0009	.023	.003	.529	.015	.505
	MAXIMUM	.001	.0009	.023	.003	.529	.015	.505
	EXCEPTION	1	0	0	0	0	0	0
	NUMBER	1	1	1	1	1	1	1
SE	MEAN	.001	.0006	.003	.006	3.143	.004	.176
	MINIMUM	.001	.0004	.003	.004	.520	.003	.095
	MAXIMUM	.001	.0010	.003	.008	6.510	.005	.290
	EXCEPTION	3	2	2	0	0	3	0
	NUMBER	3	3	3	3	3	3	3
SG	MEAN	.001	.0004	.007	.002	.679	.001	.100
	MINIMUM	.001	.0004	.007	.002	.679	.001	.100
	MAXIMUM	.001	.0004	.007	.002	.679	.001	.100
	EXCEPTION	0	1	0	0	0	1	0
	NUMBER	1	1	1	1	1	1	1
SI	MEAN	.001	.0008	.016	.006	2.810	.001	.020
	MINIMUM	.001	.0008	.016	.006	2.810	.001	.020
	MAXIMUM	.001	.0008	.016	.006	2.810	.001	.020
	EXCEPTION	1	0	0	0	0	1	0
	NUMBER	1	1	1	1	1	1	1
16	MEAN	.001	.0004	.004	.006	.048	.063	.018
	MINIMUM	.001	.0004	.004	.006	.048	.063	.018
	MAXIMUM	.001	.0004	.004	.006	.048	.063	.018
	EXCEPTION	1	1	0	0	0	0	0
	NUMBER	1	1	1	1	1	1	1
17	MEAN	.001	.0005	.003	.004	.021	.027	.017
	MINIMUM	.001	.0005	.003	.004	.021	.027	.017
	MAXIMUM	.001	.0005	.003	.004	.021	.027	.017
	EXCEPTION	1	1	1	0	0	0	0
	NUMBER	1	1	1	1	1	1	1
2E	MEAN	.001	.0004	.001	.005	.026	.007	.008
	MINIMUM	.001	.0004	.001	.005	.026	.007	.008
	MAXIMUM	.001	.0004	.001	.005	.026	.007	.008
	EXCEPTION	1	1	1	0	0	0	0
	NUMBER	1	1	1	1	1	1	1
2F	MEAN	.001	.0004	.003	.023	1.390	.003	.024
	MINIMUM	.001	.0004	.003	.023	1.390	.003	.024
	MAXIMUM	.001	.0004	.003	.023	1.390	.003	.024
	EXCEPTION	1	1	0	0	0	1	0
	NUMBER	1	1	1	1	1	1	1
2G	MEAN	.001	.0005	.009	.008	.085	.014	.011
	MINIMUM	.001	.0005	.009	.008	.085	.014	.011
	MAXIMUM	.001	.0005	.009	.008	.085	.014	.011
	EXCEPTION	0	0	0	0	0	0	0
	NUMBER	1	1	1	1	1	1	1

Reference Standards - Table 32

Table 28 (Continued)

1978 BNL Environmental Monitoring Landfill Area Wells
Water Quality and Purity-Metals

		METALS (IN PPM)						
		AG	CD	CR	CU	FE	PB	ZN
WF	MEAN	.001	.0005	.001	.004	.341	.004	.490
	MINIMUM	.001	.0004	.001	.004	.114	.003	.421
	MAXIMUM	.001	.0005	.001	.004	.567	.004	.559
	EXCEPTION	1	1	1	0	0	2	0
	NUMBER	1	2	1	2	2	2	2
WR	MEAN	.001	.0005	.009	.003	93.600	.005	.119
	MINIMUM	.001	.0005	.009	.003	93.600	.005	.119
	MAXIMUM	.001	.0005	.009	.003	93.600	.005	.119
	EXCEPTION	1	1	0	0	0	1	0
	NUMBER	1	1	1	1	1	1	1
WS	MEAN	.001	.0005	.006	.003	131.500	.005	.199
	MINIMUM	.001	.0005	.006	.003	131.500	.005	.199
	MAXIMUM	.001	.0005	.006	.003	131.500	.005	.199
	EXCEPTION	1	1	0	0	0	1	0
	NUMBER	1	1	1	1	1	1	1
WT	MEAN	.001	.0004	.023	.005	1.330	.004	1.305
	MINIMUM	.001	.0004	.023	.004	1.310	.003	1.030
	MAXIMUM	.001	.0004	.023	.006	1.350	.004	1.580
	EXCEPTION	1	1	0	0	0	2	0
	NUMBER	1	2	1	2	2	2	2
W9	MEAN	.001	.0005	.003		115.400	.005	.246
	MINIMUM	.001	.0005	.003		115.400	.005	.246
	MAXIMUM	.001	.0005	.003		115.400	.005	.246
	EXCEPTION	1	1	1	0	0	1	0
	NUMBER	1	1	1	0	1	1	1
1K	MEAN	.001	.0005	.006	.003	117.300	.005	.183
	MINIMUM	.001	.0005	.006	.003	117.300	.005	.183
	MAXIMUM	.001	.0005	.006	.003	117.300	.005	.183
	EXCEPTION	1	1	0	0	0	1	0
	NUMBER	1	1	1	1	1	1	1
2A	MEAN	.001	.0006	.013	.006	.085	.026	.465
	MINIMUM	.001	.0003	.013	.004	.030	.025	.407
	MAXIMUM	.001	.0009	.013	.007	.139	.026	.524
	EXCEPTION	1	0	0	0	0	0	0
	NUMBER	1	2	1	2	2	2	2
2B	MEAN	.001	.0004	.024	.030	.019	.008	.008
	MINIMUM	.001	.0003	.024	.006	.017	.004	.006
	MAXIMUM	.001	.0004	.024	.053	.020	.012	.010
	EXCEPTION	1	1	0	0	0	1	0
	NUMBER	1	2	1	2	2	2	2
2C	MEAN	.003	.0004	.023	.009	30.000	.008	.042
	MINIMUM	.003	.0003	.023	.009	25.900	.004	.037
	MAXIMUM	.003	.0004	.023	.009	34.100	.011	.046
	EXCEPTION	0	1	0	0	0	1	0
	NUMBER	1	2	1	2	2	2	2
2D	MEAN	.003	.0004	.013	.015	41.950	.004	.009
	MINIMUM	.003	.0003	.013	.010	28.400	.003	.006
	MAXIMUM	.003	.0004	.013	.020	55.500	.004	.012
	EXCEPTION	0	2	0	0	0	2	0
	NUMBER	1	2	1	2	2	2	2

