2009 Site Environmental Report

VOLUME 1

BROOKHAVEN NATIONAL LABORATORY

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Executive Summary

Brookhaven National Laboratory (BNL) prepares an annual Site Environmental Report (SER) in accordance with DOE Order 231.1A, Environment, Safety and Health Reporting of the U.S. Department of Energy. 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 of its environmental history since the Laboratory's inception in 1947.

Volume II of the SER, the Groundwater Status Report, also is prepared annually to report on the status of and evaluate the performance of groundwater treatment systems at the Laboratory. Volume II includes detailed technical summaries of groundwater data and its interpretation, and is intended for internal BNL users, regulators, and other technically oriented stakeholders. A brief 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 http://www.bnl.gov/ewms/ser/. *An electronic version on compact disc is distributed with each printed report. In addition, a summary of Volume I is prepared each year to provide a general overview of the report, and is distributed with a compact disc containing the full report.*

BNL is operated and managed for DOE's Office of Science by Brookhaven Science Associates (BSA), a partnership formed by Stony Brook University and Battelle Memorial Institute. For more than 60 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 motto, "Exploring Life's Mysteries…Protecting its Future," and its Environmental, Safety, Security and Health Policy reflect the commitment of BNL's management to fully integrate environmental stewardship into all facets of its mission and operations.

INTEGRATED SAFETY MANAGEMENT SYSTEM, ISO 14001, AND OHSAS 18001

The Laboratory's Integrated Safety Management System (ISMS) incorporates management of environment (i.e., environmental protection and pollution prevention), safety, and health 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 safety 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) and the Occupational Safety and Health 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 Environmental Management System (EMS) was 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 BNL's Environment, Safety, Security, and Health (ESSH) Policy. This policy makes clear the Laboratory's commitments 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 at http://www.bnl.gov/ESHQ/ESSH.asp. 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 laboratory under the DOE Office of Science to become officially registered to this standard. BNL was also the first DOE 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 2009, an EMS and OHSAS surveillance audit determined that BNL remains in conformance with both standards. In their recommendation for continued certification, auditors from NSF-International Strategic Registrations, Ltd., highlighted more than 14 noteworthy practices, some of which include: a strong commitment to achievement of Laboratory-wide environmental, safety, and health (ES&H) objectives and targets; continued improvement in analysis of ES&H data to prevent issues from occurring; and strengths in environmental planning for the development of the Long Island solar farm. The auditors also identified one minor nonconformity: to improve the use of casual analysis for ES&H issues. Nine opportunities for improvement were also noted, such as continued reductions in paper use and cafeteria waste reduction. Corrective actions were prepared and tracked to closure.

Two DOE Orders, issued in 2008, incorporated the goals of the Presidential Executive Order 13423, Strengthening Federal Environmental, Energy, and Transportation Management. DOE Order 450.1A, Environmental Protection, established federal requirements for pollution prevention, reduction in toxic chemical use, purchase of environmentally preferred products, electronic stewardship, and the implementation of an EMS. DOE Order 430.2B, Departmental Energy, Utilities, and Transportation Management, established federal requirements for certain criteria, and requires an annual certification and submission of an Executable Plan. The Executable Plan provides a roadmap on how the Laboratory intends to meet these requirements. Executive Order 13514, signed in 2009, sets sustainability goals for federal agencies and focuses on making improvements in their environmental, energy, and economic performance. It also requires federal agencies to set a 2020 greenhouse gas emissions reduction target, increase energy efficiency, reduce fleet petroleum consumption, conserve water, reduce waste, support sustainable communities, and leverage federal purchasing power to promote environmentally responsible products and technologies. The Laboratory's EMS objectives and targets have been established to mirror these requirements, and most have already been incorporated within the program.

The Laboratory's strong 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 into 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. Five of 15 P2 proposals, submitted by employees to BNL's P2 Council, were funded in 2009, for a combined investment of approximately $24,000. The anticipated annual savings from these projects is approximately $33,650, for an average payback period of approximately 0.7 years. Initiatives to reduce, recycle, and reuse 9.7 million pounds of industrial, sanitary, hazardous, and radiological waste through the P2 program resulted in more than $1.8 million in cost avoidance or savings in 2009.

Chapter 2 of this report describes the elements and implementation of BNL's EMS in further 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 2009 follows:

Compliance Monitoring Program

BNL has an extensive program in place to ensure compliance with all applicable environmental regulatory and permit requirements. The Laboratory must comply with more than 100 sets of federal, state, and local environmental regulations, numerous site-specific permits, 17 equivalency permits for the operation of 14 groundwater remediation systems, and several other binding agreements. In 2009, the Laboratory complied with the majority of these requirements, and instances of noncompliance were reported to regulatory agencies and corrected expeditiously. Routine inspections conducted during the year found no significant instances of noncompliance; however, the New York State Department of Environmental Conservation (NYSDEC) issued a warning notice in October for failure to report opacity violations within 2 days of the date of occurrence. Corrective actions have been implemented.

Nine external environmental audits were conducted in 2009 by federal, state, and local agencies that oversee BNL activities.

- NYSDEC conducted its formal inspection of the Laboratory's air compliance program; there were no violations noted.
- NYSDEC conducted its annual inspection of the Major Oil Storage Facility. Four conditions that required corrective action were identified: the need to properly prepare and paint some sections of Tank 611-06 and associated piping; provide confirmation that all "tell-tails" associated with tanks 611-09 and 611-10 are inspected and documented properly; registration and follow-up inspection of a new 1,000 gallon aboveground bio-diesel tank that was installed in the fuel off-loading facility; and evaluation of the cathodic protection system servicing tanks 3, 5, and 6, to ensure that it is adequately protecting the tanks. In addition, an inspection of the Laboratory's underground storage facilities and other smaller satellite fuel storage tanks identified one condition that required corrective action. This included the need to conduct and document testing of the automatic line-leak detectors for the tanks located at the on-site service station. Most conditions were corrected in accordance with NYSDEC directives prior to the end of calendar year 2009. With NYSDEC approval, the remaining conditions will be addressed in 2010.
- NYSDEC conducted an inspection of the Chemical Bulk Storage facilities. During this inspection, three issues were identified that required corrective action: the need to properly prepare and paint a small section on the west side of Tank 635-01; re-calibration or replacement of remote level gauges

associated with Tanks 624-05 thru -08; and properly terminating the atmospheric vent associated with Tank 634-02 within the tank containment area. These issues were corrected in accordance with the NYSDEC request.

- The Suffolk County Department of Health Services (SCDHS) collected samples and conducted its annual inspection of the BNL potable water system; no issues were identified.
- SCDHS conducted quarterly inspections of the Laboratory's Sewage Treatment Plant (STP) to evaluate operations and sample the effluent; no performance or operational issues were identified. NYSDEC did not perform its annual surveillance inspection in 2009.
- SCDHS inspected several of the State Pollutant Discharge Elimination System (SPDES)-regulated outfalls and collected samples; no issues were identified.

Each year, several DOE assessments and inspections are performed at BNL. The DOE Brookhaven Site Office (BHSO) and the DOE Chicago Office evaluated the Laboratory's readiness to declare conformance to DOE Order 450.1A in December 2008. This order, along with its companion DOE Order 430.2B, established new requirements for DOE facilities in the areas of energy and water conservation, improved fleet management, and other sustainable practices. Order 450.1A requires DOE facilities to have an EMS that includes objectives and targets supporting the sustainability goals of the order, and the energy, water, fleet, and other goals of Order 430.2B. Overall, the assessment found that the EMS culture at BNL was strong due to the prior long-term establishment of an ISO 14001-registered EMS, and is clearly in conformance with DOE Order 450.1A. The Laboratory formally declared its conformance to these new requirements in April 2009. In addition, the DOE Chicago Office conducted an assessment of BNL's Environmentally Preferable Purchasing (EPP) program in June as part of the BHSO independent oversight program. The findings of this assessment were rolled up into one finding. The results indicated that, although an improvement plan was prepared with actions to comply with the requirements related to the EPP requirements of DOE Order 450.1A, BNL was behind schedule on implementation of the actions. While the Laboratory committed to have all actions completed by early October 2009, one action remained opened at the end of 2009. This action, to revise and issue the procurement subject area which includes requirements for EPP, will be completed in 2010.

Also in 2009, BNL conducted a programmatic self-assessment on several aspects of its environmental management program. Topics for this assessment were determined based on institutional risk, DOE and regulatory agency expectations, and the need to ensure that key environmental requirements are being implemented as designed. The self-assessment focused on requirements related to properly managing wastes generated at the Laboratory, including hazardous, industrial, mixed, radioactive, radioactive-regulated medical waste, and regulated medical waste. During the self-assessment, two Noteworthy practices, seven Nonconformances, and three Observations were noted. A causal analysis was performed and a corrective action plan was prepared for the identified nonconformances to address the issues. Progress on the actions will be tracked to closure in BNL's Institutional Assessment Tracking System.

BNL continues to be a certified Nevada Test Site (NTS) waste generator. As part of the NTS waste certification process, the NTS Maintenance and Operations Contractor conducts random unannounced inspections. NTS performed an unannounced inspection in May of 2009; there were no findings noted.

In 2009, emissions of nitrogen oxides, carbon monoxide, and sulfur dioxide from the Central Steam Facility (CSF) were all within permit limits. There were 24 individual opacity excursions noted. These occurred in the first (3 instances), second (16 instances), and fourth (5 instances) quarters.

Approximately 1,232 pounds of ozone-depleting refrigerants were recovered from refrigeration equipment for reuse by other DOE facilities or federal agencies. These reductions included the disposition of eight cylinders of Halon 1301

from fixed fire suppression systems removed from operation and eight cylinders of Halon 1301 associated with portable fire extinguishing systems. These materials have been transferred to storage for shipment to the Department of Defense Ozone Depleting Substances Reserve.

Monitoring of BNL's potable water supply showed that all drinking water quality requirements were met in 2009. Most of the liquid effluents discharged to surface water and groundwater met applicable SPDES permit requirements; however, two minor excursions occurred during the year and were reported to NYSDEC and SCDHS. Groundwater monitoring at the Major Petroleum Facility continued to demonstrate that current oil storage and transfer operations are not affecting groundwater quality.

The Laboratory continues to reduce the number and severity of spills on site. In 2009, there were 11 reportable spills of petroleum products, antifreeze, or chemicals. While the total number of spills increased by two from 2008, the severity of releases was less. All releases were cleaned up to the satisfaction of NYSDEC.

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 on site to ensure compliance with the requirements of the Clean Air Act. During 2009, Laboratory facilities released a total of 1,833 curies of short-lived radioactive gases. 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. Although the dose to the public is less than 0.1 mrem and monitoring is not required by EPA, the Brookhaven Linear Isotope Producer (BLIP) is continuously monitored. Oxygen-15 (half-life: 122 seconds) and carbon-11 (half-life: 20.48 minutes) emitted from the BLIP constituted more than 97.9 percent of radiological air emissions on site in 2009. The combined emissions were approximately 31 percent lower than 2008 levels, primarily due to operation at lower energy levels.

Monitoring was also conducted at one other active facility, the Target Processing Laboratory (TPL), and one inactive facility, the High Flux Beam Reactor (HFBR). Releases from the TPL in 2009 continued to be very small (0.025 µCi). The rise in tritium releases from the HFBR in 2009 was due to decontamination and dismantlement (D&D) activities that included the removal of control rod blades; draining of tritiated heavy water from the reactor vessel, piping systems, and the fuel canal; and the opening of contaminated piping systems to allow for the removal of residual volumes of tritiated heavy water. From 2002 through 2008, emissions from the HFBR facility were monitored via air sampling at a frequency of one week per month. In 2009, the monitoring frequency was increased to bi-weekly to better account for changes in tritium emissions during planned D&D activities.

The Laboratory conducts ambient radiological air monitoring to verify local air quality and assess possible environmental and health impacts from BNL operations. Air monitoring stations around the perimeter of the site measure tritium and gross alpha and beta airborne activity. Results for 2009 continued to demonstrate that onsite radiological air quality was consistent with off-site measurements and with results from locations in New York State that are not located near radiological facilities.

Various state and federal regulations governing nonradiological releases require facilities to conduct periodic or continuous emissions monitoring to demonstrate compliance with emission limits. The CSF is the only BNL facility that requires monitoring. Two of the four boilers at the CSF, specifically 6 and 7, are equipped with continuous emission monitors to measure opacity and nitrogen oxide (NOx) emissions. Opacity levels cannot exceed 20 percent, except for one 6-minute period per hour of not more than 27 percent opacity. In 2009, there were no exceedances of the NOx emission standards for either boiler.

In 2009, opacity measurements in Boiler 6 were exceeded 16 periods during the second quarter and 5 periods during the fourth quarter. The first 12 second quarter excess opacity read-

ings occurred during the initial soot blowing cycle after the boiler was brought on line while combusting natural gas. Since opacity readings began to rise immediately after the boiler was fired with natural gas, it appears that the natural cleansing affect of natural gas caused these opacity excursions. The four other excess opacity readings recorded during the second quarter were the result of dust build-up on the optical head assembly. Subsequent cleaning of the assembly returned opacity levels back to normal. There was no apparent cause for the five excess opacity readings recorded during the fourth quarter. Two excess opacity readings for Boiler 7 recorded in February during a soot blowing cycle appear to have been an isolated incident. Changes in the sequence of the soot blowing cycle for Boiler 6 made in August 2005 have proven effective in eliminating most opacity exceedances due to soot blowing. Similar changes made to the soot blowing cycle on Boiler 7, after the installation of a new soot blowing controller in March 2006, have also been successful in eliminating most soot blowing opacity exceedances from this boiler.

Because natural gas prices were lower than residual fuel oil prices from May through December 2009, BNL used natural gas for most heating and cooling needs during these months. As a result, annual facility emissions of particulate matter, nitrogen oxides, and sulfur dioxide were considerably lower than in years when residual fuel oil was predominantly used.

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

Water Quality Surveillance Program

BNL discharges treated wastewater into the headwaters of the Peconic River via the STP, and non-contact cooling water and storm water runoff to groundwater via recharge basins. Some wastewater may contain very low levels of radiological, organic, or inorganic contaminants. Monitoring, pollution prevention, and careful operation of treatment facilities ensure that these discharges comply with all applicable requirements and that the public, employees, and the environment are protected.

To assess the potential impact of discharges on the water quality of the Peconic River, surface water monitoring is conducted at several locations upstream and downstream of the STP discharge. The Carmans River, located to the west of BNL, is monitored as a geographical control location for comparative purposes, as it is not affected by Laboratory operations. In 2009, the average gross alpha and beta activity levels in the STP discharge were well below drinking water standards (DWS). Tritium detected at the STP originates from either HFBR sanitary system releases, or from small, infrequent batch releases that meet BNL discharge criteria from other facilities. Although the HFBR is no longer operating, tritium continues to be released from the facility at very low concentrations due to off-gassing. To minimize the quantity of tritium released to the STP, efforts have been made to capture most of the air compressor condensate collected in the equipment areas of the structure. In 2009, tritium was detected once in the STP effluent at a concentration above the minimum detectable activity (490 pCi/L), which is less than 3 percent of the drinking water standard. Although this was a low level of detection with high uncertainty, it may have been attributed to work to further ready the HFBR for decommissioning and decontamination. Tritium was also detected twice in the influent, but at levels just above the minimum detectable activity. In 2009, analysis of the STP effluent and the Peconic River continued to show no detection of cesium-137 (Cs-137), strontium-90 (Sr-90), or other gamma-emitting nuclides attributable to BNL operations.

The STP is also monitored for nonradiological contaminants. In 2009, nonradiological monitoring of the STP effluent showed that, except for isolated incidents of noncompliance, organic and inorganic parameters were within SPDES effluent limitations or other applicable standards. Two volatile organic compounds (VOCs), methyl chloride and acetone, were detected in the STP effluent, but at very low levels.

Discharges to recharge basins are sampled throughout the year for analyses of 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 2009, there were no reported gamma-emitting nuclides attributable to BNL operations in any discharges to recharge basins. Tritium was detected in a single sample collected at Basin HT-W at a very low level, and with high uncertainty. This basin receives discharges from the Collider-Accelerator complex.

Low concentrations of disinfection byproducts were periodically detected in discharges to several of the basins throughout the year. Sodium hypochlorite and bromine, used to control bacteria in the drinking water and algae in cooling towers, lead to the formation of VOCs, including bromoform, chloroform, dibromochloromethane, and dichlorobromomethane. Bromoform and acetone were detected above the minimum detection level for most recharge basins. In most instances, acetone was also found as a contaminant in the contract analytical laboratory, as evidenced by detections in blank 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 goals of the program include protecting and monitoring the ecosystem, conducting research, and communicating with the public, stakeholders, and staff members regarding environmental issues. Precautions are taken to protect and enhance habitats and natural resources at BNL. Activities to eliminate or minimize negative effects on sensitive or critical species (such as the eastern tiger salamander, eastern hognose snake, and banded sunfish) are incorporated into procedures or into specific programs or project plans. Restoration efforts continue to remove pollutant sources that could contaminate habitats. In some cases, habitats are enhanced to improve survival or increase populations. The Laboratory also monitors and manages other wildlife populations, such as white-tailed deer and Canada geese.

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. Generally, deer sampled on site contain higher concentrations of Cs-137 than deer sampled from more than 1 mile off site. This is most likely because on-site deer consume small amounts of contaminated soil and graze on vegetation growing in soil where elevated Cs-137 levels are known to exist. The maximum on-site concentration in 2009 was 1.8 times higher than the highest level reported in 2008, but continues to be much lower than the highest level ever reported (1996). The New York State Department of Health (NYSDOH) has formally reviewed the potential public health risk associated with elevated levels of Cs-137 in on-site deer and determined that neither hunting restrictions or formal health advisories are warranted. Testing of deer bones for Sr-90 indicated background levels. Sr-90 is present in the environment at background levels as a result of worldwide fallout from nuclear weapons testing. BNL continues to test for Sr-90 in bone to develop baseline information on this radionuclide and its presence in local while-tailed deer.

In an effort to restore fish populations, the Laboratory suspended most on-site fish sampling in 2001. By 2007, fish populations had recovered and annual on site sampling resumed. In 2009, Cs-137 was detected at low levels in all but two samples from the Peconic River system and appears to be declining compared with historic values. The cleanup of both on-and off-site portions of the Peconic River in 2004 and 2005 removed approximately 88 percent of Cs-137 in the sediment that was co-located with mercury. Natural decay and the removal of this contamination are expected to result in further deceases.

Nonradiological analysis of fish continued in 2009. All concentrations for metals are considered safe and do not pose any health risks to humans or other animals that may consume fish. Due to its known health risk, mercury is the metal of most concern. In general, a trend of decreasing mercury content downstream from BNL's STP is evident. Pesticide analysis in fish

was discontinued in 2008, since several years of sampling detected pesticides in only a few fish far off site. Polychlorinaded biphenyl (PCB) analysis in fish was also discontinued off site, but continued to be performed for fish on site. Two fish samples tested positive for PCBs. Historically, PCBs have been found in both fish and sediment at BNL and periodically at other locations in the Peconic River. The cleanup of the Peconic River has removed most PCBs within the sediments on site.

Annual sampling of sediment, vegetation, and freshwater in the Peconic River and a control location on the Carmans River was conducted in 2009. On- and off-site aquatic vegetation and sediments contained low levels of Cs-137 and metals in amounts that were consistent with levels detected in previous years. Pesticides and PCB analyses of aquatic sampling were discontinued in 2008.

Under the Peconic River remediation project, sediment from the Peconic River was remediated to remove mercury and associated contaminants from the river. All sample results for 2009 met the mercury cleanup goal of 2.0 mg/kg. Five additional samples in a known area of higher mercury concentrations were also sampled; only one sample exceeded the cleanup goal. Supplemental sediment sampling was also conducted to evaluate elevated water column mercury concentrations at one station within the Peconic River, and identified a small on-site section of the river which will receive supplemental cleanup in the fall of 2010.

Water column sampling for mercury and methylmercury was performed at 20 Peconic River sampling locations, the STP, and one reference location on the Connetquot River in 2009. The general trend of total mercury in water samples decreased with increasing distance downstream from the STP. Methylmercury concentrations increased slightly from the STP to the BNL site border; then decreased gradually with increasing distance downstream of the BNL site border until reaching the historic range of concentrations for the Connetquot River reference station.

The five-year periodic confirmatory sampling of local farm vegetables was completed in 2009. Data shows that vegetables grown in the BNL garden plot continue to support historic analyses that there are no Laboratory-generated radionuclides in on-site produce.

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 DOE, 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 2009, the Environmental Protection Division hosted 19 interns and one faculty member who worked on a variety of projects, some of which include: invertebrate distribution surveys of the Carmans River, small mammal and flying squirrel surveys, the quantification of nitrogen in soils, bathymetry of a small lake, and surveying dragonflies and damselflies. Also in 2009, the Laboratory's GREEN institute and Open Space Stewardship Program (OSSP), established by BNL's Office of Education, continued to grow, and the Foundation for Ecological Research in the Northeast (FERN) continued work on video-based instruction for protocols used within OSSP.

The goal of BNL's Cultural Resource Management Program (CRMP) is to ensure the proper stewardship of BNL and DOE historic resources. Additional goals include maintaining compliance with various historic preservation and archeological laws and regulations, and ensuring the availability of resources to Laboratory personnel and the public for research and interpretation. Cultural resource management activities performed in 2009 included two field studies to evaluate the proposed Long Island solar farm project site; an archaeological survey on 33 acres formally occupied by the World War I Camp Upon Remount Facility, in order to access the overall potential of the area for the presence of cultural resources; an architectural and archeological data recovery/assessment of a standing Civilian Conservation Corps era privy; identifying and relocating artifacts from BNL's Brookhaven Graphite Research Reactor (BGRR) and HFBR; and outreach activities, in-

cluding presentation on the Laboratory's cultural resources and tours of the on-site WWI trenches.

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

Groundwater Protection Management Program

BNL's extensive groundwater monitoring well network is used to evaluate progress in restoring groundwater quality, to comply with regulatory permit requirements, to monitor active research and support facilities, and to assess the quality of groundwater that enters and exits the site. The Laboratory monitors research and support facilities where there is a potential for environmental impact, as well as areas where past waste handling practices or accidental spills have already degraded groundwater quality. In 2009, the Laboratory collected groundwater samples from 806 on- and off-site monitoring wells during 1,800 individual sampling events.

