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 (CAA). In addition, BNL conducts ambient air monitoring to verify local air quality and assess possible environmental impacts from Laboratory operations.

During 2018, BNL facilities released a total of 23,035 curies of short-lived radioactive gases. Oxygen-15 and Carbon-11 emitted from the Brookhaven Linac Isotope Producer constituted more than 99.9 percent of the site's radiological air emissions.

Because natural gas prices were comparatively lower than residual fuel oil prices throughout the year, BNL's Central Steam Facility used natural gas to meet 99.2 percent of the heating and cooling needs of the Laboratory's major facilities in 2018. As a result, emissions of particulates, oxides of nitrogen, sulfur dioxide, and volatile organic compounds were well below the respective regulatory permit criteria pollutant limits.

4.1 RADIOLOGICAL EMISSIONS

Federal air quality laws and U.S. Department of Energy (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 CAA and DOE Order 458.1 Chg. 3, 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.

BNL has two active facilities: the Brookhaven Linac Isotope Producer (BLIP), which is continuously monitored with an inline detection system; the Target Processing Laboratory (TPL), which has a particulate filter sampling system to continuously collect gross alpha and gross beta samples; and one inactive facility, the High Flux Beam Reactor (HFBR), where periodic monitoring is conducted. Figure 4-1 provides the locations of these monitored facilities and Table 4-1 presents airborne release data from these facilities. Annual emissions from monitored facilities are discussed in the following sections of this chapter. The associated radiation dose estimates are presented in Table 8-5 in Chapter 8.

4.2 FACILITY MONITORING

Radioactive emissions are monitored at the HFBR, BLIP, and TPL. The samplers in the exhaust stack for BLIP and the TPL exhaust duct are equipped with glass-fiber filters that capture samples of airborne particulate matter generated at these facilities (see Figure 4-1 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 in 2018 are reported in Table 4-2. The average gross alpha and beta airborne activity levels for samples collected from the BLIP exhaust stack were 0.0005 and 0.0077 pCi/m^3, respectively. Annual average gross alpha and beta airborne activity levels for samples collected from the TPL were 0.0008 and 0.0114 pCi/m^3, respectively.

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

4.2.1 High Flux Beam Reactor

In 1997, a groundwater plume was traced back to a leak in the HFBR spent fuel storage pool. Consequently, the HFBR was put in standby mode until November 1999, when the DOE declared that it was to be permanently shut down. Residual tritium in water in the reactor vessel and piping systems continued to diffuse into the building's air through valve seals and other system penetrations, though emission rates were much lower than during the years of operation.

In 2010, the HFBR was disconnected from the 100-meter stack, and a new HFBR exhaust system was installed in 2011. As part of the HFBR Long-Term Surveillance Program (BNL 2018), air samples are collected from outside the HFBR confinement structure using a permanently installed sample port. Samples are analyzed for tritium to evaluate facility emissions and to ensure that air quality within the building is acceptable to permit staff entry. Samples are collected for three or four weeks per month using a standard desiccant sampling system for tritium analysis. Desiccant samples are analyzed by an off-site contract laboratory.

4.2.2 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: 20.4 minutes). Both isotopes are released as gaseous, airborne emissions through the facility's 33-foot stack. Emissions of these radionuclides are dependent on the current and energy of the proton beam used to manufacture the radioisotopes.

In 2018, BLIP operated over a period of 26.7 weeks, during which 7,678 Ci of C-11 and 15,357 Ci of O-15 were released (see Table 4-1). Tritium produced from activation of the target cooling water was also released, but in a much smaller quantity, at 3.10 E-2 Ci. Combined emissions of C-11 and O-15 were 23,035 Ci, more than double the combined emissions of 10,660 Ci in 2017. This increase is primarily due to operation at a higher-than-average beam energy in 2018, almost 50 percent more operating days at beam energy above normal than 2017, and the fact that cooling water gaps for thorium targets are up to 50 percent greater than those for radium chloride targets. The thorium target irradiations are in support of future actinium-25 production programs.