Reference Standards - Table 32

Table 28 (Continued)

1978 BNL Environmental Monitoring Former Dump Area Wells
Water Quality and Purity-Metals

		METALS (IN PPM)						
		AG	CD	CR	CU	FE	PB	ZN
WH	MEAN	.002	.0011		.004	.319	.004	.393
	MINIMUM	.002	.0011		.004	.319	.004	.393
	MAXIMUM	.002	.0011		.004	.319	.004	.393
	EXCEPTION	1	0	0	0	0	0	0
	NUMBER	1	1	0	1	1	1	1
WO	MEAN	.002	.0010		.004	1.250	.058	.015
	MINIMUM	.002	.0010		.004	1.250	.058	.015
	MAXIMUM	.002	.0010		.004	1.250	.058	.015
	EXCEPTION	1	0	0	0	0	0	0
	NUMBER	1	1	0	1	1	1	1
WP	MEAN	.002	.0014		.006	2.020	.004	.014
	MINIMUM	.002	.0014		.006	2.020	.004	.014
	MAXIMUM	.002	.0014		.006	2.020	.004	.014
	EXCEPTION	1	0	0	0	0	1	0
	NUMBER	1	1	0	1	1	1	1
WQ	MEAN	.005	.0008		.007	.726	.004	.006
	MINIMUM	.005	.0008		.007	.726	.004	.006
	MAXIMUM	.005	.0008		.007	.726	.004	.006
	EXCEPTION	1	0	0	0	0	1	0
	NUMBER	1	1	0	1	1	1	1
II	MEAN	.005	.0256		.023	.383	.004	.742
	MINIMUM	.005	.0256		.023	.383	.004	.742
	MAXIMUM	.005	.0256		.023	.383	.004	.742
	EXCEPTION	1	0	0	0	0	1	0
	NUMBER	1	1	0	1	1	1	1
IJ	MEAN	.009	.0004		.007	.927	.004	.004
	MINIMUM	.009	.0004		.007	.927	.004	.004
	MAXIMUM	.009	.0004		.007	.927	.004	.004
	EXCEPTION	1	0	0	0	0	1	0
	NUMBER	1	1	0	1	1	1	1

1978 BNL Environmental Monitoring Solid Waste Management Area Wells
Water Quality and Purity-Metals

		METALS (IN PPM)						
		AG	CD	CR	CU	FE	PB	ZN
WB	MEAN	.001	.0004	.001	.006	.081	.005	.600
	MINIMUM	.001	.0004	.001	.006	.081	.005	.600
	MAXIMUM	.001	.0004	.001	.006	.081	.005	.600
	EXCEPTION	0	1	1	0	0	0	0
	NUMBER	1	1	1	1	1	1	1
WC	MEAN	.001	.0004	.001	.004	.217	.004	.208
	MINIMUM	.001	.0004	.001	.004	.217	.004	.208
	MAXIMUM	.001	.0004	.001	.004	.217	.004	.208
	EXCEPTION	1	1	1	0	0	0	0
	NUMBER	1	1	1	1	1	1	1
WD	MEAN	.001	.0004	.008	.005	.045	.009	.594
	MINIMUM	.001	.0004	.003	.003	.023	.003	.427
	MAXIMUM	.001	.0005	.019	.007	.064	.014	.816
	EXCEPTION	3	3	1	0	0	0	0
	NUMBER	3	3	3	3	3	3	3
WE	MEAN	.001	.0004	.001	.004	.035	.008	.405
	MINIMUM	.001	.0004	.001	.004	.035	.008	.405
	MAXIMUM	.001	.0004	.001	.004	.035	.008	.405
	EXCEPTION	1	1	1	0	0	0	0
	NUMBER	1	1	1	1	1	1	1
WJ	MEAN	.001	.0004	.001	.006	.990	.003	.376
	MINIMUM	.001	.0004	.001	.006	.990	.003	.376
	MAXIMUM	.001	.0004	.001	.006	.990	.003	.376
	EXCEPTION	1	1	1	0	0	1	0
	NUMBER	1	1	1	1	1	1	1
WK	MEAN	.001	.0008	.005	.004	.094	.004	.627
	MINIMUM	.001	.0004	.003	.003	.049	.003	.407
	MAXIMUM	.001	.0014	.007	.007	.122	.005	.921
	EXCEPTION	3	3	1	0	0	2	0
	NUMBER	3	3	2	3	3	3	3
WL	MEAN	.001	.0004	.002	.004	.088	.004	.481
	MINIMUM	.001	.0004	.001	.003	.042	.003	.389
	MAXIMUM	.001	.0005	.003	.004	.120	.005	.580
	EXCEPTION	3	3	3	0	0	3	0
	NUMBER	3	3	3	3	3	3	3

