Brookhaven National Laboratory

2020 Site Environmental Report

VOLUME 1

managed by Brookhaven Science Associates
on behalf of the U.S. Department of Energy

U.S. DEPARTMENT OF ENERGY

In 2020, the United States was impacted by the coronavirus (COVID-19) pandemic, resulting in severe illness and death for millions in the United States and globally, interruption of economies and livelihoods, and the dramatic development of vaccines to fight the pandemic.

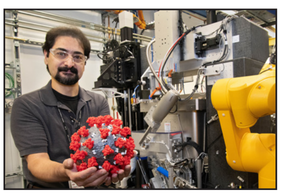
As with many businesses in the U.S. and worldwide, the impact for Brookhaven National Laboratory was significant, with two-thirds of its employees working from home and many operations delayed or stunted.

Remarkably, though, the Lab has maintained operations throughout the pandemic, with hundreds of employees working on site as essential staff to run scientific facilities and other mission-critical operations.

Heeding the call to serve and protect the nation and assist in the worldwide effort to develop vaccines and treatments for COVID-19, right from the start of the pandemic the Lab mobilized its scientific resources. Starting in the spring of 2020, Lab scientists began to focus their expertise and the Laboratory's unique scientific tools on National Virtual Biotechnology Laboratory-supported efforts, user studies, and research to address the challenges COVID-19 presented—from computational modeling, to drug-discovery experiments at the National Synchrotron Light Source II (NSLS-II), to exploring the properties of face coverings, and more.

Some of the most notable research findings conducted by scientists at Brookhaven Lab included development of a new mathematical model for predicting how COVID-19 spreads, an understanding of how the virus envelope protein behaves and promotes viral spread, and development of computer models that helped speed the discovery of drugs to combat the novel coronavirus that causes COVID-19, to name a few.

Additionally, researchers outside of the Lab harnessed the strengths of the Lab's world-class facilities to tackle the pandemic. A number of research groups used the NSLS-II to investigate the various proteins of the virus, creating the needed structural data that was used in various models and potentially in drug development. Notably, Pfizer scientists utilized the NSLS-II facility to research certain structural properties of their vaccine.



Lab employee Babak Andi holds a 3-D model of the coronavirus responsible for the COVID-19 pandemic. He's at the end station of the AMX beamline at Brookhaven Lab's National Synchrotron Light Source II, where scientists are studying virus proteins and potential inhibitor drugs.

The Laboratory also took action on behalf of the Department of Energy (DOE) to gather and distribute excess personal protective equipment to health care professionals working on the "front lines" in hospitals.

COVID-19 and the Environment

Despite the catastrophic effects of the pandemic on many aspects of life, an unforeseen consequence of the pandemic was a reduction in negative environmental impacts.

According to a National Institutes of Health study, "the pandemic situation significantly [improved] air quality in different cities across the world, [reduced greenhouse gas] emission, [lessened] water pollution and noise, and [reduced] the pressure on the tourist destinations, which may assist with the restoration of the ecological system."[1]

Likewise, the COVID-19 pandemic had significant impacts on transportation greenhouse gas (GHG) emissions at the Lab. Air travel GHG emissions dropped 4,756 MT CO_2e, a 66 percent decrease from fiscal year 2019, while employee GHG emissions decreased by 1,267 MT CO_2e, a 33 percent drop from fiscal year 2019. These transportation GHG emission reductions were due to the Laboratory's implementation of its limited operations plan (consistent with New York State and DOE guidelines) from March 23 to September 30, 2020.

The various impacts of COVID-19 on the Brookhaven Lab environmental program are discussed in greater detail throughout each chapter of this year's report.

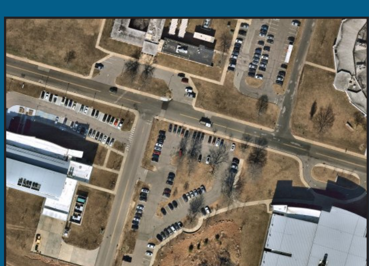
About the Cover

The cover photo for this year's Site Environmental Report was taken by Douglas Beard, Radiological Control Supervisor for Cabrera Services, Inc., on Jan. 12, 2021, at sunrise from atop the "stack," one of the highest vantage points at the Lab for more than 70 years until its recent demolition. Beard captured the image while implementing radiological controls of the International Chimney Corporation (ICC) Commonwealth Mantis working platform, one of the primary tools ICC used for the Bldg. 750 Stack Demolition Project at Brookhaven.

This view, looking southeast, highlights how the Lab is situated in the heart of the Long Island Pine Barrens, a key natural resource of Long Island and New York State.

The lower photos were taken by Near Map Aerial Photography Services and show the comparison in parking volume before and after the pandemic at the NSLS-II and the Center for Functional Nanomaterials parking lots.

[1] *https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7498239/*



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The report is available to the general public on the internet at http://www.bnl.gov/ewms/ser/.
To obtain a copy of the report, please write or call:

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SITE ENVIRONMENTAL REPORT

BROOKHAVEN NATIONAL LABORATORY

Volume I

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EXPLORING EARTH'S MYSTERIES
...PROTECTING ITS FUTURE

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Executive Summary

Brookhaven National Laboratory (BNL) is managed on behalf of the Department of Energy (DOE) by Brookhaven Science Associates (BSA), a partnership between the Research Foundation for the State University of New York on behalf of Stony Brook University and Battelle. For over 70 years, the Laboratory has played a lead role in the DOE Science and Technology mission and continues to contribute to the DOE's missions in energy resources, environmental quality, and national security. BNL manages its world-class scientific research with particular sensitivity to environmental issues and community concerns. The Laboratory's Environmental, Safety, Security, and Health (ESSH) Policy reflects the commitment of BNL's management to fully integrate environmental stewardship into all facets of its mission and operations.

BNL prepares an annual Site Environmental Report (SER) in accordance with DOE Order 231.1B, Environment, Safety, and Health Reporting. The report is written to inform the public, regulators, employees, and other stakeholders of the Laboratory's environmental performance during the calendar year in review. Volume I of the SER summarizes environmental data; environmental management performance; compliance with applicable DOE, federal, state, and local regulations; and performance in restoration and surveillance monitoring programs. BNL has prepared annual SERs since 1971 and has documented nearly all its environmental history since the Laboratory's inception in 1947.

Volume II of the SER, the Groundwater Status Report, is also prepared annually to report on the status of groundwater protection and restoration efforts. Volume II includes detailed technical summaries of groundwater data and treatment system operations and is intended for regulators and other technically oriented stakeholders. A summary of the information contained in Volume II is included in Chapter 7, Groundwater Protection, of this volume.

Both reports are available in print and as downloadable files on the BNL web page at https:// www. bnl.gov/ esh/env/ser/.

As described in the Inside Cover of this year's report, calendar year 2020 witnessed extraordinary circumstances created by the COVID-19 pandemic. This Executive Summary highlights some of the pandemic's impacts on Laboratory usage of natural resources, as well as environmental compliance and regulatory activities. These topics are explored in further detail throughout the chapters.

ENVIRONMENTAL MANAGEMENT SYSTEM

The Laboratory's Integrated Safety Management System (ISMS) incorporates management of environment (i.e., environmental protection and pollution prevention), safety, and health (ES&H) issues into all work planning. BNL's ISMS ensures that the Laboratory integrates DOE's five Core Functions and seven Guiding Principles into all work processes. These processes contributed to BNL's achievement of registration under the International Organization for Standardization (ISO) 14001 Standard for the Laboratory's Environmental Management System (EMS). This standard requires an organization to develop a policy, create plans to implement the policy, implement the plans, check progress and take correction actions, and review the system periodically to ensure its continuing suitability, adequacy, and effectiveness.

An EMS was fully established at BNL in 2001 to ensure that environmental issues are systematically identified, controlled, and monitored. The EMS also provides mechanisms for responding to changing environmental conditions and requirements, reporting on environmental performance, and reinforcing continual environmental improvement. The cornerstone of the Laboratory's EMS is the ESSH Policy. The policy makes clear the Laboratory's commitment to environmental stewardship, the safety and health of its employees, and the security of the site. Specific environmental commitments in the policy include compliance, pollution prevention, conservation, community outreach, and continual improvement. The policy is posted throughout the Laboratory and on the BNL website. It is also included in all training programs for new employees, guests, and contractors.

The Laboratory's EMS was designed to meet the rigorous requirements of the globally recognized ISO 14001 Environmental Management Standard. BNL was the first DOE Office of Science Laboratory to become officially registered to this standard. BNL's external certification organization, ERM Certification Verification Services, conducted an external surveillance audit of BNL's conformance to the ISO 14001 Standard in July 2020. The Surveillance identified no nonconformances and determined that the Laboratory was in full conformance to the Standard; therefore, BNL will maintain its current certification.

BNL follows Executive Order (EO) 13834, Efficient Federal Operations, which replaced EO 13693, Planning for Federal Sustainability in the Next Decade, in 2018. The order establishes sustainability goals for federal agencies with a focus on sustainability initiatives that save money and increase efficiency across the government with guidance, recommendations, plans, and numerical targets. DOE Order 436.1, Departmental Sustainability, provides requirements and responsibilities for managing sustainability within DOE to ensure facilities are working towards sustainability goals established in its Strategic Sustainability Performance Plan (SSPP) pursuant to EO 13834. Each DOE facility is required to have a Site Sustainability Plan (SSP) in place detailing the strategy for achieving these long-term goals and due dates and to provide an annual status. The requirements influence the future of the Laboratory's EMS program and have been incorporated into BNL's SSP. For a status summary of BNL's 2020 SSP, see Appendix E.

The Laboratory's Pollution Prevention (P2) Program is an essential element for the successful implementation of BNL's EMS. The P2 Program reflects the national and DOE pollution prevention goals and policies and represents an ongoing effort to make pollution prevention and waste minimization an integral part of the Laboratory's operating philosophy.

Pollution prevention and waste reduction goals have been incorporated as performance measures into the DOE contract with BSA and BNL's ESSH Policy. The overall goal of the P2 Program is to create a systems approach that integrates pollution prevention and waste minimization, resource conservation, recycling, and affirmative procurement into all planning and decision making. The implementation of pollution prevention opportunities, recycling programs, and conservation initiatives continues to reduce both waste volumes and management costs.

In 2020, the P2 Program resulted in nearly $1.7 million in cost avoidance or savings and resulted in the reduction or reuse of approximately 0.9 million pounds of waste. Reduced revenue and volume of recyclables compared to previous years are a direct impact of limited operational status caused by the COVID-19 pandemic. The P2 Program funded 15 new proposals, investing approximately $21,500. The proposals involved reducing risk, promoting use of bio-friendly alternative products, improving small energy efficiency projects or reducing water, and promoting overall environmentally sustainable business practices.

The baseline recycling rate goal for federal facilities is 50 percent. BNL's annual average recycling rate consistently outperforms the baseline. The 2020 annual recycling rate was 63 percent.

As a testament to its strong environmental program, the Lab received the Green Electronics Council's Electronic Product Environmental Assessment Tool Gold Award, the DOE's GreenBuy Award, and a second GreenBuy Prime Award.

BNL continues to decrease its energy consumption and increase savings. In each of the past ten years, the water consumption total was approximately half the 1999 total—a reduction of nearly a half billion gallons per year. In 2020, natural gas was used to meet over 99 percent of the heating and cooling needs of the Laboratory's major facilities, further reducing greenhouse gas (GHG) emissions. Additional information on natural gas and fuel oil use can be found in Chapter 4.

The Laboratory also scheduled operations at the Relativistic Heavy Ion Collider to avoid peak demand periods. This reduced the electric demand by approximately 25 megawatts, saving approximately $1.4 million in electric demand costs.

In 2020, BNL maintained its contract with the New York Power Authority, resulting in an overall cost avoidance of $29.1 million.

In addition, the 2020 output from the Lab's Long Island Solar Farm (LISF) was 48 million kWh and resulted in an avoidance of approximately 26,000 tons of carbon.

Chapter 2 of this report further describes these and other sustainability efforts, as well as implementation of BNL's EMS and P2 Program, in more detail.

BNL'S ENVIRONMENTAL MANAGEMENT PROGRAM

BNL's Environmental Management Program consists of several Laboratory-wide and facility-specific environmental monitoring and surveillance programs. These programs identify potential pathways of public and environmental exposure and evaluate the impacts BNL activities may have on the environment. An overview of the Laboratory's environmental programs and a summary of performance for 2020 are provided below.

COMPLIANCE MONITORING PROGRAM

BNL has an extensive program in place to ensure compliance with all applicable regulatory and permit requirements. The Laboratory must comply with more than 100 sets of federal, state, and local environmental regulations; numerous site-specific permits; ten equivalency permits for the operation of groundwater remediation systems; and several other binding agreements.

In 2020, the Laboratory operated in compliance with most of the requirements; any instance of noncompliance was reported to regulatory agencies and corrected expeditiously, or a plan was put in place to come into compliance. Emissions of nitrogen oxides, carbon monoxide, and sulfur dioxide from the Central Steam Facility (CSF) were well within permit limits in 2020.

Recorded excess opacity measurements from CSF boilers were investigated and documented in quarterly Site-Wide Air Emissions and Monitoring Systems Performance Reports submitted to the New York State Department of Environmental Conservation (NYSDEC).

There were no discharges of Halon 1211 from portable fire extinguishers or Halon 1301 from accidental or fireinduced activation of fixed fire suppression systems in 2020. Portable Halon fire extinguishers continue to be removed and replaced by dry-chemical or clean agent units as part of an ongoing program to phase out the use of chlorofluorocarbons as extinguishing agents to eliminate possible ozone-depleting substance emissions.

With the exception of a lead action level exceedance in August, BNL's drinking water and the supply and distribution system were in compliance with all applicable county, state, and federal regulations regarding drinking water quality, monitoring, operations, and reporting in 2020. Most of the liquid effluents discharged to surface water and groundwater also met applicable New York State Pollutant Discharge Elimination System (SPDES) permit requirements.

An investigation into the cause(s) of tolyltriazole (TTA) exceedances at the Sewage Treatment Plant (STP) and associated corrective actions continued throughout 2020. BNL staff continue to work closely with the DOE and NYSDEC to identify possible solutions.

In 2020, groundwater monitoring at the Laboratory's Major Petroleum Facility (MPF) and Waste Management Facility (WMF) demonstrated that current operations are not affecting groundwater quality.

As part of the ongoing CERCLA program, BNL continued the surveillance and maintenance of the Brookhaven Graphite Research Reactor (BGRR) and the HFBR. The exterior coating abatement of the HFBR stack was completed and demolition of the stack was initiated in December. Due to contractor mobilization delays related to COVID-19, DOE submitted a milestone extension request to the EPA and NYSDEC in August 2020 to extend the administrative closeout until July 2021.

Efforts to implement release prevention measures and minimize impacts of spills of materials continued in 2020. There were 14 spills in 2020 and four of those spills met regulatory agency reporting criteria. All spills were immediately cleaned up and waste was properly disposed.

Hazardous waste from routine operations decreased during 2020, mostly due to the Lab's limited operational status related to COVID-19. There was also a significant reduction in non-routine waste generation during 2020 due to the Lab's limited operational status. No major construction or demolition projects occurred during 2020.

In 2020, due to the pandemic, inspections by federal, state, or local regulators were limited. BNL was inspected on seven occasions. These inspections included STP operations, hazardous waste management facilities, and the potable water system. Immediate corrective actions were taken to address all compliance issues raised during these inspections.

The DOE Brookhaven Site Office (BHSO) continued to provide oversight of BNL programs during 2020 and participated as an observer of BSA's Multi-Topic Assessment of BNL's environmental protection programs. BHSO participation comprised of observing BSA's scoping, assessment conduct, and reporting.

Despite the COVID-19 pandemic, BNL proactively communicated with its internal and external stakeholders through virtual platforms during 2020. Monthly interagency calls were held, and the Summer Sunday series was held virtually. Additionally, all regularly scheduled Community Advisory Council and Brookhaven Executive Roundtable meetings were held virtually to ensure continued and timely communication with the community.

Chapter 3 of this report describes BNL's Compliance Program and status in further detail.

AIR QUALITY PROGRAM

BNL monitors radioactive emissions at three facilities to ensure compliance with the requirements of the Clean Air Act. Environmental Protection Agency (EPA) regulations require continuous monitoring of all sources that have the potential to deliver an annual radiation dose greater than 0.1 mrem to a member of the public; all other facilities capable of delivering any radiation dose require periodic confirmatory sampling.

BNL has two active facilities: the Brookhaven Linac Isotope Producer (BLIP), whose emissions are continuously monitored with an inline detection system, and the Target Processing Laboratory (TPL), which has a particulate filter sampling system to continuously collect samples for gross alpha and gross beta activity, and one inactive facility, the High Flux Beam Reactor (HFBR), where periodic emissions monitoring is conducted.

During 2020, BNL facilities released a total of 0.242 Curies of tritium. Because the Lab used natural gas to meet 99 percent of its heating and cooling needs in 2020, emissions of particulates, oxides of nitrogen, sulfur dioxide, and volatile organic compounds were well below the respective regulatory permit criteria pollutant limits.

In 2020, the LISF, a large array of more than 164,000 solar photovoltaic panels constructed on the BNL site, provided 48 million kilowatt-hours of solar energy to Long Island. This equates to 25,988 metric tons CO_2 equivalents (MT CO_2e) GHG offset or reduction. BNL consumed 116,430 megawatts of hydropower, providing a net combined GHG reduction of 39,117 MT CO_2e from the LISF and hydropower.

The COVID-19 pandemic had significant impacts on air travel GHG emissions. Air travel GHG emissions dropped 4,756 MT CO_2e, a 66 percent decrease from fiscal year 2019, while employee GHG emissions decreased by 1,267 MT CO_2e, a 33 percent drop from fiscal year 2019. These transportation GHG emission reductions were due to the Laboratory's implementation of its limited operations plan (consistent with New York State and DOE guidelines) from March 23 to September 30, 2020.

Chapter 4 of this report describes BNL's Air Quality Program, monitoring data, and other GHGreducing efforts in further detail.

WATER QUALITY SURVEILLANCE PROGRAM

Wastewater generated from BNL operations is treated at the STP before it is discharged to nearby groundwater recharge basins. Some wastewater may contain very low levels of radiological, organic, or inorganic contaminants. Monitoring, pollution prevention, and vigilant operation of treatment facilities ensure that these discharges comply with all applicable regulatory requirements and that the public, employees, and the environment are protected.

Analytical data for 2020 shows that the average gross alpha and beta activity levels in the STP discharge (EA, Outfall 001) were within the typical range of historical levels and well below New York State Drinking Water Standards (NYS DWS). Tritium was detected once above method detection limits (MDL) in the STP discharge in January 2020. No cesium-137, strontium-90, or other gamma-emitting nuclides attributable to Laboratory operations were detected. Non-radiological monitoring of the STP effluent showed that, with the exception of tolyltriazole exceedances, organic and inorganic parameters were within SPDES effluent limits or other applicable standards.

Stormwater and cooling water discharges to recharge basins are sampled throughout the year and analyzed for gross alpha and beta activity, gamma-emitting radionuclides, and tritium. Each recharge basin is a permitted point-source discharge under the Laboratory's SPDES permit. In 2020, the average concentrations of gross alpha and beta activity in stormwater and cooling water discharged to recharge basins were within typical ranges and no gamma-emitting radionuclides were detected.

Disinfection byproducts continue to be detected at low concentrations above the MDL in discharges to recharge basins due to the use of chlorine and bromine for the control of algae and bacteria in potable and cooling water systems. Inorganics (i.e., metals) were detected; however, their presence is due primarily to sediment runoff in stormwater discharges.

The Peconic River did not flow offsite in 2020. Radiological data from Peconic River surface water sampling show that the average concentrations of gross alpha and gross beta activity from on-site locations were indistinguishable from control locations, and all detected levels were below the applicable NYS DWS. No gamma-emitting radionuclides attributable to Laboratory operations were detected either upstream or downstream of the former STP outfall, and tritium was not detected above MDL's in any of the surface water samples.

Chapter 5 of this report describes BNL's Water Quality Surveillance Program and monitoring data in further detail.

NATURAL AND CULTURAL RESOURCE MANAGEMENT PROGRAM

The BNL Natural Resource Management Program was designed to promote stewardship of the natural resources found on site and to integrate natural resource management and protection with the Laboratory's scientific mission. The program includes protecting and monitoring the ecosystem on site, conducting research, and communicating the results with the public, stakeholders, and staff members.

BNL conducts routine monitoring of flora and fauna to assess the impact, if any, of past and present activities on the Laboratory's natural resources. In 2020, deer, vegetation, and soil sampling results were consistent with previous years' results.

In cooperation with NYSDEC, habitat surveys have been routinely conducted since 1999. In 2020, surveys were not completed due to time constraints and impacts from COVID-19.

To control the goose population, the Laboratory manages nesting through egg oiling under an annual permit from the U.S. Fish & Wildlife Service. In 2020, the nest management program was suspended due to restrictions associated with COVID-19.

High deer populations are a regional problem, and the Laboratory is just one area on Long Island with such an issue. The removal of 82 deer effectively brought the population to approximately 275 animals. With reproduction at approximately 55 percent, the population at the end of 2020 was estimated at approximately 425 deer. Efforts were underway in December 2020 to plan for the next round of population management in 2021.

Deer-related collisions on site decreased in 2020 compared to 2019, an indication of decreased population from the 2020 deer harvest as well as fewer employees onsite due to the COVID-19 pandemic.

In January 2020, the DOE announced the award for construction of the Electron-Ion Collider at BNL. This resulted in the development of an Environmental Evaluation and Notification Form that was submitted to the BHSO and a determination was issued that an Environmental

Assessment (EA) would be necessary. The EA was developed and presented to the Community Advisory Council in September 2020 and was further developed for submission to New York State by year's end.

The Laboratory sponsors a variety of educational and outreach activities involving natural resources. These programs are designed to help participants understand the ecosystem and to foster interest in science. Wildlife programs are usually conducted at BNL in collaboration with local agencies, colleges, and high schools. Ecological research is also conducted on site to update the current natural resource inventory, gain a better understanding of the ecosystem, and guide management planning.

In 2020, due to COVID-19 restrictions, Lab internships were required to be conducted virtually. However, the Environmental Protection Division was able to host one intern who focused on developing photo recognition software as part of the 4-Poster™ tick management project.

The Lab continued its collaboration with the State University of New York's School of Environmental Science and Forestry allowing for greater levels of research within the Central Pine Barrens and Upton Reserve. The collaboration continued a forest health monitoring program that began in 2019.

The Laboratory manages its cultural resources under requirements of the National Historic Preservation Act. In 2020, additional buildings over 50-years of age were evaluated and nineteen were determined to be eligible for the National Register of Historic Places.

Chapter 6 of this report describes BNL's natural and cultural resources in further detail.

GROUNDWATER PROTECTION MANAGEMENT PROGRAM

BNL has made significant investments in environmental protection programs over the past 25 years and continues to make progress in achieving its goal of preventing new groundwater impacts and remediating previously contaminated groundwater. The Laboratory's extensive groundwater monitoring well network is used to evaluate progress in restoring groundwater quality, comply with regulatory permit requirements, and monitor active research and support facilities where there is a potential for environmental impact.

Due to the detection of Per and Polyfluoroalkyl Substances (PFAS) in water samples collected from three BNL water supply wells in 2017, BNL conducted a search of available records to determine a source of PFAS. In 2018, BNL identified eight areas where firefighting foam containing PFAS had been used for firefighter training or fire suppression system maintenance from 1966 until 2008. Groundwater characterization confirmed the presence of PFAS in each of the eight areas, with the highest concentrations detected at the location of the BNL's former firehouse (1947-1985) and at the current firehouse (1986-present). The Laboratory continues its efforts to prevent new groundwater impacts and is vigilant in measuring and communicating its performance.

During 2020, BNL collected groundwater samples for PFAS and 1,4-dioxane analyses from approximately 360 on-site and off-site monitoring wells, as well as conducted a detailed characterization of the PFAS plumes associated with the current and former firehouse facilities to support the design of two groundwater treatment systems. The results for these samples are summarized in the 2020 Groundwater Status Report (BNL 2021).

Groundwater quality at BNL is routinely monitored through a network of on- and off-site wells. In addition to water quality assessments, water levels are routinely measured in monitoring wells annually to assess variations in the direction and velocity of groundwater flow.

During 2020, BNL collected groundwater samples from 802 permanent monitoring wells and 102 temporary wells during 1,816 individual sampling events. Groundwater elevations were measured in 160 monitoring wells for mapping purposes. Seven groundwater remediation systems removed 44 pounds of volatile organic compounds and returned approximately 823 million gallons of treated water to the Upper Glacial aquifer. Also, one groundwater treatment system removed approximately 0.4 millicurie of strontium-90 (Sr-90) while remediating approximately 16 million gallons of groundwater.

Since 2003, BNL has removed approximately 34 millicuries of Sr-90 from the groundwater while remediating 260 million gallons of groundwater.

As a result of the successful operation of these treatment systems, significant reductions in contaminant concentrations have occurred in several on- and offsite areas.

Chapter 7 of this report provides an overview of this program, and the SER Volume II, Groundwater Status Report, provides detailed descriptions, data, and maps relating to all groundwater monitoring and remediation performed in 2020.

RADIOLOGICAL DOSE ASSESSMENT PROGRAM

The Laboratory routinely reviews its operations to ensure that any potential radiological dose to members of the public, workers, and the environment is "As Low As Reasonably Achievable" (ALARA). The potential radiological dose to members of the public is calculated at an off-site location closest to an emission source as the maximum dose that could be received by an off-site individual, defined as the "maximally exposed off-site individual" (MEOSI). The dose to the MEOSI is the sum total from direct and indirect dose pathways via air immersion, inhalation of particulates and gases, and ingestion of local fish and deer meat.

In 2020, the total effective dose (TED) to the MEOSI of 0.913 mrem (9.13 µSv) from Laboratory operations was well below the dose limit of 100 mrem in a year required by DOE Order 458.1, as well as all other EPA and DOE regulatory dose limits for the public, workers, and the environment.

Dose to the maximally exposed individual (MEI) on site and outside of controlled areas, calculated from thermo-luminescent dosimeter monitoring records, was 27 mrem above natural background radiation levels, also well below the 100-mrem DOE limit on dose.

Based on a five-year analysis of measurement data for ambient radiation dose, the ambient dose decreased slightly in 2020 as readiness reviews took place in preparation for ramping up production testing for that same process. Dose to aquatic and terrestrial biota were also evaluated and found to be well below DOE regulatory limits. In summary, the overall dose impact from all Laboratory activities in 2020 was comparable to that of natural background radiation levels.

Chapter 8 of this report describes the BNL Radiological Dose Assessment Program and monitoring data in further detail.

QUALITY ASSURANCE PROGRAM

The multilayered components of the BNL Quality Assurance (QA) Program ensure that all analytical data reported in this report are reliable and of high quality and meet quality assurance and quality control objectives. Samples are collected and analyzed in accordance with EPA methods and BNL standard operating procedures that are designed to ensure samples are representative and the resulting data are reliable and defensible.

Quality control in the analytical laboratories is maintained through daily instrument calibrations, efficiency and background checks, and testing for precision and accuracy. Data are verified and validated as required by projectspecific quality objectives before being used to support decision making.

In 2020, environmental samples were analyzed by five contract analytical laboratories. All samples were analyzed according to EPA-approved methods or by standard industry methods where no EPA methods are available. In addition, field sampling technicians performed field monitoring for parameters such as conductivity, dissolved oxygen, pH, temperature, and turbidity. In 2020, procedures for calibrating instruments, analyzing samples, and assessing QC were consistent with EPA methodology.

The data validations, data verifications, and Data Quality Objective checks conducted on analytical results at BNL were designed to eliminate any data that fails to meet the DQO of each project. The results of the independent performance evaluation assessments and assessments of contractor laboratories summarized in this report were used to assess the quality of the results. Therefore, the data used in this Site Environmental Report are of acceptable quality.

Chapter 9 of this report describes the BNL Quality Assurance/Quality Control Program in further detail.

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2020 SITE ENVIRONMENTAL REPORT

The SER Team thanks the many Lab employees who contributed to and assisted with this report.

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(Back row, left to right) Jennifer Higbie, Timothy Green, Douglas Paquette, Jason Remien, and William Dorsch. (Front row, left to right) Larry Singh, Robert Howe, Jeffrey Williams, Amber Aponte, and Timothy Welty (not pictured: Deborah Bauer).

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A Note from the Editor

Throughout the Site Environmental Report, there are many references to Brookhaven National Laboratory (BNL), the U.S. Department of Energy (DOE), and the U.S. Environmental Protection Agency (EPA). These acronyms, and others that are explained in each chapter, are used interchangeably with their spelled-out forms as an aid to readers. The most up-to-date, accurate version of this report is online at *https://www.bnl.gov/esh/env/ser/.*

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1 Introduction

Established in 1947, Brookhaven National Laboratory (BNL) is one of ten national laboratories overseen and primarily funded by the U.S. Department of Energy's (DOE) Office of Science. The only multi-program national laboratory in the Northeast, the Laboratory is operated and managed by Brookhaven Science Associates (BSA), which was founded by the Research Foundation for the State University of New York on behalf of Stony Brook University, and Battelle, a non-profit applied science and technology organization. BNL is committed to longstanding partnerships with researchers, academic institutions, industry, students, teachers, and the surrounding community.

BSA has been managing and operating the Laboratory under a performance-based contract with DOE since 1998. From 1947 to 1998, BNL was operated by Associated Universities, Incorporated. Prior to 1947, the site operated as Camp Upton, a U.S. Army training camp, which was active from 1917 to 1921 during and after World War I and from 1940 to 1946 during World War II.

BNL has a history of outstanding scientific achievements. For nearly 75 years, Laboratory researchers have successfully worked to envision, construct, and operate large and innovative scientific facilities in pursuit of research advances in many fields. Programs in place at BNL emphasize continual improvement in environmental, safety, security, and health performance.

1.1 LABORATORY MISSION AND POLICY

BNL advances fundamental research in nuclear and particle physics to gain a deeper understanding of matter, energy, space, and time; applies photon sciences and nanomaterials research to solve energy challenges of critical importance to the nation; provides capabilities in computational science and data management for large-scale research and experimental endeavors; and performs cross-disciplinary research on computation, sustainable energy, national security, and earth's climate and ecosystems.

The fundamental elements of the Laboratory's role in support of DOE's strategic missions are the following:

- To conceive, design, construct, and operate complex, leading-edge, user-oriented research facilities in response to the needs of DOE and the international community of users;
- To carry out basic and applied research in long-term, high-risk programs at the frontier of science;
- To develop advanced technologies that address national needs and transfer them to other organizations and the commercial sector; and
- To disseminate technical knowledge, educate future generations of scientists and engineers, maintain technical capabilities in the nation's workforce, and encourage scientific awareness in the general public.

Brookhaven produces transformative science and advanced technologies, and does it safely, securely, and responsibly, with the cooperation and involvement of the local, state, and international scientific communities. BNL's Environmental, Safety, Security, and Health (ESSH) Policy articulates the Laboratory's commitment to continual improvement in ESSH performance. Under this policy, the Laboratory's goals are to protect the environment, conserve resources, and prevent pollution; maintain a safe workplace by planning work and performing it safely; provide security for people, property, information, computing systems, and facilities; protect human health within its boundaries and in the surrounding community; achieve and maintain compliance with applicable ESSH requirements; and maintain an open, proactive, and constructive relationship with employees, neighbors, regulators, DOE, and other stakeholders.

In 2001, BNL was the first DOE Office of Science National Laboratory to achieve full registration under the International Organization for Standardization (ISO) 14001 environmental management standard. This program is discussed in Chapter 2 of this report.

1.2 RESEARCH AND DISCOVERIES

The Laboratory operates cutting-edge large-scale facilities for studies in physics, chemistry, biology, medicine, applied science, and a wide range of advanced technologies. BNL's world-class research facilities are also available to university, industrial, and government personnel from around the world. The Laboratory integrates sustainable operations and environmental stewardship into all facets of its research and operations and is committed to managing its programs in a manner that protects the local ecosystem and public health.

Current research includes energy security to help address the world's need for new, more efficient, and sustainable energy sources powered by solar, wind, hydrogen, and other renewable sources; photon sciences, focusing ultra-bright light to reveal the structures of materials critically important to energy security, environment, and human health; quantum chromodynamics, using colliding sub-atomic particles to recreate matter from the dawn of time, and study the source that gives shape to visible matter in the universe today; physics of the universe, to explore cosmic mysteries across the smallest and largest scales, from neutrinos to dark energy; and climate, environment, and biosciences, to map climate change, greenhouse gas emissions, and plant biology to protect the planet's future.

In addition to major research activities, the Laboratory provides expertise and other programs in a range of areas including accelerator science and technology, biological imaging, homeland and national security, and advanced computation.

To date, researchers working at BNL have received seven Nobel Prizes, multiple National Medals of Science, National Medal of Technology and Innovation, National Academy of Sciences, Enrico Fermi Awards, Wolf Foundation Prizes, nearly 40 R&D 100 Awards, as well as other recognitions for discoveries made wholly or partly at BNL. Some significant discoveries and developments made at the Laboratory include new forms of matter, subatomic particles, technologies that fuel leading experimental programs around the world, and life-saving medical imaging techniques for diagnosis and treatment of disease.

Joanna Fowler, recipient of the 2009 National Medal of Science

1.3 HISTORY

BNL was founded in 1947 by the Atomic Energy Commission (AEC), a predecessor to the present DOE. The AEC provided the initial funding for BNL's research into peaceful uses of the atom. The objective was to promote basic research in the physical, chemical, biological, and engineering aspects of the atomic sciences. The result was the creation of a regional laboratory to design, construct, and operate large scientific machines that individual institutions could not afford to develop on their own.

Although BNL no longer operates any research reactors, the Laboratory's first major scientific facility was the Brookhaven Graphite Research Reactor (BGRR), which was the first reactor to be constructed in the United States following World War II. In operation from 1950 to 1968, the reactor's primary mission was to produce neutrons for scientific experimentation and to refine reactor technology. Decommissioning of the BGRR was completed in June 2012, and the remaining structures are currently undergoing long-term routine inspection and surveillance.

The High Flux Beam Reactor (HFBR) was in operation from 1965 through 1996. The facility was used solely for scientific research and provided neutrons for experiments in materials science, chemistry, biology, and physics. The HFBR also allowed researchers to study the basic nature of chemical structures, including the hydrogen bond that holds much of our world together. In late 1996, workers discovered that a leak in the HFBR spent fuel storage pool had been releasing tritium to the groundwater (see SER, Volume II, Groundwater Status Report, for further details). The reactor was shut down for routine maintenance at the time of the discovery and was never restarted. In November 1999, DOE decided that the HFBR would be permanently shut down. With input from the community, a final Record of Decision (ROD) was approved outlining the remedy for the HFBR's permanent decontamination and decommissioning.

Medical research at BNL began in 1950 with the opening of one of the first hospitals devoted to nuclear medicine. It was followed by the Medical Research Center in 1958 and the Brookhaven Medical Research Reactor (BMRR) in 1959. The BMRR was the first nuclear reactor in the nation to be constructed specifically for medical research. Due to a reduction of research funding, the BMRR was shut down in December 2000. All spent fuel from the BMRR has been removed and transported off site. The facility is currently in a "cold" shutdown mode as a radiological facility and has entered a period of surveillance and maintenance.

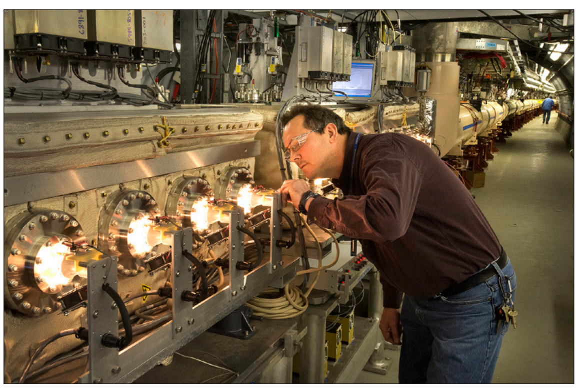
The Brookhaven Linac Isotope Producer (BLIP) has been in operation since 1972. Positioned at the forefront of research into radioisotopes used in cancer treatment and diagnosis, the BLIP produces commercially unavailable radioisotopes for use by the medical community and related industries. BLIP consists of an accelerator beam line and target area for generating radioisotopes already in high demand and for developing those required at the frontiers of nuclear medicine. In conjunction with this mission, scientists also perform irradiations for non-isotope applications and explore opportunities for emerging radioisotope applications.

High-energy particle physics research at BNL began in 1952 with the Cosmotron, the first particle accelerator to achieve billion-electron-volt energies. Work at the Cosmotron resulted in a Nobel Prize in 1957. After 14 years of service, the Cosmotron ceased operation in 1966 and was dismantled in 1969. Knowledge gained from the Cosmotron led to design improvements and paved the way for construction of the Alternating Gradient Synchrotron (AGS). The AGS is a much larger particle accelerator and became operational in 1960. The AGS has allowed scientists to accelerate protons to energies that have yielded many discoveries of new particles and phenomena, for which BNL researchers were awarded three Nobel Prizes. The AGS receives protons from BNL's linear accelerator (LINAC), designed and built in the late 1960s as a major upgrade to the AGS complex. The LINAC's purpose is to provide accelerated protons for use at AGS facilities and BLIP. The AGS booster, constructed in 1991, further enhanced the capabilities of the AGS, enabling it to accelerate protons and heavy ions to even higher energies.

AGS Control Room, circa 1966

The Tandem Van de Graaff accelerator began operating in 1970 and is the starting point of the chain of accelerators that provide ions of gold, other heavy metals, and protons for experiments at the Relativistic Heavy Ion Collider (RHIC). In 2010, BNL began operating a new heavy ion beam source for use by RHIC and the NASA Space Radiation Laboratory, the Electron Beam Ion Source (EBIS). This large electrostatic accelerator can provide researchers with beams of more than 40 different types of ions ranging from hydrogen to uranium. By simulating the effects of radiation both in space and on the ground, scientists and engineers from several other laboratories and companies are improving the reliability of computers.

RHIC began operation in 2000. Inside this two-ringed particle accelerator, two beams of gold ions, heavy metals, or protons circulate at nearly the speed of light and collide, head-on, releasing large amounts of energy. By smashing particles together to recreate the conditions of the early universe, scientists can explore the most fundamental building blocks of matter as they existed just after the Big Bang. This research unlocks secrets of the force that holds together 99 percent of the visible universe—everything from stars to planets and people—and triggers advances in science and technology that have applications in fields from medicine to national security. RHIC has been continuously upgraded and its productivity now exceeds its initial design by 100 times. The most recent upgrade is the Low-Energy RHIC Electron Cooling project, which supports a new research program.



Relativistic Heavy Ion Collider

The NASA Space Radiation Laboratory (NSRL) became operational in 2003. It is jointly managed by DOE's Office of Science and NASA's Johnson Space Center. The NSRL uses heavy ions to simulate space radiation and study the effects on biological specimens, such as cells, tissues, and DNA, as well as industrial materials. Studies are conducted to identify materials and methods that would reduce the risks astronauts will face on future long-term space missions.

The National Synchrotron Light Source (NSLS) used a linear accelerator and booster synchrotron to guide charged particles in orbit inside two electron storage rings for use in a wide range of physical and biological experiments. Using beams of very intense light in the x-ray, ultraviolet, and infrared spectra, the NSLS allowed scientists to study the structure of proteins, investigate the properties of new materials, and understand the fate of chemicals in the environment. Although the NSLS had been continually updated since its commissioning in 1982, the practical limits of its performance had been reached and operations permanently ceased in September 2014.

To continue advances in these fields, the NSLS-II was constructed. The NSLS-II generates intense beams of x-ray, ultraviolet, and infrared light and offers an array of sophisticated imaging techniques to capture atomic-level "pictures" of a wide variety of materials, from biological molecules to semi-conductor devices. NSLS-II has a nanometer-scale resolution—a key resource for researchers at BNL's Center for Fundamental Nanomaterials (CFN)—that will enhance the development of next-generation sustainable energy technologies and improve imaging of complex protein structures.

National Synchrotron Light Source II

The Laboratory's Research Support Building (RSB) was completed in 2006 and provides administrative and support functions in a single location for employees and visiting scientists. The RSB has been awarded the Leadership in Energy and Environmental Design (LEED) Silver certification from the U.S. Green Building Council. This award is based on five categories: sustainability, water efficiency, energy and atmosphere, materials and resources, and indoor environmental quality.

Construction of a 32-megawatt Long Island

Solar Farm (LISF) at BNL was completed in the fall of 2011 in collaboration with BP Solar, Long Island Power Authority, the State of New York, and other organizations. The LISF, when constructed, was the largest solar photo-voltaic (PV) electric generating plant in the eastern United States. Its goal is to help Long Island be less reliant on fossil fuel-driven power generation and to meet peak load demands from summertime air conditioning use. It is generating enough renewable energy to power approximately 4,500 homes and is helping New York State meets its clean energy and carbon reduction goals. The LISF will be one of the most studied solar installations, as it is a focal point of the Northeast Solar Energy Research Center at BNL. Compared to conventional electric-generating facilities on Long Island, the LISF drastically reduces local sources that contribute to climate change, such as reducing the amount of carbon dioxide by 30,950 metric tons per year and methane by 80 metric tons over 40 years.

BNL's CFN is one of five Nanoscale Science Research Centers funded by DOE's Office of Science and provides state-of-the-art tools for creating and exploring the properties of materials with dimensions spanning just billionths of a meter. CFN scientists are dedicated to atomic-level tailoring that addresses a wide range of energy challenges. CFN focus areas include improving solar cells and other electronic nano-materials; designing more efficient catalysts; developing new capabilities and uses for electron microscopy; and nanofabrication based on soft and biological nanomaterials—all aided by theory and advanced computation. The CFN building has also been awarded LEED Silver certification.

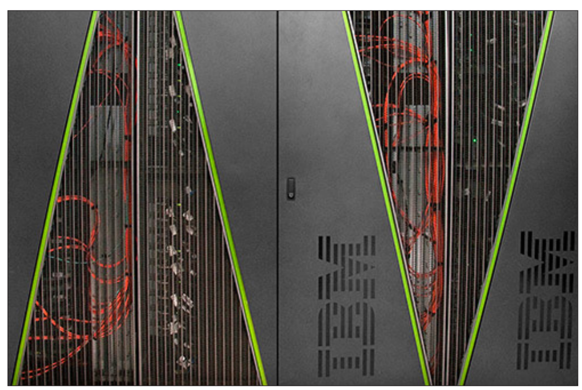
The Interdisciplinary Science Building (ISB), completed in 2013, is an energy-efficient and environmentally sustainable building that provides labs, offices, and support functions to bring together a broad spectrum of researchers, including industry, universities, and other national laboratories. The ISB fosters energy research, focusing on the effective uses of renewable energy through improved conversion, transmission, and storage. The ISB has been awarded LEED Gold certification.

Brookhaven Lab is establishing itself as a global leader in tackling the challenges of Big Data, building on existing expertise, capabilities, and investments in computational science and data management, and enabling scientific discovery in large-scale experimental environments.

Based in the former NSLS-I facility, and established in 2016, the Computational Science Initiative (CSI) oversees the following areas: Computer Science and Applied Mathematics, Computing for National Security, Scientific Data and Computing Center, Computation and Data-Driven Discovery, and the Computational Science Lab.

CSI takes a multidisciplinary, collaborative approach to its research, targeting challenges in cooperation with fellow researchers in science, national security, and industry, both at home and abroad.

BNL operates a Blue Gene Q as part of three facilities/collaborations. The Blue GeneQ is connected to 1PB of NFS storage. Researchers in biology, chemistry, physics, and medicine together with applied mathematicians and computer scientists—from Brookhaven, Stony Brook University, Columbia University, and other collaborating institutions—use these tools to address questions in computational biology, nano-science, sustainable energy, environental science, and homeland security.



Blue Gene/Q, Computational Science Initiative

While these facilities have set the stage for exciting and world-changing discoveries and innovations over the course of its more than 70-year history, BNL aims to continually improve and innovate its infrastructure. Efforts to improve the face of the Laboratory have been underway for years, by eliminating aging infrastructure and envisioning and constructing sophisticated new facilities. One such exciting development is Discovery Park, a transformative vision for the Lab's

Figure 1-1. Major Scientific Facilities at BNL.

1. Relativistic Heavy Ion Collider
2. NASA Space Radiation Laboratory
3. Alternating Gradient Synchrotron
4. Alternating Gradient Synchrotron Booster
5. Brookhaven Linac Isotope Producer and Linear Accelerator
6. Tandem to Booster
7. Interdisciplinary Science Building
8. Center for Functional Nanomaterials
9. National Synchrotron Light Source II
10. Computational Science Initiative
11. Tandem Van de Graaff and Cyclotron
12. Accelerator Test Facilities
13. Medical Isotope Research Laboratories

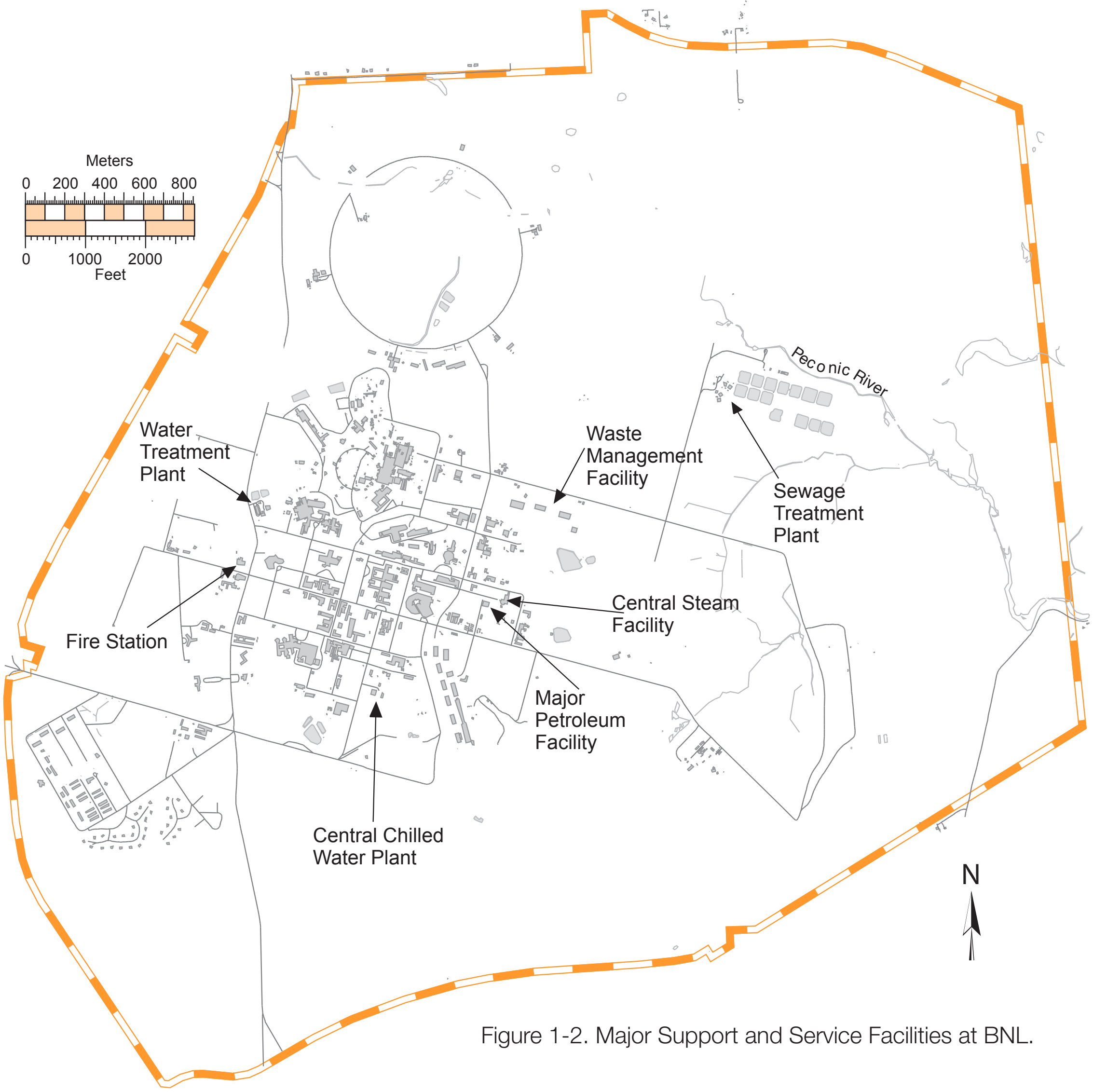


Figure 1-2. Major Support and Service Facilities at BNL.

entryway to welcome visitors, provide housing for facility users and guests, and offer new opportunities for private industry to collaborate. It will also provide an opportunity for economic and community development on Long Island, New York State, and beyond. The Discovery Park concept is built upon environmentally responsible development that aligns with the interests of the DOE, Brookhaven Lab, and the regional New York and Long Island economies.

Plans for Discovery Park include Upton Square and a Technology Park, and the Science User Support Center (SUSC), the first building among

A rendering of the future Science and User Support Center several planned for Discovery Park. The SUSC and Discovery Park, more broadly, will help the Lab reach its mission support goal for a renewed research campus. Additionally, reducing the Lab's building footprint will help minimize costs for overall operations and maintenance. The SUSC will be the only federally funded building in Discovery Park. Other buildings planned for Discovery Park will be funded privately.

Before that building's construction begins, a major project to install a traffic circle along the road to the Lab's main gate was completed in 2019.

1.4 FACILITIES AND OPERATIONS

Most of the Laboratory's principal facilities are located near the center of the site. The developed area is approximately 1,820 acres consisting of the following:

- 500 acres originally developed by the Army as part of Camp Upton, and still used for offices and other operational buildings
- 200 acres occupied by large, specialized research facilities
- 520 acres used for outlying facilities, such as the STP, ecology field, housing facilities, and fire breaks
- 400 acres of roads, parking lots, and connecting areas
- 200 acres occupied by the LISF

The balance of the site, approximately 3,400 acres, is mostly wooded and represents the native pine barrens ecosystem. The location of the major scientific facilities at BNL are shown on Figure 1-1. Additional facilities, shown on Figure 1-2 and briefly described below, support BNL's science and technology mission by providing basic utility and environmental services.

- *Central Chilled Water Plant.* This plant provides chilled water sitewide for air conditioning and process refrigeration via underground piping. The plant has a large refrigeration capacity and reduces the need for local refrigeration plants and air conditioning.
- *Central Steam Facility (CSF).* This facility provides high-pressure steam for facility and process heating sitewide. Either natural gas or fuel oil can be used to produce the steam, which is conveyed to other facilities through underground piping. Condensate is collected and returned to the CSF for reuse to conserve water and energy.
- *Fire Station.* The Fire Station houses six response vehicles. The BNL Fire Rescue Group provides on-site fire suppression, emergency medical services, hazardous material response, salvage, and property protection.
- *Major Petroleum Facility (MPF).* This facility provides reserve fuel for the CSF during times of peak operation. With a total capacity of 1.9 million gallons, the MPF primarily stores No. 6 fuel oil. The 1997 conversion of CSF boilers to burn natural gas and oil has significantly reduced the Laboratory's reliance on oil as a sole fuel source when other fuels are more economical.
- *Sewage Treatment Plant (STP).* This plant treats sanitary and certain process wastewater from BNL facilities prior to discharge into groundwater recharge beds, similar to the operations of a municipal sewage treatment plant. The plant has a design capacity of three million gallons per day. Effluent is monitored and controlled under a permit issued by the New York State Department of Environmental Conservation.
- *Waste Management Facility (WMF).* This facility is a state-of-the-art complex for managing the wastes generated from BNL's research and operations activities. The facility was built with advanced environmental protection systems and features and began operation in December 1997.
- *Water Treatment Plant (WTP).* The potable water treatment plant has a capacity of five million gallons per day. Potable water is obtained from five on-site wells. Water pumped from three supply wells located in the western section of the site is treated at the WTP with a lime-softening process to remove naturally occurring iron and with sodium hypochlorite for bacterial control. The plant is also equipped with dual air towers to ensure that volatile organic compounds are at or below New York State drinking water standards. Water from two supply wells located in the eastern section of the developed site is treated by the addition of sodium hydroxide to increase the pH of the water to make it less corrosive and control bacteria.

Past operations and research at the BNL site, dating back to the early 1940s when it was Camp Upton, have resulted in localized environmental contamination. As a result, the Laboratory was added to the federal Comprehensive Environmental Response, Compensation and Liability Act National Priorities List of contaminated sites in 1989. One of 40 sites on Long Island identified for priority cleanup, BNL has made significant progress toward improving environmental operations and remediating past contamination. DOE will continue to fund cleanup projects until the Laboratory is restored and removed from the National Priorities List. Major accomplishments in cleanup activities at BNL are discussed further throughout this report.

1.5 LOCATION, LOCAL POPULATION, AND LOCAL ECONOMY

Brookhaven Lab is the only national laboratory located in the Northeast and one of New York State's largest centers of scientific research, and places special emphasis on growing the technology-based elements of the Long Island economy. The future competitiveness of New York's economy depends on its capacity for innovation, and Brookhaven represents a uniquely valuable resource—both as a major science-based enterprise, and as a source of discoveries that drive entrepreneurs and innovators.

BNL is located near the geographical center of Suffolk County, Long Island, New York. The Laboratory's 5,320-acre site is located in

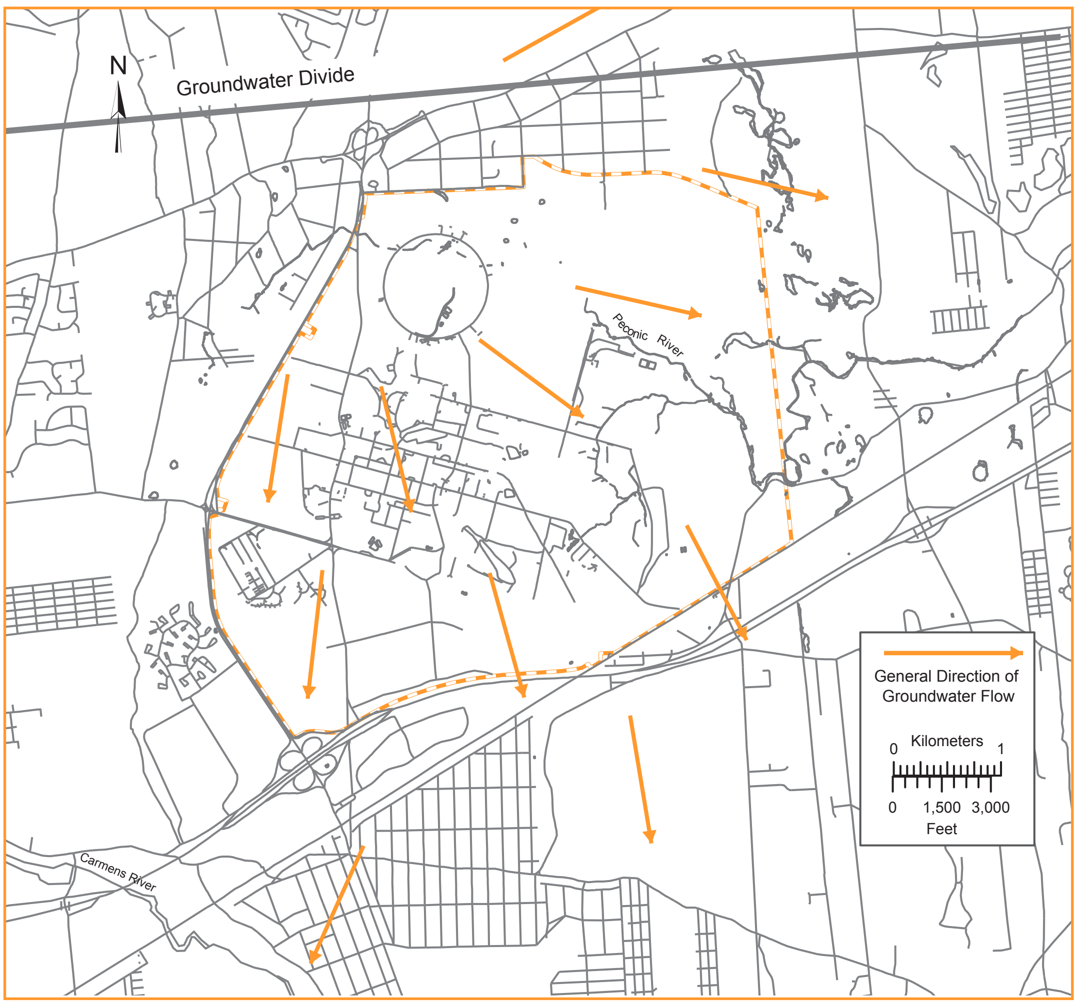


Figure 1-3. BNL Groundwater Flow Map.

Brookhaven Town, approximately 65 miles east of midtown Manhattan. Brookhaven Lab employs 2,550 employees who include scientists, engineers, technicians, and support staff. In addition, the Laboratory annually hosts more than 5,000 visiting scientists and students from universities, industries, and government agencies, who often stay in apartments and dormitories onsite or in nearby communities.

Aerial, Brookhaven Lab, 2013

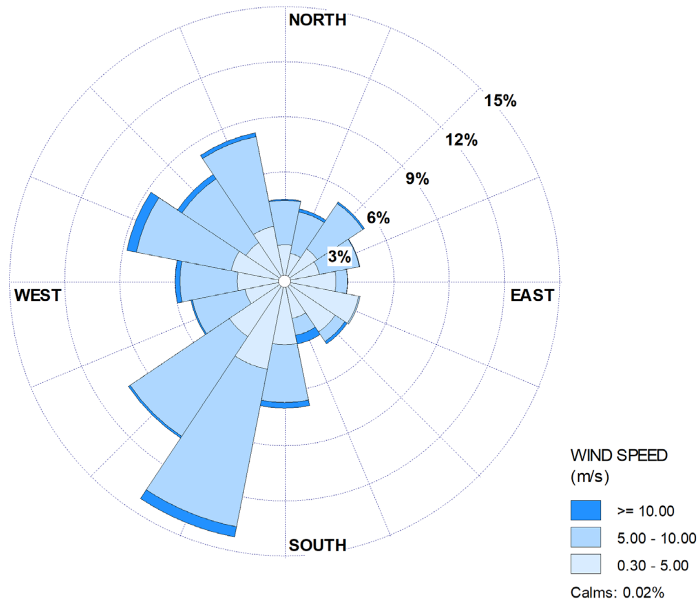
BNL strengthens Long Island's position as a center of innovation in energy, materials sciences, nanotechnology, and other fields crucial to the growth of New York State's economy. With more than 2,500 employees, 5,075 visiting facility users and guest researchers, and a fiscal year 2020 budget of $752 million, the Lab has a significant economic impact on New York State. In 2020, Lab employee salaries, wages, and fringe benefits accounted for approximately $407 million, or 54 percent of its total budget. Supporting local and state businesses whenever possible, the Lab spent just over $50 million in 2020 on goods and services in New York State alone, about $36 million of that with Long Island companies.

1.6 GEOLOGY AND HYDROLOGY

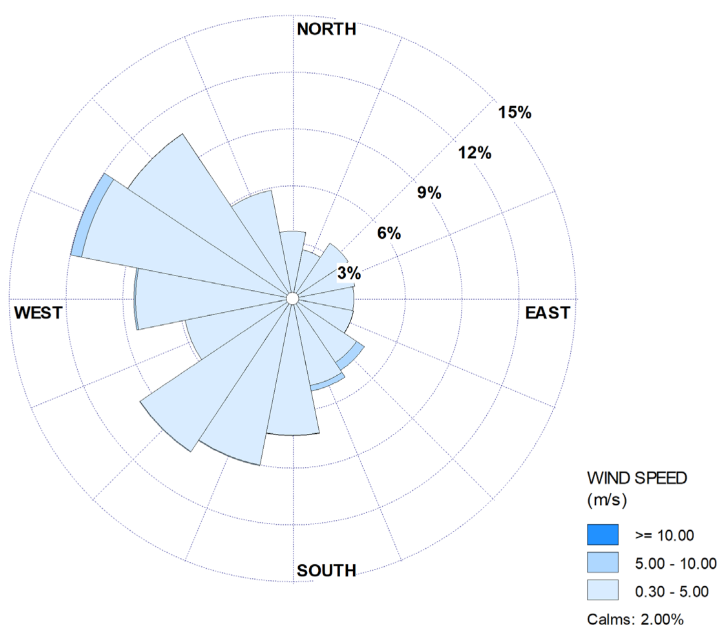
BNL is situated on the western rim of the shallow Peconic River watershed. The marshy areas in the northern and eastern sections of the site are part of the headwaters of the Peconic River. Depending on the height of the water table relative to the base of the riverbed, the Peconic River both recharges to and receives water from the underlying Upper Glacial aquifer. In times of sustained drought, the river water recharges to the groundwater; with normal to above-normal precipitation, the river receives water from the aquifer. The terrain of the BNL site is gently rolling, with elevations varying between 44 and 120 feet above mean sea level. Depth to groundwater from the land surface ranges from five feet near the Peconic River to approximately 80 feet in the higher elevations of the central and western portions of the site. Studies of Long Island hydrology and geology near the Laboratory indicate that the uppermost Pleistocene deposits, composed of highly permeable glacial sands and gravel, are between 120 and 250 feet thick (Warren et al., 1968; Scorca et al., 1999). Water penetrates these deposits readily and there is little direct runoff into surface streams unless precipitation is intense. The sandy deposits store large quantities of water in the Upper Glacial aquifer. On average, approximately half of the annual precipitation is lost to the atmosphere through evapotranspiration, and the other half percolates through the soil to recharge the groundwater (Franke & McClymonds, 1972; Aronson & Seaburn, 1974).

The Long Island Regional Planning Board and Suffolk County have identified the Laboratory site as overlying a deep-flow recharge zone for Long Island groundwater (Koppelman, 1978). Precipitation and surface water that recharge within this zone have the potential to replenish the Magothy and Lloyd aquifer systems lying below the Upper Glacial aquifer. It has been estimated that up to two-fifths of the recharge from rainfall moves into the deeper aquifers. The extent to which groundwater on site contributes to deep-flow recharge has been confirmed using an extensive network of shallow and deep wells installed at BNL and surrounding areas (Geraghty & Miller, 1996). This groundwater system is the primary source of drinking water for both on- and off-site private and public supply wells and has been designated a sole source aquifer system by the U.S. Environmental Protection Agency.

The Laboratory's five in-service drinking water wells draw up to 1,000 gallons per minute, or approximately 1.34 million gallons of water per day, from the aquifer to supply drinking water, process cooling water, or fire protection. This water is treated to remove contaminants and is then returned to the aquifer by way of recharge basins or injection wells. In 2020, BNL pumped



Wind Rose for Jan. 1 to Dec. 31, 2020 taken at the 85m height



Wind Rose for Jan. 1 to Dec. 31, 2020 taken at the 10m height

Explanation: Wind direction was measured at heights of 10 (bottom) and 85 (top) meters above the ground. The readings were plotted on the charts to indicate how often wind came from each direction. The concentric circles represent multi-percentage increases in the frequency. For example, at 10 meters above the ground, wind was from due south seven percent of the time. The predominant wind direction in 2020 was from the northwest at the 10-m level and from the southwest at the 85-m level.

Figure 1-4. BNL Wind Rose (2020).

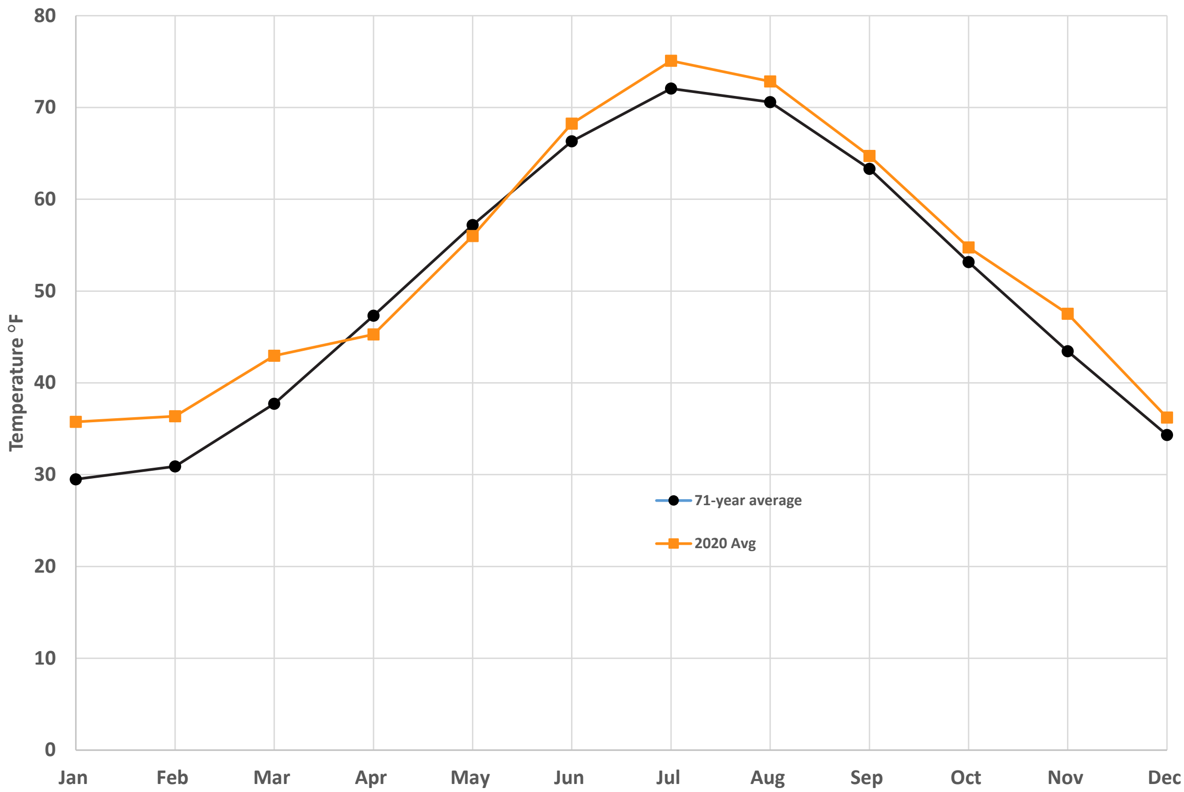


Figure 1-5. BNL 2020 Monthly Mean Temperature versus 71-Year Monthly Average.

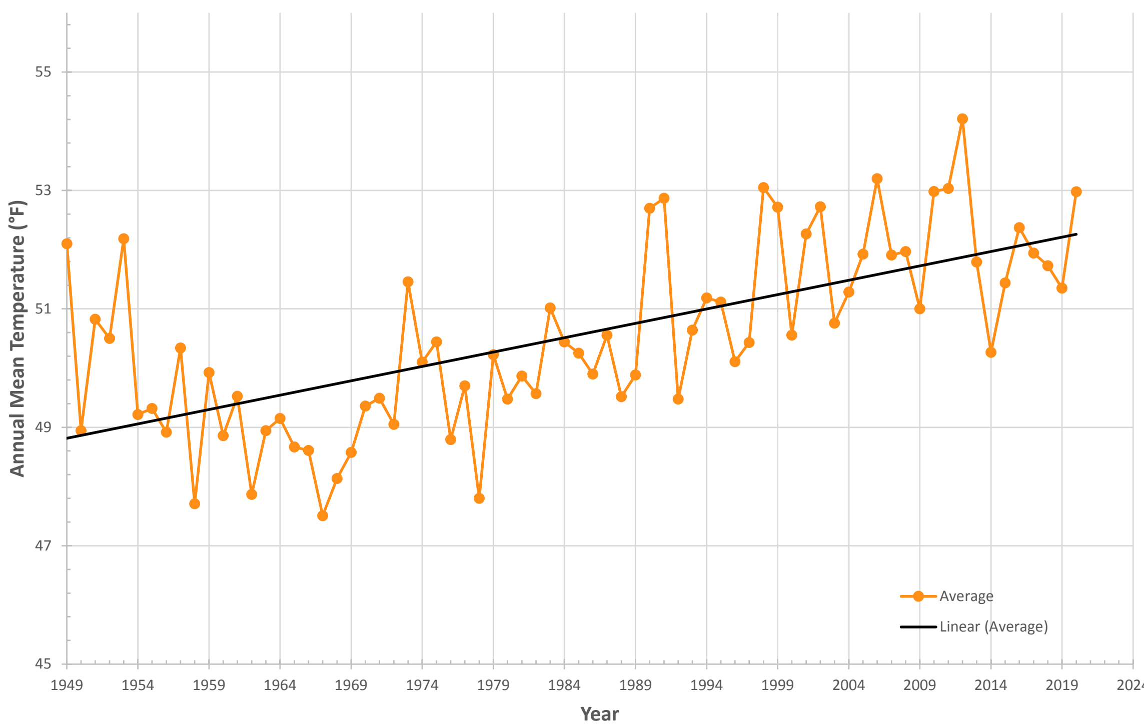


Figure 1-6. BNL 2020 Annual Mean Temperature Trend (71 Years).

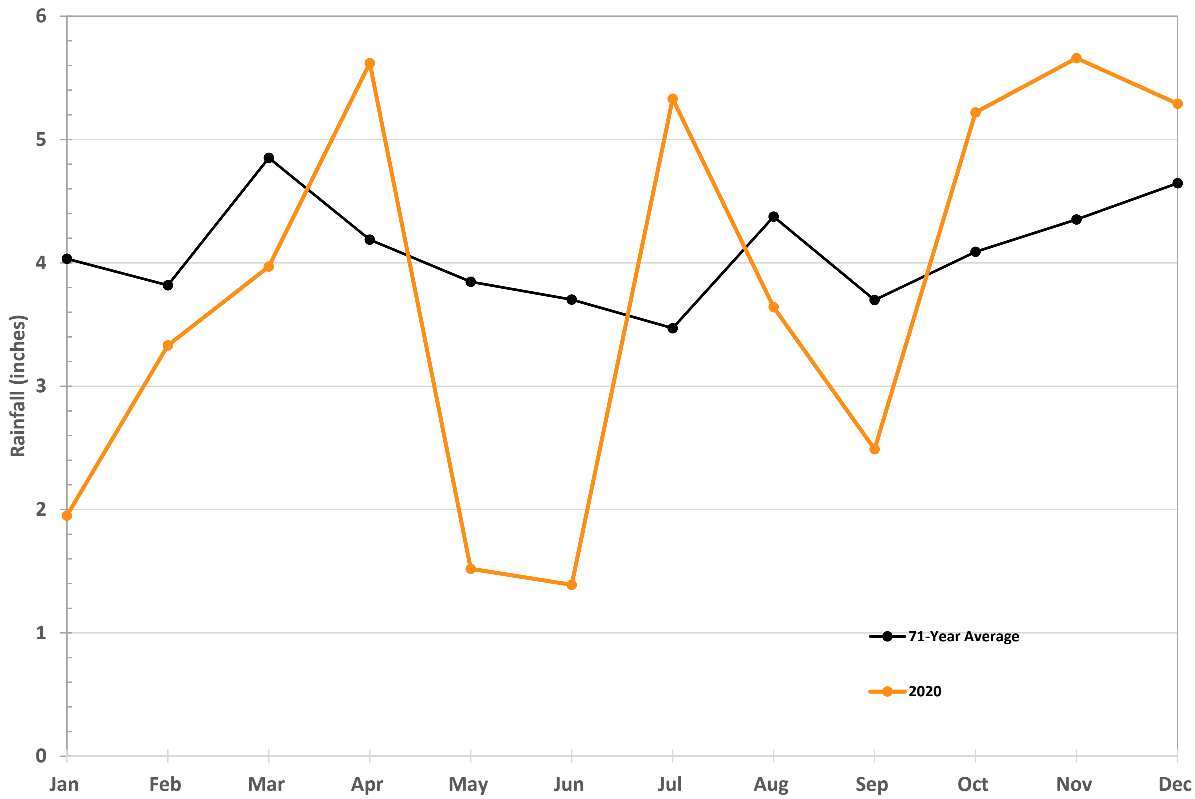


Figure 1-7. BNL 2020 Monthly Precipitation versus 71-Year Monthly Average.

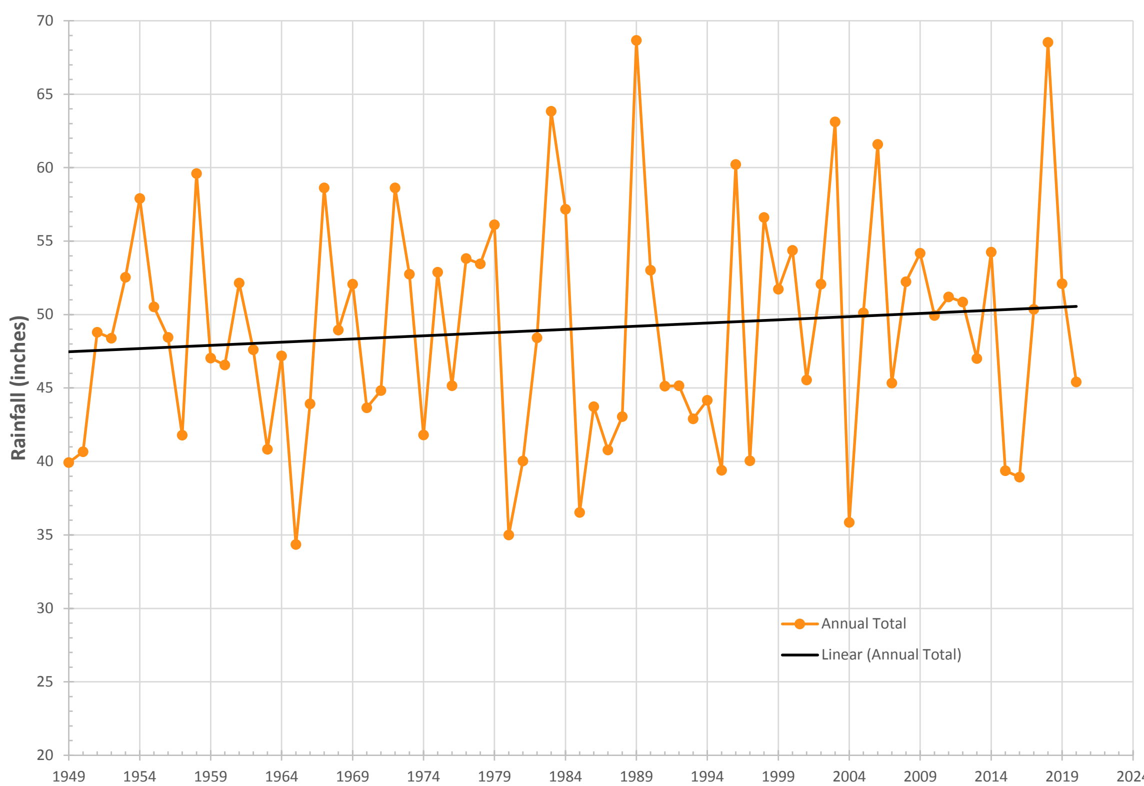


Figure 1-8. BNL 2020 Annual Precipitation Trend (71 Years).

approximately 357 million gallons of water.

Groundwater flow directions across the BNL site are influenced by natural drainage systems: eastward along the Peconic River, southeast toward the Forge River, and south toward the Carmans River (Figure 1-3). Pumping from on-site supply wells affects the direction and speed of groundwater flow, especially in the central, developed areas of the site. The main groundwater divide on Long Island is aligned generally east–west and lies approximately one-half mile north of the Laboratory. Groundwater north of the divide flows northward and ultimately discharges to the Long Island Sound. Groundwater south of the divide flows east and south, discharging to the Peconic River, Peconic Bay, south shore streams, Great South Bay, and Atlantic Ocean. The regional groundwater flow system is discussed in greater detail in Stratigraphy and Hydrologic Conditions at the Brookhaven National Laboratory and Vicinity, Suffolk County, New York, 1994-97 (Scorca et al., 1999). In most areas at BNL, the horizontal velocity of groundwater is approximately 0.75 to 1.2 feet per day (Geraghty & Miller, 1996). In general, this means that groundwater travels for approximately 20 to 22 years as it moves from the central, developed area of the site to the Laboratory's southern boundary.

1.7 CLIMATE

Meteorological Services (MET Services) at BNL has been recording on-site weather data since August 1948. MET Services is responsible for the maintenance, calibration, data collection, and data archiving for the weather instrumentation network at BNL. Measurements include wind speed, wind direction, temperature, rain fall, barometric pressure, and relative humidity.

The Laboratory is broadly influenced by continental and maritime weather systems. Locally, the Long Island Sound, Atlantic Ocean, and associated bays influence wind directions and humidity and provide a moderating influence on extreme summer and winter temperatures.

The prevailing ground-level winds at BNL are from the southwest during the summer, from the northwest during the winter, and about equally from those two directions during the spring and fall (Nagle 1975, 1978). Figure 1-4 shows the 2020 annual wind rose for BNL, which depicts the annual frequency distribution of wind speed and direction, measured at an on-site meteorological tower at heights of 33 feet (10 meters) and 300 feet (85 meters) above land surface.

In 2020, the average yearly temperature for this area of Long Island was 53°F. The coolest month of the year, January, had a monthly average temperature of 35.8ºF while the warmest month of the year, July, had a monthly average temperature of 75.1ºF. Figures 1-5 and 1-6 show the 2020 monthly mean temperatures and the historical annual mean temperatures, respectively. The total annual precipitation in 2020 was 45.41 inches.

Figures 1-7 and 1-8 show the 2020 monthly and the 70-year annual precipitation data, respectively. The yearly total snowfall for 2020 was 10.5 inches, well below the 33.0 inches average yearly snowfall for this area of Long Island.

1.8 NATURAL RESOURCES

The Laboratory is located in the oak and chestnut forest region of the Coastal Plain and constitutes about five percent of the 100,000-acre New York State–designated region on Long Island known as the Central Pine Barrens. The section of the Peconic River running through BNL is designated as "scenic" under the New York State Wild, Scenic, and Recreational River System Act of 1972. Due to the general topography and porous soil, the land is very well drained and there is little surface runoff or open standing water. However, depressions form numerous small, pocket wetlands with standing water on a seasonal basis (vernal pools), and there are six regulated wetlands on site. Thus, a mosaic of wet and dry areas correlates with variations in topography and depth to the water table.

Vegetation on site is in various stages of succession, which reflects a history of disturbances to the area. For example, when Camp Upton was constructed in 1917, the site was entirely cleared of its native pines and oaks. Although portions of the site were replanted in the 1930s, portions were cleared again in 1940 when Camp Upton was reactivated by the U.S. Army. Other past disturbances include fire, local flooding, and draining. Current operations minimize disturbances to the undeveloped areas of the site.

