4 Air Quality

Brookhaven National Laboratory monitors both radioactive and nonradioactive emissions at several facilities on site to ensure compliance with the requirements of the Clean Air Act. In addition, the Laboratory conducts ambient air monitoring to verify local air quality and assess possible environmental impacts from BNL operations.

During 2005, BNL facilities released a total of 3,266 curies of short-lived radioactive gases. Oxygen-15 and carbon-11 emitted from the Brookhaven Linac Isotope Producer constituted more than 99.4 percent of the site's radiological air emissions.

Since natural gas prices were comparatively higher than residual fuel prices throughout 2005, the Central Steam Facility continued to rely on residual fuel to meet the heating and cooling needs of BNL's major facilities. As a result, annual facility emissions of particulate matter, nitrogen oxides, and sulfur dioxide were considerably higher in 2005 than in 1999, when natural gas was the predominant fuel used at the Central Steam Facility.

4.1 RADIOLOGICAL EMISSIONS

Federal air quality laws and DOE regulations that govern the release of airborne radioactive material include 40 CFR 61 Subpart H: National Emission Standards for Hazardous Air Pollutants (NESHAPs)—part of the Clean Air Act, and DOE Order 5400.5, Radiation Protection of the Public and the Environment. Under NESHAPs Subpart H, facilities that have the potential to deliver an annual radiation dose of greater than 0.1 mrem (1 µSv) to a member of the public must be continuously monitored for emissions. Facilities capable of delivering radiation doses below that limit require periodic, confirmatory monitoring. Although not required, BNL has one facility that is continuously monitored, the Brookhaven Linac Isotope Producer (BLIP). Periodic monitoring is conducted at one active facility, the Target Processing Laboratory (TPL), and one inactive facility, the High Flux Beam Reactor (HFBR). Figure 4-1 indicates the locations of these monitored facilities, and Table 4-1 presents the airborne release data from each of these facilities during 2005. Annual emissions from monitored facilities are discussed in the following sections of this chapter. Also discussed is a fourth inactive facility, the Evaporator Facility, which was periodically monitored in past years. The associated radiation dose estimates are presented in Chapter 8, Table 8-4.

4.1.1 Brookhaven Medical Research Reactor

In August 2000, DOE announced that the Brookhaven Medical Research Reactor (BMRR) would be permanently shut down due to a reduction of research funding. Until it stopped operating in late December 2000, the BMRR was fueled with enriched uranium, moderated and cooled by "light" (ordinary) water, and was operated intermittently at power levels up to 3 MW, thermal. Air from the interior of the containment building was used to cool the neutron reflector surrounding the core of the reactor vessel. As air was drawn through the reflector, it was exposed to a neutron field, resulting in activation of the argon fraction of the air. This produced argon-41 (Ar-41), an inert, radioactive gas (half-life 1.8 hours). After passage through the reflector, the air was routed through a roughing filter and a high-efficiency particulate air (HEPA) filter to remove any particulate matter.

Figure 4-1. Air Emission Release Points Subject to Monitoring.

Charcoal filters were also used to remove radioiodines produced during the fission process. Following filtration, the air was exhausted to the atmosphere through a 150-ft stack adjacent to the reactor containment building. This air was continuously monitored for Ar-41 emissions.

After the BMRR stopped operating, continuous Ar-41 monitoring was reduced to periodic, semi-annual monitoring to confirm that radionuclide concentrations remain below detection limits. In January 2003, the remaining fuel was removed from the BMRR reactor vessel, eliminating the last significant source for radionuclide emissions. The sole remaining BMRR emission source was evaporation of the cooling water, which contained the radioactive isotope tritium (H-3, half-life 12.3 years) produced by neutron activation when the BMRR operated. In January 2005, EPA approved BNL's petition to discontinue emissions monitoring at the BMRR. As a result, no samples were collected.

In 2005, the facility was in a cold shut-down mode and was downgraded from a nuclear facility to a radiological facility. During the year, the remaining primary cooling water, Janus plates, control rod blades, and activated hydraulic fluid were shipped to a DOE-approved disposal facility.

