

Executive Summary

Brookhaven National Laboratory (BNL) is managed on behalf of the Department of Energy (DOE) by Brookhaven Science Associates (BSA), a partnership between Stony Brook University and Battelle, and six core universities: Columbia, Cornell, Harvard, Massachusetts Institute of Technology, Princeton, and Yale. For over 75 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 operations with 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 the International Organization for Standardization (ISO) 14001 Standard for Environmental Management Systems (EMS). The 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, sustainability, 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 Standard for Environmental Management Systems. BNL was the first DOE Office of Science Laboratory to become officially registered to this standard. The Laboratory achieves certification to the standard by undergoing annual audits by an accredited third-party registrar who ensures that the Lab's EMS is maintained and continually improved. In 2022, BNL's third-party registrar conducted a surveillance assessment of the Lab to the ISO 14001 Standard. The surveillance assessment did not identify any nonconformances, verifying the Laboratory's full conformance to the Standard.

BNL has established sustainability goals with a focus on initiatives that save money and increase efficiency. 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). Each DOE facility is required to have a Site Sustainability Plan (SSP) that details the strategy for achieving these long-term goals and due dates, and to provide an annual status report. The requirements influence the future of the Laboratory's EMS program and have been incorporated into BNL's SSP. For a summary of BNL's 2022 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 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 2022, the P2 Program resulted in nearly \$1.4 million in cost avoidance or savings and resulted in the reduction or reuse of approximately 1.4 million pounds of waste.

BNL continues to decrease its energy consumption. 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 systems to reduce use of once-through cooling water for other systems. In the past ten years, water consumption total was approximately half the 1999 total—a reduction of nearly a half billion gallons per year. In 2022, BNL used 258 million kilowatt hours (kWh) of electricity, 382,000 gallons of fuel oil, 8,580 gallons of propane, and 568 million cubic feet of natural gas. Though BNL usually saves over \$2 million per year using natural gas compared to oil, oil was burned this year both to reduce the supply of now banned #6 fuel oil as well as to empty and clean its storage tanks for testing purposes. Also, in 2022, BNL's energy supply included 121 million kWh of clean, renewable hydropower energy, 644,500 kWh of on-site generated solar photovoltaic (PV), and 24 million kWh of purchased renewable energy certificates. In addition, the Long Island Solar Farm, located on the BNL property and one of the largest solar PV arrays (32 megawatts) in the Northeast, has been producing over 50 million kWh/year. The Laboratory will continue to seek alternative energy sources to meet its future energy needs, support federally required "green" initiatives, and reduce energy costs.

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. Furthermore, BNL maintained a high level of communication and interaction with the community, regulators, and employees, as the Lab began to lift COVID-19 controls. In 2022, BNL hosted virtual meetings of the Community Advisory Council (CAC), 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.

BNL conducts these activities while maintaining

a commitment to environmental justice in line with elements of Justice40, a requirement of EO 14008, by considering the impacts of its activities on local disadvantaged communities, including members from such communities in the Lab's CAC, and providing accessible community involvement activities and educational opportunities, such as the Science in the Community program.

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 2022 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; 11 equivalency permits for the operation of groundwater remediation systems; and several other binding agreements. In 2022, the Laboratory was in compliance with most regulatory requirements. Instances of noncompliance were 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 2022. Recorded excess opacity measurements from CSF boilers were investigated and documented in quarterly Site-Wide Air Emissions and Monitoring Systems Performance Reports and 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 2022. 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 chloro-fluorocarbons as extinguishing agents to eliminate possible ozone-depleting substance emissions.

BNL's drinking water system complied with all applicable county, state, and federal regulations regarding drinking water quality, monitoring, operations, and reporting.