More than 350 plant, 30 mammal, 131 bird, 13 amphibian, 12 reptile, and 10 fish species have been identified on site, some of which are New York State threatened, endangered, exploitably vulnerable, and species of special concern. To eliminate or minimize any negative effects that BNL operations might cause to these species, precautions are in place to protect habitats and natural resources at the Laboratory.

Yellow-billed cuckoo, photographed on the campus of BNL

In November 2000, DOE established the Upton Ecological and Research Reserve at BNL. The 530-acre Upton Reserve (ten percent of the Laboratory's property) is on the eastern portion of the site, in the Core Preservation Area of the Central Pine Barrens. The Upton Reserve creates a unique ecosystem of forests and wetlands that provides habitats for plants, mammals, birds, reptiles, and amphibians. From 2000 to 2004, funding provided by DOE under an Inter-Agency Agreement between DOE and the U.S. Fish & Wildlife Services was used to conduct resource management programs for the conservation, enhancement, and restoration of wildlife and habitat in the reserve. Management of the Upton Reserve falls within the scope of BNL's Natural Resource Management Plan, and the area will continue to be managed for its key ecological values and as an area for ecological research (BNL 2016).

Additional information regarding the Upton Reserve and the Laboratory's natural resources can be found in Chapter 6 of this report.

1.9 CULTURAL RESOURCES

The Laboratory is responsible for ensuring compliance with historic preservation requirements. BNL's Cultural Resource Management Plan was developed to identify, assess, and document the Laboratory's historic and cultural resources (BNL 2013). These resources include World War I trenches; Civilian Conservation Corps features; World War II buildings; and historic structures, programs, and discoveries associated with high-energy physics, research reactors, and other science conducted at BNL. The Laboratory currently has multiple facilities classified as eligible for listing on the National Register of Historic Places: including numerous buildings and facility complexes, and the World War I training trenches associated with Camp Upton. Further information can be found in Chapter 6.

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Environmental Management System 2

Brookhaven Science Associates (BSA), the contractor operating the Laboratory on behalf of the Department of Energy (DOE), takes environmental stewardship very seriously. As part of its commitment to environmentally responsible operations, BSA has established the Brookhaven National Lab (BNL) Environmental Management System (EMS). An EMS ensures that environmental issues are systematically identified, controlled, and monitored. Moreover, an EMS provides mechanisms for responding to changing environmental conditions and requirements, reporting on environmental performance, and reinforcing continual improvement.

The Laboratory's EMS was designed to meet the rigorous requirements of the globally recognized International Organization for Standardization (ISO) 14001 Environmental Management Standard, which encompasses ideals such as compliance, pollution prevention, and community involvement. Annual audits by an independent third party are required to maintain an EMS registration; an audit of the entire EMS occurs every three years. In 2020, an EMS surveillance audit determined that BNL continues to conform to the ISO 14001 Standard.

The Laboratory continues its strong support of its Pollution Prevention Program, which seeks ways to eliminate waste and toxic materials on site, but also to promote sustainable business activities. The program generates new ideas to grow the Lab's existing recycling program or otherwise improve sustainable operations. In 2020, the Pollution Prevention Program resulted in nearly $1.7 million in cost avoidance or savings and resulted in the reduction or reuse of approximately 0.9 million pounds of waste. Also, the Pollution Prevention Program funded 15 new proposals, investing approximately $21,500. The proposals involved reducing risk, promoting use of bio-friendly alternative products, improving small energy efficiency projects, and promoting overall environmentally sustainable business practices.

The ISO 14001-registered EMS and the nationally recognized Pollution Prevention Program continue to contribute to the Laboratory's success in improving sustainable operations. Support was also provided in 2020 to line organizations for lab cleanouts and disposal of chemicals. As a testament to its strong environmental program, the Lab received the Green Electronics Council's Electronic Product Environmental Assessment Tool (EPEAT) Gold Award, the DOE's GreenBuy Award, and a second GreenBuy Prime Award.

BNL continues to address legacy environmental issues and openly communicates with neighbors, regulators, employees, and other interested parties on environmental issues and cleanup progress on site. Even during the challenges that the COVID-19 pandemic posed, BNL was successful in maintaining a high level of communication and interaction with the community, regulators, and employees. This was accomplished through virtual meetings of the Community Advisory Committee, Brookhaven Executive Roundtable, virtual tours, a reenergized virtual speakers bureau, and monthly interagency calls with regulators. BNL is committed to transparency and open communication with its internal and external stakeholders.

2.1 INTEGRATED SAFETY MANAGEMENT AND ISO 14001

The Laboratory's Integrated Safety Management System (ISMS) integrates environmental protection, pollution prevention, safety, health, and quality (ESH&Q) management into all work planning and execution. The purpose of BNL's ISMS is to ensure that the way we work integrates DOE's five Core Functions and seven Guiding Principles into all work processes. The five Core Functions, as defined by DOE P 450.4, Safety Management System Policy, are:

- *Define the scope of work:* Missions are translated into work, expectations are set, tasks are identified and prioritized, and resources are allocated.
- *Analyze the hazards:* Hazards associated with the work are identified, analyzed, and categorized.
- *Develop and implement hazard controls:* Applicable standards and requirements are identified and agreed-upon; controls to prevent/mitigate hazards are identified; the safety envelope is established; and controls are implemented.
- *Perform work within controls:* Readiness is confirmed, and work is performed safely.
- *Provide feedback and continuous improvement:* Feedback information on the adequacy of controls is gathered; opportunities for improving the definition and planning of work are identified and implemented.

The seven Guiding Principles, also as defined by DOE P 450.4, are:

- *Line management responsibility for safety:* Line management is directly responsible for the protection of the workers, the public, and the environment.
- *Clear roles and responsibilities:* Clear and unambiguous lines of authority and responsibility for ensuring safety are established and maintained at all organizational levels within the Department and its contractors.
- *Competence commensurate with responsibilities:* Personnel possess the experience, knowledge, skills, and abilities that are necessary to discharge their responsibilities.
- *Balanced priorities:* Resources are effectively allocated to address safety, programmatic, and operational considerations. Protecting the workers, the public, and the environment is a priority whenever activities are planned and performed.
- *Identification of safety standards and requirements:* Before work is performed, the associated hazards are evaluated and an agreed-upon set of safety standards and requirements is established which, if properly implemented, will provide adequate assurance that the workers, public, and environment are protected from adverse consequences.
- *Hazard controls tailored to work being performed:* Administrative and engineering controls to prevent and mitigate hazards shall be tailored to the work being performed and associated hazards.
- *Operations authorization:* The conditions and requirements to be satisfied for operations to be initiated and conducted shall be clearly established and agreed upon.

The integrated processes within ISMS contributed to BNL achieving ISO 14001 registration. The ISO 14001 Standard is globally recognized and defines the structure of an organization's EMS for purposes of improving environmental performance. The process-based structure of the ISO 14001 Standard is based on the "Plan-Do-Check-Act" improvement cycle. The ISO 14001 standard requires an organization to develop a policy, create plans to implement the policy, implement the plans, check progress and take corrective actions, and review the system periodically to ensure its continuing suitability, adequacy, and effectiveness.

The Laboratory has been officially registered to the ISO 14001 Standard since 2001. The Laboratory was the first DOE Office of Science Laboratory to achieve this registration. The certification requires the Laboratory to undergo annual audits by an accredited, third-party registrar to assure that the system is maintained. BNL's external certification organization, ERM Certification Verification Services, conducted an external surveillance audit of BNL's conformance to the ISO 14001 Standard in July 2020.

The Surveillance identified no nonconformances and determined that the Laboratory was in full conformance to the Standard and, therefore, BNL will maintain its current certification.

2.2 ENVIRONMENTAL, SAFETY, SECURITY, AND HEALTH POLICY

The cornerstone of an EMS is a commitment to environmental protection at the highest levels of an organization. BNL's environmental commitments are incorporated into a comprehensive Environmental, Safety, Security, and Health (ESSH) Policy. The policy, issued and signed by the Laboratory Director, states the Laboratory's commitment to environmental stewardship, the safety of the public and BNL employees, and the security of the site. The policy continues as a statement of the Laboratory's intentions and principles regarding overall environmental performance. It provides a framework for planning and action and is included in employee, guest, and contractor training programs. The ESSH Policy is posted throughout the Laboratory and on the BNL website at *http://www.bnl.gov/esh/policy.php*. The Policy's goals and commitments focus on compliance, pollution prevention, community outreach, and continual improvement:

- *Environment:* We protect the environment, conserve resources, and prevent pollution.
- *Safety:* We maintain a safe workplace, plan our work, and perform it safely.
- *Security:* We protect people, property, information, computing systems, and facilities.
- *Health:* We protect human health within our boundaries and in the surrounding community.
- Compliance: We achieve and maintain compliance with applicable ESSH requirements.
- *Community:* We maintain open, proactive, and constructive relationships with our employees, neighbors, regulators, DOE, and other stakeholders.
- *Continual Improvement:* We continually improve ESSH performance.

2.3 PLANNING

The planning requirements of the ISO 14001 Standard require BNL to identify the environmental aspects and impacts of its activities, products, and services; evaluate applicable compliance obligations; establish objectives and targets; create action plans to achieve the objectives and targets; and identify and address risks and opportunities that can impact the success of the EMS.

2.3.1 Environmental Aspects

An "environmental aspect" is any element of an organization's activities, products, and services that can impact the environment. As required by the ISO 14001 Standard, BNL evaluates its operations, identifies the aspects that can impact the environment, and determines which of those impacts are significant. The Laboratory's criteria for significance are based on actual and perceived impacts of its operations and on regulatory requirements. BNL uses its work planning process to identify and review environmental aspects associated with activities. A Process Assessment Procedure is used for facilities and equipment or for deeper analysis of activities not sufficiently covered by work planning. Evaluations are documented on work plans and Process Assessment Forms (PAFs).

Environmental professionals work closely with Laboratory personnel to ensure that work plans, PAFs, and other related reviews thoroughly capture all aspects, requirements, and associated environmental controls. Aspects and impacts are evaluated annually to ensure that they continue to reflect stakeholder concerns and changes in regulatory requirements.

2.3.2 Compliance Obligations

To implement the compliance commitments of the ESSH Policy and meet its compliance obligations, BNL has systems in place to review changes in federal, state, or local environmental regulations and communicate those changes to affected staff. Laboratory-wide procedures for documenting these reviews and recording the actions required to ensure compliance are available to all staff through BNL's web-based Standards-Based Management System (SBMS) subject areas.

BNL follows Executive Order (EO) 13834, Efficient Federal Operations. This order establishes goals for federal agencies with a focus on sustainability initiatives that save money and increase efficiency across the government with guidance, recommendations, plans, and numerical targets. DOE Order 436.1, Departmental Sustainability, provides requirements and responsibilities for managing sustainability within DOE to ensure facilities are working towards sustainability goals established in its Strategic Sustainability Performance Plan (SSPP) pursuant to EO 13834. Each DOE facility is required to have a Site Sustainability Plan (SSP) in place detailing the strategy for achieving these long-term goals and due dates and to provide an annual status. The requirements influence the future of the Laboratory's EMS program and have been incorporated into BNL's SSP, which can be found in Appendix E and identifies the DOE SSP goals, the Laboratory's performance in 2020, and future planned actions and contributions.

2.3.3 Objectives and Targets

The establishment of environmental objectives and targets is accomplished through a Performance-Based Management System. This system is designed to develop, align, balance, and implement the Laboratory's strategic objectives, including environmental objectives. The system drives BNL's improvement agenda by establishing a prioritized set of key objectives, called the Performance Evaluation Management Plan (PEMP). BSA works closely with DOE to clearly define expectations and performance measures. Factors for selecting environmental priorities include:

- Meeting the intent and goals of relevant executive orders or other requirements.
- Significant environmental aspects;
- Risk and vulnerability (primarily, threat to the environment);
- Compliance obligations (e.g., laws, regulations, permits, enforcement actions, and memorandums of agreement);
- Commitments in the ESSH Policy to regulatory agencies and to the public;
- Importance to DOE, the public, employees, and other stakeholders.

Laboratory-level objectives and targets are developed on a fiscal year (FY) schedule. For FY 2020, BNL's environmental objectives included maintaining ISO 14001 certification and the Laboratory's performance in purchasing environmentally preferable items and reducing the overall hazard footprint by reducing chemical inventories.

2.3.4 Environmental Management Programs

The Environmental Protection Division (EPD) takes on the largest role for developing action plans for implementing institutional environmental priorities, while other organizations within BNL develop action plans as applicable to their operations. The plans detail how the organization will achieve its environmental objectives and targets, as well as commit the resources necessary to successfully implement both Laboratory-wide and facility-specific programs. BNL has a budgeting system designed to ensure that priorities are balanced and provide resources essential to the implementation and control of the EMS. The Laboratory continues to review, develop, and fund important environmental programs to further integrate environmental stewardship into all facets of its missions.

2.3.4.1 Compliance

BNL has an extensive program to ensure that the Laboratory remains in full compliance with all applicable environmental regulatory requirements and permits. Legislated compliance is outlined by the Clean Air Act, National Emission Standards for Hazardous Air Pollutants (NESHAPs), Clean Water Act (e.g., State Pollutant Discharge Elimination System [SPDES]), Safe Drinking Water Act (SDWA), Resource Conservation and Recovery Act (RCRA), and other programs. Other compliance initiatives at the Laboratory involve special projects, such as upgrading petroleum and chemical storage tank facilities, monitoring drinking water systems for emerging contaminants, closing underground injection control devices, retrofitting or replacing air conditioning equipment refrigerants, and managing legacy facilities. See Chapter 3 for a list of regulatory programs to which BNL subscribes and a thorough discussion of these programs and their status.

2.3.4.2 Groundwater Protection

BNL's Groundwater Protection Program is designed to prevent negative impacts to groundwater and restore groundwater quality by integrating pollution prevention efforts, monitoring, groundwater restoration projects, and communicating performance. The Laboratory has developed a Groundwater Protection Contingency Plan that defines an orderly process for quickly verifying the results and taking corrective actions in response to unexpected monitoring results (BNL 2018). Key elements of the groundwater program are full, timely disclosure of any off-normal occurrences and regular communication on the performance of the program.

Chapter 7 and SER Volume II, Groundwater Status Report, provide additional details about this program, its performance, and monitoring results for 2020.

2.3.4.3 Waste Management

Due to the world-class research it conducts, BNL generates a wide range of wastes. These wastes include materials common to many businesses and industries, such as office wastes (e.g., paper, plastic, etc.), aerosol cans, batteries, paints, and oils. However, the Laboratory's unique scientific activities also generate specialized waste streams that are subject to additional regulation and special handling, including radioactive, hazardous, industrial, and mixed waste. BNL's Waste Management Facility (WMF), operated by the EPD, is responsible for collecting, storing, transporting, and managing the disposal of these specialized wastes. This modern facility was designed for handling hazardous, industrial, radioactive, and mixed waste, and is comprised of two staging areas: a facility for hazardous, industrial, and mixed waste in Building 855, regulated by RCRA, and a reclamation building for radioactive material in Building 865. The RCRA building is managed under a permit issued by the New York State Department of Environmental Conservation (NYSDEC).

These buildings are used for short-term storage of waste before it is packaged or consolidated for off-site shipment to permitted treatment and disposal facilities. Waste

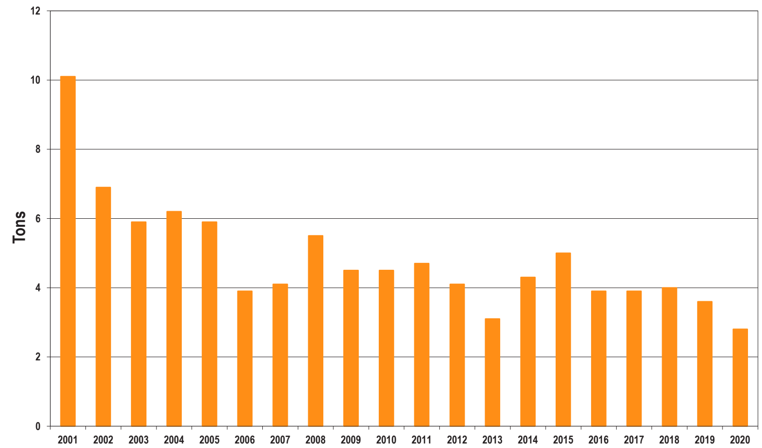

Figure 2-1a. Hazardous Waste Generation from Routine Operations, 2001 – 2020.

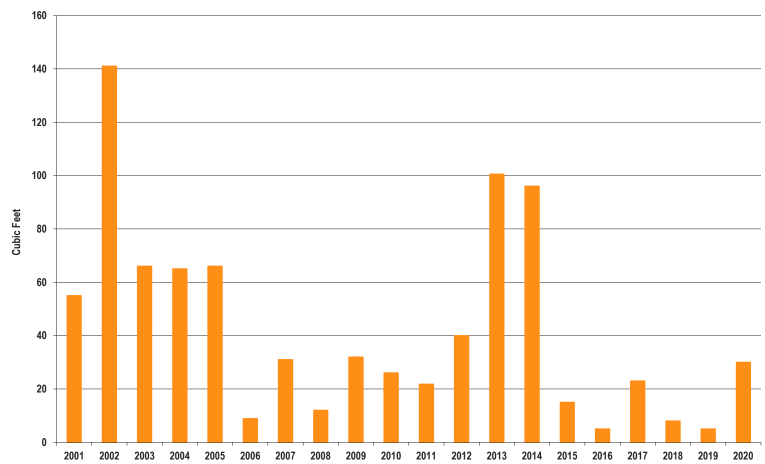

Figure 2-1b. Mixed Waste Generation from Routine Operations, 2001 – 2020.

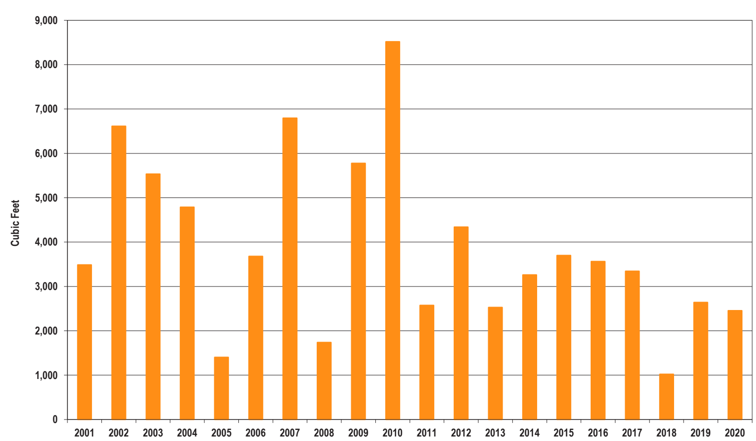

Figure 2-1c. Radioactive Waste Generation from Routine Operations, 2001 – 2020.

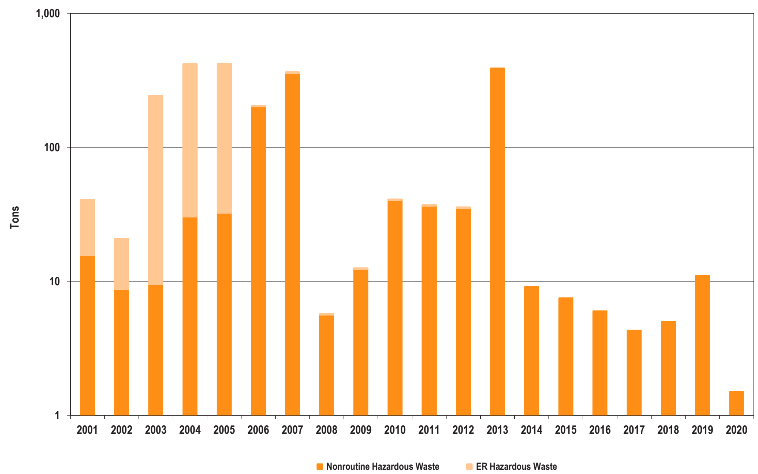

Figure 2-1d. Hazardous Waste Generation from ER and Nonroutine Operations, 2001 – 2020.

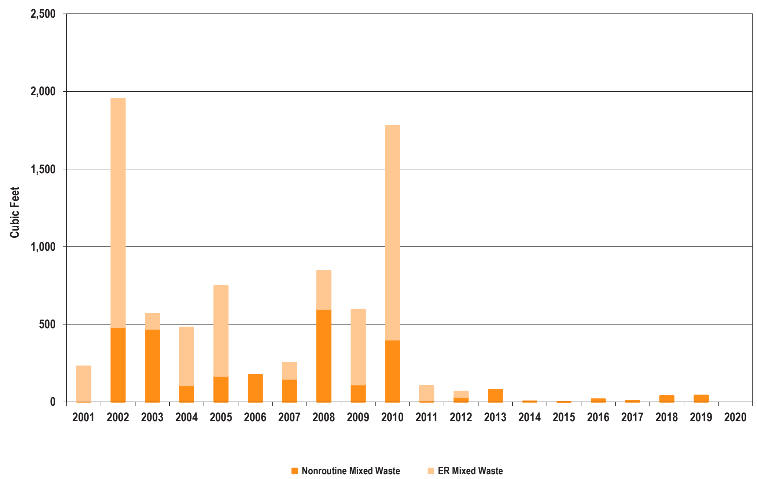

Figure 2-1e. Mixed Waste Generation from ER and Nonroutine Operations, 2001 – 2020.

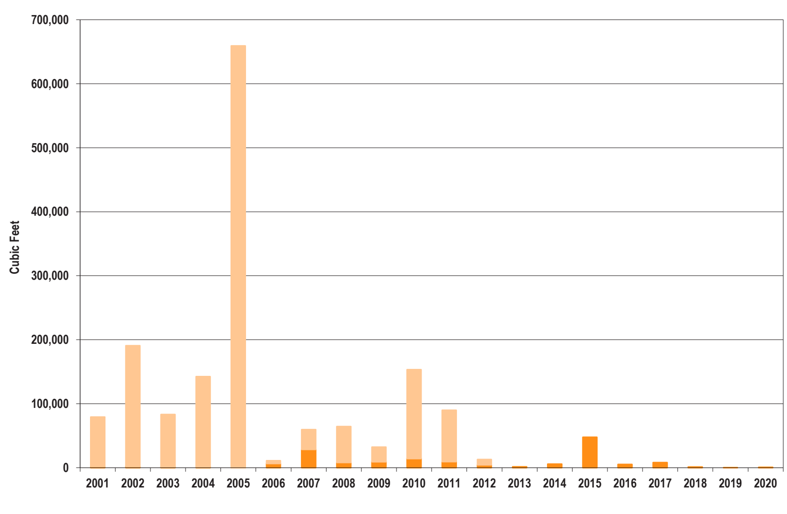

Figure 2-1f. Radioactive Waste Generation from ER and Nonroutine Operations, 2001 – 2020.

can either be generated from routine operations, defined as ongoing industrial and experimental operations, or from non-routine, defined by that generated by remediation projects, facility decommissioning activities, or one-time events (e.g., lab cleanouts). In 2020, BNL generated the following types and quantities of waste from routine operations:

- Hazardous waste: 2.8 tons
- Mixed waste: 30 ft^3
- Radioactive waste: 2,454 ft^3

Hazardous waste from routine operations decreased during 2020, as shown in Figure 2-1a, mostly due to the Lab's limited operational status related to COVID-19. Mixed waste generation increase consists of lead shielding from C-AD beamlines, as shown in Figure 2-1b. The change is due to fluctuations in operations at BNL's accelerator facilities. Radioactive waste generation from routine operations has stayed consistent with 2019 generation rates, as shown in Figure 2-1c.

BNL's inventory of legacy waste has been significantly reduced over the years. Figures 2-1d through 2-1f show waste generated from non-routine operations. Waste generation from these activities can vary significantly from year to year as various decommissioning and remedial actions are conducted.

The significant reduction in non-routine waste generation during 2020 is due to the Lab's limited operational status related to COVID-19. No major construction or demolition project occurred during 2020.

2.3.4.4 Pollution Prevention and Waste Minimization

The BNL Pollution Prevention (P2) Program reflects national and DOE pollution prevention goals and policies and represents an ongoing effort to make pollution prevention and waste minimization an integral part of BNL's operating philosophy.

Pollution prevention and waste reduction goals have been incorporated into the DOE contract with BSA, BNL's ESSH Policy, the PEMP associated with the Laboratory's operating contract with DOE, and BNL's SSP. Key elements of the P2 Program include:

- Eliminate or reduce emissions, effluents, and waste at the source where possible, as practicable;
- Procure environmentally preferable products (known as "affirmative procurement");
- Conserve natural resources and energy;
- Reuse and recycle materials;
- Achieve or exceed BNL/DOE waste minimization, P2, recycling, and affirmative procurement goals;
- Comply with applicable requirements (e.g., New York State Hazardous Waste Reduction Goal, executive orders, etc.);
- Reduce waste management costs;
- Implement P2 projects;
- Improve employee and community awareness of P2 goals, plans, and progress.

The BNL P2 and recycling programs have achieved reductions in waste generated by routine operations, as shown in Figures 2-1a through 2-1c, though 2018 and 2019 show an uptick in hazardous waste generation resulting from building demolition debris. However, the decrease for 2020 is due to the impact that COVID-19 had on the Lab's activities. The positive trends are also driven by the EMS emphasis on establishing objectives and targets to drive sustainable business practices. These efforts will reduce the risk of environmental impacts from BNL operations. Table 2-1 describes the P2 projects implemented through 2020, and provides the number of pounds of materials reduced, reused, or recycled, as well as the estimated cost benefit of each project.

The P2 program also provides funding for the line organizations to implement new hazard reduction or sustainability ideas. During 2020, EPD provided $21,500 for 15 projects that provided an environmental benefit. The projects included spill response equipment for several organizations, equipment modification to reduce herbicide use, leak monitoring equipment, oil scrubbers, purchase of three bio-friendly products for testing, and a safety vent ball valve to prevent loss of helium from storage balloons. Future projects funded through this process will be added to Table 2.1 when they involve an ongoing, trackable cost/benefit worth reporting.

The implementation of pollution prevention opportunities, recycling programs, and conservation initiatives has reduced both waste volumes and management costs. In 2020, these efforts resulted in nearly $1.7 million in cost avoidance or savings and approximately 0.9 million pounds of materials being reduced, recycled, or reused annually. Reduced revenue and volume of recyclables compared to previous years are a direct impact of limited operational status caused by the COVID-19 pandemic.

However, even with the challenges of the past year, the Laboratory's active and successful solid waste recycling program continued to function. In 2020, BNL collected approximately 234 tons of scrap metal for recycling. Cardboard, office paper, bottles and cans, construction debris, motor oil, lead, automotive batteries, electronic scrap, fluorescent light bulbs, and drill press/ machining coolant were also recycled. Table 2-2 shows the total number of tons of the materials recycled. The baseline recycling rate goal for federal facilities is 50 percent. BNL's annual average recycling rate consistently outperforms the baseline. The 2020 annual recycling rate was 63 percent. Last year, BNL reported a recycling rate of 55 percent that was modified to 68 percent along with a revision to the recycling rate reported back in 2016 (from 74 percent to 67 percent) based on errors in the calculation.

In 2020, BNL's sustainability program was honored by receiving the Green Electronics Council's Electronic Product Environmental Assessment Tool (EPEAT) Award for purchasing EPEAT-registered electronic products which meet strict environmental criteria that address the full product lifecycle, from energy conservation to toxic materials to product longevity and end-of-life management. BNL also

Table 2-1. BNL Pollution Prevention, Waste Reduction, and Recycling Programs, 2020.

Waste Description	Type of Project	Pounds Reduced, Reused, Recycled, or Conserved in 2020	Waste Type	Potential Costs for Treatment and Disposal	Revenue/(Cost) of Recycle, Prevention	Estimated Cost Savings	Project Description Details
Office Paper	Recycled	67,180	Regular Trash	$5,509	($15,193)	($2,619)	Collected and transported to a transfer facility for recycling along with regular trash; daily Construction and Demolition Debris (C&D) waste from daily maintenance activities and other recyclables. Savings for all are based on cost to dispose of as trash based on an average cost of disposal of $164/ton. The cost of recycling is $198.16/ton for paper and cardboard and no cost/revenue for bottles and cans.
Cardboard	Recycled	86,160	Regular Trash	$7,065			
Bottles/Cans	Recycled	15,440	Regular Trash	$1,266	$0	$1,266	
Printer Toner Cartridges	Recycled	986	Regular Trash	$81	$0	$81	Printer toner cartridges were picked up by vendor for recycling, saving the cost to dispose as regular trash at $164/ton.
Metals	Recycled	467,720	Regular Trash	$38,353	$19,575	$57,928	Cost avoidance was based on $164/ton for disposal as trash, plus $19,575 revenue (various pricing).
Electronic Waste	Recycled	75,620	Electronic Waste	$6,201	$30,248	$36,449	Cost avoidance was based on $164/ton for disposal as trash, plus $30,248 revenue based on $0.40/lb.
Electronic Reuse	Reuse	16,600	Electronic Waste	$1,544,400	$9,605	$1,554,005	The Laboratory tracked electronic equipment and took a reuse credit for transfer of equipment to another user. Savings were based on the cost to purchase a new version of the item minus the scrap value of that item.
Building 452 Oil Skimmer	Source Reduction	0	Industrial Waste	$0	$0	$0	Reduced oily water waste stream (non-halogenated oil) from air compressors by skimming off oil and leaving water phase. Water may be discharged to sanitary system. In 2020, no oil was sent for reprocessing. Plans are to send the skimmed oil collected over the last several years for reprocessing during 2021.
Used Motor Oil	Energy Recovery	8,338	Industrial Waste	$3,659	($579)	$3,080	Used motor oil from Building 452 and the motor pool was given to Strebel's Laundry Service to fire their boilers. In 2020, they collected 1,158 gallons (8,338 lbs) of oil at $0.50 /ga, which avoided the costs for disposal and 24 shipping drums ($120/drum).
Blasocut Machining Coolant	Recycled/ Reused	5,172	Industrial Waste	$11,732	$0	$11,732	Central Shops Division operates a recycling system that reclaims Blasocut, an aqueous machining coolant. Recycling involves aeration, centrifuge, and filtration. The system provides reclaimed coolant for use Lab-wide reducing purchases of new Blasocut. The associated cost avoidance is based on the cost to dispose of the unreclaimed Blasocut as industrial waste, the empty drums needed to disposal as industrial waste ($120/drum) as well as the cost of buying 13 drums of concentrate ($750/drum). In 2020, the impact of COVID and mechanical issues prevented reclamation for most of the year. Only 651 gallons (5,172 lb) of Blasocut lubricant were recycled during 2020.

(continued on next page)

Table 2-1. BNL Pollution Prevention, Waste Reduction, and Recycling Programs, 2020 *(concluded).*

Waste Description	Type of Project	Pounds Reduced, Reused, Recycled, or Conserved in 2020	Waste Type	Potential Costs for Treatment and Disposal	Revenue/(Cost) of Recycle, Prevention	Estimated Cost Savings	Project Description Details
Concrete Reuse	Recycled/ Reused	0	C&D Debris	$0	$0	$0	Concrete from demolitions stored onsite and crushed for reuse in other construction projects (sidewalks, parking lots). No on-site stored concrete was crushed for reuse during 2020.
Tires	Recycled	22,080	Regular Trash	$1,811	$0	$1,811	Truck tires were sent for recycling from the motor pool. Cost savings were based on cost to dispose of as trash at $164/ton.
Lead Acid Batteries and lead scrap	Recycled	42,505	Universal Waste	$11,476	$23,378	$34,854	Avoided universal waste disposal costs for lead and sulfuric acid batteries by sending directly for recycling. The large generation rate for CY20 is due to computer equipment maintenance on UPS units during COVID-related operational slowdowns.
Fluorescent Bulbs	Recycled	6,332	Universal Waste	$1,710	($1,672)	$38	20,900 linear feet of fluorescent bulbs were collected and sent to a recycling facility under the Universal Waste exemption rule. Savings were in comparison to cost to dispose of them as hazardous waste versus the cost to have them recycled as Universal Waste.
Garnet	Recycled	36,650	Industrial Waste	$49,478	($1,600)	$47,878	Garnet used in machine shop sent for recycling. Cost savings is based on cost to dispose of as Regulated Industrial Waste.
Subtotal		**850,783**		**$1,682,741**	**$63,762**	**$1,746,503**	**BNL disposed 252 tons of Regular Trash. BNL's 2020 recycling rate is 63%.**
Building Demolition - Concrete and metal (2019 update)	Recycled	994,000	C&D Debris	$81,508	$0	$81,508	Concrete collected from the demolition of the Apartment buildings that occurred during 2019 for which data was unavailable for last year's report. The material was sent offsite for recycling/reuse. The savings is based on disposal as regular trash.
Building Demolition - Wood and roofing material (2019 update)	Recycling	904,000	C&D Debris	$74,128	($45,645)	$28,483	Wood and roofing material collected from the demolition of the Apartment buildings that occurred during 2019 for which data was unavailable for last year's report. The material was sent offsite for recycling/reuse. The savings is based on disposal as regular trash.
Other C&D	Trash	298,000	C&D Debris	$24,436	($15,193)	$9,243	Generated by daily routine activities including small demolition and renovation projects as well as general maintenance activities. Collected and transported to a transfer facility for recycling by Facilities & Operation's contracted hauler along with other recyclables and regular trash at a cost of $15,193. The savings are based on disposal as regular trash.
Subtotal		**2,196,000**		**$180,072**	**($60,838)**	**$119,234**	
	TOTALS	**3,046,783**		**$1,862,813**	**$2,924**	**$1,865,737**	

Note: BNL is conducting end-of-year demolitions of apartment buildings during 2020 that will be reported next year.

Table 2-2. BNL Recycled Program Summary, 2011-2020.

Recycled Waste	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Mixed paper	186	142	160	150	91	89	84	65	60	34
Cardboard	126	100	97	78	12.4	73	74	74	71	43
Bottles/Cans	22.5	18	16.5	17.1	22.1	11	7.9	10.2	10.6	7.7
Tires	9.2	10	7.1	7.6	5.4	6.4	5.2	8.8	11	1.4
Concrete (Crushed onsite)	0	4,050	3,500	4,000	0	4,200	3,500	0	0	0
Used motor oil	5.7	6.3	6.2	8.0	5.3	10.9	12.5	9.3	4.0	4.2
Metals	84	278	174	256	737	426	621	559	513	234
Automotive & UPS batteries	2.1	2	2.1	1.4	1.9	1.4	0.6	15	13	30
Printer/Toner cartridges	2.1	2.1	5.6	1.1	1.0	n/a	1.2	1.1	1.0	0.5
Fluorescent bulbs	10.1	7.9	6.8	9.9	8.0	4.8	2.5	2.3	2.3	3.2
Blasocut coolant	22.6	22.4	22.6	19.4	10.2	9.4	7.8	11.7	5.1	2.6
Electronic reuse	11.6	3.2	1.4	10.5	25	17	19	21.7	17.3	7.5
Scrap electronics	19.9	30.9	23	29.3	42	24	23.1	53.3	93.9	37.8
Garnet	---	---	---	---	---	---	20.5	21	0	18.3
Recycling Subtotal:	**502**	**4,673**	**4,022**	**4,588**	**961**	**4,873**	**4,379**	**852**	**802**	**424**
Municipal Solid Waste	536	492	494	499	429	344	386	391	383	252
Recycling Rate (%)	**59%**	**63%**	**76%**	**58%**	**77%**	**67%**[1]	**69%**	**69%**	**68%**[2]	**63%**
Construction and Demolition (C&D) Summary:										
Construction Debris (Routine)	256	380	304	351	372	266	256	208	271	149
Demolition Projects:										
Metals	0	60	90	0	0	0	0	51.5	13**	NA**
Concrete (Sent offsite)	0	4,050	3,500	4,000	0	4200	3500	0	491**	NA**
Construction and demolition (other)	0	0	0	0	0	0	0	664	499**	NA**

Note: All units are tons.
[1]Revised from 74% (incorrectly included C&D material).
[2]Revised from 55% (incorrectly included C&D material).
**Revised to include end-of-year projects for which data wasn't (or won't be) available in time to meet publication dates.

received the DOE's GreenBuy Award and received a second GreenBuy Prime Award after receiving the first during 2019. The GreenBuy Award recognizes DOE sites for purchases of materials that are energy and water efficient and made from biobased or recycled content material. The GreenBuy Prime Award identifies BNL as a site that has achieved GreenBuy Gold status three times.

2.3.4.5 Water Conservation

BNL's water conservation program has achieved dramatic reductions in water use since the mid-1990's. The Laboratory continually evaluates water conservation as part of facility upgrades or new construction initiatives. These efforts include more efficient and expanded use of chilled water for cooling and heating/ventilation and air conditioning (HVAC) systems to reduce use of once-through cooling water for other systems.

The Laboratory's goal is to reduce the consumption of water and reduce the possible impact of clean water dilution on STP operations.

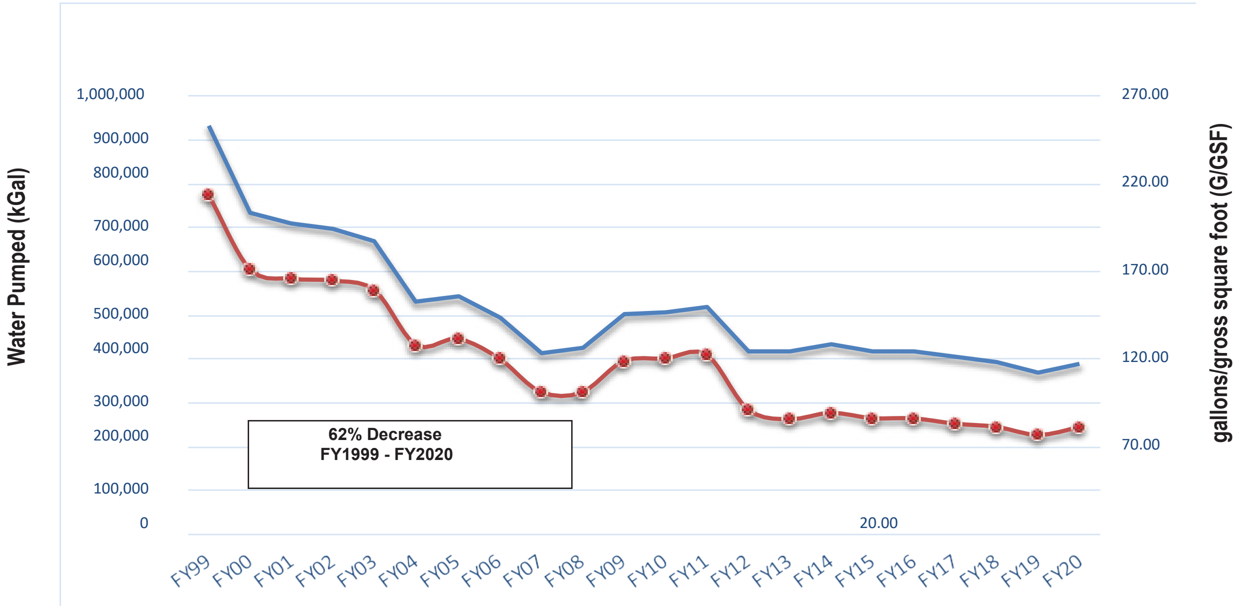

Figure 2-2. Annual Potable Water Use, 1999-2020.

Figure 2-2 shows the 20-year trend of water consumption. Total water consumption in 2020 was up slightly from 2019, mainly due to increased cooling tower maintenance requirements from the State. The water intensity (gallon/gross square foot) also continues to decrease. In each of the past ten years, the water consumption total was approximately half the 1999 total—a reduction of nearly a half billion gallons per year.

2.3.4.6 Energy Management and Conservation

The Laboratory's Energy Management Group continues to reduce energy use and costs by identifying and implementing cost-effective, energy-efficient projects; monitoring energy use and utility bills; and assisting in obtaining the least expensive energy sources possible. The group is responsible for developing, implementing, and coordinating BNL's energy management efforts and assisting DOE in meeting the energy and sustainability goals in EO's 13834, DOE Order 436.1, and the U.S. Secretary of Energy's initiatives. The Laboratory's SSP addresses all aspects of the DOE energy, water, transportation, and other sustainability goals.

BNL has more than 4.8 million square feet of building space. Many scientific experiments at the Laboratory use particle beams generated and accelerated by electricity, with the particles controlled and aligned by large electromagnets. In 2020, BNL used 282 million kilowatt hours (kWh) of electricity, 98,214 gallons of fuel oil, 12,631 gallons of propane, and 590 million cubic feet of natural gas. Fuel oil and natural gas produce steam at the Central Steam Facility (CSF).

Responding to market conditions, fuel oil and natural gas have been historically used whenever each respective fuel is least expensive. In 2020, natural gas prices once again continued to be substantially lower than fuel oil prices. As a result, natural gas was used to meet over 99 percent of the heating and cooling needs of the Laboratory's major facilities. Given the price disparity between natural gas and oil, the Laboratory will continue to purchase natural gas over oil, further reducing greenhouse gas (GHG) emissions. Additional information on natural gas and fuel oil use can be found in Chapter 4.

BNL continues to participate in available electric load reduction curtailment programs when available. Through these programs, the Laboratory agrees to reduce electrical demand during critical days throughout the summer when New York Independent System Operator expects customer demand to meet or exceed the available supply. In return, BNL sometimes receives a rebate

Northeast Solar Energy Research Center (NSERC)

View of the Northeast Solar Energy Research Center (NSERC)

for each megawatt reduced on each curtailment day. The Laboratory strives to keep electric loads at a minimum during the summer by scheduling operations at the Relativistic Heavy Ion Collider to avoid peak demand periods. This scheduling reduces the electric demand by approximately 25 megawatts (MW), saving approximately $1.4 million in electric demand costs and helping to maintain the reliability of the Long Island Power Authority (LIPA) electric system to meet all its users' needs. BNL also maintains a contract with the New York Power Authority that resulted in an overall cost avoidance of $29.1 million for 2020.

In 2020, BNL's energy supply included 116 million kWh of clean, renewable hydropower energy, 1.0 million kWh of on-site generated solar photovoltaic (PV), and 22 million kWh of purchased renewable energy certificates (REC). The Laboratory will continue to seek alternative energy sources to meet its future energy needs, support federally required "green" initiatives, and reduce energy costs.

In 2011, BP Solar completed construction of the Long Island Solar Farm (LISF) on BNL property. The array is one of the largest solar PV arrays (32 MW) in the Northeast and spans 195 acres with more than 164,000 panels. BNL worked extensively with LIPA, BP Solar, the State of New York, and other organizations to evaluate the site and develop the project, with LIPA purchasing the output through a 20-year Power Purchase Contract.

The annual output for 2020 was 48 million kWh and resulted in an avoidance of approximately 26,000 tons of carbon. At the time of the installation, the estimated annual output was 44 million kWh. The actual output for the first nine operational years was an average of 50.1 million kWh/year, substantially above the estimated annual average value. As an outcome of constructing this large array on site, the Laboratory has developed a solar research program that looks at impacts of climate change on large utility-scale PV systems, as well as research and development for solar power storage and inverter efficiencies. The Federal Energy Management Program recognizes the importance of the efforts of BNL and the DOE Brookhaven Site Office to host the LISF and provides credit toward BNL's SSP renewable energy goal.

In May 2015, the Laboratory completed the installation of the first phase of the solar PV research array as part of the Northeast Solar Energy Research Center (NSERC). In 2016, the array was increased to 816 kW with substantial funding assistance from the Sustainability Performance Office (SPO). In 2020, the NSERC generated 977,967 kWh of electricity for use on site.

To reduce energy use and costs at non-research facilities, several activities were continued or undertaken by the BNL Energy Management Group in 2020:

- NYPA Power Contract: Ninth full year of a ten-year contract that includes 15 MW of renewable (nearly zero greenhouse gas [GHG]) hydropower. This contract saved $29.1 million in 2020.
- DOE Sustainability Initiative: The Energy Management Group continues to provide substantial support to the Federal/DOE-wide Sustainability Initiative and has created a BNL Sustainability Leadership Team. The team has developed a formal site-wide sustainability program beyond DOE requirements, participates in one of three subcommittees for DOE on sustainability initiatives, and provides numerous evaluations and estimates

on energy use, GHG, renewable energy, and energy-efficiency options.

- Continued progress occurred on several initiatives included in BNL's annual SSP in 2020, such as the following: New electric, chilled water, and steam meter installations; funding for energy conservation initiatives; the purchase of RECs in meeting BNL's SSP goal; and training various parties on energy conservation initiatives.
- Utility Energy Services Contract (UESC): A UESC contract/project was completed in 2015 with the National Grid which installed energy-efficient lighting, new building controls, and an energy-efficient water chiller. The environmental benefits of this UESC were estimated to include electrical savings of 3,549,114 kWh/year, fuel savings of 89,541 mm British thermal units (Btu)/year, a GHG reduction of 7,022 MT-CO2e, and a building energy intensity reduction of 11 percent. To date, actual energy savings meet or exceed the original estimates. Through a comprehensive Measurement and Verification process, BNL has been able to verify that actual energy savings were within a few percent of the original projections for five years of operation.
- UESC II: BNL completed an Investment Grade Audit (IGA) for a potential second UESC effort. The IGA identified several projects that will reduce BNL's deferred maintenance backlog while reducing energy intensity and GHG's. A contract for the second UESC project was expected to be awarded in 2020. However, due to some technical and financial issues the effort has been delayed.
- Energy Conservation: Energy and water evaluations are completed for 25 percent of the site each year. Cost-effective projects are identified and proposed for funding, as appropriate.
- High Performance Sustainability Buildings (HPSB): Substantial completion of various energy and water conservation projects has achieved compliance in the EPA Portfolio Manager program. BNL is currently on target to meet or exceed the HPSB goal.
- Renewable Energy: Project support continues for the LISF and NSERC facilities and annual purchases of REC's to meet targeted goals.
- The Central Chilled Water Facility (CCWF): The CCWF continues to utilize a 3.2-million-gallon chilled water storage tank to reduce peak electric demand by producing and storing chilled water during the night.
- Natural Gas Purchase Contract: BNL is currently saving over $2 million per year using natural gas compared to oil.
- Energy Savings: As mentioned above, 25 MW of demand is rescheduled each year to avoid coinciding with the utility summer peak, saving over $1.4 million in electricity charges. In addition, work continues in the replacement of aging, inefficient T-40 fluorescent lighting fixtures with new, high-efficiency T-8 lighting fixtures and/or LED fixtures as appropriate. Typically, 200 to 300 fixtures are replaced annually, saving tens of thousands of kWhs each year and reducing costs by several thousand dollars. Due to continued conservation efforts, overall facilities energy usage for 2020 was approximately 27.4 percent less than in 2003, producing annual savings of $2.2 million.

The National Energy Conservation Policy Act, as amended by the Federal Energy Management Improvement Act of 1988 and the Energy Policy Acts of 1992 and 2005, as well as the Energy Independence and Security Act of 2007, requires federal agencies to apply energy conservation measures and improve federal building design to reduce energy consumption per square foot (Energy Intensity). Current goals included with EO 13834 are to reduce energy consumption per square foot, relative to 2015, by 25 percent by the year 2025. As shown in Figure 2-3, BNL's energy use per square foot in 2020 was 27 percent less than in FY 2003. It is important to note that energy use for most buildings and facilities at the Laboratory is largely weather dependent. Further, after decades of various energy conservation measures nearly all the cost-effective measures have been implemented. Regardless, BNL will continue to strive to meet the energy intensity reduction goals. In 2020, energy intensity was 1.4 percent less than the base year of 2015.

2.3.4.7 Natural and Cultural Resource Management Programs

Through its Natural Resource Management Plan (BNL 2016), BNL continues to enhance its Natural

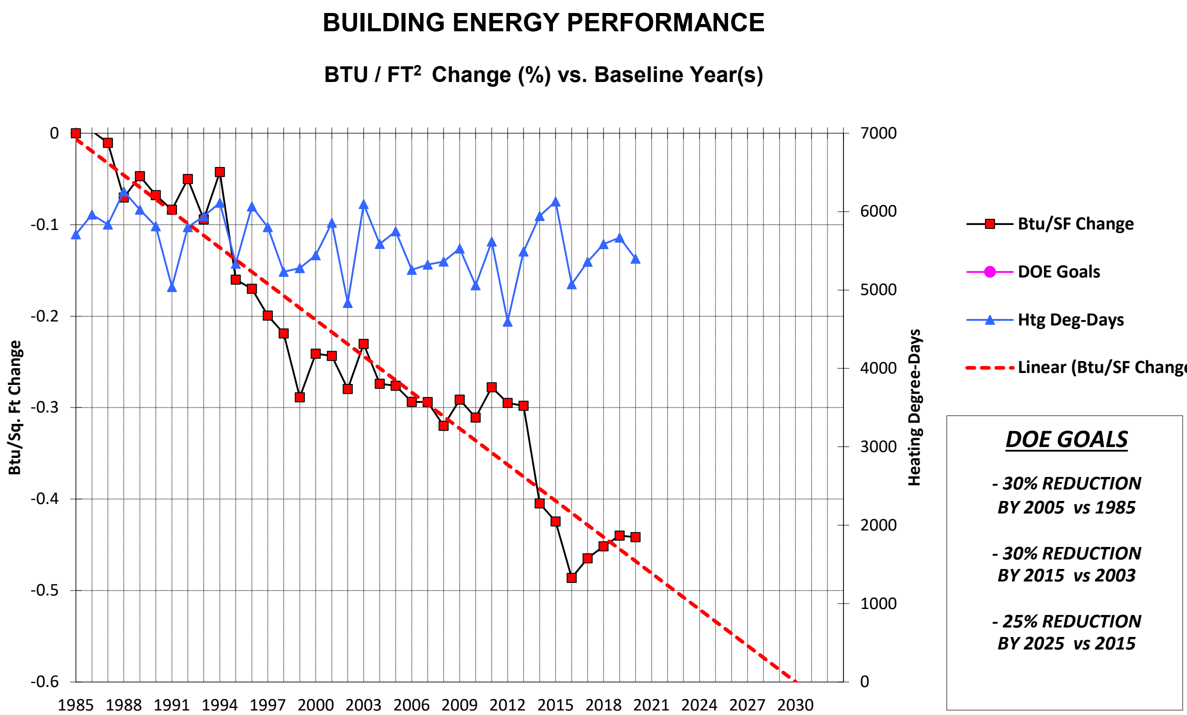

Figure 2-3. BNL Building Energy Performance for 2020 (Btu/SF Change Percent vs. Baseline Years).

Resource Management Program for the Lab and the Upton Ecological and Research Reserve. The Laboratory also continues to enhance its Cultural Resource Management Program. A BNL Cultural Resource Management Plan (BNL 2013a) was developed to identify and manage properties that are determined to be eligible for inclusion on the National Register of Historic Places. See Chapter 6 for further information about these programs.

2.3.4.8 Environmental Restoration

The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), commonly known as Superfund, was enacted by Congress in 1980. As part of CERCLA, EPA established the National Priorities List, which identifies sites where cleanup of past contamination is required. BNL was placed on the list with 27 other Long Island sites, 12 of which are in Suffolk County. Each step of the CERCLA cleanup process is reviewed and approved by DOE, EPA, and NYSDEC, under an Interagency Agreement (IAG). This agreement was formalized in 1992. Although not formal signatories of the IAG, the New York State Department of Health (NYSDOH) and the Suffolk County Department of Health Services (SCDHS) also play key roles in the review process.

Most of the contamination at the Laboratory is associated with past accidental spills and outmoded practices for handling, storing, and disposing of chemical and radiological material. BNL follows the CERCLA process, which includes the following steps:

- Conduct a remedial investigation to characterize the nature and extent of contamination and assess the associated risks;
- Prepare a feasibility study and proposed plan to identify and evaluate remedial action alternatives and present the proposed alternative;
- Issue a Record of Decision (ROD), which is the corrective action agreed to by DOE, EPA, and NYSDEC;
- Perform the Remedial Design/Remedial Action, which includes final design, construction specifications, and carrying out the corrective action selected; and

- Removal actions (time critical or non-time critical) are also performed under the CERCLA process.

In 2020, BNL's eight active groundwater treatment systems removed approximately 44 pounds of volatile organic compounds (VOCs) and 0.4

Table 2-3. Summary of BNL 2020 Environmental Restoration Activities.

Project	Description	Environmental Restoration Actions
Soil Projects	Operable Unit (OU) I/II/III/VII	▪ Performed monitoring and maintenance of institutional controls for cleanup areas.
Groundwater Projects	OU III/V/VI	▪ Continued operation of seven groundwater treatment systems that remove volatile organic compounds (VOCs) and one system that removes strontium-90 (Sr-90). ▪ Two additional extraction wells were installed at North Street East and became operational in July to remediate the ethylene dibromide (EDB) plume in this area. ▪ Removed 44 pounds of VOCs and 0.4 mCi of Sr-90 during the treatment of 0.8 billion gallons of groundwater. Since the first groundwater treatment system started operating in December 1996, approximately 7,700 pounds of VOCs and 34 mCi of Sr-90 have been removed, while treating approximately 29 billion gallons of groundwater. ▪ Collected and analyzed approximately 1,674 sets of groundwater samples from 698 monitoring wells. ▪ Installed 102 temporary wells and collected multiple samples from each location.
	OU VIII (PFOS/PFOA/1,4-Dioxane	▪ New York State adopted MCLs for PFOS, PFOA, and 1.4-dioxane in August 2020. ▪ New Areas of Concern 33 (PFOS and PFOA) and 34 (1,4-Dioxane) identified in early 2021. ▪ Collected groundwater samples for PFAS and 1,4-dioxane analyses downgradient of the current and former firehouse facilities to support design of two PFAS groundwater treatment systems.
Peconic River	OU V	▪ Satisfied State vegetation monitoring requirements for the Peconic River Equivalency Permit for Area PR-WC-06. Monitoring will continue for three additional years to satisfy federal requirements.
Reactors	Brookhaven Graphite Research Reactor (BGRR)	▪ Continued long-term surveillance and maintenance, including repair to an atrium window on the east air intake. Vegetation was removed and cracks were sealed in the engineered cap. Lighting was installed on the west stairwell and a new stairway was installed to the roof to support a research effort.
	High Flux Beam Reactor (HFBR)	▪ Continued long-term surveillance and maintenance, including removal of asbestos-containing material on the floor. Overhead piping insulation was repaired, openings on the air intakes on the exterior walls adjacent to the generator room were resealed, and cracked masonry on the east side exterior of the confinement dome was repaired.
	Stack (Building 705)	▪ Continued long-term surveillance and maintenance, including pump-out of the stack drain tank and collection and disposal of stack paint chips on the grounds. ▪ The U.S. Army Corps of Engineers contractor performed the stack exterior coating abatement between August and November. ▪ DOE submitted a milestone extension request to EPA in August 2020 to extend the administrative closeout until July 2021 due to contractor mobilization delays associated with COVID-19. ▪ Demolition of the stack was initiated in December.
	Brookhaven Medical Research Reactor (BMRR)	▪ Continued surveillance and maintenance activities.
Former Buildings 810/811	Former Radiological Liquid Processing Facility	▪ Maintained institutional controls of the area.
Building 801	Inactive Radiological Liquid Holdup Facility	▪ Performed routine surveillance and maintenance of the facility.
Building 650	Inactive Radiological Decon Facility	▪ Initiated decontamination and decommissioning of the facility.

millicurie (mCi) of strontium-90 (Sr-90) and returned 0.8 billion gallons of treated water to the sole source aquifer. A modification to the North Street East Groundwater Treatment System, which included the installation of two new extraction wells to remediate an ethylene dibromide (EDB) plume, was completed. The system became operational in July 2020. A Petition for Closure of the North Street Treatment System was approved by the regulatory agencies.

In August 2020, New York State adopted maximum contaminant levels (MCLs) of 10 nanograms per liter (ng/L) for PFOS and PFOA, and 1.0 microgram per liter (µ/L) for 1,4-dioxane in drinking water. During 2020, BNL collected groundwater samples for PFAS and 1,4-dioxane analyses from approximately 360 on-site and off-site monitoring wells, as well as conducting a detailed characterization of the PFAS plumes associated with the current and former firehouse facilities to support the design of two groundwater treatment systems. The results for these samples were summarized in the 2020 Groundwater Status Report (BNL 2021). In early 2021, BNL proposed to the regulatory agencies the addition of new Areas of Concern 33 (PFOS and PFOA) and 34 (1,4-Dioxane). Installation of the two PFAS treatment systems will be performed in 2021 as a Time Critical Removal Action under CERCLA.

The groundwater systems operated in accordance with the Operations and Maintenance manuals, while the Peconic vegetation and surface soil cleanup areas were monitored via the Soil and Peconic River Surveillance and Maintenance Plan (BNL 2013b). Institutional controls were also monitored and maintained for the cleanup areas in accordance with the RODs to help ensure the remedies remain protective of human health and the environment. An annual evaluation of these controls was submitted to the regulatory agencies. Table 2-3 provides a description of each Operable Unit and a summary of environmental restoration actions taken. See Chapter 7 and SER Volume II, Groundwater Status Report, for further details. In 2020, BNL continued the surveillance and maintenance of the Brookhaven Graphite Research Reactor (BGRR) and the HFBR. The exterior coating abatement of the HFBR stack was completed and demolition of the stack was initiated in December. Due to contractor mobilization delays related to COVID-19, DOE submitted a milestone extension request to the EPA and NYSDEC in August 2020 to extend the administrative closeout until July 2021.

2.4 IMPLEMENTING THE ENVIRONMENTAL MANAGEMENT SYSTEM

2.4.1 Structure and Responsibility

All employees at BNL have clearly defined roles and responsibilities in key areas, including environmental protection. Supervisors are required to work with their employees to develop and document Roles, Responsibilities, Accountabilities, and Authorities (R2A2). BSA has clearly defined expectations for management and staff which must be included in the R2A2 document. Under the BSA performance-based management model, senior managers must communicate their expectation that all line managers and staff take full responsibility for their actions and be held accountable for ESSH performance. Environmental and waste management technical support personnel assist the line organizations with identifying and carrying out their environmental responsibilities. Environmental Compliance Representatives (ECRs) are deployed to organizations throughout the Laboratory as an effective means of integrating environmental planning and sustainability into the work planning processes of the line organizations. A comprehensive training program for staff, visiting scientists, and contractor personnel is also in place, thus ensuring that all personnel are aware of their ESSH responsibilities.

2.4.2 Communication and Community Involvement

In support of BNL's commitment to open communication and community involvement, the Stakeholder and Community Relations (SCR) Office develops best-in-class communications, science education, government relations, and community involvement programs that advance the science and science education missions of the Laboratory. SCR contributes to the public's understanding of science, enhances the value of the Laboratory as a community, and ensures that internal and external stakeholders are properly informed and have a voice in decisions of interest and importance to them. SCR also works to maintain relationships with BNL employees and external stakeholders, such as neighbors, business leaders, elected officials, and regulators to provide an understanding of the Laboratory's science and operations, including environmental stewardship and restoration activities, and to incorporate community input into BNL's decision-making process.

To facilitate stakeholder input, SCR's Stakeholder Relations Office, in coordination with the EPD, participates in or conducts on- and off-site meetings which include discussions, presentations, roundtables, and workshops. Stakeholder Relations and EPD staff attend local civic association meetings, canvass surrounding neighborhoods, conduct Laboratory tours, and coordinate informal information sessions and formal public meetings, which are held during public comment periods for environmental projects.

BNL's Internal Communications Office manages programs to increase internal stakeholder awareness, understanding, and support of Laboratory initiatives; fosters two-way communications; and updates internal stakeholders on BNL priorities, news, programs, and events.

The SCR's Office of Educational Programs manages various education initiatives and programs that support the scientific mission at BNL and the DOE. Programs include Summer Science Explorations for grades four through 12, the Science Learning Center, internships, contests in science, technology, engineering, math, and postdoctoral programs.

2.4.2.1 Communication Forums

To create opportunities for effective dialogue between the Laboratory and its stakeholders, several forums for communication and involvement have been established, such as the following:

- The Brookhaven Executive Roundtable (BER), established in 1997 by DOE's Brookhaven Site Office, meets routinely to update local, state, and federal elected officials and their staff, regulators, and other government agencies on environmental and operational issues, as well as scientific discoveries and initiatives.
- The Community Advisory Council (CAC), established by BNL in 1998, advises Laboratory management primarily on environmental, health, and safety issues related to BNL that are of importance to the community. The CAC is comprised of 26 member organizations and individuals representing civic, education, employee, community, environmental, business, and health interests. The CAC sets its own agenda in cooperation with the Laboratory meeting six months a year. The CAC is one of the primary ways the Laboratory keeps the community informed. Meetings are open to the public and are announced on the BNL homepage calendar and on the Stakeholder Relations website which links to the CAC webpage, meeting agendas, and past meeting presentations and minutes. An opportunity for public comment is provided at each meeting. Organizations interested in participating on the CAC are encouraged to attend meetings and make their interest known.
- Monthly teleconference calls are held with parties to the Laboratory's Interagency Agreement and other federal, state, and local regulators to update them on project status. The calls also provide the opportunity to gather input and feedback and to discuss emerging environmental findings and initiatives.
- Stakeholder Relations also manages several outreach programs that provide opportunities for stakeholders to become familiar with the Laboratory's facilities and research projects. Outreach programs include:
  - *Tour Program:* Opportunities to learn about BNL are offered to college, university, professional, and community groups. Tour groups visit the Laboratory's scientific machines and research facilities and meet with scientists to discuss research. Agendas are developed to meet the interests of the groups and may include sustainability and environmental stewardship issues. Tours were provided for more than 2,500 visitors in 2019. However, due to COVID-19 tours were not permitted in 2020.
  - *Summer Sundays:* Held on four Sundays each summer, these open houses enable the public to visit BNL science facilities, experience hands-on activities, and learn about research projects and environmental stewardship programs. In 2019, more than 4,700 visitors participated in the program.

However, due to the COVID-19 pandemic, Summer Sundays was offered only virtually in 2020.

– *PubSci:* BNL's science café and conversation series features distinguished Laboratory scientists who appear at public venues to discuss cutting-edge topics and research in an informal setting. During 2019, science- interested community members and BNL and Stony Brook University researchers discussed topics such as Building Blocks of Matter, Big Bang Physics and Sculpture, Sound and Simulation. Due to the COVID-19 pandemic, no Pub-Sci events were held in 2020.

The Laboratory also participates in and hosts various outreach events throughout the year such as festivals, workshops, BNL's Earth Day celebration, the World Science Festival, the City of Science, the New York City Maker Faire, and the Port Jefferson Mini-Maker Faire. Brown bag lunch meetings for employees are held periodically and cover topics of interest, including project updates, newly proposed initiatives, wildlife management concerns, and employee benefits information.

BNL's Media & Communications Office issues press releases to news and media outlets and the Internal Communications Office publishes electronic and printed weekly employee newsletters, such as *Brookhaven This Week* and *The Brookhaven Digest*. In addition, a Director's Office web-based publication, Monday Memo, is issued bi-weekly to employees and focuses on topics important to the Laboratory population.

The Laboratory maintains an informative website at ***www.bnl.gov***, where these publications, as well as extensive information about BNL's science and operations, past and present, are posted. In addition, employees and the community can subscribe to the Laboratory's e-mail news service.

Community members can ask questions or comments by clicking on the "Let us know" link found under "Listening to you" on the Stakeholder Relations website at ***www.bnl.gov/stakeholder/***. Community members can also subscribe to the weekly e-newsletter, Brookhaven This Week, found on the Media Communications webpage at ***www.bnl.gov/***, which keeps Lab employees and the community informed about happenings at BNL, explains some of the science behind Laboratory research, and invites subscribers to educational and cultural events.

The COVID-19 pandemic did not stop BNL from proactively communicating with its internal and external stakeholders through many virtual platforms during 2020. Monthly interagency calls were held and, as stated above, all of the traditional Summer Sunday open house forums were held virtually. Additionally, all regularly scheduled Community Advisory Committee and Brookhaven Executive Roundtable meetings were held virtually to ensure continued and timely communication with the community.

2.4.2.2 Community Involvement in Cleanup Projects

In 2020, BNL updated stakeholders virtually on the progress of environmental cleanup projects, additional initiatives, and health and safety issues via mailings, briefings, and presentations given at CAC and BER meetings. These topics included the following:

- *Response to COVID-19:* The CAC received updates on the National Synchrotron Light Source II's (NSLS-II) active role in combating the COVID-19 pandemic.
- *Electron Ion Collider:* The CAC received updates about the timeline, approval process, infrastructure, and science that will be necessary for the construction and operation of the Electron Ion Collider (EIC), a particle accelerator that will collide electrons with protons and nuclei to produce snapshots of those particles' internal structure. EIC research will spark innovation and enable widespread technological advances.
- *Natural & Cultural Resources:* The CAC received updates on BNL's natural resources, such as the status of flora and fauna on site, Cesium-137 in deer, terrestrial vegetation, and soil. Cultural resource updates included status of current historical determinations for buildings over 50 years old. However, the COVID-19 pandemic caused cancellation of most the Natural Resources Program in 2020.
- *Environmental Updates:* In 2020, the CAC also received environmental updates such as the general status of the groundwater con-

taminant plumes and remediation systems; planned modifications to the North Street East treatment system needed to remediate EDB; updates on the demolition and decommissioning of the High Flux Beam Reactor (HFBR) Stack; updates on emerging contaminants PFAS and 1,4 Dioxane in groundwater and proposed NYS drinking water standards for these contaminants.

2.4.3 Monitoring and Measurement

DOE Order 436.1 requires DOE sites to maintain an EMS which conforms to the ISO14001 Standard for Environmental Management Systems. BNL's EMS specifies requirements for conducting general surveillance to determine impact from site operations to the environment. DOE Order 458.1 Admin Chg 4, (2020), Radiation Protection of the Public and Environment, requires DOE sites to maintain surveillance monitoring for determining radiological impacts, if any, to the public and environment from site operations.

BNL's EMS includes an Environmental Monitoring Program (EMP) which is a comprehensive, sitewide program that identifies potential pathways for exposure of the public and employees, evaluates the impact activities have on the environment, and ensures compliance with environmental permit requirements. The EMP defines how the Laboratory will monitor effluents and emissions to ensure the effectiveness of controls, adherence to regulatory requirements, and timely identification and implementation of corrective measures. The plan uses the EPA Data Quality Objective approach for documenting the decisions associated with the monitoring program. In addition to the required triennial update, an annual electronic update is also prepared. The monitoring programs are reviewed and revised, as necessary, to reflect changes in permit requirements, changes in facility-specific monitoring activities, or the need to increase or decrease monitoring based on a review of previous analytical results.

As shown in Table 2-4, in 2020, there were 6,860 sampling events of groundwater, potable water, precipitation, air, plants and animals, soil, sediment, and discharges under the Environmental Monitoring Program. Specific sampling programs for the various media are described further in Chapters 3 through 8.

The Environmental Monitoring Program addresses three components: compliance, restoration, and surveillance monitoring.

2.4.3.1 Compliance Monitoring

Compliance monitoring is conducted to ensure that wastewater effluents, air emissions, and groundwater quality comply with regulatory and permit limits issued under the federal Clean Air Act, Clean Water Act, Oil Pollution Act, SDWA, and the New York State equivalents.

Air emissions monitoring is conducted at reactors no longer in operation, accelerators, and other radiological emission sources, as well as the CSF. Real-time, continuous emission monitoring equipment is installed and maintained at some of these facilities, as required by permits and other regulations. At other facilities, samples are collected and analyzed periodically to ensure compliance with regulatory requirements. Analytical data are routinely reported to the permitting agencies. See Chapters 3 and 4 for details.

Wastewater monitoring is performed at the point of discharge to ensure that the effluent complies with release limits in the Laboratory's SPDES permits. Twenty-four point-source discharges are monitored—12 under BNL's SPDES Permit and ten under equivalency permits issued to the Environmental Restoration Program for groundwater treatment systems. As required by permit conditions, samples are collected daily, weekly, monthly, or quarterly, and monitored for organic, inorganic, and radiological parameters. Monthly discharge monitoring reports that provide analytical results and an assessment of compliance for that reporting period are filed with the NYSDEC. See Chapter 3, Section 3.6, for details.

Groundwater monitoring is performed to comply with regulatory operating permits. Specifically, monitoring of groundwater is required under the Major Petroleum Facility License for the CSF, the RCRA permit for the Waste Management Facility, and the SPDES permit for the Sewage Treatment Plant (STP). Extensive groundwater monitoring is also conducted under the CERCLA program (described in Section 2.4.3.2 below). Additionally, to ensure that the Laboratory maintains a safe drinking water supply, BNL's potable water supply is monitored as required by SDWA, which is administered by SCDHS.

2.4.3.2 Restoration Monitoring

The Environmental Restoration Program operates and maintains groundwater treatment systems to remediate contaminant plumes both on and off site. BNL maintains an extensive network of groundwater monitoring wells to verify the effectiveness of the remediation effort. Modifications to groundwater remediation systems are implemented, as necessary, based upon a continuous evaluation of monitoring data and system performance. Details on the Peconic River monitoring program are provided in Chapter 6, and details on groundwater monitoring and restoration program are provided in Chapter 7 and SER Volume II, Groundwater Status Report.

2.4.3.3 Surveillance Monitoring

Surveillance monitoring is performed, in addition to compliance monitoring, to assess potential environmental impacts that could result from routine facility operations. The BNL Surveillance Monitoring Program involves collecting samples of ambient air, surface water, groundwater, flora, fauna, and precipitation.

Samples are analyzed for organic, inorganic, and radiological contaminants. Additionally, data collected using thermoluminescent dosimeters (i.e., devices that measure radiation exposure) strategically positioned on- and off-site is routinely reviewed under this program. Control samples (also called background or reference samples) are collected on and off the site to compare Laboratory results to areas that could not have been affected by BNL operations.

The monitoring programs can be broken down further by the relevant law or requirement (e.g., Clean Air Act) and even further by specific environmental media and type of analysis. The results of monitoring and the analysis of the monitoring data are the subject of the remaining chapters of this report. Chapter 3 summarizes environmental requirements and compliance data, Chapters 4 through 8 give details on media-specific monitoring data and analysis, and Chapter 9 provides supporting information for understanding and validating the data shown in this report.

Table 2-4. Summary of BNL Sampling Program Sorted by Media, 2020.

Environmental Media	No. of Sampling Events(a)	Purpose
Groundwater	2,419	Groundwater is monitored to evaluate impacts from past and present operations on groundwater quality under the Environmental Restoration, Environmental Surveillance, and Compliance sampling programs. See Chapter 7 and SER Volume II, Groundwater Status Report, for further detail.
On-Site Recharge Basins	63	Recharge basins used for wastewater and stormwater disposal are monitored in accordance with discharge permit requirements and for environmental surveillance purposes. See Chapter 5 for further detail.
Potable Water	24 ES 204 C	Potable water wells and the BNL distribution system are monitored routinely for chemical and radiological parameters to ensure compliance with Safe Drinking Water Act requirements. In addition, samples are collected under the Environmental Surveillance Program to ensure the source of the Laboratory's potable water is not impacted by contamination. See Chapters 3 and 7 for further detail.
Sewage Treatment Plant (STP)	118	The STP influent and effluent and several upstream and downstream Peconic River stations are monitored routinely for organic, inorganic, and radiological parameters to assess BNL impacts. The number of samples taken depends on flow. For example, samples are scheduled for collection at Station HQ quarterly, but if there is no flow, no sample can be collected. See Chapters 3 and 5 for further detail.
Precipitation	11	Precipitation samples are collected from two locations to determine levels of mercury present in rain to support long-term monitoring of atmospheric deposition of mercury.
Air – Tritium	180	Silica gel cartridges are used to collect atmospheric moisture for subsequent tritium analysis. These data are used to assess environmental tritium levels. See Chapter 4 for further detail.

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Table 2-4. Summary of BNL Sampling Program Sorted by Media, 2020 *(concluded).*

Environmental Media	No. of Sampling Events(a)	Purpose
Air – Particulate	384 ES/C 48 NYSDOH	Samples are collected to assess impacts from BNL operations and to facilitate reporting of emissions to regulatory agencies. Samples are also collected for the New York State Department of Health Services as part of their program to assess radiological air concentrations statewide. See Chapter 4 for further detail.
Fauna	84	Fish and deer are monitored to assess impacts on wildlife associated with past or current BNL operations. See Chapter 6 for further detail.
Flora	12	Vegetation is sampled to assess possible uptake of contaminants by plants and fauna, since the primary pathway from soil contamination to fauna is via ingestion. See Chapter 6 for further detail.
Soils	14	Soil samples are collected as part of the Natural Resource Management Program to assess faunal uptake, during Environmental Restoration investigative work, during the closure of drywells and underground tanks, and as part of preconstruction background sampling.
Miscellaneous	473	Samples are collected periodically from potable water fixtures and dispensers, manholes, spills, to assess process waters, and to assess sanitary discharges.
Groundwater Treatment Systems Monitoring	1130	Samples are collected from groundwater treatment systems and as long-term monitoring after remediation completion under the Comprehensive Environmental Response, Compensation, and Liability Act program. The Laboratory has eight operating groundwater treatment systems. See discussion in Chapter 7.
State Pollutant Discharge Elimination System (SPDES)	337	Samples are collected to ensure that the Laboratory complies with the requirements of the New York State Department of Environmental Conservation-issued SPDES permit. Samples are collected at the STP, recharge basins, and two process discharge sub-outfalls to the STP.
Flow Charts	583	Flowcharts are exchanged weekly as part of BNL's SPDES permit requirements to report discharge flow at the recharge basin outfalls.
Floating Petroleum Checks	96	Tests are performed on select petroleum storage facility monitoring wells to determine if floating petroleum products are present. The number of wells and frequency of testing is determined by NYSDEC licensing requirements (e.g., Major Petroleum Facility), NYSDEC spill response requirements (e.g., Motor Pool area), or other facility-specific sampling and analysis plans.
Radiological Monitor Checks	480	Daily instrumentation checks are conducted on the radiation monitors located in Buildings 569 and 592. These monitors are located 30 minutes upstream and at the STP. Monitoring at these locations allows for diversion of wastes containing radionuclides before they are discharged to the Sewage Treatment Plant recharge basins.
Quality Assurance/ Quality Control Samples (QA/ QC)	200	To ensure that the concentrations of contaminants reported in the Site Environmental Report are accurate, additional samples are collected. These samples detect if contaminants are introduced during sampling, transportation, or analysis of the samples. QA/QC samples are also sent to the contract analytical laboratories to ensure their processes give valid, reproducible results.
Total number of sampling events	**6,860**	The total number of sampling events includes all samples identified in the Environmental Monitoring Plan (BNL 2020), as well as samples collected to monitor Environmental Restoration (CERCLA) projects, air and water treatment system processes, and by the Environmental Protection Division Field Sampling Team as special requests. The number does not include samples taken by Waste Management personnel, waste generators, or Environmental Compliance Representatives for waste characterization purposes.

Notes:
(a) A sampling event is the collection of samples from a single georeferenced location. Multiple samples for different analyses (i.e., tritium, gross alpha, gross beta, and volatile organic compounds) can be collected during a single sample event.
C = Compliance
ES = Environmental Surveillance

2.4.4 EMS Assessments

To periodically verify that the Laboratory's EMS is operating as intended, assessments are conducted as part of BNL's Contractor Assurance Program. Self-assessment is the systematic evaluation of internal processes and performance. Two types of assessments are conducted: the ISO 14001 Standard conformance assessment and the regulatory compliance assessments.

The approach for the ISO14001 program self-assessment includes evaluating programs and processes within organizations that have environmental aspects to verify conformance to the ISO14001 Standard. The assessment is performed by qualified external assessors or BNL staff members who do not have line responsibility for the work processes involved. Progress toward achieving environmental objectives is monitored, as are event-related metrics to determine the overall effectiveness of the EMS. The assessment determines if there are Laboratory-wide issues that require attention, and facilitates the identification and communication of best management practices used in one part of the Laboratory that could improve performance in other parts of the Lab.

Compliance assessments are also performed by BNL staff members who do not have line responsibility for the work processes involved to ensure that operations are in compliance with Laboratory requirements that reflect external compliance requirements. These assessments verify the effectiveness and adequacy of management processes (including self-assessment programs) at the division, department, directorate, and Laboratory levels. Special investigations are conducted to identify the root causes of events and identify corrective actions and lessons learned if regulatory noncompliance or impact occurs to correct the problem and prevent reoccurrence.

BNL management routinely evaluates progress on key environmental improvement projects. The Laboratory and DOE periodically perform assessments to facilitate the efficiency of assessment activities and ensure that the approach to performing the assessments meets DOE expectations.

The Laboratory's Contractor Assurance Program is augmented by programmatic external audits conducted by DOE. BSA staff and subcontractors also perform periodic independent reviews, and an independent third-party conducts ISO 14001 registration audits of BNL's EMS. The Laboratory is subject to extensive oversight by external regulatory agencies (see Chapter 3 for details). Results of all assessment activities related to environmental performance are included, as appropriate, throughout this report.

2.5 ENVIRONMENTAL STEWARDSHIP AT BNL

BNL has extensive knowledge of its potential environmental vulnerabilities and current operations due to ongoing process evaluations, the work planning and control system, and the management systems for groundwater protection, environmental restoration, and information management. Compliance assurance programs have improved the Laboratory's compliance status and pollution prevention projects have reduced costs, minimized waste generation, and reused and recycled significant quantities of materials. BNL is openly communicating with neighbors, regulators, employees, and other interested parties on environmental issues and progress. To maintain stakeholder trust, the Laboratory will continue to deliver on commitments and demonstrate improvements in environmental performance. The Site Environmental Report is an important communication mechanism, as it summarizes BNL's environmental programs and performance each year.

Additional information about the Laboratory's environmental programs is available on BNL's website at *http://www.bnl.gov.* BNL is often asked to share its experiences, lessons learned, and successes. The Laboratory's environmental programs and projects have been recognized with international, national, and regional awards, and audits have consistently observed a high level of management involvement, commitment, and support for environmental protection and the EMS.

For over 70 years, the unique, leading-edge research facilities and scientific staff at BNL have made many innovative scientific contributions possible. Today, BNL continues its research mission while focusing on cleaning up and protecting the environment.

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Compliance Status 3

Brookhaven National Laboratory (BNL) is subject to more than 100 sets of federal, state, and local environmental regulations; numerous site-specific permits; ten equivalency permits for operation of groundwater remediation systems; and several other binding agreements. In 2020, the Laboratory operated in compliance with most of the requirements defined in these governing documents. Instances of noncompliance were reported to regulatory agencies and corrected expeditiously.

Emissions of nitrogen oxides, carbon monoxide, and sulfur dioxide from the Central Steam Facility were all well within permit limits in 2020. There were 20 recorded excess opacity measurements. Two excess opacity readings recorded in July and five in December were due to the startup and shutdown of Boiler 6. Ten excess readings on December 15 were due to heavy snowfall which obstructed the transmission of the light path of the Boiler 6 monitor, and a single excess reading recorded by the Boiler 6 monitor in October was from an unknown cause. All the excursions were documented in quarterly Site-Wide Air Emissions and Monitoring Systems Performance Reports submitted to the New York State Department of Environmental Conservation (NYSDEC).