4.1.2 High Flux Beam Reactor

When the HFBR operated, "heavy" water was used as a neutron moderator and fuel coolant. Heavy water, or D_2O, is water composed of a nonradioactive isotope of hydrogen known as deuterium. When exposed to neutron fields generated inside a reactor vessel, deuterium becomes activated and produces radioactive tritium. As a result of the transfer of fuel elements from the reactor, tritiated heavy water (HTO) from the HFBR system was contained in the spent fuel storage pool. In 1997, a leak in the pool was discovered when a plume of tritiated groundwater was traced back to it. The HFBR was put in standby mode, the pool was pumped out, and the HTO from the pool was properly disposed of as radioactive waste. The pool was then repaired and double lined, in accordance with Suffolk County Article 12 regulations (SCDHS 1993) and remained empty while the facility was in a standby mode.

The HFBR continued in standby mode until November 1999, when DOE declared that it was to be permanently shut down. Residual tritium in water in the reactor vessel and piping systems continues to diffuse into the building's air through valve seals and other system penetrations, though emission rates are much lower than during the years of operation (Figure 4-2).

Table 4-1. Airborne Radionuclide Releases from Monitored Facilities.

Facility	Nuclide	Half-Life	Ci Released
HFBR	Tritium	12.3 years	1.79E+01
BLIP	Carbon-11	20.4 minutes	8.16E+02
	Oxygen-15	122 seconds	2.43E+03
	Tritium	12.3 years	5.16E-02
TPL - Bldg. 801	Germanium-68	270.8 days	7.71E-08
Total			3.27E+03

Notes:
Ci = 3.7E+10 Bq
BLIP = Brookhaven Linac Isotope Producer
HFBR = High Flux Beam Reactor (operations were terminated in November 1999)
TPL = Target Processing Laboratory (Bldg. 801)

The increase in emissions in 2003 was attributed to evaporative losses when HTO remaining in the reactor core was pumped out for approved disposal. In 2004, the downward trend in emissions resumed: the level dropped from 9.0 Ci (the 2003 value) to 3.94 Ci. In 2005, tritium emissions climbed to 17.9 Ci. Following an investigation to determine possible sources

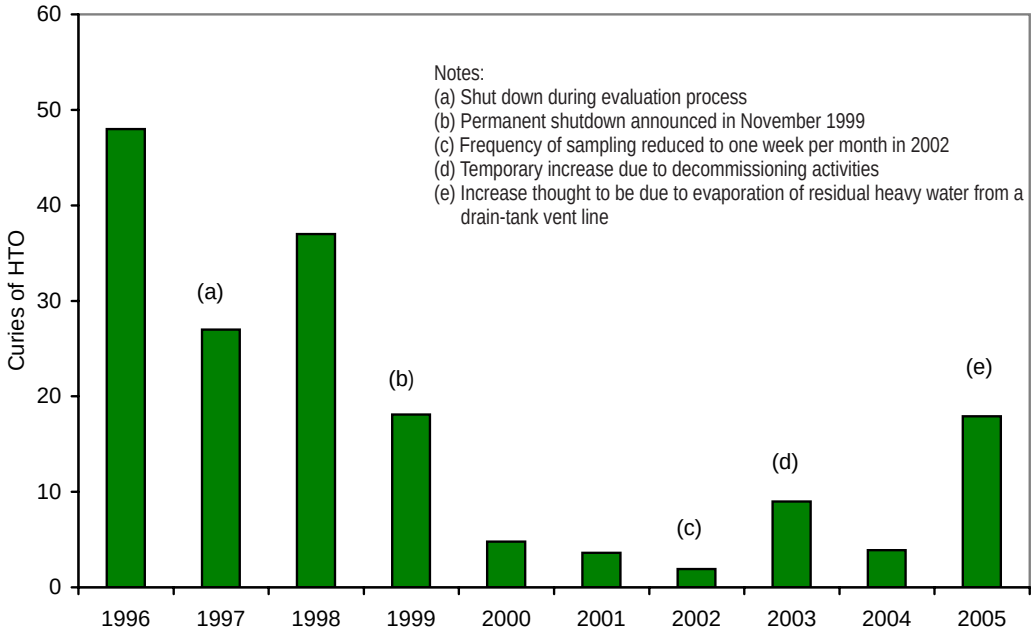

Figure 4-2. High Flux Beam Reactor Tritium Emissions, Ten-Year Trend (1996–2005).

for the rise, evaporation of residual heavy water through an open drain-tank vent line appears to have been the most likely source. The air emissions from the HFBR facility have been monitored since 2002 via air sampling of the building at a frequency of one week per month.