Most of the liquid effluents discharged to surface water and groundwater also met applicable New York State Pollutant Discharge Elimination System (SPDES) permit requirements. From 2018 to 2021, the Lab was not able to routinely meet the SPDES permit limit for Tolytriazole (TTA), a water treatment chemical used to control the corrosion of cooling water systems. Among the multiple corrective actions taken to address this issue over the years, the Lab hired a consultant to prepare a Tolytriazole Management and Treatability Report in response to a Consent Order issued by the NYSDEC in 2021. This report was submitted to NYSDEC on September 29, 2022, and included a full evaluation of the management, alternatives, and possible treatment of TTA. Based on the report's recommendations, BNL decided to convert all cooling water systems that discharge to a permitted SPDES Outfall to a non-TTA treatment chemical that was approved by NYSDEC. Since that conversion was made, BNL has been able to maintain SPDES compliance and the new water treatment chemical has provided equivalent corrosion protection.

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 on a site-wide basis continued in 2022. There were 14 spills in 2022, six of which met regulatory agency reporting criteria.

In 2022, there were eight site inspections by federal, state, or local regulators. These inspections included Sewage Treatment Plant (STP) operations, hazardous waste management facilities, petroleum and chemical storage tank management, and the potable water system. For all inspections, no violations were identified. For the Annual Water Supply Sanitary Survey of the BNL potable water system,

corrective actions for minor deficiencies were established and communicated with Suffolk County Department of Health Services.

The DOE Brookhaven Site Office (BHSO) performs routine inspections, assessments, and surveillances of BNL operations to ensure continual improvement and success in meeting the Laboratory's mission. In 2022, BHSO, with assistance from the DOE Office of Science Consolidated Service Center, performed an assessment of BNL's Packaging and Transportation Program. There was one Noteworthy Practice, four Strengths, and four Level 3 Findings identified during the assessment. A causal analysis was performed for the identified findings 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 millirem (mrem) to a member of the public; all other facilities capable of delivering any radiation dose require periodic confirmatory sampling.

During 2022, BNL facilities released a total of 14,116 curies of short-lived radioactive gases. Oxygen-15 and Carbon-11 emitted from the Brookhaven Linac Isotope Producer (BLIP) constituted 99.9 percent of the site's radiological air emissions.

Radiological emissions at the BLIP are continuously monitored with an in-line detection system, and the Isotope program's Target Processing Laboratory (TPL) has a particulate filter sampling system to continuously collect samples for gross alpha and gross beta activity. At the inactive High Flux Beam Reactor (HFBR), periodic emissions monitoring is also conducted. The average gross alpha and beta airborne activity concentration levels for samples collected from the BLIP exhaust stack were 0.0003 and 0.0070 pico curies per cubic meter (pCi/m³), respectively. Annual average gross alpha and beta airborne activity concentration levels for samples collected from the TPL were 0.0005 and 0.0047 pCi/m³, respectively, and well below standards.

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 0.0013 and 0.0123 pCi/m³, respectively. The results for these locations are typical for the site and show seasonal variation in activity within a range that is representative of natural background levels.

Airborne tritium in the form of tritiated water (HTO) is monitored throughout the BNL site. In 2022, samples were collected from site perimeter monitoring stations to assess the 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 4.7 to 20.2 pCi/m³.

Because natural gas prices were comparatively lower than residual fuel oil prices throughout the year, BNL's CSF used natural gas to meet 91.4 percent of the heating and cooling needs of the Laboratory's major facilities. 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 2022, there were nine recorded excess opacity measurements at the CSF. One recorded reading was due to a load shift and eight excess opacity readings were artificially induced during the opacity calibration test.

BNL has taken several actions to meet DOE greenhouse (GHG) reduction goals. In 2022, BNL consumed 120,747 megawatts of hydropower, providing a net combined GHG reduction of 66,420 metric tons (MT) of carbon dioxide equivalent (CO₂e). Also, in 2022, the Lab's Northeast Solar Energy Research Center (NSERC), a solar photovoltaic facility that has a total peak capacity of 907 kW, provided 644,479 kWh and offset 355 MT CO₂e. Combined hydropower from the New York Power Authority and NSERC power offset 66,775 MT CO₂e. Finally, BNL's Utility Energy Service Contract, which implements energy savings measures to reduce Scope 1 and 2 GHG levels by approximately 7,000 MT CO₂e has been a success, with annual energy savings within three

percent of the original estimates for each of the seven years since its inception in 2013.