Under the environmental surveillance program, 10 active research and support facilities were monitored during 2009. Although no new impacts to groundwater quality have been discovered since 2001, groundwater quality continues to be impacted from past releases at two facilities: the former g-2 experiment within the Alternating Gradient Synchrotron (AGS) facility, and the Upton service station facility. Tritium continues to be detected at concentrations above the 20,000 pCi/L DWS in wells monitoring the g-2 source area. A short-term spike in tritium levels was observed in October 2009, and appears to be related to the flushing of residual tritium from the deep vadose zone following significant natural periodic fluctuations in the local water table. As a result of natural radioactive decay and dispersion in the aquifer, the g-2 tritium plume is breaking up into discrete segments. At the Upton service station, VOCs associated with historical petroleum and solvent spills continue to be detected in the groundwater at concentrations above the applicable DWS. The levels of VOCs are expected to decrease over time by means of natural attenuation.

The primary mission of the Laboratory's Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) groundwater program is to operate and maintain groundwater treatment systems and prevent additional groundwater contamination from migrating off site. During 2009, BNL continued to make significant progress in restoring groundwater quality with the removal of approximately 229 pounds of VOCs and approximately 1.9 mCi of Sr-90 with the treatment of more than 1.6 billion gallons of groundwater. To date, 6,363 pounds of VOCs have been removed from the aquifer, and noticeable improvements in groundwater quality are evident in the Operable Unit (OU) I South Boundary, OU III South Boundary, OU III Industrial Park, OU III Industrial Park East, OU III North Street, OU IV, Building 96, and Carbon Tetrachloride areas. Also to date, two of the treatment systems have removed approximately 21 mCi of Sr-90.

Chapter 7 of this report provides an overview of this program, and the SER Volume II, Groundwater Status Report, provides a detailed description, data, and maps relating to all groundwater monitoring performed in 2009.

Radiological Dose Assessment Program

BNL routinely assesses its operations to ensure that any potential radiological dose to members of the public, BNL workers, visitors, and the environment is "As Low As Reasonably Achievable" (ALARA). The potential radiological dose is calculated as the largest possible dose to a hypothetical Maximally Exposed Individual (MEI) at the BNL site boundary. For dose assessment purposes, the pathways include direct radiation exposure, inhalation, ingestion, immersion, and skin absorption. Radiological dose assessments at the Laboratory have consistently shown that the effective dose equivalent from operations is well below the EPA and DOE regulatory dose limits for the public and the environment. The dose impact from all BNL activities in 2009 was comparable to natural background radiation levels.

To measure direct radiation from Laboratory operations, 58 thermoluminescent dosimeters (TLDs) are placed on site and 14 TLDs are placed in surrounding communities. An additional 30 TLDs are placed in a lead-shielded container for use as reference and control TLDs

for comparison purposes. In 2009, the average dose from all TLDs showed there was no additional contribution to on- and off-site locations from BNL operations.

The annual on-site external dose from all potential sources, including cosmic and terrestrial radiation, was 71 ± 10 mrem (710 ± 100 µSv), and the annual off-site external dose was 67 ± 7 mrem (670 ± 70 µSv). The effective dose to the MEI from air emissions was 7.20E-2 mrem (0.72 µSv). The ingestion pathway dose was estimated as 7.10 mrem (71 µSv) from consumption of deer meat and 0.17 mrem (1.7 µSv) from consumption of fish caught in the vicinity of the Laboratory. The total dose to the MEI from all pathways was estimated as 7.34 mrem (73 µSv). The dose from the air inhalation pathway attributable to BNL operations was less than 1 percent of EPA's annual regulatory dose limit of 10 mrem (100 µSv), and the total dose was less than 8 percent of DOE's annual dose limit of 100 mrem (1,000 µSv) from all pathways. Doses to aquatic and terrestrial biota were also evaluated and found to be well below the regulatory limits.

As a part of the National Emission Standards for Hazardous Air Pollutants (NESHAPs) review process at BNL, any source that has the potential to emit radioactive materials is evaluated for regulatory compliance. In 2009, the following radiological sources were evaluated for potential contribution to the overall site dose:

A prelimary NESHAP evaluation was performed in 2008 for the removal of the graphite pile and bioshield at the BGRR. In 2009, based on the results of waste characterization studies, smear results, and radiological inventory of the graphite pile and biological shield, the effective dose equivalent to the MEI from this project was estimated to be 1.33E-02 mrem/year. The facility will be continuously monitored for radionuclides during the removal of these materials, which is expected to be completed in 2011.

Underground waste lines, which were abandoned in 1961, were used to transfer radioactive liquid waste from the BNL Hot Laboratory in Building 801 to the Waste Concentration Facility. In 2009, remediation work began on the removal of the waste transfer lines, stream line, soil below the pipes, a portion of the concrete culvert, and the non-acid off-gas pipe under the HFBR. The effective dose equivalent to the MEI from this project was estimated to be 1.38E-03 mrem/year.

A NESHAPS compliance review for venting of the radioactive gases used in the gallium trichloride experiment in Building 555 was performed. A conservative estimate of effective dose equivalent to the MEI was estimated to be 2.37E-08 mrem/year.

An investigation and characterization of the Brookhaven Avenue Cs-137 contamination at the Waste Loading Area within the former Hazardous Waste Management Facility was reviewed to determine the source term. The effective dose equivalent to the MEI was estimated to be 6.67E-05 mrem/year.

A NESHAPS dose assessment was performed for the potential release of carbon-11 (half-life: 20 minutes) in an "Accident" scenario for inclusion in the Safety Analysis Report of BNL's cyclotron. A conservative estimate of effective dose equivalent to the MEI was estimated to be 2.64E-04 mrem/year.

Stack modifications were made at the BLIP facility in order to comply with American National Standards Institute standards. The existing stack duct was removed and a new duct was installed. In addition, a new emission sampling system was also installed and will be tested during BLIP operations in 2010.

The HFBR reactor vessel, primary cooling water system, and fuel canal were drained in 2009. Control rod blades and beam plugs were also removed and shipped off site to a licensed disposal facility. Tritium levels in the reactor building were much higher than in previous years due to the remediation work being performed. The effective dose equivalent to the MEI was estimated to be 1.92E-4 mrem/year.

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 document are reliable and of high quality, and that all

environmental monitoring data meet quality assurance and quality control objectives. Samples are collected and analyzed in accordance with EPA methods and 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 2009, the Laboratory used five off-site contract analytical laboratories to analyze environmental samples: General Engineering Lab (GEL), H2M Lab, Test American (TA), Chemtex Lab, and Brooks Rand. All analytical laboratories were certified by NYSDOH for the tests they performed for BNL, and were subject to oversight that included state and national performance evaluation (PE) testing, review of QA programs, and audits.

Based on the data reviews, data validations, and results of the independent PE assessments, the chemical and radiological results reported in this 2009 SER are of acceptable quality.

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

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1 Introduction

Established in 1947, Brookhaven National Laboratory is a multi-program national laboratory managed for the U.S. Department of Energy by Brookhaven Science Associates (BSA), a partnership formed by Stony Brook University and Battelle Memorial Institute. BSA has been managing and operating the Laboratory under a performance-based contract with DOE since 1998. From 1947 to 1998, BNL was operated by Associated Universities Incorporated. Prior to 1947, the site operated as Camp Upton, a U.S. Army training camp, which was active from 1917 to 1920 during World War I and from 1940 to 1946 during World War II.

BNL is one of 10 national Laboratories under DOE's Office of Science, which provides most of the Laboratory's research dollars and direction. BNL has a history of outstanding scientific achievements. For over 60 years, Laboratory researchers have successfully worked to envision, construct, and operate large and innovative scientific facilities in pursuit of research advances in many fields. Programs in place at BNL emphasize continual improvement in environmental, safety, security, and health performance.

1.1 LABORATORY MISSION

BNL's broad mission is to produce excellent science and advanced technology in a safe and environmentally sound manner with the cooperation, support, and involvement of its scientific and local communities. The fundamental elements of the Laboratory's role in support of DOE's strategic missions in energy resources, environmental quality, and national security are:

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

BNL's Environmental, Safety, Security, and Health (ESSH) Policy is the Laboratory's commitment to continual improvement in ESSH performance. Under this policy, the Laboratory's goals are to protect the environment, conserve resources, and prevent pollution; maintain a safe workplace by planning work and performing it safely; provide security for people, property, information, computing systems, and facilities; protect human health within our boundaries and in the surrounding community; achieve and maintain compliance with applicable ESSH requirements; maintain an open, proactive, and constructive relationship with employees, neighbors, regulators, DOE, and other stakeholders; and continually improve ESSH performance.

BNL was the first DOE Office of Science National Laboratory to be registered under the prestigious International ISO 14001 environmental management standard in 2001. In addition, in December 2006, BNL was the first DOE

Laboratory to achieve full registration under the Occupational Health and Safety Assessment Series (OHSAS) 18001 Standard. These programs are described in detail in Chapter 2 of this report. Registration to these standards was maintained throughout 2009.

1.2 HISTORY

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

Although BNL no longer operates any research reactors, the Laboratory's first major scientific facility was the Brookhaven Graphite Research Reactor (BGRR), which was the first reactor to be constructed in the United States following World War II. The reactor's primary mission was to produce neutrons for scientific experimentation in the fields of medicine, biology, chemistry, physics, and nuclear technology. The BGRR operated from 1950 to 1968 and is currently being decommissioned and will be dismantled. The BGRR will undergo long-term routine inspection and surveillance when decommissioning is complete.

The BGRR's research capacity was replaced and surpassed in 1965 by the High Flux Beam Reactor (HFBR). The HFBR was used solely for scientific research and provided neutrons for experiments in materials science, chemistry, biology, and physics. For more than 30 years, the HFBR was one of the premier neutron beam reactors in the world. In 1997, workers discovered that a leak in the HFBR spent fuel storage pool had been releasing tritium to the groundwater (see Chapter 7 for further details). In November 1999, the Secretary of Energy decided that the HFBR would be permanently shut down. With input from the community, a final Record of Decision was approved outlining the remedy for HFBR's permanent decontamination and dismantling (D&D). To date, completed actions include the removal and disposal of HFBR fuel and primary coolant, shipment of equipment for reuse at other facilities, cleanup and transfer of the Cold Neutron Facility for reuse, dismantling of ancillary buildings in the HFBR complex, removal and disposal of the reactor control rod blades and beam plugs, draining and isolation of all utility piping penetrating the reactor building, and rendering all former hazardous material storage tanks permanently out of service. Near-term actions include the dismantling of the remaining ancillary buildings, removal of contaminated underground utilities and piping, and preparation of the confinement building for safe long-term storage.

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

The Brookhaven Linac Isotope Producer (BLIP) was built in 1973. It creates radioactive forms of ordinary chemical elements that can be used alone or incorporated into radiotracers for use in nuclear medicine research or for clinical diagnosis and treatment. BNL's Center for Translational Neuroimaging (CTN) uses brain-imaging tools, including positron emission tomography (PET) and magnetic resonance imaging (MRI) equipment, to research causes of, and treatments for, brain diseases such as drug addiction, appetite disorders, attention deficit disorder, and neurodegenerative disease. The development of PET and MRI also has helped facilitate the development of new drugs for physicians worldwide to treat patients for cancer and heart disease.

High-energy particle physics research at BNL began in 1952 with the Cosmotron, the first particle accelerator to achieve billion-electron-

volt energies. Work at the Cosmotron resulted in a Nobel Prize in 1957. After 14 years of service, the Cosmotron ceased operation and was dismantled due to design limitations that restricted the energies it could achieve. The Alternating Gradient Synchrotron (AGS), a much larger particle accelerator, became operational in 1960. The AGS allowed scientists to accelerate protons to energies that yielded many discoveries of new particles and phenomena, for which BNL researchers were awarded three Nobel Prizes in physics. The AGS receives protons from BNL's linear accelerator (Linac), designed and built in the late 1960s as a major upgrade to the AGS complex. The Linac's purpose is to provide accelerated protons for use at AGS facilities and BLIP. The AGS booster, constructed in 1991, further enhanced the capabilities of the AGS, enabling it to accelerate protons and heavy ions to even higher energies. The Tandem Van de Graaff accelerator began operating in 1970 and is the starting point of the chain of accelerators that provide ions of gold, other heavy metals, and protons for experiments at the Relativistic Heavy Ion Collider (RHIC).

RHIC began operation in 2000. Inside this two-ringed particle accelerator, two beams of gold ions, heavy metals, or protons circulating at nearly the speed of light, collide head-on, releasing large amounts of energy. RHIC is used to study what the universe may have looked like in the first few moments after its creation, offering insights into the fundamental forces and properties of matter. Planned upgrades to RHIC will expand the facility's research capabilities. The first upgrade, RHIC II, will increase the collider's collision rate and improve the sensitivity of the large detectors it uses. Another planned upgrade, the eRHIC, will add a high-energy electron ring to create the world's only electron-heavy ion collider, which physicists expect will probe a new form of matter.

The NASA Space Radiation Laboratory (NSRL) became operational in 2003. It is jointly managed by DOE's Office of Science and NASA's Johnson Space Center. The NSRL uses heavy ions extracted from the AGS booster to produce beams of radiation similar to radiation that would be encountered by astronauts on long missions. Studies are conducted to assess risks and test protective measures. The NSRL is one of the few facilities in the world that can simulate the harsh cosmic and solar radiation environment found in space.

The National Synchrotron Light Source (NSLS) uses a linear accelerator and booster synchrotron to guide charged particles in orbit inside two electron storage rings for use in a wide range of physical and biological experiments. The NSLS produces beams of very intense light in the x-ray, ultraviolet, and infrared spectra, allowing scientists to study the structure of proteins, investigate the properties of new materials, and understand the fate of chemicals in the environment. Although the current NSLS has been continually updated since its commissioning in 1982, today the practical limits of its performance have been reached. To continue advances in these fields, construction of the NSLS-II, conceived as the next generation synchrotron light source, began in 2008. To help meet the critical scientific challenges of our energy future, this new state-of-the-art, medium-energy electron storage ring synchrotron will provide x-rays more than 10,000 times brighter than the current NSLS and will focus on research at the nanoscale. The NSLS-II will enable scientists to focus on some of the nation's most important scientific challenges at the nanoscale level, including clean, affordable energy, molecular electronics, and high-temperature superconductors.

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

Construction of BNL's newest building, the Center for Functional Nanomaterials (CFN), was completed in May 2007. The CFN provides state-of-the-art capabilities for the fabrication and study of nanoscale materials, with an

emphasis on atomic-level tailoring to achieve desired properties and functions. Nanoscience has the potential to bring about and accelerate new technologies in energy distribution, drug delivery, sensors, and industrial processes. The CFN is a science-based user facility, used for developing strong scientific programs while offering broad access to its capabilities and collaboration through an active user program. It is one of five Nanoscale Science Research Centers funded by DOE's Office of Science and supports the Laboratory's goal of leadership in the development of advanced materials and processes for energy applications. Like the RSB, the CFN building has also been awarded LEED Silver certification.

In addition, site preparation began in 2009 for the new Interdisciplinary Science Building (ISB), an energy-efficient and environmentally sustainable building that will provide labs, offices, and support functions to bring together a broad spectrum of researchers in a single location to foster energy research.

In 2008, the Laboratory was a proposed host-site for the construction of the largest solar energy project in New York State. Under this project, the Long Island Power Authority sought proposals for the construction of up to 50 megawatts of solar-generated power. This project was awarded to BP Solar in 2009. BP Solar's proposal included the construction of a 32MW solar power plant on the BNL site. This project will help the U.S. become less reliant on foreign energy sources and help meet renewable energy goals. In addition, a solar photovoltaic research and development facility may be developed for research, education, and community outreach to foster increased knowledge in the use of solar energy. Construction of the site will begin in 2010.

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

1.3 RESEARCH AND DISCOVERIES

BNL conducts research in nuclear and high-energy physics, the physics and chemistry of materials, nanoscience, energy and environmental research, national security and nonproliferation, neurosciences and medical imaging, structural biology, and computational sciences. BNL's world-class research facilities are also available to university, industrial, and government personnel.

To date, seven Nobel Prizes have been awarded for discoveries made wholly or partly at BNL. Some significant discoveries and developments made at the Laboratory include L-dopa, used to treat Parkinson's disease; the first synthesis of human insulin; the use of x-rays and neutrons to study biological specimens; the radionuclide thallium-201, used in millions of cardiac stress tests each year; the radionuclide technetium-99, also used to diagnose heart disease; x-ray angiography for noninvasive cardiac imaging; research on solar neutrinos and how they change form as they move through space; magnetically-levitated (maglev) trains; energy technologies studies; and researching pollution-eating bacteria.

Examples of current research at the Laboratory include the investigation of new nanostructures and nanoparticles; the development of high-temperature superconductors; novel states of matter being revealed at RHIC; medical imaging techniques to investigate the brain mechanisms underlying drug addiction, psychiatric disorders, and metabolism; new methods of understanding the earth's climate; and research into how infections begin.

1.4 FACILITIES AND OPERATIONS

Most of the Laboratory's principal facilities are located near the center of the site. The de-

veloped area is approximately 1,650 acres:

- 500 acres originally developed by the Army (as part of Camp Upton) and still used for offices and other operational buildings
- 200 acres occupied by large, specialized research facilities
- 550 acres used for outlying facilities, such as the Sewage Treatment Plant, research agricultural fields, housing facilities, and fire breaks
- 400 acres of roads, parking lots, and connecting areas

The balance of the site, approximately 3,600 acres, is mostly wooded and represents the native pine barrens ecosystem.

The major scientific facilities at BNL are briefly described in Figure 1-1. Additional facilities, shown in Figure 1-2 and briefly described below, support BNL's science and technology mission by providing basic utility and environmental services.

- *Central Chilled Water Plant*. This plant provides chilled water sitewide for air conditioning and process refrigeration via underground piping. The plant has a large refrigeration capacity and reduces the need for local refrigeration plants and air conditioning.
- *Central Steam Facility (CSF)*. This facility provides high-pressure steam for facility and process heating sitewide. Either natural gas or fuel oil can be used to produce the steam, which is conveyed to other facilities through underground piping. Condensate is collected and returned to the CSF for reuse, to conserve water and energy.
- *Fire Station*. The Fire Station houses six response vehicles. The BNL Fire Rescue Group provides on-site fire suppression, emergency medical services, hazardous material response, salvage, and property protection.
- *Major Petroleum Facility (MPF)*. This facility provides reserve fuel for the CSF during times of peak operation. With a total capacity of 2.3 million gallons, the MPF primarily stores No. 6 fuel oil. The 1997 conversion of CSF boilers to burn natural gas as well as oil has significantly reduced the Laboratory's reliance on oil as a sole fuel source when other fuels are more economical.
- *Sewage Treatment Plant (STP)*. This plant treats sanitary and certain process wastewater from BNL facilities prior to discharge into the Peconic River, similar to the operations of a municipal sewage treatment plant. The plant has a design capacity of 3 million gallons per day. Effluent is monitored and controlled under a permit issued by the New York State Department of Environmental Conservation (NYSDEC).
- *Waste Concentration Facility (WCF)*. This facility was previously used for the receipt, processing, and volume reduction of aqueous radioactive waste. At present, the WCF houses equipment and auxiliary systems required for operation of the liquid low-level radioactive waste storage and pump systems.
- *Waste Management Facility (WMF)*. This facility is a state-of-the-art complex for managing the wastes generated from BNL's research and operations activities. The facility was built with advanced environmental protection systems and features, and began operation in December 1997.
- *Water Treatment Plant (WTP)*. The potable water treatment plant has a capacity of 5 million gallons per day. Potable water is obtained from six on-site wells. Three wells located along the western boundary of the site are treated at the WTP with a lime-softening process to remove naturally occurring iron and by the addition of sodium hypochlorite for bacterial control. The plant is also equipped with dual air-stripping towers to ensure that volatile organic compounds (VOCs) are at or below New York State drinking water standards. Three wells located along the eastern section of the developed site are treated by the addition of sodium hydroxide to increase the pH of the water to make it less corrosive and by the addition of sodium hypochlorite to control bacteria. BNL's potable water met all drinking water standards in 2009.

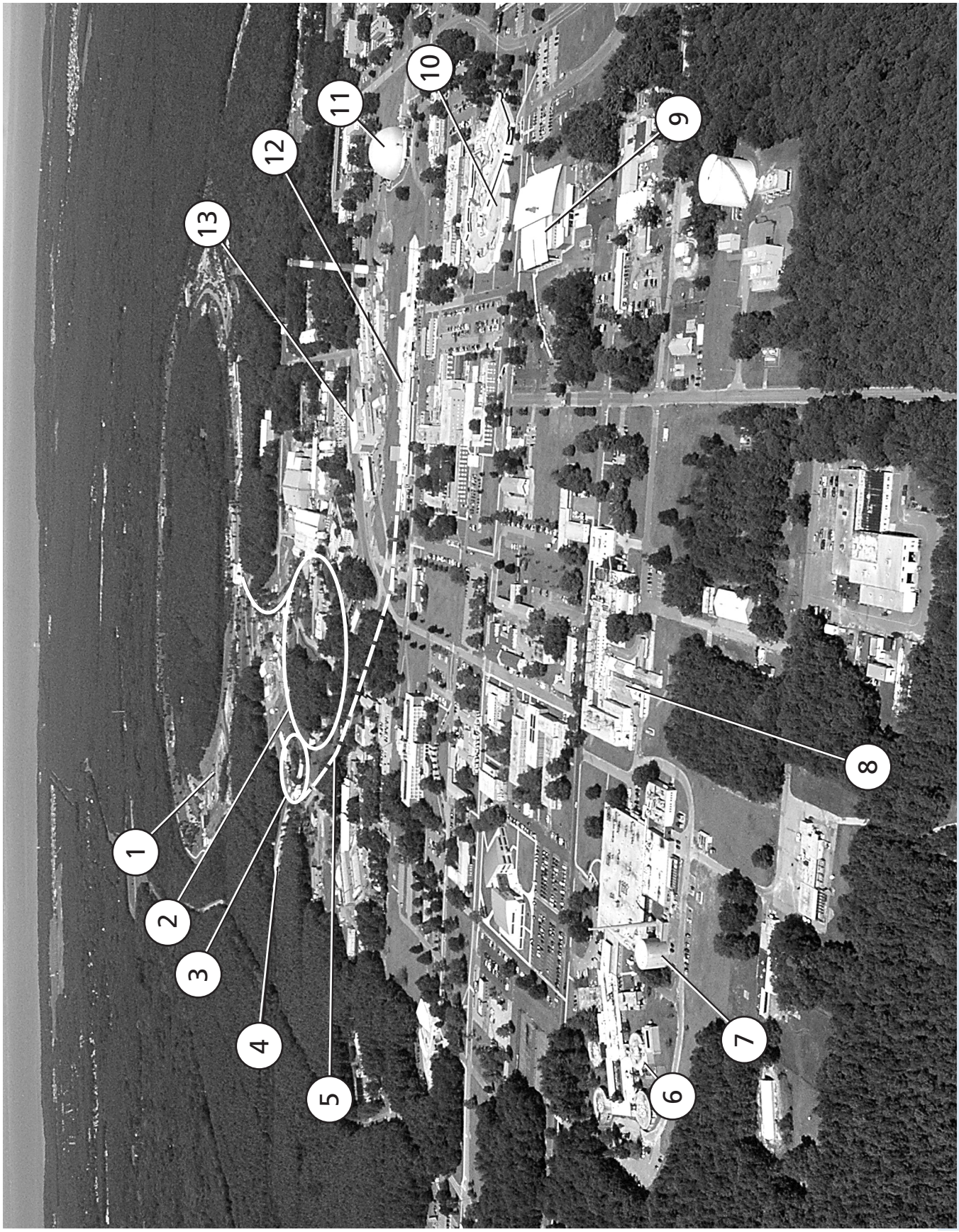


Figure 1-1. Major Scientific Facilities at BNL.