4.1.3 Brookhaven Linac Isotope Producer

Protons from the Linear Accelerator (Linac) are sent via an underground beam tunnel to the BLIP, where they strike various metal targets to produce new radionuclides for medical diagnostics. The activated metal targets are transferred to the TPL in Building 801 for separation and shipment to various radiopharmaceutical research laboratories. During irradiation, the targets become hot and are cooled by a continuously recirculating water system. The cooling water also becomes activated during the process, producing secondary radionuclides. The most significant of these radionuclides are oxygen-15 (O-15, half-life 122 seconds) and carbon-11 (C-11, half-life 20.48 minutes). Both of these isotopes are released as gaseous, airborne emissions through the facility's 33-ft stack.

In 2005, the BLIP operated over a period of 17 weeks. During this period, 816 Ci of C-11 and 2,432 Ci of O-15 were released. Tritium produced from activation of the target cooling water was also released, but in a much smaller quantity, 5.16 E-02 Ci. Combined emissions of C-11 and O-15 were roughly 20 percent higher than in 2004, primarily due to six extra weeks of operation, but the combined emissions were 15 percent lower than the 2003 total. This drop in emissions was facilitated by the installation of a lucite enclosure over the continuously recirculating water system. Section 8.4.1 provides more details on the effectiveness of the shroud enclosure.

4.1.4 Evaporator Facility

In the past, liquid waste generated on site that contained residual radioactivity was accumulated at the Waste Concentration Facility (WCF) in Building 811. At the WCF, reverse osmosis was used to remove suspended solids and a high percentage of radionuclides from the liquid. Because tritium is an isotope of hydrogen, it could not be removed from aqueous wastes. The tritiated water that remained following waste concentration was transferred to the Evaporator Facility in Building 802B, where it was converted to steam and released as an airborne emission. The Evaporator Facility was constructed primarily to reduce the amount of tritiated water released to the Peconic River through the BNL Sewage Treatment Plant. Emissions from the Evaporator Facility were previously directed to the same stack used by the HFBR to exhaust building air. This method was preferable to releases to surface water because there was virtually no potential for the airborne emissions to influence groundwater (the primary drinking water source on Long Island), and the potential for the released tritium to contribute to an off-site dose was minimized by atmospheric dispersion.

No aqueous waste has been processed at the WCF since 2001. As a result, the Evaporator Facility has not been used and has produced no emissions of tritiated water vapor. Because generation rates of aqueous wastes containing residual radioactivity are expected to remain low, it is no longer cost effective to process the waste in the same manner. Wastes are now processed through solidification, with off-site disposal. As a result, planning is underway to decommission the WCF reverse osmosis process and the Evaporator Facility. Subject to funding availability, the plans call for demolishing the Building 802B stack and decontaminating the WCF.

4.1.5 Target Processing Laboratory

As mentioned in Section 4.1.3, the metal targets irradiated at the BLIP are transported to the TPL in Building 801, where isotopes are chemically extracted for radiopharmaceutical production. Airborne radionuclides that are released during the extraction process are drawn through multistage HEPA and charcoal filters and then vented to the HFBR stack. The types of radionuclides that are released depend on the isotopes chemically extracted from the irradiated metal targets, which can change from year to year. Annual radionuclide quantities released

from this facility are very small, typically in the µCi to mCi range. In 2005, the total release from the TPL was 0.0771 µCi. See Table 4-1 for details of all radionuclides released in 2005.

4.1.6 Additional Minor Sources

Several research departments at BNL use designated fume hoods for work that involves small quantities of radioactive materials (in the µCi to mCi range). The work typically involves transferring material between containers using pipettes, and labeling chemical compounds. Due to the use of HEPA filters and activated charcoal filters, the nature of the work conducted, and the small quantities involved, these operations have a very low potential for atmospheric releases of any significant quantities of radioactive materials. Compliance with NESHAPs Subpart H is demonstrated through the use of an inventory system that allows an upper estimate of potential releases to be calculated. Facilities that demonstrate compliance in this way include Buildings 463, 490, 490A, 510, 535, 555, 725, and 801, where research is conducted in the fields of biology, medicine, high energy physics, chemistry, applied and materials science, and advanced technology. See Table 8-4 in Chapter 8 for the calculated dose from these facility emissions.