The COVID-19 pandemic had significant impacts on Laboratory air travel, initially leading to a significant decrease in GHG emissions during Fiscal Year (FY) 2021. In 2022, Scope 3 GHG emissions increased by 2,801 MT CO₂e, up 27.4 percent from FY 2021. The 2022 emissions were, however, 35 percent less than the FY 2008 baseline value. The increase from FY 2021 is mostly due to a 1,097 MT CO₂e increase in GHG emissions from business air travel, and a 767 MT CO₂e increase in commuting GHG emissions. In anticipation of more employees returning to the work site, an additional uptick in emissions is expected in FY 2023.

Chapter 4 of this report describes BNL's Air Quality Program, monitoring data, and other GHG reduction 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 wastewaters 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.

Monitoring results for 2022 indicate that the average gross alpha and beta activity levels in the STP discharge (EA, Outfall 001) were well below New York State Drinking Water Standards (NYS DWS). Tritium was not detected above the method detection limit (MDL) in the STP discharge; 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 all 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. The average gross alpha and beta concentrations 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 in discharges to recharge basins due to the use of chlorine and bromine to control algae and bacteria in potable and cooling water systems. Inorganics (e.g., metals) were also detected; however, their presence is due primarily to sediment runoff in stormwater discharges.

The Peconic River did not flow off site in 2022. Radiological data from Peconic River surface water sampling show that the average gross alpha and gross beta concentrations from on-site locations were indistinguishable from background sample 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 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 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 employees 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.

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. The Laboratory

also monitors or manages other populations, including species of interest, to ensure that they are sustained and to control invasive species.

To evaluate Cs-137 in deer, BNL has established a routine on- and off-site deer sampling program. In 2022, a total of 24 deer were taken both on and off the BNL site. The highest Cs-137 level in an on-site sample (1.40 pCi/g, wet weight) was roughly 30 percent lower than the highest on-site sample reported in 2021 (1.99 pCi/g, wet weight) and eight times lower than the highest level ever reported in 1996 (11.74 pCi/g, wet weight). Deer taken greater than one mile from the Lab ranged from 0.05 pCi/g to 2.62 pCi/g, wet weight with the arithmetic average being 0.92 pCi/g, wet weight. The New York State Department of Health (NYS-DOH) 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).

During 2022, 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. Six vegetation samples were non-detect for Cs-137; the remaining four samples had Cs-137 levels ranging from 0.06 pCi/g to 1.25 pCi/g, wet weight. Soil samples had Cs-137 levels ranging from 0.08 pCi/g to 32.4 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.

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 2022, precipitation samples were collected quarterly at two air monitoring stations. Mercury was detected in all the precipitation samples, with concentrations ranging from 2.9 ng/L to 5.93 ng/L. The 5.93 ng/L concentration is eight 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 2022, four interns completed projects related to the effects of wildland fires on bat species diversity, camera trapping, and small mammal trapping for comparison to previous work conducted in 2014.

BNL continued its active support of ecological education programs by hosting the Day in the Life of a River Program which ran from September 23 to November 4, 2022. This program is a place-based educational experience where students and teachers collaborate with environmental professionals to collect scientific information to obtain a snapshot of the health of Long Island rivers and creeks. The Day in the Life of a River is a collaboration between the Central Pine Barrens Commission, the NYSDEC, and BNL, and supported by 145 experts from the U.S. Geological Survey, the Town of Brookhaven, Trout Unlimited, New York State Parks, Cornell Cooperative Extension, and the Seatuck Environmental Association, among others.

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 2022, all buildings and infrastructure greater than 50 years of age were evaluated for historic significance. The only additional resource determined to be eligible for listing on the National Register of Historic Places was the Gamma Forest, a scientific facility operated from 1962 through 1978 to investigate gamma ray impacts on ecosystems.