1. Relativistic Heavy Ion Collider (RHIC)

The RHIC is a world-class scientific research facility. The RHIC accelerator drives two intersecting beams of gold ions, other heavy metal ions, and protons head-on to form subatomic collisions. What physicists learn from these collisions may help us understand more about why the physical world works the way it does, from the smallest subatomic particles, to the largest stars. Current RHIC experiments include the Solenoidal Tracker at RHIC (STAR), a detector used to track particles produced by ion collisions; the PHENIX detector, used to record different particles emerging from collisions; the Broad Range Hadron Magnetic Spectrometer (BRAHMS), used to study particles as they pass through detectors; and PHOBOS, a detector designed to examine and analyze a very large number of unselected gold ion collisions.

2. Alternating Gradient Synchrotron (AGS)

The AGS is a particle accelerator used to propel protons and heavy ions, such as gold and iron, to high energies for physics research. The Linear Accelerator (Linac) serves as a proton injector for the AGS Booster.

3. AGS Booster

The AGS Booster is a circular accelerator used for physics research and radiobiology studies. It receives either a proton beam from the Linac or heavy ions from the Tandem Van de Graaff and accelerates these before injecting them into the AGS ring for further acceleration. The Booster also serves as the energetic heavy ion source for the NASA Space Radiation Laboratory, which is used to simulate the harsh cosmic and solar radiation environment found in space.

4. Linear Accelerator (Linac) and Brookhaven Linac Isotope Producer (BLIP)

The Linac provides beams of polarized protons for the AGS and RHIC. The excess beam capacity is used to produce radioisotopes for research and medical imaging at the BLIP. The BLIP is one of the nation's key production facilities for radioisotopes, which are crucial to clinical nuclear medicine. The BLIP also supports research on new diagnostic and therapeutic radiopharmaceuticals.

5. Heavy Ion Transfer Line (HITL)

The HITL connects the Tandem Van de Graaff and the AGS Booster. This interconnection enables the transport of ions of intermediate mass to the AGS Booster, where they are accelerated before injection into the AGS. The ions are then extracted and sent to the AGS experimental area for physics research.

6. Radiation Therapy Facility (RTF)

Part of the Medical Research Center, the RTF is a high-energy dual x-ray mode linear accelerator used for radiation therapy for cancer patients. This accelerator delivers therapeutically useful beams of x-rays and electrons for conventional and advanced medical radiotherapy techniques.

7. Brookhaven Medical Research Reactor (BMRR)

The BMRR was the world's first nuclear reactor built exclusively for medical research and therapy. It produced neutrons in an optimal energy range for experimental treatment of a type of brain cancer known as glioblastoma multiforme. The BMRR was shut down in December 2000 due to a reduction in medical research funding.

8. Scanning Transmission Electron Microscope (STEM)

The STEM facility includes two microscopes, STEM 1 and STEM 3, used for biological research. Both devices allow scientists to see the intricate details of living things, from bacteria to human tissue. The images provide a picture and data that are used in Mass Analysis.

9. Center for Functional Nanomaterials (CFN)

The CFN provides state-of-the-art capabilities for the fabrication and study of nanoscale materials, with an emphasis on atomic-level tailoring to achieve desired properties and functions. The CFN is a science-based user facility, simultaneously developing strong scientific programs while offering broad access to its capabilities and collaboration through an active user program. The overarching scientific theme of the CFN is the development and understanding of nanoscale materials that address the Nations' challenges in energy security, consistent with the Department of Energy mission.

10. National Synchrotron Light Source (NSLS)

The NSLS uses a linear accelerator and booster synchrotron as an injection system for two electron storage rings that provide intense light spanning the electromagnetic spectrum from the infrared through x-rays. The properties of this light and the 80 specially designed experimental stations, called beamlines, allow scientists to perform a large variety of experiments.

11. High Flux Beam Reactor (HFBR)

The HFBR was one of the premier neutron physics research facilities in the world. Neutron beams produced at the HFBR were used to investigate the molecular structure of materials, which aided in pharmaceutical design and materials development and expanded the knowledge base of physics, chemistry, and biology. The HFBR was permanently shut down in November 1999 and is currently being decommissioned under the Environmental Restoration Program.

12. Tandem Van de Graaff and Cyclotron

These accelerators are used in medium energy physics investigations and for producing special nuclides. The Tandem Van de Graaff accelerators are used to bombard materials with ions for manufacturing and testing purposes, and to supply RHIC with heavy ions. The cyclotrons, operated by the Chemistry Department, are used for the production of radiotracers for use in Positron Emission Tomography and Magnetic Resonance Imaging studies.

13. Brookhaven Graphite Research Reactor (BGRR)

The BGRR was the first reactor to be constructed in the United States following World War II. It was used for scientific exploration in the fields of medicine, biology, chemistry, physics, and nuclear engineering. The BGRR is currently being decommissioned under the Environmental Restoration Program.

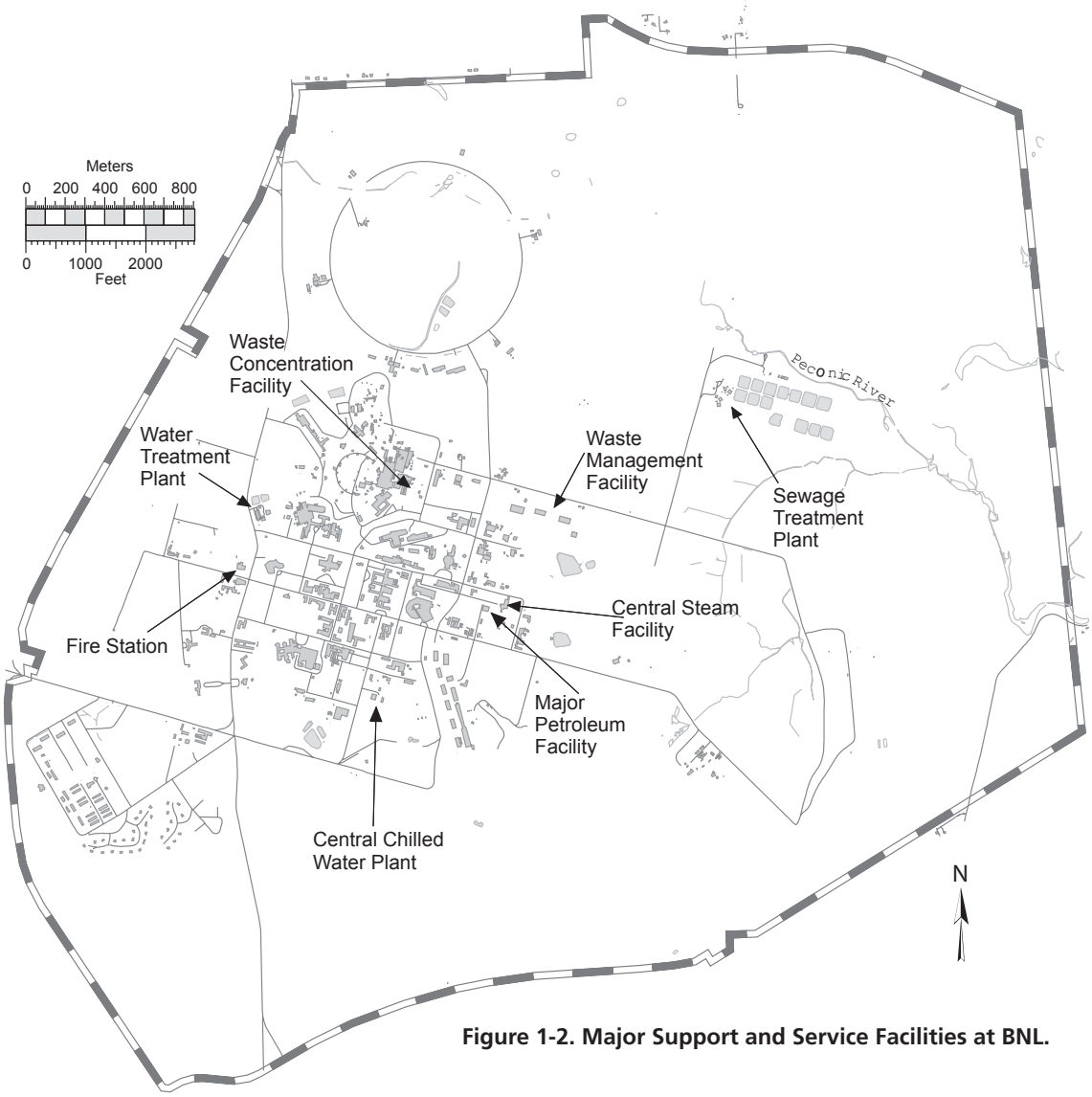


Figure 1-2. Major Support and Service Facilities at BNL.

1.5 LOCATION, LOCAL POPULATION, AND LOCAL ECONOMY

BNL is located on Long Island, 60 miles east of New York City. The Laboratory's 5,265-acre site is near Long Island's geographic center and is part of the Town of Brookhaven, the largest township (both in area and population) in Suffolk County. The Laboratory is one of the five largest high-technology employers on Long Island, with approximately 2,700 employees that include scientists, engineers, technicians, and administrative personnel. More than 75 percent of BNL employees live and shop in Suffolk County. In addition, BNL annually hosts an estimated 4,000 visiting scientists, more than 30 percent of whom are from New York State universities and businesses. The visiting scientists and sometimes their families, as well as visiting students, reside in apartments and dormitories on site or in nearby communities.

A recent economic impact report found that BNL is a significant contributor to the Long Island and New York state economy. In FY2009, the Laboratory spent $212 million on purchases of goods and services (other than construction). Of this total, $75.2 million was spent on purchases of goods and services from New York State companies, including $62.7 million in purchasing from Long Island companies. This spending directly supported approximately 295

full-time-equivalent (FTE) jobs throughout New York State, including 255 FTE jobs with vendors and contractors on Long Island.

1.6 GEOLOGY AND HYDROLOGY

BNL is situated on the western rim of the shallow Peconic River watershed. The marshy areas in the northern and eastern sections of the site are part of the headwaters of the Peconic River. Depending on the height of the water table relative to the base of the riverbed, the Peconic River both recharges to, and receives water from, the underlying upper glacial aquifer. In times of sustained drought, the river water recharges to the groundwater; with normal to above-normal precipitation, the river receives water from the aquifer.

In general, the terrain of the BNL site is gently rolling, with elevations varying between 44 and 120 feet above mean sea level. Depth to groundwater from the land surface ranges from 5 feet near the Peconic River to about 80 feet in the higher elevations of the central and western portions of the site. Studies of Long Island hydrology and geology in the vicinity of the Laboratory indicate that the uppermost Pleistocene deposits, composed of highly permeable glacial sands and gravel, are between 120 and 250 feet thick (Warren et al. 1968, Scorca et al. 1999). Water penetrates these deposits readily, and there is little direct runoff into surface streams unless precipitation is intense. The sandy deposits store large quantities of water in the Upper Glacial aquifer. On average, about half of the annual precipitation is lost to the atmosphere through evapotranspiration, and the other half percolates through the soil to recharge the groundwater (Koppelman 1978).

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

During 2008, the Laboratory used approximately 1.15 million gallons of groundwater per day to meet potable water needs and heating and cooling requirements. Approximately 75 percent of the water pumped from BNL supply wells is returned to the aquifer through on-site recharge basins and permitted discharges to the Peconic River. Under normal hydrologic conditions, most of the water discharged to the river recharges to the Upper Glacial aquifer before leaving the site. Human consumption, evaporation (cooling tower and wind losses), and sewer line losses account for the remaining 25 percent. An additional 3.4 million gallons of groundwater were pumped each day from remediation wells. This water is treated to remove contaminants and is then returned to the aquifer by way of recharge basins or injection wells.

Groundwater flow directions across the BNL site are influenced by natural drainage systems: eastward along the Peconic River, southeast toward the Forge River, and south toward the Carmans River (Figure 1-3). Pumping from on-site supply wells affects the direction and speed of groundwater flow, especially in the central, developed areas of the site. The main groundwater divide on Long Island is aligned generally east–west and lies approximately one-half mile north of the Laboratory. Groundwater north of the divide flows northward and ultimately discharges to the Long Island Sound. Groundwater south of the divide flows east and south, discharging to the Peconic River, Peconic Bay, south shore streams, Great South Bay, and Atlantic Ocean. The regional groundwater flow system is discussed in greater detail in Stratigraphy and Hydrologic Conditions at the Brookhaven National Laboratory and Vicinity (Scorca et al. 1999). In most areas at BNL, the horizontal velocity of groundwater is approximately 0.75

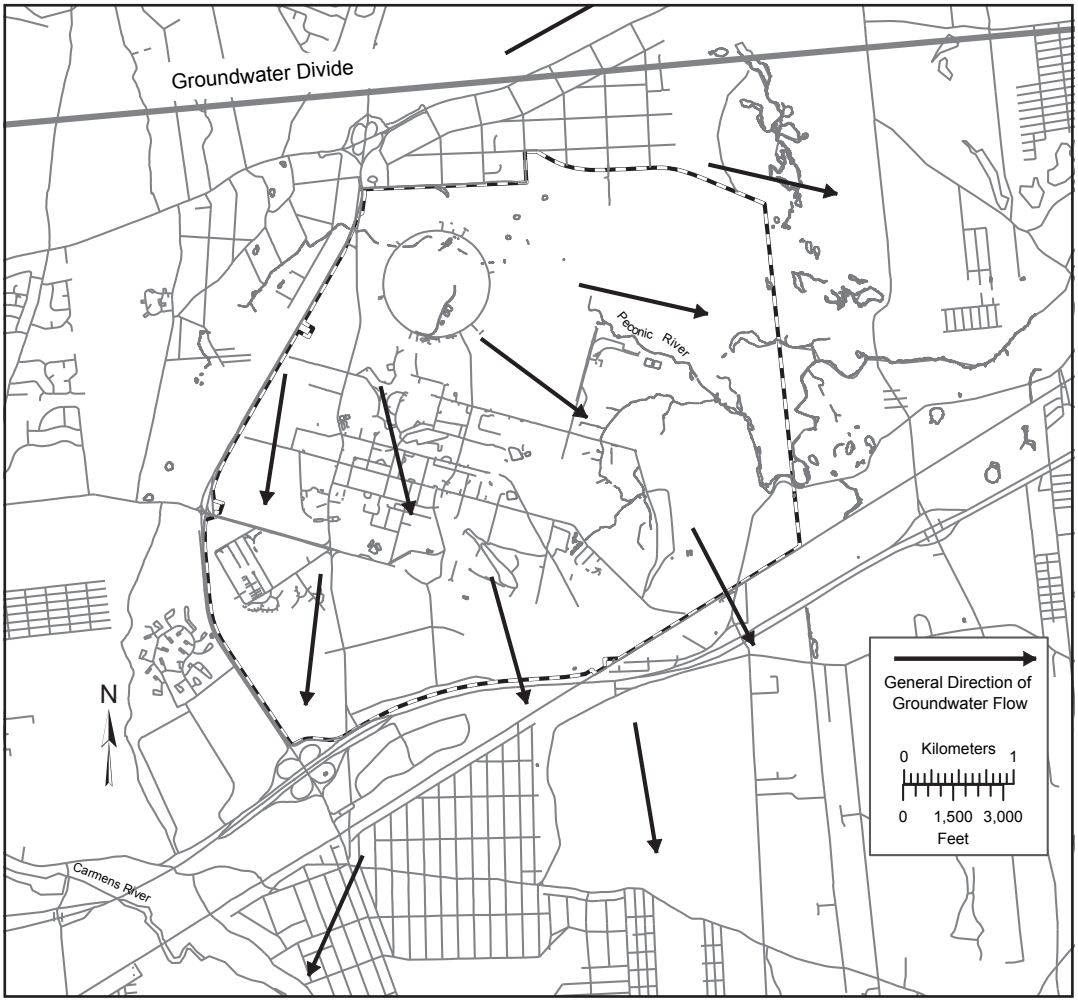


Figure 1-3. BNL Groundwater Flow Map.

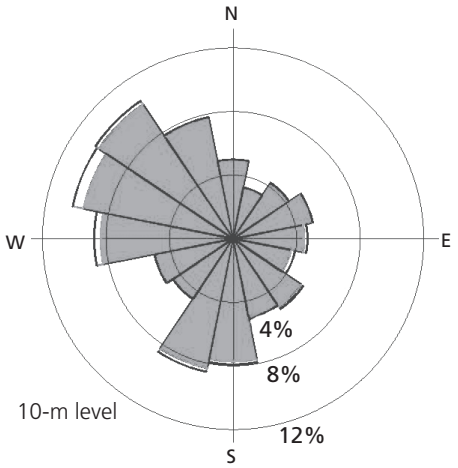
to 1.2 feet per day (Geraghty & Miller 1996). In general, this means that groundwater travels for approximately 20 to 22 years as it moves from the central, developed area of the site to the Laboratory's southern boundary.

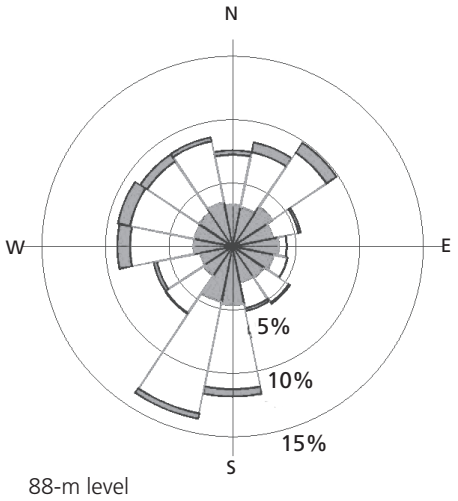
1.7 CLIMATE

The Meteorological Group at BNL has been recording weather data on site since 1949. The Laboratory is broadly influenced by continental and maritime weather systems. Locally, the Long Island Sound, Atlantic Ocean, and associated bays influence wind directions and humidity and provide a moderating influence on extreme summer and winter temperatures. The prevailing ground-level winds at BNL are from the southwest during the summer, from the northwest during the winter, and about equally from those two directions during the spring and fall (Nagle 1975, 1978). Figure 1-4 shows the 2009 annual wind rose for BNL, which depicts the annual frequency distribution of wind speed and direction, measured at an on-site meteorological tower at heights of 33 feet (10 meters) and 300 feet (88 meters) above land surface.

The average monthly temperature in the area for 2009 was 51 degrees Fahrenheit (°F). The average yearly temperature for the area was 52°F. Figures 1-5 and 1-6 show the 2009 monthly mean temperatures and the historical annual mean temperatures, respectively.

The total annual precipitation in 2009 was 54 inches. Figures 1-7 and 1-8 show the 2009 monthly and the 60-year annual precipitation





Explanation: Wind direction was measured at heights of 10 and 88 meters above the ground, for a total of 524,021 measurements at each height. The readings were plotted on the charts to indicate how often wind came from each direction. The concentric circles represent multi-percentage increases in the frequency. So, for example, at 10 meters above the ground, wind was from due south 8 percent of the time. The predominant wind direction in 2009 was from the northwest at the 10-m level, and from the south-southwest at the 88-m level.

Figure 1-4. BNL Wind Rose (2009).

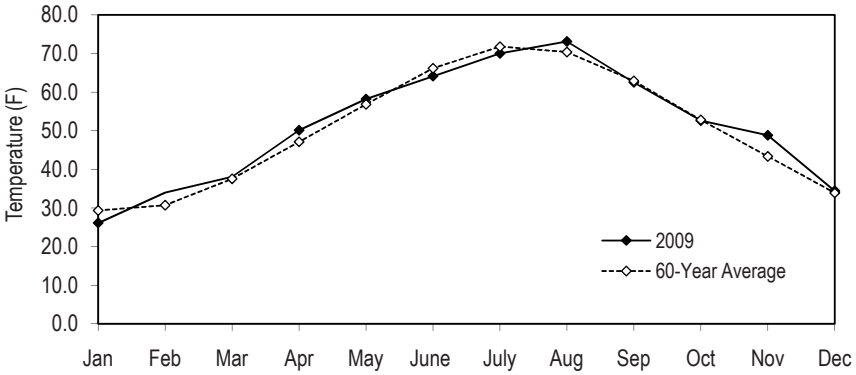


Figure 1-5. BNL 2009 Monthly Mean Temperature versus 60-Year Monthly Average.

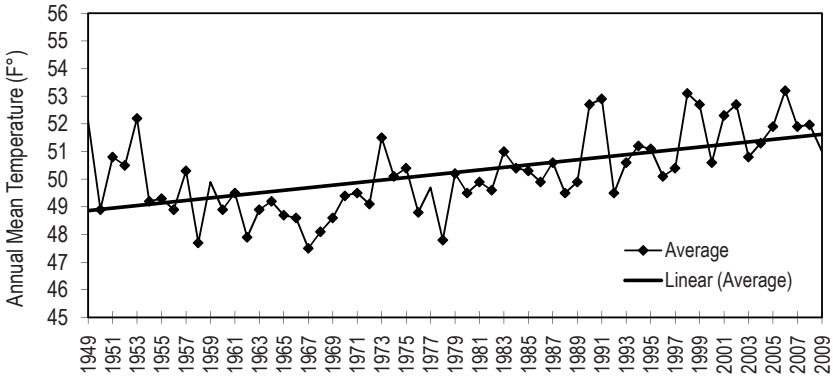


Figure 1-6. BNL 2009 Annual Mean Temperature Trend (60 Years).