Reference Standards - Table 32

Table 28 (Continued)

1978 BNL Environmental Monitoring Solid Waste Management Area Wells Water Quality and Purity-Metals

		METALS (IN PPM)						
		AG	CD	CR	CU	FE	PB	ZN
WM	MEAN	.001	.0004	.001	.001	.138	.001	.141
	MINIMUM	.001	.0004	.001	.001	.138	.001	.141
	MAXIMUM	.001	.0004	.001	.001	.138	.001	.141
	EXCEPTION	1	1	1	0	0	0	0
	NUMBER	1	1	1	1	1	1	1
WN	MEAN	.001	.0004	.001	.003	.568	.112	.166
	MINIMUM	.001	.0004	.001	.003	.568	.112	.166
	MAXIMUM	.001	.0004	.001	.003	.568	.112	.166
	EXCEPTION	1	0	1	0	0	0	0
	NUMBER	1	1	1	1	1	1	1
WV	MEAN	.001	.0022	.001	.009	.060	.045	1.340
	MINIMUM	.001	.0004	.001	.006	.057	.011	1.220
	MAXIMUM	.001	.0040	.001	.012	.063	.078	1.460
	EXCEPTION	2	0	2	0	0	0	0
	NUMBER	2	2	2	2	2	2	2
WX	MEAN	.001	.0004	.001	.006	.059	.026	1.310
	MINIMUM	.001	.0004	.001	.006	.059	.026	1.310
	MAXIMUM	.001	.0004	.001	.006	.059	.026	1.310
	EXCEPTION	1	1	1	0	0	0	0
	NUMBER	1	1	1	1	1	1	1
WZ	MEAN	.001	.0004	.008	.008	7.300	.115	2.430
	MINIMUM	.001	.0004	.008	.008	7.300	.115	2.430
	MAXIMUM	.001	.0004	.008	.008	7.300	.115	2.430
	EXCEPTION	1	1	0	0	0	0	0
	NUMBER	1	1	1	1	1	1	1
W1	MEAN	.001	.0020	.007	.003	.023	.011	.430
	MINIMUM	.001	.0004	.003	.003	.012	.003	.353
	MAXIMUM	.001	.0050	.012	.004	.036	.024	.469
	EXCEPTION	3	2	1	0	0	1	0
	NUMBER	3	3	3	3	3	3	3
W3	MEAN	.001	.0004	.001	.004	.031	.005	.529
	MINIMUM	.001	.0004	.001	.004	.031	.005	.629
	MAXIMUM	.001	.0004	.001	.004	.031	.005	.629
	EXCEPTION	1	0	1	0	0	0	0
	NUMBER	1	1	1	1	1	1	1
W4	MEAN	.001	.0004	.001	.004	.023	.008	.507
	MINIMUM	.001	.0004	.001	.004	.023	.008	.507
	MAXIMUM	.001	.0004	.001	.004	.023	.008	.507
	EXCEPTION	1	1	1	0	0	0	0
	NUMBER	1	1	1	1	1	1	1
W5	MEAN		.0004	.001	.004	.045	.008	.797
	MINIMUM		.0004	.001	.004	.045	.008	.797
	MAXIMUM		.0004	.001	.004	.045	.008	.797
	EXCEPTION	0	0	1	0	0	0	0
	NUMBER	0	1	1	1	1	1	1
W6	MEAN	.001	.0004	.001	.004	.206	.044	.774
	MINIMUM	.001	.0004	.001	.004	.206	.044	.774
	MAXIMUM	.001	.0004	.001	.004	.206	.044	.774
	EXCEPTION	0	1	1	0	0	0	0
	NUMBER	1	1	1	1	1	1	1
W7	MEAN	.001	.0004	.007	.002	.023	.047	.687
	MINIMUM	.001	.0004	.007	.002	.023	.047	.687
	MAXIMUM	.001	.0004	.007	.002	.023	.047	.687
	EXCEPTION	1	0	0	0	0	0	0
	NUMBER	1	1	1	1	1	1	1
W8	MEAN	.001	.0004	.001	.003	.058	.026	1.150

1978 BNL Environmental Monitoring Building 650 Sump Area Wells Water Quality and Purity-Metals

		METALS (IN PPM)						
		AG	CD	CR	CU	FE	PB	ZN
1A	MEAN	.001	.0006	.010	.004	.635	.004	.713
	MINIMUM	.001	.0006	.010	.004	.635	.004	.713
	MAXIMUM	.001	.0006	.010	.004	.635	.004	.713
	EXCEPTION	1	0	0	0	0	0	0
	NUMBER	1	1	1	1	1	1	1
1E	MEAN	.001	.0050	.011	.015	.313	.014	2.170
	MINIMUM	.001	.0050	.011	.015	.313	.014	2.170
	MAXIMUM	.001	.0050	.011	.015	.313	.014	2.170
	EXCEPTION	1	0	0	0	0	0	0
	NUMBER	1	1	1	1	1	1	1
1F	MEAN	.001	.0004	.003	.005	2.850	.003	.153
	MINIMUM	.001	.0004	.003	.005	2.850	.003	.153
	MAXIMUM	.001	.0004	.003	.005	2.850	.003	.153
	EXCEPTION	1	0	0	0	0	1	0
	NUMBER	1	1	1	1	1	1	1
1H	MEAN	.001	.0009	.014	.015	.137	.076	1.630
	MINIMUM	.001	.0009	.014	.015	.137	.076	1.630
	MAXIMUM	.001	.0009	.014	.015	.137	.076	1.630
	EXCEPTION	1	0	0	0	0	0	0
	NUMBER	1	1	1	1	1	1	1

