# 4 Air Quality

*Brookhaven National Laboratory (BNL) 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 2004, BNL facilities released a total of 2,711 curies of short-lived radioactive gases. Oxygen-15 and carbon-11 emitted from the Brookhaven Linac Isotope Producer constituted more than 99.8 percent of the site's radiological air emissions.*

*Since natural gas prices were comparatively higher than residual fuel prices throughout 2004, the Central Steam Facility (CSF) 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 2004 than in 1999, when natural gas was the predominant fuel used at the CSF.*

## 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 (1μSv) 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. BNL has one facility that requires continuous monitoring, the Brookhaven Linac Isotope Producer (BLIP). Periodic monitoring is conducted at one active facility, the Target Processing Laboratory (TPL), and two inactive facilities, the Brookhaven Medical Research Reactor (BMRR) and 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 2004. 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 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. After passage through the reflector, the air was routed through a roughing filter and a high-efficiency particulate air (HEPA) filter to

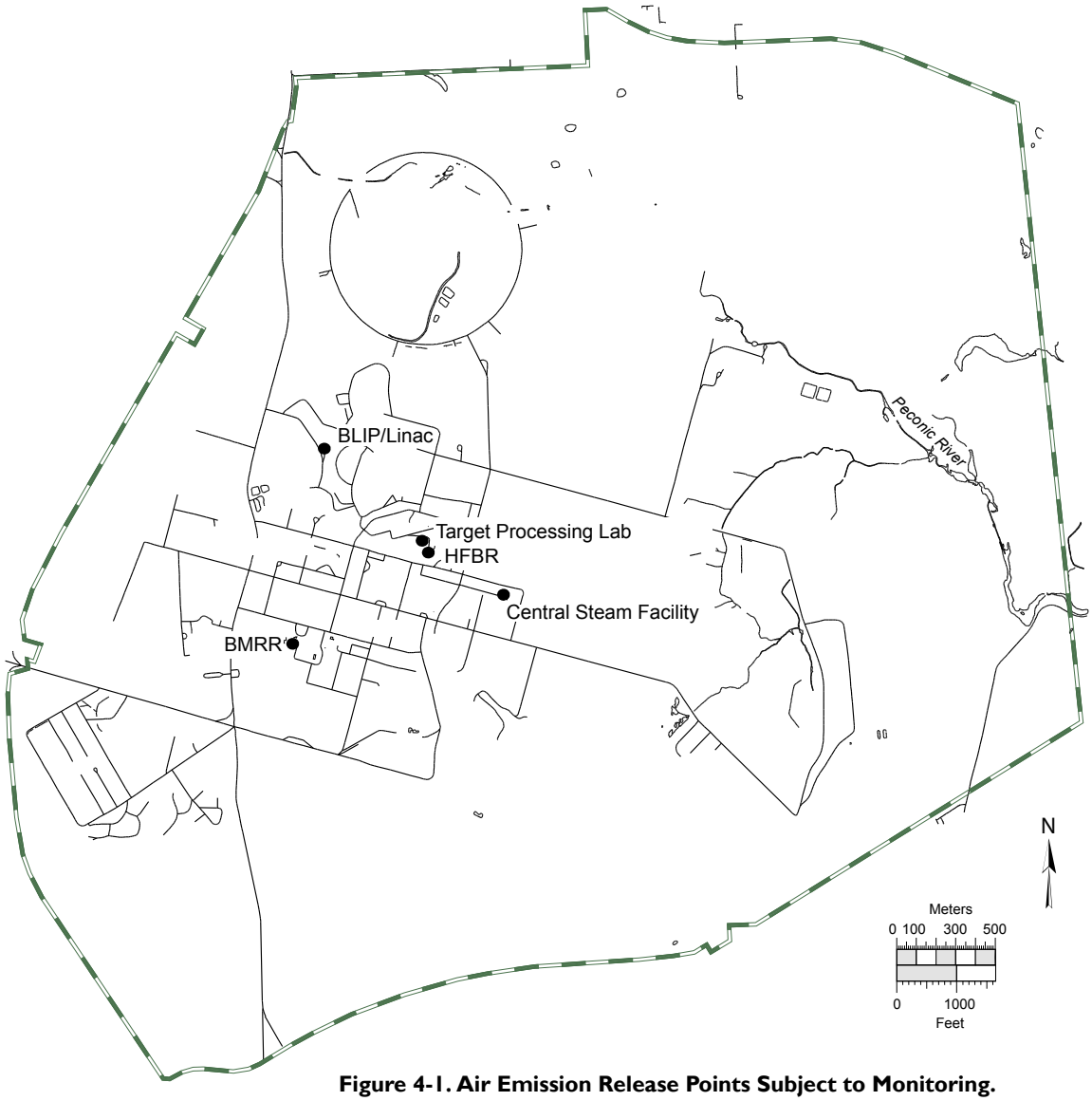


**Figure 4-1. Air Emission Release Points Subject to Monitoring.**

remove any particulate matter. 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 2004, sampling showed there were no detectable emissions of Ar-41 or other radionuclides with building ventilation turned on.