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

Facility	Nuclide	Half-Life	Ci Released
HFBR	Tritium	12.3 years	4.13E-01
BLIP	Carbon-11	20.4 minutes	7.68E+03
	Oxygen-15	122 seconds	1.54E+04
	Tritium	12.3 years	3.10E-02
Total			**2.30E+04**

Notes:
Ci = 3.7E+10 Bq
BLIP = Brookhaven Linac Isotope Producer
HFBR = High Flux Beam Reactor (operations were terminated in November 1999)

4.2.3 Target Processing Laboratory

As mentioned in Section 4.2.2, metal targets irradiated at the BLIP are transported to the TPL in Building 801, where isotopes are chemically extracted for radiopharmaceutical production.

Airborne radionuclides released during the extraction process are drawn through multistage HEPA and charcoal filters and the filtered air is then vented to the atmosphere. The types of radionuclides that are processed depend on the isotopes chemically extracted from the irradiated metal targets, which may change from year to year. Annual radionuclide quantities released from this facility are very small, typically in the µCi to mCi range. Gamma analysis of monthly composite samples was discontinued in 2013. This decision was based on historical analytical results of TPL particulate filters that showed gross alpha/beta levels to be very low and consistent with background concentrations. As a result, there are no reported radionuclide emissions from the TPL in Table 4-1. Should future gross beta analyses of TPL emissions show the potential for other radionuclide emissions, gamma analyses will be resumed.

4.2.4 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 labeling chemical compounds and transferring material between containers. 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 significant quantities of radioactive materials. Compliance with NESHAPs Subpart H is demonstrated using an inventory system that allows an upper estimate of potential releases to be calculated. Facilities that demonstrate compliance in this way include Buildings 348, 463, 490, 490A, 510A, 555, 740, 741, 743, 744, 745, and 911, where research is conducted in the fields of nuclear safety, biology, chemistry, high energy physics, medicine, medical therapy, photon science, advanced technology, environmental

chemistry, and synthetic biology. See Table 8-5 in Chapter 8 for the calculated dose from these facility emissions.

4.2.5 Nonpoint Radiological Emission Sources

Nonpoint radiological emissions from a variety of diffuse sources may be evaluated for compliance with NESHAPs Subpart H. Diffuse sources evaluated often include planned research, planned waste management activities, and planned decontamination and decommissioning activities. Evaluations determine whether NESHAPs permitting and continuous monitoring requirements are applicable, or periodic confirmatory sampling is needed to ensure compliance with Subpart H standards for radionuclide emissions. Chapter 8 discusses the NESHAPs evaluations of diffuse sources in 2018.

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 (see Figure 4-2). There are four block-house stations equipped for collecting samples. At each blockhouse, vacuum pumps draw air through columns where particulate matter is captured on a glass-fiber filter. Particulate filters are collected weekly and analyzed for gross alpha and beta activity using a gas-flow proportional counter. Also, water vapor for tritium analysis is collected on silica-gel adsorbent material for processing by liquid scintillation analysis. In 2018, silica-gel samples were collected every two weeks.

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. Ambient air samples are collected weekly from site perimeter monitoring stations P2, P4, P7, and P9. 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 four monitoring stations were 0.0010 and 0.0124 pCi/m^3,

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

Monitored Facility		Gross Alpha	Gross Beta
		(pCi/m^3)	
BLIP	N	50	50
	Max.	0.0017 ± 0.0007	0.0265 ± 0.0018
	Avg.	0.0005 ± 0.0004	0.0077 ± 0.0010
	MDL	0.0007*	0.0008*
TPL - Bldg. 801	N	52	52
	Max.	0.0041 ± 0.0010	0.1200 ± 0.0038
	Avg.	0.0008 ± 0.0005	0.0114 ± 0.0012
	MDL	0.0006*	0.0008*