Reference Standards - Table 32

Table 29

1978 BNL Environmental Monitoring Potable Supply Wells
Water Quality and Purity-Metals

		METALS (IN PPM)						
		AG	CD	CR	CU	FE	PB	ZN
FA	MEAN	.001	.0004	.002	.008	.056	.004	.003
	MINIMUM	.001	.0002	.001	.002	.028	.001	.002
	MAXIMUM	.001	.0005	.003	.014	.085	.005	.005
	EXCEPTION	5	3	5	0	0	5	2
	NUMBER	5	5	5	5	5	5	5
FB	MEAN	.001	.0004	.003	.015	.444	.004	.010
	MINIMUM	.001	.0003	.002	.005	.017	.003	.004
	MAXIMUM	.001	.0006	.003	.024	1.290	.005	.017
	EXCEPTION	2	2	2	0	0	3	0
	NUMBER	2	3	3	3	3	3	3
FC	MEAN	.001	.0004	.014	.033	.135	.004	.011
	MINIMUM	.001	.0002	.003	.008	.042	.002	.003
	MAXIMUM	.001	.0005	.035	.059	.208	.005	.017
	EXCEPTION	3	3	2	0	0	2	0
	NUMBER	3	3	3	3	3	3	3
FD	MEAN	.001	.0005	.002	.021	2.600	.004	.013
	MINIMUM	.001	.0004	.001	.012	2.270	.001	.002
	MAXIMUM	.001	.0005	.003	.030	2.850	.005	.034
	EXCEPTION	3	3	3	0	0	3	2
	NUMBER	3	3	3	3	3	3	3
FE	MEAN	.001	.0004	.002	.007	.144	.004	.170
	MINIMUM	.001	.0003	.001	.007	.067	.003	.140
	MAXIMUM	.001	.0005	.003	.007	.291	.005	.209
	EXCEPTION	2	3	3	0	0	3	0
	NUMBER	2	3	3	3	3	3	3
FF	MEAN		.0004	.003		3.477	.003	.002
	MINIMUM		.0003	.003		3.320	.001	.002
	MAXIMUM		.0005	.003		3.700	.005	.003
	EXCEPTION	0	3	2	0	0	3	1
	NUMBER	0	3	3	0	3	3	3
FG	MEAN	.001	.0004	.003	.004	1.897	.005	.010
	MINIMUM	.001	.0003	.003	.002	1.710	.004	.008
	MAXIMUM	.001	.0005	.003	.005	2.000	.007	.011
	EXCEPTION	2	3	1	0	0	2	0
	NUMBER	2	3	2	3	3	3	3

1978 BNL Environmental Monitoring Cooling Water Wells
Water Quality and Purity-Metals

		METALS (IN PPM)						
		AG	CD	CR	CU	FE	PB	ZN
FH	MEAN	.001	.0004	.006	.044	1.270	.003	.003
	MINIMUM	.001	.0004	.006	.044	1.270	.003	.003
	MAXIMUM	.001	.0004	.006	.044	1.270	.003	.003
	EXCEPTION	1	1	0	0	0	1	0
	NUMBER	1	1	1	1	1	1	1
FI	MEAN	.001	.0005	.003	.006	3.105	.004	.011
	MINIMUM	.001	.0004	.002	.004	3.100	.003	.009
	MAXIMUM	.001	.0005	.003	.008	3.110	.005	.013
	EXCEPTION	2	2	1	0	0	2	0
	NUMBER	2	2	2	2	2	2	2
FJ	MEAN	.001	.0006	.005	.005	4.380	.004	.032
	MINIMUM	.001	.0005	.003	.004	4.100	.003	.031
	MAXIMUM	.001	.0006	.007	.006	4.660	.005	.033
	EXCEPTION	2	1	1	0	0	2	0
	NUMBER	2	2	2	2	2	2	2
FK	MEAN	.001	.0004	.003	.004	.488	.005	.027
	MINIMUM	.001	.0003	.003	.003	.435	.004	.026
	MAXIMUM	.001	.0005	.003	.004	.540	.007	.028
	EXCEPTION	1	2	1	0	0	1	0
	NUMBER	1	2	1	2	2	2	2
FL	MEAN	.001	.0005	.007	.081	1.908	.005	.012
	MINIMUM	.001	.0004	.003	.030	.502	.005	.010
	MAXIMUM	.001	.0005	.014	.127	4.560	.005	.014
	EXCEPTION	3	3	1	0	0	2	0
	NUMBER	3	3	3	3	3	2	2

Reference Standards - Table 32
Locations indicated on Fig. 9 and identified as:

Potable		Cooling	
FA:	1	FH:	101
FB:	2	FI:	102
FC:	3	FJ:	103
FD:	4	FK:	104
FE:	5	FL:	105
FF:	6		
FG:	7		

Laboratory's surveillance wells downstream in the direction of the ground water flow, has indicated significant decreases, such as 60% along the Peconic River, 25 to 30% in the waste management area and 50% in the 650 sump area. Investigations into the Laboratory-wide use of zinc-containing chemicals focused our attention on a compound used as a cleaning agent for cooling towers in the past. A recent analysis of this compound made by the Laboratory indicated a concentration of zinc to be about 3 mg/ml of the compound. It was gathered from discussions with Plant Engineering that the washings were discharged into the sewage system. It seems possible that this input may be retained in the sand filter beds and leached into the ground water system, thereby contributing to the increases noted. Also, the industrial hygiene group of Safety and Environmental Protection Division has instituted a program whereby purchases of chemical compounds that have the potential of polluting the river water are flagged and the user is notified of the proper disposal method. This program has helped Safety and Environmental Protection Division to identify and thereby advise the users on a score of such compounds during 1978.

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.