In January 2003, the remaining fuel was removed from the BMRR reactor vessel, eliminating the last significant source for radionuclide emissions to the environment. The sole remaining emission source is evaporation of the cooling water, which contains the radioactive isotope tritium produced by neutron activation when the BMRR operated. In 2004, the release of tritium as tritiated water vapor (HTO) was estimated at 76.3 mCi, based on the concentration of tritium and previously measured decreases in the volume of water. In December 2004, a petition with supporting analytical data and dose calculations was filed with EPA with

the intention to discontinue emissions monitoring at the BMRR.

#### 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. Tritiated heavy water from the HFBR system was stored in a spent fuel storage pool. In 1997, a leak in this 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 water 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 tritiated water in the vessel and cooling loops 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). The increase in emissions that occurred in 2003 was attributed to evaporative losses when tritiated water remaining in the reactor core was pumped out for off-site disposal. In 2004, the downward trend in emissions resumed: the level dropped from 9.0 Ci (the 2003 value) to 3.94 Ci. This downward trend is expected to continue as tritiated water vapor in the HFBR air equilibrates. Sampling frequency continues at 1 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. The proton beam activates these metal targets to produce new radionuclides for medical diagnostic tests. The activated metal targets are transferred to the TPL in Building 801 for separation and later shipment to various radiopharmaceutical research laboratories. During irradiation, the targets become hot and

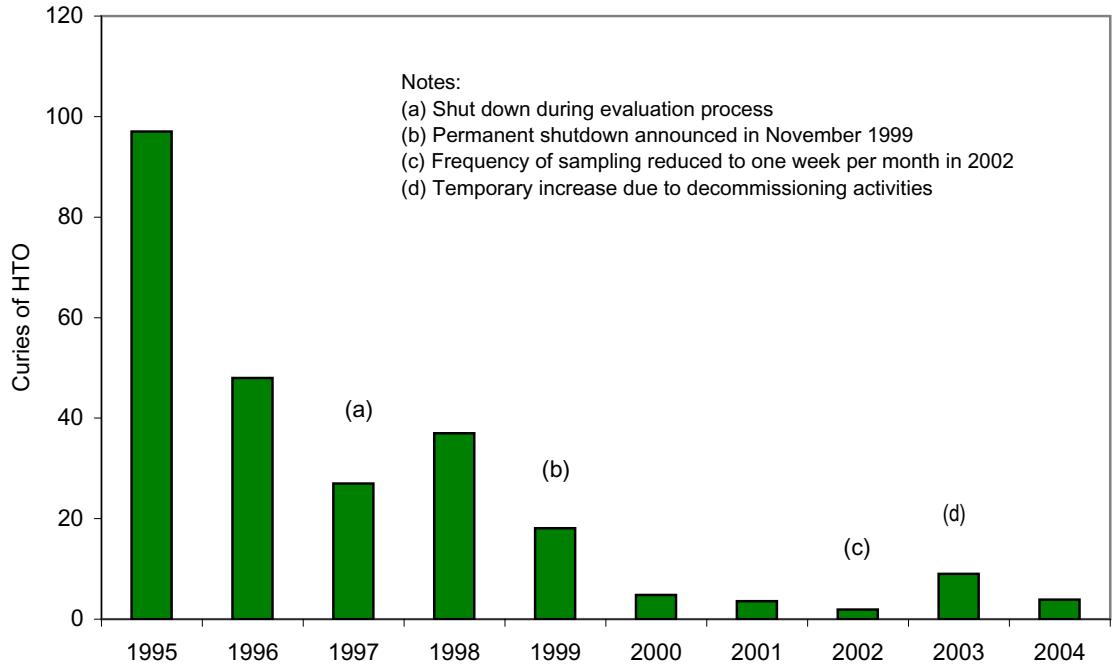


**Figure 4-2. High Flux Beam Reactor Tritium Emissions, Ten-Year Trend (1995–2004).**

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) and carbon-11 (C-11). Both of these isotopes are released as gaseous, airborne emissions through the facility's 33-ft stack.