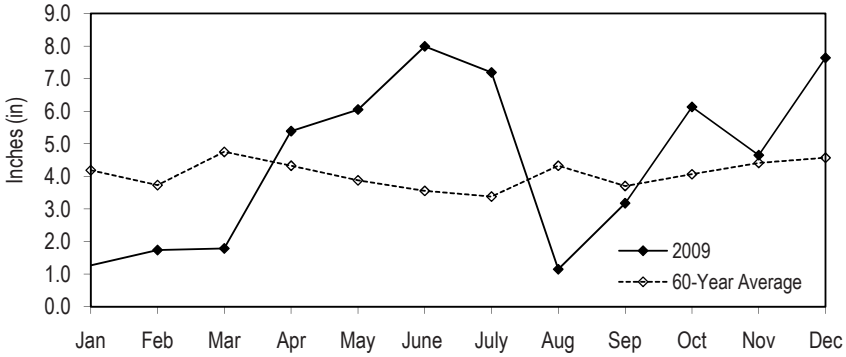


Figure 1-7. BNL 2009 Monthly Precipitation versus 60-Year Monthly Average.

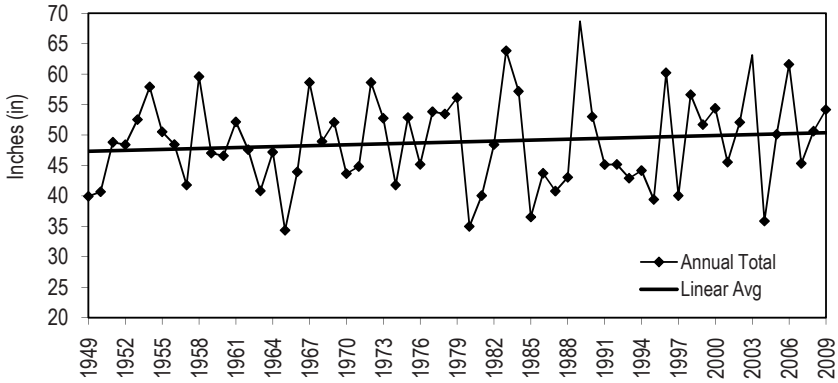


Figure 1-8. BNL 2009 Annual Precipitation Trend (60 Years).

data. Snowfall for the 2008–2009 winter season was 67.8 inches, well above the 31.29 inches of average yearly snowfall for Long Island.

1.8 NATURAL RESOURCES

The Laboratory is located in the oak/chestnut forest region of the Coastal Plain and constitutes about 5 percent of the 100,000-acre New York State–designated region on Long Island known as the Central Pine Barrens. The section of the Peconic River running through BNL is designated as "scenic" under the New York State Wild, Scenic, and Recreational River System Act of 1972. Due to the general topography and porous soil, the land is very well drained and there is little surface runoff or open standing water. However, depressions form numerous small, pocket wetlands with standing water on a seasonal basis (vernal pools), and there are six regulated wetlands on site. Thus, a mosaic of wet and dry areas correlates with variations in topography and depth to the water table.

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

More than 230 plant species have been identified at the Laboratory, including two species that are threatened in New York State and two that are classified as rare. Fifteen animal species identified on site include a number that are protected in New York State, as well as species common to mixed hardwood forests and open grassland habitats. At least 85 species of birds have been observed nesting on site, and more than 200 transitory bird species have been documented visiting the site. (BNL is located within the Atlantic Flyway, with scrub/shrub habitats that offer food and rest to migratory songbirds.) Permanently flooded retention basins and other watercourses support amphibians and aquatic reptiles. Thirteen amphibian and 12 reptile species have been identified at BNL. Recent ecological studies have confirmed 26 breeding sites for the New York State endangered eastern tiger salamander in ponds and recharge basins. Ten species of fish have been identified as endemic to the site, including the banded sunfish and the swamp darter, both of which are threatened in New York State. Two types of butterflies that are protected in New York State are believed to breed on site due to the presence of their preferred habitat and host plants, and a New York State threatened damselfly was found on site in 2005. To eliminate or minimize any negative effects that Laboratory operations might cause to these species, precautions are in place to protect the on-site habitats and natural resources.

In November 2000, DOE established the Upton Ecological and Research Reserve at BNL. The 530-acre Upton Reserve (10 percent of the Laboratory's property) is on the eastern portion of the site, in the Core Preservation Area of the Central Pine Barrens. The Upton Reserve creates a unique ecosystem of forests and wetlands that provides habitats for plants, mammals, birds, reptiles, and amphibians. From 2000 to 2004, funding provided by DOE under an Inter-Agency Agreement between DOE and the U.S. Fish & Wildlife Services was used to conduct resource management programs for the conservation, enhancement, and restoration of wildlife and habitat in the reserve. In 2005, management was transitioned to the Foundation for Ecological Research in the Northeast (FERN). Management of the Upton Reserve falls within the scope of BNL's Natural Resource Management Plan, and the area will continue to be managed for its key ecological values and as an area for ecological research. Additional information regarding the Upton Reserve and the Laboratory's natural resources can be found in Chapter 6 of this report.

1.9 CULTURAL RESOURCES

The Laboratory is responsible for ensuring compliance with historic preservation requirements. BNL's Cultural Resource Management Plan was developed to identify, assess, and document the Laboratory's historic and cultural resources. These resources include World War I

trenches; Civilian Conservation Corps features; World War II buildings; and historic structures, programs, and discoveries associated with high-energy physics, research reactors, and other science conducted at BNL. The Laboratory currently has three facilities classified as eligible for listing on the National Register of Historic Places: the Brookhaven Graphite Research Reactor complex, the High Flux Beam Reactor complex, and the World War I training trenches associated with Camp Upton. Further information can be found in Chapter 6.

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2 Environmental Management System

One of Brookhaven National Laboratory's highest priorities is ensuring that its environmental commitment is as strong as its passion for discovery. The contractor operating the Laboratory on behalf of DOE, Brookhaven Science Associates (BSA), takes environmental stewardship very seriously. As part of their commitment to environmentally responsible operations, they have established the BNL Environmental Management System (EMS).

One measure of an effective EMS is recognition of good environmental performance. In 2009, the Laboratory was recognized with two national or regional environmental awards: DOE awarded BNL a P2 STAR Honorable Mention for pollution prevention practices for Total Nitrogen Reduction at the BNL Sewage Treatment Plant Using Cafeteria Wastes, and the Laboratory received its third Silver Level Award for Electronics Recycling from the Office of the Federal Environmental Executive. BNL reused or recycled approximately 81,000 pounds of electronics during fiscal year 2009, a period from October 1, 2008 to September 30, 2009.

An EMS ensures that environmental issues are systematically identified, controlled, and monitored. Moreover, an EMS provides mechanisms for responding to changing environmental conditions and requirements, reporting on environmental performance, and reinforcing continual improvement. The Laboratory's EMS was designed to meet the rigorous requirements of the globally recognized International Organization for Standardization (ISO) 14001 Environmental Management Standard, with additional emphasis on compliance, pollution prevention, and community involvement.

Annual audits are required to maintain EMS registration. Recertification audits of the entire EMS occur every three years. In 2009, an EMS Surveillance Audit determined that BNL remains in conformance with the ISO 14001: 2004 Standard.

BNL continued its strong support of its Pollution Prevention Program, which seeks ways to eliminate waste and toxic materials. In 2009, pollution prevention projects resulted in more than $5.5 million in cost avoidance or savings and resulted in the reduction or reuse of approximately 17.9 million pounds of waste. Also in 2009, the BNL Pollution Prevention Council funded five new proposals or special projects, investing approximately $24,000. Anticipated annual savings from these projects are estimated at approximately $33,650, for an average payback period of less than 0.7 years. The ISO 14001-registered EMS and the nationally recognized Pollution Prevention Program continue to contribute to the Laboratory's success in promoting pollution prevention.

BNL continues to address legacy issues under the Environmental Restoration Projects Group and openly communicates with neighbors, regulators, employees, and other interested parties on environmental issues and cleanup progress on site.

2.1 INTEGRATED SAFETY MANAGEMENT, ISO 14001, AND OHSAS 18001

The Laboratory's Integrated Safety Management System (ISMS) integrates environment, safety, and health management into all work planning. The integrated safety processes within ISMS contributed to BNL achieving ISO 14001 and Occupational Health and Safety Assessment Series (OHSAS) 18001 registrations.

The ISO 14001 Standard is globally recognized and defines the structure of an organization's EMS for purposes of improving environmental performance. OHSAS 18001 mirrors the ISO 14001 structure. The process-based structure of the ISO 14001 and OHSAS 18001 Standards are based on the "Plan-Do-Check-Act" improvement cycle. Both standards require an organization to develop a policy, create plans to implement the policy, implement the plans, check progress and take corrective actions, and review the system periodically to ensure its continuing suitability, adequacy, and effectiveness.

BNL's EMS was officially registered to the ISO 14001 Standard in July 2001 and was the first DOE Office of Science Laboratory to obtain third-party registration to this environmental standard. BNL was officially registered to the OHSAS 18001 Standard in 2006, and was again the first DOE Office of Science Laboratory to achieve this registration. Each certification requires the Laboratory to undergo annual audits by an accredited registrar to assure that the systems are maintained.

In 2009, an EMS and OHSAS Surveillance Audit determined that BNL remains in conformance with the ISO 14001 and OHSAS 18001 Standards. In their recommendation for continued certification, auditors from NSF-International Strategic Registrations, Ltd. highlighted more than 14 noteworthy practices, some of which include: a strong commitment to achievement of Laboratory-wide environmental, safety & health (ES&H) objectives and targets; continued improvement in analysis of ES&H data to prevent issues from occurring; and strengths in environmental planning for the Long Island Solar Farm. The auditors also identified one minor nonconformity: to improve the use of causal analysis for ES&H issues. Nine opportunities for improvement were also noted, such as continued reductions in paper use and cafeteria waste reduction. Corrective actions were prepared and will be tracked to closure.

2.2 ENVIRONMENTAL, SAFETY, SECURITY, AND HEALTH POLICY

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

- **ENVIRONMENT:** We protect the environment, conserve resources, and prevent pollution.
- **SAFETY:** We maintain a safe workplace, and we plan our work and perform it safely. We take responsibility for the safety of ourselves, coworkers, and guests.
- **SECURITY:** We protect people, property, information, computing systems, and facilities.
- **Health:** We protect human health within our boundaries and in the surrounding community.
- **COMPLIANCE:** We achieve and maintain compliance with applicable ESSH requirements.
- **COMMUNITY:** We maintain open, proactive, and constructive relationships with our employees, neighbors, regulators, DOE, and our other stakeholders.
- **CONTINUAL IMPROVEMENT:** We continually improve ESSH performance.

2.3 PLANNING

The planning requirements of the ISO 14001 Standard require BNL to identify the environmental aspects and impacts of its activities, products, and services; to evaluate applicable legal and other requirements; to establish objectives and targets; and to create action plans to achieve the objectives and targets.

2.3.1 Environmental Aspects

An "environmental aspect" is any element of an organization's activities, products, and services that can interact with the environment. As required by the ISO 14001 Standard, BNL evaluates its operations, identifies the aspects that can impact the environment, and determines which of those impacts are significant. The Laboratory's criteria for significance are based on actual and perceived impacts of its operations and on regulatory requirements. BNL utilizes several processes to identify and review environmental aspects. Key among these is the Process Assessment Procedure. This is an evaluation that is documented on a Process Assessment Form, which consists of a written process description, a detailed process flow diagram, a regulatory determination of all process inputs and outputs, identification of pollution prevention opportunities, and identification of any assessment, prevention, and control measures that should be considered. Environmental professionals work closely with Laboratory personnel to ensure that environmental requirements are integrated into each process. Aspects and impacts are evaluated annually to ensure that they continue to reflect stakeholder concerns and changes in regulatory requirements.

2.3.2 Legal and Other Requirements

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

DOE Order 450.1A, Environmental Protection Program, established federal requirements for pollution prevention, reduction of toxic chemical use, purchase of environmentally preferred products, electronic stewardship, and the implementation of an Environmental Management System. The Laboratory's EMS objectives and targets have been established to mirror these requirements and are discussed in section 2.3.3. DOE Order 430.2B, Departmental Energy, Utilities, and Transportation Management, established federal requirements for certain criteria, and requires an annual certification and submission of an Executable Plan. The Executable Plan provides a roadmap on how the Laboratory intends to meet these requirements. Both orders incorporate the goals of Executive Order (EO) 13423, Strengthening Federal Environmental, Energy and Transportation Management.

EO 13514, Federal Leadership in Environmental, Energy, and Economic Performance, which was signed in 2009, sets sustainability goals for federal agencies and focuses on improving their environmental, energy, and economic performance. It also requires federal agencies to set a 2020 greenhouse gas emissions reduction target, increase energy efficiency, reduce fleet petroleum consumption, conserve water, reduce waste, support sustainable communities, and leverage federal purchasing power to promote environmentally responsible products and technologies. These requirements will direct the future of BNL's EMS program, and most have already been incorporated.

Table 2-1 provides a summary status on meeting the goals of DOE Order 430.2B and EO 13514.

2.3.3 Objectives and Targets

The establishment of environmental objectives and targets is accomplished through a Performance-Based Management System. This system is designed to develop, align, balance, and implement the Laboratory's strategic objectives, including environmental objectives. The system drives BNL's improvement agenda by establishing a prioritized set of key objectives, called the Performance Evaluation Management Plan. Annually, BSA works closely with DOE

Table 2-1. DOE Order 430.2B and Executive Order (EO) 13514 Goal Status.

430.2B Requirements	BNL Status
30 percent energy intensity reduction by FY2015, from an FY2003 baseline	FY2009 was 7.9 percent below the established baseline. BNL is currently developing solicitation for an energy service provider contractor for energy conservation measures. In addition, the Laboratory is implementing a steam charge-back and continuing lighting and controls upgrades.
16 percent water intensity reduction by FY2015, from an FY2007 baseline	FY2009 water intensity was above baseline due to increased programmatic (process cooling) usage. Based on forecasted loads, it is currently unlikely that the FY2015 goal can be achieved.
7.5 percent of a site's annual electricity consumption from on-site renewable sources by FY2010: FY2009 goal—3 percent; FY2010 goal—5 percent	BNL purchased 6,500 MWh (2.6 percent) of renewable energy credits in FY2009. The Laboratory is working with the Long Island Power Authority to develop a 37-MW solar photovoltaic (PV) project on site and investigating biomass feasibility.
Every site to have at least one on-site renewable energy generating system	A solar thermal heating system was installed on the BNL pool and a second solar thermal demonstration project at Building 30 is underway. BNL is working with the Long Island Power Authority to develop a 37-MW solar PV system on site.
10 percent annual increase in fleet alternative fuel consumption, relative to a FY2005 baseline	Due to lack of readily available compressed natural gas (CNG) vehicles, the Laboratory did not meet the goal for FY2009. BNL is in the process of providing E85 capability and installing a biodiesel fueling system. Currently, it is expected that the Laboratory may not meet the goal for FY2010 and later years.
2 percent annual reduction in fleet petroleum consumption, relative to a FY2005 baseline	Exceeded goal for FY2009; expect to meet goal for FY2010.
75 percent of light duty vehicle purchases must consist of alternative fuel vehicles	Exceeded goal for FY2009; may not be able to meet goal for FY2010.
All new construction and major renovations greater than $5 million to be LEED® Gold certified	Current major projects have been designed to achieve Gold certification; expect to meet goal.
15 percent of existing buildings to be compliant with the Five Guiding Principles of High Performance & Sustainable Buildings (HPSB) Design	Estimate goal will be exceeded by due date of 2015.
Advanced metering to the maximum extent practicable	Chilled water metering complete, electric metering nearly complete, and steam charge-back effort in process.
EO 13514 Requirements	**BNL Status**
Greenhouse gas emissions baseline inventory, reductions, and reporting	BNL computed its 2008 baseline inventory (using a model developed by Sandia National Laboratory) in December 2009. FY2009 emissions were 7.9 percent below baseline. As per EO requirements, the Laboratory will be ready to report comprehensive green house gas emission inventory for FY2010 by January 2011, and annually thereafter by the end of January of each year.
Increase use of renewable energy	A solar thermal heating system was installed on the BNL pool and a second solar thermal demonstration project at Building 30 is underway. The Laboratory is working with the Long Island Power Authority to develop a 37-MW solar PV project on site. BNL purchased 6,500 MW of REC's in FY2009.
Reduce fleet's consumption of petroleum products by 2 percent annually through the end of FY2020 (baseline FY2005)	Exceeded goal for FY2009.
2 percent annual reduction of potable water consumption intensity through FY2020 or 26 percent reduction by the end of FY2020 (baseline FY2007 water consumption)	FY2009 water intensity above baseline due to increased programmatic (process cooling) usage. See section 2.3.4.5, Water Conservation, for further detail.
Minimize generation of waste and pollutants through source reduction	BNL has an award-winning P2 program that has focused on minimizing wastes and pollutants since the program's inception. See section 2.3.4.4, Pollution Prevention and Waste Minimization, for further detail.
Divert 50 percent of non-hazardous solid waste from disposal and divert 50 percent of construction and demolition materials and debris from disposal by the end of FY2015	Based on the past 10 years, the Laboratory's annual recycling rate ranges between 53.8-68 percent. In addition, BNL diverts over 95 percent of construction and demolition materials. See section 2.3.4.4, Pollution Prevention and Waste Minimization, for further detail.

(continued on next page)

Table 2-1. DOE Order 430.2B and Executive Order (EO) 13514 Goal Status *(concluded).*

EO 13514 Requirements	BNL Status
Acquire uncoated printing and writing paper containing at least 30 percent post-consumer fiber	BNL printing/copy paper has a minimum 30 percent recycled content. Some paper used by the Laboratory contains 100 percent recycled content.
Reduce and minimize the quantity of toxic and hazardous chemicals and materials acquired, used, and disposed of by FY2015	BNL has an active P2 program which has resulted in the reduction in hazardous waste generation by 85 percent or more since 1995. See section 2.3.4.3., Waste Management, for more detail.
Increase diversion of compostable and organic material from waste streams	A portion of the cafeteria waste is diverted to the BNL Sewage Treatment Plant as part of a P2 process change, and used animal bedding is composted on site.
Implement pest management and other landscaping management practices	The Laboratory has an established Integrated Pest Management policy, plants native vegetation where practical, and does not install inground sprinklers as a rule.
Participate in regional transportation planning	In 2009, BNL received a grant from the Long Island Transportation Management group to foster ride sharing and the reduction of single occupancy vehicles. The Laboratory also participates in NURIDE, a ridesharing network available to BNL employees.
By 2003, achieve zero-net-energy in buildings entering the planning process after 2020	BNL's design standard for all new construction and major renovations requirements have been modified to include energy conservation design that has a goal (where life-cycle, cost-effective) to exceed the base case of ASHRAE 90.1--2004 by a minimum of 30 percent of energy cost; attain a minimum of LEED Gold certification; purchase Energy Star equipment where applicable; and provide a Sustainability Design Report, which includes a metering plan for energy inputs.
Ensure 95 percent of new contract actions for products and services are energy efficient, water efficient, bio-based-content, environmentally preferable, non-ozone depleting, recycled-content, and non-toxic or less-toxic than alternatives	The Laboratory's web requisition system has been revised to inform users of Environmentally Preferable Products (EPP) requirements. The system is used to track EPP purchases to demonstrate the level of compliance with the requirement. An electronic justification is required for eligible purchases not meeting the requirement.
Ensure Procurement Preference for EPEAT-Registered electronic products	The BNL web requisition system has been revised to inform users of the EPEAT/Energy Star requirement for electronic products. An electronic justification is required for eligible purchases not meeting the requirement.
Continue implementation of an Environmental Management System (EMS) and ensure it is maintained to achieve the goals of the EO	BNL has an established EMS, which has been certified by NSF International since 2001. See section 2.1, Integrated Safety Management, ISO 14001, and OHSAS 18001, for further detail.

to clearly define expectations and performance measures. Factors for selecting environmental priorities include:

- Significant environmental aspects
- Risk and vulnerability (primarily, threat to the environment)
- Legal requirements (laws, regulations, permits, enforcement actions, and memorandums of agreement)
- Commitments (in the ESSH Policy) to regulatory agencies, and to the public
- Importance to DOE, the public, employees, and other stakeholders

Laboratory-level objectives and targets are developed on a fiscal year (FY) schedule. In FY2009 (October 1, 2008 through September 30, 2009), BNL's environmental objectives included:

- Reduce or eliminate the generation and/or toxicity of waste and other pollutants at the source through pollution prevention
- Reduce or eliminate the acquisition, use, and release of toxic and hazardous chemicals and materials
- Maximize the acquisition and use of environmentally preferable products in the conduit of operations
- Reduce or eliminate the environmental impacts of electronics assets
- Reduce degradation and depletion of environmental resources through post-consumer materials recycling
- Increase energy efficiency

2.3.4 Environmental Management Programs

Each organization within BNL develops an action plan detailing how they will achieve their environmental objectives and targets and commit the resources necessary to successfully implement both Laboratory-wide and facility-

specific programs. BNL has a budgeting system designed to ensure that priorities are balanced and to provide resources essential to the implementation and control of the EMS. The Laboratory continues to review, develop, and fund important environmental programs to further integrate environmental stewardship into all facets of its missions.

2.3.4.1 Compliance

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

2.3.4.2 Groundwater Protection

BNL's Groundwater Protection Management Program is designed to prevent negative impacts to groundwater and to restore groundwater quality by integrating pollution prevention efforts, monitoring groundwater restoration projects, and communicating performance. The Laboratory has also developed a Groundwater Protection Contingency Plan that defines an orderly process for quickly taking corrective actions in response to unexpected monitoring results. Key elements of the groundwater program are full, timely disclosure of any off-normal occurrences, and regular communication on the performance of the program. Chapter 7 and SER Volume II, Groundwater Status Report, provide additional details about this program, its performance, and monitoring results for 2009.