A depiction of the general direction and rate of ground water movement, originally published in the U.S. Geological Survey Study, is shown in Figure 12. The Upland Recharge Project [23] has determined a ground water velocity of 13.4 cm d^{-1} which is in good agreement with the U.S. Geological Survey Study estimate of 16.2 cm d^{-1} [6]. Thus, it appears 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.

3.4 Unusual Occurrences:

3.4.1 Oil Spills

During 1978, the Laboratory did not experience any oil spills. Followup on the two oil spills that occurred in 1977 has indicated that the actions taken by Plant Engineering (PE) to fertilize the region and tilling the soil has aided in the biodegradation of the oil. In addition, grass seeding has almost returned the surface to normal conditions. Wells adjoining the steam plant have given no indication that any oil or its compounds have broken through the retaining clay barrier. Monitoring will be continued on a regular basis in order to maintain a vigilance on the movement of oil, if any, in the ground water system.

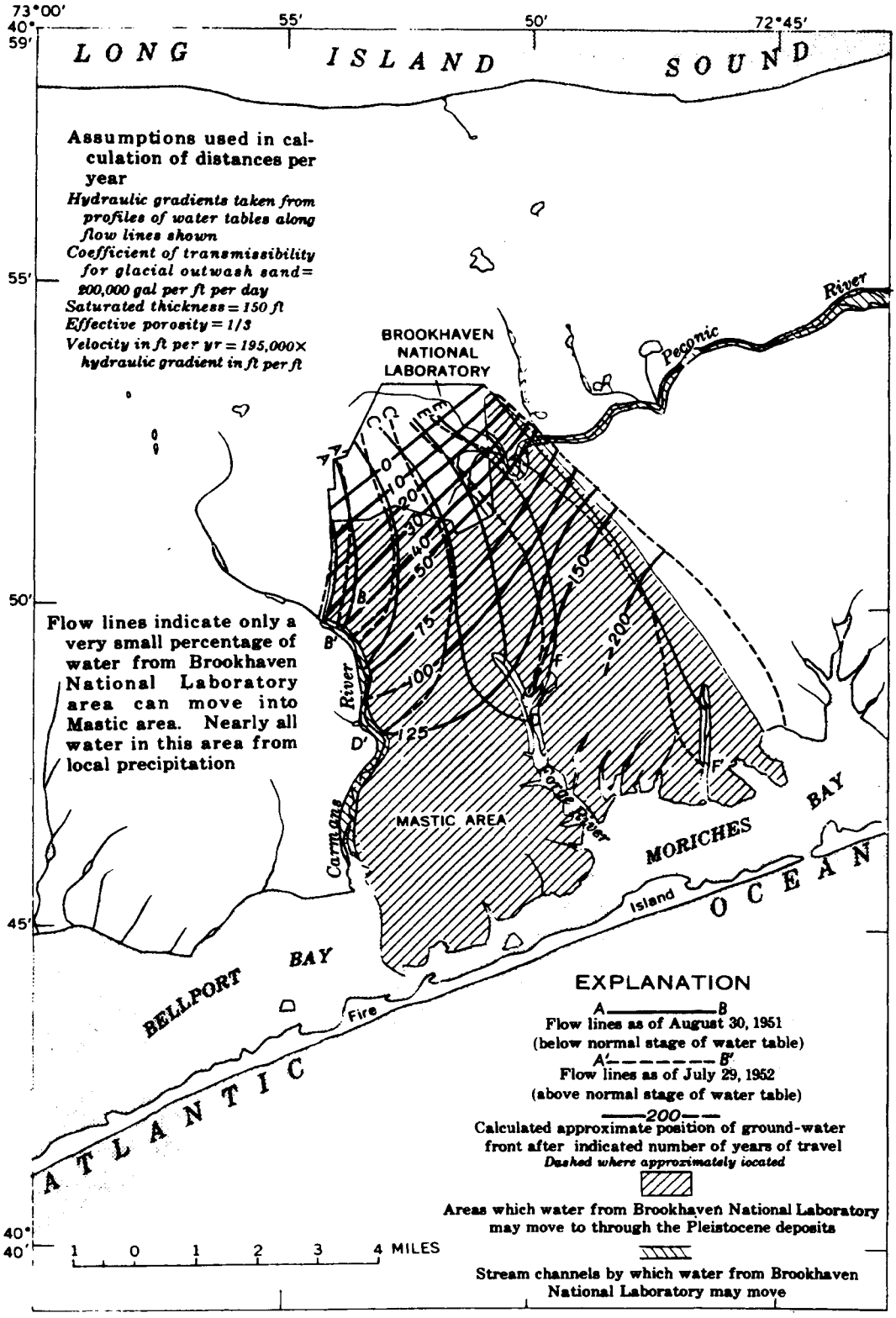

Figure 12. Direction and time of travel of ground water laterally in upper Pleistocene deposits from the Brookhaven National Laboratory area to points of discharge.

3.4.2 Chinese Nuclear Tests

Two atmospheric nuclear tests were detonated by the Chinese on March 14 and December 14, 1978 (#21 and #22 in their series). An intensive monitoring program was instituted after each event. As indicated in Section 3, slight increases in gross beta activity were noted in air samples and precipitation and a very slight increase over the MDL was detected for ^{140}Ba-La in precipitation. Fallout radionuclide concentrations were at or below MDL in milk and grass samples collected from dairy farms in the vicinity of the site in spite of the two nuclear tests. Unlike the previous years, 1976 in particular, the 1978 values may be considered as insignificant in terms of a health hazard.

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, result from the following four Laboratory sources:

1. Airborne radioactive effluents, primarily tritium,
2. Radioactive liquid effluents,
3. The ^{137}Cs source in the Biology Department Ecology Forest,
4. Skyshine from the Alternating Gradient Synchrotron (AGS).

