

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/>.

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 2019, an EMS certification audit determined that BNL continues to conform to the ISO 14001:2015 Standard.

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

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 2019 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 2019, these efforts resulted in nearly \$3.1 million in cost avoidance or savings and approximately 1.6 million pounds of materials being reduced, recycled, or reused annually.

BNL continues to decrease its energy consumption and increase savings. In the past ten years, water consumption total was approximately half the 1999 total—a reduction of nearly 30 million gallons per year. In 2019, natural gas was used to meet over 99 percent of the heating and cooling needs of the Laboratory's major facilities, further reducing greenhouse (GHG) emissions. 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 (MW), saving approximately \$1.0 million in electric demand costs. In addition, the 2019 output from the Lab's Long Island Solar Farm was 50.6 million kWh and resulted in an avoidance of approximately 33,000 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 2019 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 2019, 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 2019. 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 fire-induced activation of fixed fire suppression systems in 2019. 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 a violation for missing the collection of an iron sample 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 2019. 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 2019. TTA is a corrosion inhibitor. BNL staff continue to work closely with the DOE and NYSDEC on this issue to identify possible solutions.

Also in 2019, groundwater monitoring at the Laboratory's Major Petroleum Facility (MPF) and Waste Management Facility (WMF) demonstrated that current operations are not affecting groundwater quality.

Efforts to minimize impacts of spills of materials continued in 2019. There were 23 spills in 2019 and ten of those spills met regulatory agency reporting criteria.

BNL participated in 11 environmental inspections or reviews by external regulatory agencies in 2019. These inspections included STP operations; hazardous waste management facilities; regulated emission sources; 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 and performed two surveillances of BNL operations in 2019: a surveillance of BNL's compliance with National Emission Standards for Hazardous Air Pollutants, specifically, 40 CFR 61, Subpart H, *National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities*, and an assessment of BNL's Packaging and Transportation Program, as required by DOE O 460.2A, Departmental Material Transportation and Packaging Management. For the first assessment, no findings were identified. For the Transportation and Packaging assessment, four Level 3 Findings, five Observations, three Improvement Opportunities, four Best Practices, and one Noteworthy Practice were identified. A causal analysis was performed and corrective actions

were developed to minimize the risk of recurrence.

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 2019, BNL facilities released a total of 19,022 curies of short-lived radioactive gases. Oxygen-15 and Carbon-11 emitted from the Brookhaven Linac Isotope Producer (BLIP) constituted more than 99.9 percent of the site's radiological air emissions. The remaining 0.1 percent was due to tritium releases from the High Flux Beam Reactor.

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 99.6 percent of the heating and cooling needs of the Laboratory's major facilities in 2019. 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 2019, there were five recorded excess opacity measurements. Three recorded readings on January 23 were due to the start-up and shutdown of Boiler 6 in preparation for periodic emissions tests conducted later that day, and two Boiler 6 excess opacity readings on December 30 were due to unknown causes. 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. The annual average gross alpha and beta airborne activity levels for the four monitoring stations were 0.0011 and 0.0128 pCi/m³, respectively.

Airborne tritium in the form of tritiated water (HTO) is monitored throughout the BNL site. In 2019, tritium samples were collected from four sampling stations every two weeks to assess potential impacts from the Laboratory's two tritium sources. The average tritium concentrations at all the sampling locations were less than the typical minimum detection limits, ranging from 4.0 to 11.0 pCi/m³. 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. All but five of the BNL samples fell within this range, demonstrating that on-site radiological air quality was consistent with that observed at locations in New York State not located near radiological facilities.

In 2019, BNL took several actions to meet DOE GHG reduction goals. Fifty million kilowatt-hours of solar energy were provided to Long Island from the BNL-based Long Island Solar Farm (LISF). This equates to 33,828 metric tons CO₂ equivalents (MtCO₂e) GHG offset or reduction. Also in 2019, BNL consumed 118,847 megawatts of hydropower, providing a net combined GHG reduction of 97,629 MtCO₂e from the LISF and hydropower. In 2016, BNL completed an expansion of the Northeast Solar Energy Research Center, a solar photovoltaic facility that has a capacity of 816 kW. In 2019, it provided 1,018,000 kWh and offset 1,179 MtCO₂e. Chapter 4 of this report describes BNL's Air Quality Program, monitoring data, and other GHG-reducing 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 2019 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 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, with the exception of multiple TTA 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. 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 method detection limit, 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 flowed the first half of 2019, then stopped flowing offsite by July as groundwater levels began subsiding. 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 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.