2.3.4.3 Waste Management

As a byproduct of the world-class research it conducts, BNL generates a large range of wastes. These wastes include materials common to many businesses and industries, such as aerosol cans, batteries, paints, and oils. However, the Laboratory's unique scientific activities also generate waste streams that are subject to additional regulation and special handling, including radioactive, hazardous, and mixed waste.

Collecting, storing, transporting, and disposing of waste generated at the Laboratory is the responsibility of BNL's Waste Management Facility (WMF). This modern facility was designed for handling hazardous, industrial, radioactive, and mixed waste and is comprised of three staging areas: a facility for hazardous waste, regulated by RCRA; a mixed-waste building for material that is both hazardous and radioactive; and a reclamation building for radioactive material. The RCRA and mixed-waste buildings are managed under a permit issued by the New York State Department of Environmental Conservation (NYSDEC). These buildings are used for short-term storage of waste before it is packaged or consolidated for off-site shipment to permitted treatment and disposal facilities. Due to the relatively small quantities and infrequent generation of mixed waste, BNL has reduced its waste storage footprint by consolidating hazardous and mixed wastes into its RCRA waste building. The Laboratory has submitted a permit modification request to NYSDEC to effect the closure of its mixed waste building and subsequently remove the building from BNL's NYSDEC RCRA Permit.

In 2009, BNL generated the following types and quantities of waste from routine operations:

- Hazardous waste: 4.5 tons
- Mixed waste: 32 ft^3
- Radioactive waste: 5,778 ft^3

Hazardous waste from routine operations in 2009 were 20 percent less than 2008 generation rates, as shown in Figure 2-1a. This is typically attributed to operational changes and waste reduction techniques. The increase in routine mixed waste generation, as shown in Figure 2-1b, can be attributed primarily to increased operations within the Collider–Accelerator

Department (CAD), which is normally associated with the dismantling/reconstruction of beamlines. As shown in Figure 2-1c, the radioactive waste quantity for routine operations increased, but is still considered a normal operating quantity, based on historical generation rates and facility operations. The primary contributor to this waste stream is also CAD. Routine operations are defined as ongoing industrial and experimental operations.

Wastes generated by remediation projects, decommissioning activities performed by the Environmental Restoration Projects (ERP) Group, or one-time events (e.g., lab clean-out) are considered non-routine. In 2009, EPD continued to reduce the inventory of legacy waste materials and disposed of equipment from the Brookhaven Medical Research Reactor (BMRR) and the former Building 462 Hot Machine Shop. Restoration and decommissioning activities included: remediation of contaminated soils in the former Hazardous Waste Management Facility perimeter areas and Waste Loading Area (WLA); removal of underground waste piping systems (A&B waste lines) and a old duct running between Buildings 801 and 811; removal of control rod blades, other reactor internal components, and beam plugs from the HFBR; disposal of water from the spent fuel canal and reactor at the HFBR; and the removal of contaminated and non-contaminated equipment from the former fan house,

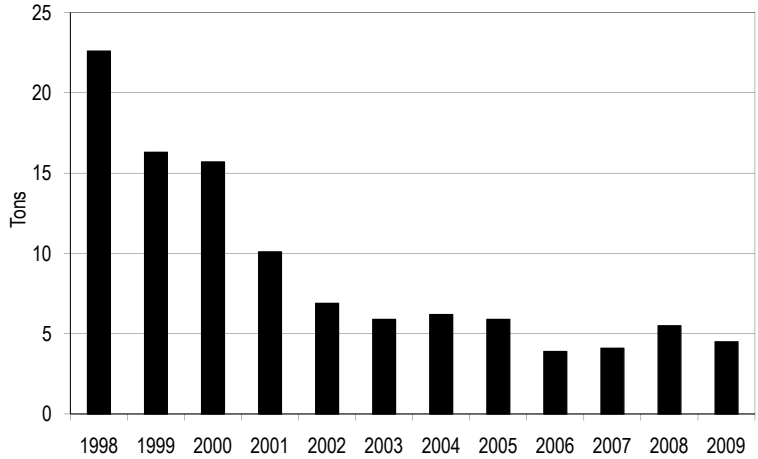

Figure 2-1a. Hazardous Waste Generation from Routine Operations, 1998 – 2009.

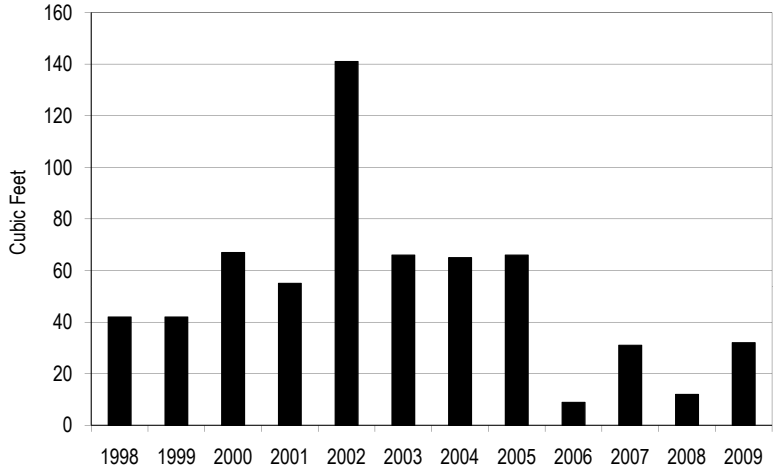

Figure 2-1b. Mixed Waste Generation from Routine Operations, 1998 – 2009.

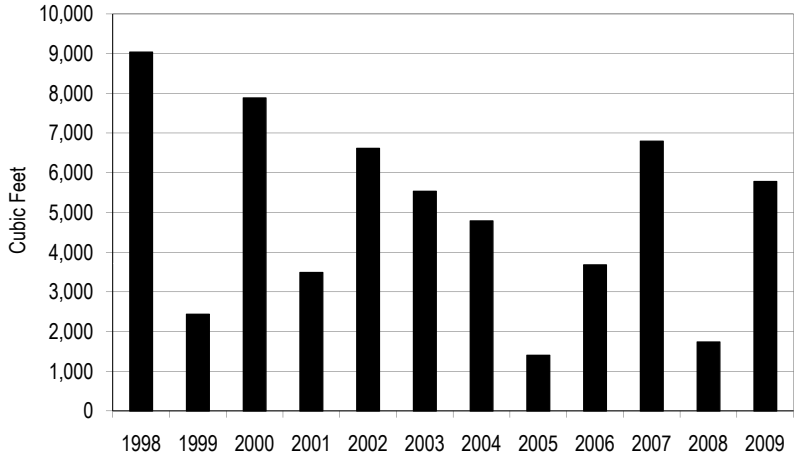

Figure 2-1c. Radioactive Waste Generation from Routine Operations, 1998 – 2009.

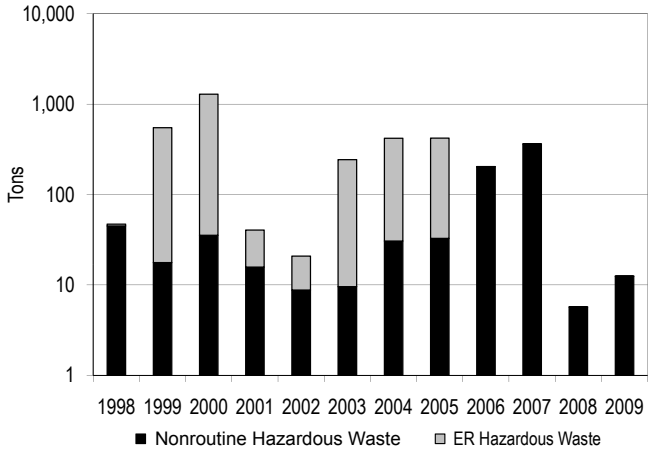

Figure 2-1d. Hazardous Waste Generation from ER and Nonroutine Operations, 1998 – 2009.

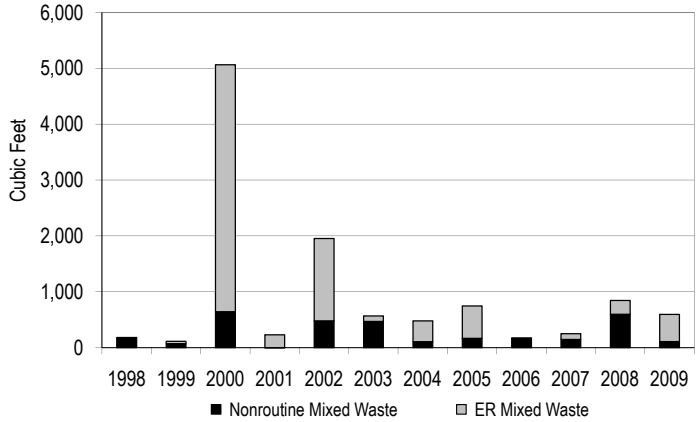

Figure 2-1e. Mixed Waste Generation from ER and Nonroutine Operations, 1998 – 2009.

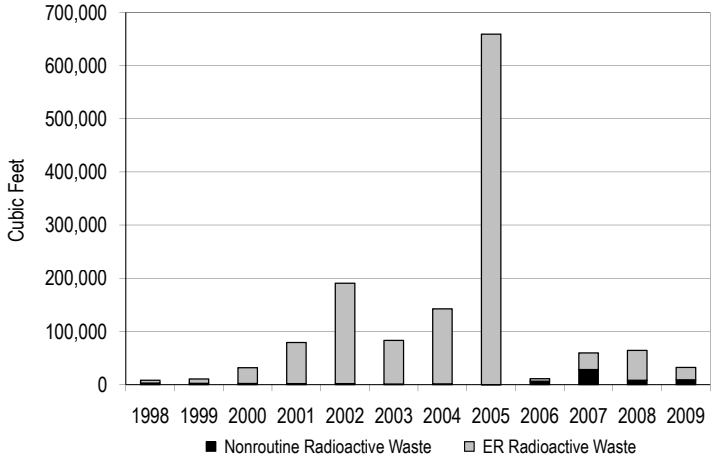

Figure 2-1f. Radioactive Waste Generation from ER and Nonroutine Operations, 1998 – 2009.

Building 704. Other non-routine wastes included disposal of lead contaminated debris, lead shielding, and polychlorinated biphenyl (PCB) wastes.

Figures 2-1d through 2-1f show wastes generated under the ERP Group, as well as non-routine operations. Waste generation from these activities has varied significantly from year to year. This is expected, as restoration activities move from remedial investigations and feasibility studies to remedial actions, which change annually based on the progress of the Laboratory's cleanup schedule.

2.3.4.4 Pollution Prevention and Waste Minimization

The BNL Pollution Prevention (P2) Program is an essential element for the successful accomplishment of the Laboratory's broad mission. 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 into the DOE contract with BSA, into BNL's ESSH Policy, and into the Performance Evaluation Management Plan associated with the Laboratory's operating contract with DOE. Key elements of the P2 Program include:

- Eliminate or reduce emissions, effluents, and waste at the source where possible, and ensure that they are "as low as reasonably achievable" (i.e., uphold the E-ALARA policy)
- Procure environmentally

preferable products (known as "affirmative procurement")
- Conserve natural resources and energy
- Reuse and recycle materials
- Achieve or exceed BNL/DOE waste minimization, P2, recycling, and affirmative procurement goals
- Comply with applicable requirements (e.g., New York State Hazardous Waste Reduction Goal, Executive Orders, etc.)
- Reduce waste management costs
- Implement P2 projects
- Improve employee and community awareness of P2 goals, plans, and progress

Fifteen P2 proposals were submitted to the BNL P2 Council for funding in FY2009. Five proposals were funded, for a combined investment of approximately $24,000. The anticipated annual savings from these projects is estimated at $33,650, for an average payback period of approximately 0.7 years. The BNL P2 and recycling programs have achieved significant reductions in waste generated by routine operations, as shown in Figures 2-1a through 2-1c. This continues a positive trend and is further evidence that pollution prevention planning is well integrated into the Laboratory's work planning process. These positive trends are also driven by the EMS emphasis on preventing pollution and establishing objectives and targets to reduce environmental impacts. Table 2-2 describes the P2 projects implemented through 2009, and provides the number of pounds of materials reduced, reused, or recycled, as well as the estimated cost benefit of each project.

The implementation of pollution prevention opportunities, recycling programs, and conservation initiatives has significantly reduced both waste volumes and management costs. In 2009, these efforts resulted in more than $5.5 million in cost avoidance or savings and approximately 17.9 million pounds of materials being reduced, recycled, or reused annually.

The Laboratory also has an active and successful solid waste recycling program, which involves all employees. In 2009, BNL collected approximately 127 tons of office paper for recycling. Cardboard, bottles and cans, construction debris, motor oil, scrap metals, lead, automotive

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

Waste Description	Type of Project	Pounds Reduced, Reused, Recycled or Conserved in 2009	Waste Type	Potential Costs for Treatment and Disposal	Cost of Recycle, Prevention	Estimated Cost Savings	Project Description Details *
Alkaline batteries	Recycling	200	Industrial waste	$10	$0	$10	Two hundred pounds of alkaline batteries were collected and recycled.
Solar-powered street lamp	Energy conservation	N/A	Greenhouse gas/Energy conservation	$10,000	$5,131	$5,386	Installation of a solar-powered street lamp in the rear parking area of Building 490. Cost savings based on avoided costs of trenching and wire pulling.
Bio-diesel tank	Alternative fuels	0	Greenhouse gas/Energy Conservation	$0	$11,772	$0	Per DOE Order 430.2B, BNL is utilizing bio-diesel to operate maintainance vehicles.
Sewage sludge and sand filter media	Landfill	9,690,000	Low-level Radiological waste	$4,000,000	$755,000	$3,245,000	Processing, treatment, and disposal of sewage sludge and sand filter media from the BNL Sewage Treatment Facility. This process removed all low-level radioactive contaminants from the operating facility. The sludge can now be shipped to a municipally owned facility.

(continued on next page)

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

Waste Description	Type of Project	Pounds Reduced, Reused, Recycled or Conserved in 2009	Waste Type	Potential Costs for Treatment and Disposal	Cost of Recycle, Prevention	Estimated Cost Savings	Project Description Details *
Recycling containers	Recycling	600	Industrial waste	$3,000	$3,253	$0.00	Purchased four sets of recycling containers in 2009 to increase recycling rates in conference rooms.
Timer switches*	Energy conservation	N/A	Greenhouse gas/Energy Conservation	N/A	$3,415	$5,386	Installation of motion detector and infrared lighting in labs in Building 535.
Water timers	Water conservation	80,000	Potable water	N/A	$580	$164	Water timers allow taps to be shut off after a specified amount of time running or a specified number of gallons are released, which saves water and energy required to run the still.
Motion sensors for labs*	Energy conservation	N/A	Greenhouse gas/Energy Conservation	N/A	$4,320	$5,817	Installation of motion detector lighting in common areas of Buildings 490 and 463.
"Bio Circle Cleaner" parts washer	Substitution	640	Hazardous waste	$10,000	$4,461	$10,000	Eliminates the need for toxic solvents, chemical storage, and disposal associated with the cleaning of vacuum parts.
Aerosol can disposal system	Recycling	528	Hazardous waste	$12,000	$0	$12,000	Empty aerosol cans are recycled as scrap, rather then sent to the Waste Management Division as hazardous waste. Eight units (Facilities and Operations=5; Collider Accelerator=1; National Synchrotron Light Source=1; Basic Energy Sciences=1) each handle 66 lbs. of hazardous waste.
Portable closed-head drum mixer	Neutralization	1,600	Hazardous waste	$15,089	$0	$15,089	The National Synchrotron Light Source purchased a closed drum mixer to neutralize Rydlyme, used to descale cooling pipes.
Formaldetox	Source reduction	280	Non-hazardous waste (neutralized ~ 1 gallon)	$3,772	$0	$3,772	Neutralizes nonhazardous para-formaldehyde, chlorix, bleach, and rat blood.
High Performance Liquid Chromatography (HPLC) solvent recycler	Reuse	110	Hazardous waste	$2,500	$0	$6,755	Allows reuse of approximately 50 liters of solvent and saves approximately 50 labor hours.
Propane cylinder de-valver	Recycling	75	Hazardous waste	$7,500	$0	$7,500	The Collider Accelerator Division purchased a propane cylinder de-valver to avoid sending cylinders to a disposal vendor at $75 each; they are now recycled as scrap.

(continued on next page)

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

Waste Description	Type of Project	Pounds Reduced, Reused, Recycled or Conserved in 2009	Waste Type	Potential Costs for Treatment and Disposal	Cost of Recycle, Prevention	Estimated Cost Savings	Project Description Details *
Fluorescently labeled oligonucleotides	Waste minimization	3,144	Radiological waste (396 ft^3); Mixed waste (35 galllons); Hazardous waste (108 galllons)	$67,600	$0	$67,600	This project was cost-shared with Biology. The process avoids the use of radioactivity, thus avoiding radiological waste generation. This process won a 2008 DOE P2 Star Award.
Electronic recycling	Recycling	33,907	E-waste	$84,768	$2,300	$82,468	The Laboratory has partnered with a government-based e-waste recycler (UNICOR), which gurantees that its e-waste is recycled in the most environmentally friendly manor. BNL pays shipping fees to the recycling facility.
Electronic Reuse	Reuse	22,851	E-waste	$57,128	$0	$57,128	BNL tracks electronic equipment and takes a reuse credit for transfer of equipment to another user.
Building demolition recycling	Recycling	6,400,000	Industrial waste	$291,200	$32,000	$259,200	On-site demolition products (steel and concrete) are segregated, recycled, and reused.
System One parts cleaner	Substitution	1,280	Hazardous waste	$11,317	$0	$11,317	Central Fabrications and Motor Pool each purchased a System One parts washer to re-distill dirty solvent, eliminating the need for a vendor, such as Safety Kleen. Removed grit and sludge are mixed with the waste oil.
Photon-counting spectro-fluorimeter	Substitution	54	Mixed waste (2 ft^3)	$20,730	$0	$70,730	Eliminated the need for radioactive assays and their radioactive waste. Savings include 1,000 work-hours and savings on material costs.
Replacement of mercury utility devices	Substitution	16	Mercury	$2,350	$4,000	$2,350	Approximately 48 lbs. of mercury-containing devices were removed from utility devices during 2009. Savings are based on the cost of one mercury spill and cleanup.
Animal bedding conveying system	Composting	72,000	Low-level Radiological Waste	$1,153,475	$0	$1,153,475	Animal bedding material is no longer sent to sanitary landfill. It is now conveyed to a dumpster that is emptied or composted at the stump dump.
Plant Engineering grounds vehicle wash system *	Waste minimization	8,000	Oils/grease to soils	$16,000	$3,000	$13,000	This multi-year, multi-department project was completed in 2007 and eliminates the potential of oil and grease being released to soil.
Organic solvents	Substitution	678	Hazardous waste	$1,694	$0	$26,000	Life Sciences utilizes a Microwave Peptide Synthesizer, which significantly reduces the hazardous wastes generated and saves ~1,000 work-hours/year (reflected in cost savings).

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

Waste Description	Type of Project	Pounds Reduced, Reused, Recycled or Conserved in 2009	Waste Type	Potential Costs for Treatment and Disposal	Cost of Recycle, Prevention	Estimated Cost Savings	Project Description Details *
Organic solvents	Purification/re-use	44	Hazardous waste	$110	$0	$3,510	The primary savings of the solvent purification system used by Basic Energy Sciences are in not purchasing new solvent and labor savings from not running the stills.
Cooling water	Reuse	63,400	Deionized water	$0	$0	$7,925	A closed-cycle water recycling system for the Building 480 melt spinner saved 7,925 gallons of ultra-pure water and extends the life expectancy of equipment worth $100,000.
Lead acid batteries	Recycled	7,920	Universal waste	$59,753	$0	$59,753	Avoids hazardous waste disposal costs for approximately 40 lbs. of lead per battery.
Short half-life waste	Decay in storage	136	Radioactive waste	$69,168	$0	$69,168	During 2009, 19 boxes of filters from Buildings 914 and 918 (136 ft^3) were managed in accordance with BNL decay-in-storage requirements, rendering the wastes eligible for volumetric release.
Cooling Tower chemicals	Source reduction	9,563	Industrial waste	$22,500	$0	$22,500	Ozone water treatment units were installed on cooling towers at SEM, the National Space Radiation Laboratory, and the Relativistic Heavy Ion Collider Reseach Facility, for biological control of cooling water. These systems eliminate the need for water treatment chemicals (typically, toxic biocides), save labor, and reduce analytical costs for monitoring cooling tower blowdown.
Blasocut machining coolant	Recycled/ re-used	30,480	Industrial waste	$74,345	$0	$79,945	Central Shops Division operates a recycling system that reclaims Blasocut machining coolant and supplies it Laboratory-wide. In 2009, 3,340 gal (26,720 lbs.) of Blasocut lubricant were recycled. Recycling involves aeration, centrifuge, and filtration. This avoids cost of disposal as industrial waste and an avoided cost of buying seven drums of concentrate ($800/drum) and 67 empty drums for shipping ($50/drum).
Fluorescent bulbs	Recycled	11,780	Universal waste	$88,875	$20,000	$68,875	Fluorescent bulbs are collected and sent to a recycling facility under the Universal Waste exemption rule.
Tyvek	Recycled	180	Industrial waste	$10	$0	$10	BNL is recycling tyvek through Garment Recovery Systems.

(continued on next page)

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

Waste Description	Type of Project	Pounds Reduced, Reused, Recycled or Conserved in 2009	Waste Type	Potential Costs for Treatment and Disposal	Cost of Recycle, Prevention	Estimated Cost Savings	Project Description Details *
Used motor oil	Energy recovery	12,544	Industrial waste	$35,508	$0	$35,508	Used motor oil from the motor pool and the on-site gas station is given to Strebel's Laundry Service to fire their boilers. In 2009, they collected 1,568 gallons of oil at no charge to BNL, which avoided the costs for disposal and 32 shipping drums ($50/drum).
Office paper	Recycled	254,880	Industrial waste	$13,509	$0	$13,509	Cost avoidance based on $106/ton for disposal as trash.
Cardboard	Recycled	303,760	Industrial waste	$16,099	$0	$16,099	Cost avoidance based on $106/ton for disposal as trash.
Metals	Recycled	181,050	Industrial waste	$9,596	$0	$27,701	Cost avoidance based on $106/ton for disposal as trash, plus $150/ton revenue.
Bottles/cans	Recycled	47,480	Industrial waste	$2,516	$0	$2,516	Cost avoidance based on $106/ton for disposal as trash.
Construction debris	Recycled	624,540	Industrial waste	$14,052	$0	$14,052	Cost avoidance based on $45/ton difference for disposal as trash.
	TOTALS	17,863,720		$6,176,173	$849,232	$5,481,217	

* Cost savings of projects funded by the BNL Pollution Prevention Council will be tracked for 3 years.

batteries, electronic scrap, fluorescent light bulbs, and drill press/machining coolant were also recycled. Table 2-3 shows the total number of tons (or units) of the materials recycled in 2009.