In 2020, there were no discharges of Halon 1211 from portable fire extinguishers or Halon 1301 from accidental or fire-induced activation of fixed fire suppression systems. Halon-portable fire extinguishers continue to be removed and replaced by dry-chemical or clean agent units as part of an ongoing program to phase out the use of chlorofluorocarbons as extinguishing agents.

With the exception of a lead action level exceedance in August, BNL's drinking water and the supply and distribution system were in compliance with all applicable county, state, and federal regulations regarding drinking water quality, monitoring, operations, and reporting in 2020. Most of the liquid effluents discharged to surface water and groundwater also met applicable New York State Pollutant Discharge Elimination System (SPDES) permit requirements. An investigation into the cause(s) of Tolyltriazole (TTA) exceedances at the Sewage Treatment Plant and associated corrective actions continued throughout 2020. BNL staff continue to work closely with the Department of Energy (DOE) and NYSDEC on this issue to identify possible solutions. Groundwater monitoring at the Laboratory's Major Petroleum Facility continued to demonstrate that current oil storage and transfer operations are not affecting groundwater quality. Efforts to implement release prevention measures and minimize impacts of spills of materials continued in 2020. There were 14 spills in 2020 and four of those spills met regulatory agency reporting criteria.

In 2020, due to the pandemic, inspections by federal, state, or local regulators were limited. BNL was only inspected on seven occasions. These inspections included Sewage Treatment Plant operations, hazardous waste management facilities, and the potable water system. Immediate corrective actions were taken to address all compliance issues raised during these inspections.

3.1 COMPLIANCE WITH REQUIREMENTS

The federal, state, and local environmental statutes and regulations that BNL operates under are summarized in Table 3-1, along with a discussion of the Laboratory's compliance status. A list of all applicable environmental regulations is contained in Appendix D.

3.2 COMPLIANCE WITH REQUIREMENTS

3.2.1 Existing Permits

Many processes and facilities at BNL operate under permits issued by environmental regulatory agencies. Table 3-2 provides a complete list of the existing permits, some of which are briefly described below.

- State Pollutant Discharge Elimination System (SPDES) permits, issued by NYSDEC
- Major Petroleum Facility (MPF) license, issued by NYSDEC
- Resource Conservation and Recovery Act (RCRA) permit, issued by NYSDEC for BNL's Waste Management Facility
- Registration certificate from NYSDEC for tanks storing bulk quantities of hazardous substances (e.g., fuel oil)
- Eight radiological emission authorizations issued by the U.S. Environmental Protection Agency (EPA) under the National Emission Standards for Hazardous Air Pollutants (NESHAPs)
- Air emissions permit issued by NYSDEC under Title V of the Clean Air Act (CAA) Amendments authorizing the operation of 12 emission units
- Permit for the operation of six domestic water supply wells, one irrigation well, and one fire protection well issued by NYSDEC
- Ten SPDES equivalency permits for the operation of groundwater remediation systems installed via the Interagency Agreement (Federal Facility Agreement under the Comprehensive Environmental Response, Compensation and Liability Act [CERCLA])

3.2.2 New or Modified Permits

3.2.2.1 New York State Wetlands and Wild, Scenic, Recreational Rivers Act

The New York State Wild, Scenic, and Recreational Rivers Act was created by the state legislature in 1972 to protect and preserve certain rivers considered to have remarkable scenic, recreational, geologic, fish wildlife, historic, cultural, or other similar values. The Laboratory has one Wetland and Wild, Scenic, and Recreational Rivers Permit that was opened in 2017. The permit is an equivalency permit for the cleanup of a small area of contamination within the Peconic River. The Laboratory completed required vegetation monitoring in August 2019 and submitted documentation to NYSDEC to request permit closure. A site visit is required and was delayed until summer 2020 due to COVID-19 and the permit closed later in 2020.

3.2.2.2 Title V Permit

On August 6, 2018, the Laboratory submitted an application to NYSDEC to renew its Title V Permit, which was due to expire on February 3, 2019. After several months of discussions and modifications to the draft working permit transmitted to the Laboratory in January 2019, NYSDEC sent a notice of complete application to the Laboratory in August 2019. Following the issuance of the notice of complete application, the following actions were taken in accordance with New York State Uniform Procedures:

- NYSDEC conducted a facility inspection which included a visit to the Laboratory's Central Steam Facility and a review of records and reports to ensure the Laboratory was complying with Title V Permit terms and conditions.
- NYSDEC published the notice of complete application in the Environmental Notice Bulletin.
- The Laboratory sent a request to the Long Island Advance to publish the notice of complete application in an upcoming issue, and proof of publication that the notice appeared in the September 5, 2019 issue was forwarded to NYSDEC.

After allowing 30 days for the public to submit written comments and another 45 calendar days for EPA to review the proposed permit renewal, the NYSDEC reissued the Laboratory's Title V Permit for a period of five years on January 29, 2020.

Table 3-1. Federal, State, and Local Environmental Statutes and Regulations Applicable to BNL.

Regulator: Codified Regulation	Regulatory Program Description	Compliance Status	Report Sections
EPA: 40 CFR 300 40 CFR 302 40 CFR 355 40 CFR 370	The Comprehensive Environmental Response, Compensation & Liability Act (CERCLA) provides the regulatory framework for remediation of releases of hazardous substances and remediation (including decontamination and decommissioning [D&D]) of inactive hazardous waste disposal sites. Regulators include EPA, DOE, and the New York State Department of Environmental Conservation (NYSDEC).	In 1992, BNL became subject to a tri-party agreement among EPA, NYSDEC, and DOE. BNL site remediation is conducted by the Environmental Protection Division in accordance with milestones established under this agreement. The cleanup is currently in the long-term surveillance and maintenance mode for the groundwater treatment systems, former soil/sediment cleanup areas, and the reactors, and includes monitoring of institutional controls. BNL has been proactively characterizing PFAS and 1,4-dioxane in groundwater prior to New York State's establishment of drinking water standards for these compounds in August 2020. In late 2020, the exterior coating of the High Flux Beam Reactor (HFBR) stack was abated, with D&D of the stack and associated structures expected to be complete in 2021. The HFBR reactor vessel is scheduled for D&D by 2072.	2.3.4.8
Council for Env. Quality: 40 CFR 1500–1508 DOE: 10 CFR 1021	The National Environmental Policy Act (NEPA) requires federal agencies to follow a prescribed process to anticipate the impacts on the environment of proposed major federal actions and alternatives. DOE codified its implementation of NEPA in 10 CFR 1021.	BNL is in full compliance with NEPA requirements. The Laboratory has established sitewide procedures for implementing NEPA requirements.	3.3
Advisory Council on Historic Preservation: 36 CFR 60 36 CFR 63 36 CFR 79 36 CFR 800 16 USC 470	The National Historic Preservation Act (NHPA) identifies, evaluates, and protects historic properties eligible for listing in the National Register of Historic Places, commonly known as the National Register. Such properties can be archeological sites or historic structures, documents, records, or objects. NHPA is administered by state historic preservation offices (SHPOs; in New York State, NYSHPO). At BNL, structures that are subject to NHPA include the HFBR (Bldg. 750), the Brookhaven Graphite Research Reactor (BGRR) complex (Bldgs. 701, 703, 705, and 801), 1960's era Apartments (Bldgs. 364 and 365,), Bldg. 120, Berkner Hall (Bldg.488), Chemistry (Bldg. 555), Physics (Bldg. 510), Computational Sciences (Bldg. 515), Instrumentation (Bldg. 535), Medical (Bldgs. 490 and 491), WW II era water tower (ST0-49), Accelerator Test Facility (Bldgs. 820, 820A, and 820B), EBNN research (Bldg. 830), Magnet Division (Bldg. 902), Alternating Gradient Synchrotron complex (Bldgs. 901, 901A, 911, 912, 913, 913a-e, and 930) and the World War I training trenches found throughout the site.	There are now multiple buildings and features at BNL that have been determined to be National Register Eligible (see list to the left). Any proposed activities involving these facilities must be identified through the NEPA/NHPA processes and evaluated to determine if the action would affect the features that make the facility eligible. BNL has a Cultural Resource Management Plan to ensure compliance with cultural resource regulations. Buildings that are 50 years old or older are reviewed under Section 106 of NHPA when proposed projects may significantly alter the structure or for building demolition. See Chapter 6 for detailed information on Cultural Resources.	3.4
EPA: 40 CFR 50 40 CFR 60-61 40 CFR 63 40 CFR 80 40 CFR 82 40 CFR 98 NYSDEC: 6 NYCRR 200–257 6 NYCRR 307	The Clean Air Act (CAA) and the NY State Environmental Conservation Laws regulate the release of air pollutants through permits and air quality limits. Emissions of radionuclides are regulated by EPA via the National Emission Standards for Hazardous Air Pollutants (NESHAPs) authorizations.	All air emission sources are incorporated into the BNL Title V permit or have been exempted under the New York State air program, which is codified under the New York Codes, Rules, and Regulations (NYCRR). All applicable CAA and NYCRR regulations are incorporated into the BNL Title V permit. Radiological air emission sources are registered with the EPA.	3.5
EPA: 40 CFR 109–140 40 CFR 230, 231 40 CFR 401, 403 NYSDEC: 6 NYCRR 700–703 6 NYCRR 750	The Clean Water Act (CWA) and NY State Environmental Conservation Laws seek to improve surface water quality by establishing standards and a system of permits. Wastewater discharges are regulated by NYSDEC permits through the State Pollutant Discharge Elimination System (SPDES).	At BNL, permitted discharges include treated sanitary waste and cooling tower and stormwater discharges. With the exception of nine excursions of Tolyltriozole (TTA) at BNL's sewage treatment plant, these discharges met the SPDES permit limits in 2020.	3.6

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Table 3-1. Federal, State, and Local Environmental Statutes and Regulations Applicable to BNL.*(continued).*

Regulator: Codified Regulation	Regulatory Program Description	Compliance Status	Report Sections
EPA: 40 CFR 141–149 NYSDOH: 10 NYCRR 5	The Safe Drinking Water Act (SDWA) and New York State Department of Health (NYSDOH) standards for public water supplies establish minimum drinking water standards and monitoring requirements. SDWA requirements are enforced by the Suffolk County Department of Health Services (SCDHS).	BNL maintains a sitewide public water supply. With the exception of an action level exceedance on lead, BNL's drinking water and the supply and distribution system were in compliance with all applicable county, state, and federal regulations regarding drinking-water quality, monitoring, operations, and reporting in 2020. Corrective actions for all identified operation and maintenance deficiencies identified during the annual SCDHS sanitary survey were established and communicated with SCDHS and are being addressed by the Laboratory's Energy and Utilities Division.	3.7
EPA: 40 CFR 112 40 CFR 300 40 CFR 302 40 CFR 355 40 CFR 370 40 CFR 372	The Oil Pollution Act, the Emergency Planning and Community Right-to-Know Act (EPCRA), and the Superfund Amendment Reauthorization Act (SARA) require facilities with large quantities of petroleum products or chemicals to prepare emergency plans and report their inventories to EPA, the state, and local emergency planning groups.	Since some facilities at BNL store or use chemicals or petroleum in quantities exceeding threshold planning quantities, the Laboratory is subject to these requirements. BNL fully complied with all reporting and emergency planning requirements in 2020.	3.8.1 3.8.2 3.8.3
EPA: 40 CFR 280 NYSDEC: 6 NYCRR 595–597 6 NYCRR 611–613 SCDHS: SCSC Article 12	Federal, state, and local regulations govern the storage of chemicals and petroleum products to prevent releases of these materials to the environment. Suffolk County Sanitary Codes (SCSC) are more stringent than federal and state regulations.	The regulations require that these materials be managed in facilities equipped with secondary containment, overfill protection, and leak detection. BNL complies with all federal and state requirements and continues to conform to county codes.	3.8.4 3.8.5 3.8.6
EPA: 40 CFR 260–280 NYSDEC: 6 NYCRR 360–372	The Resource Conservation Recovery Act (RCRA) and New York State Solid Waste Disposal Act govern the generation, storage, handling, and disposal of hazardous wastes.	BNL is defined as a large-quantity generator of hazardous waste and has a permitted waste management facility.	3.9
EPA: 40 CFR 700–763	The Toxic Substances Control Act (TSCA) regulates the manufacture, use, and distribution of all chemicals.	BNL manages all TSCA-regulated materials, including PCBs, and is in compliance with all requirements.	3.10
EPA: 40 CFR 162–171(f) NYSDEC: 6 NYCRR 320 6 NYCRR 325–329	The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and corresponding NY State regulations govern the manufacture, use, storage, and disposal of pesticides, herbicides, biocides, rodenticides, fungicides, tickicides, as well as the pesticide containers and residuals.	BNL contracts and/or employs NYSDEC-certified pesticide applicators for specific pesticide categories to apply pesticides, herbicides, biocides, rodenticides, fungicides, and tickicides. Each applicator attends Continuing Education training, as needed, to maintain current category certifications and BNL (or the contractor that applies regulated materials) files an annual report to the NYSDEC Pesticide Bureau detailing the above applications including EPA Registration Nos., dates of applications, method of application, target organisms, types, locations, quantity, and dosage rates of pesticides applied.	3.11
DOE: 10 CFR 1022 NYSDEC: 6 NYCRR 663 6 NYCRR 666	DOE regulations require its facilities to comply with floodplain/wetland review requirements. The New York State Fresh Water Wetlands and Wild, Scenic, and Recreational Rivers rules govern development in the state's natural waterways. Development or projects within a half-mile of regulated waters must have NYSDEC permits.	BNL is in the Peconic River watershed and has several jurisdictional wetlands; consequently, development of locations in the north and east of the site requires NYSDEC permits and review for compliance under DOE wetland/floodplain regulations. A small section of the Peconic River required additional clean-up which was conducted under a Wetlands Equivalency Permit in 2017. As part of the permit requirements, the restoration process requires evaluation of vegetation for at least two growing seasons after completion. The clean-up area was evaluated, and most of the area is considered 'open water' which does not have a vegetative cover standard; therefore, the area is meeting permit requirements. After evaluation of the area in 2019, a request to close the permit was sent to NYSDEC and included a request for a verification visit during the next growing season in 2020. The permit was closed in late 2020.	3.12

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Table 3-1. Federal, State, and Local Environmental Statutes and Regulations Applicable to BNL. *(continued).*

Regulator: Codified Regulation	Regulatory Program Description	Compliance Status	Report Sections
U.S. Fish & Wildlife Service: 50 CFR 17 NYSDEC: 6 NYCRR 182	The Endangered Species Act and corresponding New York State regulations prohibit activities that would jeopardize the continued existence of an endangered or threatened species or cause adverse modification to a critical habitat.	BNL is host to numerous species of flora and fauna. Many species have been categorized by New York State as endangered, threatened, or of special concern; and one threatened species has been designated under the Endangered Species Act. The Laboratory's Natural Resource Management Plan outlines activities to protect these vulnerable species and their habitats (see Chapter 6 for details).	3.13
U.S. Fish & Wildlife Service: Migratory Bird Treaty Act 16 USC 703-712 The Bald and Golden Eagle Protection Act 16 USC 668 a-d	The Migratory Bird Treaty Act (MBTA) implements various treaties and conventions between the U.S. and Canada, Japan, Mexico, and the former Soviet Union for the protection of migratory birds. Under the Act, taking, killing, or possessing migratory birds is unlawful. Birds protected under the act include all common songbirds, waterfowl, shorebirds, hawks, owls, eagles, ravens, crows, native doves and pigeons, swifts, martins, swallows, and others, and includes their body parts (feathers, plumes, etc.), nests, and eggs. The Bald and Golden Eagle Protection Act (BGEPA) prohibits any form of possession or taking of both bald and golden eagles.	Compliance with the MBTA and the BGEPA are documented through the BNL Natural Resource Management Plan. The plan includes provisions for enhancing local habitat through the control of invasive species, planting of native grasses as food sources, and construction of nesting sites. All construction activities, including demolition, are reviewed to ensure there are no impacts to nesting birds. Bald Eagles have been seen routinely at various locations on the BNL site and a pair of eagles were observed investigating the use of an osprey nest. NYSDEC was consulted for requirements should the eagles establish a nest. See Chapter 6 for more on migratory birds and bald eagles.	3.13
DOE: Order 231.1B Manual 231.1-1A	The Environment, Safety, and Health Reporting program objective is to ensure timely collection, reporting, analysis, and dissemination of information on environment, safety, and health issues as required by law or regulations or as needed to ensure that DOE is kept fully informed on a timely basis about events that could adversely affect the health and safety of the public, workers, the environment, the intended purpose of DOE facilities, or the credibility of the Department. Included in the order are the requirements for the Occurrence Reporting and Processing of Operations Program (ORPS).	BNL prepares an annual Site Environmental Report and provides data for DOE to prepare annual NEPA summaries and other Safety, Fire Protection, and Occupational Health and Safety Administration (OSHA) reports. The Laboratory developed the ORPS Subject Area for staff and management who perform specific duties related to discovery, response, notification, investigation, and reporting of occurrences to BNL and DOE management. The ORPS Subject Area is supported by: Occurrence Reporting Program Description, Critiques Subject Area, Occurrence Categorizer's Procedure, and the ORPS Office Procedure.	All chapters
DOE: Order 414.1D 10 CFR 830, Subpart A Policy 450.5	The Quality Assurance (QA) program objective is to establish an effective management system using the performance requirements of this Order/ Rule, coupled with consensus standards, where appropriate, to ensure: 1) products and services meet or exceed customers' expectations; 2) management support for planning, organization, resources, direction, and control ; 3) performance and quality improvement thorough rigorous assessment and corrective action and; and 4) environmental, safety, and health risks and impacts associated with work processes are minimized while maximizing reliability and performance of work products.	BNL has a Quality Assurance (QA) Program in place to implement quality management methodology throughout its management systems and associated processes to: (1) achieve and maintain compliance with applicable environmental, safety, security, and health (ESSH) requirements; (2) continue improvement in ESSH performance; (3) provide a safe and healthy workplace; (4) protect the environment and conserve resources; (5) prevent pollution; (6) provide services and products of the highest quality consistent with the needs, expectations, and resources of our customers; and (7) continuously improve processes, systems, and capabilities to improve operations and increase the value of research products delivered to customers. Having a comprehensive program ensures that all environmental monitoring data meet QA and quality control requirements. Samples are collected and analyzed using standard operating procedures to ensure representative samples and reliable, defensible data. Quality control in the analytical labs is maintained through daily instrument calibration, efficiency and background checks, and testing for precision and accuracy. Data are verified and validated according to project-specific quality objectives before they are used to support decision making.	Chapter 9

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Table 3-1. Federal, State, and Local Environmental Statutes and Regulations Applicable to BNL *(concluded).*

Regulator: Codified Regulation	Regulatory Program Description	Compliance Status	Report Sections
DOE: Order 435.1 Chg. 1	The Radioactive Waste Management Program objective is to ensure that all DOE radioactive waste is managed in a manner that protects workers, public health and safety, and the environment. Order 435.1 requires all DOE organizations that generate radioactive waste to implement a waste certification program. DOE Laboratories must develop a Radioactive Waste Management Basis (RWMB) Program description, which includes exemption and timeframe requirements for staging and storing both routine and non-routine radioactive wastes.	The BNL Waste Certification Program Plan (WCPP) in the RWMB Program description defines the radioactive waste management program's structure, logic, and methodology for waste certification. New or modified operations or activities that do not fall within the scope of the RWMB Program description must be documented and approved before implementation. The Laboratory's RWMB Program description describes the BNL policies, procedures, plans, and controls demonstrating that the Laboratory has the management systems, administrative controls, and physical controls to comply with DOE Order 435.1 Chg. 1.	2.3.4.3
DOE: Order 436.1	The DOE Departmental Sustainability Order replaces former DOE Orders 450.1A, Environmental Protection Programs, and 430.2B, Departmental Energy, Renewable Energy and Transportation Management. The intent of the new order is to incorporate and implement the requirements of Executive Order (EO) 13514 and to continue compliance with EO 13423 though both of those orders were replaced by EO 13693 "Planning for Federal Sustainability in the Next Decade". However, O 436.1 is still supported by DOE requirements for sound sustainability programs implemented under the DOE 2010 Strategic Sustainability Performance Plan (SSPP). Contractor requirements under the order require preparation of a Site Sustainability Plan and implementation of a sound Environmental Management System (EMS).	In accordance with the requirements of the DOE Strategic Sustainability Performance Plan, BNL has developed and implemented a Site Sustainability Plan. The Goals and Strategic Objectives of the DOE SSPP are tracked and reported on annually. BNL's EMS was officially registered to the ISO 14001:2015 revised standard in 2018.	Chapter 2
DOE: Order 458.1, Change 3	In February 2011, DOE released DOE Order 458.1 Radiation Protection of the Public and Environment, which replaced former Order 5400.5. The order establishes requirements to protect the public and the environment against undue risk from radiation associated with radiological activities conducted under the control of DOE pursuant to the Atomic Energy Act of 1954, as amended. The Order requires the preparation of an Environmental Radiation Protection Plan which outlines how facilities monitor their impacts on the public and environment. Full compliance with the Order was required by August 2012.	In accordance with the requirements of DOE Order 458.1, BNL maintains and implements several plans and programs for ensuring that the management of facilities, wastes, effluents, and emissions do not present a risk to the public, workers, or environment. These plans and programs have existed for decades and were previously implemented under prior DOE Order 5400.5 and in accordance with the current DOE O 435.1, Radioactive Waste Management, and 10 CFR 835. Environmental monitoring plans are well documented, and the results are published annually in BNL's Site Environmental Report, which is prepared in accordance with DOE O 231.1B. The Environmental Radiation Protection Program (ERPP), which was published in September 2012, provides a record of the requirements of DOE O 458.1 and documents how the Laboratory meets these requirements. This document is reviewed annually and updated, as necessary to ensure compliance with this requirement.	Chapters 3, 4, 5, 6, and 8

Notes:
CFR = Code of Federal Regulations
NYCRR = New York Codes, Rules, and Regulations
SCSC = Suffolk County Sanitary Code

Table 3-2. BNL Environmental Permits

Issuing Agency	Bldg. or Facility	Process/Permit Description	Permit ID No.	Expiration or Completion	Emission Unit ID	Source ID
EPA - NESHAPs	510	Calorimeter Enclosure	BNL-689-01[1]	None	NA	NA
EPA - NESHAPs	705	Tritium Evaporator	BNL-288-01[1]	None	NA	NA
EPA - NESHAPs	820	Accelerator Test Facility	BNL-589-01	None	NA	NA
EPA - NESHAPs	AGS	AGS Booster - Accelerator	BNL-188-01	None	NA	NA
EPA - NESHAPs	RHIC	Accelerator	BNL-389-01	None	NA	NA
EPA - NESHAPs	931	Brookhaven LINAC Isotope Producer	BNL-2009-1	None	NA	NA
EPA - NESHAPs	REF	Radiation Effects/Neutral Beam	BNL-789-01	None	NA	NA
EPA - NESHAPs	RTF	Radiation Therapy Facility	BNL-489-01[1]	None	NA	NA
NYSDEC - Air Equivalency	517/518	South Boundary/Middle Road System	1-51-009	NA	NA	NA
NYSDEC - Air Equivalency	598	OU I Remediation System	1-52-009	NA	NA	NA
NYSDEC - Air Equivalency	539	Western South Boundary System	1-52-009	NA	NA	NA
NYSDEC - Air Equivalency	TR 867	T-96 Remediation System	1-52-009	NA	NA	NA
NYSDEC - Air Equivalency	644	Freon-11 Treatment System	1-52-009	NA	NA	NA
NYSDEC - SPDES Equivalency	517/518	South Boundary/Middle Road System	1-52-009	NA	NA	NA
NYSDEC - SPDES Equivalency	539	Western South Boundary System	1-52-009	NA	NA	NA
NYSDEC - SPDES Equivalency	670	Sr-90 Treatment System - Chemical Holes	1-52-009	25-Feb-23	NA	NA
NYSDEC - SPDES Equivalency	OS-4	Airport/LIPA Treatment System	1-52-009	NA	NA	NA
NYSDEC - SPDES Equivalency	OS-5	North St./North St. East Treatment System	1-52-009	26-Mar-25	NA	NA
NYSDEC - SPDES Equivalency	OS-6	Ethylene Di-Bromide Treatment System	1-52-009	26-Mar-25	NA	NA
NYSDEC - SPDES Equivalency	855	Sr-90 Treatment System - BGRR/WCF	1-52-009	26-Mar-25	NA	NA
NYSDEC - SPDES Equivalency	TR 867	T-96 Remediation System	1-52-009	20-Mar-22	NA	NA
NYSDEC - SPDES Equivalency	644	Freon-11 Treatment System	1-52-009	20-Mar-22	NA	NA
NYSDEC - SPDES Equivalency	OS-2	Industrial Park Treatment System	1-52-009	26-Mar-25	NA	NA
NYSDEC - Hazardous Substance	BNL	Bulk Storage Registration Certificate	1-000263	27-Jul-21	NA	NA
NYSDEC - LI Well Permit	BNL	Domestic Potable/Process Wells	1-4722-00032/00151	17-Jul-26	NA	NA
NYSDEC - Air Quality	423	Metal Parts Cleaning Tanks (2)	1-4722-00032/00115	30-Jan-25	U-METAL	42307-08
NYSDEC - Air Quality	423	Gasoline & E85 Storage and Fuel Pumps	1-4722-00032/00115	30-Jan-25	U-FUELS	42309-10
NYSDEC - Air Quality	423	Motor Vehicle A/C Servicing	1-4722-00032/00115	30-Jan-25	U-MVACS	MVAC2
NYSDEC - Air Quality	423	Motor Vehicle A/C Servicing	1-4722-00032/00115	30-Jan-25	U-MVACS	MVAC5
NYSDEC - Air Quality	244	Paint Spray Booth	1-4722-00032/00115	30-Jan-25	U-PAINT	24402
NYSDEC - Air Quality	244	Flammable Liquid Storage Cabinet	1-4722-00032/00115	30-Jan-25	U-PAINT	244AE
NYSDEC - Air Quality	734	Spin Coating Operation	1-4722-00032/00115	30-Jan-25	U-INSIG	734AA
NYSDEC - Air Quality	801	Target Processing Laboratory	1-4722-00032/00115	30-Jan-25	U-INSIG	80101
NYSDEC - Air Quality	Site	Aerosol Can Processing Units	1-4722-00032/00115	30-Jan-25	U-INSIG	AEROS
NYSDEC - Air Quality	498	Aqueous Cleaning Facility	1-4722-00032/00115	30-Jan-25	U-METAL	49801
NYSDEC - Air Quality	610	Combustion Unit	1-4722-00032/00115	30-Jan-25	U-61005	61005
NYSDEC - Air Quality	610	Combustion Unit	1-4722-00032/00115	30-Jan-25	U-61006	61006
NYSDEC - Air Quality	610	Combustion Unit	1-4722-00032/00115	30-Jan-25	U-61007	61007
NYSDEC - Air Quality	610	Metal Parts Cleaning Tray	1-4722-00032/00115	30-Jan-25	U-METAL	61008
NYSDEC - Air Quality	610	Combustion Unit	1-4722-00032/00115	30-Jan-25	U-61005	61005
NYSDEC - Air Quality	610	Combustion Unit	1-4722-00032/00115	30-Jan-25	U-61006	61006
NYSDEC - Air Quality	610	Combustion Unit	1-4722-00032/00115	30-Jan-25	U-61007	61007
NYSDEC - Air Quality	610	Metal Parts Cleaning Tray	1-4722-00032/00115	30-Jan-25	U-METAL	61008

(continued on next page)

Table 3-2. BNL Environmental Permits *(concluded).*

Issuing Agency	Bldg. or Facility	Process/Permit Description	Permit ID No.	Expiration or Completion	Emission Unit ID	Source ID
NYSDEC - Air Quality	610	Combustion Unit	1-4722-00032/00115	30-Jan-25	U-61005	6101A
NYSDEC - Air Quality	902	Epoxy Coating/Curing Exhaust	1-4722-00032/00115	30-Jan-25	U-COILS	90206
NYSDEC - Air Quality	922	Electroplating Operation	1-4722-00032/00115	30-Jan-25	U-INSIG	92204
NYSDEC - Air Quality	Site	Commercial Refrigeration Equipment	1-4722-00032/00115	30-Jan-25	U-RFRIG	COMRE
NYSDEC - Air Quality	Site	Packaged A/C Units (16)	1-4722-00032/00115	30-Jan-25	U-RFRIG	PKG01-16
NYSDEC - Air Quality	Site	Reciprocating Chillers (44)	1-4722-00032/00115	30-Jan-25	U-RFRIG	REC01-65
NYSDEC - Air Quality	Site	Rotary Screw Chillers (19)	1-4722-00032/00115	30-Jan-25	U-RFRIG	ROTO1-20
NYSDEC - Air Quality	Site	Split A/C Units	1-4722-00032/00115	30-Jan-25	U-RFRIG	SPL01-02
NYSDEC - Air Quality	Site	Centrifugal Chillers (17)	1-4722-00032/00115	30-Jan-25	U-RFRIG	CEN06-29
NYSDEC - Air Quality	463	Diesel Emergency Generator	1-4722-00032/00115	30-Jan-25	U-GENER	46301
NYSDEC - Air Quality	490	Diesel Emergency Generator	1-4722-00032/00115	30-Jan-25	U-GENER	49006
NYSDEC - Air Quality	515	Diesel Non-Emergency Generator	1-4722-00032/00115	30-Jan-25	U-GENER	51501
NYSDEC - Air Quality	555	Diesel Emergency Generator	1-4722-00032/00115	30-Jan-25	U-GENER	55503
NYSDEC - Air Quality	635	Diesel Emergency Generator	1-4722-00032/00115	30-Jan-25	U-GENER	63501
NYSDEC - Air Quality	734	Diesel Emergency Generator	1-4722-00032/00115	30-Jan-25	U-GENER	73401
NYSDEC - Air Quality	735	Diesel Emergency Generator	1-4722-00032/00115	30-Jan-25	U-GENER	73501
NYSDEC - Air Quality	740	Diesel Emergency Generators (2)	1-4722-00032/00115	30-Jan-25	U-GENER	74001-02
NYSDEC - Air Quality	801	Diesel Emergency Generator	1-4722-00032/00115	30-Jan-25	U-GENER	80102
NYSDEC - Air Quality	912	Diesel Emergency Generators (3)	1-4722-00032/00115	30-Jan-25	U-GENER	912A1-A3
NYSDEC - Air Quality	30	Combustion Unit	1-4722-00032/00115	30-Jan-25	U-SMBLR	030AB
NYSDEC - Air Quality	422	Combustion Unit	1-4722-00032/00115	30-Jan-25	U-SMBLR	422AF
NYSDEC - Air Quality	423	Combustion Unit	1-4722-00032/00115	30-Jan-25	U-SMBLR	42304
NYSDEC - Hazardous Waste	WMF	Waste Management	1-4722-00032/00102	06-Sep-22	NA	NA
NYSDEC - Water Quality	CSF	Major Petroleum Facility	1-1700	31-Mar-22	NA	NA
NYSDEC - WQ- Equivalency	Site	Peconic River Cleanup	1-4722-00032/00153	Closed 2020	NA	NA

Notes:
[1] Source Facility Removed and awaiting EPA termination of NESHAPs authorization.
A/C = Air Conditioning
AGS = Alternating Gradient Synchrotron
BGRR = Brookhaven Graphite Research Reactor
CSF = Central Steam Facility
EPA = Environmental Protection Agency
LIPA = Long Island Power Authority
NA = Not Applicable
NESHAPs = National Emission Standards for Hazardous Air Pollutants
NYSDEC = New York State Department of Environmental Conservation
OU = Operable Unit
RTF = Radiation Therapy Facility
RHIC = Relativistic Heavy Ion Collidar
SDWA = Safe Drinking Water Act
SPDES = State Pollutant Discharge Elimination System
Sr-90 = Strontium-90
STP = Sewage Treatment Plant
WCF = Waste Concentration Facility
WMF = Waste Management Facility

3.3 NEPA ASSESSMENTS

National Environmental Policy Act (NEPA) regulations require federal agencies to evaluate the environmental effects of proposed major federal activities. The prescribed evaluation process ensures that the proper level of environmental review is performed before an irreversible commitment of resources is made. During 2020, environmental evaluations were completed for 114 proposed projects at BNL. All 114 projects were considered minor actions requiring no additional documentation. An Environmental Assessment for the Construction and Operation of the Electron-Ion Collider was started in 2020 and was near completion by the end of the year.

3.4 PRESERVATION LEGISLATION

The Laboratory is subject to several cultural resource laws, most notably the National Historic Preservation Act and the Archeological Resource Protection Act. These laws require agencies to consider the effects of proposed federal actions on historic structures, objects, and documents, as well as cultural or natural places important to Native Americans or other ethnic or cultural groups.

BNL has 34 structures or sites that are eligible for listing on the National Register of Historic Places: the Brookhaven Graphite Research Reactor (BGRR) complex (Buildings 701, 703, 705, and 801), the High Flux Beam Reactor (HFBR) complex (Building 750 and 750A), two 1960s-era efficiency apartments (Building 364 and 365), Berkner Hall (Building 488), Medical Complex (Building 490 and 491), Chemistry (Building 555), Physics (Building 510), Computational Sciences (Building 515), Instrumentation (Building 535), Accelerator Test Facility (Buildings 820, 820A, and 820B), Environment, Biology, Nuclear Science & Nonproliferation Research (Building 820), Magnet Division (Building 902), the Alternating Gradient Synchrotron Complex (Buildings 901, 901A, 911, 912, 913, 913A-E, and 930), the World War-II (WWII) barracks portion of Building 120, the WWII-era Water Tower, and the WWI Army training trenches associated with Camp Upton. Cultural resource activities are described in Chapter 6.

3.5 CLEAN AIR ACT (CAA)

The objectives of the CAA, which is administered by EPA and NYSDEC, are to improve or maintain regional ambient air quality through operational and engineering controls on stationary or mobile sources of air pollution. Both conventional and hazardous air pollutants are regulated under the CAA.

3.5.1 Conventional Air Pollutants

The Laboratory has a variety of conventional, nonradioactive air emission sources that are subject to federal or state regulations. The following subsections describe the more significant sources, and the methods used by BNL to comply with the applicable regulatory requirements.

3.5.1.1 Boiler Emissions

BNL has four boilers (Nos. 1A, 5, 6, and 7) at the Central Steam Facility (CSF) that are subject to NYSDEC Reasonably Available Control Technology (RACT) requirements. Three of the boilers can burn either residual fuel oil or natural gas; Boiler 1A burns fuel oil only. In 2020, natural gas was the predominant fuel burned at the CSF. For boilers with maximum operating heat inputs greater than or equal to 25 MMBtu/hr. (7.3 MW), the RACT requirements establish emission standards for oxides of nitrogen (NOx). The NOx RACT standard for the combustion of natural gas and No. 6 oil burned in the Laboratory's three large boilers (Nos. 5, 6, and 7) is 0.15 lbs./MMBtu for both fuels. The NOx RACT emission limit for the CSF's one mid-size boiler (No. 1A) is 0.20 lbs./MMBtu.

Boilers with a maximum operating heat input between 25 and 250 MMBtu/hr. (7.3 and 73.2 MW) can demonstrate compliance with the NOx standard using periodic emission tests or by using continuous emission monitoring equipment; all four CSF boilers fall in this operating range. Boilers 6 and 7 use continuous emission monitoring systems (CEMS) to demonstrate compliance with NOx standards. Because past emissions testing and CEMS results when No. 6 oil was burned have shown that CSF boilers 5, 6, and 7 cannot meet the new lower NOx RACT standards effective as of July 2014, BNL uses an approved system averaging plan to demonstrate compliance in quarterly reports submitted to NYSDEC.

The Laboratory also maintains continuous opacity monitors for Boilers 6 and 7. These monitors measure the transmittance of light through the exhaust gas and report the measurement in percent attenuated. Opacity limitations state that no facility may emit particulates such that the opacity exceeds 20 percent, calculated in six-minute averages, except for one period not to exceed 27 percent in any one hour.

During 2020, there were no recorded exceedances of the NOx RACT limit by the Boiler 6 or Boiler 7 CEMS. Using the system averaging approach, actual weighted average NOx emission rates for operating boilers for the first through fourth quarters were 0.085, 0.088, 0.087, and 0.108 lbs./MMBtu, respectively, which were below the corresponding quarterly permissible weighted average emissions rate of 0.150 lbs./MMBtu each quarter.

In 2020, there were 20 recorded excess opacity measurements. Two excess opacity readings recorded in July and five in December were due to the startup and shutdown of Boiler 6. Ten excess readings on December 15 were due to heavy snowfall which obstructed the transmission of the light path of the Boiler 6 monitor, and a single excess reading recorded by the Boiler 6 monitor in October was from an unknown cause. All the excursions were documented in quarterly Site-Wide Air Emissions and Monitoring Systems Performance Reports submitted to NYSDEC. Chapter 4 discusses CSF compliance with NOx RACT standards and opacity limits in greater detail.

3.5.1.2 Ozone-Depleting Substances

Refrigerant: The Laboratory's preventative maintenance program requires regular inspection and maintenance of refrigeration and air conditioning equipment that contains ozone-depleting substances such as R-11, R-12, and R-22. All refrigerant recovery and recycling equipment are certified to meet refrigerant evacuation levels specified by 40 CFR 82.158. As a matter of BNL's standard practice, if a refrigerant leak is found, technicians will either immediately repair the leak or isolate it and prepare a work order for the needed repairs. This practice is more stringent than the leak repair provisions of 40 CFR 82.156.

In 2020, 593 pounds of R-22, 200 pounds of R-134A, and 40 pounds of R-410A were recovered and recycled from refrigeration equipment that was serviced. Meanwhile, 335 pounds of R-22 and 24 pounds of R-410A leaked from refrigeration and air conditioning equipment on site. These leaks were subsequently reported as emissions in the Annual Emissions Statement transmitted to NYSDEC.

Halon: Halon 1211 and 1301 are extremely efficient fire suppressants but are being phased out due to their effect on the earth's ozone layer. Halon recovered from excessed systems is shipped to the Department of Defense Ozone Depleting Substances Reserve in accordance with the Class I Ozone Depleting Substances Disposition Guidelines prepared by the DOE Office of Environmental Policy and Guidance. In 2020, no excess Halon 1301 was shipped to the Department of Defense Ozone Depleting Substances Reserve, and there were no discharges of Halon 1211 from portable fire extinguishers or Halon 1301 from accidental or fire-induced activation of fixed fire suppression systems.

3.5.2 Hazardous Air Pollutants

In 1970, the CAA established standards to protect the general public from hazardous air pollutants that may lead to death or an increase in irreversible or incapacitating illnesses. The NESHAPs program was established in 1977 and the governing regulations were updated significantly in 1990. EPA developed NESHAPs to limit the emission of air pollutants and since 1990, EPA has modified the list through rulemaking to include 187 hazardous air pollutants. The program includes a list of regulated contaminants, a schedule for implementing control requirements, aggressive technology-based emission standards, industry-specific requirements, special permitting provisions, and a program to address accidental releases.The following subsections describe BNL's compliance with NESHAPs regulations.

3.5.2.1.Maximum Available Control Technology

Based on the Laboratory's periodic review of Maximum Available Control Technology (MACT) standards in 2020, it has been determined that none of the proposed or newly promulgated MACT standards apply to the emissions from existing permitted operations or the anticipated emissions from proposed activities and operations at BNL.

3.5.2.2 Asbestos

In 2020, the Laboratory notified the EPA Region II office regarding the removal of materials containing asbestos. During the year, 27,680 pounds of both scheduled and non-scheduled friable asbestos from maintenance operations materials and building demolition preparation (e.g., pipe insulation, sheetrock, popcorn ceiling, transite board, floor tiles, water main pipes) were removed and disposed of according to EPA requirements.

3.5.2.3 Radioactive Airborne Emissions

Minor and major sources of radiological airborne emissions from BNL's facilities and activities are evaluated to ensure that they do not impact the environment, on-site workers, or people residing at or near the Laboratory. A full description of radiological emissions monitoring conducted in 2020 is provided in Chapter 4.

BNL transmitted all data pertaining to radioactive air emissions and dose calculations to EPA in fulfillment of its annual reporting requirement. As in past years, the maximum off-site dose due to airborne radioactive emissions from the Laboratory continued to be far below the 10 mrem (100 µSv) annual dose limit specified in 40 CFR 61 Subpart H (see Chapters 4 and 8 for more information on the estimated air dose). Using EPA modeling software, the dose to the maximally exposed off-site individual resulting from BNL's airborne emissions in 2020 was 5.6 E-5 mrem (5.65 E-4 µSv). This dose is significantly less than previous years due to the fact that there were no target irradiations performed at the BLIP facility in 2020.

3.6 CLEAN WATER ACT

The disposal of wastewater generated by Laboratory operations is regulated under the Clean Water Act (CWA) as implemented by NYSDEC and under DOE Order 458.1, Radiation Protection of the Public and the Environment. The goals of the CWA are to achieve a level of water quality that promotes the propagation of fish, shellfish, and wildlife; to provide waters suitable for recreational purposes; and to eliminate the discharge of pollutants into surface waters. New York State was delegated CWA authority in 1975. NYSDEC has issued a SPDES permit to BNL that regulates wastewater effluents. The permit specifies monitoring requirements and effluent limits for nine of 12 outfalls, as described below. See Figure 5-3 in Chapter 5 for the locations of the following BNL outfalls:

- Outfall 001 is used to discharge treated effluent from the Sewage Treatment Plant (STP) to groundwater recharge basins.
- Outfalls 002, 002B, 003, 005, 006A, 006B, 008, 010, 011, and 012 are recharge basins used to discharge cooling tower blowdown, once-through cooling water, and/or stormwater. Because only stormwater or once-through cooling water is discharged to Outfalls 003, 011, and 012, NYSDEC imposes no monitoring requirements for these discharges.
- Outfall 007 receives backwash water from the Potable Water Treatment Plant filter building.
- Outfall 009 consists of numerous subsurface and surface wastewater disposal systems (e.g., cesspools) that receive predominantly sanitary waste and steam- and air-compressor condensate discharges. NYSDEC does not require monitoring of these disposal systems.

Each month, the Laboratory prepares Discharge Monitoring Reports (DMRs) that describe monitoring results, evaluate compliance with permit limitations, and identify corrective measures taken to address permit excursions. These reports are submitted electronically to EPA, NYSDEC central and regional offices, and the Suffolk County Department of Health Services (SCDHS) through a Network DMR (NetDMR) system. Details of the monitoring program conducted for the groundwater treatment systems where SPDES equivalency permits are in effect are provided in SER Volume II, Groundwater Status Report. Evaluation of the current effluent quality shows it to consistently meet groundwater effluent standards, and in most cases, ambient water quality standards for surface water. Details on monitoring

Table 3-3. Analytical Results for Wastewater Discharges to Sewage Treatment Plant Outfall 001.

Analyte	Low Report	High Report	Min. Monitoring. Freq.	SPDES Limit	Exceedances	% Compliance*
pH (SU)	7.0	7.9	Continuous Recorder	Min 5.8, Max. 8.5	0	100
Solids, Total Dissolved (mg/L)	320	433	Monthly	1000	0	100
Total nitrogen (mg/L)	3.3	8.5	Twice Monthly	10	0	100
Total phosphorus (mg/L)	0.4	1.5	Twice Monthly	NA	0	100
Cyanide (mg/L)	< 0.001	0.007	Twice Monthly	0.1	0	100
Copper (mg/L)	0.005	0.14	Twice Monthly	0.15	0	100
Iron (mg/L)	0.12	0.55	Twice Monthly	0.6	0	100
Lead (mg/L)	0.001	0.004	Twice Monthly	0.025	0	100
Mercury (ng/L)	3	82	Twice Monthly	200	0	100
Methylene chloride (ug/L)	<2	3	Twice Monthly	5	0	100
Nickel (mg/L)	< 0.002	0.006	Twice Monthly	0.1	0	100
Silver (mg/L)	< 0.001	< 0.001	Twice Monthly	0.015	0	100
Toluene (ug/L)	< 1	< 1	Twice Monthly	5	0	100
Zinc (mg/L)	0.02	0.18	Twice Monthly	2	0	100
1,1,1-trichloroethane (ug/L)	< 1	< 1	Twice Monthly	5	0	100
Max. Flow (MGD)	0.21	0.51	Continuous Recorder	2.3	0	100
Avg. Flow (MGD)	0.13	0.3	Continuous Recorder	NA	0	100
HEDP (mg/L)	<0.05	0.06	Monthly	0.5	0	100
Tolytriazole (mg/L)	< 0.05	1	Monthly	0.05	9	25

Notes: Notes:
See Figure 5-3 for location of Outfall 001.
* % Compliance = total no. samples – total no. exceedances/total no. of samples x 100
HEDP = 1-hydroxyethylidene diphosphonic acid
MGD = million gallons per day
NA = Not Applicable
SPDES = State Pollutant Discharge Elimination System
SU = standard unit

results, evaluation of compliance with permit limits, and description of any corrective actions taken to address permit excursions are provided in the following sections.

3.6.1 Sewage Treatment Plant

Sanitary and process wastewater generated by BNL operations is conveyed to the STP for processing before discharge to groundwater recharge basins. The STP provides tertiary treatment of the wastewater and includes the following processes: settling/sedimentation, biological reduction of organic matter and nitrogen, and final filtration. Chapter 5 provides a detailed description of the treatment process.

A summary of SPDES monitoring results for the STP discharge at Outfall 001 is provided in Table 3-3, along with relevant SPDES permit limits. The Laboratory monitors the STP discharge for more than 100 parameters monthly and more than 200 parameters quarterly. BNL's overall compliance with effluent limits was greater than 96 percent in 2020.

There were nine excursions of SPDES permit limits at Outfall 001 in 2020, all of which involved Tolyltriazole (TTA). The effluent limit for TTA (0.05 mg/L) at Outfall 001 was exceeded in April through December 2020. TTA is a stable corrosion inhibitor that produces a protective electrochemical film on metal surfaces to slow the rate of corrosion. It can shield multiple types of metals against corrosion, though it is most commonly used for copper and copper alloy systems. TTA is the industry standard for this type of protection and BNL uses it throughout the site to protect valuable machinery and equipment from the corrosive conditions found in harsh operating environments, such as cooling towers.

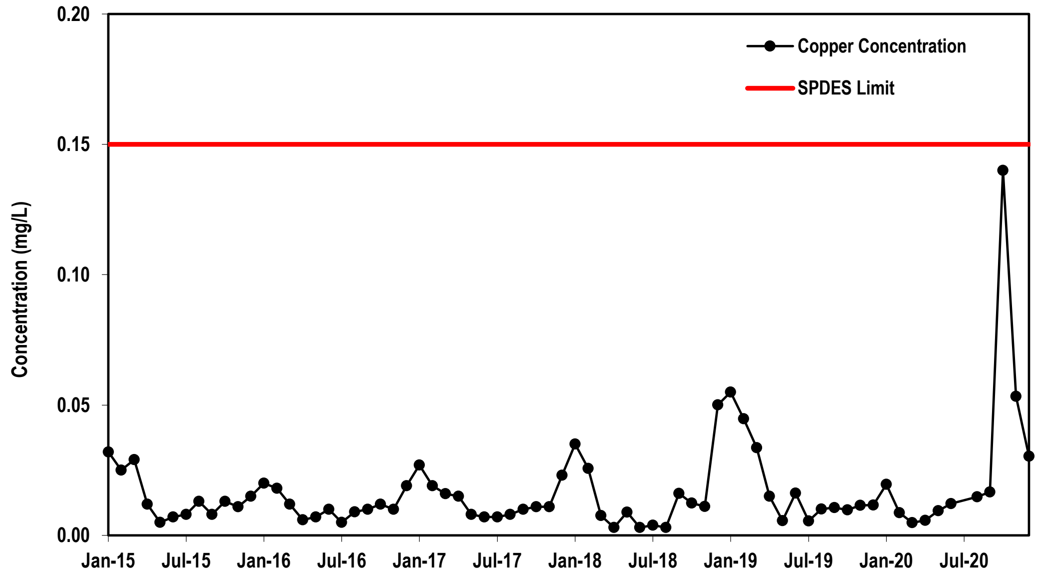

Figure 3-1. Maximum Concentrations of Copper Discharged from the BNL Sewage Treatment Plant, 2015–2020.

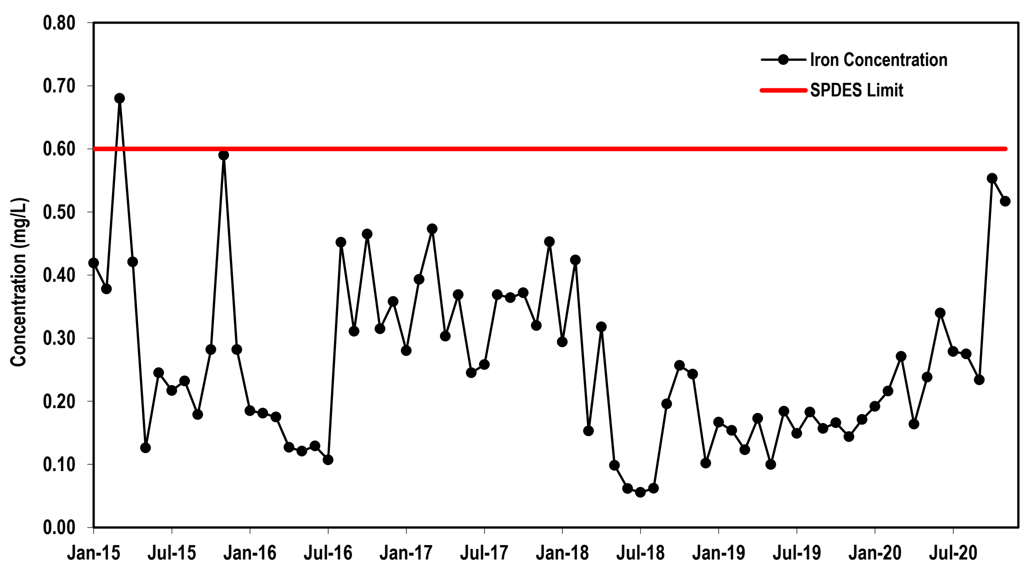

Figure 3-2. Maximum Concentrations of Iron Discharged from the BNL Sewage Treatment Plant, 2015–2020.

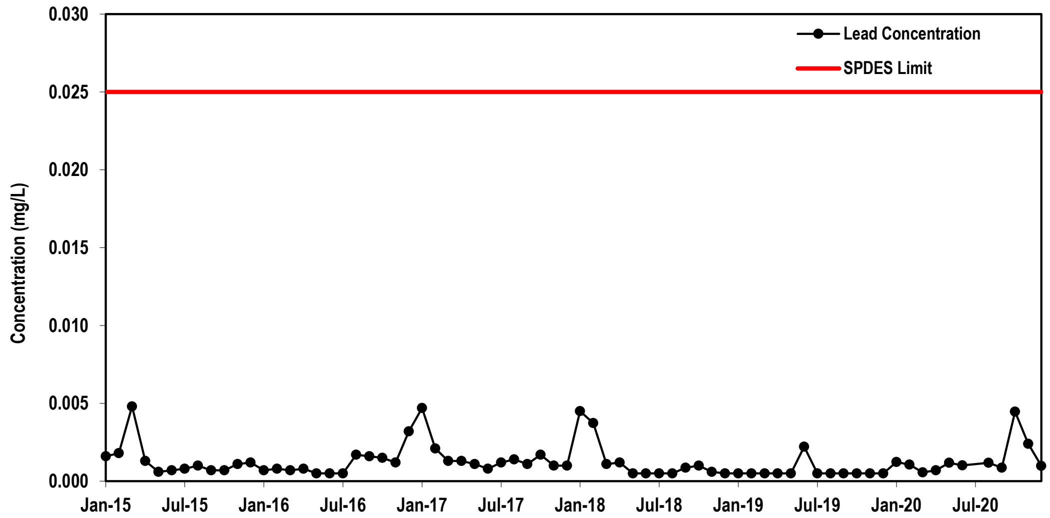

Figure 3-3. Maximum Concentrations of Lead Discharged from the BNL Sewage Treatment Plant, 2015–2020.

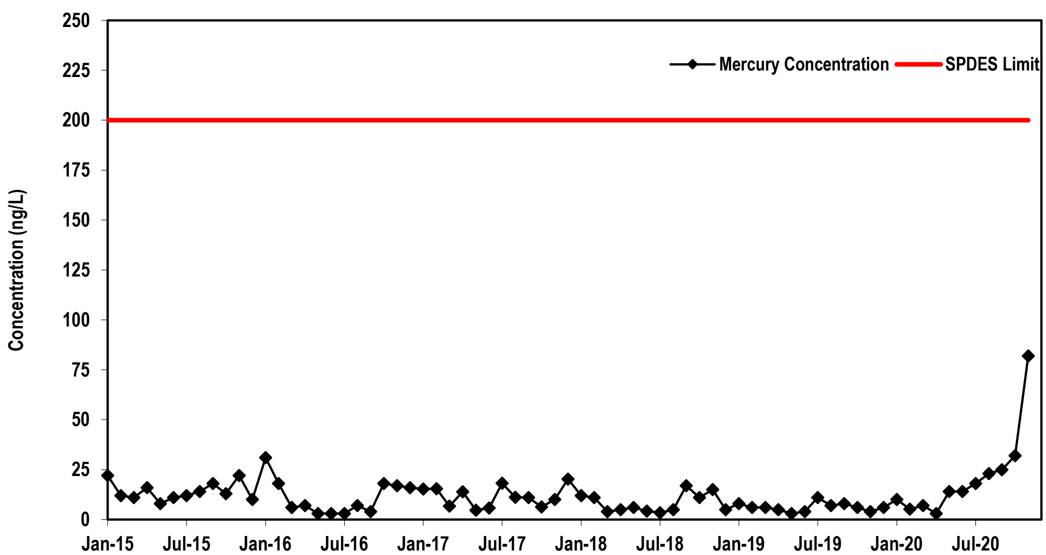

Figure 3-4. Maximum Concentrations of Mercury Discharged from the BNL Sewage Treatment Plant, 2015–2020.

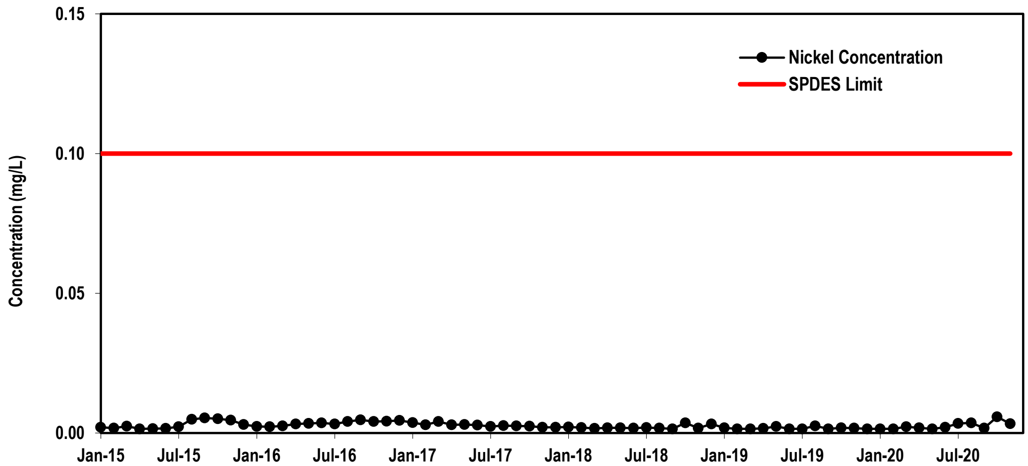

Figure 3-5. Maximum Concentrations of Nickel Discharged from the BNL Sewage Treatment Plant, 2015–2020.

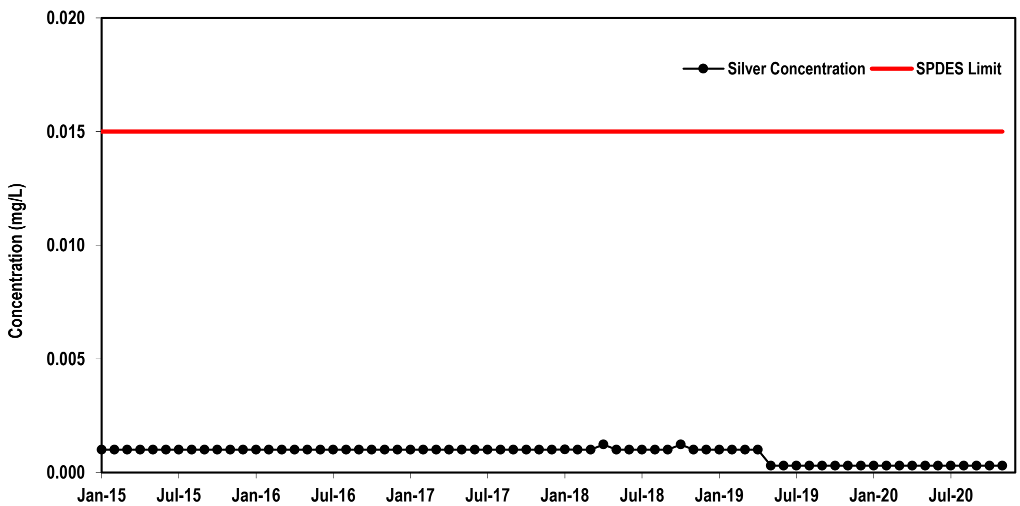

Figure 3-6. Maximum Concentrations of Silver Discharged from the BNL Sewage Treatment Plant, 2015–2020.

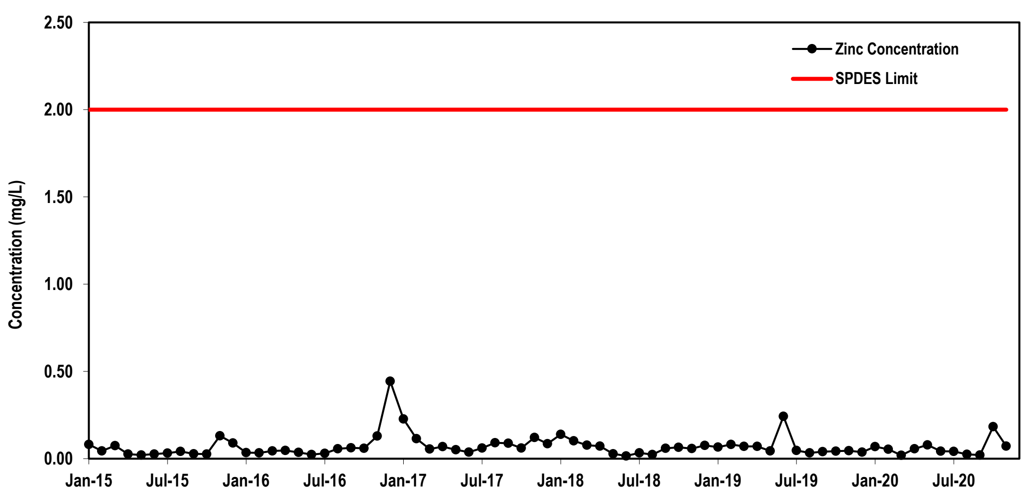

Figure 3-7. Maximum Concentrations of Zinc Discharged from the BNL Sewage Treatment Plant, 2015–2020.

Despite many efforts to address TTA SPDES permit limit issues over the past couple of years, BNL continues to be challenged in routinely meeting the current discharge limit due to the large number of operating cooling water systems that require water treatment chemicals like TTA to prevent corrosion and the need to maintain compliance with New York State Department of Health Legionella Disease prevention regulations. The primary causes of the exceedances in 2020 were associated with extremely low flows due to the Laboratory being in a Limited Operations phase in response to the COVID-19 pandemic during the cooling season (i.e., 65-70 percent of Laboratory staff working remotely) and continued Legionella hits at several Collider Accelerator Department cooling towers. Every time Legionella bacteria is detected in a cooling tower, New York State Law requires that the Laboratory follow its water safety plan which includes additional disinfections and draining of water that has residual levels of water treatment chemicals, including TTA. As a result, a large percentage of wastewater entering the STP during the cooling season (typically between June and September) is tower blowdown from cooling towers.

The Lab's Environmental Protection Division and Facilities & Operations (F&O) Directorate staff have been working closely with the DOE and NYSDEC to investigate the cause(s) of this issue and possible solutions. In November 2020, NYSDEC requested BNL to complete a Certification of Compliance Form that provides a summary of actions taken to address TTA excursions at Outfall 001(STP). A summary was prepared and submitted to NYSDEC in December that included copies of all non-compliance reports that were submitted as part of BNL's monthly discharge reports and provided further details on both immediate and long-term preventative actions that have been taken by BNL to address this issue.

Some of the corrective actions summarized in that submittal included:

- Identified a water treatment chemical that does not contain TTA (Assetguard C-7286T) that was approved by NYSDEC in February 2020. This product was added to the Lab's chemical treatment and service contract and is being used during an ongoing pilot study (see below).
- Pilot Study with the new TTA free corrosion inhibitor went into service at cooling tower 600N and 600S on August 31, 2020, and October 12, 2020 at Tower 930. This pilot program will help determine the effects on the discharge water and the corrosion rates on the mild steel and the copper coupons. The Laboratory has been providing updates to NYSDEC on the progress of this pilot study and the chemicals' overall effectiveness.
- Initiated hydrogen peroxide treatments at targeted cooling towers to help alleviate Legionella issues, which in turn helps reduce tower dilutions and additional blowdowns when the required disinfections are performed.
- The following cooling towers were updated with chemical control systems and are now online: 928, 1002, 1004, 1005P, 1006, and 1010. This will allow for better control of corrosion inhibitors and less TTA in the blowdown.

After receipt of the Certification of Compliance Form in December 2020, NYSDEC Regional and Central Offices agreed to review the form and meet internally to discuss this issue further and identify what other options BNL may have to address this issue.

Figures 3-1 through 3-7 plot the five-year trends for monthly concentrations of copper, iron, lead, mercury, nickel, silver, and zinc in the STP discharge.

3.6.2 Recharge Basins and Stormwater

Water discharged to Outfalls 002 through 008 and Outfalls 010 through 012 recharges to groundwater. Monitoring requirements for each of these discharges vary, depending on the type of wastewater received and the type of cooling water treatment reagents used. Table 3-4 summarizes the monitoring requirements and performance results.

In 2020, there was one non-compliance reported for Outfall 006B (HT-E). A quarterly grab sample collected on April 3, 2020, exhibited a TTA concentration of 0.58 mg/L (permit limit, 0.5 mg/L). The causes of this exceedance and resulting corrective actions are similar to those described above for the Sewage Treatment Plant.

Table 3-4. Analytical Results for Wastewater Discharges to Outfalls 002, 005 - 008, and 010.

Analyte		Outfall 002	Outfall 002B	Outfall 005	Outfall 006A	Outfall 006B	Outfall 007	Outfall 008	Outfall 010	SPDES Limit	No. of Exceedances	% Compliance*
Flow (MGD)	N	CR	CR	CR	CR	CR	CR	10	10			
	Min.	0.48	0	0.07	0.07	0.005	0.04	0	0	NA		
	Max.	1.76	0.05	0.81	0.18	0.08	0.16	12.5	5.8	NA	NA	NA
pH (SU)	Min.	7.1	6.9	6.5	7.2	7.2	7	6.7	7.1	NA		
	Max.	8.6	8.8	8.3	8.6	8.3	8.9	8.5	8.3	8.5, 9.0 (a)	0	100
Oil and Grease (mg/L)	N	12	11	12	11	12	NR	10	10			
	Min.	1.1	< 1.1	< 1.1	< 1.1	< 1.1	NR	< 1.1	1.1	NA		
	Max.	1.5	1.4	1.5	1.2	1.2	NR	1.8	1.9	15	0	100
Copper (mg/L)	N	NR	NR	4	NR	NR	NR	NR	4			
	Min.	NR	NR	0.001 (T)	NR	NR	NR	NR	0.002 (D)	NA		
	Max.	NR	NR	0.002 (T)	NR	NR	NR	NR	0.006 (D)	1.0	0	100
Aluminum (mg/L)	N	4	NR	NR	NR	NR	NR	4	4			
	Min.	< 0.07 (T)	NR	NR	NR	NR	NR	< 0.07 (D)	< 0.07 (D)	NA		
	Max.	0.11 (T)	NR	NR	NR	NR	NR	< 0.07 (D)	< 0.07 (D)	2.0	0	100
Lead, Dissolved (mg/L)	N	NR	NR	NR	NR	NR	NR	NR	4			
	Min.	NR	NR	NR	NR	NR	NR	NR	<0.0005	NA		
	Max.	NR	NR	NR	NR	NR	NR	NR	<0.001	0.05	0	100
Vanadium, Dissolved (mg/L)	N	NR	NR	NR	NR	NR	NR	NR	4			
	Min.	NR	NR	NR	NR	NR	NR	NR	0.002	NA		
	Max.	NR	NR	NR	NR	NR	NR	NR	0.01	NPL	NA	NA
Chloroform (µg/L)	N	4	NR	NR	NR	NR	NR	NR	NR			
	Min.	< 1.0	NR	NR	NR	NR	NR	NR	NR	NA		
	Max.	< 1.0	NR	NR	NR	NR	NR	NR	NR	7	0	100
Bromodichloromethane (µg/L)	N	4	NR	NR	NR	NR	NR	NR	NR			
	Min.	0.9	NR	NR	NR	NR	NR	NR	NR	NA		
	Max.	1.0	NR	NR	NR	NR	NR	NR	NR	50	0	100
1,1,1-trichloroethane (µg/L)	N	4	NR	NR	NR	NR	NR	10	NR			
	Min.	< 1.0	NR	NR	NR	NR	NR	< 1.0	NR	NA		
	Max.	< 1.0	NR	NR	NR	NR	NR	< 1.0	NR	5	0	100
1,1-dicloroethane (µg/L)	N	NR	NR	NR	NR	NR	NR	10	NR			
	Min.	NR	NR	NR	NR	NR	NR	< 1.0	NR	NA		
	Max.	NR	NR	NR	NR	NR	NR	< 1.0	NR	5	0	100

Table 3-4. Analytical Results for Wastewater Discharges to Outfalls 002, 005 - 008, and 010 *(concluded).*

Hydroxyethylidene-diphosphonic acid (mg/L)	N	4	NR	4	4	4	NR	NR	NR			
	Min.	0.05	NR	<0.05	<0.05	<0.05	NR	NR	NR	NA		
	Max.	<0.05	NR	<0.05	<0.05	<0.05	NR	NR	NR	0.5	0	100
Tolyltriazole (mg/L)	N	4	NR	4	4	4	NR	NR	NR			
	Min.	<0.05	NR	<0.005	<0.005	<0.005	NR	NR	NR	NA		
	Max.	0.1	NR	<0.005	<0.005	0.58	NR	NR	NR	0.2	1	75

Notes:
See Figure 5-3 for location of outfalls.
There are no monitoring requirements for Outfalls 009, 011, and 012.
* % Compliance = total no. samples – total no. exceedances/total no. of samples x 100
(a) pH limit is 8.5 for Outfalls 005, 008, and 010; pH limit is 9.0 for Outfalls 002, 002B, 006A, 006B, and 007
CR = continuous recorder

D = dissolved
MGD = million gallons per day
Max. = maximum value
Min. = minimum value
N = number of samples

NA = not applicable
NPL = no permit limit; monitoring only
NR = analysis not required
SU = standard unit
T = total recoverable

3.7 SAFE DRINKING WATER ACT

The extraction and distribution of drinking water are regulated under the federal Safe Drinking Water Act (SDWA). In New York State, implementation of the SDWA is delegated to the New York State Department of Health (NYSDOH) and administered locally by SCDHS. Because BNL provides potable water to more than 25 full-time residents, it is subject to the same requirements as a municipal water supplier. Monitoring requirements are prescribed annually by SCDHS, and a Potable Water Sampling and Analysis Plan (Bruno 2020) is prepared by the Laboratory to comply with these requirements.

3.7.1 Potable Water

The Laboratory has six water supply wells for on-site distribution of potable water, five of which were active during 2020. As required by NYSDOH regulations, BNL monitors the potable wells regularly for bacteria, inorganics, organics, and pesticides. The Laboratory also voluntarily monitors drinking water supplies for radiological contaminants yearly. Tables 3-5 and 3-6 provide potable water supply monitoring data. With the exception of a lead action level exceedance in August, BNL's drinking water and the supply and distribution system were in compliance with all applicable county, state, and federal regulations regarding drinking water quality, monitoring, operations, and reporting in 2020.

As part of the EPA's Lead and Copper Rule, BNL tests 20 locations on site every three years. During routine testing in August, three unoccupied apartments tested above the 15 parts per billion action level defined in the rule. As a result of the pandemic, most of the apartments and dorms had been vacant for months prior to testing and stagnant water can lead to increased lead levels.

BNL has been working proactively to minimize lead in the water. The five in-service wells are tested for lead annually and show little to no lead in the ground water. The Water Treatment Plant has an existing corrosion control plan that maintains the pH of the water at approximately 8.0 to 8.5 to minimize leaching of lead from the pipes and will be reviewed for possible improvements. In accordance with the rule, sampling

Table 3-5. Potable Water Wells and Potable Distribution System: Analytical Results (Maximum Concentration, Minimum pH Value)

Compound	Well No. 4	Well No. 6	Well No. 7	Well No. 10	Well No. 11	Potable Distribution Sample	NYS DWS
Water Quality Indicators							
Ammonia (mg/L)	< 0.1	< 0.1	0.11	< 0.1	< 0.1	< 0.1	SNS
Chlorides (mg/L)	7.6	59.5	36.7	72.6	73.2	76.5	250
Color (units)	20*	60*	40*	< 5	< 5	< 5	15
Conductivity (mmhos/cm)	90	242	198	436	422	425	SNS
Cyanide (mg/L)	< 10	< 10	< 10	< 10	< 10	< 10	SNS
MBAS (mg/L)	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	SNS
Nitrates (mg/L)	0.06	0.14	0.21	0.59	0.62	0.4	10
Nitrites (mg/L)	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	1
Odor (units)	0	0	0	0	0	0	3
pH (Standard Units)	6.2	6	6.9	8.6	8.8	8.8	SNS
Sulfates (mg/L)	8.9	9	11.2	12	14.5	10.5	250
Total coliform	ND	ND	ND	ND	ND	ND	Negative
Metals							
Antimony (mg/L)	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	6
Arsenic (mg/L)	< 1.0	2.3	2.84	< 1.0	< 1.0	< 1.0	50
Barium (mg/L)	0.02	0.05	0.03	0.06	0.06	0.02	2
Beryllium (mg/L)	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	4
Cadmium (mg/L)	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	5
Chromium (mg/L)	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	0.1
Copper (mg/L)	0.008	0.04	0.005	0.003	0.004	0.004	1.3
Fluoride (mg/L)	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	2.2
Hexavalent Chromium (mg/L)	NR	NR	NR	< 0.02	<0.02	< 0.02	0.05
Iron (mg/L)	3.7*	4.0*	2.9*	< 0.20	< 0.20	0.03	0.3
Lead (mg/L)	1.6	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	15
Manganese (mg/L)	0.03	0.06	0.09	< 0.010	< 0.010	< 0.010	0.3
Mercury (mg/L)	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	2
Nickel (mg/L)	0.002	0.39	0.002	0.001	0.001	<0.0005	SNS
Selenium (mg/L)	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	50
Sodium (mg/L)	7.2	34.9	23.9	48.2	47.9	37.1	SNS
Silver (mg/L)	< 1	< 1	< 1	< 1	< 1	< 1	100
Thallium (mg/L)	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	2
Zinc (mg/L)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	5
Radioactivity							
Gross alpha activity (pCi/L)	< 1.98	<1.94	<1.97	2.46 ±1.57	<1.97	NR	15
Gross beta activity (pCi/L)	3.37 ± 1.62	2.74 ± 0.98	2.65 ±1.37	2.63 ± 1.25	4.11 ± 1.24	NR	(a)
Radium-228 (pCi/L)	<0.83	< 0.89	0.77±0.43	0.93±0.62	< 1.18	NR	5
Strontium-90 (pCi/L)	< 0.80	< 0.79	< 0.77	< 0.77	< 0.80	NR	8
Tritium (pCi/L)	< 497	< 402	< 394	< 393	< 455	NR	20,000

(continued on next page)

Table 3-5. Potable Water Wells and Potable Distribution System: Analytical Results (Maximum Concentration, Minimum pH Value) *(concluded)*.

Compound	Well No. 4	Well No. 6	Well No. 7	Well No. 10	Well No. 11	Potable Distribution Sample	NYS DWS
Other							
Alkalinity (mg/L)	6.4	6.3	10.8	30.7	29.7	72.2	SNS
Asbestos (M. fibers/L)	NR	NR	NR	NR	NR	2	7
Calcium (mg/L)	3.42	6.1	6.2	15.1	12.6	17.2	SNS
HAA5 (mg/L)	NR	NR	NR	NR	NR	0.003	0.06**
Residual chlorine - MRDL (mg/L)	NR	NR	NR	NR	NR	1.4	4
TTHM (mg/L)	NR	NR	NR	NR	NR	0.014	0.08**

Notes:
See Figure 7-1 for well locations.
Well 12 was not operational for 2020; no testing was completed during this time.
HAA5 = five haloacetic acids
MBAS = methylene blue active substances
MRDL = maximum residual disinfectant level
ND = not detected
NR = analysis not required
NS = not sampled
NYS DWS = New York State Drinking Water Standard
SNS = drinking water standard not specified
TTHM = total trihalomethanes

* Water from these wells is treated at the Water Treatment Plan for color and iron reduction prior to site distribution.
** Limit imposed on distribution samples only.

(a) The drinking water standard was changed from 50 pCi/L (concentration based) to 4 mrem/yr (dose based) in late 2003. Gross beta activity does not identify specific radionuclides; therefore, a dose equivalent can not be calculated. No specific nuclides were detected; therefore, compliance with the requirement is demonstrated.

will continue every six months until samples are under the action level. Residents and users in the buildings were notified of all results and, if necessary, apartments will be closed, and faucets turned off depending on results of future sampling and other mitigative measures.

In 2013, the EPA required large water providers to start testing for six common Per- and Polyfluoroalkyl Substances (PFAS) chemicals under the third Unregulated Contaminant Monitoring Rule (UCMR 3). As a medium-size system, BNL was not required to participate in this testing program. In 2017, SCDHS began routine testing of all water supply systems for PFAS, including BNL. PFAS chemicals were detected in three of BNL's water supply wells. In these initial tests, Perfluorooctanoic Acid (PFOA) and Perfluorooctanesulfonic Acid (PFOS) were detected at concentrations below the current EPA Health Advisory Level of 70 ng/L (ppt) that was established specifically for the combined concentration of these two chemicals. Following repeated confirmed detections of PFAS in the supply wells, the Lab started routine quarterly testing for PFAS in 2018. The results for 2020 are provided in Table 3-6.

In 2020, New York State established enforceable drinking water standards for PFOS and PFOA at concentrations of 10 ng/L (ppt). The other four PFAS chemicals would continue to be regulated under the current New York State limit of 50 µg/L (ppb) for unregulated contaminants. In May 2020, Granular Activated Carbon (GAC) filters were restored on Well 11 to remove PFOS and low levels of the other PFAS chemicals that may be present. In October 2020, the Laboratory received a one-year deferral from New York State to reactivate the GAC system on Well 10. It is scheduled to be completed by the summer of 2021.

To ensure that consumers are informed about the quality of Laboratory-supplied potable water, BNL publishes a Consumer Confidence Report (CCR) in May of each year, a deadline stipulated by the SDWA. This report provides information regarding source water supply system and the analytical tests conducted, and detected contaminants are compared to federal drinking water standards. The CCR also describes the measures the Laboratory takes to protect its water source

Table 3-6. Potable Water Wells: Analytical Results for Principal Organic Compounds, Synthetic Organic Chemicals, Pesticides, Micro-Extractables, and Perfluorinated Compounds.