4.1.7 Nonpoint Radiological Emission Sources

Nonpoint radiological emissions from a variety of diffuse sources were evaluated in 2005 for compliance with NESHAPs Subpart H. Diffuse sources evaluated included planned research, environmental restoration, and waste management activities. The EPA-approved CAP88-PC dose modeling computer program was used to calculate the possible dose to members of the public from each of the planned activities. The evaluations determined whether NESHAPs permitting and continuous monitoring requirements were applicable, or whether periodic confirmatory sampling was needed to ensure compliance with Subpart H standards for radionuclide emissions. Chapter 8 discusses the NESHAPs evaluations of the research, environmental restoration, and waste management activities that occurred in 2005.

4.2 FACILITY MONITORING

In the past, potential sources of radioactive emissions that have been monitored included the BMRR, the HFBR, the Evaporator Facility, the TPL, and the BLIP. Since the BMRR and HFBR are permanently shut down and the Evaporator Facility has not processed any aqueous wastes since 2001, no particulate sampling was conducted at these facilities.

The samplers in the exhaust duct for the TPL and the exhaust stack for the BLIP are equipped with glass-fiber filters that capture samples of airborne particulate matter generated at these facilities (see Figure 4-3 for locations). The filters are collected and analyzed weekly for gross alpha and beta activity. Particulate filter analytical results for gross alpha and beta activity are reported in Table 4-2. Annual average gross alpha and beta airborne activity levels for samples collected from the TPL were 0.0037 and 0.0365 pCi/m^3, respectively. The average gross alpha and beta airborne activity levels for samples collected from the BLIP exhaust stack were 0.0752 and 1.1776 pCi/m^3, respectively.

4.3 AMBIENT AIR MONITORING

As part of the Environmental Monitoring Program, air monitoring stations are in place around the perimeter of the BNL site. Samples are collected using sampling equipment at six blockhouse stations and three pole-mounted samplers (see Figure 4-3 for locations). The blockhouses are fenced to control access and protect costly sampling equipment. In 2003, the number of pole-mounted, battery-powered silica-gel samplers used for tritium monitoring was reduced from 16 to three. The elimination of redundant samplers was justified on the basis that historical air surveillance data after the shutdown of the HFBR and the BMRR revealed that, at most of the sampling stations, the tritium concentrations were below minimum detection limits (MDL) obtained on the day of analysis.

At each blockhouse, particulate matter is captured on a glass-fiber filter, and water vapor for tritium analysis is collected on silica-gel absorbent material. Particulate filters are collected weekly and are analyzed for gross alpha