The BNL Cultural Resource Management Program ensures that the Laboratory fully complies with numerous cultural resource regulations. Doing so also ensures that the contributions BNL and the site have made to local and national history and culture are documented and available for interpretation. In 2022, cultural resource efforts entailed

completion of a Memorandum of Agreement (MOA) with the New York State Historic Preservation Office for the demolition of the Brookhaven Medical Research Reactor Stack, and the continued negotiation of an MOA for the demolition of a 1940s-era water tower that has been replaced with a modern water tower.

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

GROUNDWATER PROTECTION MANAGEMENT PROGRAM

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 2022, BNL collected groundwater samples from 676 permanent monitoring wells and 32 temporary wells. Seven groundwater remediation systems removed 53 pounds of volatile organic compounds (VOCs) and returned approximately 937 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 7,819 pounds of VOCs by treating almost 31 billion gallons of groundwater.

In October 2022, BNL started the operation of the Current Firehouse Per- and Polyfluoroalkyl Substances (PFAS) Remediation System. During a two-month period, the system removed 0.08 pound of total PFAS while treating 33 million gallons of groundwater. Also, one groundwater treatment system removed approximately 0.3 millicurie of strontium-90 (Sr-90) while remediating approximately 10 million gallons of groundwater. Since 2003, BNL has removed approximately 34.6 millicuries of Sr-90 from the groundwater while remediating approximately 284 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.

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 2022.

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 offsite individual, defined as the “maximally exposed off-site individual” (MEOSI). The dose to the MEOSI is from direct and indirect dose pathways via air immersion, inhalation of particulates and gases, and ingestion of local fish and deer meat.

In 2022, the total effective dose (TED) to the MEOSI from Laboratory operations was five percent of the dose limit of 100 mrem in a year required by DOE Order 458.1, and well below all other EPA and DOE regulatory dose limits for the public, workers, and the environment. The effective dose equivalent (EDE) from air emissions in 2022 was estimated at 1.19 mrem (11.9 microSieverts [μSv]) to the MEOSI. The BNL dose level from the inhalation pathway was 11.9 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 3.82 mrem (38.2 μSv) from the consumption of deer meat. In summary, the total annual dose to the MEOSI from all pathways was estimated at 5.01 mrem (50.1 μSv), which is five percent of DOE's 100 mrem limit. The aggregate population dose was 5.6 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 (outside of radiological controlled work areas), calculated from thermo-luminescent dosimeter (TLD) monitoring records, was 26 mrem (26 μSv) above natural background radiation levels, also well below the 100-mrem DOE dose limit. The average annual external dose from ambient sources on site was 61 ± 7 mrem (610 ± 70 μSv), while the dose from off-site ambient sources was 58 ± 6 mrem (580 ± 60 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 53 on-site

TLDs and 16 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. 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 2022 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 multi-layered 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 2022, environmental samples were analyzed by five contract analytical laboratories, whose selection is discussed in Section 9.3.1 in Chapter 9. All samples were analyzed according to EPA-approved methods or by standard industry methods where no EPA methods are available (e.g., for Tolyltriazole). The most common quality control issue encountered during 2022 was the detection of low-level contamination in the trip, field, and method blanks used in VOC analyses.

Environmental monitoring samples were collected as specified in the 2022 BNL Environmental Monitoring Plan Update (BNL 2022) and project-specific work plans. BNL uses Standard Operating Procedures that are consistent with industry and regulatory standards for the collection of environmental samples, including groundwater, surface water, soil, sediment, air, flora, and fauna. During

sample collection, field sampling technicians used calibrated field instrumentation for parameters such as conductivity, dissolved oxygen, pH, temperature, and turbidity. To ensure the integrity of samples, chain-of-custody was maintained and documented for all samples collected in 2022.

The data validations, data verifications, and Data Quality Objectives (DQO) checks conducted on analytical results at BNL are designed to eliminate any data that fails to meet the DQOs of each project. The results of the independent Performance Evaluation assessments and assessments of contractor laboratories summarized in this chapter are also 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.