In 2004, the BLIP operated over a period of 11 weeks. During this period, 680 Ci of C-11 and 2,027 Ci of O-15 were released. Tritium produced from activation of the target cooling water was also released, but in a much smaller quantity, 7.32E-02 Ci. Emissions of C-11 and O-15 declined by more than 28 percent from 2003, primarily due to a reduced period of operation (11 weeks in 2004 compared to 16 weeks in 2003).

#### 4.1.4 Evaporator Facility

In the past, liquid wastes 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 the 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 produced no emissions of tritiated water vapor in 2004. Because generation rates of aqueous wastes containing residual radioactivity are expected to remain low, it was no longer cost effective to process the waste in the same manner. Wastes are now processed through solidification with off-site disposal.

#### 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 2004, the total release from the TPL was 0.0016 μCi. See Table 4-1 for details of all radionuclides released in 2004.

#### 4.1.6 Additional Minor Sources

Several research departments at BNL use designated fume hoods for work that involves very small quantities of radioactive materials (in the μCi to mCi range). The work done using fume hoods 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

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

| Facility | Nuclide | Half-Life | Ci Released |
|---|---|---|---|
| BMRR | Argon-41 | 1.8 hours | None |
| | Tritium | 12.3 years | 0.0763* |
| HFBR | Tritium | 12.3 years | 3.94E+00 |
| BLIP | Carbon-11 | 20.4 minutes | 6.80E+02 |
| | Oxygen-15 | 122 seconds | 2.03E+03 |
| | Tritium | 12.3 years | 7.32E-02 |
| TPL - Bldg. 801 | Cesium-137 | 30.1 years | 2.06E-12 |
| | Cobalt-60 | 5.3 years | 5.97E-11 |
| | Germanium-68 | 270.8 days | 1.87E-08 |
| | Europium-152 | 13.5 years | 9.96E-10 |
| **Total** | | | **2.71E+03** |

Notes:
Ci = 3.7E+10 Bq
BLIP = Brookhaven Linac Isotope Producer
BMRR = Brookhaven Medical Research Reactor (operations were terminated in December 2000)
HFBR = High Flux Beam Reactor (operations were terminated in November 1999)
TPL = Target Processing Laboratory
* Estimated release (see Section 4.1.1 for details)

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 2004 for compliance with NESHAPs Subpart H. Diffuse sources evaluated included planned environmental restoration and waste management activities. The EPA-approved CAP88-PC dose modeling program was used to calculate the 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 environmental restoration and waste management activities that occurred in 2004.

### 4.2 FACILITY MONITORING

In the past, potential sources of radioactive particulate 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 did not process any aqueous wastes in 2004, 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 0.0102 and 0.0611 pCi/m$^3$, respectively. The annual average airborne activity levels for samples collected from the BLIP exhaust stack were 0.0496 pCi/m$^3$ (gross alpha) and 1.0106 pCi/m$^3$ (gross beta).

### 4.3 AMBIENT AIR MONITORING

As part of the Environmental Monitoring Program, air monitoring stations are in

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

| Facility Monitor | | Gross Alpha | Gross Beta |
|---|---|---|---|
| | | pCi/m$^3$) | |
| BLIP | N | 50 | 50 |
| | Max. | 0.1900 ± 0.1400 | 1.5600 ± 0.2840 |
| | Avg. | 0.0496 ± 0.0201 | 1.0106 ± 0.0383 |
| | MDL | 0.1810* | 0.3224* |
| TPL - Bldg. 801 | N | 52 | 52 |
| | Max. | 0.3460 ± 0.1660 | 1.5700 ± 0.2640 |
| | Avg. | 0.0102 ± 0.0062 | 0.0611 ± 0.0098 |
| | MDL | 0.0066* | 0.0111* |