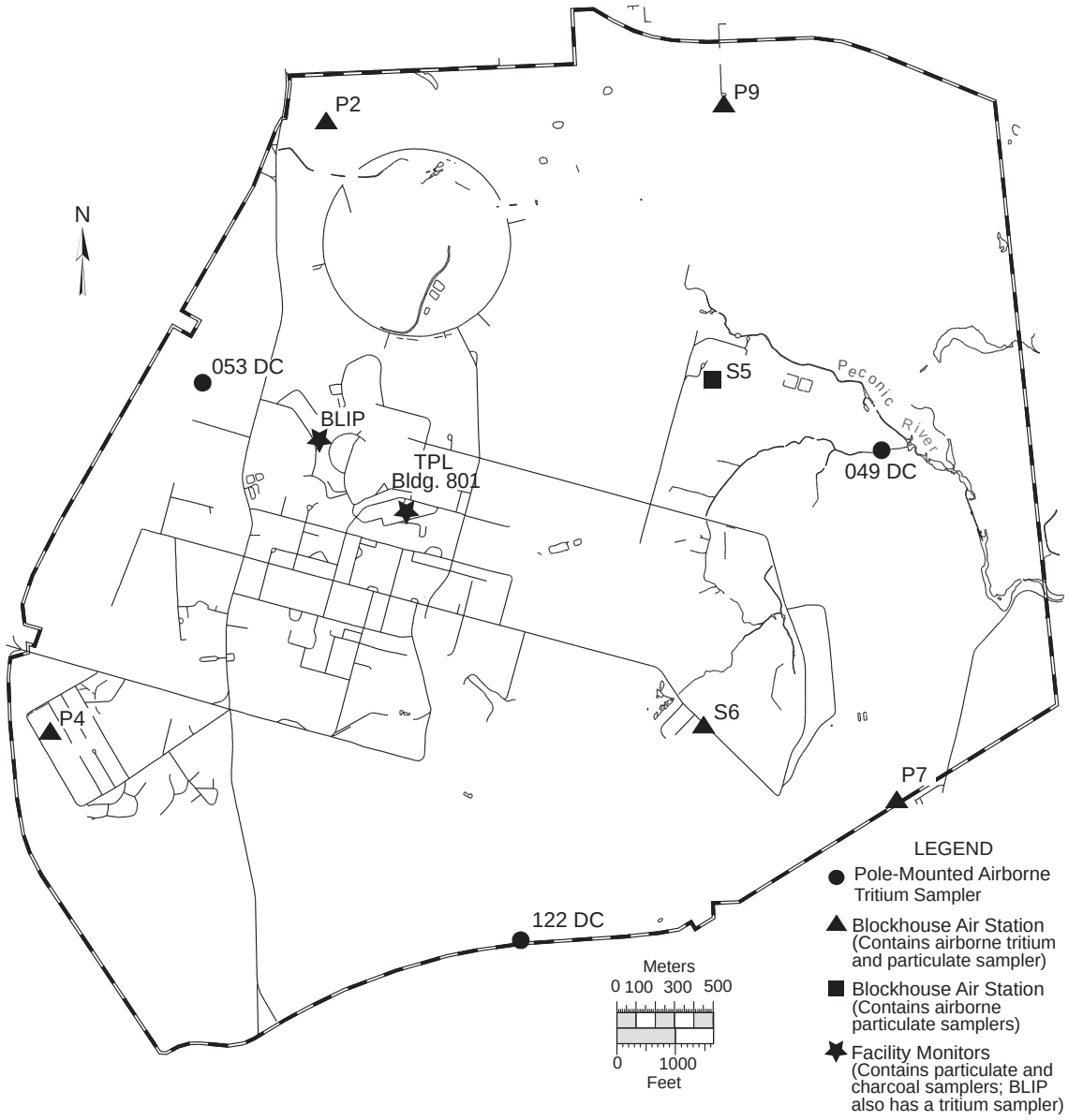

Figure 4-3. BNL On-Site Ambient Air Monitoring Stations.

and beta activity using a gas-flow proportional counter. In 2005, silica-gel samples were collected biweekly for processing by liquid scintillation analysis.

4.3.1 Gross Alpha and Beta Airborne Activity

Particulate filter analytical results for gross alpha and beta airborne activity are reported in Table 4-3. Validated samples are those not rejected due to equipment malfunction or other factors (e.g., sample air volumes were not acceptable). The annual average gross alpha and beta airborne activity levels for the six monitoring stations were 0.0014 and 0.0147 pCi/m^3, respectively. Annual gross beta activity trends recorded at Station P7 are plotted in Figure 4-4. The results for this location are typical for the site. The trend shows seasonal variation in activity within a range that is representative of natural background levels. The New York State Department of Health (NYSDOH) received duplicate filter samples that were collected at Station P7 using a sampler they provided. These samples were collected weekly and analyzed by the NYSDOH laboratory for gross beta activity only. The analytical results received were

Table 4-2. Gross Activity in Facility Air Particulate Filters.

Facility Monitor		Gross Alpha (pCi/m^3)	Gross Beta (pCi/m^3)
BLIP	N	48	48
	Max.	0.2100 ± 0.1960	2.6700 ± 0.4000
	Avg.	0.0752 ± 0.0233	1.1776 ± 0.0313
	MDL	0.1703*	0.3138*
TPL - Bldg. 801	N	49	49
	Max.	0.0115 ± 0.0029	0.1560 ± 0.0108
	Avg.	0.0037 ± 0.0005	0.0365 ± 0.0007
	MDL	0.0028*	0.0049*

Notes:
See Figure 4-3 for sample station locations.
All values shown with a 95% confidence interval.
BLIP = Brookhaven Linac Isotope Producer
MDL = Minimum Detection Limit
N = Number of validated samples collected
TPL = Target Processing Laboratory (Bldg. 801)
*Average MDL for all samples taken at this location

Table 4-3. Gross Activity Detected in Ambient Air Monitoring Particulate Filters.