Notes:
See Figure 4-1 for monitored facility 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
*Average MDL for all validated samples taken at this location

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

Sample Station		Gross Alpha	Gross Beta
		(pCi/m^3)	
P2	N	49	49
	Max	0.0018 ± 0.0006	0.0260 ± 0.0018
	Avg.	0.0009 ± 0.0004	0.0107 ± 0.0010
	MDL	0.0004*	0.0006*
P4	N	51	51
	Max	0.0015 ± 0.0006	0.0297 ± 0.0018
	Avg.	0.0007 ± 0.0004	0.0102 ± 0.0009
	MDL	0.0004*	0.0005*
P7	N	52	52
	Max	0.0019 ± 0.0010	0.0208 ± 0.0024
	Avg.	0.0010 ± 0.0005	0.0131 ± 0.0012
	MDL	0.0006*	0.0007*
P9	N	47	47
	Max	0.0115 ± 0.0016	0.0320 ± 0.0021
	Avg.	0.0015 ± 0.0006	0.0157 ± 0.0014
	MDL	0.0007*	0.0008*
Grand Average		**0.0010 ± 0.0005**	**0.0124 ± 0.0011**

Notes:
See Figure 4-2 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 validated samples taken at this location

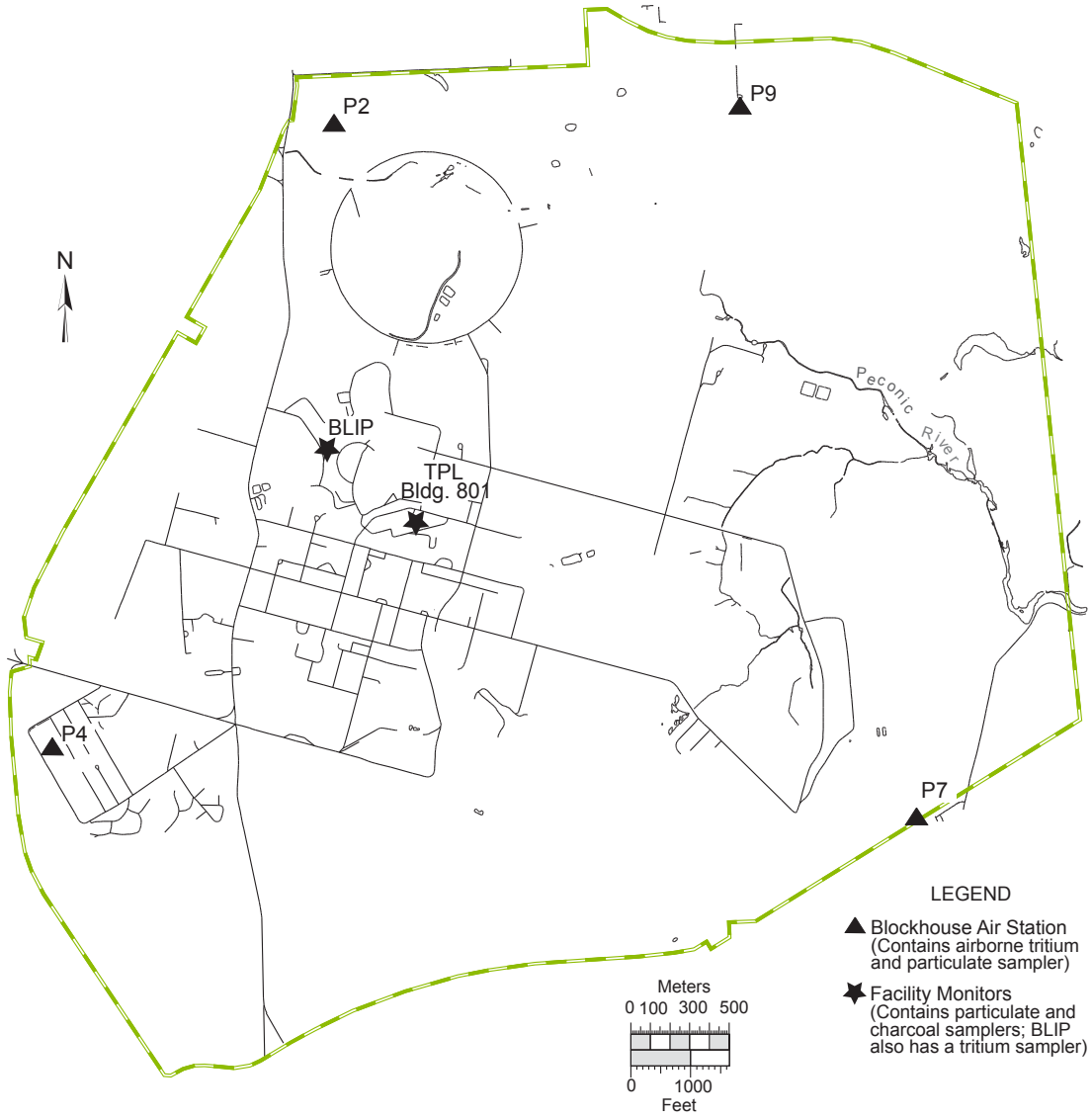


Figure 4-2. BNL On-Site Ambient Air Monitoring Stations.

respectively. Annual gross beta activity trends recorded at Station P7 are plotted in Figure 4-3. The results for this location are typical for the site and show 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 provided by NYSDOH. These samples were collected weekly and analyzed by the NYSDOH laboratory for gross beta activity. The analytical results were comparable to the Station P7 samples analyzed by General Engineering Lab, an analytical laboratory contracted by BNL. New York State's analytical results for gross beta activity at the Laboratory were between 0.0020 and 0.0209 pCi/m^3, with an average concentration of 0.0082 pCi/m^3. BNL results ranged from 0.0010 to 0.0208 pCi/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 2018, NYSDOH reported that airborne gross beta activity at that location varied between 0.0033 and 0.0318 pCi/m^3 and had an average concentration of 0.0109 pCi/m^3. All but one of the BNL samples 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 tritiated water (HTO) is monitored throughout the BNL site. In 2018, tritium samples were collected from Stations P2, P4, P7, and P9 to assess the potential impacts from the Laboratory's two tritium sources. 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, insufficient sample volumes, or the loss of sample during preparation at the contract analytical laboratory). Airborne tritium samples were collected every two weeks from each sampling station during 2018; however, two samples could not be analyzed because the sample pumps tripped off. The average tritium concentrations at all the sampling locations were less than the typical minimum detection limits, ranging from 4.0 to 12.6 pCi/m^3.