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

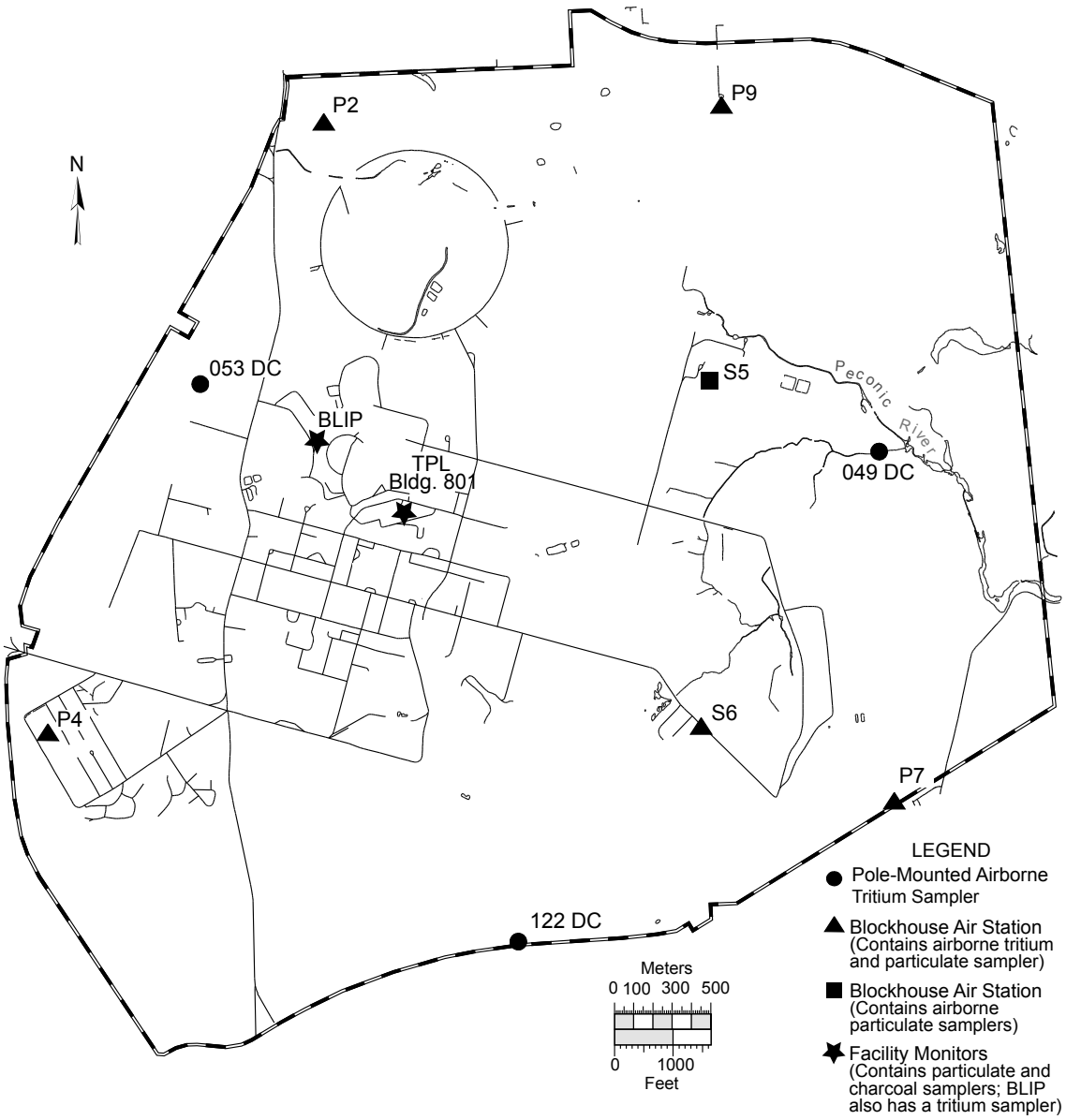


**Figure 4-3. BNL On-Site Ambient Air Monitoring Stations.**

place around the perimeter of the BNL site. Samplers are housed within six blockhouse stations (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 the minimum detection limits (MDL). Figure 4-3 in the 2003 Site Environmental Report may be referenced for the locations of portable samplers no longer included in surveillance monitoring.

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 col-

lected weekly and are analyzed for gross alpha and beta activity using a gas-flow proportional counter. In 2004, silica-gel samples were collected biweekly.