Sample Station		Gross Alpha (pCi/m^3)	Gross Beta (pCi/m^3)
P2	N	50	50
	Max	0.0036 ± 0.0009	0.0233 ± 0.0017
	Avg.	0.0012 ± 0.0001	0.0138 ± 0.0002
	MDL	0.0006*	0.0011*
P4	N	52	52
	Max	0.0036 ± 0.0009	0.0308 ± 0.0020
	Avg.	0.0014 ± 0.0001	0.0167 ± 0.0002
	MDL	0.0006*	0.0011*
P7	N	50	50
	Max	0.0035 ± 0.0008	0.0220 ± 0.0024
	Avg.	0.0010 ± 0.0001	0.0100 ± 0.0002
	MDL	0.0005*	0.0008*
P9	N	50	50
	Max	0.0056 ± 0.0012	0.0337 ± 0.0020
	Avg.	0.0016 ± 0.0001	0.0154 ± 0.0002
	MDL	0.0006*	0.0011*
S5	N	50	50
	Max	0.0034 ± 0.0007	0.0327 ± 0.0019
	Avg.	0.0014 ± 0.0001	0.0166 ± 0.0002
	MDL	0.0007*	0.0012*
S6	N	50	49
	Max	0.0038 ± 0.0012	0.0284 ± 0.0017
	Avg.	0.0016 ± 0.0001	0.0162 ± 0.0002
	MDL	0.0006*	0.0012*
Grand Average		0.0014 ± 0.0001	0.0147 ± 0.0006

Notes:
See Figure 4-3 for sample station locations.
All values shown with a 95% confidence interval.
MDL = Minimum Detection Limit
N = Number of validated samples collected
*Average MDL for all samples taken at this location

comparable to the Station P7 samples analyzed by Severn Trent Lab, a contract analytical laboratory. Analytical results for gross beta activity were between 0.0072 and 0.0264 pCi/m^3, with an average concentration of 0.0144 pCi/m^3, whereas the BNL results ranged from 0.0039 to 0.022 pCi/m^3, with an average concentration of 0.0100 pCi/m^3. As part of a statewide monitoring program, NYSDOH also collects air samples in Albany, New York, a control location with no potential to be influenced by nuclear facility emissions. In 2005, NYSDOH reported that airborne gross beta activity at that location varied between 0.0037 and 0.0187 pCi/m^3 and the average concentration was 0.0093 pCi/m^3. Sample results measured at BNL generally fell within this range, demonstrating that on-site radiological air quality was consistent with that observed at locations in New York State not located near radiological facilities.

4.3.2 Airborne Tritium

Airborne tritium in the form of HTO is monitored throughout the Laboratory site. In addition to the five blockhouses containing tritium samplers, three pole-mounted monitors used for tritium sampling are located at or near the property boundary (see Figure 4-3 for locations). A pump is used to draw air through a column of silica gel, a water-absorbent medium, to capture airborne tritium. The absorbed HTO is recovered by distillation and analyzed using liquid scintillation counting techniques.

Table 4-4 lists the number of validated samples collected at each location, the maximum value observed, and the annual average concen-