To evaluate Cs-137 in deer, BNL has established a routine on and off-site deer sampling program. In 2019, three deer were obtained on site, five from off-site locations within one mile of the Laboratory, and three from greater than one mile from the BNL boundary. 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).

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 herd was estimated at between 350 and 450 animals; in April 2019, a harvest was conducted during which 250 animals were taken, effectively bringing the population to approximately 200 animals. With a reproduction rate of approximately 60 percent, the population at the end of 2019 was estimated at 300 to 350 deer.

During 2019, grassy vegetation samples were collected from ten locations around the Laboratory and a control location in Ridge, New York. All samples were analyzed for Cs-137 which ranged from non-detectable to 0.07 pCi/g, wet weight at a single location. Soil samples had Cs-137 levels ranging from non-detect to 0.84 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 2019, precipitation samples were collected quarterly at two air monitoring stations. Mercury was detected in all the precipitation samples collected at both stations. Mercury ranged from 3.55 ng/L at station P4 in October to 13.1 ng/L at station S5 in July. The 13.1 ng/L concentration is 3.4 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 2019, BNL hosted 16 student interns, a graduate student, and two faculty members within the Natural Resources program. One intern conducted statistical analysis of bird survey data during the spring, and a second worked on statistics of the 4-Poster™ tick management program in the fall. During summer, 14 interns participated in programs looking at forest health of the Long Island Pine Barrens, pollinator use of the Long Island Solar Farm, modified feeding effects on effectiveness of the 4-Poster™ tick management devices, and mapping valves and other infrastructure associated with the Laboratory's potable water system.

Also in 2019, BNL continued its active support of ecological education programs by hosting the Long Island Natural History Conference; participating in the Tenth Annual Pine Barrens Discovery Day at the Wertheim National Wildlife Refuge; and assisting the Central Pine Barrens Commission with "A Day in the Life of the Rivers," which allowed students from multiple school districts to

acquire environmental and biological data around 11 different rivers on Long Island. In 2019, BNL entered its 15th year of the Open Space Stewardship Program and worked with 30 schools and nearly 2,500 students.

The Laboratory also hosted the annual New York Wildfire & Incident Management Academy, offered by NYSDEC and the Central Pine Barrens Commission. BNL has developed and is implementing a Wildland Fire Management Plan that includes the use of prescribed fire for fuel and forest management. No prescribed fires were conducted in 2019.

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 continues its 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 2019, BNL collected groundwater samples from 625 permanent monitoring wells and 32 temporary wells during 1,704 individual sampling events. Seven groundwater remediation systems removed 61 pounds of volatile organic compounds and returned approximately 750 million gallons of treated water to the Upper Glacial aquifer. Also, one groundwater treatment system removed approximately 0.8 millicurie of strontium-90 (Sr-90) while remediating approximately 14 million gallons of groundwater. Since 2003, BNL has removed approximately 33.6 millicuries of Sr-90 from the groundwater while remediating 245 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 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 2019.

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 2019, the total effective dose (TED) to the MEOSI of 2.8 mrem (28 μ Sv) 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 25 mrem above natural background radiation levels, also well below the 100-mrem DOE limit on dose.

Based on five-year analysis of measurement data for ambient radiation dose, the radiological footprint at BNL increased slightly due to the production of Ac-225 at the BLIP. The ambient dose decreased slightly in 2019 as readiness reviews took place in preparation for ramping up production testing for the 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 2019 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 project-specific quality objectives before being used to support decision making.

In 2019, 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 2019, procedures for calibrating instruments, analyzing samples, and assessing QC were consistent with EPA methodology.

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