

## 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 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/>.*

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### 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 both the International Organization for Standardization (ISO) 14001 Standard for the Laboratory's Environmental Management System (EMS) and the Occupational Health and Safety Assessment Series (OHSAS) 18001 Standard for the Laboratory's Safety and Health Program. Both standards require 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 was also the first Office of Science Laboratory to achieve registration under the OHSAS 18001 Standard. Each certification requires the Laboratory to undergo annual audits by an accredited registrar to assure that the systems are maintained and to identify evidence of continual improvement. In 2018, an EMS certification audit determined that BNL conformed to the revised ISO 14001:2015 Standard.

Executive Order (EO) 13693, Planning for Federal Sustainability in the Next Decade, establishes goals for federal agencies and focuses on greenhouse gas (GHG) reduction across the government. In addition to guidance, recommendations, and plans which must be prepared by specific due dates, EO 13693 has set numerical targets for agencies. 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 13693. 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 2018 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 2018, these efforts resulted in nearly \$3.8 million in cost avoidance or savings and approximately 3.2 million pounds of materials being reduced, recycled, or reused annually.

In addition, BNL decreased its energy consumption and increased savings. In the past ten years, water consumption total was approximately half the 1999 total—a reduction of nearly 30 million gallons per year. BNL's energy use per square foot in 2018 was 30 percent less than in FY 2003. The Laboratory kept electric use at a minimum during the peak demand periods, mainly by scheduling the Relativistic Heavy Ion Collider's (RHIC) maintenance shut-down period during the summer season's peak energy demand period. This scheduling reduced the electric demand by 25 MW, saving approximately \$1 million in electric demand costs. Finally, natural gas was used to meet over 98 percent of the heating and cooling needs of the Laboratory's major facilities in 2018, further reducing GHG emissions.

Chapter 2 of this report describes the elements and 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 2018 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; 12 equivalency permits for the operation of groundwater remediation systems; and several other binding agreements. In 2018, the Laboratory operated in compliance with most of the requirements, and 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 2018. 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).

In 2018, 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 to eliminate possible ozone-depleting substance emissions.

With the exception of an iron exceedance at the Water Treatment Plant in June, 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 2018. 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 have been ongoing throughout 2018. Environmental Protection Division and Facilities & Operations Directorate staff continue to work closely with the DOE and NYSDEC on this issue and possible solutions. Groundwater monitoring at the Laboratory's Major Petroleum Facility (MPF) and Waste Management Facility (WMF) continued to demonstrate that current operations are not affecting groundwater quality.

Efforts to minimize impacts of spills of materials continued in 2018. There were 12 spills in 2018 and six of those spills met regulatory agency reporting criteria.

BNL participated in ten environmental inspections or reviews by external regulatory agencies in 2018. These inspections included Sewage Treatment Plant operations; hazardous waste management facilities; regulated emission sources; and the potable water system. Immediate corrective actions were taken to address all issues raised during these inspections.

The DOE Brookhaven Site Office (BHSO) continued to provide oversight of BNL programs and performed two surveillances of BNL operations in 2018. In April, BHSO performed a radiological posting surveillance at Building 865 (Radiological Waste Storage Facility). The scope of the surveillance was to review radiological postings in and around Building 865 and evaluate compliance with Radiological Control Procedures and 10 CFR 835 regulations. No findings were identified. In July, a surveillance of Brookhaven Linac Isotope Producer (BLIP) waste transfer operations at the WMF was performed. One minor finding was identified in reference to editorial and formatting procedural

issues and immediately addressed. 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.

During 2018, Laboratory facilities released a total of 23,035 curies of short-lived radioactive gases. The BLIP facility is subject to EPA's continuous monitoring requirements. Oxygen-15 (half-life: 122 seconds) and Carbon-11 (half-life: 20.4 minutes) emitted from the BLIP constituted more than 99.9 percent of radiological air emissions on site.