4.4 NONRADIOLOGICAL AIRBORNE EMISSIONS

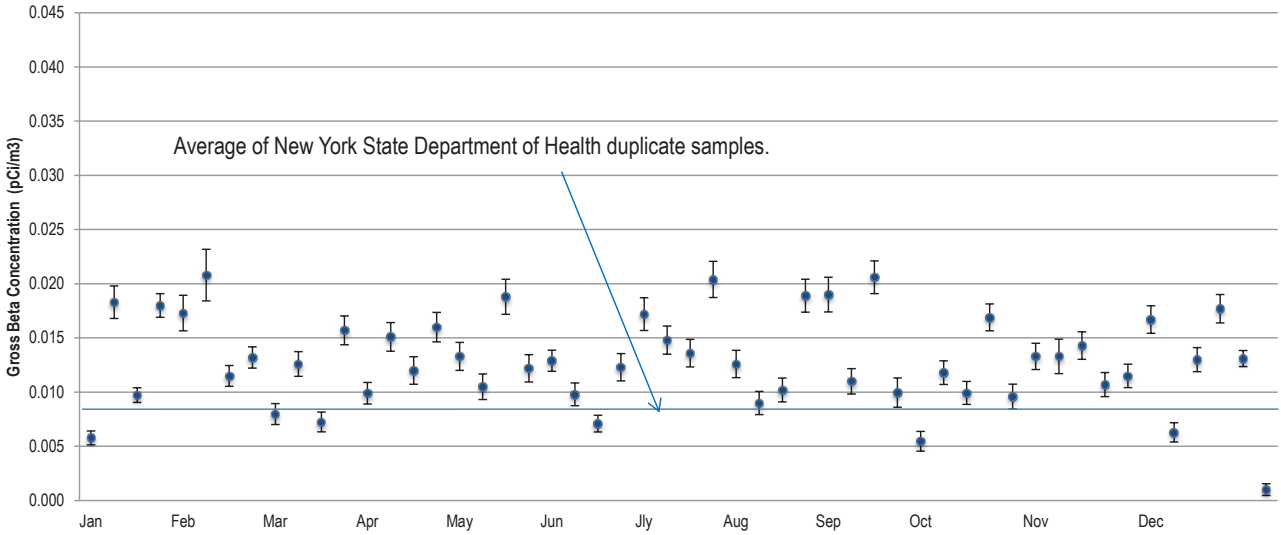
Various state and federal regulations governing nonradiological releases require facilities to conduct periodic or continuous emission monitoring to demonstrate compliance with emission limits. The Central Steam Facility (CSF) is the only BNL facility that requires monitoring for nonradiological emissions. The Laboratory has several other emission sources subject to state and federal regulatory requirements that do not require emission monitoring (see Chapter 3 for details).

The CSF supplies steam for heating and cooling to major BNL facilities 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 million British thermal units [MMBtu per hour). 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, National Grid's Northport, New York, power station has four utility-sized turbine/generator boilers, each with a maximum rated heat input of 1,082 MW (3,695 MMBtu/hr).

Because the CSF boilers have the potential to emit more than 100 tons per year of oxides of nitrogen (NOx), the CSF is considered a major facility, and all four of its boilers are subject to the Reasonably Available Control Technology (RACT) requirements of Title 6 of the New York Code, Rules, and Regulations (NYCRR) Subpart 227-2. Because of their design, heat inputs, and dates of installation, Boilers 6 and 7 are also subject to the Federal New Source Performance Standard (40 CFR 60 Subpart Db: Standards of Performance for Industrial-Commercial-Institutional Steam Boilers). Both boilers are equipped with continuous emission monitoring systems (CEMS) to show compliance with NOx standards of Subpart 227-2 and Subpart Db, and with continuous opacity monitors to demonstrate compliance with Subpart Db opacity monitoring requirements. To measure combustion efficiency, the boilers are also monitored for carbon monoxide (CO). Continuous emission monitoring results from the two boilers are reported quarterly to EPA and the New York State Department of Environmental Conservation (NYSDEC).

On July 1, 2014, new Subpart 227-2 lower RACT standards for NOx emissions became effective. The respective NOx RACT emission limits of lbs/MMBtu for the combustion of natural gas and 0.30 lbs/MMBtu for the combustion of No. 6 oil burned in the CSF three large boilers dropped to 0.15 lbs/MMBtu for both fuels. The NOx RACT emission limit for the CSF's one mid-size boiler (Boiler 1A) dropped from 0.30 lbs/MMBtu to 0.20 lbs/MMBtu.

From May 1 to September 15 of each year,



Note: All values are presented with a 95 percent confidence interval.

Figure 4-3. Airborne Gross Beta Concentration Trend Recorded at Station P7.

the peak ozone period, owners and operators of boilers equipped with CEMS must demonstrate compliance with Subpart 227-2 NOx RACT limits by calculating the 24-hour average emission rate from CEMS readings and comparing the value to the emission limit. During the remainder of the year, the calculated 30-day rolling average emission rate is used to establish compliance. Owners and operators of boilers not equipped with CEMS must demonstrate compliance with NOx RACT limits via periodic emissions testing. Following the end of each calendar quarter, facilities with boilers equipped with CEMS must tabulate and summarize emissions, monitoring, and operating parameter measurements recorded during the preceding three months. Measured opacity levels cannot exceed 20 percent opacity, except for one six-minute period per hour of not more than 27 percent opacity.