Compound	WTP Effluent	Well No. 4	Well No. 6	Well No. 7	Well No. 10	Well No. 11	NYS DWS
				µg/L			
Dichlorodifluoromethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
Chloromethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
Vinyl Chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	2
Bromomethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
Chloroethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
Trichlorofluoromethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
1,1-dichloroethene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
Methylene Chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
trans-1,2-dichloroethene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
1,1-dichloroethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
cis-1,2-dichloroethene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
2,2-dichloropropane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
Bromochloromethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
1,1,1-trichloroethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
Carbon Tetrachloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
1,1-dichloropropene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
1,2-dichloroethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
Trichloroethene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
1,2-dichloropropane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
Dibromomethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
trans-1,3-dichloropropene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
cis-1,3-dichloropropene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
1,1,2-trichloroethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
1,3-dichloropropane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
Chlorobenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
1,1,1,2-tetrachloroethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
Bromobenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
1,2,3-trichloropropane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
2-chlorotoluene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
4-chlorotoluene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
1,3-dichlorobenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
1,4-dichlorobenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
1,2-dichlorobenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
1,2,4-trichlorobenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
Hexachlorobutadiene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
Tetrachloroethene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
1,1,2,2-Tetrachloroethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
1,2,3-trichlorobenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
Benzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
Toluene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
Ethylbenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
m,p-xylene	< 1	< 1	< 1	< 1	< 1	< 1	5
o-xylene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
Styrene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
Isopropylbenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
n-propylbenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
1,3,5-trimethylbenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5

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Table 3-6. Potable Water Wells: Analytical Results for Principal Organic Compounds, Synthetic Organic Chemicals, Pesticides, Micro-Extractables, and Perfluorinated Compounds. *(continued).*

Compound	WTP Effluent	Well No. 4	Well No. 6	Well No. 7	Well No. 10	Well No. 11	NYS DWS
	µg/L						
Chlorodifluoromethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
Tert-butylbenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
1,2,4-trimethylbenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
sec-butylbenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
4-Isopropyltoluene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
n-butylbenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
Chloroform	3.5	1.1	0.8	1.0	1.3	4.5	50
Bromodichloromethane	3.2	< 0.5	< 0.5	< 0.5	< 0.5	0.6	50
Dibromochloromethane	6.1	< 0.5	< 0.5	< 0.5	< 0.5	0.7	50
Bromoform	6.7	< 0.5	< 0.5	< 0.5	< 0.5	1.3	50
Methyl tert-butyl ether	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	50
Toxaphene	< 1	< 1	< 1	< 1	< 1	< 1	3
Total PCB's	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	<0.4	0.5
2,4,5,-TP (Silvex)	< 0.13	< 0.13	< 0.13	< 0.13	< 0.13	< 0.13	10
Dinoseb	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	50
Dalapon	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	50
Pichloram	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	50
Dicamba	<1	<1	<1	<1	<1	<1	50
Pentachlorophenol	<0.04	<0.04	< 0.04	< 0.04	< 0.04	< 0.04	1
Hexachlorocyclopentadiene	<0.1	0.018	< 0.1	< 0.1	< 0.1	< 0.1	5
Bis(2-ethylhexyl)Phthalate	<0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	50
Bis(2-ethylhexyl)Adipate	<0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	50
Hexachlorobenzene	<0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	5
Benzo(A)Pyrene	0.029	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	50
Aldicarb Sulfone	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	SNS
Aldicarb Sulfoxide	<0.5	<0.5	<0.5	<0.5	1.1	1.1	SNS
Aldicarb	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	SNS
Oxamyl	<1	< 1	< 1	< 1	< 1	< 1	50
3-Hydroxycarbofuran	<1	< 1	< 1	< 1	< 1	< 1	50
Carbofuran	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	40
Carbaryl	<1	< 1	< 1	< 1	< 1	< 1	50
Methomyl	<1	< 1	< 1	< 1	< 1	< 1	50
Glyphosate	<6	< 6	< 6	< 6	< 6	< 6	50
Diquat	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	50
1,2-dibromoethane (EDB)	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.05
1,2-dibromo-3-chloropropane	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.2
Lindane	<0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.2
Heptachlor	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	0.4
Aldrin	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	5
Heptachlor Epoxide	<0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.2
Dieldrin	<0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	5
Endrin	<0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.2
Methoxychlor	<0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	40
Chlordane	<0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	2
2,4,-D	<0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	50
Alachlor	<0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	2
Simazine	<0.07	< 0.07	< 0.07	< 0.07	< 0.07	< 0.07	50

(continued on next page)

Table 3-6. Potable Water Wells: Analytical Results for Principal Organic Compounds, Synthetic Organic Chemicals, Pesticides, Micro-Extractables, and Perfluorinated Compounds *(concluded).*

Compound	WTP Effluent	Well No. 4	Well No. 6	Well No. 7	Well No. 10	Well No. 11	NYS DWS
				µg/L			
Atrazine	<0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	3
Metolachlor	<1	<1	<1	<1	<1	<1	50
Chlordane	<0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	2
2,4,-D	<0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	50
Alachlor	<0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	2
Simazine	<0.07	< 0.07	< 0.07	< 0.07	< 0.07	< 0.07	50
Atrazine	<0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	3
Metolachlor	<1	<1	<1	<1	<1	<1	50
Metribuzin	<0.5	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	50
Butachlor	<1	<1	<1	<1	<1	<1	50
Endothall	<9	< 9	< 9	< 9	< 9	< 9	100
Propachlor	<1	<1	<1	<1	<1	<1	50
Freon-113	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	50
Perfluorobutanesulfonic Acid (PFBS)	<0.002	<0.002	0.002	<0.002	0.003	0.001	50
Perfluoroheptanoic Acid (PFHpA)	<0.002	<0.002	0.002	<0.002	0.002	0.001	50
Perfluorohexanesulfonic Acid (PFHxS)	<0.002	<0.002	0.002	0.001	0.019	0.007	50
Perfluorooctanoic Acid (PFOA) (ng/L)*	0.7	<2	3.94	1	6.6**	3.8***	10
Perfluorooctanesulfonic Acid (PFOS) (ng/L)*	1.88	0.8	3.21	1.71	37.1**	10.4***	10
Perfluorononanoic Acid (PFNA)	<0.002	<0.002	<0.002	<0.002	0.002	0.001	50
1,4 dioxide	0.05	< 0.02	0.03	0.05	0.06	0.04	1

Notes:
See Figure 7-1 for well locations.
For compliance determination with New York State Department of Health standards, potable water samples were analyzed quarterly for Principal Organic Compounds and annually for other organics by Pace Labs, a New York State-certified contractor laboratory.
The minimum detection limits for principal organic compound analytes are 0.5 mg/L. Minimum detection limits for synthetic organic chemicals and micro-extractables are compound-specific, and, in all cases, are less than the New York State Department of Health drinking water standard.
* Compounds results are reported in ng/L
** Well 10 was active under a deferral from the NYSDOH while the GAC system was installed.
***Well 11 data is raw water data. Water was run through a GAC system and samples were below the detection limit.
Well 12 was offline and remained unused during 2020.
SNS = drinking water standard not specified
NYS DWS = New York State Drinking Water Standard
WTP = Water Treatment Plant

and limit consumer exposure to contaminants. The CCR is distributed to all BNL employees and on-site residents, either in paper form or electronically at *http://www.bnl.gov/water/*.

3.7.2 Cross-Connection Control

The SDWA requires that public water suppliers implement practices to protect the water supply from sanitary hazards. One of the safety requirements is to rigorously prevent cross-connections between the potable water supply and facility piping systems. Cross-connection control is the installation of control devices (e.g., double-check valves, reduced pressure zone valves, etc.) at the interface between a facility and the domestic water main. Cross-connection control devices are required at all facilities where hazardous materials are used in a manner that could result in their accidental introduction into the domestic water system, especially under low-pressure conditions. In addition, secondary cross-connection controls at the point of use are recommended to protect users within a specific facility from hazards that may be posed by intra-facility operations.

During 2020, the Laboratory inspected 274 cross-connection control devices, including primary devices installed at interfaces to the potable water main, and secondary control devices at the point of use. If a problem with a cross-connection device is encountered during testing, the device is repaired and re-tested to ensure proper function. Copies of the cross-connection device test reports are filed with SCDHS throughout the year.

3.7.3 Underground Injection Control

Underground Injection Control (UIC) wells are regulated under the SDWA. At the Laboratory, UICs include drywells, cesspools, septic tanks, and leaching pools, all of which are classified by EPA as Class V injection wells. Proper management of UIC devices is vital for protecting underground sources of drinking water. In New York State, the UIC program is implemented through EPA because NYSDEC has not adopted UIC regulatory requirements. (Note, New York State regulates the discharges of pollutants to cesspools under the SPDES program.) Under EPA's UIC program, all Class V injection wells must be included in an inventory maintained with the agency.

In addition to the UICs maintained for routine Laboratory discharges of sanitary waste and stormwater, UICs also are maintained at several on- and off-site treatment facilities used for groundwater remediation. Contaminated groundwater is treated and then returned to the aquifer via drywells, injection wells, or recharge basins. Discharges to these UICs are authorized by rule rather than by permit. Under the authorized by rule requirements, a separate inventory is maintained for these treatment facilities, and is periodically updated whenever a new device is added or closed.

In 2020, the Laboratory closed two UICs associated with former Buildings 367 (Supply Well House #12) and 637 (efficiency-type apartment building) and added one new UIC at Building 367. Prior to closing a UIC, an assessment is performed to ensure that past operations did not result in the deposition of contaminants in the environment. This assessment is performed in accordance with an EPA-approved Closure Plan. As outlined in the Closure Plan, assessment of UICs include collection of a bottom end-point sample for subsequent chemical analysis. Analysis typically includes volatile and semi-volatile organic compounds, PCB's, pesticides, herbicides, inorganic elements, and gamma spectroscopy detectable radioisotopes. The analytical findings collected during this UIC investigation were found to be less than the clean-up guidance levels and/or are within typical background ranges. Approval to backfill the UICs was received from Suffolk County Department of Health Services (SCDHS) prior to the end of the calendar year.

BNL's total UIC inventory at the end of 2020 was 114.

3.8 PREVENTING AND REPORTING SPILLS

Federal, state, and local regulations are in place to address the management of storage facilities containing chemicals, petroleum, and other hazardous materials. The regulations include specifications for the design of storage facilities, requirements for written plans relating to unplanned releases, and requirements for reporting releases that do occur. BNL's compliance with these regulations is further described in the following sections.

3.8.1 Preventing Oil Pollution and Spills

As required by the Oil Pollution Act, BNL maintains a Spill Prevention Control and Countermeasures (SPCC) Plan as a condition of its license to store petroleum fuel (Bruno, 2016). The purpose of this plan is to provide information regarding release prevention measures, the design of storage facilities, and maps detailing storage facility locations. The plan also outlines mitigating and remedial actions that would be taken in the event of a major spill. BNL's SPCC plan is filed with NYSDEC, EPA, and DOE, and must be updated every five years. BNL remained in full compliance with SPCC requirements in 2020.

3.8.2 Emergency Reporting Requirements

The Emergency Planning and Community Right-to-Know Act (EPCRA) and Title III of the Superfund Amendments and Reauthorization Act require that facilities report inventories and releases of certain chemicals that exceed specific release thresholds. Community Right-to-Know requirements are codified under 40 CFR Parts 355, 370, and 372. Table 3-7 summarizes the applicability of the regulations to BNL.

The Laboratory complied with these requirements

Table 3-7. Applicability of EPCRA to BNL.

Applicability of EPCRA to BNL				
EPCRA 302–303	Planning Notification	YES [X]	NO [ ]	NOT REQUIRED [ ]
EPCRA 304	EHS Release Notification	YES [ ]	NO [ ]	NOT REQUIRED [X]
EPCRA 311–312	MSDS/Chemical Inventory	YES [X]	NO [ ]	NOT REQUIRED [ ]
EPCRA 313	TRI Reporting	YES [X]	NO [ ]	NOT REQUIRED [ ]

through the submittal of Tier II and Tier III Reports required under EPCRA Sections 302, 303, 311, 312, and 313. In fulfillment of the Tier II requirements, BNL submitted an inventory of 37 on-site chemicals (with thresholds greater than 10,000 pounds or 500 pounds for acutely toxic materials) via E-Plan, the New York State-approved computer-based submittal program. The chemicals ranged from road salt (about 1,225 tons) to Portland cement (10,656 pounds). To satisfy the requirements of the Tier III submittal, the Laboratory submitted its data via the EPA-approved TRI-ME computer-based submittal program.

During 2020, BNL reported releases of lead (about 6,000 pounds), mercury (about ten pounds), polychlorinated biphenyls (PCBs) (about two pounds), benzo(g,h,i)perylene (less than one pound), polycyclic aromatic compounds (less than one pound), and friable asbestos (about 28,000 pounds). Releases of lead, PCBs, mercury, and asbestos were predominantly in the form of shipments of waste for off-site recycling or disposal. Releases of benzo(g,h,i) perylene and polycyclic aromatic compounds were as byproducts of the combustion of fuel oils. These totals include lead and asbestos from the HFBR stack removal project. In 2020, there were no releases of extremely hazardous substances reportable under Part 304.

3.8.3 Spills and Releases

When a spill of hazardous material occurs, Laboratory and contractor personnel are required to immediately notify the BNL Fire Rescue Group, whose members are trained to respond to such releases. Fire Rescue's initial response is to contain and control any release and to notify additional response personnel (e.g., BNL environmental professionals, industrial hygienists, etc.). Environmental professionals reporting to the scene assess the spill for environmental impact and determine if it is reportable to regulatory agencies. Any release of petroleum products to soil must be reported to both NYSDEC and SCDHS, and any release affecting surface water is also reported to the EPA National Response Center. In addition, a release of more than five gallons of petroleum product to impermeable surfaces or containment areas must be reported to NYSDEC and SCDHS. Spills of chemicals in quantities greater than the CERCLA-reportable limits must be reported to the EPA National Response Center, NYSDEC, and SCDHS. Remediation of spills is conducted, as necessary, to prevent impacts to the environment, minimize human health exposures, and restore the site.

There were 14 spills in 2020 and four of those spills met regulatory agency reporting criteria. The remaining spills were small-volume releases either to containment areas or to other impermeable surfaces that did not exceed a reportable quantity. Table 3-8 summarizes each of the four reportable events, including a description of the cause and corrective actions taken. There were no long-term effects from these releases and no significant impact on the environment. In all instances, any recoverable material was removed, spill absorbents were used to remove the residual product, and all materials were collected and containerized for off-site disposal. For releases to soil, contaminated soil was removed to the satisfaction of the State inspector and containerized for off-site disposal.

3.8.4 Major Petroleum Facility (MPF) License

The storage and transfer of 1.9 million gallons of fuel oil (principally No. 6 oil) subjects the Laboratory to MPF licensing by NYSDEC. The fuel oil used at the CSF to produce high-pressure steam to heat and cool BNL facilities is stored in five tanks with capacities ranging from 300,000 to 600,000 gallons. The remaining storage facilities at BNL have capacities that range from 100 to 10,000 gallons and are located throughout the site where there is a need for building heat, emergency power, fuel, or other miscellaneous petroleum needs (e.g., motor oil, used oil, lube oil, biodiesel).

There are currently 68 petroleum storage facilities listed on the license, not including a large bulk tank that has been permanently closed (Tank No. 611-09). BNL remained in full compliance with MPF license requirements in 2020, which include monitoring groundwater near six above-ground storage tanks at the MPF. The license also requires the Laboratory to inspect the storage facilities monthly, test the tank leak detection systems, and ensure high-level monitoring and secondary containment is functional. Tank integrity is also checked periodically. Groundwater monitoring consists of monthly checks for the presence of floating products and twice-yearly analyses for VOCs and semi-volatile organic compounds (SVOCs). In 2020, no VOCs, SVOCs, or floating products attributable to MPF activities were detected above detectable limits. See SER Volume II, Groundwater Status Report, for additional information on groundwater monitoring results.

There was no NYSDEC inspection of registered Petroleum Bulk Storage Facilities in 2020 due to the pandemic.

The recently refurbished Storage Facility STO-651 berm has performed adequately in 2020, the digital fuel gauges for all three tanks have been calibrated as per the manufacturer's recommendations, and two of the three tanks have been cleaned and tightness tested.

3.8.5 Chemical Bulk Storage

Title 6 of the Official Compilation of the Codes, Rules, and Regulations of the State of New York (NYCRR) Part 597 requires that all aboveground tanks larger than 185 gallons and all underground tanks that store specific chemicals are registered with NYSDEC. The Laboratory holds a Hazardous Substance Bulk Storage Registration Certificate for six tanks that store treatment chemicals for potable water (sodium hydroxide and sodium hypochlorite). The tanks range in capacity from 200 to 1,000 gallons.

There was no NYSDEC regulatory inspection of the Lab's CBS-registered tanks in 2020 due to the pandemic.

In 2020, modifications and upgrades were made to the Well House 10 and 11 potable water treatment chemical conveyance systems. Double-walled, underground chemical lines for disinfection and pH adjustment were installed and pressure tested for potential leaks. Real-time leak detection systems were also installed. The above chemical lines were routed from the well houses to Granular Activated Carbon (GAC) Treatment Vessels in adjacent buildings. The GAC treatment systems were installed to meet new NYS drinking water standards for PFAS compounds. These modifications and upgrades were reviewed with NYSDEC prior to installation and information was included in the Lab's Spill Prevention Report.

3.8.6 County Storage Requirements

Article 12 of the Suffolk County Sanitary Code (SCSC) regulates the storage and handling of toxic and hazardous materials in aboveground or underground storage tanks, drum storage facilities, piping systems, and transfer areas. Article 12 specifies design criteria to prevent environmental impacts resulting from spills or leaks, and specifies administrative requirements such as identification, registration, and spill reporting procedures. In 1987, the Laboratory entered into a voluntary Memorandum of Agreement with SCDHS, in which DOE and BNL agreed to conform to the environmental requirements of Article 12. In April 2010, due to a directive from NYSDEC asserting its sole jurisdiction over petroleum storage at Major Oil Storage Facilities, SCDHS notified BNL that it will cease permitting activities (e.g., review/approval for new construction and modifications, issuance of operating permits, and registration requirement) for all petroleum bulk storage facilities. In 2011, the Laboratory received further information that indicated SCDHS had ceased applying Article 12 requirements to both petroleum and chemical storage at BNL regardless of whether the storage is regulated by NYSDEC. Currently, there are approximately 121 active storage facilities that are not regulated by

Table 3-8. Summary of Chemical and Oil Spill Reports.

Spill No. and Date	Material/ Quantity	ORPS Report	Source/Cause and Corrective Actions
20-01 01/24/20	Motor Oil / 148 gallons	Yes	After discovering oil in the secondary containment compartment of the double walled Lube Cube (Tank No. 423-16) located inside the Motor Pool, HEMO Shop personnel utilized the pump system on the trailer-mounted Transfueler to transfer oil from the secondary containment compartment into the Transfueler oil tank. Due to the oil's high viscosity, HEMO Shop personnel switched over to a dual filter pump to recover the remaining oil in the tank interstitial space. After seeing no additional oil in the tank interstitial space three days later, oil was transferred from the Transfueler oil tank back into the Lube Cube primary tank. Since ORPS report corrective actions to ascertain whether the primary tank was leaking showed that the tank was not leaking, the oil likely entered the interstitial space when the driver overfilled the tank during a prior delivery. To prevent a recurrence of an overfill, a new Guest Services Division procedure was prepared (SS-ESH-005). To prevent overfilling, the new procedure requires Motor Pool staff to: 1) Determine the volume of oil needed so that it does not exceed the tank's working capacity; 2) Remain in the immediate vicinity of the tank to monitor the delivery operation, and 3) Terminate the delivery if there are any signs of leaks from hoses, fittings, and truck pump glands.
20-02 02/21/20	Diesel Fuel / 2 gallons	No	Approximately two gallons of diesel fuel leaked out of the fuel tank fill line of a trailer- mounted generator that had been set up for use on a sloped surface in the north parking lot of Bldg. 835. Most of the fuel leaked onto the parking lot asphalt while a small amount reached the soil adjacent to the lot. Speedi-dri absorbent used to clean fuel on the pavement and contaminated soil was placed into a five-gallon pail subsequently taken to the Bldg. 321 waste accumulation area to be consolidated with similar debris for off-site disposal.
20-06 07/07/20	Antifreeze / 1 gallon	No	Approximately one gallon of antifreeze leaked to pavement in the northeast end of the parking lot of Bldg. 741 when a valve failed on a contractor vehicle. Fire Rescue personnel responded and spread speedi dri absorbent beneath the vehicle to capture leaking product. The vehicle driver swept up the contaminated absorbent and took it with him back to Harbor Freight for disposal after a tow truck arrived to take the vehicle back to the contractor's facility to be repaired.
20-07 07/09/20	Hydraulic Fluid / 1 gallon	No	After crossing West Princeton Avenue near the Main Gate entrance, the back end of a Toro Grondmaster 7210 mower bottomed out and broke the fitting to a hydraulic line. The operator continued to cut the grass heading east adjacent to West Princeton Avenue until he realized the mower was leaking hydraulic fluid. After turning the mower off, he reported the spill to Fire/ Rescue Group. Upon their arrival, Grounds personnel used shovels to recover the top two inches of contaminated soil and grass along a three-inch wide 200 foot-long path where the mower leaked hydraulic fluid. The contaminated soil and grass were placed into the bucket of a Bobcat front-end loader. After the Bobcat returned to Bldg. 326, Grounds personnel transferred the contaminated grass and soil into two 55-gallon drums. The drums were held in the Bldg. 326 90-day storage area awaiting pick-up by Waste Management for off-site disposal. The mower was taken to the Hemo Shop for repairs.

NYSDEC that would normally fall under SCSC Article 12 jurisdiction. This includes storage of wastewater and chemicals, as well as storage facilities used to support BNL research.

To ensure that storage of chemicals and petroleum continues to meet Article 12 requirements, BNL will continue to abide by the original 1987 agreement with Suffolk County and will maintain conformance with applicable requirements of Article 12. These requirements include design, operational, and closure requirements for current and future storage facilities. Although the Laboratory will no longer submit new design plans for SCDHS review/approval, or continue to perform other administrative activities such as registration of exempt facilities and updates of shared databases, it will continue to inspect all storage facilities to ensure operational requirements of SCDHS Article 12 are maintained.

3.9 RCRA REQUIREMENTS

The Resource Conservation and Recovery Act (RCRA) regulates hazardous wastes that, if mismanaged, could present risks to human health or the environment. The regulations are designed to ensure that hazardous wastes are managed from the point of generation to final disposal. In New York State, EPA delegates the RCRA program to

NYSDEC with EPA retaining an oversight role. Because the Laboratory may generate greater than 1,000 Kg (2,200 pounds) of hazardous waste in a month, it is considered a large quantity generator and has an RCRA permit to store hazardous wastes for up to one year before shipping the wastes offsite to licensed treatment and disposal facilities.

As noted in Chapter 2, BNL also has several satellite accumulation and 90-Day Hazardous Waste Accumulation Areas. Included with the hazardous wastes regulated under RCRA are mixed wastes which are generated in small quantities at BNL. Mixed wastes are materials that are both hazardous (under RCRA guidelines) and radioactive.

In December 2020, BNL received a data request from the EPA to facilitate the performance of an Off-Site Compliance Monitoring Activity (OfCM) to determine RCRA compliance. The OfCM was being performed in lieu of a facility visit due to COVID-19 restrictions. Data requested included photos of waste storage areas, copies of relevant permits, transportation documents, and shipping manifests. The requested information was collected and forwarded to the EPA and a closeout meeting to discuss the results of the OfCM was scheduled for February 2021.

3.10 POLYCHLORINATED BIPHENYLS

The storage, handling, and use of Polychlorinated Biphenyls (PCBs) are regulated under the Toxic Substance and Control Act. Capacitors manufactured before 1979 that are believed to be oil filled are handled as if they contain PCBs, even when that cannot be verified from the manufacturer's records. All equipment containing PCBs must be inventoried, except for capacitors containing less than three pounds of dielectric fluid and items with a concentration of PCB source material of less than 50 parts per million. Certain PCB-containing articles or PCB containers must be labeled. The inventory is updated by July 1 of each year. The Laboratory responds to any PCB spill in accordance with standard emergency response procedures. BNL was in compliance with all applicable PCB regulatory requirements during 2020 and disposed of 42.5 pounds of PCB-contaminated equipment comprised predominantly of lighting ballasts and small capacitors. The Laboratory has aggressively approached reductions in its PCB inventory, reducing it by more than 99 percent since 1993. The only known regulated PCB-contaminated piece of electrical equipment remaining on site is a one-of-a-kind klystron located in BNL's Chemistry Department.

3.11 PESTICIDES

The storage and application of pesticides (e.g., insecticides, rodenticides, herbicides, and algicides) are regulated under the Federal Insecticide, Fungicide and Rodenticide Act. BNL uses an Integrated Pest Management plan that was developed over a decade ago and has subsequently been audited by a third-party (Cornell Cooperative). Pesticides are used at the Laboratory to control undesirable insects and mice and microbial growth in cooling towers and to maintain certain areas free of vegetation (e.g., around fire hydrants and inside secondary containment berms). Insecticides are also applied in research greenhouses on site and the Biology Field. Herbicide use is minimized wherever possible (e.g., through spot treatment of weeds). Pesticides are applied by BNL-employed, NYSDEC pesticide–certified applicators. On an infrequent basis and for special projects, an outside vendor who also possesses the required NYSDEC application licenses applies pesticides. Cooling towers are regularly treated by a different vendor that has NYSDEC-licensed pesticide applicators with NYSDEC approved biocides in order to prevent corrosion and to disinfect the towers onsite.

By February 1 of every year, each BNL pesticide applicator submits application records to Environmental Protection staff that are reviewed and an electronic annual report is created and submitted to the NYSDEC detailing insecticide, rodenticide, algaecide, and herbicide use for the previous year. Contractors who apply pesticides and cooling tower biocides are responsible for filing their own reports.

3.12 WETLANDS AND RIVER PERMITS

As noted in Chapter 1, portions of the site are situated in the Peconic River floodplain. Portions of the Peconic River are listed by NYSDEC as "scenic" under the New York Wild, Scenic, and Recreational River Systems Act. The Laboratory also has six areas regulated as wetlands and several vernal (seasonal) pools. Construction or modification activities performed within these areas require permits from NYSDEC.

Activities that could require review under the BNL Natural and Cultural Resource Management Programs (BNL 2016 and BNL 2013a) are identified during the NEPA process (see Section 3.3). In the preliminary design stages of a construction project, design details required for the permit application process are specified. These design details ensure that the construction activity will not negatively affect the area, or if it does, that the area will be restored to its original condition. When design is near completion, permit applications are filed. During and after construction, the Laboratory must comply with the permit conditions.

In 2019, BNL had a single wetlands equivalency permit open. This permit was associated with the final cleanup of a small area of contamination within the Peconic River. The project was completed in 2017 and the area is being restored naturally. A final restoration report was submitted to the NYSDEC with a request to confirm restoration and close the permit. The NYSDEC inspected the area in summer 2020 and the permit was closed.

3.13 PROTECTION OF WILDLIFE

3.13.1 Endangered Species Act

BNL updates its list of species that are endangered, threatened, and/or of special concern (see Table 6-1 in Chapter 6) as data from state and federal sources are provided. The northern long-eared bat (Myotis septentrionalis) is the first federally listed species known to be present at the Laboratory. This species is known to utilize the site at least during the summer months, and management options have been established for the protection of this species on site.

State-recognized endangered (E) or threatened (T) species at BNL include: eastern tiger salamander (E), peregrine falcon (E), persius duskywing (E), bracken fern (E), crested fringed orchid (E), Engelman spikerush (E), dwarf huckleberry (E), whorled loose-strife (E), prostrate knotweed (E), possum haw (E), ipecac spurge (E), swamp darter (T), banded sunfish (T), frosted elfin (T), little bluet (T), scarlet bluet (T), pine barrens bluet (T), northern harrier (T), stargrass (T), eastern showy aster (T), and stiff-leaved goldenrod (T).

Tiger salamanders are listed as endangered in New York State because populations have declined due to habitat loss through development, road mortality during breeding migration, introduction of predatory fish into breeding sites, historical collection for the bait and pet trade, water level fluctuations, pollution, and general disturbance of breeding sites. The BNL Natural Resource Management Plan (NRMP) (BNL 2016) formalizes the strategy and actions needed to protect 26 confirmed tiger salamander breeding locations on site. The strategy includes identifying and mapping habitats, monitoring breeding conditions, improving breeding sites, and controlling activities that could negatively affect breeding.

Peregrine falcons are listed as endangered in New York State due to historic declines associated with DDT. Falcons were confirmed nesting on the HFBR stack in 2019. Because the HFBR stack was scheduled for demolition in 2020, the nest was removed prior to the falcon's return, allowing the project to move forward. The falcons continued to be seen on site and likely found an alternate nesting site.

Banded sunfish and swamp darter have historically been found in the Peconic River drainage areas on site. Both species are listed as threatened within New York State, with eastern Long Island having the only known remaining populations of these fish in New York. Measures taken, or being taken, by the Laboratory to protect the banded sunfish and swamp darter and their habitats include eliminating, reducing, or controlling pollutant discharges to the Peconic River; monitoring populations and water quality to ensure that habitat remains viable; and minimizing disturbances to the river and adjacent banks. Due to an extended drought from 2015 through mid-2017, these two fish are not likely to be found on site. Should NYSDEC establish a recovery plan, fish may be restored to historic habitats in the future.

Three butterfly species that are endangered, threatened, or of special concern have been historically documented at the Laboratory. These include the frosted elfin, persius duskywing, and the mottled duskywing. None have been documented in recent surveys. Limited habitat for the frosted elfin and persius duskywing exists on Laboratory property and the mottled duskywing is likely to exist on site; therefore, the need to manage habitat and surveys for the three butterflies has been added to the NRMP.

Surveys for damselflies and dragonflies conducted periodically during the summer months confirmed the presence of one of the three threatened species of damselflies expected to be found on site. The pine-barrens bluet, a threatened species, has been documented at one of the many coastal plain ponds at BNL.

The Laboratory is also home to 14 species that are listed as species of special concern. Such species have no protection under the state endangered species laws but may be protected under other state and federal laws (e.g., Migratory Bird Treaty Act). New York State monitors species of special concern and manages their populations and habitats, where practical, to ensure that they do not become threatened or endangered. Species of special concern found at BNL include the mottled duskywing butterfly, marbled salamander, eastern spadefoot toad, spotted turtle, eastern box turtle, eastern hognose snake, worm snake, horned lark, whippoor-will, vesper sparrow, grasshopper sparrow, red-headed woodpecker, osprey, sharp-shinned hawk, and Cooper's hawk.

The management efforts for the tiger salamander also benefit the marbled salamander. At present, no protective measures are planned for the eastern box turtle or spotted turtle, as little activity occurs within their known habitat at the Laboratory. The Laboratory continues to evaluate bird populations as part of the management strategy outlined in the NRMP.

The Laboratory has 33 plant species that are protected under state law: eight are endangered; three are threatened (as listed above); and four are rare plants: the small-flowered false fox-glove, narrow-leafed bush clover, wild lupine, and long-beaked bald-rush. The other 18 species are "exploitably vulnerable," meaning that they may become threatened or endangered if factors that result in population declines continue. These plants are currently sheltered due to the large areas of undeveloped pine barren habitat on site. Five species on the BNL list are likely present or possible due to presence of correct habitat. As outlined in the NRMP, locations of these rare plants must be determined, populations estimated, and management requirements established. See Chapter 6 for further details.

3.13.2 Migratory Bird Treaty Act

As mentioned in Chapter 1, the Laboratory has identified more than 185 species of migratory birds since 1948; of those, approximately 84 species nest on site. Under the Migratory Bird Treaty Act, migratory birds are protected from capture, harassment, and destruction or disturbance of nests without permits issued by the U.S. Fish and Wildlife Service. In the past, migratory birds have caused health and safety issues, especially through the deposition of fecal matter and the birds' assertive protection of nesting sites. When this occurs, proper procedures are followed to allow the birds to nest and preventive measures are taken to ensure that they do not cause problems in the future (e.g., access to nesting is closed or repaired, and/or deterrents to nesting are installed). Canada geese (Branta canadensis) are managed under an annual permit from the U.S. Fish and Wildlife Services goose nest management program. Occasionally, nesting migratory birds come in conflict with ongoing or planned construction activities. When this occurs, the USDA-APHIS-Wildlife Services Division is called for consultation and resolution, if possible. Each incident is handled on a case-by-case basis to ensure the protection of migratory birds, while maintaining fiscal responsibility. See Chapter 6 for more information on migratory birds.

3.13.3 Bald and Golden Eagle Protection Act

While BNL does not have bald or golden eagles nesting on site, these birds are occasionally observed visiting the area during migration. At times, immature golden eagles have spent several weeks in the area. Bald eagles are known to spend long periods of time on the north and south shores of Long Island, and the first documentation of nesting on the island occurred in 2013.

Since that time, at least ten additional nesting pairs have been documented on Long Island. Bald eagles have been documented on the BNL site and are routinely seen in the vicinity of the STP, National Weather Service, and the cell tower near Building 30. A pair of eagles frequented the osprey nest located on the cell tower in December 2019, suggesting the potential for utilizing the nest in 2020, but ultimately the pair did not nest there. Further information on bald eagles is presented in Chapter 6.

3.14 PUBLIC NOTIFICATION OF CLEARANCE OF PROPERTY

In accordance with DOE Order 458.1, authorized releases of property suspected of containing residual radioactive material must meet DOE and other federal, state, and local radiation protection policies and requirements. Released property must be appropriately surveyed, and the Laboratory must adequately demonstrate that authorized limits are met. In addition, documentation supporting the release of property should be publicly available. The release of property off the BNL site from radiological areas is controlled. No vehicles, equipment, structures, or other materials from these areas can be released from the Laboratory unless the amount of residual radioactivity on such items is less than the authorized limits. The default authorized limits are specified in the BNL Site Radiological Control Manual (BNL 2021 Rev. 11) and are consistent with the pre-approved authorized release limits set by DOE Order 458.1.

In 2020, excess materials not identified as radioactive, such as scrap metal and electronics equipment resulting from normal operations, were released to interested parties or to an off-site location. All materials were surveyed, as required, using appropriate calibrated instruments and released based on the DOE pre-approved authorized release limits. There were no releases of real property in 2020.

3.15 EXTERNAL AUDITS AND OVERSIGHT

3.15.1 Regulatory Agency Oversight

A number of federal, state, and local agencies oversee BNL activities. In addition to external audits and oversight, the Laboratory has a comprehensive self-assessment program, as described in Chapter 2. In 2020, due to the pandemic, BNL was only inspected by federal, state, or local regulators on seven occasions. These inspections included:

- *Potable Water.* In July, SCDHS collected samples and conducted its annual inspection of the BNL potable water system. Corrective actions for all identified deficiencies were established and communicated with SCDHS and are being addressed by the Laboratory's Energy & Utilities Division.
- *Sewage Treatment Plant.* SCDHS conducts quarterly inspections of the Laboratory's STP to evaluate operations and sample the effluent for SPDES compliance. No performance or operational issues were identified. NYSDEC also visited the site in January 2020 to collect samples and perform SPDES inspections. No issues were identified.
- *RCRA.* In December 2020, BNL received a data request from the USEPA to facilitate the performance of an OfCM to determine RCRA compliance. The OfCM was being performed in lieu of a facility visit due to COVID-19 restrictions. Data requested included photos of waste storage areas, copies of relevant permits, transportation documents, and shipping manifests. The requested information was collected and forwarded to the USEPA and a closeout meeting to discuss the results of the OfCM was scheduled for February 2021.

3.15.2 DOE Assessments/Inspections

The DOE Brookhaven Site Office (BHSO) continued to provide oversight of BNL programs during 2020 and participated as an observer of Brookhaven Science Associates (BSA) Multi-Topic Assessment of BNL's environmental protection programs described below. BHSO participation comprised of observing BSA's scoping, assessment conduct, and reporting.

3.15.3 Environmental Multi-Topic Assessment

The BNL EPD conducts routine programmatic assessments. The determination of topics for these assessments is based upon past regulatory findings, results of environmental, safety and health inspections and/or other routine self-assessments, and frequency of past assessments. In 2020, EPD planned for and executed a programmatic self-assessment in three areas: Spill Response, Environmental Data Quality, and Pest Management.

The objectives of the Spill Response Assessment were to: Evaluate each organization's level of preparedness to respond to spills within their realm of operations; evaluate staff members' understanding of spill response procedures and how to use spill response resources both at the Lab level and within their organization; assess organizational and site-wide spill response strengths and opportunities for improvement; evaluate whether organizations' levels of spill response training are sufficient; and, to discover new Pollution Prevention opportunities and share noteworthy practices. This assessment resulted in two noteworthy practices and three opportunities for improvement. The identified opportunities for improvement were shared with the assessed organizations, documented in the Laboratory's Integrated Operational Performance System (IOPS), and will be tracked to closure.

The objectives of the Environmental Data Quality assessment were to evaluate the data quality review of the Laboratory's environmental monitoring program regarding Quality Assurance of the Contract Analytical Data. Project managers for several environmental programs (e.g., Potable Water, Air Quality, Liquid Effluents) were interviewed and assessed on their understanding and compliance with established quality assurance programs and procedures. This assessment resulted in one noteworthy practice, two opportunities for improvement, and two nonconformances. Per the Laboratory's Event/Issues Management Subject Area, a responsible manager was assigned the responsibility for fact finding, causal analysis, development of a corrective action plan, and managing those corrective actions to completion in IOPS to address the nonconformances.

As a best management practice, the Laboratory assessed the Integrated Pest Management programs associated with the Facilities & Operations Division and Biology Department and used Cornell Cooperative as the outside assessor. There were no findings. Several opportunities for improvement were identified for potential implementation. The opportunities for improvement were being evaluated at the end of the year.

3.15.4 Nevada National Security Site

The Laboratory continues to be a certified Nevada National Security Site (NNSS) waste generator. As part of the NNSS waste certification process, the NNSS Maintenance and Operations Contractor conducts annual assessments of generator Waste Certification Programs (WCP).

BNL was not included on the NNSS 2020

Table 3-9. Existing Agreements and Enforcement Actions Issued to BNL, with Status.

Number	Title	Parties	Effective Date	Status
Agreements				
No Number	Suffolk County Agreement	BNL, DOE, SCDHS	Originally signed on 09/23/87	This agreement was developed to ensure that the storage and handling of toxic and hazardous materials at BNL conform to the environmental and technical requirements of Suffolk County codes.
II-CERCLA-FFA-00201	Federal Facility Agreement under the CERCLA Section 120 (also known as the Interagency Agreement or "IAG" of the Environmental Restoration Program)	DOE, EPA, NYSDEC	05/26/92	This agreement provides the framework, including schedules, for assessing the extent of contamination and conducting cleanup at BNL. Work is performed either as an Operable Unit or a Removal Action. The IAG integrates the requirements of CERCLA, RCRA, and NEPA. Cleanup is currently in long-term surveillance and maintenance mode for the groundwater treatment systems, former soil/sediment cleanup areas, and the reactors; this includes monitoring of institutional controls. The High Flux Beam Reactor stack and reactor vessel are scheduled for decontamination and decommissioning by 2021 and 2072, respectively. All groundwater treatment systems operated as required in 2020.
No Notices of Violation/Enforcement Actions for 2020.				

Notes:
CERCLA = Comprehensive Environmental Response, Compensation and Liability Act
EPA = Environmental Protection Agency
NEPA = National Environmental Policy Act
NYSDEC = New York State Department of Environmental Conservation
RCRA = Resource Conservation and Recovery Act
SCDHS = Suffolk County Department of Health Services

Table 3-10. Summary of Other Environmental Occurrence Reports, 2020.

IOPS* Event #: E-00917	**Date: 07/28/2020**
On July 28, 2020, an evaporative cooler on the roof of Building 911 (Evap. #6), used for the Alternating Gradient Synchrotron main magnet cooling, leaked approximately 100 gallons of tritiated water when a Victaulic pipe fitting failed. The evaporative cooler automatically shut down from the water loss. Up to 114 gallons of water leaked and approximately 50 gallons of tritiated water were estimated to have reached a roof drain that leads to a stormwater outfall, along with a continual discharge of clean water into the drain. The tritium levels of the water released were approximately 29,900 pCi/L, which is above the drinking water standard of 20,000 pCi/L. The evaporator was isolated and repaired within hours of the incident and an investigation on the cause of the failure initiated. On September 10, 2020, a different evaporative cooler (Evap. #5) associated with the same system on the roof of Building 911 leaked approximately 174 gallons of tritiated water when a Victaulic pipe fitting failed. Similar to the first event, the evaporative cooler automatically shut down from the water loss and an estimated 50 percent of the total release volume was assumed to discharge via the roof storm drain. In response to the second failure, the Main Magnet cooling system was shut down and remained offline pending further assessment and repair. An investigation team was formed and conducted fact-finding, a causal analysis, and the development of several corrective actions to prevent similar events from occurring in the future. This included the development of an enhanced inspection program and replacement of all valves/couplings/clamps associated with the exterior portion of the Main Magnet Cooling System and re-insulation of the same.	Status: All corrective action items completed in FY21.
IOPS* Event #: E-00965	**Date: 08/11/2020**
On August 11, 2020, first draw lead and copper samples were collected at 20 locations as part of BNL's sampling plan for the required Lead & Copper Rule Triennial sampling. The associated analytical results identified an exceedance of the 90th percentile action level for lead of 15 ppb (3 out of 20 samples were over 15 ppb). The Suffolk County Department of Health Services was notified, and BNL's environmental and facility operations staff immediately initiated follow-up actions in accordance with the New York State Sanitary Code. See Section 3.7.1 for more details.	Status: Regulatory required follow-up actions have been completed.

Notes:
* Reported in accordance with BNL's Event/Issues Management Subject Area and documented in the Integrated Operational Performance System (IOPS).

assessment schedule but, as required by the NNSS Waste Acceptance Criteria, an independent assessment of the WCP was scheduled and performed by an outside contractor.

The assessment resulted in no observations against BNL's WCP, enabling BNL continued access to the NNSS for radioactive waste disposal.

3.16 AGREEMENTS, ENFORCEMENT ACTIONS, AND OTHER ENVIRONMENTAL OCCURRENCE REPORTS

In addition to the rules and regulations discussed throughout this chapter, there were two existing agreements between BNL, DOE, and regulatory agencies that remained in effect in 2020 (see Table 3-9). There were no Notices of Violation assessed in 2020; however, there were two environmental events that were reported in accordance with BNL's Event/Issues Management Subject Area and documented in IOPS. The events are summarized in Table 3-10.

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Air Quality 4

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 detect possible environmental impacts from Laboratory operations.

During 2020, BNL facilities released a total of 0.242 Curies of tritium. 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 percent of the heating and cooling needs of the Laboratory's major facilities in 2020. 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.

The COVID-19 pandemic had significant impacts on air travel greenhouse gas (GHG) emissions. From March 23 to September 30, when the Laboratory followed its limited operations plan consistent with New York State and Department of Energy guidelines, air travel emissions accounted for 2.5 percent of fiscal year 2020 totals. During this period, commuting GHG emissions were just 30 percent of the annual total, most likely due to 64 percent of employees working from home.

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. 4, Radiation Protection of the Public and the Environment. Under NESHAPs Subpart H, facilities that have the potential to cause an annual radiation dose greater than 0.1 mrem (1 µSv) to a member of the public must continuously monitor emissions. Facilities capable of delivering radiation doses below that limit require periodic, confirmatory sampling.

BNL has two active facilities: the Brookhaven Linac Isotope Producer (BLIP), whose emissions are continuously monitored with an inline detection system, and the Target Processing Laboratory (TPL), which has a particulate filter sampling system to continuously collect samples for gross alpha and gross beta activity, and one inactive facility, the High Flux Beam Reactor (HFBR), where periodic emissions 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 sampling points in the exhaust stack for BLIP and the TPL exhaust duct are equipped with glass-fiber filters that capture samples of airborne particulate matter released from these facilities (see Figure 4-1). The filters are collected and analyzed weekly for gross alpha and beta activity. Particulate filter analytical results for gross alpha and beta activity in 2020 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 0.0055 pCi/m^3, respectively. Annual average gross alpha and beta airborne activity levels for samples collected from the TPL were 0.0007 and 0.0081 pCi/m^3, respectively.

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

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

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 for inspections and routine maintenance. 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). During target irradiations, both isotopes are released as gaseous, airborne emissions through the facility's 33-foot stack. Emission levels of these radionuclides are dependent on the current and energy of the proton beam used to produce the radioisotopes. In 2020, the BLIP facility did not receive any proton beams due to year-long operational reviews and improvements. However, residual tritium produced from previous activation of the target cooling water continued to be released, totaling 0.0156 Curies. There were no emissions of O-15 or C-11 in 2020.

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

Facility	Nuclide	Half-Life	Ci Released
HFBR	Tritium	12.3 years	2.27E-01
BLIP	Tritium	12.3 years	1.56E-02
Total			**2.42E-01**

Notes:
1 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 4.2.1, 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 multi-stage HEPA and charcoal filters and the filtered air is then vented to the atmosphere. The types of radionuclides that are produced 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. Historical analytical results of TPL particulate filters show gross alpha/beta levels to be minimal. 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 analysis may be used to identify potentially emitted nuclides.

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 463, 480, 490, 510, 734, 745, 815, and 820, where research is conducted in the fields of nuclear safety, biology, chemistry, high energy physics, 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 2020.

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 blockhouse 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 2020, 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 0.0125 pCi/m^3, 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 0.0025 and 0.0183 pCi/m^3, with an average concentration of 0.0077 pCi/m^3. BNL results ranged from 0.0064 to 0.0197 pCi/m^3, with an average concentration of 0.0119 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 2020, NYSDOH reported that airborne gross beta activity at that location varied between 0.0018 and 0.0259 pCi/m^3 and had an average concentration of 0.0121 pCi/m^3. All the BNL samples were less than the maximum concentration collected at the NYSDOH control location, demonstrating that on-site radiological air quality was consistent with that observed at locations in New York State not located near radiological facilities.

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

Monitored Facility		Gross Alpha (pCi/m^3)	Gross Beta (pCi/m^3)
BLIP	N	52	52
	Max.	0.0017 ± 0.0009	0.0129 ± 0.0015
	Avg.	0.0005 ± 0.0005	0.0055 ± 0.0011
	MDL	0.0009*	0.0010*
TPL - Bldg. 801	N	51	51
	Max.	0.0059 ± 0.0012	0.0356 ± 0.0021
	Avg.	0.0007 ± 0.0005	0.0081 ± 0.0010
	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 (pCi/m^3)	Gross Beta (pCi/m^3)
P2	N	51	51
	Max	0.0023 ± 0.0006	0.0268 ± 0.0031
	Avg.	0.0010 ± 0.0005	0.0131 ± 0.0012
	MDL	0.0006*	0.0007*
P4	N	50	50
	Max	0.0027 ± 0.0006	0.0198 ± 0.0013
	Avg.	0.0010 ± 0.0005	0.0133 ± 0.0012
	MDL	0.0005*	0.0007*
P7	N	50	50
	Max	0.0033 ± 0.0006	0.0197 ± 0.0016
	Avg.	0.0010 ± 0.0005	0.0119± 0.0011
	MDL	0.0005*	0.0007
P9	N	50	50
	Max	0.0020 ± 0.0007	0.0217 ± 0.0014
	Avg.	0.0011 ± 0.0005	0.0117 ± 0.0011
	MDL	0.0005*	0.0006*
Grand Average		**0.0010 ± 0.0005**	**0.0125 ± 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

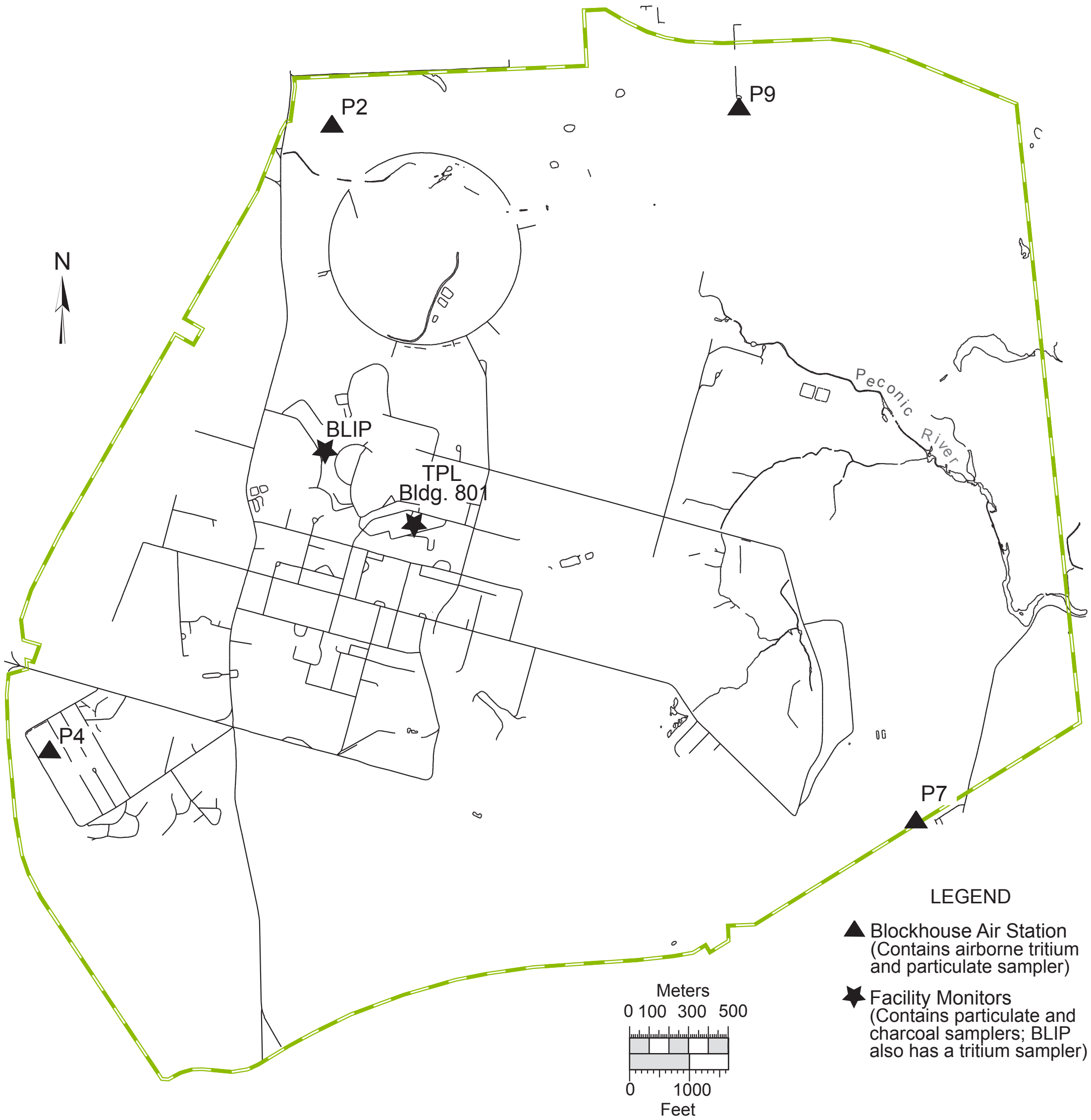


Figure 4-2. BNL On-Site Ambient Air Monitoring Stations.

4.3.2 Airborne Tritium

Airborne tritium in the form of tritiated water (HTO) is monitored throughout the BNL site. In 2020, 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). Samples for airborne tritium were collected every two weeks from each sampling station during 2020. The average tritium concentrations at all the sampling locations were less than the typical minimum detection limits, ranging from 4.3 to 12.8 pCi/m^3.

4.4 NONRADIOLOGICAL AIRBORNE EMISSIONS

Various state and federal regulations governing non-radiological 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 non-radiological 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 385 MW (1,315 MMBtu/hr).

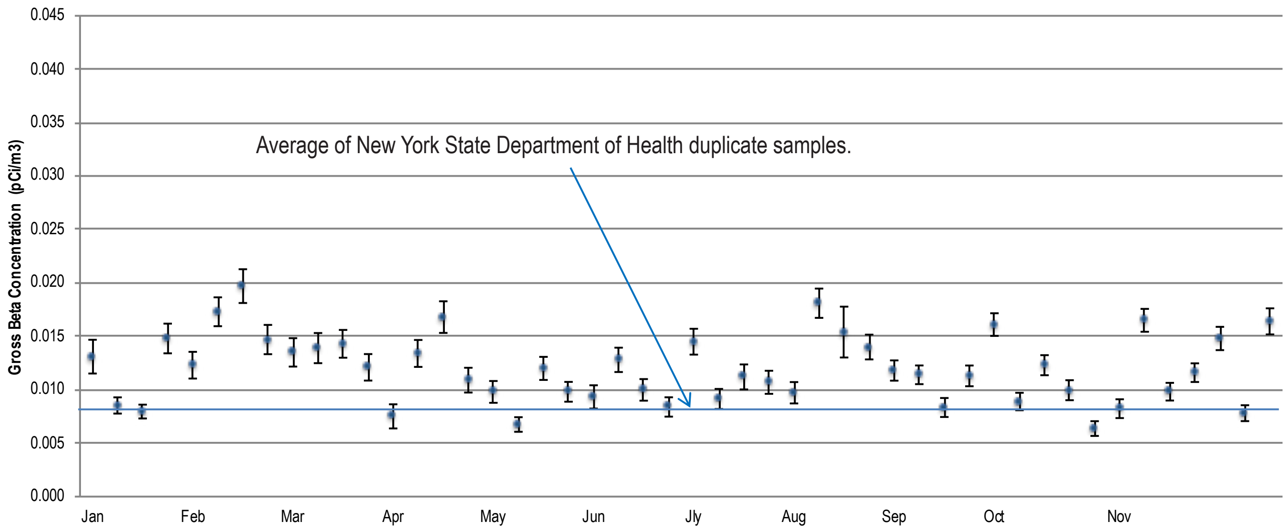
Because the CSF boilers have the potential to emit more than 100 tons per year of oxides of nitrogen (NOx), the CSF is considered a major facility, and all four of its boilers are subject to the Reasonably Available Control Technology (RACT) requirements of Title 6 of the New York Code, Rules, and Regulations (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).

The Subpart 227-2 NOx RACT emission limit for the combustion of natural gas and the combustion of No. 6 oil burned in the CSF three large boilers is 0.15 lbs/MMBtu. The NOx RACT emission limit for the CSF's one mid-size boiler (Boiler 1A) is 0.20 lbs/MMBtu. From May 1 to September 15 of each year, 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 utilizes 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 0.085, 0.088, 0.087, and 0.108 lbs/MMBtu, while the corresponding permissible weighted average emissions rate for all four quarters was 0.150 lbs/MMBtu.

In 2020, there were 20 recorded excess opacity measurements. Recorded readings on July 27 and December 1 and four recorded readings on December 15 were due to the start-up and shutdown



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

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

of Boiler 6. A single Boiler 6 excess opacity reading on October 13 was from an unknown cause. Ten additional excess opacity readings on December 15 were the result of heavy snowfall that obstructed the transmission of light in the Boiler 6 continuous opacity monitor. 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.

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 2020. 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.

In 2020, residual fuel prices exceeded those of natural gas for most of the year. As a result, natural gas was used to supply 99 percent of the heating and cooling needs of BNL's major facilities. By comparison, in 2016, residual fuel satisfied 21 percent of the major facility heating and cooling needs. Consequently, 2020 emissions of particulates, NOx, and sulfur dioxide (SO_2) were 1.5, 4.7, and 17.8 tons less than the respective totals for 2016, 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 2011.

4.5 GREENHOUSE GAS EMISSIONS

Since the implementation guidance for Executive Order (EO) 13834, Efficient Federal Operations, that was released in April 2019 did not require agencies to amend greenhouse gas (GHG) reduction targets, the Laboratory has continued to strive to achieve the numerical targets set forth in EO 13693.

One of the overarching goals of EO 13693 was for federal agencies to establish agency-wide GHG reduction targets for their combined Scope 1 and 2 GHG emissions and for their Scope 3 GHG emissions (see Appendix A for definitions). DOE set the following GHG emission reduction goals for fiscal year (FY) 2025: reduce Scope 1 and 2 GHG emissions by 50 percent relative to its FY 2008 baseline and reduce Scope 3 GHG emissions by 25 percent relative to its FY 2008 baseline. BNL includes these same goals in its annual Site Sustainability Plan (SSP), which it submits to DOE in December of each year (BNL 2020). BNL's SSP identifies several actions that have or will be taken to help the

Table 4-4. Ambient Airborne Tritium Measurements in 2020.

Sample Station	Wind Sector	Validated Samples	Maximum (pCi/m^3)	Average (pCi/m^3)
P2	NNW	26	6.0 ± 4.8	0.3 ± 4.1
P4	WSW	26	7.0 ± 5.7	-0.4 ± 5.5
P7	ESE	26	7.4 ± 5.2	-0.1 ± 5.3
P9	NE	26	8.3 ± 6.5	0.5 ± 5.2
Grand Average				**0.1 ± 5.0**

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 4.3 and 12.8 pCi/m^3.

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 2020, the LISF provided 48 million kilowatt-hours of solar energy to Long Island. This equates to 25,988 metric tons CO_2 equivalents (MT CO_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 2020, BNL consumed 116,430 megawatts of hydropower, providing a net combined GHG reduction of 39,117 MT CO_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 total peak capacity of 907 kW. In 2020, it provided 977,967 kWh and offset 529 MT CO_2e.

DOE awarded BNL's first Utility Energy Service Contract (UESC) in October 2013. This project provided for the implementation of energy savings measures to reduce Scope 1 and 2 GHG levels by approximately 7,000 MT CO_2e. The USEC project implementation was completed in May 2015 and included the following energy conservation measures:

- Installation of a 1,250-ton high-efficiency chiller to increase the efficiency of supplied chilled water;
- Upgraded lighting systems in 18 buildings; and

Table 4-5. Central Steam Facility Fuel Use and Emissions (2011–2020).

	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)
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
2019	15.56	2,335	0.13	17.94	588.49	649,343	2.3	28.5	0.5	1.6
2020	44.20	6,455	0	0	553.70	610,905	2.2	28.9	1.2	1.5
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

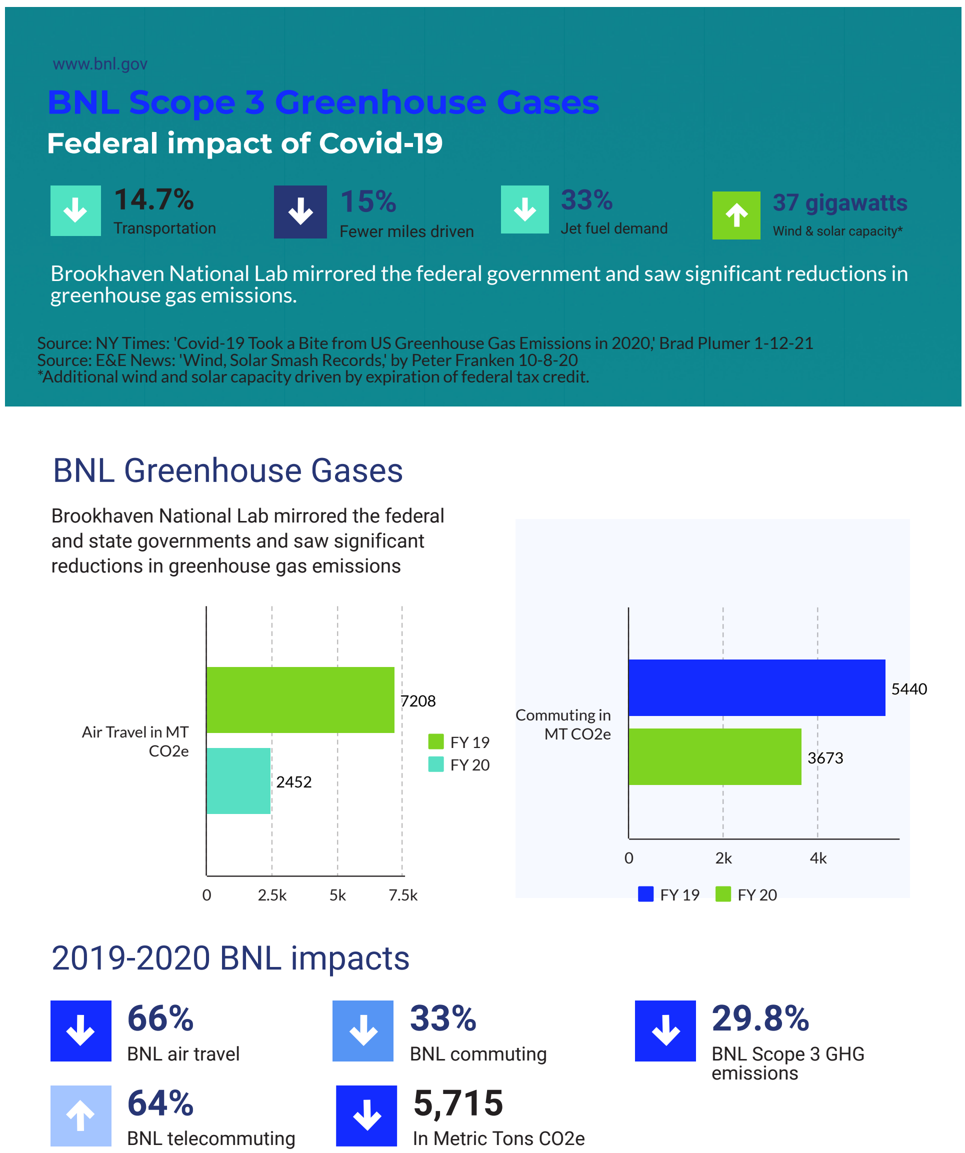
- Enhanced building control upgrades and additions to provide for heating, ventilation, and air conditioning temperature setbacks in nine buildings.

The UESC project has been a success, with annual energy savings within three percent of the original estimates for each of the six years since completion. In FY 2018, an investment grade audit (IGA) was initiated for potential Phase II UESC projects. In 2019, the IGA was completed and the process to issue a contract was begun. Planned energy savings projects under consideration include additional lighting and building control upgrades, free cooling, and some HVAC improvements for the Chemistry Building. Due to some concerns by Brookhaven Science Associates and DOE, the UESC II effort was temporarily paused. However, it is expected to resume soon. BNL continues to periodically evaluate the potential to install a combined heat and power plant, as well as renewable energy projects, and will recommend going forward if a business case is developed 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 MT CO_2e from the FY 2008 baseline of 20,136 MT CO_2e. Overall, Scope 3 GHG emissions decreased by 5,715 MT CO_2e, down 29.8 percent from FY 2019, and 33 percent less than the FY 2008 baseline value of 20,136 MT CO_2e. The decrease from FY 2019 is mostly due to a 4,756 MT CO_2e drop in GHG emissions from business air travel, and a 1,767 MT CO_2e decrease in commuting GHG emissions.

The COVID-19 pandemic had significant impacts on national transportation, as well as Laboratory air travel and commuting GHG emissions, as noted in Figure 4-4. From March 23 to September 30, when the Laboratory followed its limited operations plan consistent with New York State and DOE guidelines, air travel GHG emissions accounted for just 2.5 percent of FY 2020 total air travel emissions. During this period, commuting GHG emissions were just 30 percent of the annual total, since 64 percent of employees were working at home.

Figure 4-4. BNL Scope 3 Greenhouse Gases: Federal Impact of Covid-19



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Water Quality 5

Wastewater generated from operations at Brookhaven National Laboratory (BNL) is treated at the Sewage Treatment Plant (STP) before it is discharged to nearby groundwater recharge basins. Some wastewater may contain very low levels of radiological, organic, or inorganic contaminants. Monitoring, pollution prevention, and vigilant operation of treatment facilities ensure that these discharges comply with all applicable regulatory requirements and that the public, employees, and the environment are protected.

Analytical data for 2020 shows that the average gross alpha and beta activity levels in the STP discharge (EA, Outfall 001) were within the typical range of historical levels and were well below New York State Drinking Water Standards (NYS DWS). Tritium was detected just above the method detection limit (MDL) in the STP discharge during January 2020; no cesium-137, strontium-90, or other gamma-emitting nuclides attributable to Laboratory operations were detected. Non-radiological monitoring of the STP effluent showed that, with the exception of multiple tolyltriazole exceedances, organic and inorganic parameters were within State Pollutant Discharge Elimination System (SPDES) effluent limits or other applicable standards.

The average concentrations of gross alpha and beta activity in stormwater and cooling water discharged to recharge basins were within typical ranges and no gamma-emitting radionuclides were detected. Disinfection byproducts continue to be detected at low concentrations above the MDL in discharges to recharge basins due to the use of chlorine and bromine for the control of algae and bacteria in potable and cooling water systems. Inorganics (i.e., metals) were detected; however, their presence is due primarily to sediment runoff in stormwater discharges.

The Peconic River did not flow offsite in 2020. Radiological data from Peconic River surface water sampling show that the average concentrations of gross alpha and gross beta activity from on-site locations were indistinguishable from control locations, and all detected levels were below the applicable NYS DWS. No gamma-emitting radionuclides attributable to Laboratory operations were detected either upstream or downstream of the former STP outfall, and tritium was not detected above MDL's in any of the surface water samples.

5.1 SURFACE WATER MONITORING PROGRAM

In addition to monitoring discharges to surface waters under the SPDES program described in Chapter 3, BNL routinely monitors surface water quality (including radionuclides) as part of its site Surveillance Program. Although discharges of treated wastewater from the Laboratory's STP into the headwaters of the Peconic River ceased in October 2014, the Laboratory continues to monitor surface water at several locations along the Peconic River to assess the impact that site operations may have on surface water quality. On-site monitoring station HY is located upstream of all Laboratory operations and provides information on the background water quality of the Peconic River (see Figure 5-1). The Carmans River is monitored as a geographic control location for comparative purposes, as it is not affected by operations at BNL and is not connected to the Peconic River watershed.

On the Laboratory site, the Peconic River is an intermittent, groundwater-fed stream. Off-site flow occurs only after periods of sustained precipitation

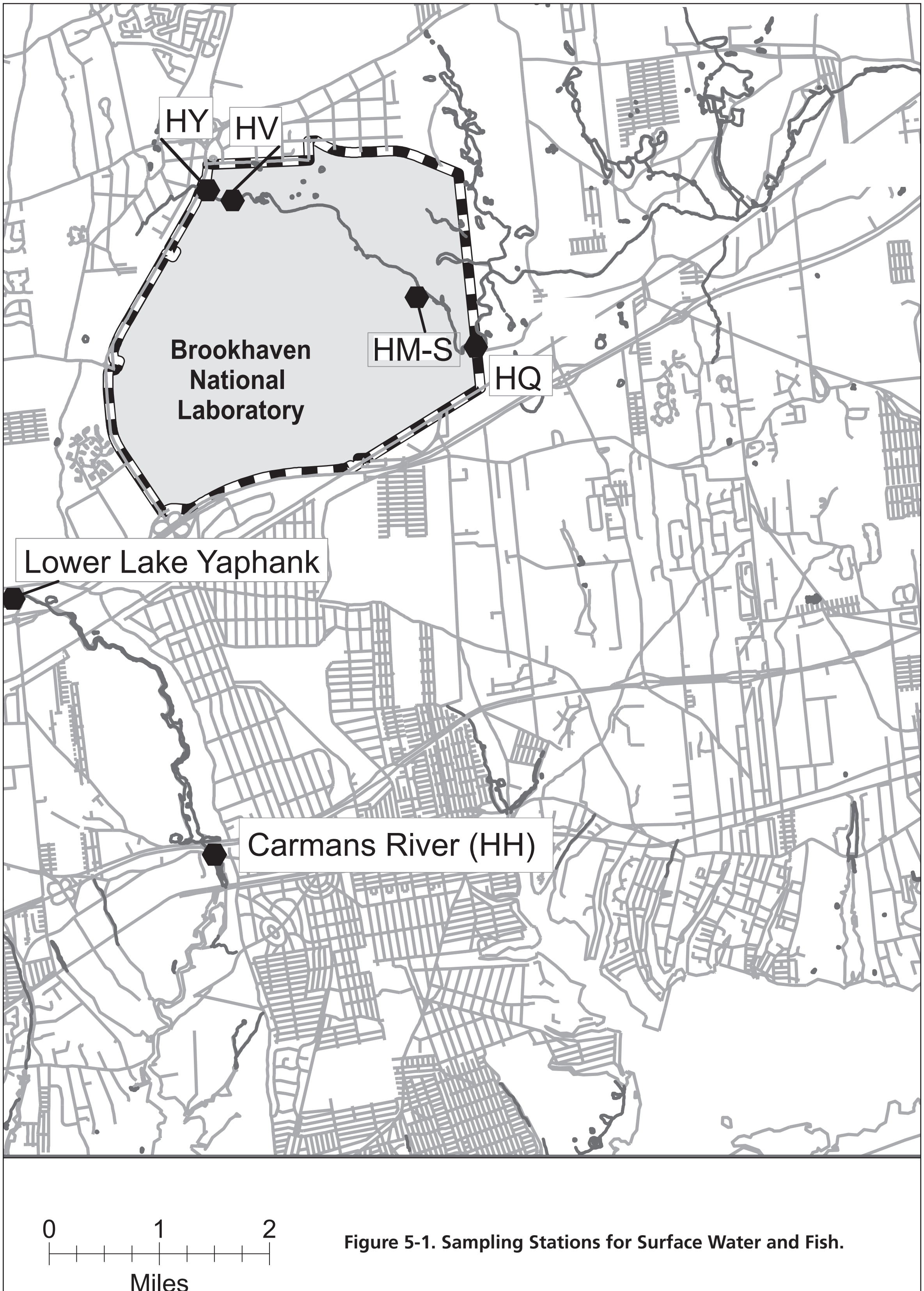

Figure 5-1. Sampling Stations for Surface Water and Fish.

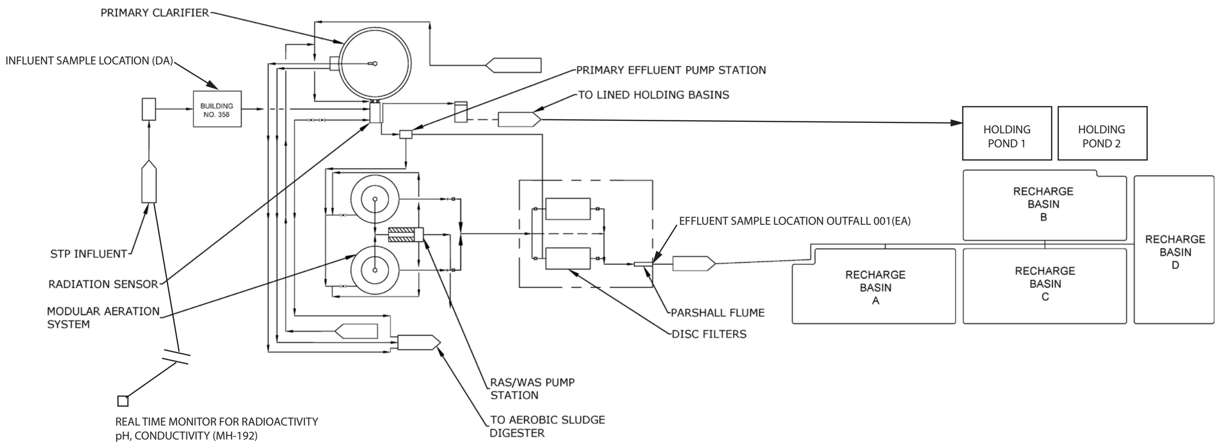

Figure 5-2. Schematic of BNL's Sewage Treatment Plant (Recharge Basin Discharge)

and a concurrent rise in the water table, typically in the spring. There was no significant off-site flow in 2020. The fluctuating cycles with periods of flow and no-flow are indicative of the combined influences of precipitation and groundwater.

Historical monitoring data indicates no significant variations in water quality throughout the Peconic River system on site, and pollution prevention efforts at the Laboratory have significantly reduced the risk of accidental releases. The following sections describe BNL's surface water monitoring and surveillance program.

5.2 SANITARY SYSTEM EFFLUENTS

The STP effluent (Outfall 001) is a discharge point authorized under BNL's SPDES permit that is issued by the NYSDEC (Section 3.6.1). Figure 5-2 shows a schematic for discharge of treated STP effluent to nearby groundwater recharge basins. The Laboratory's STP treatment process includes three principal steps: 1) aerobic oxidation for secondary removal of biological matter and nitrification of ammonia, 2) secondary clarification, and 3) filtration for final solids removal. Tertiary treatment for nitrogen removal is also provided by controlling the oxygen levels in the aeration tanks. During the aeration process, the oxygen levels are allowed to drop to the point where microorganisms use nitrate-bound oxygen for respiration; this liberates nitrogen gas and consequently reduces the concentration of nitrogen in the STP discharge.

Solids separated in the clarifier are pumped to aerobic digesters for continued biological solids reduction and sludge thickening. Once the sludge in the aerobic digester reaches a solids content of six percent, the sludge is sampled to ensure it meets the waste acceptance criteria for disposal at the Suffolk County Department of Public Works Sewage Treatment Facility at Bergen Point, in West Babylon, New York.

Real-time monitoring of the sanitary waste stream for radioactivity, pH, and conductivity occurs at two locations. The first site, MH-192, is approximately one mile upstream of the STP and provides a minimum of 30 minutes to warn the STP operators that wastewater exceeding SPDES limits or BNL administrative effluent release criteria is en route. The second monitoring site is at the point where the STP influent enters the treatment process.

Based on the data collected by the real-time monitoring systems, any influent to the STP that may not meet SPDES limits and BNL effluent release criteria can be diverted to two double-lined holding ponds. The total combined capacity of the two holding ponds exceeds six million gallons, or approximately 18 days of flow. Diversion would continue until the influent water quality would allow for the permit limits and release criteria to be met. Wastewater diverted to the holding ponds is tested and evaluated against

Table 5-1. Tritium and Gross Activity in Water at the BNL Sewage Treatment Plant (STP).

		Flow (liters)	**Tritium** (pCi/L)		**Gross Alpha** (pCi/L)		**Gross Beta** (pCi/L)	
			max.	avg.	max.	avg.	max.	avg.
January	*influent*	2.04E+07	< 288	< MDL	< 11.6	4.5 ± 3.9	10.6 ± 3.8	6.7 ± 3.2
	effluent	2.01E+07	3020 ± 466	802 ± 574	< 7.2	1.7 ± 2.8	9.7 ± 2.8	6.5 ± 2.6
February	*influent*	1.92E+07	< 364	< MDL	< 6.3	1.2 ± 0.9	6.0 ± 2.1	5.2 ± 0.8
	effluent	1.81E+07	< 320	< MDL	< 4.0	-0.1 ± 0.9	5.3 ± 1.4	4.4 ± 0.7
March	*influent*	2.07E+07	< 374	< MDL	< 17.3	3.7 ± 1.8	7.5 ± 3.8	6.5 ± 1.1
	effluent	2.79E+07	< 364	< MDL	3.2 ± 2.1	0.8 ± 1.3	6.8 ± 2.8	4.8 ± 1.4
April	*influent*	1.31E+07	< 426	< MDL	< 4.2	0.9 ± 0.6	4.5 ± 1.8	3.6 ± 0.6
	effluent	1.62E+07	< 379	< MDL	< 3.4	-0.1 ± 1.3	3.4 ± 1.2	2.7 ± 0.6
May	*influent*	1.34E+07	< 370	< MDL	< 10.9	0.7 ± 2.0	5.6 ± 2.5	3.5 ± 1.4
	effluent	1.46E+07	< 360	< MDL	< 5.1	1.4 ± 2.7	4.0 ± 1.2	2.8 ± 1.5
June	*influent*	2.35E+07	< 240	< MDL	< 7.0	2.1 ± 1.9	6.1 ± 2.5	3.4 ± 1.4
	effluent	2.28E+07	< 241	< MDL	< 6.4	-0.1 ± 0.6	4.6 ± 1.6	3.5 ± 0.6
July	*influent*	3.07E+07	< 282	< MDL	< 6.1	1.9 ± 1.8	4.4 ± 1.3	3.3 ± 0.9
	effluent	3.04E+07	< 285	< MDL	< 3.4	1.0 ± 0.4	3.9 ± 1.6	2.2 ± 1.2
August	*influent*	3.84E+07	< 274	< MDL	10.9 ± 4.9	5.4 ± 3.5	11.6 ± 2.6	6.6 ± 3.0
	effluent	3.78E+07	< 287	< MDL	13.7 ± 4.6	4.7 ± 3.9	10.5 ± 2.5	5.6 ± 2.7
September	*influent*	2.49E+07	< 366	< MDL	< 6.1	1.0 ± 1.5	4.1 ± 1.9	3.0 ± 1.0
	effluent	2.56E+07	< 415	< MDL	< 4.2	1.4 ± 1.4	4.0 ± 1.5	2.7 ± 1.3
October	*influent*	2.11E+07	2080 ± 400	411 ± 681	< 5.9	0.9 ± 2.3	< 5.6	2.7 ± 1.9
	effluent	2.16E+07	< 328	< MDL	< 5.0	-0.2 ± 1.2	3.8 ± 1.4	3.0 ± 1.2
November	*influent*	2.37E+07	< 319	< MDL	4.3 ± 3.4	1.8 ± 1.4	5.4 ± 0.9	3.4 ± 1.3
	effluent	2.43E+07	< 310	< MDL	< 1.9	-0.4 ± 0.7	5.4 ± 1.6	3.1 ± 1.3
December	*influent*	1.92E+07	< 452	< MDL	< 3.8	-0.1 ± 1.1	4.4 ± 1.5	3.3 ± 0.9
	effluent	2.11E+07	< 429	< MDL	< 3.3	0.4 ± 0.5	3.5 ± 1.1	2.5 ± 0.9
Annual Avg.	*influent*			< MDL		2.2 ± 0.7		4.4 ± 0.6
	effluent			< MDL		1.0 ± 0.7		3.8 ± 0.6
Total Release		**2.80E+08**		**9.5 mCi (a)**		**0.4 mCi**		**1.1 mCi**
Average MDL (pCi/L)				**350.3**		**4.3**		**1.8**
SDWA Limit (pCi/L)				**20000**		**15**		**50 (b)**

Notes:
All values above MDL are reported with a 95% confidence interval.
To convert values from pCi to Bq, divide by 27.03.
Negative numbers occur when the measured value is lower than background (see Appendix B for description).
MDL = minimum detection limit
SDWA = Safe Drinking Water Act
(a) The total released value for tritium is a conservative calculation that is based on an average of the 95% confidence interval maximums as estimates of monthly average release concentrations. The majority of the effluent samples showed average concentrations less than zero and all results were less than the MDL.
(b) The drinking water standards were changed from 50 pCi/L (concentration based) to 4 mrem/yr (dose based) in 2003. As gross beta activity activity does not identify specific radionuclides, a dose equivalent cannot be calculated for the values in the table.

the requirements for release. If necessary, the wastewater is treated and then reintroduced into the STP at a rate that ensures compliance with SPDES permit limits for nonradiological parameters or BNL effluent release criteria for radiological parameters. In 2020, there were no instances where influent water quality required diversion of wastewater to the hold-up ponds.

5.2.1 Sanitary System Effluent–Radiological Analyses

Wastewater at the STP is sampled at the inlet to the treatment process, Station DA, and at the STP outfall, Station EA, as shown in Figure 5-2. At each location, samples are collected on a flow-proportional basis; that is, for every 1,000 gallons of water treated, approximately four fluid ounces of sample are collected and composited into a five-gallon collection container. These samples are analyzed weekly for gross alpha and gross beta activity and for tritium. Samples collected from these locations are also composited and analyzed monthly for gamma-emitting radionuclides and strontium-90 (Sr-90: half-life, 29 years).