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

In 2018, there were 21 recorded excess opacity measurements. Thirteen were due to blizzard-like conditions that obstructed the Boiler 7 transmitter light path; three were due to unsuccessful attempts to start-up Boiler 7 on No. 6 oil; one was due to unknown causes; and four excess opacity readings occurred during quarterly quality assurance tests of the Boiler 6 and 7 opacity monitors. While there are no regulatory requirements to continuously monitor opacity for Boilers 1A and 5, surveillance monitoring of visible stack emissions is a condition of BNL's Title V operating permit. Daily observations of stack gases recorded by CSF personnel throughout the year showed no visible emissions on days when the boilers were operated.

The Laboratory conducts ambient radiological air monitoring to verify local air quality and to

assess possible environmental and health impacts from BNL operations. Samples collected from air monitoring stations around the perimeter of the site were analyzed for gross alpha and beta airborne activity. All but one of the BNL gross alpha samples fell within the New York State Department of Health data range from their control location in Albany, NY, demonstrating that on-site radiological air quality was consistent with that observed at locations in New York State not located near radiological facilities.

Airborne tritium in the form of tritiated water (HTO) is monitored throughout the BNL site. In 2018, air samples for tritium were collected from four locations to assess the potential impacts from the Laboratory's two primary tritium sources, the BLIP and the High Flux Beam Reactor (HFBR) building. The average tritium concentrations at all the sampling locations were less than the typical minimum detection limits, ranging from 4.0 to 12.6 pCi/m<sup>3</sup>. These results show there were no impacts as average tritium concentrations were less than typical minimum detection limits.

In 2018, BNL took several actions to meet DOE GHG reduction goals. BNL had a net combined GHG reduction of 89,331 metric tons CO<sub>2</sub> equivalents (MTCO<sub>2</sub>e) from consumption of 119,425 megawatts of clean hydropower and Renewable Energy Credits from the Long Island Solar Farm, which produced 46.6 million kilowatt-hours of solar energy, resulting in the Laboratory receiving credit for 25,074 MTCO<sub>2</sub>e through purchase of Renewable Energy Credits. Energy from the Northeast Solar Energy Research Center resulted in an additional 709 MTCO<sub>2</sub>e of GHG reductions. Through these reductions and credits, the Laboratory made significant progress toward meeting its Scope 1 and 2 GHG emissions reduction goal. Chapter 4 of this report describes BNL's Air Quality Program and monitoring data in further detail.

### WATER QUALITY SURVEILLANCE PROGRAM

Wastewater generated from BNL operations 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.

In 2018, the average gross alpha and beta activity levels in the STP discharge were within the typical range of historical levels and well below New York State Drinking Water Standards (NYS DWS).

Tritium was not detected above method detection limits in the STP discharge during the entire year and 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 organic and inorganic parameters, with exception of tolyltriazole exceedances, were within SPDES effluent limitations 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 2018, 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 in the discharges at concentrations just above the method detection limit due to the use of chlorine and bromine for the control of algae and bacteria in potable and cooling water systems. Inorganics, such as metals, were detected; however, their presence was due primarily to sediment runoff in stormwater discharges.

With the exception of the most upstream sampling location (Station HY), the onsite portions of the Peconic River were dry throughout the first half of 2018 due to drought conditions. When available, radiological data from Peconic River surface water sampling showed that the average concentrations of gross alpha and gross beta activity from on-site locations were indistinguishable from off-site and 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 STP area, and tritium was not detected above method detection limits 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 2018, Cs-137 concentrations in deer meat samples were obtained from six deer on site with a range of values from 0.01 pCi/g, wet weight to 2.19 pCi/g, wet weight, and an arithmetic average of 0.97 pCi/g, wet weight.

High deer populations are a regional problem, and the Laboratory is just one area on Long Island with such an issue. 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. At the end of 2018, the on-site deer population was estimated at between 350 and 450 animals. Due to damage caused by over population of the deer herd, BNL has periodically conducted population reductions of the white-tailed deer on site.

During 2018, grassy vegetation and soil samples were collected from ten locations around the Laboratory and a control location at the NYSDEC hunter check station in Ridge, New York. All samples were analyzed for Cs-137, which ranged from non-detectable to 0.22 pCi/g, wet weight. Soil samples had Cs-137 levels from non-detect to 1.36 pCi/g, dry weight. All values were consistent with historic monitoring.

Monitoring results for grassy vegetation and soils were utilized for the annual dose to biota analysis reported in Chapter 8.