When No. 6 oil was burned, past emissions testing and CEMS results have shown that CSF boilers 5, 6, and 7 cannot meet the new lower NOx RACT standards; therefore, BNL uses an approved system averaging plan to demonstrate compliance in quarterly reports submitted to NYSDEC. This plan is accomplished with a NOx ledger, where NOx rate credits accumulated during quarterly periods when natural gas is burned at levels below the NOx RACT limits offset ledger debits that occur when Boilers 5, 6, and 7 burn oil. The ledger must show that the actual NOx weighted average emission rate of operating boilers is less than the Subpart 227-2 permissible NOx weighted average rate for the quarter. The actual weighted average emission rates for operating boilers in the first, second, third, and fourth quarters, respectively, were 0.079, 0.088, 0.078, and 0.102 lbs/MMB-tu, while the corresponding permissible weighted average emissions rate for all four quarters was 0.150 lbs/MMBtu.

In 2018, there were 21 recorded excess opacity measurements. Thirteen were due to blizzard-like conditions that obstructed the Boiler 7 transmissometer light path; three were due to unsuccessful attempts to start-up Boiler 7 on No. 6 oil; one was due to unknown causes; and four excess opacity readings occurred during quarterly quality assurance tests of the Boiler 6 and 7 opacity monitors. 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 on days when the boilers were operated.

Table 4-4. Ambient Airborne Tritium Measurements in 2018.

Sample Station	Wind Sector	Validated Samples	Maximum (pCi/m^3)	Average (pCi/m^3)
P2	NNW	25	47.5 ± 11.9	4.9 ± 5.1
P4	WSW	27	62.2 ± 5.9	5.8 ± 4.4
P7	ESE	27	18.4 ± 6.3	3.2 ± 3.8
P9	NE	25	19.5 ± 3.1	2.1 ± 4.6
Grand Average				**4.0 ± 4.5**

Notes:
See Figure 4-2 for station locations.
Wind sector is the downwind direction of the sample station from the High Flux Beam Reactor (HFBR) stack.
All values reported with a 95% confidence interval.
Typical minimum detection limit for tritium is between 3.5 and 12.5 pCi/m^3.

To satisfy quality assurance requirements for the continuous emissions monitoring system of the Laboratory's Title V operating permit, a relative accuracy test audit (RATA) of the Boilers 6 and 7 continuous emissions monitoring systems for NOx and CO_2 was conducted in December 2018. The results of the RATA demonstrated that the Boiler 6 and 7 NOx and CO_2 continuous emissions monitoring systems met RATA acceptance criteria, which are defined in 40 CFR 60, Appendix B, Specifications 2 and 3.

To fulfill periodic testing requirements of the Laboratory's Title V operating permit, emission tests of Boilers 1A and 5 were conducted the first week of December while scheduled emission tests of Boilers 6 and 7 were delayed until January 23. Results of particulate matter emissions tests when the boilers burned No. 6 oil at high load conditions confirmed that Boilers 1A, 5, and 6 met the 6 NYCRR Subpart 227-1 applicable emission standard of 0.2 lbs/MMBtu, while Boiler 7 met the 40 CFR 60 Subpart Db emission standard of 0.1 lbs/MMBtu. The tests also confirmed that Boiler 1A and 5 met their respective Subpart 227-2 NOx RACT emission limits of 0.2 lbs/MMBtu for No. 6 oil and 0.15 lbs/MMBtu for natural gas. Since Boiler 5 NOx emission test results averaged 0.22 lbs/MMBtu when No. 6 oil was fired, the Laboratory will utilize its approved system averaging plan to demonstrate compliance in quarters when Boiler 5 burns No. 6 oil.