Although the STP discharge is not used as a direct source of potable water, the Laboratory applies the more stringent Safe Drinking Water Act (SDWA) standards for comparison purposes when monitoring the effluent, in lieu of Department of Energy wastewater criteria. Under the SDWA, water standards are based on a 4 mrem (40 µSv) dose limit. The SDWA specifies that no individual may receive an annual dose greater than 4 mrem from radionuclides that are beta or photon emitters, which includes up to 168 individual radioisotopes. BNL performs radionuclide-specific gamma analysis to ensure compliance with this standard. The SDWA annual average gross alpha activity limit is 15 pCi/L, including radium-226 (Ra-226: half-life, 1,600 years), but excluding radon and uranium. Other SDWA-specified drinking water limits are 20,000 pCi/L for tritium (H-3: half-life, 12.3 years), 8 pCi/L for

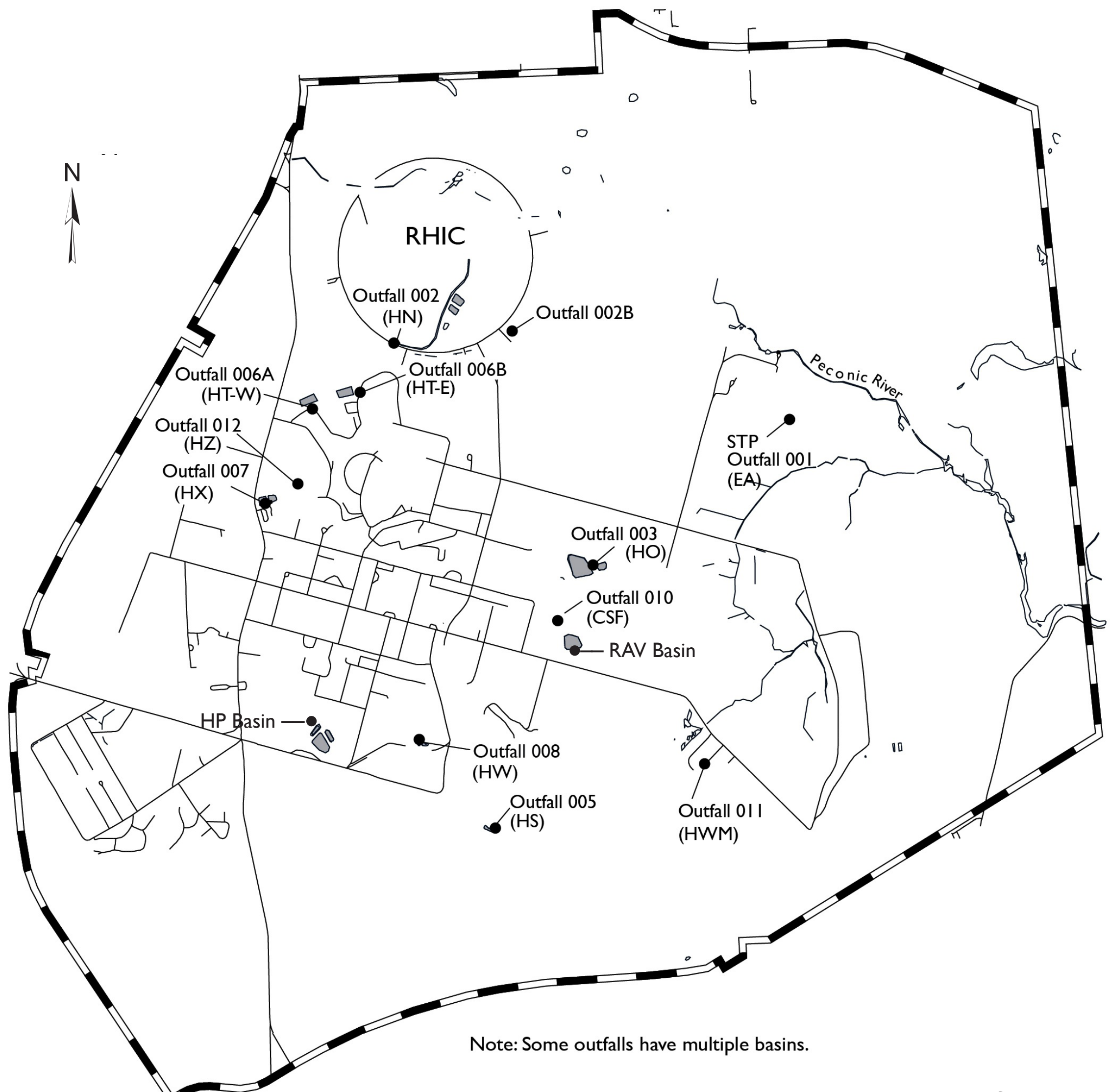

Figure 5-3. BNL Recharge Basin/Outfall Locations.

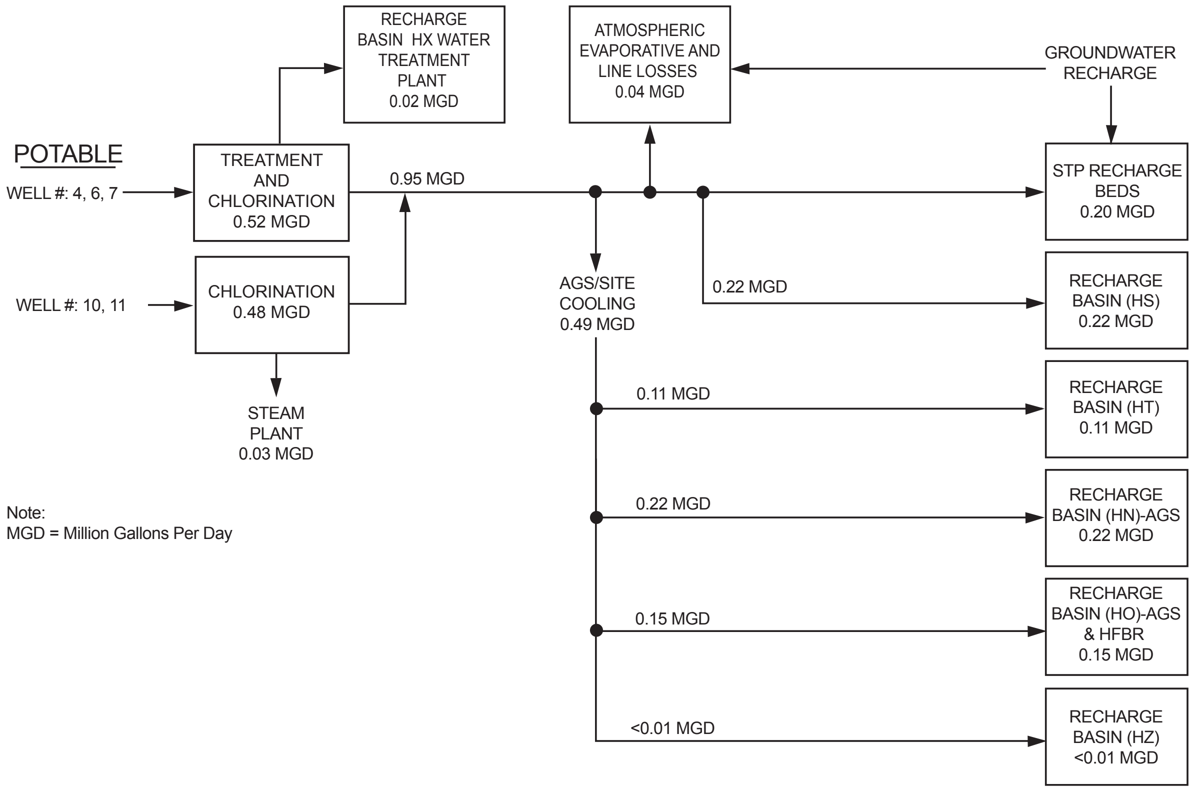

Figure 5-4. Schematic of Potable Water Use and Flow at BNL.

Sr-90, 5 pCi/L for Ra-226 and Ra-228 (Ra-228: half-life, 5.75 years), and 30 µg/L for uranium. Gross alpha and beta activity measurements are used as a screening tool for detecting the presence of radioactivity.

Table 5-1 shows the monthly gross alpha and beta activity data and tritium concentrations for the STP influent and effluent during 2020. Annual average gross alpha and beta activity levels in the STP effluent were 1.0 ± 0.7 pCi/L and 3.8 ± 0.6 pCi/L, respectively. The gross alpha average concentrations were higher than those measured at the Carman's River control location (HH) while the gross beta was lower than the control location reported in Table 5-5; however, they were well below the SDWA standards that are used for comparison purposes. Tritium was detected above the MDL in the discharge of the STP (EA, Outfall 001) during January and October 2020 with the maximum concentration being 3020 ± 466 pCi/L and an average of 802 ± 574 pCi/L, both well below the SDWA standard of 20,000 pCi/L. In 2020, there were no gamma-emitting nuclides detected in the STP effluent.

5.2.2 Sanitary System Effluent – Nonradiological Analyses

Monitoring of the STP effluent for volatile organic compounds (VOCs), inorganics, and anions is conducted as part of the SPDES Compliance Program, which is discussed in further detail in Chapter 3.

5.3 PROCESS-SPECIFIC WASTEWATER

Wastewater that may contain constituents above SPDES permit limits or ambient water quality discharge standards must be held by the generating facility and characterized to determine the appropriate means of disposal. The analytical results are compared with the appropriate discharge limit, and the wastewater is only released to the sanitary system if the volume and concentration of contaminants in the discharge would not jeopardize the quality of the STP effluent and subsequently, potentially impact groundwater quality (BNL 2020).

The Laboratory's SPDES permit includes requirements for quarterly sampling and analysis of process-specific wastewater discharged from metal-cleaning operations in Building 498 and cooling tower discharges from Building 902. These operations are monitored for contaminants such as metals, cyanide, VOCs, and semi-volatile organic compounds. In 2020, analyses of these waste streams showed that, although several operations contributed contaminants (principally metals) to the STP influent in concentrations exceeding SPDES-permitted levels, these discharges did not affect the quality of the STP effluent.

Process wastewaters that are not expected to be of consistent quality and are not routinely generated are held for characterization before release to the sanitary system. The process wastewaters typically include purge water from groundwater sampling, wastewater from cleaning of heat exchangers, wastewater generated as a result of restoration activities, and other industrial wastewaters. To determine the appropriate disposal method, samples are analyzed for contaminants specific to the process, and the concentrations are compared to the SPDES effluent limits and BNL's effluent release criteria (BNL 2020). If the concentrations are within limits, authorization for sewer system discharge is granted; if not, alternate means of disposal are used. Any waste that contains elevated levels of hazardous or radiological contaminants in concentrations that exceeded Laboratory effluent release criteria are sent to the BNL Waste Management Facility for proper management and off-site disposal.

5.4 RECHARGE BASINS

Recharge basins are used for the discharge of "clean" wastewater, including once-through cooling water, stormwater runoff, and cooling tower blowdown. These wastewaters are suitable for direct replenishment of the groundwater aquifer. Figure 5-3 shows the locations of the Laboratory's discharges to recharge basins (also called "outfalls" under BNL's SPDES permit). Figure 5-4 presents an overall schematic of potable water use at the Laboratory, and how much of this water is discharged to the 11 on-site recharge basins:

- Basins HN, HT-W, and HT-E receive once-through cooling water discharges generated at the Alternating Gradient Synchrotron (AGS), Linear Accelerator, and Relativistic Heavy Ion Collider (RHIC), as well as cooling tower blowdown and stormwater runoff.
- Basin HS receives predominantly stormwater runoff, once-through cooling water from Building 555 (Chemistry Department), and minimal cooling tower blowdown from the Computational Science Initiative facility.
- Basin HX receives Water Treatment Plant filter backwash water.

Table 5-2. Radiological Analysis of Samples from On-Site Recharge Basins.

Basin		Gross Alpha	Gross Beta	Tritium
		(pCi/L)		
No. of samples		2	2	2
HN	*max.*	2.63 ± 1.66	9.01 ± 1.6	< 387
	avg.	1.27 ± 2.67	5.36 ± 7.15	< MDL
HO	*max.*	2.72 ± 1.66	3.28 ± 1.16	< 306
	avg.	1.8 ± 1.81	2.2 ± 2.11	< MDL
HS	*max.*	< 2.44	3.51 ± 1.01	< 357
	avg.	0.73 ± 0.32	2.56 ± 1.85	< MDL
HT-E	*max.*	< 5.66	5.76 ± 2.34	< 377
	avg.	1.15 ± 1.66	4.06 ± 3.33	< MDL
HT-W	*max.*	< 1.7	2.24 ± 0.74	< 367
	avg.	0.69 ± 0.48	1.46 ± 1.52	< MDL
HW	*max.*	1.98 ± 0.92	4.16 ± 0.97	< 324
	avg.	1.34 ± 1.25	3.04 ± 2.2	< MDL
HZ	*max.*	4.04 ± 1.66	3.13 ± 0.9	< 324
	avg.	2.28 ± 3.45	1.83 ± 2.55	< MDL
SDWA Limit		**15**	**(a)**	**20,000**

Notes:
See Figure 5-3 for recharge basin/outfall locations.
All values above MDL reported with a 95% confidence interval.
Negative numbers occur when the measured value is lower than background (see Appendix B for description).
To convert values from pCi to Bq, divide by 27.03.
(a) The drinking water standard was changed from 50 pCi/L (concentration based) to 4 mrem/yr (dose based) in 2003. As gross beta activity does not identify specific radionuclides, a dose equivalent of this value cannot be calculated.
MDL = minimum detection limit
SDWA = Safe Drinking Water Act

Table 5-3. Water Quality Data for BNL On-Site Recharge Basins.

ANALYTE		Recharge Basin: HN (RHIC)	HO* (AGS)	HS (s)	HT-W (Linac)	HT-E (AGS/HFBR)	HW (s)	CSF (s)	HZ* (s)	NYSDEC Effluent Standard	Typical MDL
	No. of samples	2	2	2	2	2	2	2	2		
pH (SU)	*min.*	7.1	7.2	6.9	7.5	7.2	6.7	8.0	7.1	6.5 - 8.5	NA
	max.	7.6	7.6	7.6	8.1	8.1	7.8	8.2	7.3		
Conductivity (µS/cm)	*min.*	128	196	370	240	158	17	124	115	SNS	NA
	max.	443	405	446	441	1110	145	124	460		
	avg.	285.5	300.5	408	340.5	634	81	124	287.5		
Temperature (ºC)	*min.*	11.1	16.1	11.5	14.6	10.1	8.04	10.43	15.1	SNS	NA
	max.	22.1	25.7	20.9	22.9	22.1	24.1	26.3	23.8		
	avg.	16.6	20.9	16.2	18.8	16.1	16.1	18.4	19.5		
Dissolved oxygen (mg/L)	*min.*	7.3	8.3	8.1	8.0	7.2	8.3	7.9	8.7	SNS	NA
	max.	11.4	9.9	12.0	9.5	11.7	12.2	11.6	10.3		
	avg.	9.4	9.1	10.1	8.7	9.5	10.2	9.8	9.5		
Chlorides (mg/L)	*min.*	22	35	64	37	23	0.52	12	15	500	5.1
	max.	81	80	79	83	150	29	13	81		
	avg.	51.5	57.5	71.5	60.0	86.5	14.8	12.5	48.0		
Sulfates (mg/L)	*min.*	3.3	8.2	7.7	8.3	4.0	0.7	1.5	3.2	500	1.1
	max.	13.0	11.0	8.9	12.0	29.0	1.7	6.8	11.0		
	avg.	8.2	9.6	8.3	10.2	16.5	1.2	4.2	7.1		
Nitrate as nitrogen (mg/L)	*min.*	0.1	-	0.5	0.2	0.1	0.4	0.2	-	10	0.1
	max.	0.9	0.7	0.6	0.8	1.7	0.5	0.9	0.6		
	avg.	0.5	-	0.5	0.5	0.9	0.5	0.5	-		

Notes:
See Figure 5-3 for recharge basin/outfall locations.
NA = not applicable
(s) = stormwater
NYSDEC = New York State Department of Environmental Conservation
* = only 1 sample taken for Nitrate as Nitrogen
AGS = Alternating Gradient Synchrotron
RHIC = Relativistic Heavy Ion Collider
Linac = Linear Accelerator
SNS = effluent standard not specified

- Basin HO receives cooling water discharges from the AGS and stormwater runoff from the area surrounding the High Flux Beam Reactor (HFBR).

Several other recharge areas are used exclusively for discharging stormwater runoff. These areas include Basin HW near the National Synchrotron Light Source II (NSLS-II) site, Basin CSF at the Central Steam Facility (CSF), Basin HW-M at the former Hazardous Waste Management Facility (FHWMF), and Basin HZ near Building 902. Recharge Basins HP and RAV are used for discharge of treated water from the groundwater remediation systems and are monitored under BNL's Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) equivalency permits.

Each of the recharge basins is a permitted point-source discharge under the Laboratory's SPDES permit and equivalency permits under the CERCLA program. Where required by the permit, the basins are equipped with a flow monitoring station, allowing for weekly recordings of flow rates. The specifics of the SPDES compliance monitoring program are provided in Chapter 3. To supplement the monitoring program, samples are also routinely collected and analyzed under BNL's Environmental Surveillance Program for radioactivity, VOCs, metals, and anions. During 2020, water samples were collected from all the basins listed

Table 5-4. Metals Analysis of Water Samples from BNL On-Site Recharge Basins.

METAL		Recharge Basin: HO (AGS)		HT-E (AGS)		HT-W (Linac)		HZ (stormwater)		NYSDEC Effluent Limit or AWQS	Typical MDL
Total (T) or Filtered (F)		T	F	T	F	T	F	T	F		
No. of samples		2	2	2	2	2	2	2	2		
Ag Silver (µg/L)	*min.*	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	50	2
	max.	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0		
	avg.	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0		
Al Aluminum (µg/L)	*min.*	< 50.0	< 50.0	100	< 50.0	< 50.0	< 50.0	< 50.0	< 50.0	2000	50
	max.	50.0	50.0	450	< 50.0	< 50.0	< 50.0	50.0	76.0		
	avg.	< 50.0	< 50.0	275	< 50.0	< 50.0	< 50.0	< 50.0	63.0		
As Arsenic (µg/L)	*min.*	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	50	5
	max.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
Ba Barium (µg/L)	*min.*	17.0	18.0	10.0	8.3	18.0	18.0	7.1	6.5	2000	1
	max.	48.0	46.0	67.0	67.0	50.0	49.0	36.0	35.0		
	avg.	32.5	32.0	38.5	37.7	34.0	33.5	21.6	20.8		
Be Beryllium (µg/L)	*min.*	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	SNS	2
	max.	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0		
	avg.	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0		
Cd Cadmium (µg/L)	*min.*	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	10	2
	max.	< 2.0	2.0	2.0	< 2.0	< 2.0	< 2.0	< 2.0	2.0		
	avg.	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0		
Co Cobalt (µg/L)	*min.*	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	5	5
	max.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
Cr Chromium (µg/L)	*min.*	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	100	10
	max.	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0		
	avg.	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0		
Cu Copper (µg/L)	*min.*	< 10.0	< 10.0	22.0	16.0	< 10.0	< 10.0	< 10.0	< 10.0	1000	10
	max.	< 10.0	31.0	27.0	81.0	25.0	59.0	54.0	43.0		
	avg.	< 10.0	20.5	24.5	48.5	17.5	34.5	28.8	22.8		
Fe Iron (mg/L)	*min.*	< 0.05	< 0.1	0.3	< 0.05	< 0.05	< 0.1	< 0.05	< 0.05	0.6	0.05
	max.	< 0.05	0.1	0.4	0.1	0.1	< 0.1	0.1	0.1		
	avg.	< 0.05	0.1	0.4	0.1	< 0.05	< 0.05	0.1	< 0.05		
Hg Mercury (µg/L)	*min.*	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	1.4	0.2
	max.	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2		
	avg.	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2		
Mn Manganese (µg/L)	*min.*	< 4.0	< 4.0	12.0	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	600	4
	max.	< 4.0	4.0	20.0	11.0	< 4.0	4.0	7.9	10.0		
	avg.	< 4.0	< 4.0	16.0	6.4	< 4.0	< 4.0	4.9	7.0		

(continued on next page)

Table 5-4. Metals Analysis of Water Samples from BNL On-Site Recharge Basins *(concluded).*

METAL		Recharge Basin: HO (AGS)		HT-E (AGS)		HT-W (Linac)		HZ (stormwater)		NYSDEC Effluent Limit or AWQS	Typical MDL
	Total (T) or Filtered (F)	T	F	T	F	T	F	T	F		
	No. of samples	2	2	2	2	2	2	2	2		
Na Sodium (mg/L)	*min.*	22.0	23.0	21.0	21.0	24.0	24.0	10.0	10.0	SNS	0.1
	max.	61.0	61.0	170.0	170.0	67.0	67.0	62.0	61.0		
	avg.	41.5	42.0	95.5	95.5	45.5	45.5	36.0	35.5		
Ni Nickel (µg/L)	*min.*	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	200	10
	max.	< 10.0	< 10.0	10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0		
	avg.	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0		
Pb Lead (µg/L)	*min.*	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	50	3
	max.	< 3.0	3.0	< 3.0	3.6	3.0	3.0	15.0	8.8		
	avg.	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	9.0	5.9		
Sb Antimony (µg/L)	*min.*	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	6	5
	max.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
Se Selenium (µg/L)	*min.*	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	20	5
	max.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
Tl Thallium (µg/L)	*min.*	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	SNS	5
	max.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
V Vanadium (µg/L)	*min.*	< 6.0	< 6.0	< 6.0	< 6.0	< 6.0	< 6.0	< 6.0	< 6.0	SNS	6
	max.	< 6.0	< 6.0	< 6.0	< 6.0	< 6.0	< 6.0	< 6.0	< 6.0		
	avg.	< 6.0	< 6.0	< 6.0	< 6.0	< 6.0	< 6.0	< 6.0	< 6.0		
Zn Zinc (µg/L)	*min.*	< 20.0	< 20.0	35.0	< 20.0	< 20.0	< 20.0	34.0	33.0	5000	20
	max.	< 20.0	26.0	51.0	79.0	49.0	71.0	66.0	78.0		
	avg.	< 20.0	23.0	43.0	49.0	31.5	41.0	50.0	55.5		

Notes:
See Figure 5-3 for recharge basin/outfall locations.
AGS = Alternating Gradient Synchrotron
AWQS = Ambient Water Quality Standards
Linac = Linear Accelerator

above semi-annually except for recharge Basin HX at the Water Treatment Plant (due to previously documented non-impact to groundwater from plant operations) and a recharge basin at the FHWMF (due to absence of operations at the FHWMF that could lead to the contamination of runoff).

5.4.1 Recharge Basins – Radiological Analyses

Discharges to the recharge basins were sampled semi-annually and analyzed for gross alpha and beta activity, gamma-emitting radionuclides, and tritium. The results are presented in Table 5-2. Gross alpha activity ranged from non-detect to 4.04 ± 1.66 pCi/L and gross beta activity ranged from non-detect to 9.01 ± 1.6 pCi/L. Low-level detections of beta activity are attributable to naturally occurring radionuclides, such as potassium-40 (K-40: half-life, 1.3E+09 years). No gamma-emitting nuclides attributable

Table 5-5. Radiological Results for Surface Water Samples Collected Along the Peconic and Carmans Rivers.

Sampling Station		Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Tritium (pCi/L)	Strontium-90 (pCi/L)
HY (headwaters) on site, west of the RHIC ring	*N*	1	1	1	1
	max	< 1.29	1.47±0.66	< 368	< 0.69
	avg	NA	NA	NA	NA
HV (headwaters) on site, inside the RHIC ring	*N*	1	1	1	NS
	max	< 1.35	2.43±0.72	< 363	-
	avg	NA	NA	NA	-
HM-S tributary, on-site	*N*	1	1	1	1
	max	< 1.31	1.06±0.57	< 368	< 0.75
	avg	NA	NA	NA	NA
HQ BNL site boundary	*N*	1	1	1	1
	max	< 1.26	1.74±0.73	< 375	< 0.61
	avg	NA	NA	NA	NA
Carmans River HH control location, off site	*N*	2	2	2	2
	max	< 1.35	1.35 ± 0.57	1060 ± 486	< 0.51
	avg	< 1.34	0.86 ± 0.8	527.75 ± 517.91	<0.42
SDWA Limit (pCi/L)		**15**	**(a)**	**20,000**	**8**

Notes:
See Figure 5-1 sampling station locations.
All values reported with a 95% confidence interval.
To convert values from pCi to Bq, divide by 27.03.
MDL = minimum detection limit
N = number of samples analyzed
NA = not applicable
NS = not sampled due to dry conditions
RHIC = Relativistic Heavy Ion Collider
SDWA = Safe Drinking Water Act
STP = Sewage Treatment Plant
(a) The drinking water standard was changed from 50 pCi/L (concentration based) to 4 mrem/yr (dose based) in 2003. Because gross beta activity does not identify specific radionuclides, a dose equivalent cannot be calculated for the values in the table.

to BNL operations or tritium were detected in any discharges to recharge basins. All tritium values were below the MDL's and were well below the 20,000 pCi/L drinking water standard.

5.4.2 Recharge Basins – Nonradiological Analyses

During 2020, discharge samples were collected semi-annually for water quality parameters, metals, and VOCs. Field-measured parameters (e.g, pH, conductivity, and temperature) were routinely monitored and recorded. The water quality and metals analytical results are summarized in Tables 5-3 and 5-4, respectively. The nonradiological analytical results are compared to groundwater discharge standards promulgated under Title 6 of the New York Codes, Rules, and Regulations (NYCRR), Part 703.6.

Low concentrations of disinfection byproducts were periodically detected above the MDL's in discharges to several of the basins throughout the year. Sodium hypochlorite and bromine, used to control bacteria in the drinking water and algae in cooling towers, can break down to bromoform, chloroform, dibromochloromethane, and dichlorobromomethane. Concentrations were above the 1 ug/L MDL at Basins HO, HT-E, HT-W, and HN for all disinfection byproducts, the highest values all being under 9.5 ug/L, which was the highest value recorded for bromoform. The only other VOCs detected above MDL's was acetone, which was detected in CSF Basin during August 2020 at a concentration of 22 ug/L, about twice the MDL of 10 ug/L.

The analytical data presented in Table 5-3 show that, for 2020, the concentrations of all analytes were within effluent standards, including chlorides. Historically, chlorides are found to be higher in samples collected during the winter and are attributed to road salt used to control snow and ice buildup. The mild conditions during winter months in 2020 resulted in lower salt use. The

Table 5-6. Water Quality Analytical Results for Surface Water Samples Collected Along the Peconic and Carmans Rivers.

Analyte		Peconic River Station Locations HY	HM-S	HQ	Carmans River HH (Control)	NYSDEC Effluent Standard	Typical MDL
	No. of samples	1	1	1	2		
pH (SU)	*min.*	-	-	-	7.1	6.5 - 8.5	NA
	max.	5.1	4.2	7.6	7.6		
Conductivity (µS/cm)	*min.*	-	-	-	236	SNS	NA
	max.	55	61	156	245		
	avg.	-	-	-	241		
Temperature (°C)	*min.*	-	-	-	10.7	SNS	NA
	max.	6.9	7.7	15.9	19.1		
	avg.	-	-	-	14.9		
Dissolved oxygen (mg/L)	*min.*	-	-	-	8.1	SNS	NA
	max.	10.8	10.3	10.7	11.2		
	avg.	-	-	-	9.7		
Chlorides (mg/L)	*min.*	-	-	-	41.0	250	1.7
	max.	7.8	4.7	25	44.0		
	avg.	-	-	-	42.5		
Sulfate (mg/L)	*min.*	-	-	-	11.0	250	0.8
	max.	2.4	2	5.6	13.0		
	avg.	-	-	-	12.0		
Nitrate as nitrogen (mg/L)	*min.*	-	-	-	1.8	10	0.1
	max.	0.1	0.1	0.1	2.2		
	avg.	-	-	-	2.0		

Notes:
See Figure 5-1 for monitoring locations.
HY = Peconic River headwaters, on site, east of Wm Floyd Pkwy.
HQ = Peconic River on site at east boundary
HM-S = Peconic River tributary at east firebreak
HH = Carmans River control location, off site
NYSDEC = New York State Department of Environmental Conservation
SNS = effluent standard not specified

data in Table 5-4 show that all parameters complied with the respective water quality or groundwater discharge standards.

5.4.3 Stormwater Assessment

All recharge basins receive stormwater runoff. Stormwater at BNL is managed by collecting runoff from paved surfaces, roofs, and other impermeable surfaces and directing it to recharge basins via underground piping and above-grade vegetated swales. Recharge Basin HS receives most of the stormwater runoff from the central, developed portion of the Laboratory site. Basins HN, HZ, HT-W, and HT-E receive runoff from the Collider-Accelerator complex. Basin HO receives runoff from the area surrounding the HFBR. Basin CSF receives runoff from the CSF area and along Cornell Avenue east of Renaissance Road. Basin HW receives runoff from the NSLS-II site, and HW-M receives runoff from the fenced area at the FHWMF.

Stormwater runoff at the Laboratory typically has elevated levels of inorganics (i.e., metals) and has a low pH. The inorganics are attributable to high sediment content in stormwater (inorganics occur naturally in native soil). In an effort to further improve the quality of stormwater runoff on site, BNL has formal procedures for managing and maintaining outdoor work and storage areas. The

Table 5-7: Metals Analytical Results for Surface Water Samples Collected Along the Peconic and Carmans Rivers.

METAL		Peconic River Locations						Carmans River HH (Control)		NYSDEC AWQS (a)	Typical MDL
		HY		HM-S		HQ					
	Total (T) or Dissolved (D)	T	D	T	D	T	D	T	D		
	No. of samples	2	2	1	1	3	3	2	2		
Ag (I) Silver (µg/L)	*min.*	-	-	-	-	-	-	< 2.0	< 2.0	0.1	2
	max.	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0		
	avg.	-	-	-	-	-	-	< 2.0	< 2.0		
Al (I) Aluminum (µg/L)	*min.*	-	-	-	-	-	-	47.0	< 50.0	100	50
	max.	580	610	850	820	< 50.0	< 50.0	50.0	< 50.0		
	avg.	-	-	-	-	-	-	< 50.0	< 50.0		
As (D) Arsenic (µg/L)	*min.*	-	-	-	-	-	-	< 5.0	< 5.0	150	5
	max.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	-	-	-	-	-	-	< 5.0	< 5.0		
Ba Barium (µg/L)	*min.*	-	-	-	-	-	-	37.0	40.0	SNS	20
	max.	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	39.0	42.0		
	avg.	-	-	-	-	-	-	38.0	41.0		
Be (AS) Beryllium (µg/L)	*min.*	-	-	-	-	-	-	< 2.3	< 2.3	11	2.3
	max.	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	5.0		
	avg.	-	-	-	-	-	-	< 2	< 3.5		
Cd (D) Cadmium (µg/L)	*min.*	-	-	-	-	-	-	< 2.0	< 2.0	1.1	2
	max.	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0		
	avg.	-	-	-	-	-	-	< 2.0	< 2.0		
Co (AS) Cobalt (µg/L)	*min.*	-	-	-	-	-	-	< 5.0	< 5.0	5	5
	max.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	-	-	-	-	-	-	< 5.0	< 5.0		
Cr (I) Chromium (µg/L)	*min.*	-	-	-	-	-	-	< 10.0	< 10.0	34	10
	max.	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0		
	avg.	-	-	-	-	-	-	< 10.0	< 10.0		
Cu (D) Copper (µg/L)	*min.*	-	-	-	-	-	-	< 10.0	< 10.0	4	10
	max.	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0		
	avg.	-	-	-	-	-	-	< 10.0	< 10.0		
Fe (AS) Iron (mg/L)	*min.*	-	-	-	-	-	-	0.3	0.1	0.3	0.05
	max.	0.3	0.2	0.3	0.3	0.2	0.1	0.4	0.2		
	avg.	-	-	-	-	-	-	0.4	0.2		
Hg (D) Mercury (µg/L)	*min.*	-	-	-	-	-	-	< 0.2	< 0.2	0.2	0.2
	max.	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2		
	avg.	-	-	-	-	-	-	< 0.2	< 0.2		
Mn Manganese (µg/L)	*min.*	-	-	-	-	-	-	54	52	SNS	4
	max.	36	39	17	23	4.9	< 4.0	110	110		
	avg.	-	-	-	-	-	-	82	81		
Na Sodium (mg/L)	*min.*	-	-	-	-	-	-	26	27	SNS	0.25
	max.	5.2	6.3	3.2	4.6	18	18	27	27		
	avg.	-	-	-	-	-	-	26.5	27		

(continued on next page)

Table 5-7: Metals Analytical Results for Surface Water Samples Collected Along the Peconic and Carmans Rivers *(concluded).*

METAL		Peconic River Locations						Carmans River HH (Control)		NYSDEC AWQS (a)	Typical MDL
		HY		HM-S		HQ					
	Total (T) or Dissolved (D)	T	D	T	D	T	D	T	D		
	No. of samples	2	2	1	1	3	3	2	2		
Ni (D) Nickel (µg/L)	*min.*	-	-	-	-	-	-	< 10.0	< 10.0	23	10
	max.	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0		
	avg.	-	-	-	-	-	-	< 10.0	< 10.0		
Pb (D) Lead (µg/L)	*min.*	-	-	-	-	-	-	< 3.0	< 3.0	0.1	3
	max.	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0		
	avg.	-	-	-	-	-	-	< 3.0	< 3.0		
Sb Antimony (µg/L)	*min.*	-	-	-	-	-	-	< 5.0	< 5.0	SNS	5
	max.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	-	-	-	-	-	-	< 5.0	< 5.0		
Se (D) Selenium (µg/L)	*min.*	-	-	-	-	-	-	< 5.0	< 5.0	4.6	5
	max.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	-	-	-	-	-	-	< 5.0	< 5.0		
Tl (AS) Thallium (µg/L)	*min.*	-	-	-	-	-	-	< 5.0	< 5.0	8	5
	max.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	-	-	-	-	-	-	< 5.0	< 5.0		
V (AS) Vanadium (µg/L)	*min.*	-	-	-	-	-	-	< 5.0	< 5.0	14	5
	max.	< 7.0	< 7.0	< 7.0	< 7.0	< 7.0	< 7.0	< 7.0	< 7.0		
	avg.	-	-	-	-	-	-	< 7.0	< 7.0		
Zn (D) Zinc (µg/L)	*min.*	-	-	-	-	-	-	< 20.0	< 20.0	37	20
	max.	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0		
	avg.	-	-	-	-	-	-	< 20.0	< 20.0		

Notes:
See Figure 5-1 sampling station locations.
AWQS = Ambient Water Quality Standards
AS = Acid Soluble
SNS = effluent standard not specified for these elements in Class C surface waters
(a) NYS AWQS for Class C surface waters

requirements include covering of equipment and materials (e.g., road salt storage and bins/containers with potential to leak residual oils or any other hazardous materials) to prevent contact with stormwater, conducting an aggressive maintenance and inspection program, implementing erosion control measures during soil disturbance activities, and restoring these areas when operations cease.

Basin sediment sampling is conducted on a five-year testing cycle to ensure these discharges comply with regulatory requirements. Basin sediments were last sampled in 2017 and data were presented in Chapter 6 of the 2017 SER. The next sampling event will occur in 2022.

5.5 PECONIC RIVER SURVEILLANCE

Several locations are monitored along the Peconic River to assess the overall water quality of the river and assess any impact from BNL operations. Sampling points along the Peconic River are identified in Figure 5-1. In total, four stations (two upstream and two downstream of the former STP discharge) were sampled in 2020. A sampling station along the Carmans River (HH) was also monitored as a geographic control location not affected by Laboratory operations or located within the Peconic River watershed. The following locations were monitored for radiological and nonradiological parameters:

Upstream sampling station:

- HY, on site, immediately east of William Floyd Parkway
- HV, on site, just east of the 10 o'clock experimental hall in the RHIC Ring, radiological only

Downstream sampling stations:

- HM-S, on site, at east firebreak south of mainstem of Peconic
- HQ, on site, at east boundary of BNL

Control location:

- HH, Carmans River

5.5.1 Peconic River – Radiological Analyses

During 2020, radionuclide analyses were performed on surface water samples collected from the four Peconic River sampling locations and the Carmans River control location. HM-N, located at the east firebreak, was removed from sampling as HY and HV allow for radiological assessment of potential RHIC impacts and no other contributions from potential BNL operations enter the river until the tributary monitoring at HM-S. HQ sampling station is the final monitoring location before the river flows off site.

In 2020, the Peconic River water levels continued to recede from 2019 levels. Due to absence of flow, only one sample was obtained from Peconic River locations in 2020. The radiological data from Peconic River surface water samples are summarized in Table 5-5. Radiological analysis of water samples collected from all locations had very low concentrations of gross beta activity that were attributed to natural sources. All detected levels were below the applicable NYS DWS. No gamma-emitting radionuclides attributable to Laboratory operations were detected, and neither tritium nor Sr-90 was detected above MDL's in any of the Peconic River samples.

5.5.2 Peconic River – Nonradiological Analyses

River water samples collected in 2020 were analyzed for water quality parameters (e.g. pH, temperature, conductivity, and dissolved oxygen), anions (e.g. chlorides, sulfates, and nitrates), metals, and VOCs. The analytical data for the Peconic River and Carmans River samples are summarized in Table 5-6 (water quality) and Table 5-7 (metals). There were no VOCs detected above the MDL's in any samples collected from the Peconic River or Carmans River stations in 2020.

Water quality parameters measured in the three Peconic River locations and the Carmans River control location (HH) show that pH, temperature, conductivity, and dissolved oxygen levels were all within applicable NYS standards.

Ambient water quality standards (AWQS) for metallic elements are based on their solubility state. Certain metals are only biologically available to aquatic organisms if they are in a dissolved or ionic state, whereas other metals are toxic in any form (i.e., dissolved and particulate combined). In 2020, the BNL monitoring program continued to assess water samples for both the dissolved and particulate form. Dissolved concentrations were determined by filtering the samples prior to acid preservation and analysis. Examination of the total (i.e., particulate form) metals data showed that aluminum and iron were present in concentrations at some locations that exceeded NYS AWQS. Aluminum was detected at concentrations exceeding the NYS AWQS at locations HY and HM-S on the Peconic River for both filtered and unfiltered samples. Iron was detected throughout the Peconic and Carmans River systems at concentrations that exceed the NYS AWQS in both the filtered and unfiltered fractions; iron and aluminum are found in high concentrations in native Long Island soil and, for iron, at high levels in groundwater. Lead at concentrations greater than the NYS AWQS was found in samples collected at station HY and HM-S on the Peconic River. Filtration of the samples reduced concentrations for some metals, but not all, suggesting that suspended sediment was responsible for some metals in the samples.

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6 Natural and Cultural Resources

The Brookhaven National Laboratory (BNL) Natural Resource Management Program is designed to protect and manage flora and fauna and the ecosystems in which they exist. The Laboratory's natural resource management strategy is based on understanding the site's resources and maintaining compliance with applicable regulations. The goals of the program include protecting and monitoring the ecosystems, conducting research, and communicating with personnel and the public on ecological issues. BNL focuses on protecting both Federal and New York State threatened and endangered species on site, as well as continuing the Laboratory's leadership role within the greater Long Island Central Pine Barrens ecosystem. Monitoring to determine whether current or historical activities are affecting natural resources is also part of the program. In 2020, deer, vegetation, and soil sampling results were consistent with previous years' results.

The overriding goal of the Cultural Resource Management Program is to ensure that proper stewardship of BNL historic resources is established and maintained. Additional goals of the program include maintaining compliance with various historic preservation and archeological laws and regulations and ensuring the availability of identified resources for research and interpretation. In 2020, 19 additional buildings were determined to be eligible for listing on the National Register of Historic Places.

6.1 NATURAL RESOURCE MANAGEMENT PROGRAM

The Natural Resource Management Program at BNL promotes stewardship of the natural resources found at the Laboratory and integrates natural resource management and protection with BNL's scientific mission. The Natural Resource Management Plan (NRMP) describes the program strategy, elements, and planned activities for managing the various natural resources found on site. The NRMP is updated every five years, with the most recent update completed in 2016 (BNL 2016).

6.1.1 Identification and Mapping

An understanding of an environmental baseline is the foundation of natural resource management planning. BNL uses digital global positioning systems (GPS) and geographic information systems (GIS) to clearly relate various "layers" of geographic information (e.g., vegetation types, soil condition, habitat, forest health, etc.). This is done to gain insight into interrelationships between the biotic systems and physical conditions at the Laboratory.

Mapping associated with tracking impacts from the operation of the Long Island Solar Farm (LISF) at BNL continues to use GPS and GIS as tools to analyze changes to wildlife populations and vegetation. In 2020, the Lab secured a contract with an aerial imaging service that provides high-definition images that are updated three times each year. This service allows tracking of visually evident changes in vegetation, hydroperiod, and infrastructure. The service includes aerial imagery dating back to 2014.

A wide variety of vegetation, birds, reptiles, amphibians, and mammals inhabit the BNL site. Through implementation of the NRMP, endangered and threatened species, as well as species of special concern, have been identified as having been resident at BNL during the past 30 years or are expected to be present on site (see Table 6-1). New York State endangered animal species confirmed as currently inhabiting Laboratory property include the eastern tiger salamander *(Ambystoma t. tigrinum)* and the peregrine falcon *(Falco peregrinus)*.

Table 6-1. Federal and New York State Threatened & Endangered Species, Species of Special Concern, & Species of Greatest Conservation Need.

Federal and New York State Threatened & Endangered Species, Species of Special Concern, & Species of Greatest Conservation Need			
Common Name	**Scientific Name**	**State Status**	**BNL Status**
Insects			
Comet darner	*Anax longipes*	SGCN	Confirmed
Frosted elfin	*Callophrys iris*	T	Likely
New England bluet	*Enallagma laterale*	SGCN	Likely
Little bluet	*Enallagma minusculum*	T	Likely
Scarlet bluet	*Enallagma pictum*	T	Likely
Pine Barrens bluet	*Enallagma recurvatum*	T	Confirmed
Mottled duskywing	*Erynnis martialis*	SC	Likely
Persius duskywing	*Erynnis persius persius*	E	Likely
Pine barrens zanclognatha	*Zanclognatha martha*	SGCN	Confirmed
Black-bordered lemon moth	*Marimatha nigrofimbria*	SGCN	Confirmed
Fish			
Banded sunfish	*Enniacanthus obesus*	T	Confirmed
Swamp darter	*Etheostoma fusiforme*	T	Confirmed
Amphibians			
Marbled salamander	*Ambystoma opacum*	SC	Confirmed
Eastern tiger salamander	*Ambystoma tigrinum tigrinum*	E	Confirmed
Fowler's toad	*Bufo fowleri*	SGCN	Confirmed
Four-toed salamander	*Hemidactylium scutatum*	SGCN	Confirmed
Eastern spadefoot toad	*Scaphiopus holbrookii*	SC	Confirmed
Reptiles			
Worm snake	*Carphophis amoenus*	SC	Confirmed
Snapping turtle	*Chelydra serpentina*	SGCN	Confirmed
Spotted turtle	*Clemmys guttata*	SC	Confirmed
Northern black racer	*Coluber constrictor*	SGCN	Confirmed
Eastern hognose snake	*Heterodon platyrhinos*	SC	Confirmed
Stinkpot turtle	*Sternotherus odoratus*	SGCN	Confirmed
Eastern box turtle	*Terrapene carolina*	SC	Confirmed
Eastern ribbon snake	*Thamnophis sauritus*	SGCN	Confirmed
Birds (nesting, transient, or potentially present)			
Cooper's hawk	*Accipiter cooperii*	SC	Confirmed
Sharp-shinned hawk	*Accipiter striatus*	SC	Confirmed
Grasshopper sparrow	*Ammodramus savannarum*	SC	Confirmed
Great egret	*Ardea alba*	SGCN	Confirmed
Whip-poor-will	*Caprimulgus vociferus*	SC	Confirmed
Northern harrier	*Circus cyaneus*	T	Confirmed
Black-billed cuckoo	*Coccyzus erythropthalmus*	SGCN	Confirmed
Northern bobwhite	*Colinus virginianus*	SGCN	Confirmed
Prairie warbler	*Setophaga discolor*	SGCN	Confirmed
Horned lark	*Eremophila alpestris*	SC	Confirmed
Perigrine Falcon	*Falco peregrinus*	E	Confirmed
Bald Eagle	*Haliaeetus leucocephalus*	T	Confirmed
Wood thrush	*Hylocichla mustelina*	SGCN	Confirmed
Red-headed woodpecker	*Melanerpes erythrocephalus*	SC	Confirmed
Osprey	*Pandion haliaetus*	SC	Confirmed
Scarlet tanager	*Piranga olivacea*	SGCN	Confirmed
Glossy ibis	*Plegadis falcinellus*	SGCN	Confirmed
Brown thrasher	*Toxostoma rufum*	SGCN	Confirmed
Blue-winged warbler	*Vermivora pinus*	SGCN	Confirmed

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Endangered plants that have been confirmed on the BNL site include Engelman spikerush *(Eleocharis engelmannii)*, Ipecac spurge *(Euphorbia ipecacuanhae)*, dwarf huckleberry *(Gaylussacia bigeloviana)*, and whorled loosestrife *(Lysimachia quadrifolia)*. Five other New York State endangered species have been identified at BNL in the past or are possibly present including: Persius duskywing *(Erynnis p. persius)*, crested fringed orchid *(Plantathera cristata)*, prostrate knotweed *(Polygonum aviculare ssp. buxiforme)*, bracken fern *(Pteridium alquilinum var. pseudocaudatum)*, and possum haw *(Viburnum nudum var. nudum)*.

Eight threatened species in New York State have been positively identified on site and three other species are considered likely to be present. Threatened species include: two fish *(banded sunfish [Enneacanthus obesus]* and swamp darter *[Etheostoma fusiforme])*; three plants (stiff-leaved goldenrod *[Oligoneuron rigida]*, stargrass *[Aletris farinosa]*, and eastern showy aster *[Eurybia spectabilis])*; the northern harrier *(Circus cyaneus)* is periodically seen in the fall; and the bald eagle *(Haliaeetus leucocephalus)* is routinely seen visiting the site. Insects listed as threatened include the Pine Barrens bluet *(Enallagma recurvatum)*, a damselfly which was confirmed at one of the many coastal plain ponds located on site. Two other damselflies, the little bluet *(Enallagma miniscultum)* and the scarlet bluet *(Enallagma pictum)*, are likely to be present at one or more of the ponds on site. The frosted elfin *(Callophrys irus)*, a butterfly, has been historically present on site due to its preferred habitat

Table 6-1. Federal and New York State Threatened & Endangered Species, Species of Special Concern, & Species of Greatest Conservation Need *(concluded).*

Federal and New York State Threatened & Endangered Species, Species of Special Concern, & Species of Greatest Conservation Need			
Common Name	**Scientific Name**	**State Status**	**BNL Status**
Mammals			
Northern long-eared bat	*Myotis septentrionalis*	FT	Confirmed
Plants			
Small-flowered false foxglove	*Agalinis paupercula*	R	Confirmed
Stargrass	*Aletris farinosa*	T	Confirmed
Butterfly weed	*Asclepias tuberosa ssp. interior*	V	Confirmed
Spotted wintergreen	*Chimaphila maculata*	V	Confirmed
Flowering dogwood	*Cornus florida*	V	Confirmed
Pink lady's slipper	*Cypripedium acaule*	V	Confirmed
Ground pine	*Dendrolycopodium obscurum*	V	Confirmed
Round-leaved sundew	*Drosera rotundifolia var. rotundifolia*	V	Confirmed
Marginal wood fern	*Dryopteris marginalis*	V	Confirmed
Engelman spikerush	*Eleocharis engelmannii*	E	Confirmed
Ipecac spurge	*Euphorbia ipecacuanhae*	E	Confirmed
Eastern showy aster	*Eurybia spectabilis*	T	Confirmed
Dwarf huckleberry	*Gaylussacia bigeloviana*	E	Confirmed
Winterberry	*Ilex verticillata*	V	Confirmed
Sheep laurel	*Kalmia angustifolia*	V	Confirmed
Narrow-leafed bush clover	*Lespedeza augustifolia*	R	Confirmed
Wild lupine	*Lupinus perennis*	R	Confirmed
Whorled loosestrife	*Lysimachia quadrifolia*	E	Confirmed
Bayberry	*Myrica pensylvanica*	V	Confirmed
Stiff-leaved goldenrod	*Oligoneuron rigida*	T	Confirmed
Cinnamon fern	*Osmunda cinnamomea*	V	Confirmed
Clayton's fern	*Osmunda claytoniana*	V	Confirmed
Royal fern	*Osmunda regalis*	V	Confirmed
Crested fringed orchid	*Plantathera cristata*	E	Likely
Green fringed orchid	*Platanthera lacera*	V	Confirmed
Prostate knotweed	*Polygonum aviculare ssp. buxiforme*	E	Possible
Bracken fern	*Pteridium alquilinum var. pseudocaudatum*	E	Possible
Swamp azalea	*Rhododendron viscosum*	V	Confirmed
Long-beaked bald-rush	*Rhynchospora scirpoides*	R	Confirmed
New York fern	*Thelypteris novaboracensis*	V	Confirmed
Marsh fern	*Thelypteris palustris var. pubescens*	V	Confirmed
Possum haw	*Viburnum nudum var. nudum*	E	Possible
Virginia chain-fern	*Woodwardia virginica*	V	Confirmed

Notes:
information based on 6 NYCRR Part 182, 6 NYCRR Part 193, and BNL survey data.
E = endangered
FE=federally endangered
FT = federally threatened
R = rate
SC = species of special concern
SGCN = species of greatest conservation need
T = threatened
V = exploitably vulnerable

and host plant, wild lupine *(Lupinus perennis)*.

A number of other species that are listed as rare, of special concern, or exploitably vulnerable by New York State either currently inhabit the site, visit during migration, or have been identified historically. BNL has one federally threatened species, the northern long-eared bat *(Myotis septentrionalis)* that is found within the forests of the Lab. The federally endangered rusty-patch bumble bee *(Bombus affinis)* has been removed from the list as no verification of its presence has occurred since a tentative identification of a single individual occurred in 2016.

6.1.2 Habitat Protection and Enhancement

BNL has administrative processes in place to protect on-site habitats and natural resources. Activities to eliminate or minimize negative effects on endangered, threatened, or sensitive species are either incorporated into Laboratory procedures or into specific program or project plans. Human access to critical habitats, when necessary, is limited, and habitats are enhanced to improve survival or increase populations. Routine activities, such as road maintenance, are not performed until the planned activities have been evaluated and determined to be unlikely to affect habitat.

6.1.2.1 Salamander Protection Efforts

Many safeguards are in place to protect eastern tiger salamander breeding areas. BNL staff must review any project planned near eastern tiger salamander habitats and every effort is made to minimize impacts. A map of the breeding areas is reviewed when new projects are proposed. The current map incorporates buffer areas around tiger salamander habitats of 1,000 feet based on guidance from NYSDEC. Other efforts to protect this state-endangered species include determining when adult salamanders are migrating toward breeding locations, when metamorphosis has been completed, and when juveniles are migrating after metamorphosis.

Water quality testing is conducted as part of the routine monitoring of recharge basins, as discussed in Chapter 5. In cooperation with NYSDEC, habitat surveys have been routinely conducted since 1999. Biologists conducting egg mass and larval surveys have confirmed that 26 on-site ponds are used by eastern tiger salamanders. In 2020, surveys were not completed due to time constraints and impacts from COVID-19.

6.1.2.2 Banded Sunfish

Banded sunfish protection efforts include observing whether adequate water is present within areas currently identified as sunfish habitat, ensuring that vegetation in their habitat is not disturbed, and evaluating all activities taking place in ponds and the Peconic River on site for potential impacts on these habitats. Drought conditions that lasted from 2015 through early 2017 likely resulted in the extirpation of the banded sunfish from the BNL site. The single known habitat held water throughout 2018 and 2019 could likely sustain sunfish. However, a short survey by NYSDEC personnel in 2019 did not find sunfish in the pond. Regionally, NYSDEC determined that only a few populations of banded sunfish survived the drought and they continue to evaluate the need for restoration efforts.

6.1.2.3 Migratory Birds

A total of 216 species of birds have been identified at BNL since 1948; at least 85 species are known to nest on site. Some of these nesting birds have shown declines in their populations nationwide over the past 30 years. The Laboratory conducts routine monitoring of songbirds along seven permanent bird survey routes in various habitats on site.

In 2020, monthly surveys were conducted starting at the end of June and extending through the end of August. Surveys in April and May were suspended due to COVID-19. These surveys identified 65 bird species, compared to the 73 species identified in 2019 and 67 species in 2018. A total of 134 bird species have been identified in surveys in the past 21 years; 59 of these species were present in each of the past 21 years. Variations in the number and species identified during each survey may reflect the time of observation, variations in weather patterns between years, and possible changes in the environment.

The three most diverse transects on site are by the LISF, the Peconic River, and the eastern edge of the BNL property. The transects passing through the various forest types on site (e.g., white pine, pine-oak forest, and red maple-mesic heath forest) showed a less diverse bird community. Bird survey data are stored in an electronic database for future reference and study. Little data on the effects of a large, utility-scale solar array such as the LISF are present within scientific literature. To assess the effects of the LISF on local bird populations, the collection of migratory bird data in both the Biology Field and Solar Farm transects is important. The LISF vegetation and the way it is managed may play a key role as habitat for migratory birds.

The eastern bluebird *(Sialia sialis)* has been identified as a declining species of migratory birds in North America. This is due to loss of habitat and nest site competition from European starlings *(Sturnus vulgaris)* and house sparrows *(Passer domesticus)*. BNL's NRMP includes habitat enhancement for the eastern bluebird.

Since 2000, the Laboratory has installed more than 60 nest boxes around open grassland areas on site to enhance their population. The LISF created nearly 200 acres of suitable habitat for the eastern blue bird. Forty boxes were installed around the northern most portions of the LISF and are routinely used by bluebirds, house wrens, and tree swallows. Bluebirds have also benefited from natural nesting habitat resulting from the 2012 wildland fire that resulted in significant tree mortality. Bluebirds have been documented within the burned area in 2019 and 2020.

In 2019, a pair of peregrine falcons *(Falco peregrinus)* successfully nested on the stack of the former High Flux Beam Reactor (HFBR). The pair took over a common raven's nest and successfully raised two chicks. While the nesting is a great success, the nesting was discouraged in 2020 to allow the demolition of the stack which is required under the Record of Decision for the Decontamination and Dismantlement of the HFBR. The falcons had been seen in various locations on site in 2020 but nesting was not documented.

Migratory birds occasionally cause safety and health concerns, particularly Canada geese *(Branta canadensis)* and several species of migratory birds that occasionally nest on buildings or in construction areas on site. To control the goose population, the Laboratory manages nesting through egg oiling under an annual permit from the U.S. Fish & Wildlife Service. In 2020, the nest management program was suspended due to restrictions associated with COVID-19. Prior to the start of nesting, the population was estimated at 105 birds; nesting success resulted in a population of approximately 150 birds by August 2020. In an attempt to get the birds to move into areas where they could be hunted, a team of USDA-Wildlife Services biologists scared geese using a radio-controlled car resulting in their leaving the site. The effort resulted in a slight reduction of geese during the September early hunting season.

6.1.2.4 Bald Eagle

The bald eagle *(Haliaeetus leucocephalus)* has been increasing in population locally on Long Island with at least ten known nest sites on the island. Bald eagles were sighted numerous times in the area of the Sewage Treatment Plant (STP) throughout the year in 2020. As the eagle population increases on Long Island, the potential for them to nest on the BNL site will increase as well.

6.1.2.5 Northern Long-eared Bat

As discussed in Section 6.1.1, the northern long-eared bat was added to the list of federally threatened species in 2015. BNL began planning for the eventual listing and put in place actions to minimize the likelihood of impacting this species. The two most likely activities that could impact this bat on the BNL site are building demolitions and prescribed fires. Inspections for the presence of bats may be conducted through either acoustic or visual surveys prior to demolition. Regardless of the outcome of acoustic monitoring (when conducted), a final internal inspection of the building(s) is conducted approximately 24 hours prior to demolition to verify the absence of bats.

For growing season prescribed fires, acoustic monitoring may be done within the burn unit to determine if there is bat activity. If positive results occur, surveys of the entire burn unit are completed to identify potential roost trees and appropriate protections are put into place to ensure that bats are not impacted by fire. In 2020, two buildings were demolished, and there was no impact to bats. No prescribed fires were conducted in 2020.

6.1.3 Population Management

In addition to controlling resident Canada goose populations described above, the Laboratory also monitors or manages other populations, including species of interest, to ensure that they are sustained and to control invasive species.

6.1.3.1 Wild Turkey

The forested areas of BNL provide ideal nesting and foraging habitat for wild turkey *(Meleagris gallapavo)*. In 2020, the on-site population continued to range between 350 and 500 birds due to successful nesting. Each year, NYSDEC manages a hunting period during the week of Thanksgiving, and a youth-only hunt in May for several areas across Long Island, which typically results in approximately 100 birds taken.

6.1.3.2 White-Tailed Deer

BNL consistently updates information on the resident population of white-tailed deer *(Odocoileus virginianus)*. As there are no natural predators on site and hunting is not permitted at the Laboratory, there are no significant pressures on the population to migrate beyond their typical home range of approximately one square mile. Normally, a population density of ten to 30 deer per square mile is considered an optimum sustainable level for a given area. This would equate to approximately 80 to 250 deer inhabiting the

BNL property under optimal circumstances. This was the approximate density in 1966, when BNL reported an estimate of 267 deer on site (Dwyer 1966). The Laboratory has been conducting routine population surveys of the white-tailed deer since 2000.

Deer overpopulation can affect animal and human health (e.g., animal starvation, Lyme disease from deer ticks, and collision injuries to both humans and animals), species diversity (e.g., songbird species reduction due to selective grazing and destruction of habitat by deer), and property damage (e.g., collision damage to autos and browsing damage to ornamental plantings). Deer-related collisions on site decreased in 2020 compared to 2019, potentially an indication of decreased population from the 2020 deer harvest as well as fewer employees onsite due to the COVID-19 pandemic.

High deer populations are a regional problem, and the Laboratory is just one area on Long Island with such an issue. Multiple east end towns are now managing deer populations either through culls (aka deer harvests), hunting, or sterilization programs. Under BNL's permit for deployment of the 4-Poster™ tick management system issued by NYSDEC, the Laboratory is required to implement a deer management program. BNL has been implementing deer management since 2015 and conducting herd reductions annually since 2018. The herd was estimated at 350 at the end of 2019 and a harvest was planned for two separate weekends between February and April 2020.

The first herd reduction conducted in March 2020 resulted in 82 animals being taken. The second reduction was planned for April 2020 but was cancelled due to COVID-19 restrictions. The removal of 82 deer effectively brought the population to approximately 275 animals. With reproduction at approximately 55 percent, the population at the end of 2020 was estimated at approximately 425 deer. Efforts were underway in December 2020 to plan for the next round of population management in 2021.

4 poster™ tick management system

6.1.4 Compliance Assurance and Potential Impact Assessment

The National Environmental Policy Act (NEPA) review process at BNL ensures that environmental impacts of a proposed action or activity are adequately evaluated and addressed. The Laboratory uses NEPA reviews when identifying potential environmental impacts associated with site activities, especially projects that may result in physical alterations to the landscape and structures. As appropriate, stakeholders such as EPA, NYSDEC, Suffolk County Department of Health Services (SCDHS), BNL's Community Advisory Council (CAC), and the Brookhaven Executive Roundtable are involved in reviewing major projects that have the potential for significant environmental impacts. Formal NEPA reviews are coordinated with the State of New York.

In January 2020, the Department of Energy (DOE) announced the award for construction of the Electron-Ion Collider at BNL. This resulted in the development of an Environmental Evaluation and Notification Form that was submitted to the Brookhaven Site Office and a determination was issued that an Environmental Assessment (EA) would be necessary. The EA was developed and presented to the CAC in September 2020 and was further developed for submission to New York State by year's end.

6.2 UPTON ECOLOGICAL AND RESEARCH RESERVE

The Upton Ecological and Research Reserve (Upton Reserve) consists of 530 acres located on the eastern boundary of the BNL site. The reserve has been designated as an area for the protection of sensitive habitats and a place where researchers can study local ecosystems.

The Upton Reserve is home to a wide variety of flora and fauna. It contains wetlands and is largely within the core preservation area of the Long Island Central Pine Barrens. Based on information from a 1994-1995 biological survey of the Laboratory, experts believe the reserve is home to more than 200 plant species and at least 162 species of mammals, birds, fish, reptiles, and amphibians (LMS 1995).

The Upton Reserve is managed by BNL which also coordinates research projects that occur within the reserve and the larger Pine Barrens. After successfully establishing a Memorandum of Understanding (MOU) with the State University of New York's School of Environmental Science and Forestry (SUNY-ESF), efforts to revisit the 2005-2006 forest health monitoring program resulted in the completion of monitoring during summer 2020 (see education programs below). The MOU with SUNY-ESF will allow for greater levels of research within the Central Pine Barrens and the Upton Reserve.

6.3 MONITORING FLORA AND FAUNA

The Laboratory routinely conducts surveillance monitoring of flora and fauna to determine the effects of past and present activities on the site. Because soil contaminated with a radioactive isotope of cesium (Cs-137) was used in some BNL landscaping projects in the past, traces of Cs-137 attributable to past practices and worldwide fallout from above-ground nuclear bomb testing can be found in deer and other animals and plants. At the cellular level, Cs-137 takes the place of potassium (K), an essential nutrient. Most tables in this chapter listing Cs-137 also list analytical results for potassium-40 (K-40), a naturally occurring radioisotope of potassium that is commonly found in flora and fauna. Studies indicate that Cs-137 out-competes potassium when potassium salts are limited in the environment, which is typical on Long Island. Including K-40 in tables allows for a comparison with Cs-137 levels and is used, in part, to determine the accuracy of analytical results. The results of the annual sampling conducted under the flora and fauna monitoring program are described in the following sections.

6.3.1 Deer Sampling

White-tailed deer in New York State are typically large, with males weighing on average approximately 150 pounds; females typically weigh approximately 100 pounds. However, white-tailed deer on Long Island tend to be much smaller, weighing an average of 80 pounds. The meat available for consumption from local deer ranges from 20 to 40 pounds per animal. Samples of meat and liver are taken from each deer, when possible, and are analyzed for Cs-137. Data are reported on a wet-weight basis, as that is the form most likely used for consumption.

Since 1996, BNL has routinely collected deer samples from on- and off-site areas. While most off-site samples are the result of car/deer accidents near the Laboratory, samples from deer taken by hunters beyond BNL boundaries or samples from car/deer accidents greater than one mile from BNL have also been made available for analysis. In 1998, a statistical analysis suggested that 40 deer from off site and 25 deer from on site are needed to achieve a statistically sound data set. The number obtained each year has not met this preferred level because sample availability depends on accidents between vehicles and deer and people reporting dead deer. In 2020, a total of 13 deer were taken both on and off the BNL site.

Figure 6-1 shows the location of all deer samples taken within a five-mile radius of the Laboratory between 2016 and 2020. Most of the off-site samples are concentrated along the William Floyd Parkway on the west boundary of BNL, whereas historically most on-site samples are collected near the Laboratory's main entrance gate and the developed portions of the site. This distribution is mainly due to people reporting dead deer on their way to work. Also, vehicle collisions with deer on site occur primarily early or late in the day, when deer are more active and traffic to and from the Lab's Main Gate is greatest.

Based on more than two decades of sampling, deer taken from more than one mile from BNL are used for comparison with populations on and near the Laboratory that could acquire Cs-137 from a BNL source. In 2020, nine deer were obtained on site, of which eight were sampled as part of deer reduction efforts, two from off-site locations within one mile of the Laboratory, and two from greater than one mile from the BNL boundary, all except those from deer reduction efforts were from car/deer accidents. The number of offsite samples in 2020 is lower than what has been provided historically largely due to a reduced number of trips by Lab personnel due to reduced staffing levels associated with COVID-19 restrictions. The analytical results of deer sampling are shown in Table 6-2. The samples taken as part of deer population reductions serve a dual purpose to provide data for surveillance and to determine the safe release of meat for consumption. Every tenth deer taken was sampled for Cs-137 content in both meat and liver.

6.3.1.1 Cesium-137 in White-Tailed Deer

Based on historic and current data, white-tailed deer sampled at or near the Laboratory contain higher concentrations of Cs-137 than deer from greater than one mile off site. This is most likely because the deer graze on vegetation growing in soil where elevated Cs-137 levels are known to exist. Cesium-137 in soil can be transferred to above-ground plant matter via root uptake, where it then becomes available to browsing and grazing animals or is consumed directly with soil while the animal is grazing. Remediation of contaminated soil areas on site occurred under the Laboratory's Comprehensive Environmental Response, Compensation & Liability Act (CERCLA) program, with all major areas of contaminated soil being remediated by September 2005.

In 2020, Cs-137 concentrations in deer meat samples were obtained from nine deer on site with a range of values from 0.02 pCi/g, wet weight, to 0.24 pCi/g, wet weight, and an arithmetic average of 0.06 pCi/g, wet weight, as shown in Table 6-2. The wet weight concentration is before a sample is dried for analysis and is the form most likely to be consumed. Dry weight concentrations are typically higher than wet weight values. The highest on-site sample in 2020 (0.24 pCi/g, wet weight) was roughly equivalent to the highest on-site sample reported in 2019 (0.28 pCi/g, wet weight) and 49 times lower than the highest level ever reported in 1996 (11.74 pCi/g, wet weight).

Cs-137 concentrations in off-site deer meat samples are typically separated into two groups: samples taken within one mile of BNL (two samples) and samples taken farther away (two samples), as shown in Table 6-2. Concentrations in meat samples taken within one mile ranged from 0.03 pCi/g, wet weight, to 0.64 pCi/g, wet weight, with an arithmetic average of 0.33 pCi/g, wet weight. Because deer on site may routinely travel up to one mile off site, the arithmetic average for deer taken on site and within one mile of the Laboratory is also calculated; for 2020, this was 0.11 pCi/g, wet weight. The two deer sampled from greater than one mile from BNL had Cs-137 concentrations of 0.01 pCi/g, wet weight, with an arithmetic average of 0.01 pCi/g, wet weight. Figure 6-2 compares the average values of Cs-137 concentrations in meat samples collected in 2020 from four different location groupings. The off-site location group within one mile of the site was higher than the onsite average due to the highest value in all samples being from a sample taken immediately offsite.

Although not shown on Figure 6-2, Cs-137 concentrations in 11 of the 13 meat samples taken both on and off site were below 0.24 pCi/g, wet weight. Figure 6-3 presents the ten-year trend of on-site and near off-site Cs-137 averages in deer meat. The 2020 average is approximately 33 percent of the 2019 value of 0.34 pCi/g, wet weight, and is the lowest average seen since trending began in 2000. The higher averages shown are reflective of a significant number of samples taken in the fall when Cs-137 levels are typically higher. However, these sample results continue to indicate the effectiveness of cleanup actions across the Laboratory, with the trend being downward from 2011 to 2020 and the ten-year average being 0.59 pCi/g.

The effectiveness of the BNL soil cleanup program and the reduction of Cs-137 in deer meat was evaluated by Rispoli, et al. (2014). The average Cs-137 content was shown to be statistically lower than before cleanup. Samples taken at distances greater than one mile from the BNL site were shown to remain consistent before and after cleanup, while the on-site and near off-site

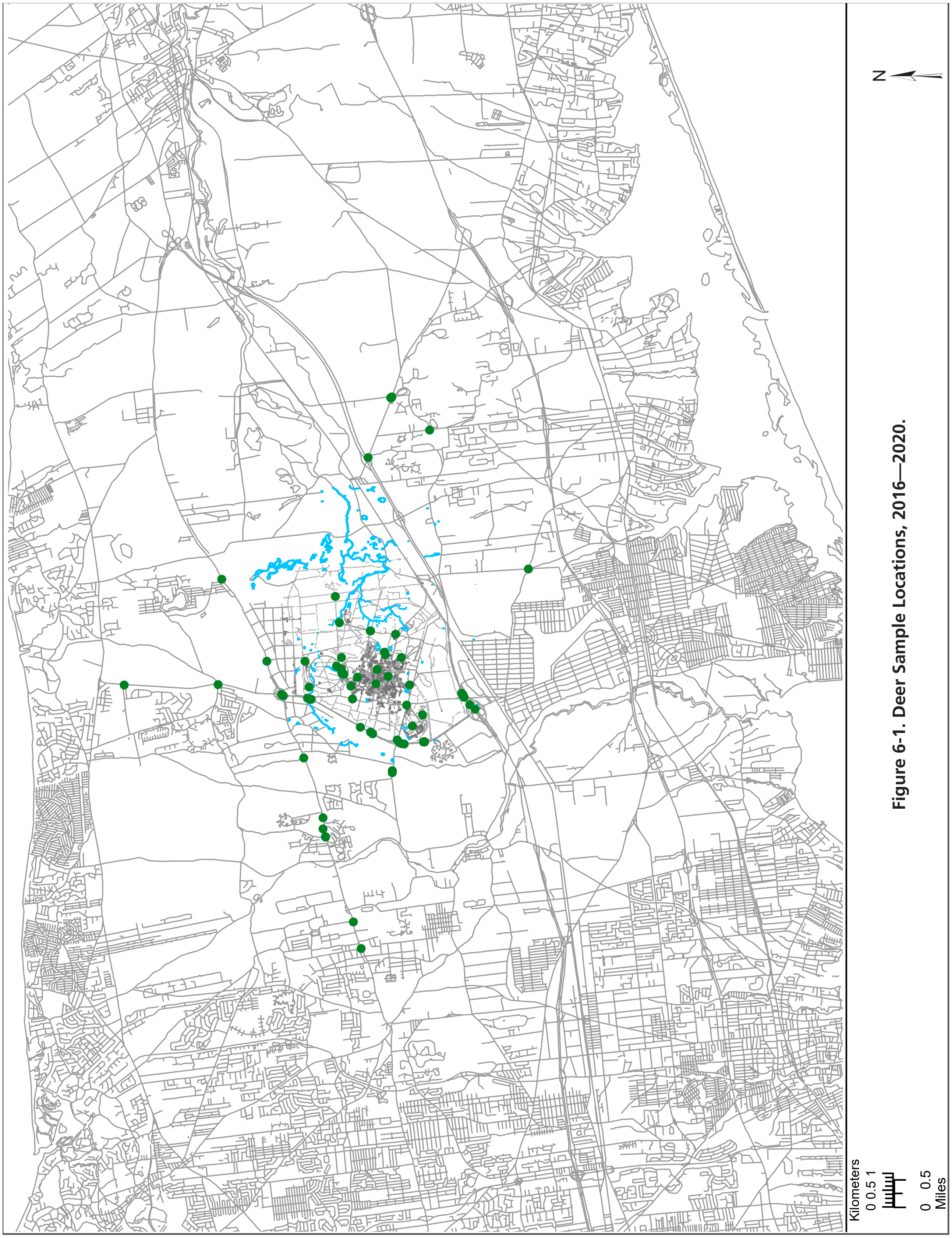


Figure 6-1. Deer Sample Locations, 2016—2020.

Table 6-2. Radiological Analyses of Deer Tissue (2020).

Sample Location	Collection Date	Tissue	K-40 pCi/g (Wet Weight)	Cs-137 pCi/g (Wet Weight)
BNL				
Forest Path 100yd west of East Firebreak	3/1/20	flesh	3.21±0.23	0.24±0.02
		liver	1.51±0.24	0.04±0.02
Cull Sample 1 Cornell Water Tower	3/6/20	flesh	2.87±0.37	0.02±0.02
		liver	1.89±0.20	ND
Cull Sample 2 1st St. and Forest Path	3/7/20	flesh	2.88±0.33	0.10±0.02
		liver	2.35±0.23	0.04±0.01
Cull Sample 3 Balloon Launch Facility	3/7/20	flesh	2.58±0.39	0.06±0.02
		liver	1.71±0.14	0.01±0.01
Cull Sample 4 Rochester & Weaver Rd.	3/7/20	flesh	2.89±0.35	0.03±0.02
		liver	1.96±0.19	0.01±0.01
Cull Sample 5 Basin HT-E	3/8/20	flesh	3.16±0.40	0.03±0.02
		liver	2.16±0.22	ND
Cull Sample 6 Bldg. 528	3/8/20	flesh	2.51±0.28	0.02±0.01
		liver*	2.20±0.17	0.01±0.01
Cull Sample 7 Former Cottage Area	3/9/20	flesh	2.62±0.28	0.06±0.01
		liver	2.52±0.18	0.01±0.01
Cull Sample 8 Upton & W 5th Ave.	3/9/20	flesh	2.62±0.33	0.03±0.02
		liver	2.40±0.15	0.01±0.01
< 1 Mile from BNL				
South Gate - LIE Service Rd.	4/1/20	flesh	2.99±0.10	0.64±0.01
		liver	1.74±0.16	0.10±0.01
WFPKY 1/2 mile south of Main Gate	11/1/20	flesh	2.99±0.18	0.03±0.01
		liver	2.03±0.20	0.02±0.01
> 1 Mile from BNL				
Middle Island, NY near Artist Lake west	2/4/20	flesh	3.64±0.22	0.01±0.01
Middle Island, NY near Artist Lake east	2/4/20	flesh*	3.36±0.19	0.01±0.00
		liver	2.60±0.20	ND
Averages by Tissue				
Flesh Averages				
All Samples (13)			2.95±1.06	0.10±0.05
BNL Average (9)			2.82±0.99	0.06±0.05
< 1 Mile Average (2)			2.99±0.21	0.33±0.01
BNL + < 1 Mile Average (11)			2.85±1.02	0.11±0.05
> 1 Mile Average (2)			3.50±0.29	0.01±0.01
Cull Average (8)			2.77±0.97	0.04±0.05
Liver Averages				
All Samples (12)			2.09±0.67	0.02±0.03
BNL Average (9)			2.08±0.58	0.02±0.03
< 1 Mile Average (2)			1.89±0.26	0.06±0.01
BNL + < 1 Mile Average (11)			2.04±0.64	0.02±0.03
> 1 Mile Average (1)			2.60±0.20	0.01±0.01
Cull Average (8)			2.15±0.53	0.01±0.02

Notes:
All values are shown with a 95% confidence interval
K-40 Occurs naturally in the environment and is presented as a comparison to Cs-137
All averages are the arithmetic average with confidence limits using a 2 sigma (95%) propogated error.
* = estimated value for Cs-137 based on laboratory qualifiers
ND = not detected

Table 6-3. Radiological analysis of grassy vegetation and associated soils.

Location/Matrix	K-40 pCi/g±95% C.I.	Cs-137 pCi/g±95% C.I.
1st St. west side, S. of East 5th Ave.		
Vegetation	3.08±1.08	ND
Soil	4.69±1.03	ND
1st St. west side, N. of East 5th Ave.		
Vegetation*	1.81±0.74	0.12±0.05
Soil	5.17±0.97	0.34±0.08
Firebreak N. of NOAA, W. of 1st St.		
Vegetation	4.97±0.80	ND
Soil*	8.64±1.14	0.20±0.06
N. side of South Firebreak E. of RR Spur		
Vegetation	3.69±0.78	ND
Soil*	7.35±1.00	0.13±0.05
West end of Brookhaven Ave.		
Vegetation*	2.99±0.59	0.04±0.04
Soil	6.36±0.79	0.22±0.04
West end of 5th Ave.		
Vegetation	1.47±0.45	ND
Soil*	5.10±1.00	0.17±0.06
West end of Middle Path		
Vegetation	2.28±0.61	ND
Soil	4.80±0.92	ND
East end of Middle Path		
Vegetation	1.82±0.85	ND
Soil*	5.65±0.93	0.09±0.06
Glass holes area		
Vegetation	0.80±0.60	ND
Soil	7.68±0.89	0.77±0.08
West of Canal leading to Basin HS		
Vegetation	4.20±0.46	ND
Soil	5.56±0.70	ND
NYSDEC Game Farm (Control)		
Vegetation	3.39±0.87	ND
Soil	5.06±0.81	ND

Notes:
All values are shown with a 95% confidence interval.
Radiological values for soils are on a 'dry weight' basis.
K-40 occurs naturally in the environment and is presented as a comparison to Cs-137.
Cs-137 = cesium-137
K-40 = potassium-40
ND = not detected
* = estimated value for Cs-137 based on laboratory qualifiers.

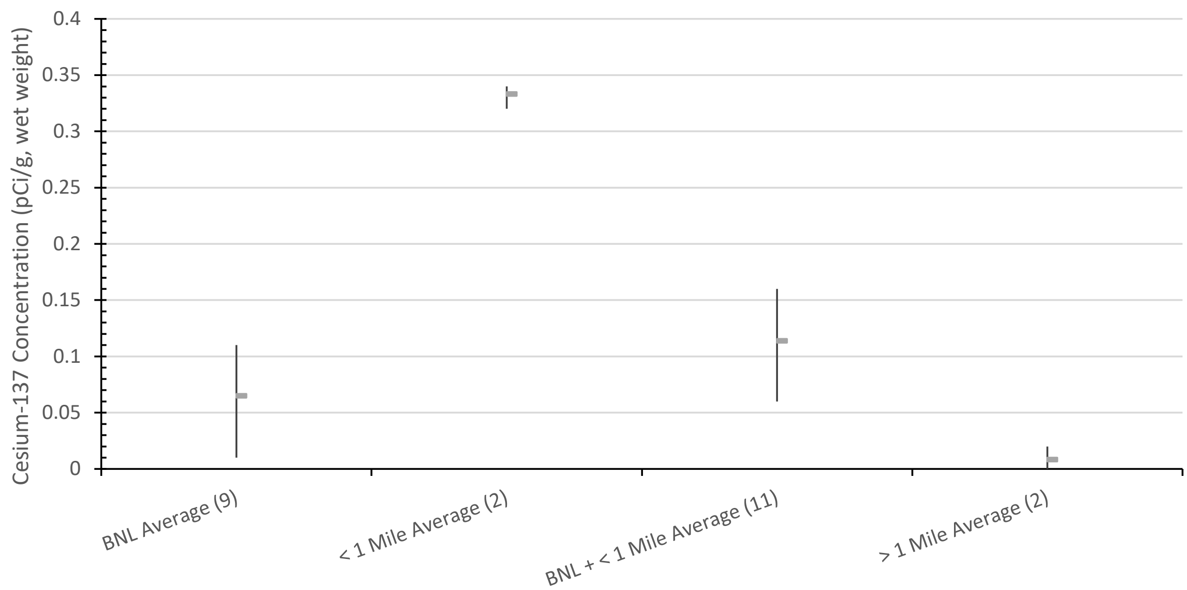
Table 6-4. Precipitation Monitoring (Mercury).

Location/Period	Mercury ng/L
P4	
1/8/20	5.75
4/8/20	7.86
7/22/20	6.31
10/14/20	4.57
S5	
1/8/20	4.76
4/8/20	7.04
7/22/20	8.37
10/14/20	5.53

Notes:
Method detection limit for mercury is 0.2 ng/L.
P4 = precipitation sampler near BNL Apartment area.
S5 = precipitation sampler near BNL Sewage Treatment Plant.

values were shown to decline. In 2017, while preparing for monitoring associated with the reduction of the deer population, the ten-year average for on-site deer samples was calculated to be 1.0 pCi/g, wet weight, and this value was used to establish an administrative release criterion for deer meat made available for donation. When possible, liver samples are taken concurrently with meat samples. The liver generally accumulates Cs-137 at a lower rate than muscle tissue. The typically lower values in liver allow the results to be used as a validity check for meat values (i.e., if liver values are higher than meat values, results can be considered questionable and should be confirmed).

In liver samples collected on site in 2020, Cs-137 concentrations ranged from non-detectable to 0.04 pCi/g, wet weight, with an average of 0.02 pCi/g, wet weight. The near off-site Cs-137 concentration in liver ranged from 0.02 pCi/g, wet weight, to 0.10 pCi/g, wet weight, with an arithmetic average for off-site liver samples within one mile of 0.06 pCi/g, wet weight. The single liver sample from deer taken greater than one mile from BNL was non-detectable for Cs-137. The potential radiological dose resulting from deer meat consumption is discussed in Chapter 8.



Notes: Ten year average of onsite and near offsite deer flesh samples is 0.59 pCi/g, wet weight.

Figure 6-2. Comparison of Cs-137 values in deer flesh for onsite, offsite within 1 mile, onsite and near offsite, and offsite greater than 1 mile from the Laboratory.