These are discussed below, and the collective dose equivalent rate due to Laboratory operations during 1978 is calculated.

4.1 Annual Average Collective Dose Equivalent Rate Due to Airborne Effluents

As indicated in Table 4, a total of 1368 Ci (5.1×10^{13} Bq) of tritium was released from various Laboratory facilities during 1978, making it a significant source of dose equivalent to persons off-site. In using this figure to estimate dose equivalent, it was conservatively assumed that all the tritium released was in the form of tritiated water vapor at the site boundary.

Air activity concentrations of tritium vapor at the site boundary were so low that measurement was difficult. Data given in Table 8 indicate an average concentration of 35 pCi m^{-3} (1.3 Bq m^{-3}) at the site boundary (~2500 meters from the HFBR stack) in addition to the background value, which equaled about 1.8 pCi m^{-3} (6.7×10^{-2} Bq m^{-3}). Continuous exposure at the Radiation Concentration Guide (2×10^5 pCi m^{-3} or 7.4×10^3 Bq m^{-3}) would result in a per caput annual average dose equivalent rate of 500 mRem a^{-1} (5×10^{-3} Sv person^{-1} a^{-1}). Thus, the per caput annual average dose equivalent rate at this distance attributable to Laboratory air effluent tritium vapor was $(35 \times 500)/(2 \times 10^5)$ or 0.09 mRem a^{-1} (0.9×10^{-6} Sv person^{-1} a^{-1}) or 0.02% of the Radiation Protection Standard. Since the background per caput dose equivalent rate (Table 2) in this area was about 68 mRem a^{-1} (6.8×10^{-4} Sv person^{-1} a^{-1}), this tritium contribution amounts to an increase at the site boundary of about 0.1%, which is within the temporal and spatial variations of the background itself.

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

Routine analyses for air particulate radioactivity and for radiohalogens were made throughout 1978 on air samples collected at several locations. Several nuclides attributable to fallout from weapons testing were found but were all at or below MDL for the detection system used. Table 30 gives the doses to the general public due to tritium releases and also indicates that beyond the site boundary, 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

TABLE 30

1978 BNL Environmental Monitoring Collective Annual Average Dose Equivalent Rate Due to BNL Airborne Effluents in Comparison with Background

Distance from HFBR Stack (km)	X/Q[25]	Population[a]	HTO Per Caput Dose Equivalent Rate mRem Person^{-1}a^{-1}	HTO Collective Average Dose Equivalent Rate rem a^{-1}	Background Collective Average Dose Equivalent Rate rem a^{-1}
1.6- 3.2	2.4×10^{-7}	1,478	0.116	0.17	100
3.2- 4.8	1.0×10^{-7}	5,331	0.049	0.26	363
4.8- 6.4	6.0×10^{-8}	11,332	0.028	0.32	770
6.4- 8.0	3.9×10^{-8}	19,938	0.019	0.37	1,357
8.0-16.1	1.7×10^{-8}	226,000	0.008	1.87	15,382
16.1-24.2	8.0×10^{-9}	241,437	0.004	1.00	16,436
24.2-32.2	5.5×10^{-9}	155,010	0.002	0.40	10,552
32.2-48.4	3.8×10^{-9}	997,749	0.002	1.54	67,916
48.4-64.5	2.7×10^{-9}	1,381,219	0.001	2.14	94,020
64.5-80.6	2.1×10^{-9}	1,753,685	0.001	1.81	119,374
1.6-80.6	-	4,739,179	-	9.88	326,270

[a] Population data taken from DOE/EIS-0003, August 1978 [3]. See Figure 2 and Table 1 for population distribution.

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 sixteen tabulated directions. While their use produces 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 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 (0.116 mRem a^{-1}) by the appropriate ratios of X/Q. The collective average dose equivalent rate (total population dose rate) due to the Laboratory tritium effluent was 9.88 rem a^{-1}, and that due to natural background (68 mRem a^{-1}) being 326,270 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 observations, discussions with the New York State Department of Environmental Conservation, and the productivity of the Peconic River, an annual catch of 500 kg of fish is reasonable. If one considers 100 fishermen (who are being treated as maximum individuals) catching the above amount of fish and that their families consume all the fish caught and, furthermore, the breakdown of adults and children (based on an average family of 2 adults and 2 children) to be 350 adults and children above 12 years and 50 infants, then the annual consumption of fish by the adult group is 1.36 kg/yr and infants is 0.46 kg/yr as opposed to the USNRC Regulatory Guide [24] value of 21 kg/yr and 6.9 kg/yr, respectively. Using the above realistic value for consumption of fish, the other assumptions recommended in the NRC Regulatory Guide 1.109 [24] and the maximum concentration of ^{90}Sr and ^{137}Cs in fish (Table 21), the estimated maximum individual dose equivalent rate is tabulated below.

Average Maximum Individual Dose Equivalent Rate (mRem a^{-1})

	^{90}Sr		^{137}Cs	
	Infant	Adult	Infant	Adult
Total Body	0.07	0.09	0.02	0.12
Bone	0.43	0.52	0.29	0.13

The collective average dose equivalent rate (total dose) from this indirect pathway, for the above population, can be estimated to be 0.30 rem a^{-1} (0.86 mRem x 350 persons) for adults and 0.04 rem a^{-1} (0.81 mRem x 50 persons) for infants.