In 2018, residual fuel prices exceeded those of natural gas for most of the year. As a result, natural gas was used to supply 99.2 percent of the heating and cooling needs of BNL's major facilities. By comparison, in 2009, residual fuel satisfied 42.6 percent of the major facility heating and cooling needs. Consequently, 2018 emissions of particulates, NOx, and sulfur dioxide (SO_2) were 6.5, 21.9, and 43.9 tons less than the respective totals for 2009, when No. 6 oil was used to supply a much higher percent of site heating and cooling needs. Table 4-5 shows fuel use and emissions since 2009.

4.5 GREENHOUSE GAS EMISSIONS

Signed in May 2018, Executive Order (EO) 13834, Efficient Federal Operations, replaced EO 13693, Planning for Federal Sustainability in the Next Decade, which established sustainability goals for federal agencies. However, implementation instructions for EO 13834 were not issued during 2018. The Laboratory continues to follow the guidance, recommendations, plans, and numerical targets set forth in EO 13693. One of the overarching goals of EO 13693 is for federal agencies to establish agency-wide greenhouse gas (GHG) reduction targets for their combined Scope 1 and 2 greenhouse gas emissions and for their Scope 3 greenhouse gas emissions (see Appendix A for definitions). DOE has set the following GHG emission reduction goals for fiscal year (FY) 2025: reduce Scope 1 and 2 GHG emissions by 50 percent relative to their FY 2008 baseline and reduce Scope 3 GHG emissions by 25 percent relative to their FY 2008 baseline. BNL includes these same goals in its annual Site Sustainability Plan (SSP), which is submitted to DOE in December of each year (BNL 2018). BNL's SSP identifies several actions that have or will be taken to help the Laboratory progress towards meeting the Scope 1 and 2 GHG emissions reduction goal.

In November 2011, the Long Island Solar Farm (LISF), a large array of more than 164,000 solar photovoltaic panels constructed on the BNL site, began producing solar power. The LISF was estimated to deliver an annual average of 44 million kilowatt-hours (kWh) per year of solar energy into the local utility grid over a 20-year period. To date, it has exceeded the estimate every year; in 2018, the LISF provided 46.6 million kilowatt-hours

Table 4-5. Central Steam Facility Fuel Use and Emissions (2009–2018).

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)
2009	1,904.32	283,734	0.00	0	375.03	382,529	9.0	53.4	44.9	2.1
2010	447.47	66,591	0.00	0	561.42	568,939	3.4	41.5	10.0	1.8
2011	31.49	4,726	0.01	2	657.06	668,564	2.6	30.4	0.9	1.8
2012	43.44	6,519	0.00	0	613.44	630,616	2.5	29.1	1.2	1.7
2013	117.21	17,590	0.00	0	631.95	649,645	2.9	30.7	2.9	1.8
2014	34.03	5,107	0.00	0	673.80	690,584	2.6	30.9	1.0	1.9
2015	9.66	1,449	0.00	0	619.98	638,209	2.4	30.3	0.4	1.7
2016	804.38	120,712	0.00	0	441.98	453,348	3.7	33.6	19.0	1.7
2017	65.07	9,765	0.00	0	564.96	579,559	2.3	28.2	1.7	1.6
2018	36.04	5,409	0.04	6	642.33	662,242	2.5	31.5	1.0	1.8
Permit Limit (in tons)							**113.3**	**159.0**	**445.0**	**39.7**