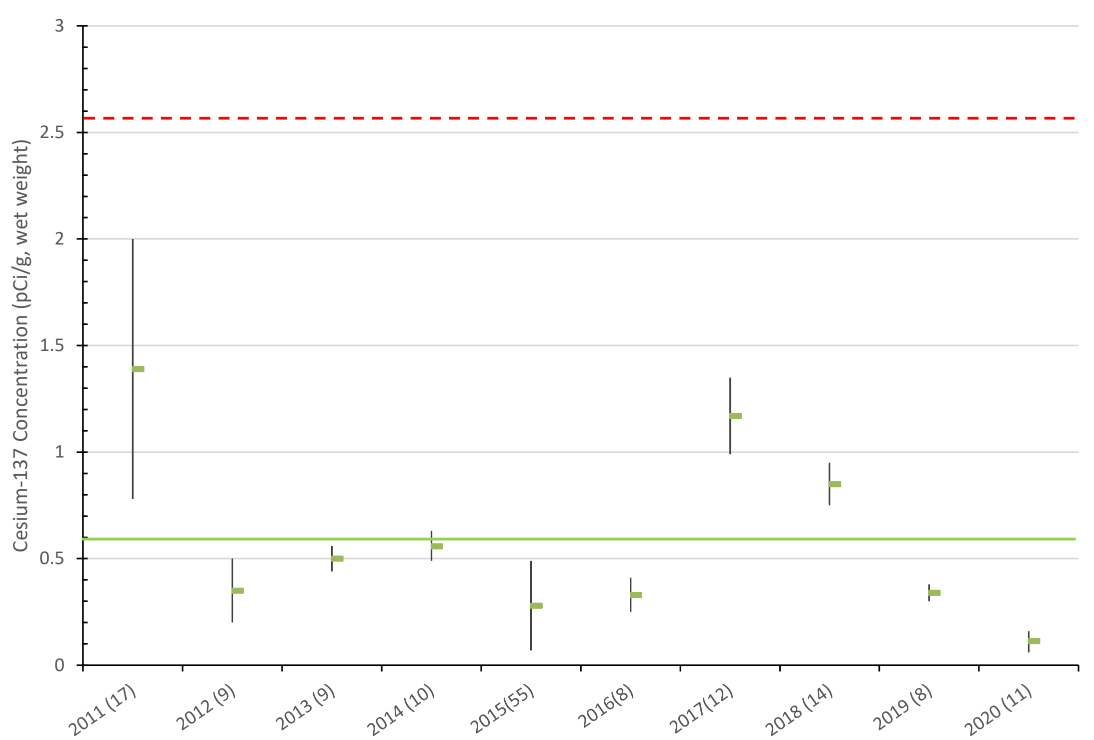


Figure 6-3. Ten year trend in Cs-137 in deer flesh for samples taken at BNL and within 1 mile of the Laboratory. Ten-year average is 0.59 pCi/g (solid line).

The New York State Department of Health (NYSDOH) has formally considered the potential public health risks associated with elevated Cs-137 levels in on-site deer and determined that neither hunting restrictions nor formal health advisories are warranted (NYSDOH 1999).

As mentioned above, BNL has established an administrative release criterion of 1.0 pCi/g, wet weight, for meat from deer removed from the Laboratory and donated for consumption. A total of 82 deer were taken during population reductions in 2020. Meat samples were obtained from every tenth deer and were sent for analysis and as mentioned above were included in Table 6-2. The results ranged from 0.02 pCi/g, wet weight, to 0.10 pCi/g, wet weight, with the arithmetic average being 0.04 pCi/g, wet weight. Since all samples were well below the 1.0 pCi/g, wet weight administrative limit, all 1,521 pounds of meat were donated to Island Harvest Food Pantry.

With respect to the health of on-site deer based on their exposure to radionuclides, the International Atomic Energy Agency (IAEA) has concluded that chronic dose rates of 100 millirad per day to even the most radiosensitive species in terrestrial ecosystems are unlikely to cause detrimental effects in animal populations (IAEA 1992). A deer containing a uniform distribution of Cs-137 within muscle tissue at the highest levels observed to date (11.74 pCi/g, wet weight, reported in 1996) would carry a total amount of approximately 0.2 µCi. That animal would receive an absorbed dose of approximately 3 millirad per day, which is only three percent of the IAEA threshold. The deer observed and sampled on site appear to have no health effects from the level of Cs-137 found in their tissues.

6.3.2 Other Animals Sampled

When other animals, such as wild turkey or Canada geese, are found dead along the roads of BNL and the immediate vicinity due to road mortality, they are tested for Cs-137. No other animals were sampled in 2020.

6.3.3 Fish Sampling

BNL maintains an ongoing program for collecting and analyzing fish from the Peconic River and surrounding freshwater bodies. Monitoring of the river has been conducted under the environmental surveillance program and the CERCLA post-cleanup program. Surveillance monitoring had occurred during even-numbered years and post-cleanup monitoring occurred in odd-numbered years. However, with the discontinuance of discharges from the STP to the Peconic River in September 2014 and current lack of flow off site, the objectives for the fish monitoring program have changed to reflect the current intermittent presence of water in the on-site portions of the river. Fish are now only sampled under the surveillance program when there is enough water to support a sufficient population of fish that can be sampled without harm to their population and that are of sufficient size for analysis.

Based upon the 2016 CERCLA Five-Year Review of the effectiveness of the environmental cleanup and the final supplemental cleanup of a small area within the river during 2017, the Laboratory has discontinued fish monitoring under the CERCLA program. However, when conditions allow, fish sampling will be conducted under the surveillance program for radionuclide, mercury, and PCB content. Analysis for radionuclides supports calculation for a dose to biota and dose to the maximally exposed off site individual. Due to lack of water and fish within the on-site portions of the Peconic River, no fish were sampled in 2020.

6.3.3.1 Fish Population Assessment

The relative sizes of fish caught during annual sampling events are tracked and modifications to future sampling events are made, as necessary, to ensure long-term health of the on-site fish populations. Successful sampling of sufficiently large fish for analysis from 2008 through 2015, even with low water levels in the on-site portion of the Peconic River, indicated that fish populations could maintain themselves. However, the combination of discontinuing STP discharges to the Peconic River results in high variability in the presence of water and flow sufficient enough to reach offsite portions of the river. In 2019, water levels began to recede, resulting in water being retained only in deeper open water areas and levels continued to recede in 2020. There was no documented offsite flow in 2020.

For fish populations to survive and flourish, water levels must be substantial enough to allow migration of fish and maintain their presence for an extended period to replenish populations. As mentioned above, new criteria for the collection of fish samples have been developed. These criteria will guide the environmental monitoring approach for fish in the future. To determine if enough fish are present to support sampling, population assessments are conducted. In 2020, a population assessment was conducted at the end of July and resulted in the capture of 51 fish composed of creek chubsucker, large-mouth bass, and bluegill sunfish. The largest fish caught had a length of 80 mm, or a little over three inches. The average length of fish was 19 mm. Since there were no fish of significant size, no samples were taken.

6.3.4 Vegetation Sampling

6.3.4.1 Grassy Plants and Soil

During 2020, grassy vegetation samples were collected from ten locations around the Laboratory (Figure 6-4) and a control location at the NYSDEC hunter check station in Ridge, New York. All samples were analyzed for Cs-137 (see Table 6-3). Cs-137 content in vegetation ranged from non-detectable to 0.12 pCi/g, wet weight. Soil samples had Cs-137 levels ranging from non-detect to 0.77 pCi/g, dry weight. All values were consistent with historic monitoring and knowledge of cleanup areas. Monitoring results for grassy vegetation and soils were utilized for the annual dose to biota analysis reported in Chapter 8.

2019 Forest Health Monitoring Team

6.4 PRECIPITATION MONITORING

6.4.1 Mercury Monitoring of Precipitation

During 2020, precipitation samples were collected quarterly at air monitoring Stations P4 and S5 (Figure 4-2 for station locations). The samples were analyzed for total mercury (Table 6-4) using low-level mercury analysis.

Mercury concentrations in precipitation have been measured at BNL since 2007. Analysis of mercury in precipitation is conducted to document mercury deposition that is attributable to off-site sources. This information has been used as a comparison to Peconic River monitoring data and aids in understanding the distribution of mercury within the Peconic River watershed.

Mercury was detected in all the precipitation samples collected at both sampling stations. Mercury ranged from 4.57 ng/L at station P4 in October to 8.37 ng/L at station S5 in July. The 8.37 ng/L concentration is 5.2 times lower than the highest value of 45.1 ng/L, recorded in 2017.

6.5 WILDLIFE PROGRAMS

BNL sponsors a variety of educational and outreach activities involving natural resources. These programs are designed to help participants understand the ecosystem, foster an interest in science, and provide a meaningful experience for interns in preparation for further studies or a career. Wildlife programs are conducted at the Laboratory in collaboration with the DOE, local agencies, colleges, and high schools. Ecological research is also conducted on site to routinely update the natural resource inventory records, gain a better understanding of the ecosystem, and guide management planning.

In 2020, due to COVID-19 restrictions, all internships were required to be conducted virtually. Due to the nature of the natural resources program, the Environmental Protection Division hosted a single intern during summer of 2020 who worked to perfect Artificial Intelligence software for sorting photos taken as part of the 4-Poster™ project for tick management.

The Forest Health Monitoring project that started in 2019 continued through collaborative efforts between SUNY-ESF in Syracuse, BNL, and the Long Island Central Pine Barrens Joint Planning and Policy Commission (Commission).

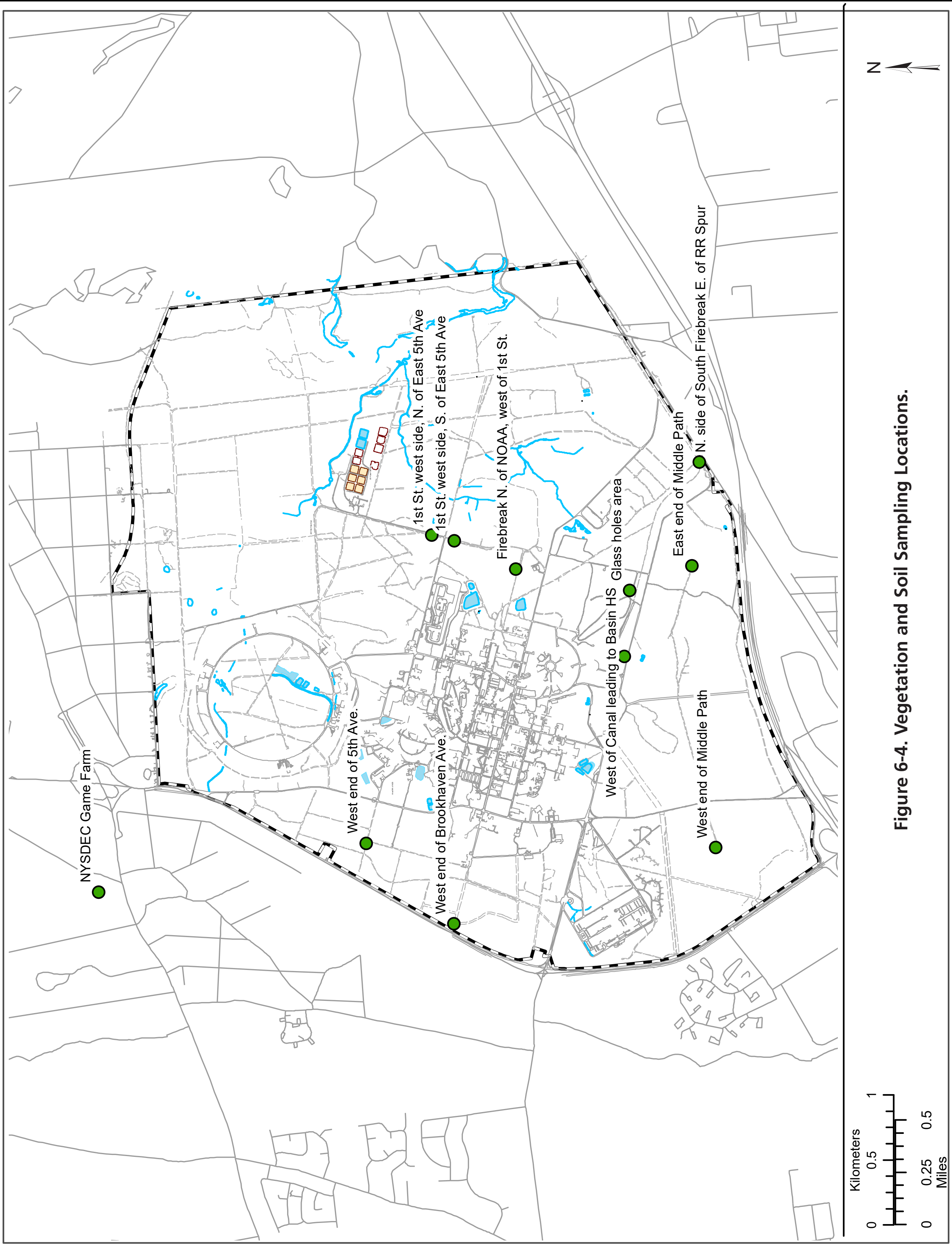


Figure 6-4. Vegetation and Soil Sampling Locations.

Because the Commission did not have the same restrictions, they were able to advertise for summer help and a few of the interns originally destined for BNL were hired and managed by Johanna Lumbsden, a SUNY-ESF Ph.D. candidate. The team was able to complete the second half of the forest health monitoring started in 2019, including the addition of new plots to gather data related to fire history. This research effort will result in several publications and award of a Ph.D. degree.

In a normal year, BNL participates in, coordinates, or hosts activities that support ecological education on Long Island. In 2020, due to restrictions associated with COVID-19, the following programs were cancelled:

- Long Island Natural History Conference
- Participation in the Pine Barrens Discovery Day
- A Day in the Life of the Rivers (student/teacher involvement in monitoring 11 Long Island rivers)
- Open Space Stewardship Program (which involves 2,500 students from 30 schools)
- NY Wildfire & Incident Management Academy

6.6 CULTURAL RESOURCE ACTIVITIES

The BNL Cultural Resource Management (CRM) Program ensures that the Laboratory fully complies with numerous cultural resource regulations. The Cultural Resource Management Plan for Brookhaven National Laboratory (BNL 2013) guides the management for all the Laboratory's historical resources. BNL's cultural resources include buildings and structures, World War I (WWI) earthwork features, the Camp Upton Historical Collection, scientific equipment, photo/audio/video archives, and institutional records. As various cultural resources are identified, plans for their long-term stewardship are developed and implemented. Achieving these goals will ensure that the contributions BNL and the site have made to local and national history and culture are documented and available for interpretation.

In 2019, the Laboratory contracted with Hartgen Archeological Associates to conduct historical architectural reviews of buildings that had recently reached 50 years of age. The contract continued into early 2020 with three reports covering the

Building 490 former Medical Complex

World War II water tower

Alternating Gradient Synchrotron (AGS) complex, Medical Complex, and several other buildings. The reports provided determinations of eligibility for the Medical Complex (Buildings 490 and 491), Buildings 820, 820A, 820B, 830, 902, and the WWII water tower, and several buildings combined within the AGS complex, including Buildings 901, 901A, 911, 912, 913, 913A through E, and 930. Several buildings were determined to not meet criteria for consideration. The reports were to be submitted to the NYSHPO in 2021.

BNL continued to negotiate an MOU with the NYSHPO on the 1960s-era apartments and came to a resolution for mitigation of their demolition. The MOU accepted all work up to the MOU including the Section 106 review and Recordation of the Structures. The final piece of the MOU addressed the development of interpretive kiosks that would describe the Apartment Complex area's history from WWI to present. Several of the initial kiosks would be placed as part of the Science User's Support Center with the remaining ones placed within the Discovery Park area as it develops. At least one of the kiosks must specifically highlight the 1960s-era apartments.

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7 Groundwater Protection

Brookhaven National Laboratory (BNL) implements aggressive pollution prevention measures to protect groundwater resources, and uses an extensive groundwater monitoring well network to verify that prevention and restoration activities are effective. During 2020, BNL collected groundwater samples from 802 permanent monitoring wells and 102 temporary wells during 1,816 individual sampling events. Seven groundwater remediation systems removed 44 pounds of volatile organic compounds (VOCs) and returned approximately 823 million gallons of treated water to the Upper Glacial aquifer. Since the beginning of active groundwater remediation in December 1996, the treatment systems have removed 7,700 pounds of VOCs by treating over 29 billion gallons of groundwater. Also, one groundwater treatment system removed approximately 0.4 millicurie of strontium-90 (Sr-90) while remediating approximately 16 million gallons of groundwater. Since 2003, BNL has removed approximately 34 millicuries of Sr-90 from the groundwater while remediating approximately 260 million gallons of groundwater. As a result of the successful operation of these treatment systems, significant reductions in contaminant concentrations have occurred in on- and off-site areas.

7.1 THE BNL GROUNDWATER PROTECTION MANAGEMENT PROGRAM

The primary goal of BNL's Groundwater Protection Program is to ensure that plans for groundwater protection, management, monitoring, and restoration are fully defined, integrated, and managed in a manner that is consistent with federal, state, and local regulations. The program helps to fulfill the environmental monitoring requirements outlined in various New York State operating permits, Department of Energy (DOE) Order 458.1, Radiation Protection of the Public and Environment, and DOE Order 436.1, Departmental Sustainability. This program also satisfies the monitoring and remediation requirements defined in Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Records of Decision (RODs). The program consists of four interconnecting elements: 1) preventing pollution of the groundwater, 2) monitoring the effectiveness of engineered and administrative controls at operating facilities, 3) restoring the environment by cleaning up contaminated soil and groundwater, and 4) communicating with stakeholders on groundwater protection issues. The Laboratory is committed to protecting groundwater resources from further chemical and radionuclide releases and remediating existing contaminated groundwater.

7.1.1 Prevention

As part of BNL's Environmental Management System, the Laboratory has implemented several pollution prevention activities that are designed to protect groundwater resources (see Chapter 2). BNL has established a work control program that requires the assessment of all experiments and industrial operations to determine their potential impact on the environment. The program enables the Laboratory to integrate pollution prevention and waste minimization, resource conservation, and compliance into planning and decision making. Efforts have been implemented to achieve or maintain compliance with regulatory requirements and to implement best management practices designed to protect groundwater (see Chapter 3). Examples include upgrading underground storage tanks, closing cesspools, adding engineered controls (e.g., barriers to prevent rainwater infiltration that could move contaminants out of the soil and into groundwater), and administrative controls (e.g., reducing the toxicity and volume of chemicals in use or storage). BNL's comprehensive groundwater monitoring program is used to confirm that these controls are working.

7.1.2 Monitoring

The Laboratory's groundwater monitoring network is designed to evaluate the impacts of groundwater contamination from former and current operations and to track cleanup progress. Each year, BNL collects groundwater samples from an extensive network of on- and off-site monitoring wells. Results from groundwater monitoring are used to verify that protection and restoration efforts are working. Groundwater monitoring is focused on two general areas: 1) Facility Monitoring, designed to satisfy DOE and New York State monitoring requirements for active research and support facilities; and 2) CERCLA monitoring related to the Laboratory's obligations under the Federal Facilities Agreement (FFA). These monitoring programs are coordinated to ensure completeness and to prevent duplication of effort in the installation, monitoring, and decommissioning of wells. The monitoring program elements include data quality objectives; plans and procedures; sampling and analysis; quality assurance; data management; and the installation, maintenance, and decommissioning of wells. These elements are integrated to create a cost-effective monitoring system and to ensure that water quality data are available for review and interpretation in a timely manner.

7.1.3 Restoration

BNL was added to the National Priorities List in 1989. To help manage the restoration effort, 32 separate Areas of Concern were grouped into six Operable Units (OUs). Remedial actions have been implemented for each OU, and the focus is currently on operating and maintaining cleanup systems. Contaminant sources (e.g., contaminated soil and underground storage tanks) have been removed or remediated to prevent further contamination of groundwater. All remediation work is carried out under the FFA involving the Environmental Protection Agency (EPA), the New York State Department of Environmental Conservation (NYSDEC), and DOE.

7.1.4 Communication

BNL's External Affairs and Stakeholder Relations Office works with the Groundwater Protection Program to ensure that the Laboratory communicates groundwater protection issues and cleanup progress with its stakeholders in a consistent, timely, and accurate manner. Several communication mechanisms are in place, such as press releases, web pages, mailings, public meetings, briefings, and roundtable discussions. Specific examples include routine meetings with the Community Advisory Council and the Brookhaven Executive Roundtable (see Chapter 2, Section 2.4.2). Quarterly and annual technical reports that summarize data, evaluations, and program indices are prepared. In addition, the Laboratory has developed a Groundwater Protection Contingency Plan (BNL 2018) that provides formal processes to promptly communicate off-normal or unusual monitoring results to BNL management, DOE, regulatory agencies, and other stakeholders, including the public and employees.

7.2 GROUNDWATER PROTECTION PERFORMANCE

BNL has made significant investments in environmental protection programs over the past 30 years and continues to make progress in achieving its goal of preventing new impacts to groundwater quality and remediating previously contaminated groundwater. The Laboratory will continue efforts to prevent new groundwater impacts and is vigilant in measuring and communicating its performance. During 2017, several Per-and Poly-fluoroalkyl Substances (PFAS) were detected in water samples collected from three BNL water supply wells. In response to these detections in 2018, BNL conducted a search of available records to determine the source of the PFAS. As a result, BNL identified eight areas where firefighting foam had been used for firefighter training or fire suppression system maintenance from 1966 through 2008. Groundwater characterization confirmed the presence of PFAS in each of the eight areas, with the highest concentrations detected near BNL's former firehouse (in operation from 1947-1985) and near the current firehouse (1986-present). In both areas, the combined concentrations of perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) significantly exceeded the current U.S. EPA Health Advisory Level (HAL) of 70 ng/L, and the 10 ng/L drinking water standards for PFOS and PFOA that were adopted by New York State in August 2020. At the former firehouse area, the maximum PFOS and PFOA concentrations detected to date in the groundwater were 5,210 ng/L and 1,400 ng/L, respectively. At the current firehouse area, the maximum PFOS and PFOA concentrations detected to date were 12,440 ng/L and 602 ng/L, respectively. In addition to PFAS, BNL has been characterizing the extent of 1,4-dioxane, which was used as a chemical stabilizer for the solvent 1,1,1-trichloroethane (TCA). BNL has confirmed the presence of 1,4-dioxane in several on-site and off-site areas that have been impacted by TCA contamination, with a maximum concentration of 23.9 µg/L in a Western South Boundary area monitoring well. The newly adopted New York State drinking water standard for 1,4-dioxane is 1.0 µg/L.

7.3 GROUNDWATER MONITORING PROGRAMS

Elements of the groundwater monitoring program include installing monitoring wells; planning and scheduling; developing and following quality assurance procedures; collecting and analyzing samples; verifying, validating, and interpreting data; and reporting. Monitoring wells are used to evaluate BNL's progress in restoring groundwater quality, comply with regulatory permit requirements, monitor active research and support facilities, and assess the quality of groundwater that enters and exits the site.

The Laboratory monitors research and support facilities where there is a potential for environmental impact, as well as areas where past waste handling practices or accidental spills have already degraded groundwater quality. The groundwater beneath the site is classified by New York State as Class GA groundwater, which is defined as a source of potable water. Federal drinking water standards (DWS), New York State DWS, and New York State Ambient Water Quality Standards for Class GA groundwater are used as goals for groundwater protection and remediation. BNL evaluates the potential impact of radiological and non-radiological contamination by comparing analytical results to the regulatory standards. Contaminant concentrations that are below the standards are also compared to background values to evaluate the potential effects of facility operations. The detection of even low concentrations of facility-specific VOCs or radionuclides may provide important early indications of a contaminant release and allow for timely identification and remediation of the source.

BNL maintains an extensive network of groundwater monitoring wells that are located on- and off-site. Water levels are routinely measured in about 170 of the wells to assess variations in the direction and velocity of groundwater flow. Groundwater flow directions near the Laboratory are shown in Figure 7-1.

The Laboratory also routinely collects groundwater samples from over 800 wells to test for various contaminants that may be in the water (see SER Volume II, Groundwater Status Report, for details).

The following active BNL facilities have groundwater monitoring programs: Sewage Treatment Plant (STP), Waste Management Facility (WMF), Major Petroleum Facility (MPF), Alternating Gradient Synchrotron (AGS), Brookhaven Linac Isotope Producer (BLIP), Relativistic Heavy Ion Collider (RHIC), National Synchrotron Light Source II (NSLS-II), and several vehicle maintenance and petroleum storage facilities. Inactive and remediated facilities are also monitored, including the former Hazardous Waste Management Facility (HWMF), two former landfill areas, former Waste Concentration Facility (WCF) area, Brookhaven Graphite Research Reactor (BGRR), High Flux Beam Reactor (HFBR), and the Brookhaven Medical Research Reactor (BMRR). Maps showing the main VOC and radionuclide plumes are provided as Figures 7-2 and 7-3, respectively.

7.4 GROUNDWATER MONITORING RESULTS

During 2020, the Facility Monitoring program monitored 104 permanent wells during 142 individual sampling events. The CERCLA groundwater monitoring program monitored 698 permanent

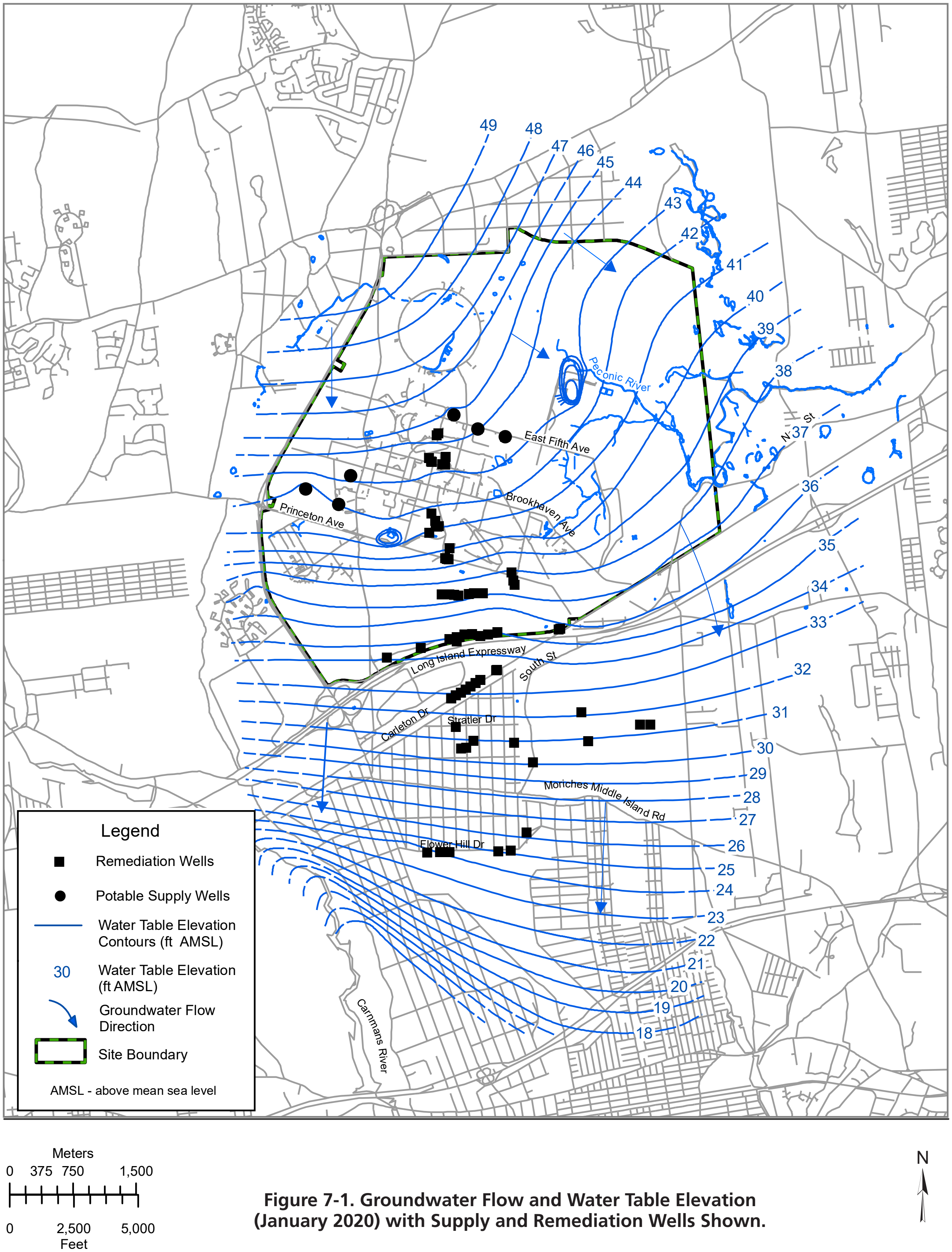

Figure 7-1. Groundwater Flow and Water Table Elevation (January 2020) with Supply and Remediation Wells Shown.

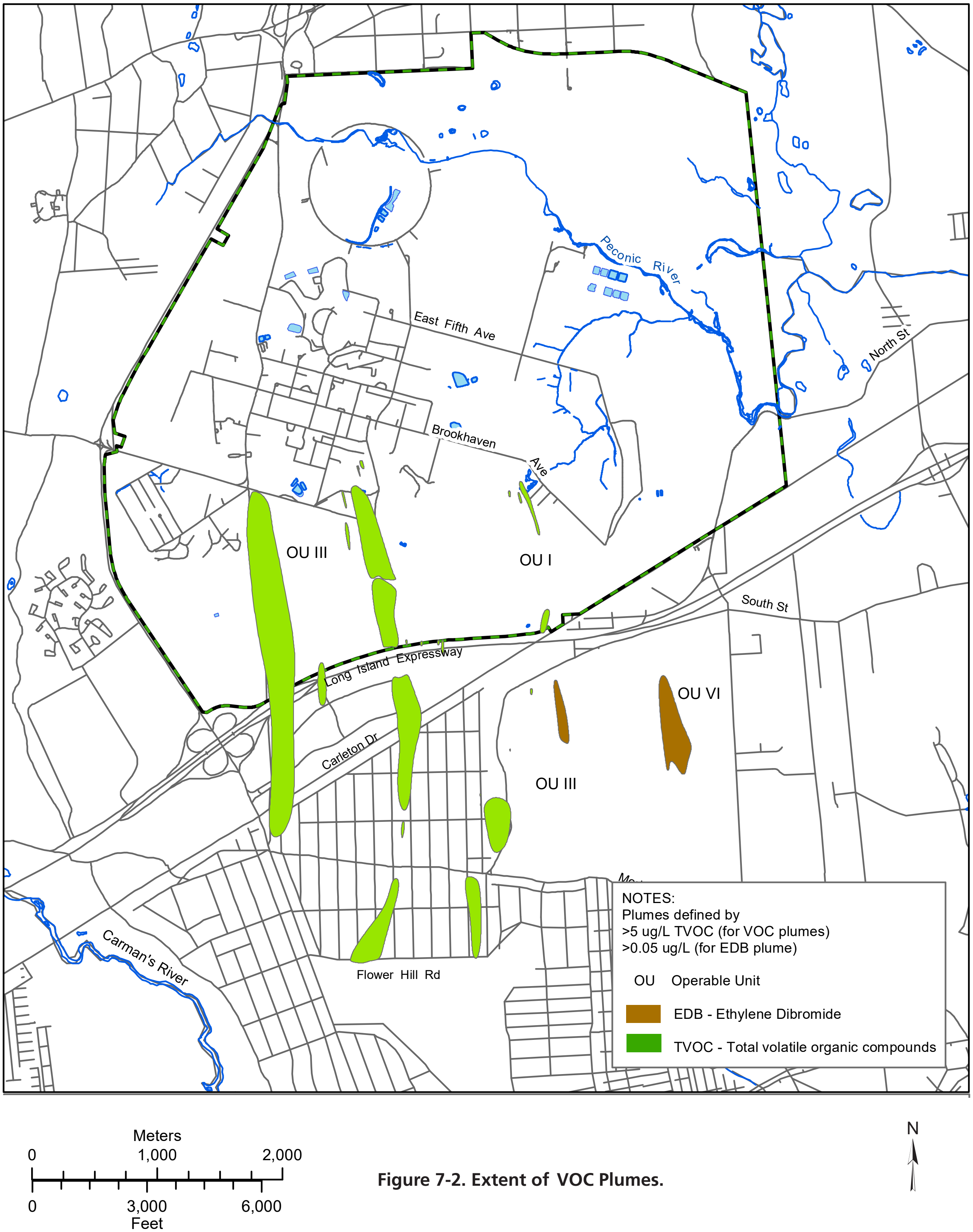

Figure 7-2. Extent of VOC Plumes.

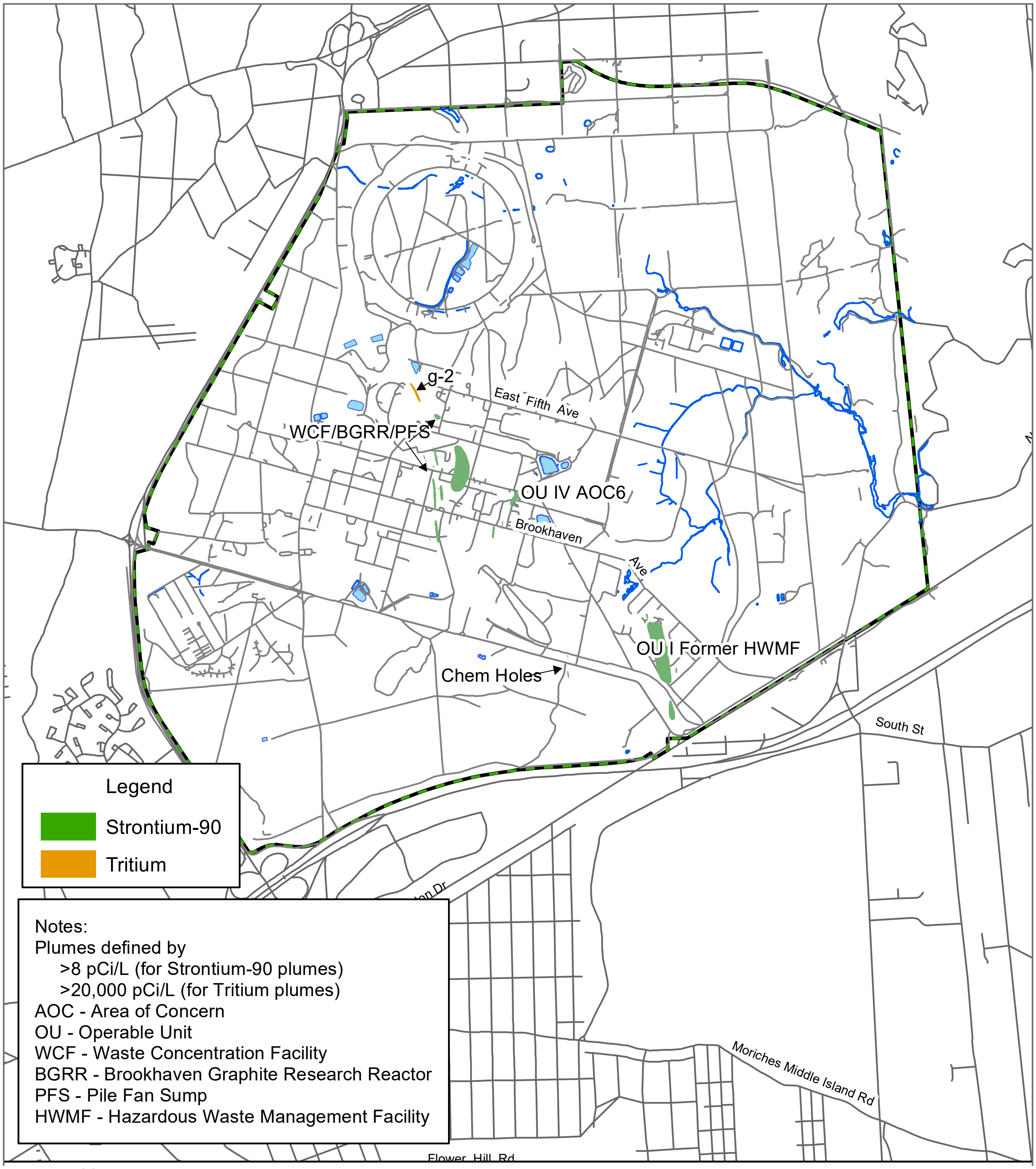

Figure 7-3. Extent of Radionuclide Plumes.

wells during 1,674 individual groundwater sampling events. One hundred and two temporary wells were also installed as part of the CERCLA program, most of which were installed for the characterization of the PFAS plumes downgradient of BNL's current and former firehouse facilities. Detailed descriptions and maps related to the groundwater monitoring programs can be found in SER Volume II, Groundwater Status Report.

Highlights of the groundwater monitoring programs for 2020 include the following:

- Monitoring conducted at BNL's major research facilities (e.g., AGS, RHIC, NSLS-II, and BLIP) and most support facilities (e.g., WMF, MPF, and the site vehicle maintenance facility) did not identify any new impacts to groundwater quality resulting from current operations. However, during 2020, the corrosion inhibitor tolyltriazole (TTA) was detected in the shallow groundwater near the STP recharge basins at concentrations up to 0.45 mg/L, which exceeded the NYS AWQS of 0.05 mg/L.
- Due to the detection of ethylene dibromide (EDB) in the North Street East area at concentrations above the 0.05 µg/L DWS since 2015, in 2019 BNL began making modifications to the existing VOC treatment system that will allow the EDB plume to be remediated within the OU III ROD-specified 2030 cleanup timeframe for the Upper Glacial aquifer. The modified treatment system was fully operational by mid-2020.
- Because the North Street treatment system met its cleanup objectives, BNL submitted a petition for its closure in early 2020. The petition was approved by the regulatory agencies.
- Continued monitoring of the former HFBR facility is now conducted using a network of monitoring wells located immediately downgradient of the facility. During 2020, tritium was detected above the 20,000 pCi/L DWS, with a maximum concentration of 25,300 pCi/L.
- Following the significant increase in Sr-90 concentrations to 1,170 pCi/L observed during 2019 in BGRR facility monitoring wells, Sr-90 concentrations decreased significantly during 2020, and were less than 5 pCi/L by early 2021. The variations in Sr-90 concentrations appear to be related to seasonal changes in the position of the water table, with higher concentrations observed following significant rises in the water table (such as in 2019) when residual Sr-90 present in the deep vadose zone soils can be leached into the groundwater.
- During 2020, BNL conducted a comprehensive sampling of approximately 360 on-site and off-site monitoring wells for PFAS and 1,4-dioxane, as well as detailed characterization of the high concentration PFAS plumes originating from the former and current firehouse facilities. The monitoring results are presented in Volume 2 of the 2020 Site Environmental Report.

7.5 GROUNDWATER TREATMENT SYSTEMS

The primary mission of the CERCLA program is to operate and maintain groundwater treatment systems to remediate contaminant plumes both on- and off-site. Modifications to groundwater remediation systems are implemented, as necessary, based upon a continuous evaluation of monitoring data and system performance. The cleanup objectives will be met by a combination of active treatment and natural attenuation: The specific cleanup goals are as follows:

- Achieve MCLs for VOCs in the Upper Glacial aquifer by 2030.
- Achieve MCLs for VOCs in the Magothy aquifer by 2065.
- Achieve MCLs for Sr-90 at the BGRR in the Upper Glacial aquifer by 2070.
- Achieve MCLs for Sr-90 at the Chemical Holes in the Upper Glacial aquifer by 2040.

During 2020, BNL continued to make significant progress in restoring groundwater quality. Figure 7-4 shows the locations of eight groundwater treatment systems currently in operation. Table 7-1 provides a summary of the amounts of VOCs and Sr-90 removed from the aquifer since the start of active remediation in December 1996. During 2020, approximately 44 pounds of VOCs and 0.4 mCi of Sr-90 were removed from the groundwater and nearly 850 million gallons of treated groundwater were returned to the

Table 7-1. BNL Groundwater Remediation Systems Treatment Summary for 1997 through 2020.

Remediation System	Start Date	1997-2019		2020	
		Water Treated (Gallons)	**VOCs Removed** (Pounds) (f)	**Water Treated** (Gallons)	**VOCs Removed** (Pounds) (f)
OU I South Boundary (a)	12/1996	4,177,473,000	369	Shutdown	0
OU III HFBR Tritium Plume (a)	05/1997	721,795,000	180	Shutdown	0
OU III South Boundary	06/1997	5,199,151,000	3,055	85,000,000	6
OU III Industrial Park	09/1999	2,577,662,000	1,077	Shutdown	0
OU III Carbon Tetrachloride (d)	10/1999	153,538,075	349	Decommissioned	0
OU III Building 96	01/2001	526,697,000	144	32,000,000	1
OU III Middle Road	10/2001	3,612,547,000	1,289	154,000,000	16
OU III Western South Boundary	09/2002	1,912,555,000	156	166,000,000	6
OU III Industrial Park East (e)	06/2004	357,192,000	38	Decommissioned	0
OU III North Street (j)	06/2004	1,680,942,000	342	Shutdown	0
OU III North Street East (h)	06/2004	1,009,798,000	44	35,000,000	1
OU III LIPA/Airport	08/2004	3,528,145,000	472	213,000,000	15
OU III Building 452 Freon-11 (i)	03/2012	124,997,400	106	Shutdown	0
OU IV AS/SVE (b)	11/1997	(c)	35	Decommissioned	0
OU VI EDB	10/2004	2,360,057,000	(g)	138,000,000	(g)
Total		**27,942,549,000**	**7,656**	**823,000,000**	**44**

Remediation System	Start Date	2003–2019		2020	
		Water Treated (Gallons)	**Sr-90 Removed** (mCi)	**Water Treated** (Gallons)	**Sr-90 Removed** (mCi)
OU III Chemical Holes Sr-90	02/2003	65,663,000	4.94	Shutdown	0
OU III BGRR/WCF Sr-90	06/2005	178,803,000	28.7	15,800,000	0.4
Total		**244,466,000**	**33.64**	**15,800,000**	**0.4**

Notes:
(a) System placed in standy mode in 2013. Approved for closure in 2019.
(b) System decommissioned in 2003.
(c) Air Sparging/Soil Vapor Extraction (AS/SVE) system performance was measured by pounds of VOCs removed per cubic feet of air treated.
(d) System decommissioned in 2010.
(e) System decommissioned in 2014.
(f) Values are rounded to the nearest whole number.
(g) Because EDB has only been detected at trace levels in the treatment system influent, no removal of VOCs is reported.
(h) North Street East system was restarted in July 2020 for treatment of EDB plume.
(i) System placed in standby mode in March 2017. Approved for closure in 2019.
(j) System placed in standby mode in August 2016.
BGRR = Brookhaven Graphite Research Reactor
EDB = ethylene dibromide
HFBR = High Flux Beam Reactor
LIPA = Long Island Power Authority
OU = operable unit
VOCs = volatile organic compounds
WCF = Waste Concentration Facility

aquifer. To date, 7,700 pounds of VOCs have been removed from the aquifer and noticeable improvements in groundwater quality are evident in several on- and off-site areas. Furthermore, two of the treatment systems have removed approximately 34 mCi of Sr-90.

During 2020, the North Street Treatment System, OU I South Boundary Treatment System, OU III Building 452 Freon-11 Treatment System, the Chemical Holes Sr-90 Treatment System, and the HFBR Tritium Pump and Recharge System remained in standby mode because they met

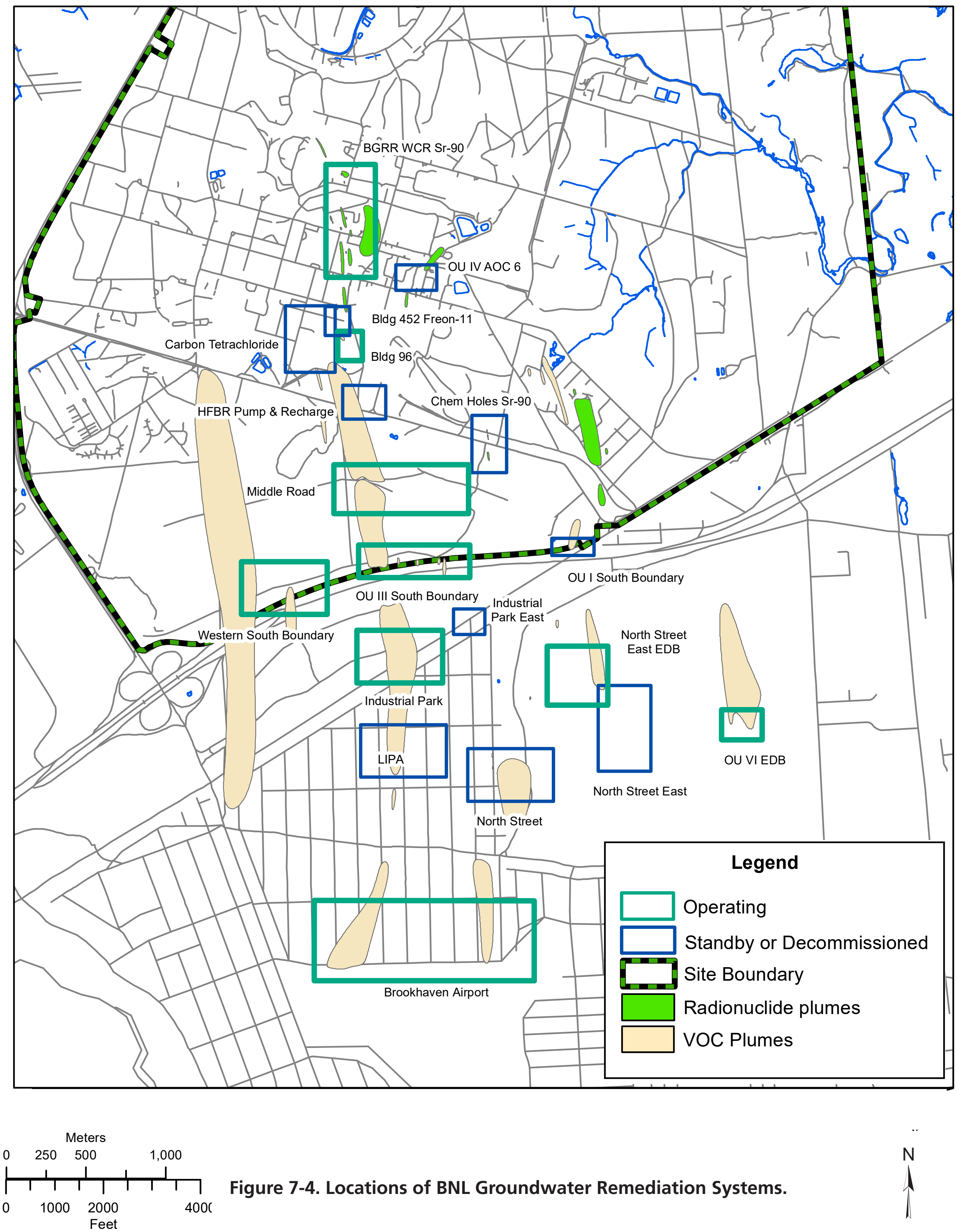

Figure 7-4. Locations of BNL Groundwater Remediation Systems.

their active remediation goals for reduction of contaminant concentrations. Detailed information on the groundwater contaminant plumes and treatment systems can be found in SER Volume II, Groundwater Status Report.

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Radiological Dose Assessment 8

Brookhaven National Lab's (BNL) annual radiological dose assessment assures stakeholders that on-site facilities and BNL operations are in compliance with federal, state, and local regulations and that the public is protected. The potential radiological dose to members of the public is calculated at an off-site location where models indicate a site-emission source could result in the maximum dose to an off-site individual, defined as the "maximally exposed off-site individual" (MEOSI). Based on MEOSI dose calculation criteria, members of the public will receive a dose less than the MEOSI under all circumstances. The dose to the MEOSI is the total dose from direct and indirect dose pathways via air immersion, inhalation of particulates and gases, and ingestion of local fish and deer meat. In 2020, the total effective dose (TED) to the MEOSI of 0.913 mrem (9.3 µSv) from Laboratory operations was well below the dose limit of 100 mrem in a year required by DOE Order 458.1, as well as all other U.S. Environmental Protection Agency (EPA) and U.S. Department of Energy (DOE) regulatory dose limits for the public, workers, and the environment.

Five years of measurement data are shown in the data tables of this chapter to present and describe trends in measured ambient radiation dose at BNL. In general, the radiological footprint at BNL continues to slowly grow, with a recent peak in 2018, as testing for Ac-225 production occurred. The ambient dose decreased slightly in 2020 as readiness reviews took place in preparation for ramping up production testing for that same process.

The dose estimates for 2020 were calculated using a recent version of the dose modeling software promulgated by the EPA. All data in this chapter are reported with uncertainties at the 95 percent (2-sigma) confidence level. As such, the effective dose equivalent (EDE) from air emissions in 2020 was estimated at 5.6E-5 mrem (5.6E-4 uSv) to the MEOSI. This BNL dose level from the inhalation pathway was less than one percent of the EPA's annual regulatory dose limit of 10 mrem (100 µSv). In addition, the dose from the ingestion pathway was estimated as 0.913 mrem (9.13 µSv) from the consumption of deer meat. The onsite portions of the Peconic River did not have sufficient water to support fish populations of sufficient size for surveillance monitoring, therefore there was no dose attributable to BNL legacy Cs-137 levels in fish in the Peconic River. In summary, the total annual dose to the MEOSI from all pathways was estimated at 0.913 mrem (9.3 µSv), which is less than 1.0 percent of DOE's 100-mrem limit. The aggregate population dose was 2.05E-3 person-rem among approximately six million people residing within a 50-mile radius of the Laboratory. On average, this is equivalent to a fraction of an airport whole body scan per person.

Dose to the maximally exposed individual (MEI) on site and outside of controlled areas, calculated from thermoluminescent dosimeter (TLD) monitoring records, was 27 mrem above natural background radiation levels, also well below the 100-mrem DOE limit on dose. The average annual external dose from ambient sources on site was 64 ± 9 mrem (640 ± 90 µSv), while the dose from off-site ambient sources was 61 ± 14 mrem (610 ± 140 µSv). Both on- and off-site external dose measurements include the contribution from natural terrestrial and cosmic background radiation. A statistical comparison of the average doses measured using 50 on-site TLDs and 17 off-site TLDs showed that there was no external dose contribution from BNL operations distinguishable from the natural background radiation level. Additional TLDs were used to measure on-site areas known to receive radiation dose slightly above the natural background radiation.

Doses to aquatic and terrestrial biota were also found to be well below DOE regulatory limits. In summary, the overall dose impact from all Laboratory activities in 2020 was comparable to that of natural background radiation levels.

8.0 INTRODUCTION

Chapter 8 discusses the dose risk consequences from research activities, radiation-generating devices, facilities, and minor bench-top radiation sources at BNL. It is important to understand the health impacts of radiation to the public and workers, as well as radiation effects to the environment, fauna, and flora. To this end, the Laboratory's routine operations, scientific experiments, and new research projects are evaluated for their radiological dose risk. The dose risks from demolishing decommissioned facilities and decontamination work are also evaluated. All environmental pathway scenarios with potential for dose to humans, aquatic life, plants, and animals are evaluated to estimate the dose risks on site.

Because all research reactors at BNL have been shut down, defueled, and partly or fully decommissioned for several years, the dose risk from these facilities was trivial in 2020. The Laboratory's current radiological risks are from very small quantities of radionuclides used in science experiments, production of radiopharmaceuticals at the Brookhaven LINAC Isotope Producer (BLIP), and small amounts of air activation produced at the BNL accelerators: Alternating Gradient Synchrotron (AGS), Relativistic Heavy Ion Collider (RHIC), and the National Synchrotron Light Source II (NSLS-II). These radiological dose assessments are performed to ensure that dose risks from all Laboratory operations meet regulatory requirements and remain "As Low As Reasonably Achievable" (ALARA) to members of the public, workers, and the environment.

8.1 DIRECT RADIATION MONITORING

A direct radiation monitoring program is used to measure the external dose contribution to the public and workers from radiation sources at BNL. This is achieved by measuring direct penetrating radiation exposures at both on- and off-site locations. The direct measurements taken at the off-site locations are based on the premise that off-site exposures represent true natural background radiation levels with contributions from cosmic and terrestrial sources, and with no contributions from Laboratory operations.

On- and off-site external dose measurements are averaged separately and then compared using standard statistical methods to assess the contribution, if any, from Laboratory operations.

8.1.1 Ambient Radiation Monitoring

To assess the dose impact of direct radiation from BNL operations, TLDs are deployed on site and in the surrounding communities. On-site TLD locations are determined based on the potential for exposure to gaseous plumes, atmospheric particulates, scattered radiation, and the location of radiation-generating devices. The Laboratory perimeter is also posted with TLDs to assess the dose impact, if any, beyond the site's boundaries (See Photo 8-1). On- and off-site land areas are divided into grids, and each TLD is assigned a unique identification code based on those grids.

Photo 8-1. TLD at P-4 Perimeter Station

In 2020, a total of 60 environmental TLDs were deployed on site, ten of which were placed in known radiation areas. A total of 17 environmental TLDs were deployed at off-site locations (see Figures 8-1 and 8-2). In 2020, all 16 wind sectors around the Laboratory had TLD locations. An additional 30 TLDs were stored in a lead-shielded container for use as reference and control TLDs for comparison purposes. The total of the control TLD dose values for 2020, reported as 075-TLD4

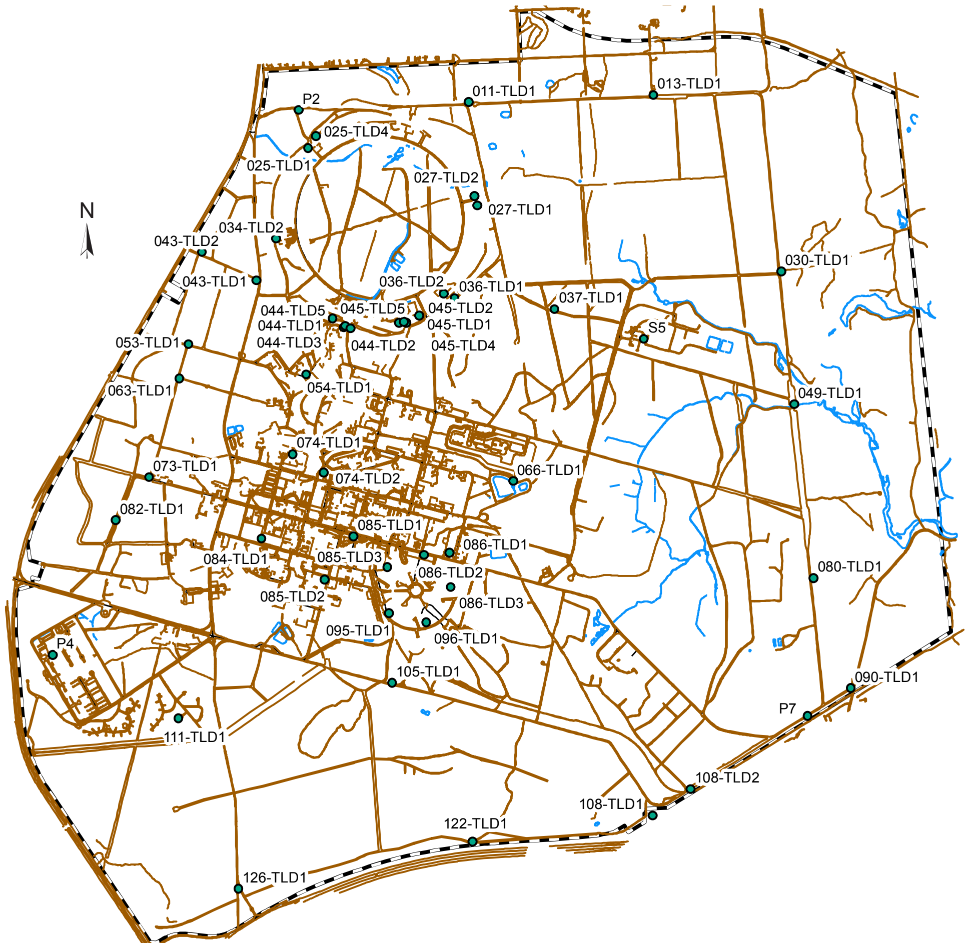

Figure 8-1. On-Site TLD Locations.

in Tables 8-1 and 8-2, was 29 ± 4 mrem. This dose accounts for any small residual dose not removed from TLDs during the annealing process and the natural background and cosmic radiation sources that are not completely shielded.

The on- and off-site TLDs were collected and read quarterly to determine the annual total external radiation dose measured. Table 8-1 shows the annual on-site radiation dose measurements from 2016 to 2020. For 2020, the on-site external dose from all potential environmental sources, including cosmic and terrestrial radiation sources, was 64 ± 9 mrem (640 ± 90 µSv). The onsite measurements in this table generally exhibit year-to-year variation within ten percent or less of the average. The same can be said about the off-site measured doses in Table 8-2, which shows the annual off-site radiation dose measurements from 2016 to 2020. The off-site ambient dose in 2020 from all potential environmental sources, including cosmic and terrestrial radiation sources, was 61 ± 14 mrem (610 ± 140 µSv).

To determine the BNL contribution to the external direct radiation dose, a statistical t-test between the measured on- and off-site external doses was conducted. The test showed no significant difference between the off-site dose (61 ± 14 mrem) and on-site dose (64 ± 9 mrem) at the

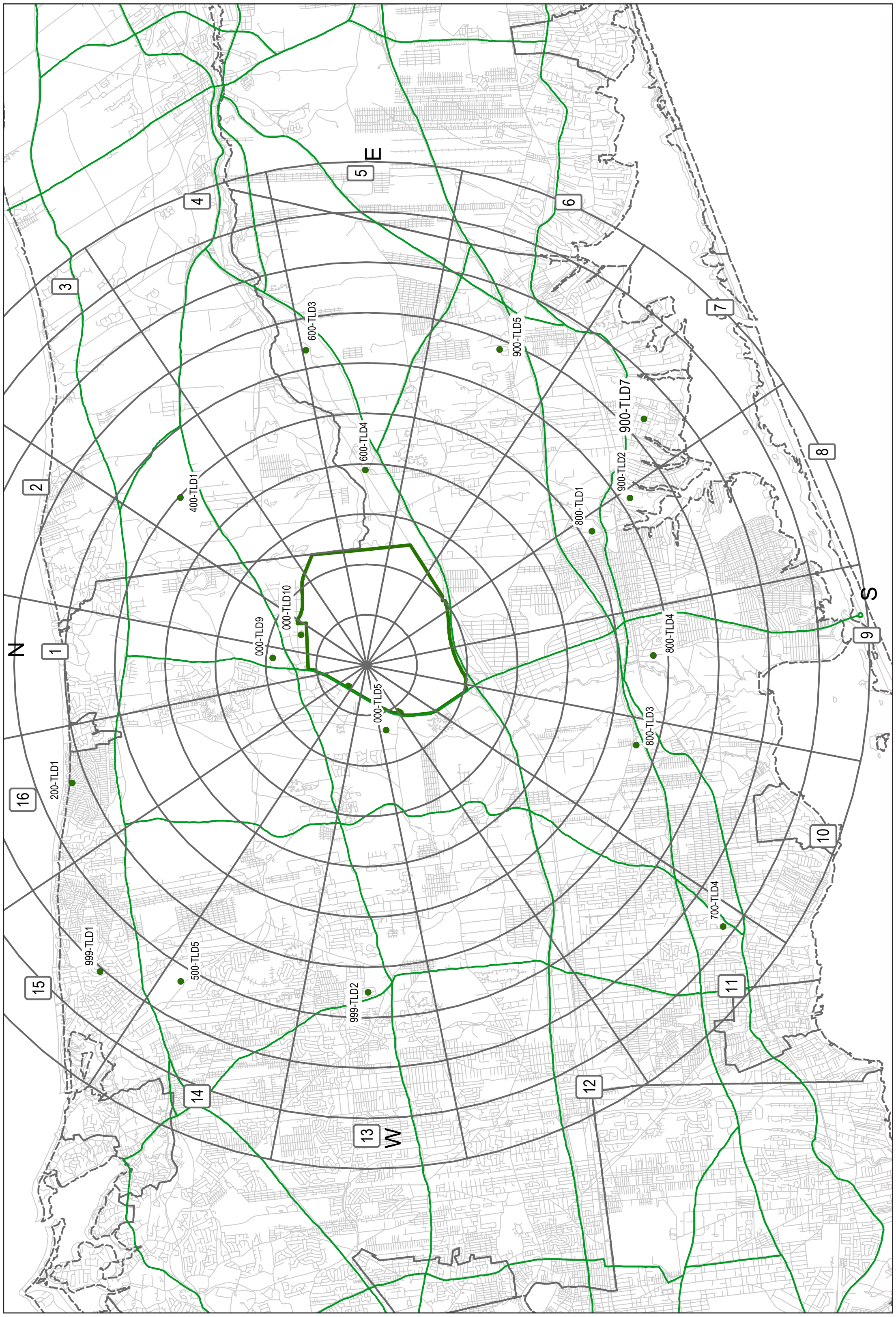

Figure 8-2. Off-Site TLD Locations.

Table 8-1. Five-Year Annual On-Site Direct Ambient Radiation Measurements (2016-2020).

		Annual Total Dose, mrem (±2σ, 95% conf. interval)				
TLD#	Location	2016	2017	2018	2019	2020
011-TLD1	North Firebreak	53±3	56±12	58±8	55±13	58±3
013-TLD1	North Firebreak	59±6	61±8	61±11	62±12	61±4
025-TLD1	Bldg. 1010, Beam Stop 1	63±9	61±12	63±7	58±14	63±19
025-TLD4	Bldg. 1010, Beam Stop 4	63±10	67±22	62±10	59±9	60±11
027-TLD1	Bldg. 1002A South	58±10	58±9	60±9	58±14	57±9
027-TLD2	Bldg. 1002D East	59±12	58±12	62±18	55±13	56±9
030-TLD1	Northeast Firebreak	62±3	64±11	64±11	59±7	64±9
034-TLD1	Bldg. 1008, Collimator 2	64±7	NLP	NLP	NLP	NLP
034-TLD2	Bldg. 1008, Collimator 4	66±11	66±9	67±12	65±11	66±10
036-TLD1	Bldg. 1004B, East	57±8	58±14	57±9	58±12	56±12
036-TLD2	Bldg. 1004, East	61±9	61±12	62±10	58±11	58±4
037-TLD1	S-13	59±6	60±11	59±7	58±12	62±7
043-TLD1	North Access Road	68±8	66±6	69±11	68±14	66±10
043-TLD2	North of Meteorology Tower	66±5	67±11	66±10	65±15	67±6
044-TLD1	Bldg. 1006	65±10	67±11	69±13	61±10	61±8
044-TLD2	South of Bldg. 1000E	67±11	67±8	67±11	64±6	62±9
044-TLD3	South of Bldg. 1000P	62±15	65±10	66±20	60±10	59±8
044-TLD4	Northeast of Bldg. 1000P	68±14	NLP	NLP	NLP	NLP
044-TLD5	North of Bldg. 1000P	68±14	67±18	67±14	59±9	63±7
045-TLD1	Bldg. 1005S	59±9	62±10	63±14	62±9	61±10
045-TLD2	East of Bldg. 1005S	62±5	62±10	67±10	59±10	63±16
045-TLD3	Southeast of Bldg. 1005S	65±7	NLP	NLP	NLP	NLP
045-TLD4	Southwest of Bldg. 1005S	65±13	64±13	69±21	61±13	62±6
045-TLD5	West-Southwest of Bldg. 1005S	63±8	60±11	66±14	64±12	61±5
049-TLD1	East Firebreak	64±6	65±11	70±11	62±10	66±16
053-TLD1	West Firebreak	69±6	66±7	71±11	71±22	72±6
063-TLD1	West Firebreak	69±8	70±13	72±6	68±14	71±4
066-TLD1	Waste Management Facility	54±6	57±12	60±9	52±11	55±5
073-TLD1	Meteorology Tower	66±6	66±12	66±11	63±6	69±10
074-TLD1	Bldg. 560	69±8	72±21	73±15	67±13	65±10
074-TLD2	Bldg. 907	63±9	63±10	66±14	61±19	62±9
080-TLD1	East Firebreak	73±6	70±10	72±6	70±18	66±5
082-TLD1	West Firebreak	73±10	71±13	73±7	71±13	74±9
084-TLD1	Tennis courts	65±4	63±7	72±19	63±12	65±8
085-TLD1	Bldg. 735	64±8	66±16	68±11	65±15	65±12
085-TLD2	Upton Gas Station	65±7	67±7	66±9	66±17	67±9
085-TLD3	NSLS-II LOB 745	NYP	64±4	71±13	68±20	66±6
086-TLD1	Baseball Fields	62±7	64±7	66±8	61±11	66±8
086-TLD2	NSLS-II LOB 741	NYP	59±3	64±14	56±11	61±17
086-TLD3	NSLS-II LOB 742	NYP	55±4	59±11	60±16	62±12
090-TLD1	North St. Gate	66±8	66±7	64±9	62±11	61±8

(continued on next page)

Table 8-1. Five-Year Annual On-Site Direct Ambient Radiation Measurements (2016-2020). *(concluded).*

		Annual Total Dose, mrem (±2σ, 95% conf. interval)				
TLD#	**Location**	**2016**	**2017**	**2018**	**2019**	**2020**
095-TLD1	NSLS-II LOB 744	NYP	68±2	70±8	68±19	70±13
096-TLD1	NSLS-II LOB 743	NYP	58±3	62±10	59±12	58±8
105-TLD1	South Firebreak	70±7	70±8	68±14	73±24	69±10
108-TLD1	Water Tower	65±5	73±25	65±11	62±12	64±5
108-TLD2	Tritium Pole	79±4	77±14	82±16	82±9	78±9
111-TLD1	Trailer Park	66±1	65±7	72±6	69±10	66±9
122-TLD1	South Firebreak	65±13	64±16	62±11	60±12	61±6
126-TLD1	South Gate	72±4	72±16	75±17	68±9	72±13
P2	NW Corner Site Perimeter Station	57±8	56±9	58±8	55±10	56±5
P4	SW Corner Site Perimeter Station	62±5	64±16	64±11	60±12	59±10
P7	SE Corner Site Perimeter Station	63±9	66±12	66±9	64±10	66±10
S5	Sewage Treatment Plant	60±3	58±11	61±11	57±13	61±9
On-Site Average		**64±8**	**65±11**	**66±11**	**62±12**	**64±9**
Off-site average (Table 8-2)		**60±8**	**61±11**	**64±10**	**59±11**	**61±14**
075-TLD4: Control TLD Average		**27±3**	**29±3**	**30±2**	**27±3**	**29±4**

Notes :
See Fig. 8-1 for TLD Locations
Note: Beginning with the 2017 calendar year, a handful of stable-dose-level TLDs were moved from other locations onsite to the NSLS-II locations.
NLP = No Longer Posted. TLDs were removed from these locations to be posted at NSLS-II.
NYP = The NSLS-II locations had not yet been posted with EM TLDs in 2015 and 2016.

95 percent confidence level. From the measured TLD doses, it can be safely concluded that there was no measurable external dose contribution to on- or off-site locations from Laboratory operations in 2020.

8.1.2 Facility Area Monitoring

Ten on-site TLDs are designated as facility area monitors (FAMs) because they are posted in known radiation areas (i.e., near facilities). Table 8-3 shows the external doses measured with the FAM TLDs from 2016 to 2020. Environmental TLDs 088-TLD1 through 088-TLD4 are posted at and near the S-6 blockhouse location on the fence of the Former Waste Management Facility (FWMF). Except for the doses at S6 and 088-TLD4, which were consistent with the site average dose, the TLDs measured external doses that were slightly elevated compared to the normal natural background radiation doses measured in other areas on site. This can be attributed to the presence of small amounts of contamination in the soil. The 088-TLD1 had the highest dose reading of the four, which can be attributed to waste-loading activities at the nearby rail spur in recent years. As shown in Table 8-3, overall dose levels near the FWMF have been fairly consistent. Access to the FWMF is controlled by fencing.

Two TLDs (075-TLD3 and 075-TLD5) near Building 356 showed a higher annual dose of 99 ± 9 mrem (990± 90 μSv) for 075-TLD3 and 107 ± 14 mrem (1070 ± 140 μSv) for 075-TLD5. These direct doses are higher than the on-site annual average because Building 356 houses a Co-60 source which is used to irradiate materials, parts, and printed circuit boards. Higher doses are to be expected there as the source collimators were removed in 2018 to allow for objects to be placed closer to the source due to declining dose rates resulting from source decay. In addition, the source is left up for longer periods, sometimes overnight, and generates “sky-shine.” Finally, this building also contains several Californium-252 (Cf-252) neutron sources in a cask near the corner

Table 8-2. Five-Year Annual Off-Site Direct Ambient Radiation Measurements (2016-2020).

TLD#	Location	Annual Total, mrem (±2σ, 95% Conf. Interval)				
		2016	2017	2018	2019	2020
000-TLD4	Private property	NLP	NLP	NLP	NLP	NLP
000-TLD5	Longwood Estate	55±3	58±8	59±11	58±15	58±7
000-TLD7	Mid-Island Game Farm	NLP	NLP	NLP	NLP	NLP
000-TLD8	Private property	52±30	NLP	NLP	NLP	NLP
000-TLD9	Private property	60±11	56±7	58±9	53±10	61±13
000-TLD10	Private property	63±6	65±7	66±10	62±8	61±16
004-TLD1	Private property**	NLP	NLP	NLP	NLP	NLP
200-TLD1	Private property	NYP	NYP	71±14	66±12	70±20
200-TLD5	Private property	NYP	NYP	78±10	74±21	69±38
400-TLD1	Calverton Nat. Cemetery	69±5	68±14	71±10	61±9	67±8
500-TLD4	Private property	63±9	58±2	NLP	NLP	NLP
600-TLD3	Private property	64±14	62±8	68±12	59±2	65±10
600-TLD4	Maples B&G	59±2	57±9	59±7	57±11	59±10
700-TLD3	Private property	58±7	58±12	NLP	NLP	NLP
700-TLD4	Private property	60±5	60±7	61±10	57±6	56±9
800-TLD1	Private property	62±5	65±21	65±14	56±9	63±11
800-TLD3	Suffolk County CD	64±2	62±5	62±8	61±16	63±12
800-TLD4	LI Nat'l Wildlife Refuge	64±6	58±12	63±4	56±12	59±10
900-TLD2	Private property	57±0	62±26	62±18	57±15	56±14
900-TLD4	Private property	60±13	72±26	NLP	NLP	NLP
900-TLD5	Private property	56±7	54±5	59±7	50±3	49±8
900-TLD6	Private property	54±10	NLP	NLP	NLP	NLP
900-TLD7	Private property	NYP	NYP	67±8	61±13	64±18
999-TLD1	Private property	61±10	61±7	64±7	58±12	64±18
999-TLD2	Private property	NYP	NYP	73±2	52±12	61±13
Off-site average		**60±8**	**61±11**	**64±10**	**59±11**	**61±14**
075-TLD4 : Control TLD Average		**27±3**	**29±3**	**30±4**	**27±3**	**29±4**

Notes:
See Fig. 8-2 for TLD Locations
Note: TLDs are placed by volunteers or other entities.
Year-to-year, willingness to participate varies among owners at these locations.
NLP = No Longer Posted. TLDs were removed from these locations.
NYP = Not Yet Posted with TLDs.
**TLD designator 004-TLD1 was changed to 000-TLD10 to align its designator with the naming convention.

Table 8-3. Five-Year Annual Facility Area Monitoring Results (2016-2020).

TLD#	Location	Annual Total, mrem (±2σ, 95% Conf. Interval)				
		2016	2017	2018	2019	2020
054-TLD1	Bldg. 914	82±34	83±44	91±48	75±33	65±12
054-TLD2	NE of Bldg. 913B	89±45	85±53	86±49	76±30	66±13
054-TLD3	NW of Bldg. 913B	77±32	76±43	81±47	72±24	66±13
S6	FWMF blockhouse	71±2	70±13	71±11	69±17	69±11
088-TLD1	FWMF, 50' East of S6	79±2	82±5	84±12	77±12	79±7
088-TLD2	FWMF, 50' West of S6	73±5	73±11	74±12	72±13	77±14
088-TLD3	FWMF, 100' West of S6	76±5	77±12	75±7	74±8	74±11
088-TLD4	FWMF, 150' West of S6	66±6	65±7	67±8	69±13	66±11
075-TLD3	Building 356	80±9	85±22	80±18	100±17	99±9
075-TLD5	North Corner of Bldg. 356	79±14	86±24	80±22	109±20	107±14

Notes:
See Figure 8-1 for TLD locations.
FWMF = Former Waste Management Facility

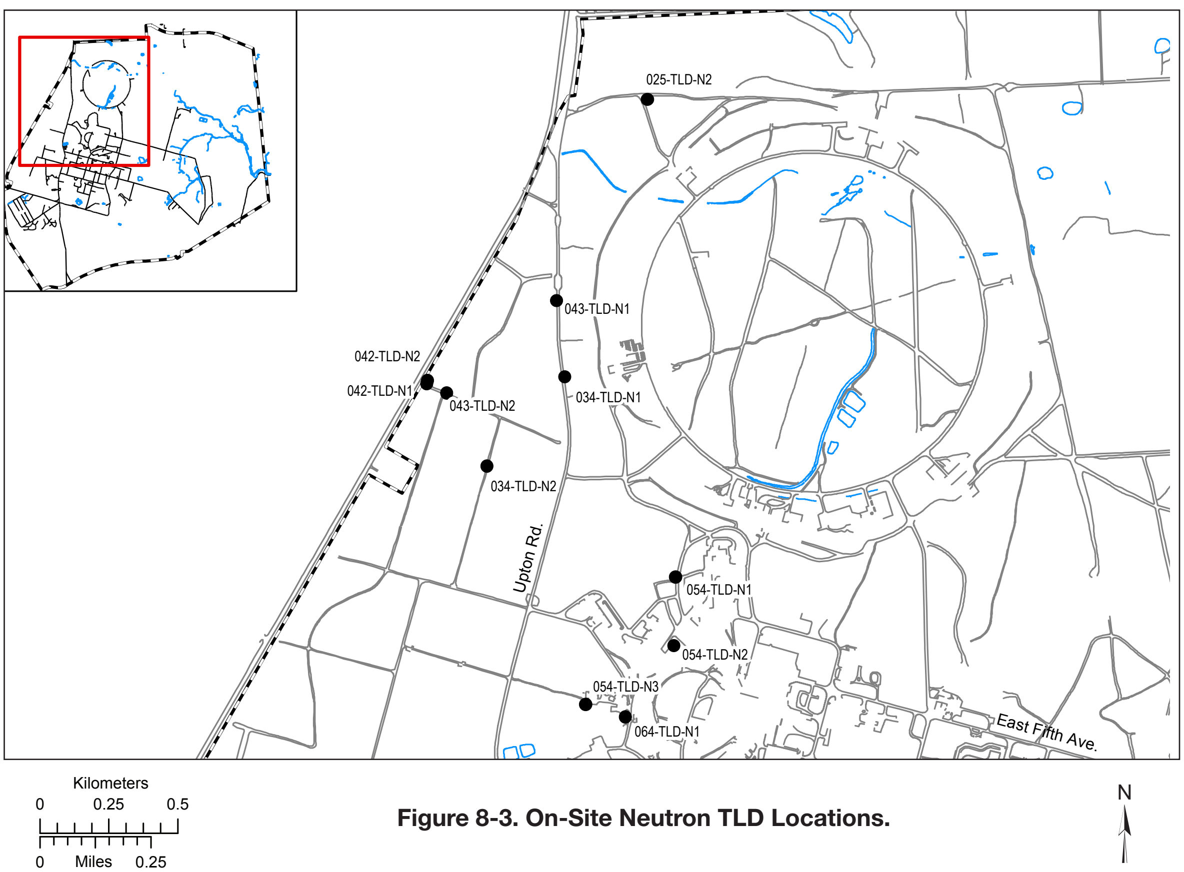

Figure 8-3. On-Site Neutron TLD Locations.

of the building where 075-TLD5 is located. Although it is conceivable that individuals who use the parking lot adjacent to Building 356 could receive a dose from these sources, the dose would be small due to the low occupancy factor.

Three FAM TLDs near Building 914 and placed on fence sections northeast and northwest of Building 913B (the AGS tunnel access) showed slightly elevated ambient external dose. The full-year dose at these sites was measured at 65 mrem for 054-TLD1, 66 mrem for 054-TLD2, and 66 mrem for 054- TLD3 (compared to the on-site dose of 64 ± 9 mrem and off-site dose of 61 ± 14 mrem). The slightly higher levels of the first and second quarters (not shown) are expected because the operating period for the AGS is typically in the first half of the calendar year.

8.1.2.1 Neutron Monitoring

The AGS accelerates protons to energies up to 30 GeV and heavy ions up to 15 GeV/amu. At the RHIC, protons and heavy ions received from the AGS are further accelerated up to final energies of 250 GeV for protons and 100 GeV for ions. Under these high-energy conditions, such accelerated particles have the potential to generate high-energy neutrons when the particles leave the walls of the accelerator and produce nuclear fragments along their path or as they collide with matter. In 2020, 11 pairs of neutron monitoring TLDs (Harshaw Badge 8814) were posted at strategic locations to measure the dose contribution from the high-energy neutrons (see Figure 8-3 for locations).

The placement of neutron TLDs is based on facility design aspects such as the thickness of the berm shielding, location of soil activation areas, beam stop areas and beam collimators, and proximity to the site boundary. The neutron TLDs are placed on polyethylene cylinders so that incident neutrons, which are at a high enough energy to pass through the TLD undetected, are thermalized by the hydrocarbons in the polyethylene and reflected back out, where the TLD can detect them. The neutron TLDs are mounted in pairs, for three reasons: The dose registered on these TLDs is low, so a matching number on the second TLD adds confidence to the dose measured by the first one; two neutron TLDs

Photo 8-2. Neutron TLDs in Monitored Area

side-by-side decreases the potential dependence of measured dose on mounting orientation; and the reflected neutron could strike either neutron TLD and be counted (see Photo 8-2).

Table 8-4 shows the measured ambient neutron doses recorded from 2016 to 2020. In 2020, four neutron TLD locations showed 1 mrem and three showed 2 mrem, for a total of 10 mrem. These low-level neutron doses indicate that engineering controls (i.e., berm shielding) in place at AGS and RHIC are effective.

8.2 DOSE MODELING FOR AIRBORNE RADIONUCLIDES

The EPA regulates radiological emissions from DOE facilities under the requirements set forth in 40 CFR 61, Subpart H, National Emission Standards for Hazardous Air Pollutants (NESHAPs). This regulation specifies the compliance and monitoring requirements for reporting radiation doses received by members of the public from airborne radionuclides. The regulation mandates that no member of the public shall receive a dose greater than 10 mrem (100 µSv) in a year from airborne emissions.