2.3.4.5 Water Conservation

BNL's water conservation program has achieved dramatic reductions in water use since the mid 1990s. The Laboratory continually evaluates water conservation as part of facility upgrades or new construction initiatives. These efforts include more efficient and expanded use of chilled water for cooling and heating/ventilation and air conditioning (HVAC) systems, and reuse of once-through cooling water for other systems, such as cooling towers. The goal is to reduce the consumption of potable water and reduce the possible impact of clean water discharges on Sewage Treatment Plant (STP) operations. Figure 2-2 shows the 10-year trend of water consumption. A slight rise in water consumption in 2009 was the result of a failed thermostatic control valve at the CAD. This resulted in 60 million gallons of water used for once-through cooling. In each of the past five years, the water consumption total was approximately half the 1998 total—a reduction of nearly a half-billion gallons per year.

2.3.4.6 Energy Management and Conservation

Since 1979, the Laboratory's Energy Management Group has been working to reduce energy use and costs by identifying cost-effective, energy-efficient projects, monitoring energy use and utility bills, and assisting in obtaining the least expensive energy sources pos-

Table 2-3. BNL Recycled Program Summary.

Recycled Material	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Mixed paper	336	246	209	182	185	193	184	177	151	127
Cardboard	132	127	157	176	179	143	135	121	147	152
Bottles/Cans	20	29	19	23	22	22.1	27.7	24.4	19.6	23.7
Tires	0	0	3.5	12.3	11	12.8	32.5	19.9	34.5	15.5
Construction debris	243	289	304	334	367	350	297	287	302	312
Used motor oil (gallons)	3,295	3,335	1,920	3,920	3,860	4,590	2,780	2,020	1,500	1,568
Metals	534	38	48	193	128	559	158	382	460	91
Lead	2.5	0	0	–	5	0	0	0	0	0
Automotive batteries	2.2	4.8	6.3	4.6	5	4.6	5.5	2.5	2.7	4
Printer/Toner cartridges (units)	–	363	449	187	105	0	0	0	3,078	1,251
Fluorescent bulbs (units)	5,874	17,112	25,067	13,611	12,592	7,930	11,740	25,448	36,741	10,223
Blasocut coolant (gallons)	7,500	10,660	8,180	5,030	6,450	3,890	3,970	2,432	3,340	3,810
Antifreeze (gallons)	110	200	0	165	325	0	0	0	0	0
Tritium exit signs (each)	185	190	28	181	142	0	0	0	0	0
Smoke detectors (each)	–	171	40	0	0	0	0	0	0	0
Road base	–	–	2,016	0	2,666	0	0	0	0	0
Electronic reuse	–	–	–	–	–	–	–	–	16.3	11.4
Scrap electronics	–	–	–	–	–	6.1	70.3	40.5	48.9	17
Animal bedding (composted)	–	–	–	–	–	--	6.3	19.6	42	41
Tyvek (lbs)	–	–	–	–	–	–	–	–	–	84
Metals (building demolition)	–	–	8	23	11	6	35	--	–	–
Concrete (building demolition)	–	–	891	590	3,000	328	5,505	6175	–	–
Other construction and debris (building demolition)	–	–	790	388	1,200	157	818	--	–	–

Notes:
All units are tons unless otherwise noted.

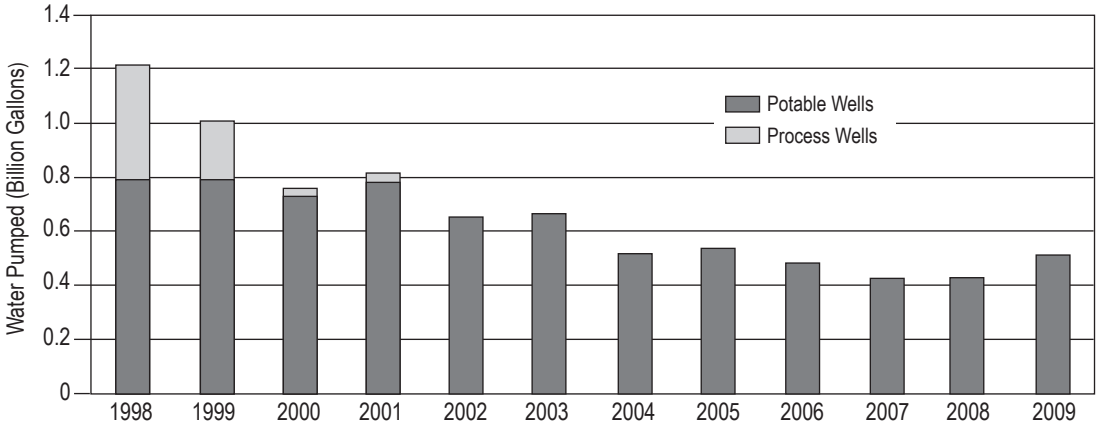

Figure 2-2. BNL Water Consumption Trend, 1998–2009.

sible. The group is responsible for developing, implementing, and coordinating BNL's Energy Management Plan and assisting DOE in meeting the energy goals in DOE Order 430.2B and the Secretary's initiatives.

The Laboratory has more than 4 million square feet of building space. Many BNL scientific experiments use particle beams generated and accelerated by electricity, with the particles controlled and aligned by large electromagnets. In 2009, the Laboratory used approximately 257 million kilowatt hours (kWh) of electricity, 2.8 million gallons of fuel oil, 36,000 gallons of propane, and 257 million ft^3 of natural gas. Fuel oil and natural gas produce steam at the Central Steam Facility (CSF). Responding to market conditions, fuel oil and natural gas were used whenever each respective fuel was least expensive. Additional information on natural gas and fuel oil use can be found in Chapter 4. In addition, over 4,000 gallons of biofuels were used in several applications.

BNL is a participant in the New York Independent System Operator (NYISO) Special Case Resource (SCR) Program, which is an electric load reduction curtailment program. Through this program, the Laboratory has agreed to reduce electrical demand during critical days throughout the summer when NYISO expects customer demand to meet or exceed the available supply. In return, BNL receives a rebate for each megawatt reduced on each curtailment day. No curtailment days were required in 2009, but BNL participated in some test exercises. However, limited participation in this program produced a rebate of $102,000. The Laboratory continues to keep electric loads at a minimum during the summer by scheduling operations at the Relativistic Heavy Ion Collidar (RHIC) to avoid peak demand periods. This scheduling reduces the electric demand by 25 MW, which allowed BNL to save $4.5 million in electric costs in 2009, and greatly helps maintain the reliability of the Long Island Power Authority (LIPA) electric system to meet all of its users' needs.

BNL also maintains a contract with the New York Power Authority (NYPA) that resulted in an overall cost avoidance of $26 million in 2009. The Laboratory will continue to seek alternative energy sources to meet its future energy needs, support federally required "green" initiatives, and reduce energy costs.

LIPA issued a Request for Proposals in 2008 for 50 MW of solar photovoltaic (PV) generating projects. The construction of a 32 MW solar array at BNL by BP Solar was one of two projects selected by LIPA for development. The Laboratory and DOE worked to complete several key requirements in 2009, including the preparation of a comprehensive Environmental Assessment (EA). The EA concluded that the project will have minimal environmental impact on the Laboratory site, and was approved by the LIPA Board in December 2009. To reduce energy use at non-research facilities, other activities also were undertaken in 2009. These activities included:

- Continued development of a sitewide Utility Energy Services Contract (UESC) that will reduce the Laboratory's overall energy intensity (Btu/ft^2) by 11 percent and will save over $2 million/year in energy costs.
- 25 MW of demand was rescheduled to avoid coinciding with the utility summer peak, saving several million dollars in electricity charges.
- A demonstration project for a solar hot water combination system at BNL's Brookhaven Center was near completion.
- Work continued in the replacement of aging, inefficient T-40 fluorescent lighting fixtures with new, efficient T-8 and T-5 units; two to three hundred fixtures are typically replaced annually, saving tens of thousands of kWhs and reducing costs by several thousand dollars.
- Due to continued conservation efforts, overall facilities energy usage for FY2009 was approximately 8 percent less than in FY2003, saving over $1.8 million.
- Efficient fuel purchasing strategies (buying and storing oil and burning the least expensive fuel) saved over $2 million, compared to purchasing only oil as it is consumed.
- Over 25,000 gge (gasoline gallon equivalents) of natural gas were used in place of gasoline for the Laboratory's vehicle fleet.

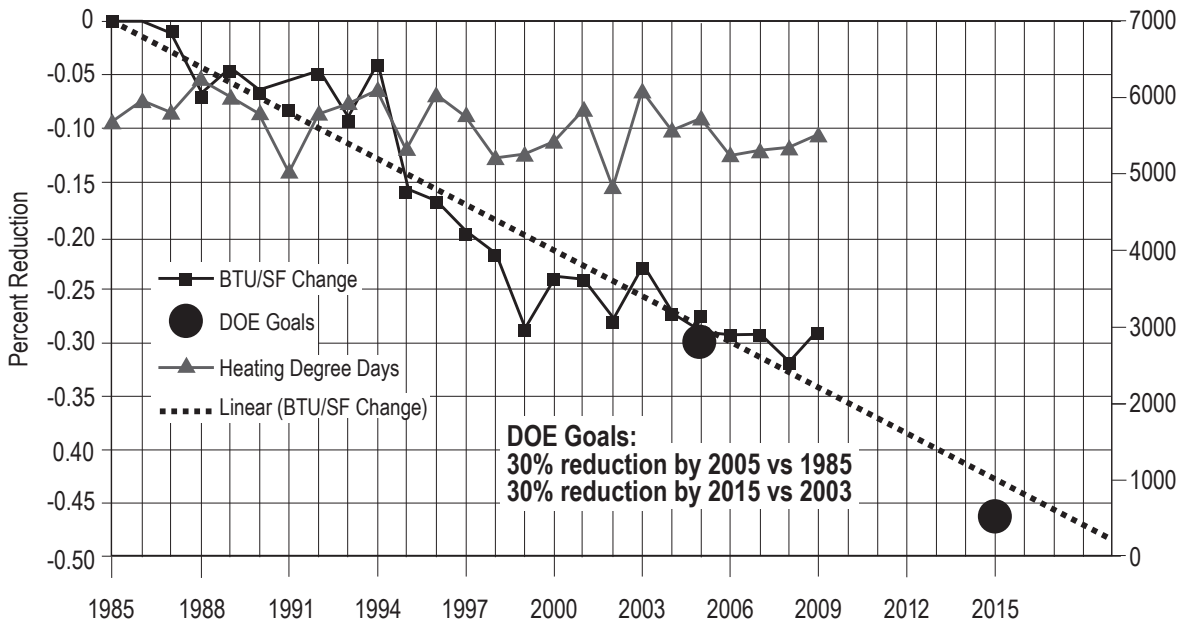

Figure 2-3. BNL Building Energy Performance.

BNL is working on its annual Executable Plan (soon to be called Strategic Sustainability Performance Plan [SSPP]) for energy, transportation, and water management. The plan includes strategies, energy costs, and indicators and goals, including energy use/square foot and an overall carbon reduction of 28 percent. The plan also documents the Laboratory's efforts to reduce energy use and costs to the lowest cost-effective levels, while striving to meet DOE and EO goals.

DOE and BNL have teamed with BP Solar and LIPA to construct a 32 MW, 200-acre PV solar farm on the Laboratory site. This collaboration will assist the Laboratory in developing additional solar research, as well as education and community outreach. The project has been approved by all of the required parties, and is scheduled to start construction by late summer or early fall of 2010.

In February 2009, NYPA agreed to provide 15 MW of low-cost hydropower to BNL, for a period of up to 15 years. Estimated savings are approximately $8 million per year. In addition, the hydropower will help stabilize electric rates and keep them competitive with other DOE Laboratories. Several key steps in the complex contractual process were completed, including the approval of the LIPA/NYPA sale-for-resale contract for the 15 MW of low-cost hydropower. Currently, the Laboratory is on track for final contract approval before the end of calendar year 2010.

The National Energy Conservation Policy Act, as amended by the Federal Energy Management Improvement Act of 1988 and the Energy Policy Acts of 1992 and 2005, requires federal agencies to apply energy conservation measures and to improve federal building design to reduce energy consumption per square foot. Current goals are to reduce energy consumption per square foot, relative to 2003, by 2 percent per year from FY2006–FY2015. In 2007, an EO increased the target reduction to 3 percent per year, which is a 30 percent reduction by the end of FY2015. Further, DOE Order 430.2B and the Secretary's TEAM initiative have set even more stringent requirements, including renewable energy and transportation fuels that go significantly beyond the previous goal of a 30 percent reduction by 2005, compared to 1985. BNL's energy use per square foot in 2009 was 30 percent less than in 1985 (see Figure 2-3) and 8 percent less than in 2003. It is important to note that energy use for buildings and facilities at the Laboratory is largely weather dependent.

2.3.4.7 Natural and Cultural Resource Management Programs

BNL continues to enhance its Natural Resource Management Program in cooperation with the Foundation for Ecological Research in the Northeast (FERN) and the Upton Ecological and Research Reserve. The Laboratory also continues to enhance its Cultural Resource Management Program. A BNL Cultural Resource Management Plan has been developed to identify and manage properties that are determined to be eligible or potentially eligible for inclusion on the National Register of Historic Places. See Chapter 6 for further information about these programs.

2.3.4.8 Environmental Restoration

The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), commonly known as Superfund, was enacted by Congress in 1980. As part of CERCLA, EPA established the National Priorities List, which identifies sites where cleanup of past contamination is required. BNL was placed on the list with 27 other Long Island sites, 12 of which are in Suffolk County.

Each step of the CERCLA cleanup process is reviewed and approved by DOE, EPA, and NYSDEC, under an Interagency Agreement (IAG) contract. This agreement was formalized in 1992. Although not a formal signatory of the IAG, the Suffolk County Department of Health Services (SCDHS) also plays a key role in the review process. Most of the contamination at the Laboratory is associated with past accidental spills and outmoded practices for handling, storing, and disposing of chemical and radiological material.

BNL follows the CERCLA process, which includes the following steps:

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

In 2009, significant work was performed for the Brookhaven Graphite Research Reactor (BGRR) and HFBR, and routine work continued for the groundwater treatment systems. The BGRR ROD requires the removal of the graphite pile and the biological shield, and the installation of a water infiltration control and monitoring system. Work planning, preparatory activities, and readiness reviews for the graphite pile removal were completed in 2009, and control rods, boron shot canisters (used for emergency shut down), and roof shielding plugs were removed. A remote manipulator fitted with special tools was installed on top of the biological shield to remove the graphite blocks from the pile and load them into soft-sided containers called “supersacks.” The supersacks will be placed inside metal containers using a remote controlled crane for shipment to DOE’s Nevada Test Site for disposal. All graphite handling will take place inside a contamination control enclosure that is maintained at a slight negative pressure (with respect to the atmosphere), in order to eliminate the release of radioactive material to the environment.

In April 2009, DOE, EPA, and NYSDEC agreed on a final cleanup action for the HFBR, and finalized the ROD. The final remedy incorporates many completed interim actions, several near-term actions, and the long-term segmentation, removal, and disposal of the remaining HFBR structures, systems, and activated components, including the reactor vessel. The near-term actions specified in the ROD include dismantling the remaining ancillary buildings, removing contaminated underground utilities and piping, and preparing the reactor confinement building for safe storage. The ROD requires that these near-term actions be completed no later than 2020. Completion date for a number of these near-term actions has been accelerated to 2011 as a result of funding made available through the American Recovery and Reinvestment Act of 2009. Planning and preparations to complete these activities were

well underway in 2009. The ROD also lays out a plan for the long-term segmentation, removal, and disposal of the remaining HFBR structures, systems, and components (including the reactor vessel and thermal and biological shields). These long-term actions will be conducted following a safe storage period (not to exceed 65 years) to allow for the natural reduction of high radiation levels to a point where conventional demolition techniques can be used to dismantle these reactor components. Stabilization activities to prepare the HFBR confinement building for long-term safe storage were initiated in 2009. The removal and disposal of the HFBR control rod blades and beam plugs were also completed in 2009. Also included in the HFBR ROD is the remediation of contaminated soils in the WLA and removal of the A&B waste lines.

The productive operation and maintenance (O&M) of the Laboratory's groundwater treatment systems removed approximately 229 pounds of solvents and 1.9 mCi of strontium-90 (Sr-90) from the sole source aquifer in 2009. Since the operation of the first treatment system in 1996, a cumulative total of approximately 6,363 pounds of solvents and 21 mCi of Sr-90 have been removed from the groundwater. The OU III Explanation of Significant Differences for the Building 96 Groundwater Treatment System was signed by the regulators in September 2009, and calls for the removal of the perchloroethylene-contaminated source area soils. Excavation and disposal of soils containing high levels of contamination will begin in 2010, and will ensure that groundwater cleanup objectives will be met.

Other planned work for 2010 includes the addition of four extraction wells to the Brookhaven Graphite Research Reactor/Waste Concentration Facility Groundwater Treatment System to remediate the downgradient high concentration area of Sr-90 identified in 2008. Post-cleanup monitoring of Peconic River surface water, sediment, fish, and wetland vegetation continued in 2009, and the results were reported in the Annual Peconic River Monitoring Report (see Chapter 6.) Sediment remediation of several areas of the Peconic River with continuing elevated concentrations of mercury is also planned for 2010. The groundwater systems operate in accordance with the O&M manuals, while the Peconic and surface soil cleanup areas are monitored via the OU I Soils and OU V Long-Term Monitoring and Maintenance Plan. Institutional controls are also monitored and maintained for the cleanup areas in accordance with the RODs to help ensure the remedies remain protective of human health and the environment. An annual evaluation of these controls is submitted to the regulators.

Table 2-4 provides a description of each OU and a summary of environmental restoration actions taken. See Chapter 7 and SER Volume II, Groundwater Status Report, for further details.

2.3.4.9 EPA Performance Track Program

BNL was accepted into the EPA's Performance Track (PTrack) Program in 2004. This program recognizes top environmental performance among participating U.S. facilities of all types, sizes, and complexity, both public and private. It is considered the "gold standard" for facility-based environmental performance—a standard that participating members strive to attain as they "meet or exceed their performance commitment." Under this program, partners provide leadership in many areas, including preventing pollution at its source. The PTrack Program requires that sites commit to several improvement goals for a three-year period and report on the progress of the goals annually. This program was suspended in 2009 while EPA conducts an overall review of the program, as well as other environmental leadership programs.

2.4 IMPLEMENTING THE ENVIRONMENTAL MANAGEMENT SYSTEM

2.4.1 Structure and Responsibility

All employees at BNL have clearly defined roles and responsibilities in key areas, including environmental protection. Employees are required to develop and sign their own Roles, Responsibilities, Accountabilities, and Authorities (R2A2) document, which must also be signed by two levels of supervision. BSA has clearly defined expectations for management and staff which must be included in this document. Under the BSA performance-based management

Table 2-4. Summary of BNL 2009 Environmental Restoration Activities

Project	Description	Environmental Restoration Actions
Soil Projects	Operable Unit (OU) I/II/III/VII	▪ Performed monitoring and maintenance of institutional controls for cleanup areas. An annual evaluation of compliance with the controls was submitted to the regulators. ▪ Completed remediation of radiologically contaminated soil at the Waste Loading area, including rail shipments for disposal. ▪ An Explanation of Significant Differences documenting the proposed Building 96 volatile organic compound (VOC) source area soil excavation project was submitted to the regulatory agencies.
Groundwater Projects	OU III/IV/VI	▪ Continued operation of 12 groundwater treatment systems that remove VOCs and two systems that remove strontium-90 (Sr-90). ▪ 229 pounds of VOCs and nearly 1.9 mCi of Sr-90 were removed during the treatment of 1.6 billion gallons of groundwater. Since the first groundwater treatment system started operating in December 1996, approximately 6,363 pounds of VOCs and 21.3 mCi of Sr-90 have been removed, while treating more than 16 billion gallons of groundwater. ▪ Collected and analyzed over 2,000 sets of groundwater samples from 806 monitoring wells. ▪ Continued monitoring and operation of the High Flux Beam Reactor tritium pump and recharge system. ▪ Obtained regulatory agency approval for the decommissioning of the Carbon Tetrachloride groundwater treatment system. ▪ Continued post-closure groundwater monitoring at OU IV. ▪ Continued installing temporary wells to characterize Sr-90 in the Waste Concentration Facility plume. This will support the installation of additional extraction wells that are necessary to achieve cleanup goals. ▪ Continued monitoring the g-2 tritium plume using temporary and permanent monitoring wells.
Peconic River	OU V	▪ Performed fourth year of long-term post-cleanup monitoring of Peconic River surface water, sediment, fish, and wetland vegetation.
Reactors	Brookhaven Graphite Research Reactor (BGRR)	▪ Developed detailed procedures for graphite pile removal. ▪ Performed a Management Self Assessment, Contractor Readiness Assessment, and Confirmatory DOE Readiness Assessment for graphite pile removal and received DOE authorization for removal. ▪ Trained and qualified personnel for graphite pile removal. ▪ Contractor for graphite pile removal mobilized on site. ▪ Installed a contaminated control enclosure around the graphite pile, biological shield, and excavation equipment. ▪ Installed structural steel supports for graphite removal equipment. ▪ Installed and tested remote excavator and associated equipment for graphite pile removal. ▪ Removed existing structural interferences from reactor face and bioshield areas. ▪ Removed control rods from the BGRR graphite pile. ▪ Implemented new Safety Basis that established the BGRR as a “Below Hazard Category 3 Facility by Analysis.”
	High Flux Beam Reactor (HFBR)	▪ Removed 16 control rod blades (CRB) and 9 beam plugs and shipped off site for disposal. ▪ Drained contaminated water from the reactor vessel, piping systems, and fuel canal needed for CRB removal; the water was solidified and shipped off site for disposal. ▪ Disposed of water cleanup systems and tools used in reactor vessel and fuel canal. ▪ Initiated draining and isolation of all utility piping penetrating the reactor building. ▪ Installed alternate power supplies to allow for the demolition of the fanhouse. ▪ Rendered all formal Article 12 storage tanks permanently out of service. ▪ Implemented revised Safety Basis to reduce the HFBR from a “Hazard Category 3” Nonreactor Nuclear Facility to a radiological facility “Below Hazard Category 3 Facility by Analysis.” ▪ Completed final survey and acceptance of the Waste Loading Area soil remediation. ▪ Completed soil remediation work at the former Hazardous Waste Management Facility perimeter soils area.