Notes:
NO_x = oxides of nitrogen
SO_2 = sulfur dioxide
TSP = total suspended particulates
VOCs = volatile organic compounds

of solar energy to Long Island. This equates to 25,074 metric tons CO_2 equivalents ($MtCO_2e$) GHG offset or reduction. Even though the power from the LISF is purchased by the local utility, the Laboratory receives GHG reduction credits by purchasing an equivalent amount of Renewable Energy Credits (RECs) each year. In March 2011, BNL began receiving 15 megawatts per hour of hydropower from the New York Power Authority. In 2018, BNL consumed 119,425 megawatts of hydropower, providing a net combined GHG reduction of 89,331 $MtCO_2e$ from the LISF and hydropower. Furthermore, in 2016 BNL completed an expansion of the Northeast Solar Energy Research Center (NSERC). The NSERC is a solar photovoltaic facility that now has a capacity of 816 kW. In 2018, it provided 1,095,183 kWh and offset 709 $MtCO_2e$.

In October 2013, DOE awarded BNL a Utility Energy Service Contract (UESC). This project called for the implementation of energy savings measures to reduce Scope 1 and 2 GHG levels by approximately 7,000 $MtCO_2e$. In May of 2015, the Laboratory completed Phase I energy conservation measures that included:

- The installation of a 1,250-ton high-efficiency chiller to increase the efficiency of supplied chilled water;
- Upgraded lighting systems in 18 buildings;
- Enhanced building control upgrades, and additions to provide for heating, ventilation, and air conditioning temperature setbacks in nine buildings.

The UESC project has been a success, with annual energy savings within three percent of the original estimates for each of the three full years since completion. In FY 2018, an investment grade audit was initiated for potential Phase II UESC projects. Planned energy savings projects under consideration include additional lighting and building control upgrades, and chilled water storage improvements. BNL will periodically evaluate the potential to install a combined heat and power plant and will recommend going forward if a business case develops to make installation a viable alternative.

To meet the 2025 Scope 3 GHG emissions reduction goal, Scope 3 emissions must be lowered by 5,034 $MtCO_2e$ from the FY 2008 baseline of 20,136 $MtCO_2e$. Overall, Scope 3 GHG emissions dropped by 1,128 $MtCO_2e$, down seven percent from FY 2017, and 25.6 percent less than the FY 2008 baseline value of 20,136 $MtCO_2e$. GHG emissions from electrical transmission and distribution losses decreased 6,696 $MtCO_2e$, accounting for most of the drop.

The decrease from FY 2017 is mostly due to a 759 MT CO_2e drop in GHG emissions from purchased electricity transmission and distribution losses, a 237 MT CO_2e decrease in commuting GHGs, and a 306 MT CO_2e decrease in business air travel GHG emissions. The transmission and distribution loss GHG emission reduction was primarily due to ten percent and 9.8 percent drops in the respective e-Grid Distribution Loss Adjustment Factors that were used to calculate electricity transmission and distribution losses from electricity purchased from the local Long Island sub-region, as well as transmission and distribution losses from hydroelectricity purchased from the upstate New York sub-region. Commuting GHG emissions were 137 MtCO_2e less than FY 2018 mostly due to a reduction in workforce that caused the number of BNL commuters to decline 6.2 percent, from 2,570 employees in FY 2017 to 2,411 in FY 2018. Meanwhile, business air travel GHG emissions dropped 306 MT CO_2e, an 8.6 percent decline from FY 2017.

The following actions were taken in 2018 to promote ridesharing and explain how BNL's flexible work arrangements can help reduce GHG emissions from employee commuting and advance BNL's efforts to achieve its Scope 3 GHG reduction goal:

- During BNL's Celebration of Earth Day on April 19, a representative of New York State's 511NYRideshare program disseminated information on ridesharing and its benefits to employees.
- BNL participated in Car Free Day Long Island on September 21, 2018, an annual event to increase employee awareness and appreciation of the environmental, health, and economic benefits of sustainable means of transportation. Through various promotional efforts, employees were encouraged to make a pledge on the Car Free Day LI website to be car-free or car-lite on September 21 and commit to drive less by carpooling, biking, walking, or teleworking. Thirty-five employees participated by making pledges to carpool, bike, walk, and telework to reduce their driving for one day.

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