The emission monitoring requirements include the use of a reference method for continuous monitoring at major release points (defined as those with a potential to exceed one percent of the 10 mrem standard) and periodic confirmatory measurements for all other release points. The regulations also require DOE facilities to submit an annual NESHAPs report to the EPA that describes the major and minor emission sources, their releases, and their resultant dose to the Maximally Exposed Off Site Individual (MEOSI). The dose estimates from various facilities are

Table 8-4. Five-Year Annual Neutron Monitoring Results (2016-2020).

Neutron TLD #	Location ID No.	Annual Total, mrem neutron				
		2016	2017	2018	2019	2020
TK275	025-TLD-N1	0	0	NLP	NLP	NLP
TK276	"	0	0	NLP	NLP	NLP
TK277	025-TLD-N2	0	0	0	0	2
TK278	"	0	2	2	0	0
TK279	034-TLD-N1	0	1	0	1	1
TK280	"	1	0	1	0	0
TK281	034-TLD-N2	0	0	0	0	0
TK282	"	0	1	1	0	0
TK283	043-TLD-N1	0	0	0	0	1
TK284	"	0	1	0	0	0
TK285	043-TLD-N2	0	0	0	0	0
TK286	"	0	0	1	2	0
TK287	042-TLD-N1	0	0	0	1	1
TK288	"	1	0	0	1	0
TK289	042-TLD-N2	3	0	0	0	0
TK290	"	0	0	0	0	0
TK291	054-TLD-N1	0	0	0	0	2
TK292	"	0	0	0	0	0
TK293	054-TLD-N2	0	1	0	0	0
TK294	"	0	2	0	0	0
TK295	054-TLD-N3	1	0	0	0	0
TK296	"	0	0	0	1	2
TK297	064-TLD-N1	2	1	0	0	0
TK298	"	0	0	1	0	1
PM-bkg		1	1	1	1	1

NLP = No Longer Posted. TLDs were removed from these locations to be posted at NSLS-II.

given in Table 8-5, and the actual air emissions for 2020 are discussed in detail in Chapter 4.

As a part of the NESHAPs review process at BNL, any emission source, such as a stack, that has the potential to release airborne radioactive materials is evaluated for regulatory compliance. Under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), certain restoration activities are also monitored and assessed for any potential to release airborne radioactive materials, and to determine their dose contribution, if any, to the environment. Any new radiological processes or activities are also evaluated for compliance with NESHAPs regulations using the EPA's approved dose modeling software (see Section 8.2.1 for details). Because this model is designed to treat radioactive emission sources as continuous over the course of a year, it is not well-suited for estimating short-term or acute releases. Consequently, it overestimates potential dose contributions from short-term projects and area sources. For that reason, modeling results are conservative.

8.2.1 Dose Modeling Program

Compliance with NESHAPs regulations is demonstrated using EPA dose-modeling software and the Clean Air Act Assessment Package

Table 8-5. Maximally Exposed Off-site Individual (MEOSI) Effective Dose Equivalent From Facilities or Routine Processes, 2020.

Building No.	Facility or Process	Construction Permit No.	MEOSI Dose (mrem) (a)	Notes
120	Instrumentation & Calibration	None	ND	(f)
348	Instrumentation & Calibration	None	ND	(f)
463	Biology	None	3.19E-08	(b)
480	Condensed Matter Physics	None	2.76E-15	(b)
490	Personnel Monitoring	None	3.02E-08	(b)
510A	Physics	None	8.25E-10	(b)
535	Instrumentation	None	ND	(f)
555	Chemistry Facility	None	ND	(f)
734	Interdisciplinary Science Building	None	7.02E-09	(b)
735	Center for Functional Nanomaterials	None	ND	(f)
745	NSLS-II	None	1.42E-08	(b)
750	HFBR	None	5.19E-05	(c)
750	Nonproliferation & National Security	None	ND	(g)
801	Target Processing Lab	None	1.56E-07	(c)
815	Nonproliferation & National Security	None	1.32E-16	(b)
820	Accelerator Test Facility	BNL-589-01	4.04E-12	(b)
830	Environmental Science Department	None	ND	(f)
865	Waste Management Facility	None	ND	(d)
902	Superconducting Magnet Division	None	ND	(f)
906	Imaging Lab	None	ND	(f)
911	Collider-Accelerator	None	ND	(f)
925	RF Systems	None	ND	(f)
931	BLIP	BNL-2009-01	3.84E-06	(c)
942	AGS Booster	BNL-188-01	ND	(e)
---	RHIC	BNL-389-01	ND	(d)
Total Potential Dose from BNL Operations			**5.60E-05**	
EPA Limit (Air Emissions)			**10**	

Notes:
MEOSI = Maximally Exposed Offsite Individual
(a) “Dose” in this table means effective dose equivalent to MEOSI.
(b) Dose is based on emissions calculated using 40CFR61, Appendix D methodology.
(c) Emissions are continuously monitored at the facility.
(d) ND=No Dose from emissions source in 2020.
(e) Booster ventilation system prevents air release through continuous air recirculation.
(f) No radiological dispersible material inventory in 2020.
(g) Sealed sources were excluded from this inventory - no emission

1988 (CAP88-PC). This computer program uses a Gaussian plume model to characterize the average dispersion of airborne radionuclides released from elevated stacks or diffuse sources. CAP88-PC then calculates the effective dose equivalent (EDE) to the MEOSI from low levels of radioactive materials released into the environment. Site-specific meteorology data was used to calculate annual emission dispersions for the midpoint of a given wind sector and distance. Facility-specific radionuclide emission rates (Ci/yr) were used for continuously monitored facilities. For small sources, the emissions were calculated using the method set forth in 40 CFR 61, Appendix D. CAP88-PC calculated the EDE at the MEOSI location from the immersion, inhalation, and ingestion pathways, and also calculated the collective population dose within a 50-mile radius of the emission source.

As stated above, these dose and risk calculations to the MEOSI are based on low emissions and chronic intakes. In most cases, the CAP88-PC model provides conservative dose estimates. For the purpose of modeling their dose to the MEOSI, all emissions are treated as having been released from the BLIP Facility, which is used to represent the developed portion of the site.

The dose calculations are based on very low concentrations of environmental releases and on chronic, continuous intakes in a year. The input parameters used in the model include radionuclide type, emission rate in Curies (Ci) per year, stack parameters such as height and diameter, and emission exhaust velocity. Site-specific weather and population data are also factored into the dose assessment. As mentioned earlier, weather data are supplied by measurements from the Laboratory's meteorological towers. Such measurements include wind speed, direction, and frequency, as well as air temperature and precipitation amount (see Chapter 1 for details). Solar radiation effects are also accounted for. A population of six million people, based on the Geographical Information System design population survey performed by Oak Ridge National Laboratory for BNL, was used in the model.

The 2020 effective dose equivalents were estimated using Version 4.0.1.17 of CAP88-PC. The following approaches and assumptions supported the dose estimates in this annual report:

- A conservative approach is used for agricultural data input to the CAP88 modeling program, with 92 percent of vegetables, 100 percent of milk, and 99 percent of meat assumed to originate from the assessment area.
- The velocity of the exhaust from the BLIP facility stack was updated to reflect current operation. The average volumetric flow rate of the BLIP exhaust system in 2020 was 509.2 cfm, or 0.240 m3/sec. With an exit diameter of 0.1 m, the exit velocity was 30.6 m/sec, down slightly from last year's 31.04 m/sec.
- The method of characterizing atmospheric stability for purposes of estimating effluent dispersion was the Solar Radiation/Delta Temperature method for conservatism.

8.2.2 Dose Calculation Methods and Pathways

8.2.2.1 Maximally Exposed Off-site and On-site Individual

The MEOSI is defined as a person who resides at a residence, office, or school located beyond the BNL site boundary such that no other member of the public could receive a higher dose. This person is assumed to reside 24 hours a day, 365 days a year, off-site, and close to the emission point nearest to the BNL site boundary. The MEOSI is also assumed to consume significant amounts of fish and deer containing radioactivity assumed to be attributable to Laboratory operations, based on projections from the New York State Department of Health (NYSDOH). It is highly unlikely that such a combination of "maximized dose" to any single individual would occur, but the concept is useful for evaluating maximum potential dose and risk to members of the public. The dose to the onsite maximally exposed individual (MEI) who could receive any dose outside of BNL's controlled areas was determined by TLD measurements (see Table 8-7). The dose to the MEI on site and outside of controlled areas (near Building 356) was measured at 27 mrem in 2020. The increase in MEI dose in 2020 was due to nearly continuous research irradiations conducted with a Co-60 source in Building 356 during the year, as discussed in section 8.1.2. The 27-mrem dose to the on-site MEI is less than the dose expected from seven round-trip flights from

Los Angeles, California to New York, New York, and equal to eight percent of the average annual natural background in the U.S. of 311 mrem.

8.2.2.2 Dose Calculation: Fish Ingestion

To calculate the EDE from fish consumption, the annual intake is estimated first, which is defined at BNL as the average weight of fish consumed in a year by a Reference Person engaged in recreational fishing on the Peconic River. Based on a New York State Department of Health (NYSDOH) study, that annual consumption rate is estimated at 15 pounds (7 kg) per year (NYSDOH 1996). For each radionuclide of concern for fish samples, the dry weight activity concentration is converted to pico-Curies per gram (pCi/g) wet weight, since wet weight is the form in which fish are caught and consumed. A dose conversion factor for a Reference Person, as listed in DOE-STD-1196-2011, Table A-1, is used for each radionuclide to convert the activity concentration to the EDE. The dose is calculated as: dose in (rem/yr) = intake (kg/yr) × activity in flesh (µCi/kg) × dose conversion factor (rem/µCi). For BNL's case, the committed dose equivalent conversion factor for Cesium-137 (Cs-137) is 4.92E-02 rem/µCi.

8.2.2.3 Dose Calculation: Deer Meat Ingestion

The dose calculation for deer meat ingestion is like that for fish consumption. The same Cs-137 dose conversion factor was used to estimate dose. No other radionuclides associated with Laboratory operations have been detected in deer meat. The total quantity of deer meat ingested during a year has been estimated by the NYSDOH at 64 pounds (29 kg) (NYSDOH 1999).

8.3 SOURCES: DIFFUSE, FUGITIVE, "OTHER"

Diffuse sources, also known as nonpoint or area sources, are described as sources of radionuclides which diffuse into the atmosphere but do not have well-defined emission points. Fugitive sources include leaks through window and door frames, as well as unintended releases to the air through vents or stacks which are supposedly inactive (i.e., leaks from vents are fugitive sources). As part of the NESHAPs review process, in addition to stack emissions, any fugitive or diffuse emission source that could potentially emit radioactive materials to the environment is evaluated. Although CERCLA-prompted actions, such as remediation projects, are exempt from procedural requirements to obtain federal, state, or local permits, any BNL activity or process with the potential to emit radioactive material must be evaluated and assessed for potential dose impact to members of the public.

8.3.1 Remediation Work

In 2020, remediation work commenced on the HFBR stack (Building 705) in October and continued through the end of the year. A NESHAPs evaluation of the levels of stack radioactivity was previously performed and confirmed again in 2018. The estimated dose resulting from demolition was found to be below the threshold for NESHAPs authorization.

8.4 DOSE FROM POINT SOURCES

8.4.1 Brookhaven LINAC Isotope Producer

Source term descriptions for point sources are given in Chapter 4. The BLIP facility is the only emission source with the potential to contribute dose to members of the public greater than one percent of the EPA limit (0.1 mrem or 1.0µSv). The BLIP facility is considered a major emission source in accordance with the ANSI N13.1-1999 standard's graded approach, specifically a Potential Impact Category (PIC) of II. The gaseous emissions are directly and continuously measured in real time with an inline, low-resolution Sodium Iodide (NaI) gamma spectrometer. The spectrometer system is connected to a computer workstation that is used to continuously record and display emission levels. The particulate emissions are sampled for gross alpha and gross beta activity weekly, using a conventional glass-fiber filter which is analyzed at an off-site contract analytical laboratory. Likewise, exhaust samples for tritium are also collected continuously using a silica gel adsorbent which is then analyzed at an off-site contract analytical laboratory on a weekly basis.

In 2020, the BLIP facility did not operate with beam due to a series of readiness reviews. Therefore, typical isotopes C-11 (half life: 20.4 minutes) and O-15 (half life: 122 seconds) were not released from the BLIP facility. A small quantity (1.56E- 02 Ci) of residual tritiated water vapor from previous activation of the targets' cooling

Table 8-6. Five-Year Site Dose Summary, 2020.

	2016	2017	2018	2019	2020
Pathway	**Annual Maximally Exposed Off-Site Individual Dose, mrem**				
Inhalation					
Air	0.62	0.72	1.63	1.28	5.6E-5
Ingestion					
Drinking Water	None	None	None	None	None
Fish[1]	0.088	0.088	0.088	0.088	NS
Deer	2.45	4.8	3.32	1.4	0.913
All Pathways	**3.16**	**5.61**	**5.04**	**2.77**	**0.913**
Pathway	**Percent of DOE 100-mrem/yr Dose Limit, %**				
Inhalation					
Air	<1.0	<1.0	<2.0	<1.5	<0.001
Ingestion					
Drinking Water	None	None	None	None	None
Fish[1]	<0.1	<0.1	<0.1	<0.1	NS
Deer	<3.0	<5.0	<4.0	<1.5	<1.0
All Pathways	**<4.0**	**<6.0**	**<6.0**	**<3.0**	**<1.0**
Pathway	**Estimated Population Dose Per Year, person-rem**				
Inhalation					
Air	0.94	1.16	2.55	1.81	2.05E-03
Ingestion					
Drinking Water	None	None	None	None	None
Fish[1]	Not Tracked	Not Tracked	Not Tracked	Not Tracked	Not Tracked
Deer	Not Tracked	Not Tracked	Not Tracked	Not Tracked	Not Tracked
All Pathways	**0.94**	**1.16**	**2.55**	**1.81**	**2.05E-03**

Note:
1 - Source River remained dried up in 2020, so no fish data was available to represent magnitude since sampling was not possible in 2020.

water was released since the exhaust system ran continuously, as normal. The EDE to the MEOSI from BLIP operations was calculated to be 3.84E-6 mrem (3.84-5 µSv) in a year.

8.4.2 Target Processing Laboratory

In 2020, there were no detectable levels of emissions from the Target Processing Laboratory.

8.4.3 High Flux Beam Reactor

In 2020, the residual tritium emissions from the HFBR facility were measured at 0.227 Ci, and the estimated dose attributed was 5.19E-5 mrem (5.19E-4 µSv) in a year.

8.4.4 Brookhaven Medical Research Reactor

In 2020, the Brookhaven Medical Research Reactor (BMRR) facility remained in a cold-shutdown mode as a radiological facility with institutional controls in place. There was no dose contribution from the BMRR in 2020.

8.4.5 Brookhaven Graphite Research Reactor

In 2020, long-term surveillance of the BGRR continued, as well as the maintenance and periodic refurbishment of structures, systems, and components. This status will continue throughout the period of radioactive decay. There were no

Table 8-7. Five-Year Annual Maximally Exposed Onsite Individual Dose (2016-2020).

TLD #	Location	Annual Total, mrem				
		2016	2017	2018	2019	2020
TK154	2nd Floor, B120	5	8	14	25	27
TK155	1st Floor, B120	3	2	5	20	18

radionuclides released to the environment from the complex in 2020.

8.4.6 Waste Management Facility

In 2020, there were no detectable levels of emissions from the Waste Management Facility.

8.4.7 Unplanned Releases

In 2020, there were no unplanned releases.

8.5 DOSE FROM INGESTION

Radionuclides in the environment may bioaccumulate in deer and fish tissue, bones, and organs. Consequently, samples collected from deer and fish are analyzed to evaluate the contribution of dose to humans from the ingestion pathway. As discussed in Chapter 6, deer meat samples collected on- and off-site near the BNL boundary were used to assess the potential dose impact to the MEOSI. The maximum tissue concentration in the deer meat collected for sampling was used to calculate the potential dose to the MEOSI. Potassium-40 (K-40) and Cs-137 were detected in the tissue samples, but K-40 is a naturally occurring radionuclide unrelated to BNL operations.

In 2020, BNL collected samples from 13 deer, eight of those from a managed cull, and analyzed them for K-40 and Cs-137. It should be noted that, since the site boundaries are not fenced, deer are able to travel back and forth across the site boundary. From Table 6-2, the average K-40 concentration in all deer tissue samples (All Samples) was 2.95 ± 1.06 pCi/g (wet weight) in the flesh (i.e., meat) and 2.09 ± 0.67 pCi/g (wet weight) in the liver. The average K-40 flesh concentration in culled deer tissue samples (Managed Cull) was 2.77 ± 0.97 pCi/g (wet weight). The average K-40 liver concentration in culled deer tissue samples (Managed Cull) was 2.15 ± 0.53 pCi/g (wet weight). The maximum Cs-137 flesh concentration in all samples on site (non-culled and culled) was 0.24 ± 0.02pCi/g (wet weight). The maximum Cs-137 flesh concentration of 0.64 ± 0.01 pCi/g, taken from a deer sample collected less than a mile from BNL, was used for MEOSI dose calculations. Therefore, the maximum estimated dose to humans from consuming deer meat containing the maximum Cs-137 concentration was estimated to be 0.913 mrem (9.13 µSv) in a year. This dose is below the health advisory limit of 10 mrem (100 µSv) established by NYSDOH.

The Laboratory maintains an ongoing program of collecting and analyzing fish from the on-site portions of the Peconic River and surrounding freshwater bodies. The Peconic River is an intermittent stream, with flow occurring predominantly via groundwater discharge in the Spring and Fall (i.e., a “gaining” stream) and completely drying up during dry periods (i.e., a “losing” stream). In 2020, the Peconic River did not have sufficient water to support fish populations, therefore there was no dose attributable to BNL legacy Cs-137 levels in fish in the Peconic River.

8.6 DOSE TO AQUATIC AND TERRESTRIAL BIOTA

DOE-STD-1153-2019, A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota, provides the guidelines for screening methods to estimate radiological doses to aquatic animals and terrestrial plants and animals using site-specific environmental surveillance data. The RESRAD-BIOTA 1.8, Biota Dose Level 2, computer program was used to evaluate compliance with the requirements for protection of biota specified in DOE Order 458.1, Radiation Protection of the Public and the Environment.

In 2020, the terrestrial animal and plant doses were evaluated based on 0.77 pCi/g of Cs-137 (see Table 6-3) found in soil near the glass holes area, and a Strontium-90 (Sr-90) concentration of 0.75 pCi/L (see Table 5-5) in the surface water collected from the HM-S station associated with a tributary on site. The resultant dose to terrestrial animals was calculated to be 37.1 µGy/day and to plants as 3.49 µGy/day. The dose to terrestrial animals was well below the biota dose limit of 1 mGy/day, and the plant dose was below the limit of 10 mGy/day for terrestrial plants.

To calculate the dose to aquatic and riparian animals in 2020, the surface water Sr-90 concentration mentioned above, 0.75 pCi/L, was used along with the estimated Cs-137 concentration in vegetation from the west side of First Street, north of East Fifth Avenue, which was 0.12 pCi/g. Using these concentrations, the calculated estimate of dose to aquatic animals was 0.163 µGy/day, and the dose to riparian animals was 2.73 µGy/day. Therefore, the dose to aquatic animals was well below the limit of 10 mGy/day, and the dose to riparian animals was also well below the 1 mGy/day limit specified by the Order.

8.7 DOSE FROM ALL PATHWAYS

Table 8-6 summarizes the estimated dose to the MEOSI from the inhalation, immersion, and ingestion pathways, the percentage of the 100-mrem annual allowable dose limit posed by the estimated MEOSI dose, by pathway, and the potential cumulative dose to the surrounding population via the inhalation pathway from the BNL site, for the years 2016 through 2020. The total dose to the MEOSI from the air and ingestion pathways was estimated to be 0.913 mrem (9.3 mSv). In comparison, the DOE limit on dose from all pathways is 100 mrem (1 mSv). Furthermore, the EPA regulatory limit for the air pathway is 10 mrem (0.10 mSv). The cumulative population dose from airborne emissions was 2.05E-3 person-rem (2.05E-2 person-Sv) in 2020.

In conclusion, the effective dose from all pathways due to BNL operations in 2020 was well below the DOE and EPA regulatory limits, and the ambient offsite TLD dose was within limits of normal background levels seen at the Laboratory site. The potential dose from drinking water was not estimated because most residents adjacent to the BNL site get their drinking water from the Suffolk County Water Authority rather than private wells. To put the potential dose impact into perspective, a comparison was made with estimated doses from other sources of radiation. The annual dose from all-natural background sources and radon in the United States is approximately 311 mrem (3.11 mSv). A mammogram gives a dose of approximately 250 mrem (2.5 mSv) and a dental x-ray gives a dose of approximately 70 mrem (0.7 mSv) to an individual. Therefore, a dose of 0.913 mrem from all environmental pathways is a minute fraction of the dose from that of several routine diagnostic procedures, as well as natural background radiation.

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9 Quality Assurance

Quality Assurance is an integral part of every activity at Brookhaven National Laboratory (BNL). A comprehensive Quality Assurance/Quality Control (QA/QC) Program is in place to ensure that all environmental monitoring samples are representative, and that data are reliable and defensible. Most analyses are performed by contract laboratories that are state certified and routinely participate in independent performance testing. Quality control at the analytical laboratories is maintained through daily instrument calibration, efficiency, background checks, and testing for precision and accuracy. Data are verified and validated, as required, by project-specific quality objectives before being used to support decision making. The multilayered components of QA monitored at BNL ensure that all analytical data reported for the 2020 Site Environmental Report are reliable and of acceptable quality.

9.1 QUALITY PROGRAM ELEMENTS

As required by Department of Energy (DOE) Order 458.1, Radiation Protection of the Public and Environment, and DOE Order 436.1, Departmental Sustainability, BNL has established a QA/QC Program to ensure that the accuracy, precision, and reliability of environmental monitoring data are consistent with the requirements of Title 10 of the Code of Federal Regulations, Part 830 10 CFR 830, Subpart A, Quality Assurance Requirements, and DOE Order 414.1D, Quality Assurance. The responsibility for quality at BNL starts with the Laboratory Director, who approves the policies and standards of performance governing work that extends throughout the entire organization. The purpose of the BNL QA Program is to implement QA methodology throughout the various Laboratory management systems and associated processes to do the following:

- Plan and perform operations in a reliable and effective manner to minimize any impact on the environment, safety, security, and health of the staff and public.
- Standardize processes and support continual improvement.
- Enable the delivery of products and services that meet customers' requirements and expectations.
- Support an environment that facilitates scientific and operational excellence.

For environmental monitoring, QA is deployed as an integrated system of management activities. These activities involve planning, implementation, control, reporting, assessment, and continual improvement. QC activities measure each process or service against the QA standards. QA/QC practices and procedures are documented in manuals, plans, and a comprehensive set of Standard Operating Procedures (SOPs) for environmental monitoring (EM-SOPs). Staff members who must follow these procedures are required to document that they have reviewed and understand them.

The goal of the environmental monitoring and analysis QA/QC program is to ensure that results are representative and defensible, and that data are of the type and quality needed to verify protection of the public, employees, and the environment. Figure 9-1 depicts the flow of the QA/QC elements of BNL's Environmental Monitoring Program and indicates the sections of this chapter that discuss each element in more detail.

Laboratory environmental personnel determine sampling requirements using the Environmental Protection Agency (EPA) Data Quality Objective (DQO) process (EPA 2006) or its equivalent. During this process, the project manager for each environmental program determines the type, amount, and quality of data needed to support decision making, legal requirements, and

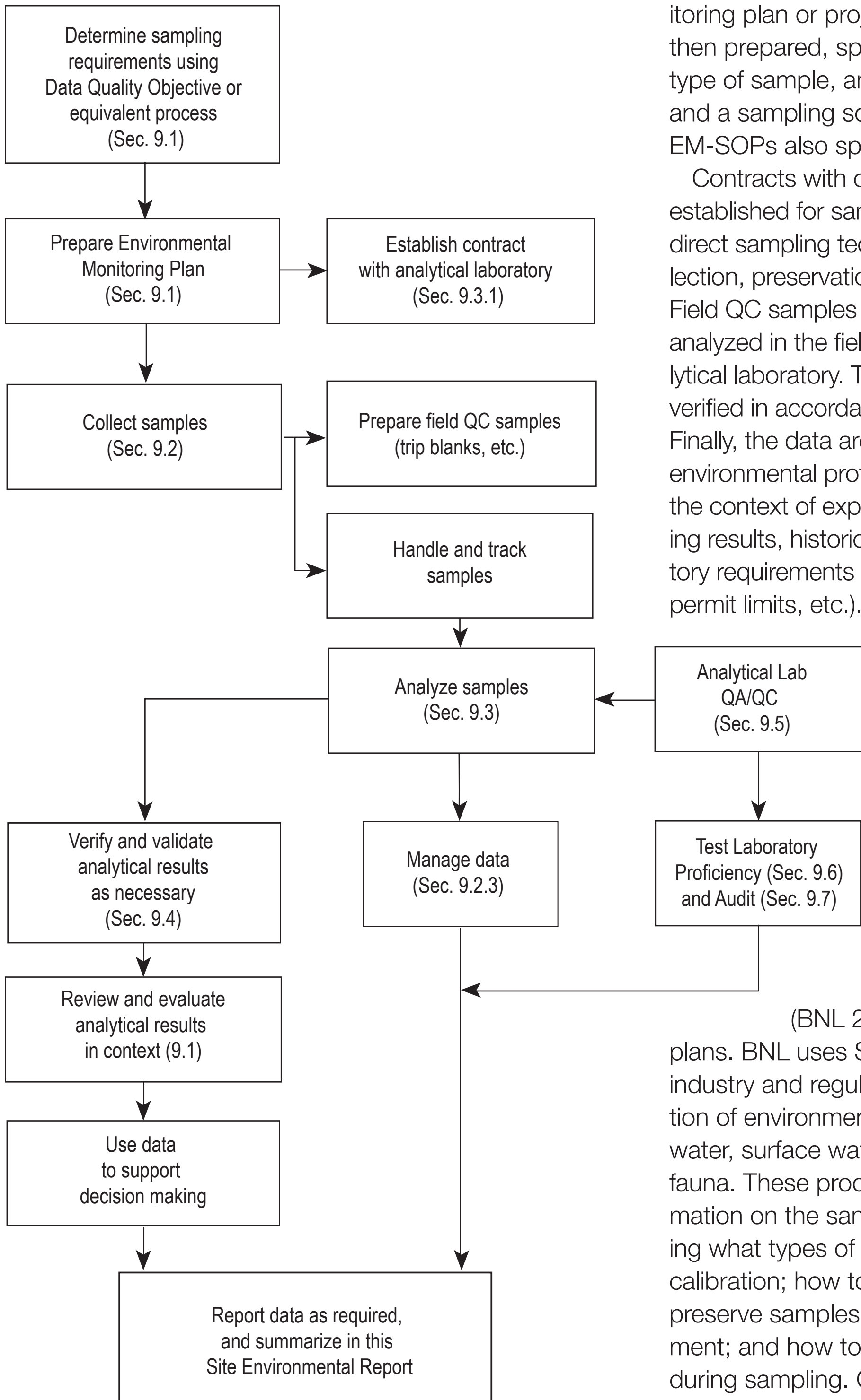


Figure 9-1. Flow of Environmental Monitoring QA/QC Program Elements.

stakeholder expectations. An environmental monitoring plan or project-specific sampling plan is then prepared, specifying the location, frequency, type of sample, analytical methods to be used, and a sampling schedule. These plans and the EM-SOPs also specify data acceptance criteria.

Contracts with off-site analytical laboratories are established for sampling analysis. The EM-SOPs direct sampling technicians on proper sample collection, preservation, and handling requirements. Field QC samples are prepared as necessary and analyzed in the field or at a certified contract analytical laboratory. The results are then validated or verified in accordance with published procedures. Finally, the data are reviewed and evaluated by environmental professionals and management in the context of expected results, related monitoring results, historical data, and applicable regulatory requirements (e.g., drinking water standards, permit limits, etc.). The data are used to support decision making, reported as required, and summarized in this annual report.

9.2 SAMPLE COLLECTION AND HANDLING

In 2020, environmental monitoring samples were collected, as specified, by EM-SOPs, the BNL Environmental Monitoring Plan Update (BNL 2020), and project-specific work plans. BNL uses SOPs that are consistent with industry and regulatory standards for the collection of environmental samples, including groundwater, surface water, soil, sediment, air, flora, and fauna. These procedures contain detailed information on the sample collection process, including what types of equipment to use, equipment calibration; how to properly collect, handle, and preserve samples; sample handling and shipment; and how to manage any wastes generated during sampling. QC checks of sampling processes include the collection of field duplicates, matrix spike samples, field blanks, trip blanks, and equipment blanks.

9.2.1 Field Sample Handling

To ensure the integrity of samples, chain-of-custody (COC) was maintained and documented for all samples collected in 2020. A sample is considered to be in the custody of a person if any or all of the following rules of custody are met:

1. The person has physical possession of the sample,
2. The sample remains in view of the person after being in possession,
3. The sample is placed in a secure location by the custody holder, or
4. The sample is in a designated secure area.

These procedures are outlined in EM-SOP 109, "Chain-of-Custody, Storage, Packaging, and Shipment of Samples" (BNL 2020).

9.2.1.1 Custody and Documentation

Field sampling technicians are responsible for the care and custody of samples until they are transferred to a receiving group or contract analytical laboratory. Samples requiring refrigeration are placed immediately into a refrigerator or a cooler with cooling media and are kept under custody rules. The technician signs the COC form when relinquishing custody and contract analytical laboratory personnel sign the COC form when accepting custody.

As required by EM-SOP-201, "Documentation of Field Activities" (BNL 2019), field sampling technicians are also required to maintain bound, weatherproof field logbooks, which are used to record sample ID numbers, collection times, descriptions, collection methods, and COC numbers. Daily weather conditions, field measurements, and other appropriate site-specific observations also are recorded in the logbooks.

9.2.1.2 Preservation and Shipment

Before sample collection, field sampling technicians prepare all bottle labels and affix them to the appropriate containers, as defined in the applicable EM-SOPs. Appropriate chemical preservatives are added to the containers before or immediately after collection, and samples are refrigerated as necessary. Sample preservation is maintained, as required, throughout the shipping of the samples to the analytical laboratory. If samples are sent via commercial carrier, a bill-of-lading is used. COC seals are placed on the shipping containers and their intact status upon receipt indicates that custody was maintained during shipment.

Upon receipt of the samples, the contract laboratory verifies that proper preservation requirements have been met. BNL is notified as soon as practical if a sample arrives unpreserved, improperly preserved, or at the wrong temperature.

Sample preservations, including incorrect preservation, are noted on the sign-in documentation and included with every data package. If the BNL Project Manager, with the help of a QC chemist and/or radiochemist, determines that an incorrect preservation issue would result in data that does not meet the data quality objectives of the project, the analysis would be cancelled.

9.2.2 Field Quality Control Samples

Field QC samples collected for the environmental monitoring program include equipment blanks, trip blanks, field blanks, field duplicate samples, and matrix spike/matrix spike duplicate samples. The rationale for selecting specific field QC samples, and minimum requirements for their use in the Environmental Monitoring Program, are provided in the BNL EM-SOP 200 series, "Quality Assurance." Equipment blanks and trip blanks were collected for all appropriate media in 2020.

An equipment blank is a volume of solution (in this case, laboratory-grade water) that is used to rinse a sampling tool after decontamination. The rinse water is collected and tested to verify that the sampling tool is not contaminated. Equipment blank samples are collected, as needed, to verify the effectiveness of the decontamination procedures on non-dedicated or reusable sampling equipment.

A trip blank is provided with each shipping container of samples to be analyzed for volatile organic compounds (VOC). The use of trip blanks provides a way to determine whether contamination of a sample container occurred during shipment from the manufacturer, while the container was in storage, during shipment to a contract analytical laboratory, or during analysis of a sample at a contract analytical laboratory. Trip blanks consist of an aliquot of laboratory-grade water sealed in a sample bottle, usually prepared by the contract analytical laboratory prior to shipping the sample bottles to BNL. If trip blanks are not provided by the contract analytical laboratory, then field sampling technicians prepare trip blanks before they collect the samples. Trip blanks were included with all shipments of aqueous samples for VOC analysis in 2020.

Field blanks are collected to check for cross-contamination that may occur during sample collection. A field blank consists of an aliquot of laboratory-grade water that is poured into a sample container in the field. For the Groundwater Monitoring Program, one field blank is collected for every 20 samples, or one per sampling round, whichever is more frequent. Field blanks are analyzed for the same parameters as groundwater samples. For other programs, the frequency of field blank collection is based on their specific DQOs.

In 2020, the most common contaminant detected in the trip, field, and equipment blanks was trace to low levels of chloroform (Table 9-1). This compound is commonly detected in blanks and does not pose significant problems with the reliability of the analytical results. Several other compounds were also detected, such as bromoform and styrene at low levels. When these contaminants are detected, validation or verification procedures are used, where applicable, to qualify the associated data as "nondetects" (see Section 9.4). The results from blank samples collected during 2020 did not indicate any significant impact on the quality of the results.

Field duplicate samples are analyzed to check the reproducibility of sampling and analytical results, based on EPA Region II guidelines (EPA 2012, 2013). For example, in the Groundwater Monitoring Program, duplicates are collected for five percent of the total number of samples collected for a project per sampling round.

During 2020, a total of 123 duplicate samples were collected for non-radiological analyses and 84 duplicates were collected for radiologic analyses. Not all parameters were analyzed in every duplicate. The parameters in each duplicate were consistent with those required for the specific program the duplicate was monitoring. Of the 3,233 non-radiologic parameters analyzed, 65 parameters (two percent) were above 50 percent Relative Percent Difference. For the radiologic parameters, 27 of the 333 parameters (8.1 percent) failed to meet criteria. These results are indicative of analytical method consistency within the laboratory, and that consistency within the sample collection process results in valid, reproducible data.

Matrix spike and matrix spike duplicates are used to determine whether the sample matrix (e.g., water, soil, air, vegetation, bone, or oil) adversely affected the sample analysis. A spike is a known amount of analyte added to a sample. Matrix spikes are performed at a rate specified by each environmental program's DQOs. The rate is typically one per 20 samples collected per project. No significant matrix effects were observed in 2020 for routine matrices such as water and soil. Non-routine matrices, such as oil, exhibited the expected matrix issues.

9.2.3 Tracking and Data Management

Most environmental monitoring samples and analytical results were tracked in BNL's Environmental Information Management System (EIMS), a database system used to store, manage, verify, protect, retrieve, and archive BNL's environmental data. A small number of environmental samples that were not tracked in the EIMS were analyzed at a contract analytical laboratory (Chemtex Lab) that cannot produce the electronic data deliverable package needed to enter the data into the EIMS. Tracking is initiated when a sample is recorded on a COC form. Copies of the COC forms and supplemental forms are provided to the project manager or the sample coordinator and forwarded to the data coordinator to be entered into the EIMS. Each contract analytical laboratory also maintains its own internal sample tracking system (also known as a Laboratory Information Management System).

Following sample analysis, the contract analytical laboratory sends the results to the BNL chemist and project manager for initial review. When required by project-specific DQOs, the analytical data may also be sent to a BNL contract chemist for full data validation. Once results of the analyses are determined to be complete and of acceptable quality, the data are entered into the EIMS. Once entered into EIMS, reports can be generated using a web-based data query tool.

9.3 SAMPLE ANALYSIS

In 2020, environmental samples were analyzed by five contract analytical laboratories, whose selection is discussed in Section 9.3.1. All samples were analyzed according to EPA-approved methods or by standard industry methods where no EPA methods are available. In addition, field sampling technicians performed field monitoring for parameters such as conductivity, dissolved oxygen, pH, temperature, and turbidity.

9.3.1 Qualifications

BNL used the following five contract analytical laboratories for analysis of environmental samples in 2020:

1. American Radiation Services (ARS) in Port Allen, Louisiana, for radiological analytes.
2. Chemtex Lab in Port Arthur, Texas, for select nonradiological analytes.
3. General Engineering Lab (GEL) in Charleston, South Carolina, for radiological and nonradiological analytes.
4. PACE Lab in Melville, New York, for nonradiological analytes; and
5. Test America (TA), based in St. Louis, Missouri, for radiological and nonradiological analytes.

The process of selecting contract analytical laboratories involves the following factors:

1. Maintaining required NYSDOH certifications for the specific analyses to be performed, as applicable.
2. Their record on performance evaluation (PE) tests.
3. Their contract with the DOE Integrated Contract Procurement Team.
4. Pre-selection bidding; and
5. Adherence to their own QA/QC programs, which must be documented and provided to BNL.

Routine QC procedures that laboratories must follow, as discussed in Section 9.5, include daily instrument calibrations, efficiency and background checks, and standard tests for precision and accuracy. Four of the five laboratories contracted by BNL in 2020 were certified by the New York State Department of Health (NYSDOH) for the relevant analytes, where such certification existed. NYSDOH does not currently certify for the specific analytes tested by Chemtex Lab (e.g., tolyltriazole), which has Texas National Environmental Laboratory Accreditation Program (NELAP) accreditation. The laboratories also were subject to PE testing and DOE-sponsored audits (see Section 9.7).

9.4 VERIFICATION AND VALIDATION OF ANALYTICAL RESULTS

Environmental monitoring data are subject to data verification and, in certain cases, data validation when the data quality objectives of the project require this step. For example, groundwater samples undergo data verification, whereas analytical results for specific waste streams undergo a full validation.

The data verification process involves checking for common errors associated with analytical data. The following criteria can cause data to be rejected during the data verification process:

- *Holding time missed* – The analysis was not initiated, or the sample was not extracted, within the time frame required by EPA or by the contract.
- *Incorrect test method* – The analysis was not performed according to a method required by the contract.
- *Poor recovery* – The compounds or radioisotopes added to the sample before laboratory processing were not recovered at the recovery ratio required by the applicable analytical method/performance criteria.
- *Insufficient QA/QC data* – Supporting data received from the contract analytical laboratory were insufficient to allow for the verification or validation of results.
- *Incorrect minimum detection limit (MDL)* – The contract analytical laboratory reported extremely low levels of analytes as "less than minimum detectable," but the contractually required limit is not used.
- *Invalid chain-of-custody* – There was a failure to maintain proper custody of samples as documented on COC forms.
- *Instrument failure* – The instrument did not perform correctly.
- *Preservation requirements not met* – The requirements identified by the specific analytical method were not met or properly documented.
- *Contamination of samples from outside sources* – Possible sources include sampling equipment, personnel, and the contract analytical laboratory.

Table 9-1. Summary of Detections in Trip and Field Blank Samples.

Constituent	Number of Analyses	Number of Detects	Minimum	Maximum	Typical Reporting Limit	Units
Trip Blank Results						
Bromoform	91	1	0.14	0.14	0.5	µg/L
Chloroform	91	3	0.17	0.28	0.5	µg/L
Tetrachloroethylene	91	1	8.9	8.9	0.5	µg/L
Trichloroethylene	91	1	0.19	0.19	0.5	µg/L
Trichlorofluoromethane	91	1	3.9	3.9	0.5	µg/L
Methyl chloride	91	1	0.19	0.19	0.5	µg/L
Styrene	89	2	0.35	0.61	0.5	µg/L
1,1,1-Trichloroethane	91	1	0.29	0.29	0.5	µg/L
Field Blank Results						
Organic Compounds						
1,2,3-Trichlorobenzene	27	1	0.61	0.61	0.5	µg/L
Trichloroethylene	29	1	0.48	0.48	0.5	µg/L
Chloroform	29	2	0.25	0.34	0.5	µg/L
Metals						
Mercury	5	1	0.124	0.124	1	µg/L
Sodium	5	1	105	105	100	µg/L
Zinc	5	1	7.08	7.08	3.3	µg/L
General Chemistry Parameters						
Chloride	2	1	0.134	0.134	0.067	mg/L
Alkalinity (as CaCO3)	2	2	1.99	2.15	1.45	mg/L
Nitrogen	5	5	0.0382	0.065	0.033	mg/L
TDS	5	2	4.29	48.6	3.4	mg/L
Total Kjeldahl Nitrogen	5	5	0.0382	0.065	0.033	mg/L
Ammonia (as N)	5	5	0.0192	0.0219	0.017	mg/L

µg/L Micrograms per liter.
mg/L Milligrams per liter.

- *Matrix interference* – Analysis was affected by dissolved inorganic/organic materials in the matrix.

Data validation involves a more extensive process than data verification. Validation includes all the verification checks, as well as checks for less common errors, including instrument calibration that was not conducted as required, internal standard errors, transcription errors, and calculation errors. The amount of data checked varies, depending on the environmental media and on the DQOs for each project. Data for some projects, such as long-term groundwater monitoring, may require only verification.

During the 2020 characterization of the per- and polyfluoroalkyl substances (PFAS) plumes associated with BNL's current and former firehouse facilities, approximately 25 percent of the data packages were validated by a contract chemist. Furthermore, verification was performed on 20 to 100 percent of the analytical results for some waste streams to satisfy QA requirements.

The results of the verification or validation process are entered into the EIMS. When analyses are determined to be outside of QC parameters, a qualifier is applied to the result stored in the

EIMS. Results that have been rejected are qualified with an "R." Rejected results are not used in the preparation of this report.

The most common QC issue during 2020 was the detection of low-level contamination of trip, field, and method blanks used in VOC analyses. Results for the trip and field blanks are summarized in Table 9-1. This issue resulted in minor qualification of sample results. Minor violations of laboratory control sample results are also common. In most cases, the violations do not result in qualified sample results. Furthermore, during 2020, 19 samples sent for VOC analysis were analyzed outside technical holding times due to the laboratory transferring the samples between their testing facilities. As a result, the analytical data were rejected due to the holding time exceedances, and BNL had to provide new samples for analysis. The contract laboratory has since fixed its courier issues.

9.4.1 Checking Results

Nonradiological data analyzed in 2020 were verified and/or validated when required by project DQOs, BNL EM-SOPs, and/or EPA contract laboratory program guidelines (EPA 2012, EPA 2013). Radiological packages were verified and validated using BNL and DOE guidance documents (BNL 2017). During 2020, the verifications were conducted using a combination of manually checking hard copy data packages and by the use of a computer program developed by BNL to verify the completeness of the electronic data deliverable (EDD) before the data are entered into BNL's EIMS.

9.5 CONTRACT ANALYTICAL LABORATORY QA/QC

In 2020, procedures for calibrating instruments, analyzing samples, and assessing QC were consistent with EPA methodology. QC checks performed included: analyzing blanks and instrument background; using Amersham Radiopharmaceutical Company or National Institute for Standards and Technology (NIST) traceable standards; and analyzing reference standards, spiked samples, and duplicate samples. Analytical laboratory contracts specify analytes, methods, required detection limits, and deliverables, which include standard batch QA/QC performance checks. As part of the laboratory selection process, candidate laboratories are required to provide BNL with copies of their QA/QC manuals and QA program plans.

When discrepancies were found in field sampling designs, documented procedures, COC forms, data analyses, data processing systems, and QA software, or when failures in PE testing occur, nonconformance reports are generated. Following investigation into the root causes, corrective actions are taken and tracked to closure.

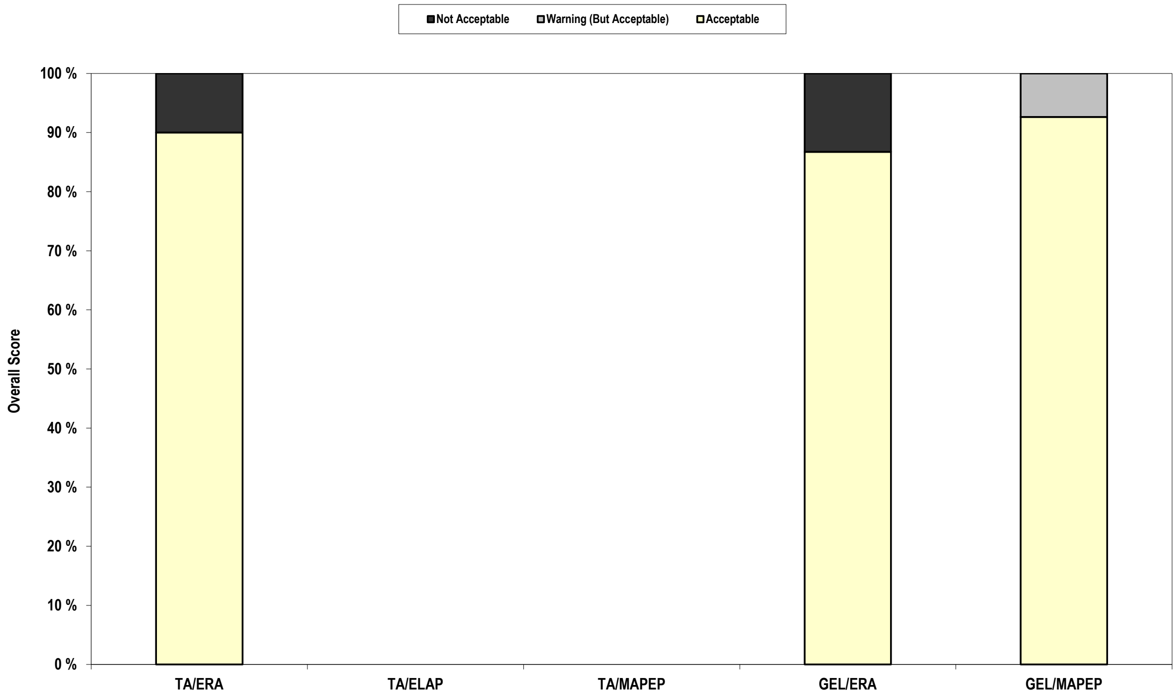
9.6 PERFORMANCE OR PROFICIENCY EVALUATIONS

Four of the contract analytical laboratories (ARS, GEL, PACE, and TA) participated in several national and state PE testing programs in 2020. Chemtex Lab did not participate in PE testing because there is no testing program for the specific analytes Chemtex analyzed for BNL (specifically for tolyltriazole, polypropylene glycol monobutyl ether, and 1,1-hydroxyethylidene diphosphonic acid). Each of the participating laboratories took part in at least one testing program, and several laboratories participated in multiple programs. Results of the tests provide information on the quality of a laboratory's analytical capabilities. The testing was conducted by Environmental Resource Associates (ERA), the DOE required Mixed Analyte Performance Evaluation Program (MAPEP), Resource Technology Corporation, Phenova, and the NYS- DOH Environmental Laboratory Accreditation Program (ELAP). The results from these tests are summarized in Section 9.6.1.

9.6.1 Summary of Test Results

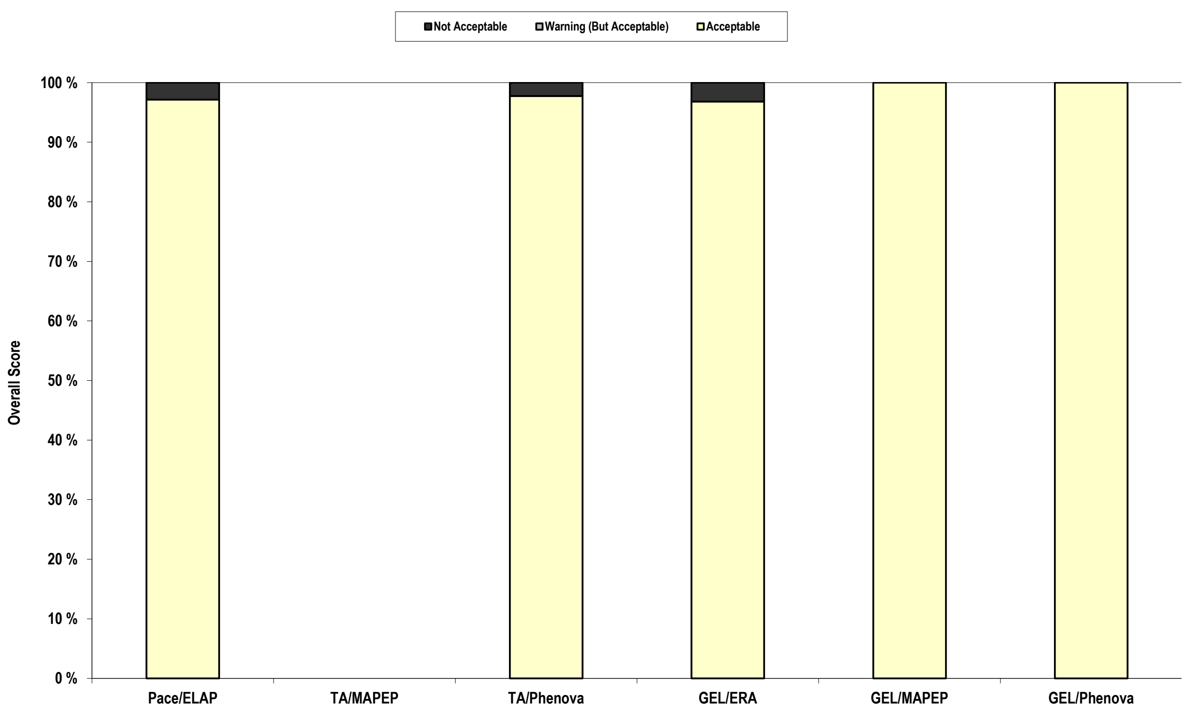
As shown by Figures 9-2 and 9-3, test results are plotted as percentage scores that were "Acceptable," "Warning (But Acceptable)," or "Not Acceptable." A Warning (But Acceptable) is considered by the testing organization to be "satisfactory." An "average overall satisfactory" score is the sum of results rated as Acceptable and those rated as Warning (But Acceptable), divided by the total number of results reported. A Not Acceptable rating reflects a result that is greater than three standard deviations from the known value—a criterion set by the independent testing organizations.

Table 9-2 provides a summary of the DOECAP audit results. TA had 3 Priority II findings, ARS has



Note that the Acceptable scores and the Warning (But Acceptable) scores combined constitute the "overall satisfactory" category referred to in the text of this chapter.

Figure 9-2. Summary of Scores in the Radiological Proficiency Evaluation Programs.



Note that the Acceptable scores and the Warning (But Acceptable) scores combined constitute the "overall satisfactory" category referred to in the text of this chapter.

Figure 9-3. Summary of Scores in the Nonradiological Proficiency Evaluation Programs.

Table 9-2. Summary Results of 2020 DOE CAP Audits*

Laboratory	Finding Priority	Area of Concentration	Number of Findings
Test America, Earth City, Missouri			
	I	Radiochemistry	NA
	II	Quality Assurance	3
	I	Organic Analyses	NA
	I	Inorganic Analyses and Wet Chemistry	NA
	I	Radiochemistry	NA
	I	Materials Management	NA
GEL Laboratories			
	II	Quality Assurance	NA
	II	Radiochemistry	NA
ARS International			
	I	Radiochemistry	NA
	II	Quality Assurance	10
	II	Organic Analyses	2
	II	Inorganic Analyses and Wet Chemistry	4
	II	Laboratory Information Management Systems	NA
	II	Materials Management	1

* There were no DOE CAP audits on these laboratories during 2020.

17 Priority II findings and GEL had no findings. Priority II findings are deviations from a requirement.

9.6.1.1 Radiological Assessments

GEL and TA participated in the ERA radiological PE studies. TA and GEL did not participate in the ELAP evaluations for 2020. Figure 9-2 summarizes radiological performance scores in the ERA and MAPEP programs. GEL had an average overall satisfactory score of 90 percent. TA also had an overall satisfactory score of 90 percent. For 2020, TA did not participate in the ELAP and MAPEP radiological Performance Tests.

9.6.1.2 Nonradiological Assessments

During 2020, PACE participated in the NYSDOH ELAP evaluations of performance on tests of nonpotable water, potable water, and solid wastes. NYSDOH found 97 percent of PACE's nonradiological tests to be in the Acceptable range. GEL participated in the ERA water supply and water pollution studies where 97 percent of GEL's tests were in the Acceptable range. GEL also participated in the MAPEP water supply and water pollution studies and received 100 in the Acceptable range.

TA and GEL participated in the Phenova Soil/Hazardous Waste and Water Pollution proficiency testing programs. Ninety-eight percent of TA's results were in the Acceptable range and 100 percent of GEL's results were in the Acceptable range.

Figure 9-3 summarizes the non-radiological performance results of three of the four participating laboratories (GEL, Pace, and TA) in the ERA, MAPEP, Phenova, and ELAP tests. For nonradiological tests, the laboratories received overall satisfactory result of 98 percent. TA did not participate in the MAPEP non-radiological PTs for 2020.

9.7 AUDITS

As part of DOE's Consolidated Audit Program (DOECAP), TA was audited in 2020 (ANAB 2020a) by ANSIASQ National Accreditation Board (ANAB). During the audits, three nonconformities were cited. In all instances concerning parameters required by BNL, these findings did not affect BNL data.

ARS was assessed by ANAB and approval was given in March 2020 (ANAB 2020a). GEL was not assessed during 2020; they are scheduled for an ANAB audit during 2021. Although Pace was not assessed during 2020, a NYSDOH audit is scheduled for 2021.

Based on the audit and assessments, the analytical laboratories met the criteria of the audit programs for Acceptable status.

9.8 CONCLUSION

The data validations, data verifications, and DQO checks conducted on analytical results at BNL are designed to eliminate any data that fails to meet the DQO of each project. The results of the independent PE assessments and assessments of contractor laboratories summarized in this report are also used to assess the quality of the results. Therefore, the data used in this Site Environmental Report are of acceptable quality.

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Acronyms and Abbreviations

These acronyms and abbreviations reflect the typical manner in which terms are used for this specific document and may not apply to all situations. Items with an asterisk (*) are described in the glossary of technical terms, which follows this list.

AEC	Atomic Energy Commission
AFV	Alternative Fuel Vehicles
AGS	Alternating Gradient Synchrotron
ALARA*	"As Low As Reasonably Achievable"
AMSL	above mean sea level
AMU	atomic mass unit
AOC*	area of concern
APG	Analytical Products Group
ARARs	Applicable, Relevant, and Appropriate Requirements
ARPA*	Archeological Resource Protection Act
ARRA	American Recovery and Reinvestment Act
AS/SVE*	air sparging/soil vapor extraction
AST	aboveground storage tank
ATF	Accelerator Test Facility
AWQS	Ambient Water Quality Standards
BAF	Booster Applications Facility
BGD	belowground duct
BGEPA	Bald and Golden Eagle Protection Act
BGRR	Brookhaven Graphite Research Reactor
BHSO	DOE Brookhaven Site Office
BLIP	Brookhaven Linac Isotope Producer
BMRR	Brookhaven Medical Research Reactor
BNL	Brookhaven National Laboratory
BOD*	biochemical oxygen demand
Bq*	becquerel
Bq/g	becquerel per gram
Bq/L	becquerel per liter
BRAHMS	Broad Range Hadron Magnetic Spectrometer
BSA	Brookhaven Science Associates
Btu	British thermal units
CAA*	Clean Air Act
CAAA*	CAA Amendments (1990)
CAC	Community Advisory Council
CAFE	Corporate Average Fuel Economy
CAP	Clean Air Act Assessment Package
CBS	chemical bulk storage
CCR	Consumer Confidence Report
CCWF	Central Chilled Water Facility
CEDR	Consolidated Energy Data Report
CEMS	continuous emission monitoring systems
CERCLA*	Comprehensive Environmental Response, Compensation and Liability Act
Cf-252	californium-252
CFC-11	chloroflourocarbon an ozone- depleting refrigerant
cfm, cfs	cubic feet per minute, per second
CFN	Center for Functional Nanomaterials
CFR	U.S. Code of Federal Regulations
CHP	combined heat and power
Ci*	curie
CO COC*	certificate to operate chain-of-custody
CRM	Cultural Resource Management
CRMP	Cultural Resource Management Plan
Cs	cesium
CSF	Central Steam Facility
CSI	Computational Science Initiative
CTN	Center for Transitional Neuroimaging
CVO	Contractor Vendor Orientation
CWA*	Clean Water Act
CY	calendar year
D2O*	heavy water
DAC	Derived Air Concentration
DCA	1,1-dichloroethane
DCE	1,1-dichloroethylene
DCG*	derived concentration guide
D&D	decontamination and decommissioning
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DMR	Discharge Monitoring Report
DOE*	U.S. Department of Energy
DOE CH	DOE Chicago Operations Office
DQO	Data Quality Objective
DSA	Documented Safety Analysis
DSB	Duct Service Building
DUV – FEL	Deep UltraViolet – Free Electron Laser
DWS	Drinking Water Standards
EA*	Environmental Assessment
EBIS	Electron Beam Ion Source
ECM	Energy Conservation Measures
EDB*	ethylene dibromide
EDE*	Effective Dose Equivalent
EDTA	ethylenediaminetetraacetic acid
EE/CA	Engineering Evaluation/Cost Analysis
EE-IOCPA	Energy Employees Occupational Illness Compensation Program Act

EIMS* Environmental Information Management System
EISA Energy Independence and Security Act
ELAP Environmental Laboratory Approval Program
EML Environmental Measurements Laboratory
EMP Environmental Monitoring Plan
EMS* Environmental Management System
EO Executive Order
EPA* U.S. Environmental Protection Agency
EPCRA* Emergency Planning and Community Right-to-Know Act
EPEAT Electronic Product Environmental Assessment Tool
EPD Environmental Protection Division
EPP Environmentally Preferable Purchasing
ERP Environmental Restoration Projects
ERA Environmental Resource Associates
ERD Environmental Restoration Division
ES* environmental surveillance
ESF SUNY School of Environmental Science and Forestry
ESPC Energy Savings Performance Contract
ESR Experimental Safety Review
ES&H Environment, Safety, and Health
ESA* Endangered Species Act
ESH&Q Environment, Safety, Health, and Quality Directorate
ESPC Energy Savings Performance Contract
ESSH Environmental Safety, Security and Health
FaST Facility and Student Teams Program
FAMS Facility area monitors
FCA Facility Condition Assessment
FCM Facility Complex Manager
FEMP Federal Emergency Management Program
FERN Foundation for Ecological Research in the Northeast
FFCA* Federal Facilities Compliance Act
FFA Federal Facilities Agreement
FHWMF Former Hazardous Waste Management Facility
FIFRA* Federal Insecticide, Fungicide, and Rodenticide Act
FM Facility Monitoring
FPM Facility Project Manager
FRP Facility Response Plan
FWS* U.S. Fish & Wildlife Service
FY fiscal year
GBq giga (billion or E+09) becquerel
GAB gross alpha and beta
GC/ECD gas chromatography/electron capture detector
GC/MS gas chromatography/mass spectrometry
GDS Groundwater Discharge Standard
GEL General Engineering Laboratory, LLC
GeV giga (billion) electron volts
gge gas gallon equivalent
GHG Greenhouse Gas
GIS Geographical Information System
GPG Groundwater Protection Group
GSA US General Services Administration
GSF gross square feet
GWh gigawatt hour
GWP Global warming potential
HEPA high efficiency particulate air
HFBR High Flux Beam Reactor
HFCs Hydrofluorocarbons
HITL Heavy Ion Transfer Line
HPRS Health Physics Reporting System
HPSB High Performance and Sustainable Buildings
HSS Health, Safety and Security
HTO tritiated water (liquid or vapor)
HVAC heating/ventilation/air conditioning
HWMF Hazardous Waste Management Facility
I Iodine
IAEA International Atomic Energy Agency
IAG Interagency Agreement
IC ion chromatography
ICP/MS inductively coupled plasma/mass spectrometry
IGA Investment Grade Audit
ILA industrial, landscaping, and agricultural
IPM Integrated Pest Management
ISB Interdisciplinary Science Building
ISMS Integrated Safety Management System
ISO* International Organization for Standardization
K potassium
kBq kilobecquerels (1,000 Bq)
KeV kilo (thousand) electron volts
Kr kryptonite
kwH kilowatt hours
LDR Land Disposal Restriction
LED light emitting diode
LEED Leadership in Energy and Environmental Design
LIE Long Island Expressway
LIMS Laboratory Information Management System
Linac Linear Accelerator
LIPA Long Island Power Authority
LISF Long Island Solar Farm
LTRA Long Term Remedial Action
mA milli-amperes
M&V Measurement and Verification
MACT Maximum Available Control Technology
MAPEP Mixed Analyte Performance Evaluation Program
MAR Materials-at-risk
MBTA Migratory Bird Treaty Act
MCL maximum contaminant level

MDL*	minimum detection limit
MEG	Miller Environmental Group
MEI*	maximally exposed individual
MEOSI	maximally exposed off-site individual
MeV	million electron volts
MGD	million gallons per day
mg/L	milligrams per liter
MMBtu	million British thermal units
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MPF	Major Petroleum Facility
MPN	most probable number
MPO	Modernization Project Office
mrem	milli (thousandth of a) rem
MRC	Medical Research Center
MRI	Magnetic Resonance Imaging
MSL*	mean sea level
mSv	millisievert
MTBE	methyl tertiary butyl ether
MW	megawatt
NA	not analyzed
NCRP	National Council on Radiation Protection and Measurements
ND	not detected
NEAR	Neighbors Expecting Accountability and Remediation
NELAC	National Environmental Laboratory Accreditation Conference
NELAP	National Environmental Laboratory Accreditation Program
NEPA*	National Environmental Policy Act
NESHAPs*	National Emission Standards for Hazardous Air Pollutants
ng/J	nano (one-billionth) gram per Joule
NHPA*	National Historic Preservation Act
NHTSA	National Highway Traffic Safety Administration
NIST	National Institute for Standards and Technology
nm	nanometer
NNSS	Nevada National Security Site
NO2	nitrogen dioxide
NOV	Notice of Violation
NOX*	nitrogen oxides
NOEC	no observable effect concentration
NPDES	National Pollutant Discharge Elimination System
NR	not required
NRMP	Natural Resource Management Plan
NS	not sampled
NSERC	Northeast Solar Energy Research Center
NSF-ISR	NSF-International Strategic Registrations, Ltd.
NSLS	National Synchrotron Light Source
NSLS-II	National Synchrotron Light Source II
NSPS	new source performance standards
NSRC	Nanoscale Science Research Centers
NSRL	NASA Space Radiation Laboratory
NT	not tested
NTS	Nevada Test Site
NYCRR*	New York Codes, Rules, and Regulations
NYISO	New York Independent System Operator
NYPA	New York Power Authority
NYS	New York State
NYSDEC	NYS Department of Environmental Conservation
NYSDOH	NYS Department of Health
NYSHPO	NYS Historic Preservation Office
O_3*	ozone
O&M	Operation and Maintenance
ODS	ozone-depleting substances
OEP	Office of Education Programs
OFIs	opportunities for improvement
OHSAS	Occupational Health and Safety Assessment Series
OMC	Occupational Medical Clinic
ORC	oxygen-releasing compound
ORNL	Oak Ridge National Laboratory
ORPS*	Occurrence Reporting and Processing System
OSHA	Occupational Health and Safety Administration
OSSP	Open Space Stewardship Program
OU*	operable unit
P2*	pollution prevention
PAAA*	Price-Anderson Act Amendment
PAF	Process Assessment Form
Pb	lead
PBT	persistent, bioaccumulative, and toxic
PCBs*	polychlorinated biphenyls
PCE	tetrachloroethylene (or perchloroethylene)
pCi/g	picocuries per gram
PE	performance evaluation
PEMP	Performance Evaluation Management Plan
PET	positron emission tomography
PFCs	Perfluorocarbons
PIC	potential impact category
ppb	parts per billion
ppm	parts per million
ppt	parts per trillion
PPTRS	Pollution Prevention Tracking System
PRAP	Proposed Remedial Action Plan
PUE	Power Utilization Effectiveness
PV	photovoltaic
QA*	quality assurance
QAPP	Quality Assurance Program Plan
QC*	quality control
QCU	quantum chromodynamics

QM	Quality Management
R-11 (etc.)	ozone-depleting refrigerant
RA*	removal action
RACT	Reasonably Available Control Technology
RATA	Relativistic accuracy test
RCA	recycled concrete aggregate
RCRA*	Resource Conservation and Recovery Act
RD/RA	Remedial Design/Remedial Action
REC	Renewable Energy Credit
RF	resuspension factor
RHIC	Relativistic Heavy Ion Collider
ROD*	Record of Decision
RPD	relative percent difference
RSB	Research Support Building
RWMB	Radioactive Waste Management Basis
RWP	Radiological Work Permit
S&M	surveillance and maintenance
SARA*	Superfund Amendments and Reauthorization Act
SBMS*	Standards Based Management System
SCDHS	Suffolk County Department of Health Services
SCR	Special Case Resource
SCR	Stakeholder and Community Relations
SCSC	Suffolk County Sanitary Code
SDL	Source Development Laboratory
SDWA*	Safe Drinking Water Act
SER	Site Environmental Report
SI	International System (measurement units)
SNS	standard not specified
SO2	sulfur dioxide
SOP	standard operating procedure
SPB	Southern Pine Beetle
SPCC	Spill Prevention Control and Countermeasures
SPDES*	State Pollutant Discharge Elimination System
SPO	Sustainability Performance Office
SPOFOA	Sustainability Performance Office Funding Opportunity Announcement
Sr	strontium
SSP	Site Sustainability Plan
SSPP	Strategic Sustainability Performance Plan
STAR	Solenoid Tracker at RHIC
STEM	Scanning Transmission Electron Microscope
STL	Severn Trent Laboratories, Inc.
STP	Sewage Treatment Plant
SU	standard unit
SULI	Science Undergraduate Laboratory Internship
SUNY	State University of New York
Sv*	sievert; unit for assessing radiation dose risk
SVE*	soil vapor extraction
SVOC*	semivolatile organic compound
$t_{1/2}$*	half-life
TA	Test America
TBq	tera (trillion, or E+12) becquerel
TCA	1,1,1-trichloroethane
TCAP	Transportation Safety and Operations Compliance Assurance Process
TCE*	trichloroethylene
TCLP	toxicity characteristic leaching procedure
TEAM	Transformational Energy Action Management
TED	Total Effective Dose
TEDE	Total Effective Dose Equivalent
TKN	Total Kjeldahl nitrogen
TLD*	thermoluminescent dosimeter
TPL	Target Processing Laboratory
TRE	Toxic Reduction Evaluation
TRI	Toxic Release Inventory
TSCA*	Toxic Substances Control Act
TTA	Tolytriazole
TVDG	Tandem Van de Graaff
TVOC*	total volatile organic compounds
UESC	Utility Energy Services Contract
µg/L	micrograms per liter
UIC*	underground injection control
UPS	uninterrupted power supplies
UST*	underground storage tank
VFP	Visiting Faculty Program
VOC*	volatile organic compound
VUV*	very ultraviolet
WAC	waste acceptance criteria
WBS	Work Breakdown Structure
WCPP	Waste Certification Program Plan
WCF	Waste Concentration Facility
WET	Whole Effluent Toxicity
WLA	Waste Loading Area
WM	Waste Management
WMF	Waste Management Facility
WTP	Water Treatment Plant
ZEV	zero emission vehicle

Technical Terms

These definitions reflect the typical manner in which the terms are used for this specific document and may not apply to all situations. Bold-face words in the descriptions are defined in separate entries.

A

AA (atomic absorption) – A spectroscopy method used to determine the elemental composition of a sample. In this method, the sample is vaporized and the amount of light it absorbs is measured.

accuracy – The degree of agreement of a measurement with an accepted reference or true value. It can be expressed as the difference between two values, as a percentage of the reference or true value, or as a ratio of the measured value and the reference or true value.

activation – The process of making a material radioactive by bombardment with neutrons, protons, or other high energy particles.

activation product – A material that has become radioactive by bombardment with neutrons, protons, or other high energy particles.

activity – Synonym for radioactivity.

Administrative Record – A collection of documents established in compliance with **CERCLA**. Consists of information the CERCLA lead agency uses in its decision on the selection of response actions. The Administrative Record file should be established at or near the facility and made available to the public. An Administrative Record can also be the record for any enforcement case.

aerobic – An aerobic organism is one that lives, acts, or occurs only in the presence of oxygen.

aerosol – A gaseous suspension of very small particles of liquid or solid.

ALARA (As Low As Reasonably Achievable) – A phrase that describes an approach to minimize exposures to individuals and minimize releases of radioactive or other harmful material to the **environment** to levels as low as social, technical, economic, practical, and public policy considerations will permit. ALARA is not a dose limit, but a process with a goal to keep dose levels as far below applicable limits as is practicable.

alpha radiation – The emission of alpha particles during radioactive decay. Alpha particles are identical in makeup to the nucleus of a helium atom and have a positive charge. Alpha radiation is easily stopped by materials as thin as a sheet of paper and has a range in air of only an inch or so. Despite its low penetration ability, alpha radiation is densely ionizing and therefore very damaging when ingested or inhaled. Naturally occurring radioactive sources such as radon emit alpha radiation.

air stripping – A process for removing **VOCs** from contaminated water by forcing a stream of air through the water in a vessel. The contaminants evaporate into the air stream. The air may be further treated before it is released into the atmosphere.

ambient air – The surrounding atmosphere, usually the outside air, as it exists around people, animals, plants, and structures. It does not include the air immediately adjacent to emission sources.

analyte – A constituent that is being analyzed.

anneal – To heat a material and then cool it. In the case of thermoluminescent dosimeters (TLDs), this is done to reveal the amount of radiation the material had absorbed.

anion – A negatively charged ion, often written as a superscript negative sign after an element symbol, such as Cl^-.

anthropogenic – Resulting from human activity; anthropogenic radiation is human-made, not naturally occurring.

AOC (area of concern) – Under **CERCLA**, this term refers to an area where releases of hazardous substances may have occurred or a location where there has been a release or threat of a release of a hazardous substance, pollutant, or contaminant (including **radionuclides)**. AOCs may include, but need not be limited to, former spill areas, landfills, surface impoundments, waste piles, land treatment units, transfer stations, wastewater treatment units, incinerators, container storage areas, scrap yards, cesspools, tanks, and associated piping that are known to have caused a release into the environment or whose integrity has not been verified.

aquifer – A water-saturated layer of rock or soil below the ground surface that can supply usable quantities of **groundwater** to wells and springs. Aquifers can be a source of water for domestic, agricultural, and industrial uses.

ARPA (Archaeological Resources Protection Act) – This law, passed in 1979, has been amended four times. It protects any material remains of past human life or activities that are of archaeological interest. Known **and potential** sites of interest are protected from uncontrolled excavations and pillage, and artifacts found on public and Indian lands are banned from commercial exchange.

AS/SVE (air sparging/soil vapor extraction) – A method of extracting **volatile organic compounds** from the **groundwater**, in place, using compressed air. (In contrast, air stripping occurs in a vessel.) The vapors are typically collected using a soil vapor extraction system.

B

background – A sample or location used as reference or control to compare BNL analytical results to those in areas that could not have been impacted by BNL operations.

background radiation – **Radiation** present in the environment as a result of naturally occurring radioactive materials in the Earth, cosmic radiation, or human-made radiation sources, including fallout.

beta radiation – Beta radiation is composed of charged particles emitted from a nucleus during radioactive decay. A negatively charged beta particle is identical to an electron. A positively charged beta particle is called a positron. Beta radiation is more penetrating than alpha radiation, but it may be stopped by materials such as aluminum or Lucite™ panels. Naturally occurring radioactive elements such as potassium-40 emit beta radiation.

blank – A sample (usually reagent-grade water) used for quality control of field sampling methods, to demonstrate that cross contamination has not occurred.

blowdown – Water discharged from either a boiler or cooling tower in order to prevent the build-up of inorganic matter within the boiler or tower and to prevent scale formation (i.e., corrosion).

BOD (biochemical oxygen demand) – A measure of the amount of oxygen in biological processes that breaks down organic matter in water; a measure of the organic pollutant load. It is used as an indicator of water quality.

Bq (becquerel) – A quantitative measure of **radioactivity**. This alternate measure of activity is used internationally and with increasing frequency in the United States. One Bq of activity is equal to one nuclear decay per second.

bremsstrahlung – Translates as "fast braking" and refers to electromagnetic radiation produced by the sudden retardation of a charged particle in an intense electric field.

C

CAA (Clean Air Act), CAA Amendments (CAAA) – The original Clean Air Act was passed in 1963, but the U.S. air pollution control program is based on the 1970 version of the law. The 1990 Clean Air Act Amendments (CAAA) are the most far-reaching revisions of the 1970 law. In common usage, references to the CAA typically mean to the 1990 amendments. (*source*: EPA's "Plain English Guide to the Clean Air Act" glossary, accessed 3-7-05)

caisson – A watertight container used in construction work under water or as a foundation.

cap – A layer of natural or synthetic material, such as clay or gunite, used to prevent rainwater from penetrating and spreading contamination. The surface of the cap is generally mounded or sloped so water will drain off.

carbon adsorption/carbon treatment – A treatment system in which contaminants are removed from **groundwater**, surface water, and air by forcing water or air through tanks containing activated carbon (a specially treated material that attracts and holds or retains contaminants).

carbon tetrachloride – A poisonous, nonflammable, colorless liquid, CCl_4.

CERCLA (Comprehensive Environmental Response, Compensation and Liability Act) – Pronounced "sir-klah" and commonly known as Superfund, this law was enacted by Congress on December 11, 1980. It created a tax on the chemical and petroleum industries and provided broad federal authority to respond directly to releases or threatened releases of hazardous substances that may endanger public health or the environment. CERCLA established prohibitions and requirements concerning closed and abandoned hazardous waste sites; provided for liability of persons responsible for releases of hazardous waste at these sites; and established a trust fund to provide for cleanup when no responsible party could be identified

The law authorizes two kinds of response actions: short-term removals, where actions may be taken to address releases or threatened releases requiring prompt response, and long-term remedial response actions that permanently and significantly reduce the dangers associated with releases or threats of releases of hazardous substances that are serious, but not immediately life threatening. These actions can be conducted only at sites listed on **EPA's** National Priorities List (NPL). CERCLA was amended by the Superfund Amendments and Reauthorization Act **(SARA)** on October 17, 1986, accessed 03-7-05)

CFR (Code of Federal Regulations) – A codification of all regulations developed and finalized by federal agencies in the Federal Register. The CFR is arranged by "title," with Title 10 covering energy- and radiation-related issues, and Title 40 covering protection of the environment. Subparts within the titles are included in citations, as in "40 CFR Subpart H."

characterization – Facility or site sampling, monitoring, and analysis activities to determine the extent and nature of contamination. Characterization provides the basis of necessary technical information to select an appropriate cleanup alternative.

Ci (curie) – A quantitative measure of radioactivity. One Ci of activity is equal to 3.7E+10 decays per second. One curie has the approximate activity of 1 gram of radium. It is named after Marie and Pierre Curie, who discovered radium in 1898.

Class GA groundwater – New York State Department of Environmental Conservation classification for high quality groundwater, where the best intended use is as a source of drinking water supply.

closure – Under **RCRA** regulations, this term refers to a hazardous or solid waste management unit that is no longer operating and where potential hazards that it posed have been addressed (through clean up, immobilization, capping, etc.) to the satisfaction of the regulatory agency.

CO_2 equivalent (CO_2e) – The universal unit of measurement to indicate the GWP of each of the six GHGs expressed in terms of the GWP of one unit of CO_2. It is used to evaluate the release (or the avoided release) of different GHG emissions against a common basis, and is commonly expressed as metirc tons carbon dioxide equivalent ($MtCO_2e$), which is calculated by multiplying the metric tons of GHG by its GWP.

COC (chain-of-custody) – A method for documenting the history and possession of a sample from the time of collection, through analysis and data reporting, to its final disposition.

cocktail – a mixture of chemicals used for **scintillation** counting.

collective Effective Dose Equivalent – A measure of health risk to a population exposed to radiation. It is the sum of the **EDEs** of all individuals within an exposed population, frequently considered to be within 50 miles (80 kilometers) of an environmental release point. It is expressed in person-**rem** or person-**sievert**.

Committed Effective Dose Equivalent – The total **EDE** received over a 50-year period following the internal deposition of a **radionuclide**. It is expressed in **rems** or **sieverts**.

composite sample – A sample of an environmental medium containing a certain number of sample portions collected over a period of time, possibly from different locations. The constituent samples may or may not be collected at equal time intervals over a predefined period of time, such as 24 hours.

confidence interval – A numerical range within which the true value of a measurement or calculated value lies. In the SER, radiological values are shown with a 95 percent confidence interval: there is a 95 percent probability that the true value of a measurement or calculated value lies within the specified range. *See also* “Uncertainty” discussion in Appendix B.

conservative – Estimates that err on the side of caution because all possibly deleterious components are included at generous or high values.

contamination – Unwanted radioactive and/or hazardous material that is dispersed on or in equipment, structures, objects, air, soil, or water.

control – *See* **background.**

cooling water – Water used to cool machinery and equipment. *Contact* cooling water is any wastewater that contacts machinery or equipment to remove heat from the metal; *noncontact* cooling water has no direct contact with any process material or final product. *Process wastewater* cooling water is water used for cooling that may have become contaminated through contact with process raw materials or final products.

cover boards – Sheets of plywood placed on the ground near ponds to serve as attractive habitat for salamanders, as part of a population study.

curie – *See* **Ci**.

CWA (Clean Water Act) – Growing public awareness and concern for controlling water pollution led to enactment of the Federal Water Pollution Control Act Amendments of 1972. As amended in 1977, this law became commonly known as the Clean Water Act. It established the basic structure for regulating discharges of pollutants into the waters of the United States, giving **EPA** the authority to implement pollution control programs such as setting wastewater standards for industry. The CWA also continued requirements to set water quality standards for all contaminants in surface waters and made it unlawful for any person to discharge any pollutant from a **point source** into navigable waters unless a permit was obtained. The CWA also funded the construction of sewage treatment plants and recognized the need for planning to address the critical problems posed by **nonpoint source pollution**.

Revisions in 1981 streamlined the municipal construction grants process. Changes in 1987 phased out the construction grants program. Title I of the Great Lakes Critical Programs Act of 1990 put into place parts of the Great Lakes Water Quality Agreement of 1978, signed by the U.S. and Canada; the two nations agreed to reduce certain toxic pollutants in the Great Lakes. Over the years many other laws have changed parts of the CWA, accessed 03-7-05).

D

D_2O – *See* **heavy water**.

daughter, progeny – A given **nuclide** produced by radioactive decay from another nuclide (the “parent”). *See also* **radioactive series**.

DCG (derived concentration guide) – The concentration of a **radionuclide** in air or water that, under conditions of continuous exposure for one year by a single pathway (e.g., air inhalation, absorption, or ingestion), would result in an effective dose equivalent of 100 mrem (1 mSv). The values were established in **DOE Order 5400.5**.

decay product – A **nuclide** resulting from the radioactive disintegration of a **radionuclide**, being formed either directly or as a result of successive transformations in a radioactive series. A decay product may be either radioactive or stable.

decontamination – The removal or reduction of **radioactive** or hazardous contamination from facilities, equipment, or soils by washing, heating, chemical or electrochemical action, mechanical cleaning, or other techniques to achieve a stated objective or end condition.

disposal – Final placement or destruction of waste.