### 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 0.0011 and 0.0136 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 comparable to the Station P7 samples analyzed by the BNL Analytical Services Laboratory and Severn-Trent Laboratories, LLC, an off-site contract laboratory. Analytical results for gross beta activity reported by the NYSDOH laboratory were between 0.0077 and 0.0246 pCi/m$^3$, with an average concentration of 0.0148 pCi/m$^3$, whereas the BNL results ranged from 0.0027 to 0.0201pCi/m$^3$, with an average concentration of 0.0129 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 2004, NYSDOH reported that airborne gross beta activity at that location varied between 0.0013 and 0.019 pCi/m$^3$ and the average concentration was 0.0088 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.

**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 | 51 | 51 |
| | Max | 0.0020 ± 0.0007 | 0.0201 ± 0.0017 |
| | Avg. | 0.0007 ± 0.0002 | 0.0105 ± 0.0004 |
| | MDL | 0.0006* | 0.0009* |
| P4 | N | 48 | 48 |
| | Max | 0.0027 ± 0.0010 | 0.0281 ± 0.0035 |
| | Avg. | 0.0012 ± 0.0002 | 0.0152 ± 0.0005 |
| | MDL | 0.0008* | 0.0013* |
| P7 | N | 45 | 45 |
| | Max | 0.0027 ± 0.0022 | 0.0201 ± 0.0035 |
| | Avg. | 0.0013 ± 0.0002 | 0.0129 ± 0.0004 |
| | MDL | 0.0007* | 0.0012* |
| P9 | N | 52 | 52 |
| | Max | 0.0021 ± 0.0007 | 0.0258 ± 0.0031 |
| | Avg. | 0.0011 ± 0.0001 | 0.0151 ± 0.0004 |
| | MDL | 0.0008* | 0.0013* |
| S5 | N | 51 | 51 |
| | Max | 0.0023 ± 0.0007 | 0.0244 ± 0.0018 |
| | Avg. | 0.0010 ± 0.0002 | 0.0135 ± 0.0004 |
| | MDL | 0.0007* | 0.0012* |
| S6 | N | 52 | 52 |
| | Max | 0.0028 ± 0.0009 | 0.0233 ± 0.0028 |
| | Avg. | 0.0011 ± 0.0002 | 0.0144 ± 0.0004 |
| | MDL | 0.0008* | 0.0013* |
| **Grand Average** | | **0.0011 ± 0.0001** | **0.0136 ± 0.0005** |

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

### 4.3.2 Airborne Tritium

Airborne tritium in the form of tritiated water vapor (HTO) is monitored throughout the BNL 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). Airborne tritium is collected by using a pump to draw air through a column of silica gel, a water-absorbent medium.