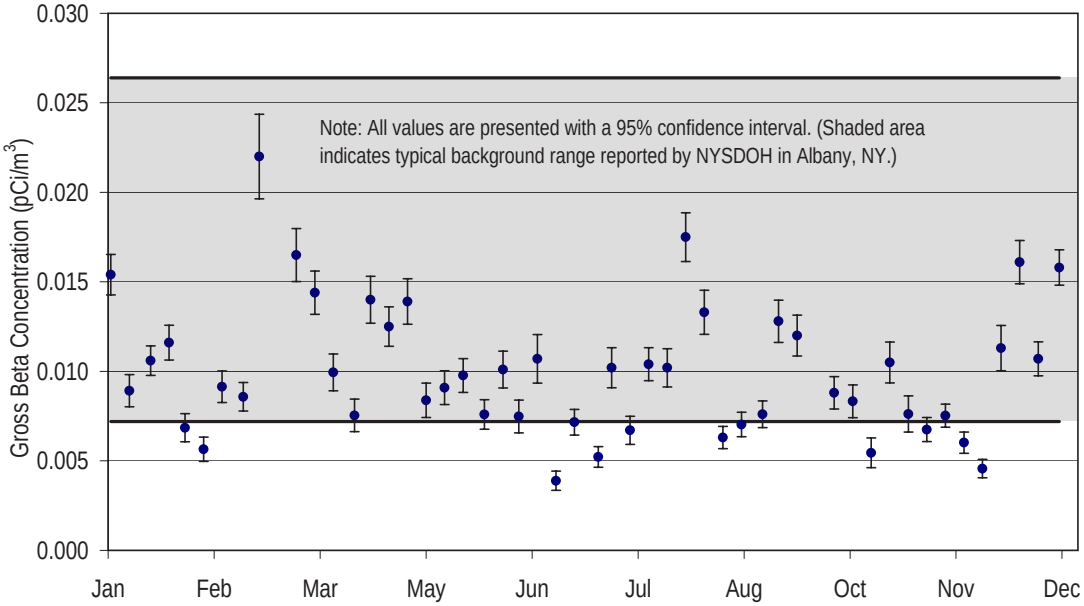

Figure 4-4. Airborne Gross Beta Concentration Trend Recorded at Station P7.

tration. Validated samples are those not rejected due to equipment malfunction or other factors (e.g., a battery failure in the sampler, frozen or supersaturated silica gel, or the loss of sample during preparation at the contract analytical laboratory). Airborne tritium samples were collected biweekly from each sampling station during 2005. The average tritium concentrations at all of the sampling locations were less than the typical MDL, which ranged from 1.0 to 6.0 pCi/m^3. The collected data demonstrate that there were no significant differences in ambient tritium concentrations on site or at the site boundary. Observed concentrations of tritium at the sampling stations in 2005 were comparable to concentrations observed in 2004.

4.4 NONRADIOLOGICAL AIRBORNE EMISSIONS

Various state and federal regulations governing nonradiological releases require facilities to conduct periodic or continuous emission monitoring to demonstrate compliance with emission limits. The Central Steam Facility (CSF) is the only BNL facility that requires monitoring for nonradiological emissions. The Laboratory has several other emission sources subject to state and federal regulatory requirements that do not require emission monitoring (see Chapter 3 for more details). The CSF supplies steam for heating and cooling to major facilities at BNL through an underground steam distribution and condensate grid. The location of the CSF is shown in Figure 4-1. The combustion units at the CSF are designated as Boilers 1A, 5, 6, and 7. Boiler 1A, which was installed in 1962, has a

Table 4-4. Ambient Airborne Tritium Measurements in 2005.

Sample Station	Wind Sector	Validated Samples	Maximum (pCi/m^3)	Average (pCi/m^3)
049	E	21	13.5 ± 3.9	2.0 ± 1.3
053	NW	24	2.9 ± 3.1	0.5 ± 0.4
122	SSE	21	5.0 ± 4.7	0.8 ± 0.7
P2	NNW	22	4.1 ± 3.6	0.6 ± 0.5
P4	WSW	23	62.1 ± 4.5	2.9 ± 5.2
P7	ESE	21	14.4 ± 4.0	1.5 ± 1.6
P9	NE	22	4.7 ± 1.2	1.0 ± 0.6
S6	SE	23	5.0 ± 0.6	0.7 ± 0.6
Grand Average				1.2 ± 0.7
DOE Order 5400.5 Air Derived Concentration Guide				100,000 pCi/m^3

Notes:
See Figure 4-3 for sample station locations.
All values reported with a 95% confidence interval.
Wind sector is the downwind direction of the sample station from the HFBR stack.
Typical minimum detection limit for tritium is between 1.0 and 6.0 pCi/m^3.

heat input of 16.4 MW (56.7 MMBtu/hr). Boiler 5, installed in 1965, has a heat input of 65.3 MW (225 MMBtu/hr). The newest units, Boilers 6 and 7, were installed in 1984 and 1996, and each has a heat input of 42.6 MW (147 MMBtu/hr). For perspective, Keyspan's Northport, New York power station has four utility-sized turbine/generator boilers, each with a maximum rated heat input of 1,004 MW (3,435 MMBtu/hr).