DOE (Department of Energy) – The federal agency that promotes scientific and technical innovation to support the national, economic, and energy security of the United States. DOE has responsibility for 10 national laboratories and for the science and research conducted at these laboratories, including Brookhaven National Laboratory.

DOE Order 231.1A – This order, Environment, Safety, and Health Reporting, is dated 8/19/03. It replaces the 1995 version, Order 231.1, as well as the “ORPS” order, DOE Order 232.1A, Occurrence Reporting and Processing of Operations Information, dated 7/21/97, and Order 210.1, Performance Indicator…, dated 9/27/95.

DOE Order 450.1A – This order, Environmental Protection Program, is dated 6/04/08. It revises DOE Order 450.1, issued in January 2003, to incorporate and implement the new requirements of Executive Order 13423, Strengthening Federal Environmental, Energy, and Transportation Management, issued in January 2007.

DOE Order 5400.5 – This order, Radiation Protection of the Public and the Environment, was first published by **DOE** in 1990 and was modified in 1993. It established the standards and requirements for operations of DOE and DOE contractors with respect to protecting the public and the **environment** against undue risk from radiation.

dose – *See* **EDE**.

dosimeter – A portable detection device for measuring exposure to ionizing radiation. See Chapter 8 for details.

downgradient – In the direction of **groundwater** flow from a designated area; analogous to “downstream.”

DQO (Data Quality Objective) –The Data Quality Objective (DQO) process was developed by EPA for facilities to use when describing their environmental monitoring matrices, sampling methods, locations, frequencies, and measured parameters, as well as methods and procedures for data collection, analysis, maintenance, reporting, and archiving. The DQO process also addresses data that monitor quality assurance and quality control.

drift fence – A stretch of temporary fencing to prevent an animal population from leaving the area, used at BNL as part of a population study.

dry weight – The dry weight concentration of a substance is after a sample is dried for analysis. Dry weight concentrations are typically higher than wet weight values.

D-waste – Liquid waste containing radioactivity.

E

EA (Environmental Assessment) – A report that identifies potentially significant effects from any federally approved or funded project that might change the physical **environment**. If an EA identifies a “significant” potential impact (as defined by **NEPA**), an Environmental Impact Statement (EIS) must be researched and prepared.

EDB (ethylene dibromide) – A colorless, nonflammable, heavy liquid with a sweet odor; slightly soluble in water. Although the U.S. Department of Health and Human Services has determined that ethylene dibromide may reasonably be anticipated to be a carcinogen, it is still used to treat felled logs for bark beetles; to control wax moths in beehives; as a chemical intermediary for dyes, resins, waxes, and gums; to spot-treat milling machinery; and to control Japanese beetles in ornamental plants.

EDE (Effective Dose Equivalent) – A value used to express the health risk from radiation exposure to tissue in terms of an equivalent whole body exposure. It is a "normalized" value that allows the risk from radiation exposure received by a specific organ or part of the body to be compared with the risk due to whole-body exposure. The EDE equals the sum of the doses to different organs of the body multiplied by their respective **weighting factors**. It includes the sum of the EDE due to radiation from sources external to the body and the committed effective dose equivalent due to the internal deposition of **radionuclides**. EDE is expressed in **rems** or **sieverts**.

effluent – Any liquid discharged to the environment, including stormwater **runoff** at a site or facility.

EIMS (Environmental Information Management System) – A database system used to store, manage, verify, protect, retrieve, and archive BNL's environmental data.

EM (environmental monitoring) – Sampling for contaminants in air, water, sediment, soil, food stuffs, plants, and animals, either by directly measuring or by collecting and analyzing samples.

emissions – Any gaseous or particulate matter discharged to the atmosphere.

EMS (Environmental Management System) – The BNL EMS meets the requirements of the **ISO 14001 EMS standard**, with emphasis on compliance assurance, pollution prevention, and community outreach. An extensive environmental monitoring program is one component of BNL's EMS.

environment – Surroundings (including air, water, land, natural resources, flora, fauna, and humans) in which an organization operates, and the interrelation of the organization and its surroundings.

environmental aspect – Elements of an organization's activities, products, or services that can interact with the surrounding air, water, land, natural resources, flora, fauna, and humans.

environmental impact – Any change to the surrounding air, water, land, natural resources, flora, and fauna, whether adverse or beneficial, wholly or partially resulting from an organization's activities, products, or services.

environmental media – Includes air, **groundwater**, surface water, soil, flora, and fauna.

environmental monitoring or **surveillance** – *See* **EM**.

EPA (U. S. Environmental Protection Agency) – The federal agency responsible for developing and enforcing environmental laws. Although state or local regulatory agencies may be authorized to administer environmental regulatory programs, EPA generally retains oversight authority.

EPCRA (Emergency Planning and Community Right-to-Know Act) – Also known as Title III of SARA, EPCRA was enacted by Congress as the national legislation on community safety, to help local groups protect public health, safety, and the environment from chemical hazards. To implement EPCRA, Congress required each state to appoint a State Emergency Response Commission (SERC). The SERCs were required to divide their states into Emergency Planning Districts and to name a Local Emergency Planning Committee for each district.

Broad representation by fire fighters, health officials, government and media representatives, community groups, industrial facilities, and emergency managers ensures that all necessary elements of the planning process are represented.

ES (environmental surveillance) – Sampling for contaminants in air, water, sediment, soil, food stuffs, plants, and animals, either by directly measuring or by collecting and analyzing samples.

ESA (Endangered Species Act) – This provides a program for conserving threatened and endangered plants and animals and their habitats. The **FWS** maintains the list of 632 *endangered* species (326 are plants) and 190 *threatened* species (78 are plants). Species include birds, insects, fish, reptiles, mammals, crustaceans, flowers, grasses, and trees. Anyone can petition FWS to include a species on this list. The law prohibits any action, administrative or real, that results in a "taking" of a listed species *or* adversely affects habitat. Likewise, import, export, interstate, and foreign commerce of listed species are all prohibited. **EPA**'s decision to register pesticides is based in part on the risk of adverse effects on endangered species as well as environmental fate (how a pesticide will affect habitat). Under **FIFRA**, EPA can issue emergency suspensions of certain pesticides to cancel or restrict their use if an endangered species will be adversely affected.

evapotranspiration – A process by which water is transferred from the soil to the air by plants that take the water up through their roots and release it through their leaves and other aboveground tissue.

exposure – A measure of the amount of ionization produced by x-rays or gamma rays as they travel through air. The unit of radiation exposure is the roentgen (R).

F

fallout – Radioactive material, made airborne as a result of aboveground nuclear weapons testing, that has been deposited on the Earth's surface.

FFCA (Federal Facility Compliance Act) – Formerly, the federal government maintained that it was not subject to fines and penalties under solid and hazardous waste law because of the doctrine of "sovereign immunity." The State of Ohio challenged this in *Ohio v. the Department of Energy (1990)*. The U.S. Circuit Court of Appeals found in favor of the State (June 11, 1990), writing that the federal government's sovereign immunity is waived under both the **CWA** sovereign immunity provision and **RCRA**'s citizen suit provision. The Circuit Court decision was overturned by the Supreme Court on April 21, 1992, in *DOE v. Ohio*, which held that the waiver of sovereign immunity in RCRA and CWA is not clear enough to allow states to impose civil penalties directly. After the high court's ruling, the consensus among lawmakers was that a double standard existed: the same government that developed laws to protect human health and the environment and required compliance in the private sector, was itself not assuming the burden of compliance. As a result, Congress enacted the FFCA (October 6, 1992, Pub. Law 102-386), which effectively overturned the Supreme Court's ruling. In the legislation Congress specifically waived sovereign immunity with respect to RCRA for federal facilities.

Under section 102, FFCA amends section 6001 of RCRA to specify that federal facilities are subject to "all civil and administrative penalties and fines, regardless of whether such penalties or fines are punitive or coercive in nature." These penalties and fines can be levied by **EPA** or by authorized states. In addition, FFCA states that "the United States hereby expressly waives any immunity otherwise applicable to the United States." Although federal agents, employees, and officers are not liable for civil penalties, they are subject to criminal sanctions. No departments, agencies, or instrumentalities are subject to criminal sanctions. Section 104 (1) and (2) require EPA to conduct annual RCRA inspections of all federal facilities.

FIFRA (Federal Insecticide, Fungicide, and Rodenticide Act) – The primary focus of this law was to provide federal control of pesticide distribution, sale, and use. **EPA** was given authority under FIFRA not only to study the consequences of pesticide usage but also to require users (farmers, utility companies, and others) to register when purchasing pesticides. Through later amendments to the law, users also must take exams for certification as applicators of pesticides. All pesticides used in the U.S. must be registered (licensed) by EPA. Registration assures that pesticides will be properly labeled and that if used in accordance with specifications, will not cause unreasonable harm to the environment.

FS (feasibility study) – A process for developing and evaluating remedial actions using data gathered during the remedial investigation. The FS defines the objectives of the remedial program for the site and broadly develops remedial action alternatives, performs an initial screening of these alternatives, and performs a detailed analysis of a limited number of alternatives that remain after the initial screening stage.

FWS (U.S. Fish & Wildlife Service) – The U.S. Fish and Wildlife Service is the principal federal agency responsible for conserving, protecting, and enhancing fish, wildlife, plants, and their habitats for the continuing benefit of the people of the United States. FWS manages the 95-million-acre National Wildlife Refuge System, which encompasses 544 national wildlife refuges, thousands of small wetlands, and other special management areas. It also operates 69 national fish hatcheries, 64 fishery resources offices, and 81 ecological services field stations. The agency enforces federal wildlife laws, administers the Endangered Species Act, manages migratory bird populations, restores nationally significant fisheries, conserves and restores wildlife habitat such as wetlands, and helps foreign and Native American tribal governments with their conservation efforts. It also oversees the Federal Assistance Program, which distributes hundreds of millions of dollars in excise taxes on fishing and hunting equipment to state fish and wildlife agencies.

fugitive source – Unanticipated sources of volatile hazardous air pollutants due to leaks from valves, pumps, compressors, relief valves, connectors, flanges, and various other pieces of equipment.

G

gamma radiation – Gamma radiation is a form of electromagnetic radiation, like radio waves or visible light, but with a much shorter wavelength. It is more penetrating than **alpha** or **beta** radiation, capable of passing through dense materials such as concrete.

gamma spectroscopy – This analysis technique identifies specific **radionuclides**. It measures the particular energy of a radionuclide's gamma radiation emissions. The energy of these emissions is unique for each nuclide, acting as a "fingerprint."

geotextile – A product used as a soil reinforcement agent and as a filter medium. It is made of synthetic fibers manufactured in a woven or loose manner to form a blanket-like product.

grab sample – A single sample collected at one time and place.

Green Building – Construction that adheres to guidelines established by the Green Building Council, a coalition of leaders from across the building industry working to promote structures that are environmentally responsible, profitable, and healthy places to live and work.

greenhouse gas (GHG) – Carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6).

global warming potential (GWP) – A factor describing the ratiative forcing impact of one unti of a given GHG relative to one unti of CO_2.

groundwater – Water found beneath the surface of the ground (subsurface water). Groundwater usually refers to a zone of complete water saturation containing no air.

gunite – A mixture of cement, sand, and water sprayed over a mold to form a solid, impermeable surface. Formerly a trademarked name, now in general usage.

H

half-life ($t_{1/2}$) – The time required for one-half of the atoms of any given amount of a radioactive substance to disintegrate; the time required for the activity of a radioactive sample to be reduced by one half.

halon – An ozone-depleting fire suppressant; suffixes (-1301, etc.) indicate variants.

hazardous waste – Toxic, corrosive, reactive, or ignitable materials that can injure human health or damage the environment. It can be liquid, solid, or sludge, and include heavy metals, organic solvents, reactive compounds, and corrosive materials. It is defined and regulated by **RCRA**, Subtitle C.

heat input – The heat derived from combustion of fuel in a steam generating unit. It does not include the heat from preheated combustion air, recirculated flue gases, or the exhaust from other sources.

heavy water (D_2O) – A form of water containing deuterium, a non-radioactive isotope of hydrogen.

herpetofaunal – Relating to the study of reptiles.

hot cell – Shielded and air-controlled facility for the remote handling of radioactive material.

hydrofluorocarbons (HFCs) – One of six primary GHGs primarily used as refrigerants; a class of gases containing hydrogen, fluorine, and carbon, and possessing a range of GWP values from 12 to 11,700.

hydrology – The science dealing with the properties, distribution, and circulation of natural water systems.

I

inert – Lacking chemical or biological action.

influent – Liquid (such as stormwater runoff or wastewater) flowing into a reservoir, basin, or treatment plant.

intermittent river – A stream that dries up on occasion, usually as a result of seasonal factors or decreased contribution from a source such as a wastewater treatment plant.

ionizing radiation – Any radiation capable of displacing electrons from atoms or molecules, thereby producing ions. High doses of ionizing radiation may produce severe skin or tissue damage. *See also* **alpha, beta, gamma radiation; x-rays**.

ISO 14001 EMS standard – The International Organization for Standardization (ISO) sets standards for a wide range of products and management operations. Following the success of the ISO 9000 Standards for quality management, ISO introduced the 14000 series for environmental management. BNL was the first DOE Office of Science laboratory to obtain third-party registration to this globally recognized environmental standard.

isotope – Two or more forms of a chemical element having the same number of protons in the nucleus (the same atomic number), but having different numbers of neutrons in the nucleus (different atomic weights). Isotopes of a single element possess almost identical chemical properties.

L

leaching – The process by which soluble chemical components are dissolved and carried through soil by water or some other percolating liquid.

light water – As used in this document, tap water, possibly filtered.

liquid scintillation counter – An analytical instrument used to quantify tritium, carbon-14, and other beta-emitting **radionuclides**. *See also* **scintillation**.

M

matrix, matrices – The natural context (e.g., air, vegetation, soil, water) from which an environmental sample is collected.

MDL (minimum detection limit) – The lowest level to which an analytical parameter can be measured with certainty by the analytical laboratory performing the measurement. While results below the MDL are sometimes measurable, they represent values that have a reduced statistical confidence associated with them (less than 95 percent confidence).

MEI (maximally exposed individual) – The hypothetical individual whose location and habits tend to maximize his/her radiation dose, resulting in a dose higher than that received by other individuals in the general population.

metamorphic – In the state of changing from larval to mature forms.

mixed waste – Waste that contains both a hazardous waste component (regulated under Subtitle C of **RCRA**) and a radioactive component.

monitoring – The collection and analysis of samples or measurements of effluents and emissions for the purpose of characterizing and quantifying contaminants, and demonstrating compliance with applicable standards.

monitoring well – A well that collects **groundwater** for the purposes of evaluating water quality, establishing groundwater flow and elevation, determining the effectiveness of treatment systems, and determining whether administrative or engineered controls designed to protect groundwater are working as intended.

MSL (mean sea level) – The average height of the sea for all stages of the tide. Used as a benchmark for establishing groundwater and other elevations.

N

NEPA (National Environmental Policy Act) – Assures that all branches of government give proper consideration to the environment before any land purchase or any construction projects, including airports, buildings, military complexes, and highways. Project planners must assess the likely impacts of the project by completing an Environmental Assessment (EA) and, if necessary, an Environmental Impact Statement (EIS).

NESHAPs (National Emissions Standards for Hazardous Air Pollutants) – Standards that limit emissions from specific sources of air pollutants linked to serious health hazards. NESHAPs are developed by **EPA** under the CAA. Hazardous air pollutants can be chemical or radioactive. Their sources may be human-made, such as vehicles, power plants, and industrial or research processes, or natural, such as radioactive gas in soils.

neutrino – A small, neutral particle created as a result of particle decay. Neutrinos were believed to be massless, but recent studies have indicated that they have small, but finite, mass. Neutrinos interact very weakly.

NHPA (National Historic Preservation Act) – With passage of the National Historic Preservation Act in 1966, Congress made the federal government a full partner and a leader in historic preservation. The role of the federal government is fulfilled through the National Park Service. State participation is through State Historic Preservation Offices. "Before 1966, historic preservation was mainly understood in one-dimensional terms: the proverbial historic shrine or Indian burial mound secured by lock and key—usually in a national park—set aside from modern life as an icon for study and appreciation. NHPA largely changed that approach, signaling a much broader sweep that has led to the breadth and scope of the vastly more complex historic preservation mosaic we know today."

nonpoint source pollution – Nonpoint source pollution occurs when rainfall, snowmelt, or irrigation water runs over land or through the ground, picks up pollutants, and deposits them into rivers, lakes, and coastal waters or introduces them into **groundwater**. Nonpoint source pollution also includes adverse changes to the hydrology of water bodies and their associated aquatic habitats. After Congress passed the Clean Water Act in 1972, the nation's water quality community emphasized **point source** pollution (coming from a discrete conveyance or location, such as industrial and municipal waste discharge pipes). Point sources were the primary contributors to the degradation of water quality then, and the significance of nonpoint source pollution was poorly understood. Today, nonpoint source pollution remains the largest source of water quality problems. It is the main reason that approximately 40 percent of surveyed rivers, lakes, and estuaries are not clean enough to meet basic uses such as fishing or swimming.

NO_x – Nitrogen oxides are gases consisting of one molecule of nitrogen and varying numbers of oxygen molecules. Nitrogen oxides are produced, for example, by the combustion of fossil fuels in vehicles and electric power plants. In the atmosphere, NO_x can contribute to the formation of smog, impair visibility, and have health consequences. NO_x are considered "criteria air pollutants" under the CAA.

nuclide – A species of atom characterized by the number of protons and neutrons in the nucleus.

NYCRR (New York Codes, Rules, and Regulations) The NYCRR primarily contains state agency rules and regulations adopted under the State Administrative Procedure Act. There are 22 Titles: one for each state department, one for miscellaneous agencies and one for the Judiciary. Title 6 addresses environmental conservation, so many references in the SER are to "6 NYCRR."

O

O_3 – *See* ozone.

on site – The area within the boundaries of a site that is controlled with respect to access by the general public.

opacity – Under the Clean Air Act (**CAA**), a measurement of the degree to which smoke (emissions other than water vapor) reduces the transmission of light and obscures the view of an object in the background.

ORPS (Occurrence Reporting and Processing System) A system for identifying, categorizing, notifying, investigating, analyzing, and reporting to DOE events or conditions discovered at the BNL site. It was originally established by DOE Order 232.1, which has been replaced by **DOE Order 231.1A**.

OU (operable unit) – Division of a contaminated site into separate areas based on the complexity of the problems associated with it. Operable units may address geographical portions of a site, specific site problems, or initial phases of an action. They may also consist of any set of actions performed over time, or actions that are concurrent, but located in different parts of a site. An OU can receive specific investigation and a particular remedy may be proposed. A Record of Decision (**ROD**) is prepared for each OU.

outfall – The place where wastewater is discharged.

oxides of nitrogen (NO_x) – *See* **NO_x**.

ozone (O_3) – A very reactive type of oxygen formed naturally in the upper atmosphere which provides a shield for the earth from the sun's ultraviolet rays. At ground level or in the lower atmosphere, it is pollution that forms when oxides of nitrogen and hydrocarbons react with oxygen in the presence of strong sunlight. Ozone at ground level can lead to health effects and cause damage to trees and crops.

P

P2 (pollution prevention) – Preventing or reducing the generation of pollutants, contaminants, hazardous substances, or wastes at the source, or reducing the amount for treatment, storage, and disposal through recycling. Pollution prevention can be achieved through reduction of waste at the source, segregation, recycle/reuse, and the efficient use of resources and material substitution. The potential benefits of pollution prevention include the reduction of adverse environmental impacts, improved efficiency, and reduced costs.

PAAA (Price-Anderson Act Amendments) – The Price-Anderson Act (PAA) was passed in 1957 to provide for prompt compensation in the case of a nuclear accident. The PAA provided broad financial coverage for damage, injury, and costs, and required DOE to indemnify contractors. The amended act of 1988 (PAAA) extended indemnification for 15 years and required DOE to establish and enforce nuclear safety rules. The PAAA Reauthorization, passed in December of 2002, extended current indemnification levels through 2004. 10 CFR 820 and its Appendix A provide DOE enforcement procedure and policy.

Parshall flume – An engineered channel used to measure the flow rate of water. It was named after the inventor, who worked for the U.S. government as an irrigation research engineer.

PCBs (polychlorinated biphenyls) – A family of organic compounds used from 1926 to 1979 (when they were banned by **EPA**) in electrical transformers, lubricants, carbonless copy paper, adhesives, and caulking compounds. PCBs are extremely persistent in the environment because they do not break down into different and less harmful chemicals. PCBs are stored in the fatty tissues of humans and animals through the bioaccumulation process.

percent recovery – For analytical results, the ratio of the measured amount, divided by the known (spiked) amount, multiplied by 100.

perfluorocarbons (PFCs) – One of the six primary GHGs consisting of a class of gases containing carbon and fluorine typically emitted as by-products of industrial and manufacturing processes, and possessing GWPs ranging from 5,700 to 11,900.

permit – An authorization issued by a federal, state, or local regulatory agency. Permits are issued under a number of environmental regulatory programs, including **CAA**, **CWA**, **RCRA**, and **TSCA**. Permits grant permission to operate, to discharge, to construct, and so on. Permit provisions may include emission/effluent limits and other requirements such as the use of pollution control devices, monitoring, record keeping and reporting. Also called a "license" or "certificate" under some regulatory programs.

pH – A measure of hydrogen ion concentration in an aqueous solution. Acidic solutions have a pH less than 7, neutral solutions have a pH of 7, and basic solutions have a pH greater than 7 and up to 14.

plume – A body of contaminated **groundwater** or polluted air flowing from a specific source. The movement of a groundwater plume is influenced by such factors as local groundwater flow patterns, the character of the aquifer in which groundwater is contained, and the density of contaminants. The movement of an air contaminant plume is influenced by the ambient air motion, the temperatures of the ambient air and of the plume, and the density of the contaminants.

point source – Any confined and discrete conveyance (e.g., pipe, ditch, well, or stack) of a discharge.

pollutant – Any hazardous or radioactive material naturally occurring or added to an environmental medium, such as air, soil, water, or vegetation.

potable water – Water of sufficient quality for use as drinking water without endangering the health of people, plants, or animals.

precision – A statistical term describing the dispersion of data around a central value, usually represented as a variance, standard deviation, standard error, or confidence interval.

putrescible waste – Garbage that contains food and other organic biodegradable materials. There are special management requirements for this waste in 6 **NYCRR** Part 360.

Q

QA (quality assurance) – In environmental monitoring, any action to ensure the reliability of monitoring and measurement data. Aspects of QA include procedures, inter-laboratory comparison studies, evaluations, and documentation.

QC (quality control) – In environmental monitoring, the routine application of procedures to obtain the required standards of performance in monitoring and measurement processes. QC procedures include calibration of instruments, control charts, and analysis of replicate and duplicate samples.

qualifier – A letter or series of letter codes in a graph or chart indicating that the associated value did not meet analytical requirements or was estimated.

quenching – Anything that interferes with the conversion of decay energy to electronic signal in the photomultiplier tubes of detection equipment, usually resulting in a reduction in counting efficiency.

R

R (roentgen) – A unit of exposure to ionizing radiation. It is the amount of gamma or x-rays required to produce ions carrying one electrostatic unit of electrical charge in one cubic centimeter of dry air under standard conditions. It is named after the German scientist Wilhelm Roentgen, who discovered x-rays.

RA (removal actions, "removals") – Interim actions that are undertaken to prevent, minimize, or mitigate damage to the public health or environment that may otherwise result from a release or threatened release of hazardous substances, pollutants, or contaminants pursuant to **CERCLA**, and that are not inconsistent with the final remedial action. Under CERCLA, **EPA** may respond to releases or threats of releases of hazardous substances by starting an RA to stabilize or clean up an incident or site that immediately threatens public health or welfare. Removal actions are less comprehensive than **remedial** actions. However, removal actions must contribute to the efficiency of future remedial actions.

radiation – Some atoms possess excess energy, causing them to be physically unstable. Such atoms become stable when the excess energy is released in the form of charged particles or electromagnetic waves, known as radiation.

radiation event – A single detection of a charged particle or electromagnetic wave.

radioactive series – A succession of **nuclides**, each of which transforms by radioactive disintegration into the next until a stable nuclide results. The first member of the series is called the parent and the intermediate members are called daughters or progeny.

radioactivity – The spontaneous transition of an atomic nucleus from a higher energy to a lower energy state. This transition is accompanied by the release of a charged particle or electromagnetic waves from the atom. Also known as "activity."

radionuclide – A radioactive element characterized by the number of protons and neutrons in the nucleus. There are several hundred known radionuclides, both artificially produced and naturally occurring.

RCRA (Resource Conservation and Recovery Act) Pronounced "rick-rah," this act of Congress gave **EPA** the authority to control the generation, transportation, treatment, storage, and disposal of hazardous waste. RCRA also set forth a framework for the management of nonhazardous wastes. The 1986 amendments to RCRA enabled EPA to address environmental problems that could result from underground tanks storing petroleum and other hazardous substances. RCRA focuses only on active and future facilities and does not address abandoned or historical sites (*see* CERCLA). In 1984, amendments to RCRA called the Hazardous and Solid Waste Amendments (HSWA, pronounced "hiss-wa") required phasing out the land disposal of hazardous waste. Some other mandates of this strict law include increased enforcement authority for EPA, more stringent hazardous waste management standards, and a comprehensive underground storage tank (UST) program.

recharge – The process by which water is added to a zone of saturation (aquifer) from surface infiltration, typically when rainwater soaks through the earth to reach an aquifer.

recharge basin – A basin (natural or artificial) that collects water. The water will infiltrate to the aquifer.

release – Spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing of a hazardous substance, pollutant, or contaminant into the environment. The National Contingency Plan also defines the term to include a threat of release.

rem – Stands for "**roentgen** equivalent man," a unit by which human radiation dose is assessed (*see also* **Sv**). The rem is a risk-based value used to estimate the potential health effects to an exposed individual or population. 100 rem = 1 sievert.

remedial (or **remediation**) **alternatives** – Options considered under **CERCLA** for decontaminating a site such as an operable unit (**OU**) or area of concern (**AOC**). Remedial actions are long-term activities that prevent the possible release, or stop or substantially reduce the actual release, of substances that are hazardous but not immediately life-threatening. *See also* feasibility study (**FS**) and Record of Decision (**ROD**).

residual fuel – Crude oil, Nos. 1 and 2 fuel oil that have a nitrogen content greater than 0.05 weight percent, and all fuel oil Nos. 4, 5, and 6, as defined by the American Society of Testing and Materials in ASTM D396-78, *Standard Specifications for Fuel Oils,* (c. 2001).

riparian – An organism living on the bank of a river, lake, or tidewater.

ROD (Record of Decision) – A document that records a regulatory agency's decision for the selected remedial action. The ROD also includes a responsiveness summary and a bibliography of documents that were used to reach the remedial decision. When the ROD is finalized, remedial design and implementation can begin.

roentgen – *See* R.

RPD (relative percent difference) – A measure of precision, expressed by the formula: RPD = [(A-B)/(A+B)] x 200, where A equals the concentration of the first analysis and B equals the concentration of the second analysis.

runoff – The movement of water over land. Runoff can carry pollutants from the land into surface waters or uncontaminated land.

S

sampling – The extraction of a prescribed portion of an effluent stream or environmental media for purposes of inspection or analysis.

SARA (Superfund Amendments and Reauthorization Act) – This Act of Congress in 1986 reauthorized CERCLA to continue cleanup activities around the country. Several site-specific amendments, definitions clarifications, and technical requirements were added to the legislation, including additional enforcement authorities. Title III of SARA also authorized EPCRA.

SBMS (Standards-Based Management System) – A document management tool used to develop and integrate systems, and to demonstrate BNL's conformance to requirements to perform work safely and efficiently.

scintillation – Flashes of light produced in a phosphor by a radioactive material.

Scope 1 emissions – Direct greenhouse gas emissions from sources that are owned or controlled by a Federal agency.

Scope 2 emissions – Indirect greenhouse gas emissions resulting from the generation of electricity, heat, or steam purchased by a Federal agency.

Scope 3 emissions – Greenhouse gas emissions from sources not owned or directly controlled by a Federal agency, but related to agency activities such as vendor supply chains, delivery services, and employee travel and commuting.

SDWA (Safe Drinking Water Act) – The Safe Drinking Water Act was established to protect the quality of drinking water in the United States. It focuses on all waters actually or potentially designed for drinking use, whether from above ground or underground sources. The SDWA authorized **EPA** to establish safe standards of purity and required all owners or operators of public water systems to comply with health-related standards. State governments assume regulatory power from EPA.

sediment – The layer of soil and minerals at the bottom of surface waters, such as streams, lakes, and rivers.

sensitivity – The minimum amount of an analyte that can be repeatedly detected by an instrument.

sievert – *See* **Sv**.

skyshine – Radiation emitted upward from an open-topped, shielded enclosure and reflected downward, resulting in the possibility that flora and fauna (including humans) outside the shielded enclosure can be exposed to radiation.

sludge – Semisolid residue from industrial or water treatment processes.

sole source aquifer – An area defined by **EPA** as being the primary source of drinking water for a particular region. Includes the surface area above the sole source aquifer and its recharge area.

SPDES (State Pollutant Discharge Elimination System) This permit program is delegated to the states, but the effluent limitations and other requirements are set by the federal government. 6 NYCRR Section 750-1.11(a) concerns the provisions of SPDES permits and lists the citations for the various effluent limitations from the Federal Register and the **CFR**.

stable – Nonradioactive.

stakeholder – People or organizations with vested interests in BNL and its environment and operations. Stakeholders include federal, state, and local regulators; the public; DOE; and BNL staff.

stripping – A process used to remove volatile contaminants from a substance (*see also* **air stripping**).

sulfur hexafluoride (SF_6) – One of six primary GHGs, consisting of a single sulfur atom and six fluoride atoms, a GWP of 23,900, and primarily used in electrical transmission and distribution systems.

sump – A pit or tank that catches liquid **runoff** for drainage or disposal.

Sv (sievert) – A unit for assessing the risk of human radiation dose, used internationally and with increasing frequency in the United States. One sievert is equal to 100 rem.

SVE (soil vapor extraction) – An *in situ* (in-place) method of extracting **VOCs** from soil by applying a vacuum to the soil and collecting the air, which can be further treated to remove the VOCs, or discharged to the atmosphere.

SVOC – A general term for volatile organic compounds that vaporize relatively slowly at standard temperature and pressure. See also VOC.

synoptic – Relating to or displaying conditions as they occur over a broad area.

T

$t_{1/2}$ (half-life) – The time required for one-half of the atoms of any given amount of a radioactive substance to disintegrate; the time required for the activity of a radioactive sample to be reduced by one half.

TCE (trichloroethylene, also known as **trichloroethene)** A stable, colorless liquid with a low boiling point. TCE has many industrial applications, including use as a solvent and as a metal degreasing agent. TCE may be toxic when inhaled or ingested, or through skin contact, and can damage vital organs, especially the liver. *See also* **VOC**.

Tier III reports – Reports, required by SARA, that are prepared to document annual emissions of toxic materials to the environment. These are also known as TRI Section 313 reports.

TLD (thermoluminescent dosimeter) – A device used to measure radiation dose to occupational workers or radiation levels in the environment.

tritium – The heaviest and only radioactive nuclide of hydrogen, with a **half-life** of 12.3 years and a very-low-energy radioactive decay (tritium is a **beta** emitter).

TSCA (Toxic Substances Control Act) – Enacted by Congress in1976, TSCA empowers **EPA** to track the 75,000 industrial chemicals produced or imported into the United States. EPA repeatedly screens these chemicals and can require reporting or testing of any that may pose an environmental or human health hazard. EPA can ban the manufacture or import of chemicals that pose an unreasonable risk.

TVOC (total volatile organic compounds) – A sum of all individual **VOC** concentrations detected in a given sample.

U

UIC (underground injection control) – A hole with vertical dimensions greater than its largest horizontal dimensions; used for disposal of wastewater.

UST (underground storage tank) – A stationary device, constructed primarily of nonearthen material, designed to contain petroleum products or hazardous materials. In a UST, 10 percent or more of the volume of the tank system is below the surface of the ground.

upgradient/upslope – A location of higher **groundwater** elevation; analogous to “upstream.”

V

vadose – Relating to water in the ground that is above the permanent groundwater level.

vernal pool – A small, isolated, and contained basin that holds water on a temporary basis, most commonly during winter and spring. It has no aboveground outlet for water and is extremely important to the life cycle of many amphibians (such as the tiger salamander), as it is too shallow to support fish, a major predator of amphibian larvae.

VOC (volatile organic compound) –A general term for organic compounds capable of a high degree of vaporization at standard temperature and pressure. Because VOCs readily evaporate into the air, the potential for human exposure is greatly increased. Due to widespread industrial use, VOCs are commonly found in soil and groundwater.

VUV – Stands for “very ultraviolet” and refers to a beamline at the NSLS with wavelengths at the far ultraviolet end of the spectrum.

W

waste minimization – Action that avoids or reduces the generation of waste, consistent with the general goal of minimizing current and future threats to human health, safety, and the environment. Waste minimization activities include recycling, improving energy usage, reducing waste at the source, and reducing the toxicity of hazardous waste. This action is associated with pollution prevention, but is more likely to occur after waste has been generated.

water table – The water-level surface below the ground where the unsaturated zone ends and the saturated zone begins. It is the level to which a well that is screened in the unconfined aquifer will fill with water.

watershed – The region draining into a river, a river system, or a body of water.

weighting factor – A factor which, when multiplied by the dose equivalent delivered to a body organ or tissue, yields the equivalent risk due to a uniform radiation exposure of the whole body. *See also* **EDE**.

wet weight – The wet weight concentration of a substance is before a sample is dried for analysis (in other words, in its “natural” state), and is the form most likely to be consumed. Wet weight concentrations are typically lower than dry weight values.

wind rose – A diagram that shows the frequency of wind from different directions at a specific location.

X

x-rays – A form of electromagnetic **radiation** with short wavelength, generated when high-energy electrons strike matter or when lower-energy **beta** radiation is absorbed in matter. **Gamma** radiation and x-rays are identical, except for the source.

Z

zeolite – A naturally occurring group of more than 100 minerals, formed of silicates and aluminum, with unique and diverse crystal properties. Zeolites can perform ion exchange, filtering, odor removal, and chemical sieve and gas absorption tasks. Synthetic zeolites are now used for most applications.

Understanding Radiation

This section introduces the general reader to some basic concepts of radioactivity and an understanding of the radiation emitted as radioactive materials decay to a stable state. To better comprehend the radiological information in the Site Environmental Report (SER), it is important to remember that not all radiations are the same and that different kinds of radiation affect living beings differently.

This appendix includes discussions on the common sources of radioactivity in the environment, types of radiation, the analyses used to quantify radioactive material, and how radiation sources contribute to radiation dose. Some general statistical concepts are also presented, along with a discussion of radionuclides that are of environmental interest at Brookhaven National Laboratory (BNL).

The discussion begins with some definitions and background information on scientific notation and numerical prefixes used when measuring dose and radioactivity. The definitions of commonly used radiological terms are found in the Technical Topics section of the glossary, Appendix A, and are indicated in boldface type here only when the definition in the glossary provides additional details.

RADIOACTIVITY AND RADIATION

All substances are composed of atoms that are made of subatomic particles: protons, neutrons, and electrons. The protons and neutrons are tightly bound together in the positively charged nucleus (plural: nuclei) at the center of the atom. The nucleus is surrounded by a cloud of negatively charged electrons. Most nuclei are stable because the forces holding the protons and neutrons together are strong enough to overcome the electrical repulsive force that tries to push them apart. When the number of neutrons in the nucleus exceeds a threshold, then the nucleus becomes unstable and will spontaneously "decay," or emit excess energy ("nuclear" energy) in the form of charged particles or electromagnetic waves. Radiation is the excess energy released by un stable atoms. Radioactivity and radioactive refer to the unstable nuclear property of a substance (e.g., radioactive uranium).

Radiation that has enough energy to remove orbital electrons (a process called ionization) is classified as ionizing radiation. Radiation that does not have enough energy to remove electrons is called nonionizing radiation. Examples of nonionizing radiation include most visible light, infrared light, micro-waves, and radio waves. All radiation, whether ionizing or not, may pose health risks. In the SER, radia tion refers to ionizing radiation.

Radioactive elements (or radionuclides) are referred to by name followed by a number, such as cesium-137. The number indicates the mass of that element and the total number of neutrons and protons contained in the nucleus of the atom. Another way to specify cesium-137 is Cs-137, where Cs is the chemical symbol for cesium in the Periodic Table of the Elements. This type of abbreviation is used throughout the SER.

SCIENTIFIC NOTATION

Most numbers used for measurement and quan tification in the SER are either very large or very small, and many zeroes would be required to express their value. To avoid this, scientific notation is used, with numbers represented in multiples of 10. For example, the number two million five hundred thousand (two and a half million, or 2,500,000) is written in scientific notation as 2.5 x 106, which represents "2.5 multiplied by 10 raised to the power of 6." Since even "2.5 x 106" can be cumbersome, the capital letter E is sub stituted for the phrase "10 raised to the power of "Using this format, 2,500,000 is represented as 2.5E+06. The "+06" refers to the number of places the decimal point was moved to the left to create the shorter version. Scientific notation is also used to represent very small numbers approaching zero, in which case a minus sign follows the E rather

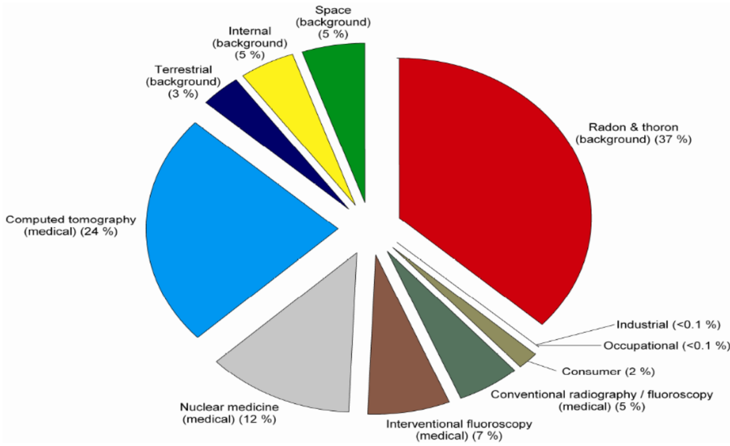

Figure B-1. Typical Annual Radiation Doses from Natural and Man-Made Sources (mrem). *Source: NCRP Report No. 160 (NCRP 2009)*

Figure B-1. Typical Annual Radiation Doses from Natural and Man Made Sources (mrem). Source: NCRP Report No. 160 (NCRP 2009) than a plus. For example, 0.00025 can be written as 2.5 x 10-4 or 2.5E-04. Here, "-04" indicates the number of places the decimal point was moved to the left.

NUMERICAL PREFIXES

Another method of representing very large or small numbers without using many zeroes is to use prefixes to represent multiples of ten. For example, the prefix milli (abbreviated m) means that the value being represented is one-thousandth of a whole unit; 3 mg (milligrams) is 3 thousandths of a gram or E-03. See Appendix C for additional common prefixes, including pico (p), which means trillionth or E-12, giga (G), which means billion or E+09, and tera (T), which means trillion, E+12.

SOURCES OF IONIZING RADIATION

Radiation is energy that has both natural and synthetic sources. Some radiation is essential to life, such as heat and light from the sun.

Exposure to high-energy (ionizing) radiation has to be managed, as it can pose serious health risks at large doses. Living things are exposed to radiation from natural background sources, such as the atmosphere, soil, water, food, and even our own bodies. Humans are exposed to ionizing radiation from a variety of common sources, the most significant of which follow.

Background Radiation – Radiation that occurs naturally in the environment is also called background activity. Background radiation consists of cosmic radiation from outer space, radiation from radioactive elements in soil and rocks, and radiation from radon and its decay products in air. Some people use the term background when referring to all non-occupational sources commonly present. Other people use natural to refer only to cosmic and terrestrial sources, and background to refer to common human-made sources such as medical procedures, consumer products, and radioactivity present in the atmosphere from former nuclear testing. In the SER, the term natural background is used to refer to radiation from cosmic and terrestrial radiation.

Cosmic – Cosmic radiation primarily consists of charged particles that originate in space, beyond the earth's atmosphere. This includes ionizing radiation from the sun, and secondary radiation generated by the entry of charged particles into the earth's atmosphere at high speeds and energies. Radioactive elements such as hydrogen-3 (tritium), beryllium-7, carbon-14, and sodium-22 are produced in the atmosphere by cosmic radiation. Exposure to cosmic radiation increases with altitude, because at higher elevations the atmosphere and the earth's magnetic field provide less shielding. Therefore, people who live in the mountains are exposed to more cosmic radiation than people who live at sea level. The average dose from cosmic radiation to a person living in the United States is approximately 31 mrem per year. (For an explanation of dose, see effective dose equivalent in Appendix A. The units rem and sieverts also are explained in Appendix A.)

Terrestrial – Terrestrial radiation is released by radioactive elements that have been present in the soil since the formation of the earth. Common radioactive elements that contribute to terrestrial exposure include isotopes of potassium, thorium, actinium, and uranium. The average dose from terrestrial radiation to a person living in the United States is approximately 21 mrem per year, but may vary considerably depending on the local geology.

Internal – Internal exposure occurs when radionuclides are ingested, inhaled, or absorbed through the skin. Radioactive material may be incorporated into food through the uptake of terrestrial radionuclides by plant roots. People can ingest radionuclides when they eat contaminated plant matter or meat from animals that have consumed contaminated plants. The average dose from food for a person living in the United States is about 31 mrem per year. A larger exposure, for most people, comes from breathing the decay products of naturally occurring radon gas. The average dose from breathing air with radon byproducts is about 230 mrem per year, but that amount varies depending on geographical location. An Environmental Protection Agency (EPA) map shows that BNL is located in one of the regions with the lowest potential radon risk.

Medical – Every year in the United States, millions of people undergo medical procedures that use ionizing radiation. Such procedures include chest and dental x-rays, Computed Tomography (CT), mammography, thallium heart stress tests, and tumor irradiation therapies. The average doses from primary sources of medical exposure are as follows: CT at 150 mrem, nuclear medicine at 74 mrem, and radiography/fluoroscopy at 74 mrem.

Anthropogenic – Sources of anthropogenic (human-made) radiation include consumer products such as static eliminators (containing polonium-210), smoke detectors (containing americium-241), cardiac pacemakers (containing plutonium-238), fertilizers (containing isotopes from uranium and thorium decay series), and tobacco products (containing polonium-210 and lead-210). The average dose from consumer products to a person living in the United States is 13 mrem per year (excluding tobacco contributions).

COMMON TYPES OF IONIZING RADIATION

The three most common types of ionizing radiation are described below.

Alpha Radiation – An alpha particle is identical in makeup to the nucleus of a helium atom, consisting of two neutrons and two protons Alpha particles have a positive charge and little or no penetrating power in matter. They are easily stopped by materials such as paper and have a range in air of only an inch or so. However, if alpha-emitting material is ingested, alpha particles can pose a health risk inside the body. Naturally occurring radioactive elements such as uranium emit alpha radiation.

Beta Radiation – Beta radiation is composed of particles that are identical to electrons. Therefore, beta particles have a negative charge. Beta radiation is slightly more penetrating than alpha radiation, but most beta radiation can be stopped by materials such as aluminum foil and plexiglass panels. Beta radiation has a range in air of several feet. Some naturally occurring radioactive elements, such as potassium-40, emit beta radiation. Beta particles present a hazard to the skin and eyes.

Gamma Radiation – Gamma radiation is a form of electromagnetic radiation, like radio waves or visible light, but with a much shorter wavelength. Gamma rays are emitted from a radioactive nucleus along with alpha or beta particles. Gamma radiation is more penetrating than alpha or beta radiation, capable of pass ing through dense materials such as concrete. Gamma radiation is identical to x-rays except that x-rays are less energetic. Only a fraction of the total gamma rays a person is exposed to will interact with the human body.

TYPES OF RADIOLOGICAL ANALYSES

The amount of radioactive material in a sample of air, water, soil, or other material can be assessed using several analyses, the most common of which are described below.

Gross alpha – Alpha particles are emitted from radioactive material in a range of different energies. An analysis that measures all alpha particles simultaneously, without regard to their particular energy, is known as a gross alpha activity measurement. This type of measurement is valuable as a screening tool to indicate the total amount but not the type of alpha-emitting radionuclides that may be present in a sample.

Gross beta – This is the same concept as that for gross alpha analysis, except that it applies to the measurement of gross beta particle activity.

Tritium – Tritium radiation consists of low-energy beta particles. It is detected and quan tified by liquid scintillation counting. More information on tritium is presented in the section Radionuclides of Environmental Interest, later in this appendix.

Strontium-90 – Due to the properties of the radiation emitted by strontium-90 (Sr-90), a special analysis is required. Samples are chemically processed to separate and collect any strontium atoms that may be present. The collected atoms are then analyzed separately. More information on Sr-90 is presented in the section Radionuclides of Environmental Interest.

Gamma – This analysis technique identifies specific radionuclides. It measures the particular energy of a radionuclide's gamma radiation emission. The energy of these emissions is unique for each radionuclide, acting as a "fingerprint" to identify it.

STATISTICS

Two important statistical aspects of measuring radioactivity are uncertainty in results and negative values.

Uncertainty – Because the emission of radiation from an atom is a random process, a sample counted several times usually yields a slightly different result each time; therefore, a single measurement is not definitive. To account for this variability, the concept of uncertainty is applied to radiological data. In the SER, analysis results are presented in an x ± y format, where "x" is the analysis result and "± y" is the 95 percent "confidence interval" of that result. That means there is a 95 percent probability that the true value of x lies between (x + y) and (x – y).

Negative values – There is always a small amount of natural background radiation. The laboratory instruments used to measure radioac tivity in samples are sensitive enough to measure the background radiation along with any con taminant radiation in the sample. To obtain a true measure of the contaminant level in a sample, the background radiation level must be subtracted from the total amount of radioactivity measured. Due to the randomness of radioactive emissions and the very low concentrations of some contaminants, it is possible to obtain a background measurement that is larger than the actual contaminant measurement. When the larger background measurement is subtracted from the smaller contaminant measurement, a negative result is generated. The negative results are reported, even though doing so may seem illogical, but they are essential when conducting statistical evaluations of data.

Radiation events occur randomly; if a radioactive sample is counted multiple times, a spread, or distribution, of results will be obtained. This spread, known as a Poisson distribution, is centered about a mean (average) value. Similarly, if background activity (the number of radiation events observed when no sample is present) is counted multiple times, it also will have a Poisson distribution. The goal of a radiological analysis is to determine whether a sample con tains activity greater than the background reading detected by the instrument.

Because the sample activity and the background activity readings are both Poisson distributed, subtraction of background activity from the measured sample activity may result in values that vary slightly from one analysis to the next. Therefore, the concept of a minimum detection limit (MDL) was established to determine the statistical likelihood that a sample's activity is greater than the background reading recorded by the instrument.

Identifying a sample as containing activity greater than background, when it actually does not have activity present, is known as a Type I error. Most laboratories set their acceptance of a Type I error at five percent when calculating the MDL for a given analysis. That is, for any value that is greater than or equal to the MDL, there is 95 percent confidence that it represents the detection of true activity.

At very low sample activity levels that are close to the instrument's background reading, it is possible to obtain a sample result that is less than zero. This occurs when the background activity is subtracted from the sample activity to obtain a net value and a negative value results. Due to this situation, a single radiation event observed during a counting period could have a significant effect on the mean (average) value result. Subsequent analysis may produce a sample result that is positive. When the annual data for the SER are compiled, results may be averaged; therefore, all negative values are retained for reporting as well. This data handling practice is consistent with the guidance provided in the Handbook of Radioactivity Measurements Procedures (NCRP 1985) and the Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance (DOE 1991).

Average values are calculated using actual analytical results, regardless of whether they are above or below the MDL, or even equal to zero. The uncertainty of the mean, or the 95 percent confidence interval, is determined by multiplying the sample standard deviation of the mean by the t(0.05) statistic.

RADIONUCLIDES OF ENVIRONMENTAL INTEREST

Several types of radionuclides are found in the environment at BNL due to historical operations.

Cesium-137 – Cs-137 is a fission-produced radionuclide with a half-life of 30 years (after 30 years, only one half of the original activity level remains). It is found in the worldwide environment as a result of past aboveground nuclear weapons testing and can be observed in near-surface soils at very low concentrations, usually less than 1 pCi/g (0.004 Bq/g). Cs-137 is a beta-emitting radionuclide, but it can be detected by gamma spectroscopy because its decay product, barium-137m, emits gamma radiation.

Cs-137 is found in the environment at BNL mainly as a soil contaminant, from two main sources. The first source is the worldwide deposi tion from nuclear accidents and fallout from weapons testing programs. The second source is deposition from spills or releases from BNL operations. Nuclear reactor operations produce Cs-137 as a byproduct. In the past, wastewater containing small amounts of Cs-137 generated at the reactor facilities was routinely discharged to the Sewage Treatment Plant (STP), result ing in low-level contamination of the STP and the Peconic River. In 2002 and 2003, under the Environmental Restoration Program, sand and its debris containing low levels of Cs-137, Sr-90, and heavy metals were removed, assur ing that future discharges from the STP are free of these contaminants. Soil contaminated with Cs-137 is associated with the following areas that have been, or are being, addressed as part of the Environmental Remediation Program: former Hazardous Waste Management Facility, Waste Concentration Facility, Building 650 Reclamation Facility and Sump Outfall Area, and the Brookhaven Graphite Research Reactor (BGRR).

Strontium-90 – Sr-90 is a beta-emitting ra dionuclide with a half-life of 28 years. Sr-90 is found in the environment principally as a result of fall-out from aboveground nuclear weapons testing. Sr-90 released by weapons testing in the 1950s and early 1960s is still present in the environment today. Additionally, nations that were not signatories of the Nuclear Test Ban Treaty of 1963 have contributed to the global inventory of fission products (Sr-90 and Cs-137). This radionuclide was also released as a result of the 1986 Chernobyl accident in the former Soviet Union.

Sr-90 is present at BNL in the soil and groundwater. As in the case of Cs-137, some Sr-90 at BNL results from worldwide nuclear testing; the remaining contamination is a by-product of reactor operations. The following areas with Sr-90 contamination have been or are being addressed as part of the Environmental Remediation Program: former Hazardous Waste Management Facility, Waste Concentration Facility, Building 650 Reclamation Facility and Sump Outfall Area, the BGRR, Former and Interim Landfills, Chemical and Glass Holes Area, and the STP.

The information in SER tables is arranged by method of analysis. Because Sr-90 requires a unique method of analysis, it is reported as a separate entry. Methods for detecting Sr-90 using state-of-the-art equipment are quite sensitive (detecting concentrations less than 1 pCi/L), which makes it possible to detect background levels of Sr-90.

Tritium – Among the radioactive materials that are used or produced at BNL, tritium has received the most public attention. Approximately four million Ci (1.5E+5 TBq) per year are pro duced in the atmosphere naturally (NCRP 1979).

As a result of aboveground weapons testing in the 1950s and early 1960s in the United States, the global atmospheric tritium inventory was increased by a factor of approximately 200. Other human activities such as consumer product manufacturing and nuclear power reactor operations have also released tritium into the environment.

Commercially, tritium is used in products such as self-illuminating wristwatches and exit signs (the signs may each contain as much as 25 Ci [925 GBq] of tritium). Tritium also has many uses in medical and biological research as a labeling agent in chemical compounds, and is frequently used in universities and other research settings such as BNL and other national laboratories.

Of the sources mentioned above, the most significant contributor to tritium in the environment has been aboveground nuclear weapons testing. In the early 1960s, the average tritium concentration in surface streams in the United States reached a value of 4,000 pCi/L (148 Bq/ L; NCRP 1979). Approximately the same concen tration was measured in precipitation. Today, the level of tritium in surface waters in New York State is less than one-twentieth of that amount, below 200 pCi/L (7.4 Bq/L; NYSDOH 1993). This is less than the detection limit of most ana lytical laboratories.

Tritium has a half-life of 12.3 years. When an atom of tritium decays, it releases a beta particle, causing transformation of the tritium atom into stable (nonradioactive) helium. The beta radia tion that tritium releases has a very low energy, compared to the emissions of most other radioac tive elements. In humans, the outer layer of dead skin cells easily stops the beta radiation from tritium; therefore, only when tritium is taken into the body can it cause an exposure. Tritium may be taken into the body by inhalation, ingestion, or absorption of tritiated water through the skin. Because of its low-energy radiation and short residence time in the body, the health threat posed by tritium is very small for most exposures.

Environmental tritium is found in two forms: gaseous elemental tritium and tritiated water or water vapor, in which at least one of the hydro gen atoms in the H2O water molecule has been replaced by a tritium atom (hence, its shorthand notation, HTO). Most of the tritium released from BNL sources is in the form of HTO, none as elemental tritium. Sources of tritium at BNL include the reactor facilities (all now non-operational), where residual water (either heavy or light) is converted to tritium via neutron bombardment; the accelerator facilities, where tritium is produced by secondary radiation interactions with soil and water; and facilities like the Brookhaven Linac Isotope Producer, (BLIP)where tritium is formed from secondary radiation interaction with cooling water. Tritium has been found in the environment at BNL as a groundwater contaminant from operations in the following areas: Current Landfill, BLIP, Alternating Gradient Synchrotron, and the High Flux Beam Reactor. Although small quantities of tritium are still being released to the environment through BNL emissions and effluents, the concentrations and total quantity have been drastically reduced, compared with historical operational releases as discussed in Chapters 4 and 5.

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Units of Measure and Half-Life Periods

UNITS OF RADIATION MEASUREMENT AND CONVERSIONS

U.S. System	International System	Conversion
curie (Ci)	becquerel (Bq)	1 Ci = 3.7 x 10^{10} Bq
rad	gray (Gy)	1 rad = 0.01 Gy
rem	sievert (Sv)	1 rem = 0.01 Sv

APPROXIMATE METRIC CONVERSIONS

When you know	multiply by	to obtain	When you know	multiply by	to obtain
centimeters (cm)	0.39	inches (in.)	in.	2.54	cm
meters (m)	3.28	feet (ft)	ft	0.305	m
kilometers (km)	0.62	miles (mi)	mi	1.61	km
kilograms (kg)	2.20	pounds (lb)	lb	0.45	kg
liters (L)	0.264	gallons (gal)	gal	3.785	L
cubic meters (m^3)	35.32	cubic feet (ft^3)	ft^3	0.03	m^3
hectares (ha)	2.47	acres	acres	0.40	ha
square kilometers (km^2)	0.39	square miles (mi^2)	mi^2	2.59	km^2
degrees Celcius (°C)	1.8 (°C) + 32	degrees Fahrenheit (°F)	°F	(°F - 32) / 1.8	°C

SCIENTIFIC NOTATION USED FOR MEASUREMENTS

Multiple	Decimal Equivalent	Notation	Prefix	Symbol
1 x 10^{12}	1,000,000,000,000	E+12	Tera-	T
1 x 10^{9}	1,000,000,000	E+9	giga-	G
1 x 10^{3}	1,000	E+03	kilo-	k
1 x 10^{-2}	0.01	E-02	centi-	c
1 x 10^{-3}	0.001	E-03	milli-	m
1 x 10^{-6}	0.000001	E-06	micro-	μ
1 x 10^{-9}	0.000000001	E-09	nano-	n
1 x 10^{-12}	0.000000000001	E-12	pico-	p

CONCENTRATION CONVERSIONS

1 ppm =	1,000 ppb			
1 ppb =	0.001 ppm	=	1μg/L*	
1 ppm =	1 mg/L	=	1000 μg/L*	

* For aqueous fractions only.

HALF-LIFE PERIODS	
Am-241	432.7 yrs
C-11	~20 min
Co-60	5.3 yrs
Cs-137	30.2 yrs
N-13	~10 min
N-22	2.6 yrs
O-15	~2 min
PU-238	87.7 yrs
Pu-239	24,100.0 yrs
Pu-240	6,560.0 yrs
Sr-90	29.1 yrs
tritium	12.3 yrs
U-234	247,000.0 yrs
U-235	~700 million yrs (7.0004E8)
U-238	~4.5 billion yrs (4.468E9)

Federal, State, and Local Laws and Regulations Pertinent to BNL

DOE DIRECTIVES, REGULATIONS, AND STANDARDS

DOE O 231.1B	Order: Admin Change 1: Environment, Safety and Health Reporting 11/28/2012
DOE O 414.1D	Order: Admin Change 1: Quality Assurance 05/08/2013
DOE O 435.1	Order: Change 1: Radioactive Waste Management 08/09/1999
DOE O 436.1	Departmental Sustainability 05/02/2011
DOE P 450.4A	Integrated Safety Management Policy 04/25/2011
DOE P 450.5	Policy: Line Environment, Safety, and Health Oversight 06/26/1997
DOE O 458.1	Order: Change 3: Radiation Protection of the Public and the Environment 02/15/2013
DOE-STD-1153-2019	A Graded Approach for Evaluation of Radiation Doses to Aquatic and Terrestrial Biota 02/12/2019
DOE-STD-1196-2011	Derived Concentration Technical Standard 05/05/2011

FEDERAL LAWS AND REGULATIONS

EO 13148	Greening of the Government Through Leadership in Environmental Management
EO 13693	Planning for Federal Sustainability in the Next Decade
10 CFR 1021	National Environmental Protection Act, Implementing and Procedures
10 CFR 1022	Compliance with Floodplain/Wetlands Environmental Review Requirements
10 CFR 830	Subpart A: Quality Assurance Requirements
10 CFR 834	Radiation Protection of the Public and the Environment
16 USC 470	National Historic Preservation Act
36 CFR 60	National Register of Historic Places
36 CFR 63	Determination of Eligibility for Inclusion in the National Register of Historic Places
36 CFR 79	Curation of Federally Owned and Administered Archaeological Collections
36 CFR 800	Protection of Historic Properties
40 CFR 50-0	National Primary and Secondary Ambient Air Quality Standards
40 CFR 61A, H	National Emission Standards for Hazardous Air Pollutants
40 CFR 82	Protection of Stratospheric Ozone
40 CFR 109	Criteria for State, Local and Regional Oil Removal Contingency Plans
40 CFR 110	Discharge of Oil

40 CFR 112	Oil Pollution Prevention Act
40 CFR 113	Liability Limits for Small Onshore Storage Facilities
40 CFR 116	Designation of Hazardous Substances
40 CFR 117	Determination of Reportable Quantities for Hazardous Substances
40 CFR 121	State Certification of Activities Requiring a Federal License or Permit
40 CFR 122	National Pollution Discharge Elimination System (NPDES)
40 CFR 123	State Program Requirements
40 CFR 124	Procedures for Decision-making
40 CFR 125	Criteria and Standards for the National Pollutant Discharge Elimination System
40 CFR 129	Toxic Pollutant Effluent Standards
40 CFR 130	Water Quality Planning and Management
40 CFR 131	Water Quality Standards
40 CFR 132	Water Quality Guidance for the Great Lakes System
40 CFR 133	Secondary Treatment Regulation
40 CFR 135	Prior Notice of Citizen Suits
40 CFR 136	Guidelines Establishing Test Procedures for the Analysis of Pollutants
40 CFR 141	National Primary Drinking Water Regulations
40 CFR 142	National Primary Drinking Water Regulations Implementation
40 CFR 143	National Secondary Drinking Water Regulations
40 CFR 144	Underground Injection Control (UIC) Program
40 CFR 146	Underground Injection Control (UIC) Program: Criteria and Standards
40 CFR 148	Hazardous Waste Injection Restrictions
40 CFR 149	Sole Source Aquifers
40 CFR 167	Submissions of Pesticide Reports
40 CFR 168	Statements of Enforcement Policies and Interpretations
40 CFR 169	Books and Records of Pesticide Production and Distribution
40 CFR 170	Worker Protection Standard
40 CFR 171	Certification of Pesticide Applicators
40 CFR 260	Hazardous Waste Management Systems: General
40 CFR 261	Identification and Listing of Hazardous Waste
40 CFR 262	Standards Applicable to Generators of Hazardous Waste
40 CFR 263	Standards Applicable to Transporters of Hazardous Waste

40 CFR 264	Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities
40 CFR 265	Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities
40 CFR 266	Standards for the Management of Special Hazardous Wastes and Specific Types of Hazardous Waste Management Facilities
40 CFR 268	Land Disposal Restrictions
40 CFR 270	EPA Administered Permit Program: The Hazardous Waste Permit Program
40 CFR 271	Requirements for Authorization of State Hazardous Waste Management Programs
40 CFR 272	Approved State Hazardous Waste Management Programs
40 CFR 273	Standards for Universal Waste Management
40 CFR 279	Standards for the Management of Used Oil
40 CFR 280	Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks (USTs)
40 CFR 300	National Oil and Hazardous Substances Pollution Contingency Plan
40 CFR 302	Designation, Reportable Quantities, and Notification
40 CFR 355	Emergency Planning and Notification
40 CFR 370	Hazardous Chemical Report: Community Right-to-Know
40 CFR 372	Toxic Chemical Release Report: Community Right-to-Know
40 CFR 700	Toxic Substances Control Act [TSCA]
40 CFR 702	Toxic Substances Control Act: General Practices and Procedures
40 CFR 704	Toxic Substances Control Act: Reporting and Recordkeeping Requirements
40 CFR 707	Chemical Imports and Exports
40 CFR 710	Inventory Reporting Regulations
40 CFR 712	Chemical Information Rules
40 CFR 716	Health and Safety Data Reporting
40 CFR 717	Records and Reports of Allegations that Chemical Substances Cause Significant Adverse Reactions to Health or the Environment
40 CFR 720	Premanufacture Notification
40 CFR 721	Significant New Users of Chemical Substances
40 CFR 723	Premanufacture Notification Exemptions
40 CFR 725	Reporting Requirements and Review Processes for Microorganisms
40 CFR 745	Lead-Based Paint Poisoning Prevention in Certain Residential Structures
40 CFR 747	Metalworking Fluids
40 CFR 749	Water Treatment Chemicals

40 CFR 750	Procedures for Rulemaking Under Section 6 of TSCA
40 CFR 761	PCBs Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions
40 CFR 763	Asbestos
40 CFR 1500	Council on Environmental Quality: Purpose, Policy, and Mandate
40 CFR 1501	NEPA and Agency Planning
40 CFR 1502	Environmental Impact Statement
40 CFR 1503	Commenting
40 CFR 1504	Predecision Referrals to the Council of Proposed Federal Actions
40 CFR 1505	NEPA and Agency Decision-making
40 CFR 1506	Other Requirements of NEPA
40 CFR 1507	Agency Compliance
40 CFR 1508	Terminology and Index
50 CFR 17	Endangered and Threatened Wildlife and Plants
50 CFR 21	Migratory Bird Treaty Act
50 CFR 22	Bald and Golden Eagle Protection Act

NEW YORK STATE LAWS, REGULATIONS, AND STANDARDS

6 NYCRR 182	Endangered and Threatened Species of Fish and Wildlife, Species of Special Concern
6 NYCRR 200	General Provisions
6 NYCRR 201	Subpart 201-1: General Provisions
6 NYCRR 202	Part 202: Emissions Verification
6 NYCRR 205	Architectural and Industrial Maintenance (AIM) Coatings
6 NYCRR 207	Control Measures for an Air Pollution Episode
6 NYCRR 208	Landfill Gas Collection and Control System for Certain Municipal Solid Waste Landfills
6 NYCRR 211	General Prohibitions
6 NYCRR 212	Process Operations
6 NYCRR 215	Open Fires
6 NYCRR 217	Environmental Conservation Rules and Regulations [Exhaust and Emission Standards]
6 NYCRR 218	Subpart 218-1 [More on Vehicle Exhaust]
6 NYCRR 221	Asbestos-Containing Surface Coating Material
6 NYCRR 225	Subpart 225-1: Fuel Composition and Use – Sulfur Limitations
6 NYCRR 226	Solvent Metal Cleaning Processes
6 NYCRR 227	Subpart 227-2: Reasonable Available Control Technology (RACT) for Major Facilities of

	Oxides of Nitrogen (NOx)
6 NYCRR 228	Subpart 228-1: Surface Coating Processes
6 NYCRR 229	Petroleum and Volatile Organic Liquid Storage and Transfer
6 NYCRR 230	Gasoline Dispensing Sites and Transport Vehicles
6 NYCRR 231	New Source Review for New and Modified Facilities
6 NYCRR 234	Graphic Arts
6 NYCRR 239	Portable Fuel Container Spillage Control
6 NYCRR 240	Conformity to State or Federal Implementation Plans
6 NYCRR 250	Miscellaneous Orders
6 NYCRR 256	Air Quality Classification System
6 NYCRR 257	Air Quality Standards
6 NYCRR 307	[Air Quality in] Suffolk County
6 NYCRR 320	Pesticides - General
6 NYCRR 325	Application of Pesticides
6 NYCRR 326	Registration and Classification of Pesticides
6 NYCRR 327	Use of Chemicals for the Control or Elimination of Aquatic Vegetation
6 NYCRR 328	Use of Chemicals for the Extermination of Undesirable Fish
6 NYCRR 329	Use of Chemicals for the Control or Elimination of Aquatic Insects
6 NYCRR 360	Solid Waste Management Facilities General Requirements
6 NYCRR 361	Siting of Industrial Hazardous Waste Facilities
6 NYCRR 364	Waste Transporter Permits
6 NYCRR 370	Hazardous Waste Management Regulations
6 NYCRR 371	Identification and Listing of Hazardous Waste
6 NYCRR 372	Hazardous Waste Manifest System and Related Standards for Generators, Transporters and Facilities
6 NYCRR 373	Hazardous Waste Management Facilities
6 NYCRR 374	Standards for the Management of Specific Hazardous Wastes
6 NYCRR 376	Land Disposal Restrictions
6 NYCRR 595	Release of Hazardous Substances
6 NYCRR 596	Hazardous Substance Bulk Storage Regulations
6 NYCRR 597	List of Hazardous Substances
6 NYCRR 611	Environmental Priorities and Procedures in Petroleum Cleanup and Removal
6 NYCRR 612	Registration of Petroleum Storage Facilities

6 NYCRR 613	Handling and Storage of Petroleum
6 NYCRR 663	Freshwater Wetlands Permit Requirements
6 NYCRR 666	Regulation for Administration and Management of the Wild, Scenic, and Recreational Rivers System in New York State Excepting Private Land in the Adirondack Park
6 NYCRR 700	Part 700 Water Quality Regulations
6 NYCRR 701	Classification – Surface Waters and Groundwaters
6 NYCRR 702	Derivation and Use of Standards and Guidance Values
6 NYCRR 703	Surface Water and Groundwater Quality Standards and Groundwater Effluent Limitations
6 NYCRR 750	Obtaining a SPDES Permit
10 NYCRR 5	State Sanitary Code – Part 5

SUFFOLK COUNTY RULES, REGULATIONS, AND STANDARDS

SCSC Art. 12	Toxic and Hazardous Material Storage, Handling and Control

APPENDIX E: BNL SITE SUSTAINABILITY PLAN:
STATUS SUMMARY FOR FISCAL YEAR 2020

Prior Department of Energy Goal	Current Performance Status	Planned Actions & Contributions
Energy Management		
30% energy intensity (Btu per gross square foot) reduction in goal-subject buildings by FY 2015 from a FY 2003 baseline and 1.0% Year-over-year (YOY) thereafter.	FY20 energy intensity was 28.1% below FY03, 3% below 2015.	A second Utility Energy Service Contract (UESC) II (or self-funded effort) effort focusing on Building HVAC controls, temperature set-back, re-heat minimization and lighting is planned. Continue emphasis on Temperature Set-back policy.
Energy Independence and Security Act (EISA) Section 432 continuous (4-year cycle) energy and water evaluations.	83 Buildings covering 706,859 sq. ft. were audited in FY20.	Continue audits meeting the 4-year cycle.
Meter all individual buildings for electricity, natural gas, steam, and water, where cost-effective and appropriate.	Eight new smart meters were added in FY20. Current status is 99% of electricity, 100% of natural gas, +90% of steam are metered. Most potable water is used for cooling tower make-up. We are currently metering ~25% of cooling tower make-up and adding meters regularly.	Continue maintaining and expanding metering installations, with an emphasis on potable water make-up for cooling towers. This process has already started.
Water Management		
20% potable water intensity (Gal per gross square foot) reduction by FY 2015 from a FY 2007 baseline and 0.5% YOY thereafter.	Potable-water usage fell from 931 million gallons/year in FY 1999 (average of 2.55 million gallons per day) to about 389 million gallons/year in FY 2020 (average of 1.07 million gallons per day), a reduction of 62.0%. BNL's annual water use intensity has decreased from 101 gallons per square foot to 80.9 gallons per square foot, a 20.1% water usage reduction since base-year 2007.	Completion of Well No. 12 in FY21. BNL will continue to implement BNL's Water Management Plan and reduce water usage by implementing best- management practices. BNL will continue to utilize water-efficient processes and plumbing fixtures to conserve water in new construction buildings and renovations.
Non-potable freshwater consumption (Gal) reduction of industrial, landscaping, and agricultural (ILA). YOY reduction; no set target.	N/A	N/A
Waste Management		
Reduce at least 50% of non-hazardous solid waste, excluding construction and demolition debris, sent to treatment and disposal facilities.	BNL's recycling rate counting only day-to-day activities is 53% and jumps to 83.9% if composting of site trees and brush for landscaping needs is included.	• Continue to recycle >50% • Fund Pollution Prevention Opportunities • Determine relationship between working-at-home and recycling rates.
Reduce construction and demolition materials and debris sent to treatment and disposal facilities. YOY reduction; no set target.	Construction & Demolition Debris (C&D) generation rates have been increasing over the last several years because of site improvement activities. As site development progresses, that trend can be expected to continue making it impossible to set reduction goals.	Use FY21 to collect all C&D data in order to establish a baseline for YOY reduction goals in future years.

Prior Department of Energy Goal	Current Performance Status	Planned Actions & Contributions
Fleet Management		
20% reduction in annual petroleum consumption by FY 2015 relative to a FY 2005 baseline and 2.0 % YOY thereafter.		41 new Telematics have been received and will be installed by the end of February in the remaining vehicles that currently do not have units. Full scope of usage on the entire Fleet can be determined including idling time. Quarterly spot checks will be implemented to ensure vehicles are not running unattended, operating efficiently and are properly maintained.
10% increase in annual alternative fuel consumption by FY 2015 relative to a FY 2005 baseline; maintain 10% increase thereafter.		E-85 fuel usage is expected to increase with the new vehicle acquisitions due for 2021.
75% of light duty vehicle acquisitions must consist of alternative fuel vehicles (AFV).		Fleet management will continue to work with the General Services Administration (GSA) to order and utilize alternative-fueled and newer, more fuel-efficient vehicles during every replacement cycle.
Clean & Renewable Energy		
"Renewable Electric Energy" requires that renewable electric energy account for not less than 7.5% of a total agency electric consumption by FY 2013 and each year thereafter.	BNL purchased 22,000,000 kilowatt hours (kWh) of RECs for 2020 to meet the "Renewable Energy" requirement of 7.5%. BNL's RECs have been and will continue to be purchased through a competitive solicitation process. In 2020 BNL's 816 kW Northeast Solar Energy Research Center (NSERC) facility produced 977,967 kWh that were consumed by BNL's facilities. The RECs are retained by BNL and are not sold. The total of the REC's and the NSERC output was 8.2% of BNL's electric consumption.	BNL will continue to operate the NSERC facility and provide for further expansion when sufficient funds are identified. Renewable energy credit (REC) purchases will continue in order to meet applicable renewable energy and clean energy goals. Renewable energy systems, especially solar hot water, are considered in all new construction and major building renovations. To date, it has been difficult to find cost effective projects. BNL continues to pursue opportunities to implement a microgrid on site and are continuing discussions with energy storage providers and various governmental agencies to explore options such as hosting large utility scale battery storage systems on site.
Continue to increase non- electric thermal usage. YOY increase; no set target but an indicator in the OMB scorecard.	A small residential solar thermal space heating system was installed in Building 30 as part of a research demonstration project. The system has fallen into disrepair but there are plans to bring it back into service.	New facilities such as the SUSC are evaluated for solar thermal opportunities. To-date the economics have not supported new installations. BNL will continue to evaluate various options such as solar domestic hot water heating and pre- heating, solar wall make-up air pre-heating, and other options.
Green Buildings		
At least 15% (by count) of owned existing buildings to be compliant with the revised Guiding Principles (GP's) for Sustainable Buildings by FY 2021, with annual progress thereafter.	Currently 8 buildings have achieved 100% of the 2008 GP's and an additional 7 buildings are considered meeting them as they have achieved Leadership in Energy & Environmental Design (LEED) Gold or higher status. This represents 20% of non-excluded buildings.	Review underway to ensure compliance with 2016 GO+P's

Prior Department of Energy Goal	Current Performance Status	Planned Actions & Contributions
Acquisitions and Procurement		
Promote sustainable acquisition and procurement to the maximum extent practicable, ensuring BioPreferred and biobased provisions and clauses are included in all applicable contracts.	• BNL has incorporated contract clauses within its vendor contracts that designate environmentally preferred products (EPP), services, and equipment. • BNL continued to provide requisitioners EPP purchasing training. • BNL successfully funded two Pollution Prevention projects that involved replacement of products with bio-preferred alternatives. • BNL received the "Green Electronics Council's 2020 Electronic Product Environmental Assessment Tool (EPEAT) Purchaser Award" at the Gold Level; and the "2020 GreenBuy Prime" award for winning the GreenBuy Gold Award three times. • BNL's weakness is the ability to collect data for reporting purposes.	▪ BNL will perform an assessment of their sustainability program in order to identify conformance status and areas for improvement. ▪ BNL will continue to establish Environmental Management System (EMS) objectives to improve EPP purchasing performance for a wide- range of products including bio-preferred. ▪ BNL will enact their Pollution Prevention Opportunity Program with a focus on EPP conforming product replacements.
Measures, Funding, and Training		
Site set annual targets for sustainability investment with appropriated funds and/or financed contracts for implementation.	Internally funded energy conservation and sustainability related initiatives include a continuation of best practices, with continued emphasis on temperature setback during unoccupied periods. Due to the impact of COVID-19, little resources were able to be directed to internal energy conservation efforts.	BNL, like other DOE sites, has been increasingly using third- party financing options that utilize cost savings to pay for the projects. BNL has low energy rates to operate its' research programs, which makes it difficult to find cost-effective projects. Due to marginal economics the 2nd UESC effort was put on hold while BNL evaluates options, including self-funding or a partnership with the New York Power Authority (NYPA). We expect to make a decision in early FY21. Training continues for various staff members to maintain their respective certifications for energy, engineering, environmental and other related capabilities.
Electronic Stewardship		
End of Life: 100% of used electronics are reused or recycled using environmentally sound disposition options each year.	▪ BNL's equipment tracking system allows 100% collection of tagged electronics for recycling through an R2 Certified recycler. ▪ BNL held one home electronics pick-up day. ▪ BNL received the "Green Electronics Council's 2020 EPEAT Purchaser Award" at the Gold Level.	Continue the current high level of performance.
Data Center Efficiency: Establish a power usage effectiveness target for new and existing data centers; discuss efforts to meet targets.	Additional metering is in progress for 4 of the existing 8 data centers. The new data center in Building 725 is estimated to be in operation in June of 2021 with a PUE of <1.3.	Meeting the PUE of 1.5 for the existing data centers will require a significant investment. 4 of the 8 existing data centers require the installation of new metering, which is partially in progress. BNL will work to identify the actions and resources needed to meet the PUE 1.5 requirement for the eight existing data centers and if cost effective, begin the process of obtaining potential funding.

Prior Department of Energy Goal	Current Performance Status	Planned Actions & Contributions
Organizational Resilience		
Discuss overall integration of climate resilience in emergency response, workforce, and operations procedures and protocols.	▪ Emergency Response Organization (ERO) is fully staffed and ready to respond to an Operational Emergency at BNL if necessary. ▪ Emergency Operations Center (EOC) is fully operational and kept in "warm mode" during normal business hours" to respond to an operational emergency within thirty minutes of declaration. ▪ All joint and partial assessments were completed in compliance with DOE O 151.D. ▪ Continuity of Operations Plan (COOP) Continuity of Emergency Response Group (CERG) is fully staffed. Ensuring all mission essential functions are operating without interruption. ▪ Required building evacuations were completed and local emergency plans updated. ▪ Supported COVID-19 response activities for BNL. ▪ Supported Safeguards and Security with Hazardous materials analysis with respect to the Design Based Threat (DBT)	Complete five joint self- assessments with BHSO and ten partial self-assessments with Office of Emergency Management (OEM). Conduct beyond design basis full scale exercise. Exercise will simulate a catastrophic emergency involving multiple facilities onsite without any outside assistance. Complete the All Hazard Survey triennial review and updates Complete the Triennial review required for Building 735 Emergency Preparedness Hazard Assessment (EPHA). Perform quarterly DOE accountability drills on behalf of the U.S. Office of Human Capital. Perform semi-annual CERG & DERG trainings and meetings. Perform annual COOP awareness briefing for BNL employees. Continue to support COVID-19 response activities for BNL. Continue to support Safeguards and Security with Hazardous materials analysis with respect to the DBT.
Multiple Categories		
YOY scope 1 & 2 Greenhouse Gas (GHG) emissions reduction from a FY 2008 baseline.	34% reduction comparing FY20 to FY08 baseline.	Continued efforts for Energy Intensity Reductions through UESC's, Energy Savings Performance Contracts (ESPC's) and other methods including self-funding. Continued hydropower allocation, REC purchases and operation of the NSERC Solar photovoltaic (PV) array. Meeting the goal will be difficult beyond 2030 due to increased electrical load associated with EIC and the new data center.
YOY scope 3 GHG emissions reduction from a FY 2008 baseline.	Currently 33% lower than the FY08 baseline value. Large reduction over past year primarily due to decline in air travel and commuting GHG emissions as a result of the COVID-19 pandemic."	Build and continue to learn from experiences using virtual meeting platforms (e.g. Microsoft Teams and Zoom) due to COVID-19 to encourage and improve teleworking and other collaborations that will likely reduce commuting GHG emissions and influence future decisions on domestic and foreign air travel. Potential Yaphank/BNL commuter rail station could significantly reduce the number of vehicles coming to BNL from current values.

Site Environmental Report

Reader Response Form

The Site Environmental Report (SER) is written to inform regulators, the public, and Brookhaven National Lab (BNL) employees of the Laboratory's environmental performance for the calendar year in review. The report summarizes the Laboratory's on-site environmental data; environmental management performance; compliance with applicable regulations; and environmental, restoration, and surveillance monitoring programs.

BNL welcomes your comments, suggestions for improvements, or any questions you may have. Please fill in the information below, and mail your response form to:

Brookhaven National Laboratory
Environmental Protection Division
Attention: SER Project Coordinator
Building 860
P.O. Box 5000
Upton, NY 11973-5000

Name ______________________________

Address ______________________________

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Phone ______________________________

Email ______________________________

Comments, Suggestions, or Questions

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