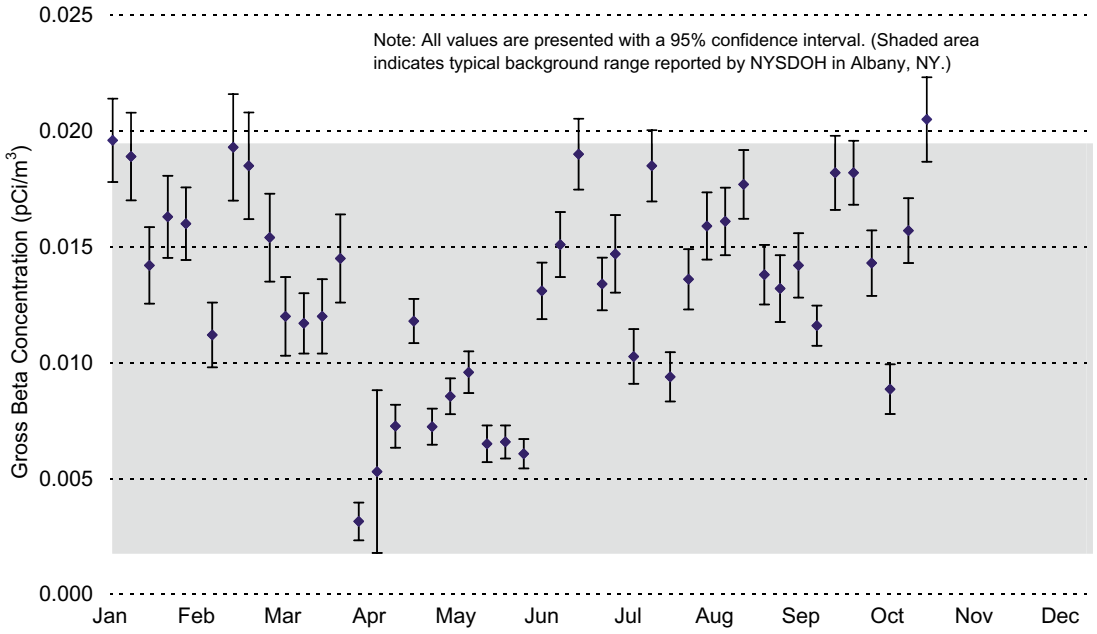


**Figure 4-4. Airborne Gross Beta Concentration Trend Recorded at Station P7.**

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 concentration. 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 laboratory preparation). Airborne tritium samples were collected biweekly from each sampling station during 2004. The average tritium concentrations at all of the sampling locations were less than the typical MDL, which ranged from 1.0 to 7.0 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 2004 were comparable to concentrations observed in 2003.

## 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 CSF is the only BNL facility that requires monitoring for nonradiological emissions. BNL 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

**Table 4-4. Ambient Airborne Tritium Measurements.**

| Sample Station | Wind Sector | Validated Samples | Maximum (pCi/m$^3$) | Average (pCi/m$^3$) |
|---|---|---|---|---|
| 049 | E | 24 | 1.7 ± 1.2 | 0.3 ± 0.4 |
| 053 | NW | 24 | 2.0 ± 1.9 | 0.8 ± 0.3 |
| 122 | SSE | 24 | 2.7 ± 4.5 | 0.4 ± 0.3 |
| P2 | NNW | 24 | 2.6 ± 0.6 | 0.7 ± 0.4 |
| P4 | WSW | 25 | 2.6 ± 0.6 | 0.7 ± 0.4 |
| P7 | ESE | 25 | 1.5 ± 1.3 | 0.3 ± 0.2 |
| P9 | NE | 25 | 2.0 ± 0.6 | 0.4 ± 0.3 |
| S6 | SE | 25 | 4.5 ± 3.2 | 0.6 ± 0.5 |
| **Grand Average** | | | | **0.4 ± 0.1** |
| **DOE Order 5400.5 Air Derived Concentration Guide** | | | | **100,000 pCi/m$^3$** |

Notes:
See Figure 4-3 for sample station locations.
Wind sector is the downwind direction of the sample station from the HFBR stack.
All values are presented with a 95% confidence interval.
Typical minimum detection limit for tritium is between 1.0 and 7.0 pCi/m$^3$.

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 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, respectively. Each of these boilers has a heat input of 42.6 MW (147 MMBtu/hr). For perspective, Keyspan's Northport, New York power station has three utility-sized turbine/generator boilers, each with a maximum rated heat input of 385 MW (3,435 MMBtu/hr) and one with a maximum rated heat input of 990 MW (3,381 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, both 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 (NYSDEC).

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 6 and 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 2004, there were no mea-

**Table 4-5. Central Steam Facility Fuel Use and Emissions (1996 – 2004).**

| | 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 | 4,290.95 | 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 |

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

sured exceedances of the $NO_x$ emission standards for either boiler. During the year, all but two of the Boiler 6 opacity measurements and all of the Boiler 7 opacity measurements that exceeded the limit occurred during boiler start-ups or routine boiler tube soot blowing operations. These exceedences were reported to NYSDEC. 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.

In the spring of 1997, the Long Island Lighting Company completed work extending a natural gas main into the CSF. To accommodate the combustion of natural gas, new gas rings were added to the burners of Boiler 5, and natural gas trains were installed to connect the gas main to Boilers 5 and 7. In 1998, existing steam-atomized oil burners on Boiler 6 were replaced with two dual-fuel low-$NO_x$ burners, and a natural gas train was added to connect the boiler to the gas main.

Throughout 2004, natural gas prices exceeded those for residual fuel oil. As a result, residual fuel supplied more than 99.9 percent of the heating and cooling needs of BNL's major facilities while the combustion of natural gas accounted for less than one tenth of 1 percent of these heating and cooling needs. By comparison, in 1999 natural gas satisfied more than 88 percent of the major facility heating and cooling needs, and in 2002, 36 percent. Consequently, 2004 emissions of particulates, $NO_x$, and $SO_2$ were 11.3, 27.4, and 98.0 tons higher than the respective totals for 1999 and were 1.0, 19.5, and 50.9 tons higher than the respective emission totals for 2002. Table 4-5 shows fuel use and emissions since 1996.

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