Because of their design, heat inputs, and dates of installation, Boilers 6 and 7 are subject to Title 6 of the New York Code, Rules, and Regulations (NYCRR) Part 227-2, and the Federal New Source Performance Standard (40 CFR 60 Subpart Db: Standards of Performance for Industrial-Commercial-Institutional Steam Boilers). Therefore, these boilers are equipped with continuous emission monitors to measure nitrogen oxides (NO_x). Boiler 7 was already equipped with a continuous opacity monitor to comply with Subpart Db opacity monitoring requirements, and after a new continuous opacity monitor for Boiler 6 was voluntarily brought online in 2004, emissions on both boilers are now continuously monitored for opacity. To measure combustion efficiency, the boilers are also monitored for carbon dioxide (CO_2). Continuous emission monitoring results from the two boilers are reported quarterly to EPA and the New York State Department of Environmental Conservation.

From May 1 to September 15 (the peak ozone period), compliance with the 0.30 lbs/MMBtu (129 ng/J) NO_x emission standard for No. 6 oil and the 0.20 lbs/MMBtu (86ng/J) NO_x emission standard for No. 2 oil and natural gas is demonstrated by calculating the 24-hour average emission rate from continuous emission monitoring system readings and comparing the value to the emission standard. The remainder of the year, the calculated 30-day rolling average emission rate is used to establish compliance. Boiler 7 opacity levels are recorded as 6-minute averages. Measured opacity levels cannot exceed 20 percent opacity, except for one 6-minute period per hour of not more than 27 percent opacity. In 2005, there were no measured exceedances of the NO_x emission standards for either boiler. During the year, all but one of the Boiler 6 opacity measurements and all of the Boiler 7 opacity measurements that exceeded the opac-

Table 4-5. Central Steam Facility Fuel Use and Emissions (1996 – 2005).

	Annual Fuel Use and Fuel Heating Values						Emissions			
Year	No. 6 Oil (10^3 gals)	Heating Value (MMBtu)	No. 2 Oil (10^3 gals)	Heating Value (MMBtu)	Natural Gas (10^6 ft^3)	Heating Value (MMBtu)	TSP (tons)	NO_x (tons)	SO_2 (tons)	VOCs (tons)
1996	4,782.55	703,991	52.77	7,388	0.00	0	14.0	104.9	109.0	0.7
1997	3,303.43	484,613	10.23	1,432	190.65	194,463	13.7	83.5	75.1	1.0
1998	354.28	52,283	9.44	1,322	596.17	608,093	2.7	75.1	8.9	1.7
1999	682.76	78,335	2.77	388	614.98	627,280	5.1	53.5	16.7	1.8
2000	2,097.32	309,317	0.82	115	342.40	349,248	9.5	81.6	45.0	1.2
2001	3,645.10	538,847	3.40	476	103.96	106,039	17.5	80.4	77.8	0.8
2002	2,785.04	407,518	0.29	41	220.62	225,030	15.4	62.4	53.8	1.0
2003	4,290.94	628,765	402.06	56,288	0.98	1,000	22.8	75.3	107.1	0.6
2004	4,288.76	628,063	2.45	343	0.11	109	16.4	81.9	104.7	2.4
2005	4,206.12	618,590	0.87	122	0.00	0	15.2	80.4	93.1	2.4
Permit Limit (in tons)							113.3	159	445	39.7

Notes:
NO_x = Oxides of Nitrogen
SO_2 = Sulfur Dioxide
TSP = Total Suspended Particulates
VOCs = Volatile Organic Compounds

ity limit occurred during boiler startups, routine boiler tube soot blowing operations, and necessary calibrations of the monitoring system. Changing the sequence of the soot blowing cycle on Boiler 6 has virtually eliminated opacity exceedances due to soot blowing. Similar changes will be made to the soot blowing cycle on Boiler 7. While there are no regulatory requirements to continuously monitor opacity for Boilers 1A and 5, surveillance monitoring of visible stack emissions is a condition of BNL's Title V operating permit. Daily observations of stack gases recorded by CSF personnel throughout the year showed no visible emissions with opacity levels exceeding the regulatory limits established for these boilers.

Although several boilers have the ability to burn natural gas, natural gas prices exceeded those for residual fuel oil throughout 2005. As a result, residual fuel supplied 100 percent of the heating and cooling needs of BNL's major facilities in 2005. By comparison, in 1999 natural gas satisfied more than 88 percent of the major facility heating and cooling needs. Consequently, 2005 emissions of particulates, NO_x, and sulphur dioxide (SO_2) were 10.1, 26.9, and 76.4 tons higher than the respective totals for 1999. All emissions were well below the respective permit limits of 113.3, 159, and 445 tons. Table 4-5 shows fuel use and emissions since 1996.

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