(continued on next page)

Table 2-4. Summary of BNL 2009 Environmental Restoration Activities *(concluded).*

Project	Description	Environmental Restoration Actions
	Building 704 Fanhouse Demolition	▪ Initiated demolition planning and design. ▪ Initiated removal and disposal of contaminated and non-contaminated materials and equipment from Building 704. ▪ Initiated characterization and disposal of contaminated materials stored in Building 704. ▪ Prepared for utility isolations. ▪ Completed radiological walkover survey of the Building 704 perimeter.
	Brookhaven Medical Research Reactor (BMRR) (Project managed by the BNL Environmental Protection Division)	▪ Continued surveillance and maintenance activities.
Buildings 801/811	A&B waste lines	▪ Completed removal of underground waste lines from Building 801 to Building 811. ▪ Work completed under Removal Action Memorandum.
Building 801	Inactive Radiological Liquid Holdup Facility	▪ Performed routine surveillance and maintenance of the facility.
Building 650	Inactive Radiological Decon Facility	▪ Performed routine surveillance and maintenance of the facility.

model, senior managers must communicate their expectation that all line managers and staff take full responsibility for their actions and be held accountable for ESSH performance. Environmental and waste management technical support personnel assist the line organizations with identifying and carrying out their environmental responsibilities. The Environmental Compliance Representative Program, initiated in 1998, is an effective means of integrating environmental planning and pollution prevention into the work planning processes of the line organizations. A comprehensive training program for staff, visiting scientists, and contractor personnel is also in place, thus ensuring that all personnel are aware of their ESSH responsibilities.

2.4.2 Communication and Community Involvement

Communication and community involvement are commitments under BNL's EMS. The Laboratory maintains relationships with its employees, key stakeholders, neighbors, elected officials, regulators, and other community members. The goals are to provide an understanding of BNL's science and operations, including environmental stewardship and restoration activities, and to incorporate community input into the Laboratory's decision-making.

BNL staff participates in or conducts: on- and off-site meetings, which include discussions, talks, presentations, and roundtables; workshops; local civic association meetings; canvassing surrounding neighborhoods; Laboratory tours; and informal information sessions and formal public meetings held during public comment periods for environmental projects.

2.4.2.1 Communication Forums

To facilitate effective dialogue between the Laboratory and key stakeholders, several forums for communication and involvement have been established. The Brookhaven Executive Roundtable (BER), established in 1997 by DOE's Brookhaven Site Office, meets routinely to update local, state, and federal elected officials and regulatory agencies on environmental and operational issues, as well as on scientific discoveries and initiatives. The Community Advisory Council (CAC), established by BNL in 1998, advises the Laboratory Director, primarily on environmental, safety, and health issues related to the Laboratory that are of importance to the community. The CAC is composed of approximately 27 member organizations representing business, civic, education, employee, community, environmental, and health organizations. The CAC sets its own agenda

in cooperation with the Laboratory and meets monthly in sessions that are open to the public. Weekly phone calls with regulators keep them up-to-date on project status, obtain feedback and input, and provide an opportunity to discuss emerging environmental findings.

The Community Relations Office manages several outreach programs that provide opportunities for stakeholders to become familiar with the Laboratory's facilities and research projects and new initiatives, while helping to identify issues of concern in the community. The Envoy Program educates employee volunteers regarding Laboratory issues and provides a link to local community organizations. Feedback shared by envoys helps BNL gain a better understanding of local community concerns. The Speakers' Bureau Program provides speakers for educational and other organizations, such as Rotary Clubs, civic organizations, and professional societies, to update the community about Laboratory research and/or operations, including environmental efforts and cleanup status. The Summer Sundays Program enables the public to visit BNL science facilities, experience hands-on activities, and learn about research projects and environmental stewardship initiatives.

The Community Relations Office also provides lunchtime tours each month to offer employees the opportunity to learn about the Laboratory's science facilities, program areas, and activities outside the scope of their jobs. Brown bag lunch meetings, held periodically with employees, have covered topics on Laboratory research, history, cleanup project status, and newly proposed initiatives. Specific topics of interest, such as health benefits or wildlife management concerns, have also been covered.

BNL's Media and Communications Office issues press releases and publishes The Bulletin, a weekly employee newsletter. A Director's Office web-based publication is issued bi-weekly, focusing on topics important to the administration. The Laboratory maintains an informative website at http://www.bnl.gov, where these publications, as well as extensive information about BNL's science and operations, past and present, are posted. Employees and the community can also subscribe to the Laboratory's e-mail update service at http://lists.bnl.gov/mailman/listinfo/bnl-announce-1.

In addition, BNL participates in various annual events hosted by EPD, such as a week-long celebration in honor of Earth Day, Earth Day Festivals, and the Brookhaven Town's Longwood Fair.

2.4.2.2 Community Involvement in Cleanup Projects

In 2009, BNL stakeholders had the opportunity to provide input for three projects that were subject to public participation notice in local and regional newspapers. These projects included: a Notice of Intent to Modify, issued by NYSDEC, that established a public comment period on the renewal of the Laboratory's SPDES permit; a Notice of Availability, announcing that the Final OU III Explanation of Significant Differences for Building 96 Remediation, which established a change to the cleanup remedy, was complete; and a legal notice announcing the completion of an EA and Finding of No Significant Impact (FONSI) to construct and operate a solar array project on site.

The Laboratory's SPDES permit, up for renewal in 2010, authorizes discharges of wastewater to surface and ground water. Established under the Clean Water Act, the goals of the SPDES program are to eliminate the discharge of pollutants into the nation's waters and to achieve water quality to protect fishing and recreational interests. BNL has 12 SPDES-permitted outfalls. A revised draft permit, subject to public comment, was issued by NYSDEC in February 2009, and a Notice of Intent to Modify was published. NYSDEC released a Response to Public Comments on the Proposed Draft SPDES Permit in June 2009, which explained how input had been used.

Under the June 2000 OU III ROD, the remedy for Building 96 consisted primarily of a groundwater treatment system to capture contamination from VOCs. When contaminants failed to respond to treatment, further characterization of the area was conducted. As a result, a change to the remedy that called for the excavation and off-site disposal of the soil, discovered to be the source of the VOC contamination, was

proposed. An Explanation of Significant Differences (ESD) was prepared and notice was published. The remedy was also discussed via Annual Groundwater Report presentations, as well as a CAC meeting.

When LIPA called for proposals for solar projects, DOE and BNL proposed making a portion of the Laboratory site available to prospective respondents. The resulting collaboration with BP Solar is for a large-scale solar PV project on 200 acres near the southeast corner of the Laboratory adjacent to a LIPA substation. Prior to the release of an EA, the community and employees provided early input into the process via a brown bag lunch meeting, CAC presentation, and a public information forum. In December 2009, a notice of a completed EA and FONSI was published, and BNL notified local civic associations, elected officials, and interested stakeholders.

Stakeholders were also updated on the progress of other environmental cleanup projects and health and safety issues via briefings and presentations given at CAC and BER meetings throughout the year. One topic of continuing interest was the safety of nanotechnology. At the CAC's request, Vicki Colvin, co-director of the Richard E. Smalley Institute for Nanoscale Science and Technology and Director of the Center for Biological and Environmental Nanotechnology at Rice University, Texas visited the Laboratory to discuss the safety of engineered nanomaterials and managing risk.

Other environmental topics covered included:

- The Laboratory's 2008 Annual Site Environmental Report provided the CAC with an overall update on BNL's clean-up projects and provided specific information on the protection and monitoring of groundwater and the remediation process, including the operational status of treatment systems, progress toward achieving cleanup goals, and recommended or proposed actions in response to monitoring data.
- Deer management employee survey results.
- Numerous updates on the BGRR and HFBR decommissioning projects.
- Environmental Management cleanup projects under the American Recovery and Reinvestment Act.
- The 2008 Annual Peconic River monitoring results, which included data on sediment, surface water, and fish sampling.
- A briefing on how the input received from the community was incorporated into the HFBR ROD, which was signed in April 2009.
- CAC members toured Peconic River restoration areas.

Working closely with the community, employees, elected officials, and regulatory agency representatives, DOE and BNL continue to openly share information on issues and projects and provide feedback on how that input was used.

2.4.3 Monitoring and Measurement

The Laboratory monitors effluents and emissions to ensure the effectiveness of controls, adherence to regulatory requirements, and timely identification and implementation of corrective measures. BNL's Environmental Monitoring Program is a comprehensive, sitewide program that identifies potential pathways for exposure of the public and employees, evaluates the impact activities have on the environment, and ensures compliance with environmental permit requirements. The monitoring program is reviewed and revised, as necessary or on an annual basis, to reflect changes in permit requirements, changes in facility-specific monitoring activities, or the need to increase or decrease monitoring based on a review of previous analytical results.

As required under DOE Order 450.1A, Environmental Protection Program, BNL prepares an Environmental Monitoring Plan, Triennial Update (BNL 2009), which outlines annual sampling goals by media and frequency. The plan uses the EPA Data Quality Objective approach for documenting the decisions associated with the monitoring program. In addition to the required triennial update, an annual electronic update is also prepared.

As shown in Table 2-5, in 2009 there were 7,810 sampling events of groundwater, potable water, precipitation, air, plants and animals, soil, sediment, and discharges under the Environmental Monitoring Program. Specific sampling

Table 2-5. Summary of BNL 2009 Sampling Program Sorted by Media.

Environmental Media	No. of Sampling Events(a)	Purpose
Groundwater	1,617 ER (b) 183 ES/C (c)	Groundwater is monitored to evaluate impacts from past and present operations on groundwater quality, under the Environmental Restoration, Environmental Surveillance, and Compliance sampling programs. See Chapter 7 and SER Volume II, Groundwater Status Report for further detail.
On-Site Recharge Basins	63	Recharge basins used for wastewater and stormwater disposal are monitored in accordance with discharge permit requirements and for environmental surveillance purposes. See Chapter 5 for further detail.
Potable Water	40 ES 141 C	Potable water wells and the BNL distribution system are monitored routinely for chemical and radiological parameters to ensure compliance with Safe Drinking Water Act requirements. In addition, samples are collected under the Environmental Surveillance Program to ensure the source of the Laboratory's potable water is not impacted by contamination. See Chapters 3 and 7 for further detail.
Sewage Treatment Plant (STP)	463	The STP influent and effluent and several upstream and downstream Peconic River stations are monitored routinely for organic, inorganic, and radiological parameters to assess BNL impacts. The number of samples taken depends on flow. For example, samples are scheduled for collection at Station HQ monthly, but if there is no flow, no sample can be collected. See Chapters 3 and 5 for further detail.
Precipitation	8	Precipitation samples are collected from two locations to determine if radioactive emissions have impacted rainfall, and to monitor worldwide fallout from nuclear testing. The data are also used, along with wind speed, wind direction, temperature, and atmospheric stability, to help model atmospheric transport and diffusion of radionuclides. See Chapter 4 for further detail.
Air – Tritium	302	Silica gel cartridges are used to collect atmospheric moisture for subsequent tritium analysis. These data are used to assess environmental tritium levels. See Chapter 4 for further detail.
Air – Particulate	482 ES/C 55 NYSDOH	Samples are collected to assess impacts from BNL operations and to facilitate reporting of emissions to regulatory agencies. Samples are also collected for the New York State Department of Health Services (NYSDOH) as part of their program to assess radiological air concentrations statewide. See Chapter 4 for further detail.
Air – Charcoal	51	Samples are collected to assess impacts from BNL operations and to facilitate reporting of emissions to regulatory agencies. See Chapter 4 for further detail.
Fauna	284	Fish, deer, and small mammals are monitored to assess impacts on wildlife associated with past or current BNL operations. See Chapter 6 for further detail.
Flora	7	Vegetation is sampled to assess possible uptake of contaminants by plants and fauna, since the primary pathway from soil contamination to fauna is via ingestion. See Chapter 6 for further detail.
Soils	68	Soil samples are collected as part of the Natural Resource Management Program to assess faunal uptake, during Environmental Restoration investigative work, during the closure of drywells and underground tanks, and as part of preconstruction background sampling.
Miscellaneous	409	Samples are collected periodically from potable water fixtures and dispensers, manholes, spills, to assess process waters, and to assess sanitary discharges.
Groundwater Treatment Systems and Remediation Monitoring	1,562	Samples are collected from groundwater treatment systems and as long-term monitoring after remediation completion under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) program. The Laboratory has 14 operating groundwater treatment systems. See discussion in Chapter 7.
Vehicle Monitor Checks	245	Materials leaving the Laboratory pass through the on-site vehicle monitor that detects if radioactive materials are present. Any radioactive material discovered is properly disposed of through the Waste Management Program. The vehicle monitor is checked on a daily basis.
State Pollutant Discharge Elimination System (SPDES)	332	Samples are collected to ensure that the Laboratory complies with the requirements of the New York State Department of Environmental Conservation (NYSDEC)- issued SPDES permit. Samples are collected at the STP, recharge basins, and four process discharge sub-outfalls to the STP.

(continued on next page)

Table 2-5. Summary of BNL 2009 Sampling Program Sorted by Media *(concluded).*

Environmental Media	No. of Sampling Events(a)	Purpose
Flow Charts	634	Flowcharts are exchanged weekly as part of BNL's SPDES permit requirements to report discharge flow at the recharge basin outfalls.
Floating Petroleum Checks	96 C 29 ES	Tests are performed on select petroleum storage facility monitoring wells to determine if floating petroleum products are present. The number of wells and frequency of testing is determined by NYSDEC licensing requirements (e.g., Major Petroleum Facility), NYSDEC spill response requirements (e.g., Motor Pool area), or other facility-specific sampling and analysis plans.
Radiological Monitor Checks	492	Daily instrumentation checks are conducted on the radiation monitors located in Buildings 569 and 592. These monitors are located 30 minutes upstream and at the STP. Monitoring at these locations allows for diversion of wastes containing radionuclides before they are discharged to the Peconic River.
Quality Assurance/ Quality Control Samples (QA/QC)	537	To ensure that the concentrations of contaminants reported in the Site Environmental Report are accurate, additional samples are collected. These samples detect if contaminants are introduced during sampling, transportation, or analysis of the samples. QA/QC samples are also sent to the contract analytical laboratories to ensure their processes give valid, reproducible results.
Total number of sampling events	**7,810**	The total number of sampling events includes all samples identified in the Environmental Monitoring Plan (BNL 2009), as well as samples collected to monitor Environmental Restoration (CERCLA) projects, air and water treatment system processes, and by the Environmental Protection Division Field Sampling Team as special requests. The number does not include samples taken by Waste Management personnel, waste generators, or Environmental Compliance Representatives for waste characterization purposes.

Notes:
(a) A sampling event is the collection of samples from a single georeferenced location. Multiple samples for different analyses (i.e., tritium, gross alpha, gross beta, and volatile organic compounds) can be collected during a single sample event.
(b) Includes 86 temporary wells; many of which are used to collect multiple samples at different depth intervals.
(c) Includes 29 temporary wells, many of which are used to collect multiple samples at different depth intervals.
C = Compliance
ER = Environmental Restoration (CERCLA)
ES = Environmental Surveillance

programs for the various media are described further in Chapters 3 through 8.

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

2.4.3.1 Compliance Monitoring

Compliance monitoring is conducted to ensure that wastewater effluents, air emissions, and groundwater monitoring data comply with regulatory and permit limits issued under the federal Clean Air Act, Clean Water Act, Oil Pollution Act, Safe Drinking Water Act, and the New York State equivalents. Included in compliance monitoring are the following:

- *Air emissions monitoring* is conducted at reactors, accelerators, and other radiological emission sources, as well as the CSF. Real-time, continuous emission monitoring equipment is installed and maintained at some of these facilities, as required by permits and other regulations. At other facilities, samples are collected and analyzed periodically to ensure compliance with regulatory requirements. Analytical data are routinely reported to the permitting authority. See Chapters 3 and 4 for details.
- *Wastewater monitoring* is performed at the point of discharge to ensure that the effluent complies with release limits in the Laboratory's SPDES permits. Twenty-four point-source discharges are monitored under the BNL program: 12 under the ER Program and 12 under the SPDES permit. As required by permit conditions, samples are collected daily, weekly, monthly, or quarterly and monitored for organic, inorganic, and radiological parameters. Monthly

reports that provide analytical results and an assessment of compliance for that reporting period are filed with the permitting agency. See Chapter 3, Section 3.6 for details.

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

2.4.3.2 Restoration Monitoring

Restoration monitoring is performed to determine the overall impact of past operations, to delineate the real extent of contamination, and to ensure that Removal Actions are effective and remedial systems are performing as designed under CERCLA.

This program typically involves collecting soil and groundwater samples to determine the lateral and vertical extent of the contaminated area. Samples are analyzed for organic, inorganic, and radiological contaminants, and the analytical results are compared with guidance, standards, cleanup goals, or background concentrations. Areas where impacts have been confirmed are fully characterized and, if necessary, remediated to mitigate continuing impacts. Follow-up monitoring of groundwater is conducted in accordance with a ROD with the regulatory agencies (see Chapter 7 and SER Volume II, Groundwater Status Report, for details).

2.4.3.3 Surveillance Monitoring

Pursuant to DOE Order 450.1, surveillance monitoring is performed in addition to compliance monitoring, to assess potential environmental impacts that could result from routine facility operations. The BNL Surveillance Monitoring Program involves collecting samples of ambient air, surface water, groundwater, flora, fauna, and precipitation. Samples are analyzed for organic, inorganic, and radiological contaminants. Additionally, data collected using thermoluminescent dosimeters (devices to measure radiation exposure) strategically positioned on and off site are routinely reviewed under this program. Control samples (also called background or reference samples) are collected on and off the site to compare Laboratory results to areas that could not have been affected by BNL operations.

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

2.4.4 EMS Assessments

To periodically verify that the Laboratory's EMS is operating as intended, audits are conducted as part of BNL's Self-Assessment Program. The audits are designed to ensure that any nonconformance to the ISO 14001 Standard is identified and addressed. In addition, compliance with regulatory requirements is verified through routine inspections, operational evaluations, and focused compliance audits. BNL's Self-Assessment Program consists of several processes:

- *Self-assessment* is the systematic evaluation of internal processes and performance. The approach for the environmental self-assessment program includes evaluating programs and processes within organizations that have environmental aspects. Conformance to the Laboratory's EMS requirements is verified, progress toward achieving environmental objectives is monitored, operations are inspected to verify compliance with regulatory requirements, and the overall effectiveness of the EMS is evaluated. BNL environmental staff routinely participate in

these assessments. Laboratory management conducts assessments to evaluate BNL environmental performance from a programmatic perspective, to determine if there are Laboratory-wide issues that require attention, and to facilitate the identification and communication of "best management" practices used in one part of the Laboratory that could improve performance in other parts. BNL management also routinely evaluates progress on key environmental improvement projects. The Laboratory and DOE periodically perform assessments to facilitate the efficiency of assessment activities and ensure that the approach to performing the assessments meets DOE expectations.

- *Independent assessments* are performed by BNL staff members who do not have line responsibility for the work processes involved, to ensure that operations are in compliance with Laboratory requirements. These assessments verify the effectiveness and adequacy of management processes (including self-assessment programs) at the division, department, directorate, and Laboratory levels. Special investigations are also conducted to identify the root causes of problems, as well as identify corrective actions and lessons learned.

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

2.5 ENVIRONMENTAL STEWARDSHIP AT BNL

BNL has extensive knowledge of its potential environmental vulnerabilities and current operations due to ongoing process evaluations, the work planning and control system, and the management systems for groundwater protection, environmental restoration, and information management. Compliance assurance programs have improved the Laboratory's compliance status; pollution prevention projects have reduced costs, minimized waste generation, and reused and recycled significant quantities of materials.

BNL is openly communicating with neighbors, regulators, employees, and other interested parties on environmental issues and progress. To regain and maintain stakeholder trust, the Laboratory will continue to deliver on commitments and demonstrate improvements in environmental performance. The Site Environmental Report is an important communication mechanism, as it summarizes BNL's environmental programs and performance each year. Additional information about the Laboratory's environmental programs is available on BNL's website at http://www.bnl.gov. The Laboratory continues to pursue other ways to communicate timely data in a more user-friendly, visual manner.

Due to external recognition of the Laboratory's knowledge and unique experience implementing the EMS program, BNL is often asked to share its experiences, lessons learned, and successes. The Laboratory's environmental programs and projects have been recognized with international, national, and regional awards.

Audits have consistently observed a high level of management involvement, commitment, and support for environmental protection and the EMS. Audits and EMS management reviews have noted the following improvements made since BSA began managing BNL:

- The EMS has been strengthened, integrated with other Laboratory management systems, and formalized.
- Line ownership for environmental stewardship has been established, key roles and responsibilities have been identified and clarified, and expectations have been made explicit.
- A comprehensive environmental training program has been implemented.
- From the process evaluation project, BNL has improved its understanding of environmental aspects, waste streams, and applicable requirements.
- There is much greater formality with regard to control of EMS documents, manuals, and procedures. Procedures and requirements

have been updated, and environmental management programs have been improved.

- The Laboratory has been very successful in achieving its environmental goals. There have been successes in ISO 14001 registration and recertification, compliance improvements (e.g., facility modifications, implementation of SBMS, enhanced operational controls), and increased environmental knowledge and awareness on the part of management, employees, contractors, and visitors.
- Communication on environmental issues has improved, occurs at the highest levels of management, and reporting is more formal. Managers are better informed about environmental aspects, issues, and performance.
- Core EMS teams representing many organizations have been formed. A consensus process is used to develop the system, improving acceptance and support.
- There has been strong implementation of the EMS throughout the organizations, and cultural change has been notable.
- The value of the EMS process led to the site certification to the OHSAS 18001 Standard, which is helping to improve ES&H awareness.