Although not directly relatable to the Laboratory liquid effluents during 1978, a ^{90}Sr concentration of 2.0 pCi l^{-1} (0.7 x 10^{-1} Bq l^{-1}) was found in an off-site surveillance well about 0.35 km east of the Laboratory site boundary along the Peconic River. This level corresponds to 25% of the EPA Drinking

Water Standard [13]. If we assume that during 1978 all the people (about 20 [3]) living in the vicinity of this well obtained their drinking water from shallow water supply wells containing ^{90}Sr in a concentration equal to that of the surveillance well then the collective average dose equivalent rate (total dose commitment) will not exceed 0.02 rem a^{-1} (since 8 pCi/1 corresponds to 4 mRem). Their collective average dose equivalent rate (total dose) from natural background (including internal radiation) would have been about 1.8 rem a^{-1} (person-rem) during 1978.

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

A 6020 Ci* ^{137}Cs source is located in the northeast part of the BNL site, 1010 meters from the north boundary. The dose rate at this boundary during 1978, as determined by the Laboratory Environmental Monitoring Group, was 1.9 mRem a^{-1} (.000019 Sv), or 0.5% of the Radiation Protection Standard.

Population doses beyond the site boundary due to this source have been computed using a population count by segments centered on the HFBR stack. Average dose rates for each population segment and for each distance from the source are given in Table 31.

Since the dose rate from this source decreases very rapidly with distance, only population segments located within 5 km from the source were considered. The off-site collective average dose equivalent (total dose) is 0.05 rem a^{-1} (person-rem a^{-1}), and appreciable contributions are found only in the NNE and NE sectors.

4.4 Doses Due to Alternating Gradient Synchrotron

The Alternating Gradient Synchrotron (AGS) is a 33 GeV proton synchrotron located 1180 meters from the nearest site boundary. Although the machine is heavily shielded, some neutrons do escape through it or 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, 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 AGS and Isabelle (when operational) and thus permit estimation of off-site doses. During 1978, the study has been experimental in nature and as such it was felt that the neutron skyshine data for 1978 would not permit a proper evaluation of the doses off-site resulting from AGS operations. As a result, it was decided to estimate the dose rate at the site boundary by comparing the total proton flux for 1977 to that for 1978 and use this ratio to derive the 1978 dose rates from the 1977 values (Table 31 - 1977 Report). As such, Table 31 gives the derived dose rate (mRem a^{-1}) and the collective average dose equivalent (average doses) rates for each population segment and for each distance from the source.

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*As of 1/1/78

TABLE 31

1978 BNL Environmental Monitoring Off-Site Collective Annual Average Dose Equivalent Rate Due to External Radiation Exposure Resulting from the Gamma Forest and AGS Operations

			Gamma Forest			AGS		
Sector	(km)	Population[a]	Distance (km)	Dose Rate (mR a^{-1})	Person-Rem	Distance (km)	Dose Rate (mR a^{-1})	Person-Rem
SSW	1.6-3.2	0	--	--	--	--	--	--
	3.2-4.8	244	>4.8	$<10^{-13}$	$<10^{-3}$	4.4	1.6×10^{-4}	3.9×10^{-5}
SW	1.6-3.2	0	--	--	--	--	--	--
	3.2-4.8	92	>4.8	$<10^{-13}$	$<10^{-14}$	4.3	2.0×10^{-4}	1.8×10^{-5}
WSW	1.6-3.2	0	--	--	--	--	--	--
	3.2-4.8	338	>4.8	$<10^{-13}$	$<10^{-14}$	4.0	3.7×10^{-4}	1.2×10^{-4}
W	1.6-3.2	265	4.4	1.6×10^{-12}	4.1×10^{-13}	2.5	1.2×10^{-2}	3.1×10^{-3}
	3.2-4.8	845	>4.8	$<10^{-13}$	$<10^{-13}$	3.9	5.2×10^{-4}	4.4×10^{-4}
WNW	1.6-3.2	265	4.2	1.2×10^{-11}	3.1×10^{-12}	2.1	2.8×10^{-2}	7.6×10^{-3}
	3.2-4.8	652	>4.8	$<10^{-13}$	$<10^{-13}$	3.6	7.8×10^{-4}	5.1×10^{-4}
NW	1.6-3.2	192	3.4	8.0×10^{-12}	1.5×10^{-12}	2.0	4.7×10^{-2}	9.1×10^{-3}
	3.2-4.8	240	>4.8	$<10^{-13}$	$<10^{-13}$	3.5	1.2×10^{-3}	2.8×10^{-4}
NNW	1.6-3.2	161	2.8	8.0×10^{-7}	1.3×10^{-7}	2.0	4.7×10^{-2}	7.6×10^{-3}
	3.2-4.8	72	>4.8	$<10^{-13}$	10^{-13}	3.5	1.2×10^{-3}	8.3×10^{-5}
N	1.6-3.2	193	2.1	1.6×10^{-9}	3.0×10^{-10}	2.3	1.8×10^{-2}	3.4×10^{-3}
	3.2-4.8	0	--	--	--	--	--	--
NNE	1.6-3.2	196	1.4	2.7×10^{-2}	5.3×10^{-3}	2.5	1.2×10^{-2}	2.3×10^{-3}
	3.2-4.8	380	2.4	1.6×10^{-5}	5.9×10^{-6}	3.6	7.8×10^{-4}	3.0×10^{-4}
NE	1.6-3.2	96	1.2	4.7×10^{-1}	4.5×10^{-2}	2.9	4.9×10^{-3}	4.7×10^{-4}
	3.2-4.8	190	2.0	3.1×10^{-4}	5.9×10^{-5}	3.5	7.8×10^{-4}	1.5×10^{-4}
RNE	1.6-3.2	0	--	--	--	--	--	--
	3.2-4.8	0	--	--	--	--	--	--
E	1.6-3.2	0	--	--	--	--	--	--
	3.2-4.8	319	2.8	8.0×10^{-7}	2.5×10^{-7}	4.0	3.6×10^{-4}	1.1×10^{-4}
ESE	1.6-3.2	0	--	--	--	--	--	--
	3.2-4.8	319	3.5	1.2×10^{-9}	3.7×10^{-10}	4.4	1.8×10^{-4}	5.7×10^{-5}
SE	1.6-3.2	0	--	--	--	--	--	--
	3.2-4.8	55	2.9	9.9×10^{-11}	5.4×10^{-12}	3.1	9.8×10^{-5}	5.4×10^{-6}
SSE	1.6-3.2	61	4.0	8.0×10^{-11}	4.9×10^{-12}	3.4	1.4×10^{-3}	8.7×10^{-5}
	3.2-4.8	700	>4.8	$<10^{-13}$	$<10^{-13}$	4.5	1.2×10^{-4}	8.7×10^{-5}
S	1.6-3.2	49	4.4	1.6×10^{-12}	7.6×10^{-14}	3.3	1.8×10^{-3}	8.7×10^{-5}
	3.2-4.8	885	>4.8	$<10^{-13}$	$<10^{-13}$	4.5	1.2×10^{-4}	1.1×10^{-4}
Total					0.05			0.036