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 is compared to Peconic River monitoring data and aids in understanding the distribution of mercury within the Peconic River watershed. During 2018, precipitation samples were collected quarterly at air monitoring stations and analyzed for total mercury. Mercury was detected in all the precipitation samples collected at both sampling stations. Mercury ranged from 1.58 ng/L at one station in January to 8.59 ng/L at the other station in April. The 8.59 ng/L concentration is five times lower than the highest value of 45.1 ng/L, recorded in 2017.

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 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 2018, BNL hosted ten student interns and two faculty members within the Natural Resources program. Interns participated in research for various projects related to the Long Island Solar Farm, box turtles, forest health and deer impacts, and pollinators.

Also in 2018, BNL continued its active support of ecological education programs on Long Island. On separate days, through the Day in the Life of a River program, more than 30 partner organizations and agencies, over 40 schools, and 3,000 students collected scientific information for analysis to be used to portray the status of the rivers and estuary systems. These events provided students hands-on experience with field techniques in catching fish, invertebrate sampling, biodiversity inventory, and water chemistry. BNL is also in its 14th year of the Open Space Stewardship Program (OSSP). The OSSP enables students to engage in activities to solve problems within their local community

through scientific discovery, conservation, and stewardship. Finally, the Lab formalized a partnership with the State University of New York School of Environmental Science and Forestry, based in Syracuse, NY, which will use the BNL site for Pine Barrens-related research.

The Laboratory also hosts the annual New York Wildfire & Incident Management Academy, offered by NYSDEC and the Central Pine Barrens Commission. Using the Incident Command System of wildfire management, this academy trains firefighters in the methods of wildland fire suppression, prescribed fire, and fire analysis. BNL has developed and is implementing a Wildland Fire Management Plan that includes the use of prescribed fire for fuel and forest management and worked with NYSDEC to conduct a single growing season fire in the northern and eastern sections of the BNL property. This successful fire provided significant experience and training for fire crews working in Pine Barrens habitat, improving capabilities of these crews to conduct and manage fire within the Long Island Central Pine Barrens. 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 PFAS-containing firefighting foam 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 will continue efforts to prevent new groundwater impacts and is vigilant in measuring and communicating its performance.

Groundwater quality at BNL is routinely monitored through a network of approximately 650 on- and off-site wells. In addition to water quality assessments, water levels are routinely measured in 725 wells to assess variations in the direction and velocity of groundwater flow.

During 2018, BNL collected groundwater samples from 646 permanent monitoring wells and 121 temporary wells during 1,504 individual sampling events. Seven groundwater remediation systems removed 62 pounds of volatile organic compounds (VOCs) and returned approximately 804 million gallons of treated water to the Upper Glacial aquifer. Also during 2018, two groundwater treatment systems removed approximately 0.6 millicurie of strontium-90 (Sr-90) while remediating approximately 16 million gallons of groundwater. As a result of the successful operation of these treatment systems, significant reductions in contaminant concentrations have been observed in several on- and off-site 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 2018.

#### **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 2018, the total effective dose (TED) of 5.0

mrem (50  $\mu$ Sv) from Laboratory operations was well below the EPA and DOE regulatory dose limits for the public, workers, and the environment. To measure direct radiation from Laboratory operations, 60 on-site thermo-luminescent dosimeters (TLDs) and 17 off-site TLDs were deployed. Results from the TLDs showed that there was no external dose contribution from BNL operations distinguishable from the natural background radiation level. Of the 60 onsite TLDs, ten were used to measure dose in on-site areas known to have radiation levels that are slightly above the natural background radiation due to facility operations.

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 2018 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 back-ground 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.

In 2018, the Laboratory used five off-site contract analytical laboratories to analyze environmental samples. Three of the five laboratories were certified by the New York State Department of Health (NYSDOH) for the relevant analytes, where such certification existed. Two of the laboratories had National Environmental Laboratory Accreditation Program accreditation. The laboratories also were subject to performance

evaluation (PE) testing and DOE-sponsored audits. All samples were analyzed according to EPA-approved methods or by standard industry methods, where no EPA methods were available. Based on the data reviews, data validations, and results of the independent PE assessments, the chemical and radiological results documented in this report are of acceptable quality.

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