[a] Population data taken from DOE/EIS-0003, August 1978 [3].

mRem = 0.00001 Sv.

Since the dose 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 (total dose) was 0.04 rem a^{-1} (person-rem a^{-1}) and applicable contributions were found only in the NW and NNW sectors.

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 1978 is the sum of the values due to the four components discussed above, as shown below:

Pathway		rem a^{-1} (person-rem a^{-1})
Airborne		
Tritium		9.88
Liquid Effluents		
Consuming fish:	Adults	0.30
	Infants	0.40
Well water		0.02
Gamma Forest Source		0.05
AGS Skyshine		0.04
Total		10.69

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 326,270 rem a^{-1}, to which about 100,530 rem a^{-1} (person-rem a^{-1}), should be added for internal radioactivity from natural sources.

TABLE 32

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

Contaminant Radionuclide		DOE 0524[11] Air	DOE 0524[11] Water	EPA-Drinking Water[13] and NYS Drinking Water Standard[14] [a]	NYS Standard[10] Air	NYS Standard[10] 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}	1×10^{-7}	1×10^{-10}	1×10^{-7}	1×10^{-15}	1×10^{-9}
^{7}Be μCi/ml	S	2×10^{-7}	2×10^{-3}	2×10^{-3}	4×10^{-8}	2×10^{-3}	1×10^{-12}	5×10^{-10}
	I	4×10^{-8}	2×10^{-3}	2×10^{-3}				
^{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^{-11}
^{60}Co μCi/ml	S	1×10^{-8}	5×10^{-5}	5×10^{-5}	3×10^{-10}	3×10^{-5}	1×10^{-14}	5×10^{-10}
	I	3×10^{-10}	3×10^{-5}	3×10^{-5}				
^{131}I μCi/ml	S	1×10^{-10}	3×10^{-7}	3×10^{-7}	1×10^{-8}	6×10^{-5}	1×10^{-14}	2×10^{-10}
	I	1×10^{-8}	6×10^{-5}	6×10^{-5}				
^{137}Cs μCi/ml	S	2×10^{-9}	2×10^{-5}	2×10^{-5}	2×10^{-9}	2×10^{-5}	1×10^{-14}	3×10^{-10}
	I	5×10^{-10}	4×10^{-5}	4×10^{-5}				
^{54}Mn μCi/ml	S	1×10^{-8}	1×10^{-4}	1×10^{-4}	1×10^{-8}	1×10^{-6}	1×10^{-14}	3×10^{-10}
	I	1×10^{-9}	1×10^{-4}	1×10^{-4}				
^{90}Sr μCi/ml	S	3×10^{-11}	3×10^{-7}	8×10^{-9}	3×10^{-11}	3×10^{-7}	1×10^{-15}	9×10^{-14}
	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		.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 [13].

[b] See Appendix B.

[c] As tritiated vapor

S: Soluble
I: Insoluble

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 at least within 5% of stated values. In some cases, certified standards were also obtained from Amersham/Searle. Daily checks of performances are made using the standards as well as backgrounds. In addition, some samples are counted both in NaI system and Ge(Li) system. Ge(Li) system were calibrated using a new multi-gamma NBS Standard obtained in October 1977. The results from 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-Lab comparisons of radioactivity in samples of different matrices of water, air filters, soil, vegetation and bone. These samples are distributed by the Department of Energy (DOE) through the Environmental Measurements Laboratory (EML), New York, formerly known as the Health and Safety Laboratory (HASL), on a quarterly basis. The radionuclides assayed were ^{3}H, ^{90}Sr, plutonium isotopes (following wet chemistry) and a number of gamma emitting nuclides. Our results agree within 10% for water samples and within 15% for other sample matrices.

b. TLD Dosimeters

The Dosimetry Services Section of the Safety and Environmental Protection Division participated in the Third International Intercomparison of Environmental Dosimeters conducted at Oak Ridge National Laboratory during July 1977. There were a total of 109 laboratories from 26 countries who participated in this test.

The estimated field exposure, as measured by the BNL environmental monitoring TLD dosimeter, agreed within 12% of the value measured by a continuously operated recording pressurized ion chamber corrected for energy response. In the estimated laboratory exposure test, the BNL dosimeter agreed within 6% of the actual exposure. Further comparisons are planned in February 1979 at the Fourth International Intercomparison of Environmental Dosimeters in Houston, Texas.

Nonradioactive Measurements

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 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 tables 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: 145 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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