For more than 50 years, the unique, leading-edge research facilities and scientific staff at BNL have made many innovative scientific contributions possible. Today, BNL continues its research mission while focusing on cleaning up and protecting the environment. The Laboratory's environmental motto, which was generated in an employee suggestion contest, is "Exploring Earth's Mysteries … Protecting Its Future," and reflects the Laboratory's desire to balance world-class research with environmentally responsible operations.

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3 Compliance Status

Brookhaven National Laboratory (BNL) is subject to more than 100 sets of federal, state, and local environmental regulations; numerous site-specific permits; 17 equivalency permits for operation of 14 groundwater remediation systems; and several other binding agreements. In 2009, the Laboratory operated in compliance with most of the requirements defined in these governing documents. Instances of noncompliance were reported to regulatory agencies and corrected expeditiously. Routine inspections conducted during the year found no significant instances of noncompliance; however, a warning notice was received from the New York State Department of Environmental Conservation (NYSDEC) in October for failure to report opacity violations within 2 days of the date of occurrence. Corrective actions have been implemented to prevent recurrence of the delayed reporting.

Emissions of nitrogen oxides, carbon monoxide, and sulfur dioxide from the Central Steam Facility were all within permit limits. There were 24 individual opacity excursions noted during 2009. These occurred in the first (3 instances), second (16 instances), and fourth (5 instances) quarters. Approximately 1,232 pounds of ozone-depleting refrigerants were recovered for eventual reuse by other DOE facilities or other federal agencies. These reductions included the disposition of eight cylinders of Halon 1301 from fixed fire suppression systems that were removed from operation, and eight cylinders of Halon 1211 associated with portable fire extinguishing systems. These materials have been transferred to storage for shipment to the Department of Defense Ozone Depleting Substances Reserve in 2010. Monitoring of BNL's potable water system showed that all drinking water requirements were met. During 2009, most of the liquid effluents discharged to surface water and groundwater met applicable New York State Pollutant Discharge Elimination System permit requirements. Two minor excursions above permit limits were reported for the year; one at the Sewage Treatment Plant and one at Outfall 006. The permit excursions were reported to NYSDEC and the Suffolk County Department of Health Services. Groundwater monitoring at the Major Petroleum Facility continued to demonstrate that current oil storage and transfer operations are not affecting groundwater quality.

Laboratory efforts to minimize spills of materials continued in 2009. There were 12 reportable spills of petroleum products, antifreeze, or chemicals. While the total number of spills increased by two from 2008, the severity of releases was less. All releases were cleaned up to the satisfaction of NYSDEC.

BNL participated in nine environmental inspections by external regulatory agencies in 2009. These inspections included petroleum and chemical storage, Sewage Treatment Plant operations, waste water discharges to other regulated outfalls and recharge basins, hazardous waste management facilities, and the potable water system. Immediate corrective actions were taken to address all issues raised during these inspections.

3.1 COMPLIANCE WITH REQUIREMENTS

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

3.2 ENVIRONMENTAL PERMITS

3.2.1 Existing Permits

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

- State Pollutant Discharge Elimination System (SPDES) permit, issued by the New York State Department of Environmental Conservation (NYSDEC)
- Major Petroleum Facility (MPF) license, issued by NYSDEC
- Resource Conservation and Recovery Act (RCRA) permit, issued by NYSDEC for the Waste Management Facility

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

Regulator: Codified Regulation	Regulatory Program Description	Compliance Status	Report Sections
EPA: 40 CFR 300 40 CFR 302 40 CFR 355 40 CFR 370	The Comprehensive Environmental Response, Compensation & Liability Act (CERCLA) provides the regulatory framework for remediation of releases of hazardous substances and remediation (including decontamination and decommissioning [D&D]) of inactive hazardous waste disposal sites. Regulators include EPA, DOE, and the New York State Department of Environmental Conservation (NYSDEC).	In 1989, BNL entered into a tri-party agreement with EPA, NYSDEC, and DOE. BNL site remediation is conducted by the Environmental Restoration Program in accordance with milestones established under this agreement. In 2005, BNL completed the restoration portion of the cleanup project and entered the surveillance and maintenance mode. Reactor D&D will continue under the CERCLA program in 2009.	2.3.4.8
Council for Env. Quality: 40 CFR 1500–1508 DOE: 10 CFR 1021	The National Environmental Policy Act (NEPA) requires federal agencies to follow a prescribed process to anticipate the impacts on the environment of proposed major federal actions and alternatives. DOE codified its implementation of NEPA in 10 CFR 1021.	BNL is in full compliance with NEPA requirements. The Laboratory has established sitewide procedures for implementing the NEPA requirements.	3.3
Advisory Council on Historic Preservation: 36 CFR 60 36 CFR 63 36 CFR 79 36 CFR 800 16 USC 470	The National Historic Preservation Act (NHPA) identifies, evaluates, and protects historic properties eligible for listing in the National Register of Historic Places, commonly known as the National Register. Such properties can be archeological sites or historic structures, documents, records, or objects. NHPA is administered by state historic preservation offices (SHPOs; in New York State, NYSHPO). At BNL, structures that may be subject to NHPA include the High Flux Beam Reactor (HFBR), the Brookhaven Graphite Research Reactor (BGRR) complex, World War I training trenches near the Relativistic Heavy Ion Collider project, and the former Cosmotron building.	The HFBR, BGRR complex, and World War I trenches are eligible for inclusion in the National Register. The former Cosmotron building was identified as potentially eligible in an April 1991 letter from NYSHPO. Any proposed activities involving these facilities must be identified through the NEPA process and evaluated to determine if the action would affect the features that make the facility eligible. Some actions required for D&D of the BGRR were determined to affect its eligibility, and mitigative actions are proceeding according to a Memorandum of Agreement between DOE and NYSHPO. BNL has a Cultural Resource Management Plan to ensure compliance with cultural resource regulations.	3.4
EPA: 40 CFR 50-0 40 CFR 82 NYSDEC: 6 NYCRR 200–257 6 NYCRR 307	The Clean Air Act (CAA) and the NY State Environmental Conservation Laws regulate the release of air pollutants through permits and air quality limits. Emissions of radionuclides are regulated by EPA, via the National Emission Standards for Hazardous Air Pollutants (NESHAPs) authorizations.	All air emission sources are incorporated into the BNL Title V permit or have been exempted under the New York State air program, which is codified under the New York Codes, Rules, and Regulations (NYCRR). Radiological air emission sources are registered with the EPA.	3.5
EPA: 40 CFR 109–140 40 CFR 230, 231 40 CFR 401, 403 NYSDEC: 6 NYCRR 700–703 6 NYCRR 750	The Clean Water Act (CWA) and NY State Environmental Conservation Laws seek to improve surface water quality by establishing standards and a system of permits. Wastewater discharges are regulated by NYSDEC permits through the State Pollutant Discharge Elimination System (SPDES).	At BNL, permitted discharges include treated sanitary waste, and cooling tower and stormwater discharges. With the exception of three excursions, these discharges met the SPDES permit limits in 2008.	3.6

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

Regulator: Codified Regulation	Regulatory Program Description	Compliance Status	Report Sections
EPA: 40 CFR 141–149 NYSDOH: 10 NYCRR 5	The Safe Drinking Water Act (SDWA) and New York State Department of Health (NYSDOH) standards for public water supplies establish minimum drinking water standards and monitoring requirements. SDWA requirements are enforced by the Suffolk County Department of Health Services (SCDHS).	BNL maintains a sitewide public water supply. This water supply met all primary drinking water standards, as well as operational and maintenance requirements.	3.7
EPA: 40 CFR 112 40 CFR 300 40 CFR 302 40 CFR 355 40 CFR 370 40 CFR 372	The Oil Pollution Act, the Emergency Planning and Community Right-to-Know Act (EPCRA), and the Superfund Amendment Reauthorization Act (SARA) require facilities with large quantities of petroleum products or chemicals to prepare emergency plans and report their inventories to EPA, the state, and local emergency planning groups.	Since some facilities at BNL store or use chemicals or petroleum in quantities exceeding threshold planning quantities, the Laboratory is subject to these requirements. BNL fully complies with all reporting and emergency planning requirements.	3.8.1 3.8.2 3.8.3
EPA: 40 CFR 280 NYSDEC: 6 NYCRR 595–597 6 NYCRR 611–613 SCDHS: SCSC Article 12	Federal, state, and local regulations govern the storage of chemicals and petroleum products to prevent releases of these materials to the environment. Suffolk County Safety Codes (SCSC) are more stringent than federal and state regulations.	The regulations require that these materials be managed in facilities equipped with secondary containment, overfill protection, and leak detection. BNL complies with all federal and state requirements and has achieved conformance to county codes.	3.8.4 3.8.5 3.8.6
EPA: 40 CFR 260–280 NYSDEC: 6 NYCRR 360–372	The Resource Conservation Recovery Act (RCRA) and New York State Solid Waste Disposal Act govern the generation, storage, handling, and disposal of hazardous wastes.	BNL is defined as a large-quantity generator of hazardous waste and has a permitted waste management facility.	3.9
EPA: 40 CFR 700–763	The Toxic Substances Control Act (TSCA) regulates the manufacture, use, and distribution of all chemicals.	BNL manages all TSCA-regulated materials, including PCBs, in compliance with all requirements.	3.10
EPA: 40 CFR 162–171 NYSDEC: 6 NYCRR 320 6 NYCRR 325–329	The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and corresponding NY State regulations govern the manufacture, use, storage, and disposal of pesticides and herbicides, as well as the pesticide containers and residuals.	BNL employs NY State-certified pesticide applicators to apply pesticides and herbicides. Each applicator attends training, as needed, to maintain current certification and files an annual report to the state detailing the types and quantity of pesticides applied.	3.11
DOE: 10 CFR 1022 NYSDEC: 6 NYCRR 663 6 NYCRR 666	DOE regulations require its facilities to comply with floodplain/wetland review requirements. The New York State Fresh Water Wetlands and Wild, Scenic, and Recreational Rivers rules govern development in the state's natural waterways. Development or projects within a half-mile of regulated waters must have NYSDEC permits.	BNL is in the Peconic River watershed and has several jurisdictional wetlands; consequently, development of locations in the north and east of the site requires NYSDEC permits and review for compliance under DOE wetland/floodplain regulations. In 2009, there were two projects permitted under the NYS Fresh Water Program.	3.12
U.S. Fish & Wildlife Service: 50 CFR 17 NYSDEC: 6 NYCRR 182	The Endangered Species Act and corresponding New York State regulations prohibit activities that would jeopardize the continued existence of an endangered or threatened species, or cause adverse modification to a critical habitat.	BNL is host to numerous species of flaura and fauna. Many species have been categorized by NYS as endangered, threatened, or of special concern. The Laboratory's Natural Resource Management Plan outlines activities to protect these vulnerable species and protect their habitats (see Chapter 6).	3.13
U.S. Fish & Wildlife Service: Migratory Bird Treaty Act 16 USC 703-712 The Bald and Golden Eagle Protection Act 16 USC 668 a-d	The Migratory Bird Treaty Act (MBTA) implements various treaties and conventions between the U.S. and Canada, Japan, Mexico and the former Soviet Union for the protection of migratory birds. Under the Act, taking, killing, or possessing migratory birds is unlawful. Birds protected under the act include all common songbirds, waterfowl, shorebirds, hawks, owls, eagles, ravens, crows, native doves and pigeons, swifts, martins, swallows, and others, and includes their body parts (feathers, plumes etc), nests, and eggs. The Bald and Golden Eagle Protection Act (BGEPA) prohibits any form of possession or taking of both bald and golden eagles.	Compliance with the MBTA and the BGEPA are documented through the BNL Natural Resource Management Plan. The plan includes provisions for enhancing local habitat through the control of invasive species, planting of native grasses as food sources, and construction of nesting sites. All construction activities, including demolition, are reviewed to ensure no impacts to nesting individuals.	3.13

(continued on next page)

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

Regulator: Codified Regulation	Regulatory Program Description	Compliance Status	Report Sections
DOE: Manual 231.1-1A	The Environment, Safety, and Health Reporting program objective is to ensure timely collection, reporting, analysis, and dissemination of information on environment, safety, and health issues as required by law or regulations or as needed to ensure that DOE is kept fully informed on a timely basis about events that could adversely affect the health and safety of the public, workers, the environment, the intended purpose of DOE facilities, or the credibility of the Department. Included in the order are the requirements for the Occurrence Reporting and Processing of Operations Program (ORPS).	BNL prepares an annual Site Environmental Report and provides data for DOE to prepare annual NEPA summaries and other Safety, Fire Protection, and Occupational Safety and Health Administration (OSHA) reports. The Laboratory developed the ORPS Subject Area for staff and management who perform specific duties related to discovery, response, notification, investigation, and reporting of occurrences to BNL and DOE management. The ORPS Subject Area is supported by: Occurrence Reporting Program Description, Critiques Subject Area, Occurrence Categorizer's Procedure, and the ORPS Office Procedure.	All chapters
DOE: Order 414.1 10 CFR 830, Subpart A Policy 450.5	The Quality Assurance (QA) program objective is to establish an effective management system using the performance requirements of this Order, coupled with technical standards, where appropriate, to ensure: senior management provides planning, organization, direction, control, and support to achieve DOE objectives; line organizations achieve and maintain quality while minimizing safety and health risks and environmental impacts, and maximizing reliability and performance; line organizations have a basic management system in place supporting this Order; and each DOE element reviews, evaluates, and improves its overall performance and that of its contractors using a rigorous assessment process based on an approved QA Program.	BNL has a Quality Management (QM) system to implement quality management methodology throughout its management systems and associated processes to: 1) plan and perform Laboratory operations reliably and effectively to minimize the impact on the safety and health of humans and on the environment; 2) standardize processes and support continuous improvement in all aspects of Laboratory operations; and 3) enable the delivery of products and services that meet customers' requirements and expectations. Having a comprehensive program ensures that all environmental monitoring data meet QA and quality control requirements. Samples are collected and analyzed using standard operating procedures, to ensure representative samples and reliable, defensible data. Quality control in the analytical labs is maintained through daily instrument calibration, efficiency and background checks, and testing for precision and accuracy. Data are verified and validated according to project-specific quality objectives before they are used to support decision making.	Chapter 9
DOE: Order 430.2B	DOE-O-430.2B implements the energy conservation, renewable energy, transportation management, and sustainable building program objectives of Executive Orders 13423 and 13514. The goal of the order is to provide requirements and responsibilities for managing DOE facilities and sites in meeting or exceeding the energy requirement goals of all applicable laws, Executive Orders, and Federal Regulations. These goals include continuous improvements in energy efficiencies and water conservation; distributed renewable and clean energy resources; increased number of sustainable buildings; and optimized utilization of alternative fuels, hybrids and plug-in electric vehicles. In addition, the program requires the maximum utilization of private sector financing, particularly from Energy Savings Performance Contracts (ESPC) and Utility Energy Service Contracts (UESC). The program establishes certain Departmental Leadership Goals, which must be tracked over time and met within certain time limits.	Compliance with the requirements is documented each year in an Executable Plan, which identifies the Laboratory's respective contributions toward meeting the Departmental Leadership Goals. This document is prepared and updated by BNL's Energy Management Group. In addition, many of the requirements of Sustainability Goals are implemented through BNL's Environmental Management System (EMS) by establishing and implementing institutional level objectives and targets. Progress on achieving these targets is reviewed annually.	2.3.3 2.3.4.4
DOE: Order 435.1	The Radioactive Waste Management Program objective is to ensure that all DOE radioactive waste is managed in a manner that protects workers, public health and safety, and the environment. Order 435.1 requires all DOE organizations that generate radioactive waste to implement a waste certification program. DOE Laboratories must develop a Radioactive Waste Management Basis (RWMB) Program Description, which includes exemption and timeframe requirements for staging and storing both routine and non-routine radioactive wastes.	The BNL Waste Certification Program Plan (WCPP) in the RWMB Program Description defines the radioactive waste management program's structure, logic, and methodology for waste certification. New or modified operations or activities that do not fall within the scope of the RWMB Program Description must be documented and approved before implementation. The Laboratory's RWMB Program Description describes the BNL policies, procedures, plans, and controls demonstrating that BNL has the management systems, administrative controls, and physical controls to comply with DOE Order 435.1.	2.3.4.3

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

Regulator: Codified Regulation	Regulatory Program Description	Compliance Status	Report Sections
DOE: Order 450.1A (former Order 5400.1)	The Environmental Protection Program objective is to implement sound stewardship practices that protect the air, water, land, and other natural and cultural resources affected by DOE operations, in a cost-effective manner, meeting or exceeding applicable environmental; public health; and resource protection laws, regulations, and DOE requirements. DOE facilities meet this objective by implementing an Environmental Management System (EMS) that is part of an Integrated Safety Management System (ISMS). Other components include establishing sound environmental monitoring programs to comply with former DOE Order 5400.1. The Standards-Based Management System (SBMS) provides staff with procedural guidance. In 2008, Order 450.1A was finalized and requires all federal agencies and contractors to include the goals of Executive Order 13423 in their EMS. These goals include energy and water conservation, renewable energy, use of alternate fuels, and other "green" initiatives.	BNL's EMS was officially registered to the ISO 14001:1996 standard in 2001 and recertified to the revised standard in 2004 and 2007. In June 2009, a surveillance audit was conducted that found the BNL EMS to be robust. The BNL ISMS Program Description presents the Laboratory's approach to integrating environment, safety, and health (ES&H) requirements into the processes for planning and conducting work at the Laboratory. It describes BNL's programs, including the SBMS, for accomplishing work safely and provides the road map of the systems and processes. In accordance with DOE Order 450.1A, the Laboratory has included the Executive Order objectives in its Objectives and Targets for 2009. An audit of the EMS by the Brookhaven Site Office in December 2008 found that the system should be ready to declare conformance to the requirements of 450.1A by June 2009.	Chapter 2
DOE: Order 5400.5, Change 2	To protect members of the public and the environment against undue risk from radiation, the Radiation Protection of the Public and Environment Program establishes standards and requirements for operations of DOE and DOE contractors.	BNL uses the guidance values provided in DOE Order 5400.5 to ensure that effluents and emissions do not affect the environment or public and worker safety and health, and to ensure that all doses meet the "As Low As Reasonably Achievable" (ALARA) policy.	Chapters 4, 5, 6, and 8

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

- Registration certificate from NYSDEC for tanks storing bulk quantities of hazardous substances
- Seven radiological emission authorizations issued by the United States Environmental Protection Agency (EPA) under the National Emission Standards for Hazardous Air Pollutants (NESHAPs)
- Air emissions permit, issued by NYSDEC under Title V of the Clean Air Act Amendments authorizing the operation of 37 emission sources
- Two permits issued by NYSDEC for construction activities within the Peconic River corridor
- An EPA Underground Injection Control (UIC) Area permit for the operation of 90 UIC wells
- Permit for the operation of six domestic water supply wells, issued by NYSDEC
- Seventeen equivalency permits for the operation of 14 groundwater remediation systems installed via the Interagency Agreement (Federal Facility Agreement under the Comprehensive Environmental Response, Compensation and Liability Act [CERCLA])

3.2.2 New or Modified Permits

3.2.2.1 Air Emissions Permits

Air emission permits are granted by NYSDEC. The Title V permit consolidates all applicable federal and state requirements for BNL's regulated emission sources into a single document. The Laboratory has a variety of nonradioactive air emission sources covered under the permit that are subject to federal or state regulations. Section 3.5 describes the more significant sources and the methods used by the Laboratory to comply with the applicable regulatory requirements. In June 2008, BNL's Title V permit was renewed by NYSDEC after a two-year review. The renewed permit includes numerous changes to reflect the removal of certain processes previously included in the permit, as well as the addition of new processes. These changes are reflected in Table 3-2. There were no permit actions related to the Title V permit in 2009.

Air emissions permits are also issued as "equivalency" permits for the installation and

Table 3-2. BNL Environmental Permits.

Issuing Agency	Bldg. or Facility	Process/Permit Description	Permit ID No.	Expiration or Completion	Emission Unit ID	Source ID
EPA - NESHAPs	510	Calorimeter Enclosure	BNL-689-01	None	NA	NA
EPA - NESHAPs	705	Building Ventilation	BNL-288-01	None	NA	NA
EPA - NESHAPs	820	Accelerator Test Facility	BNL-589-01	None	NA	NA
EPA - NESHAPs	AGS	AGS Booster - Accelerator	BNL-188-01	None	NA	NA
EPA - NESHAPs	RHIC	Accelerator	BNL-389-01	None	NA	NA
EPA - SDWA	BNL	Underground Injection Control	NYU500001	11-Feb-11	NA	NA
NYSDEC - Air Equivalency	517	Middle Road System	1-51-009	NA	NA	NA
NYSDEC - Air Equivalency	518	South Boundary System	1-51-009	NA	NA	NA
NYSDEC - Air Equivalency	598	OU I Remediation System	1-52-009	NA	NA	NA
NYSDEC - Air Equivalency	539	Western South Boundary System	1-52-009	NA	NA	NA
NYSDEC - Air Equivalency	TR 867	T-96 Remediation System	1-52-009	NA	NA	NA
NYSDEC - SPDES Equivalency	517	Middle Road System	1-51-009	NA	NA	NA
NYSDEC - SPDES Equivalency	518	South Boundary System	1-51-009	NA	NA	NA
NYSDEC - SPDES Equivalency	539	West South Boundary System	1-52-009	NA	NA	NA
NYSDEC - SPDES Equivalency	598	OU I Remediation System	1-52-009	04-May-11	NA	NA
NYSDEC - SPDES Equivalency	598	Tritium Remediation System	1-52-009	04-May-11	NA	NA
NYSDEC - SPDES Equivalency	670	Sr-90 Treatment System	None	25-Feb-13	NA	NA
NYSDEC - SPDES Equivalency	TR 829	Carbon Tetrachloride System	None	NA	NA	NA
NYSDEC - SPDES Equivalency	OS-4	Airport/LIPA Treatment System	None	NA	NA	NA
NYSDEC - SPDES Equivalency	OS-2	Industrial Park East Treatment System	None	NA	NA	NA
NYSDEC - SPDES Equivalency	OS-5	North St./North St. East Treatment System	None	NA	NA	NA
NYSDEC - SPDES Equivalency	OS-6	Ethylene Di-Bromide Treatment System	None	01-Aug-09	NA	NA
NYSDEC - SPDES Equivalency	855	Sr-90 Treatment System - BGRR/WCF	None	01-Jan-10	NA	NA
NYSDEC - SPDES Equivalency	TR 867	T-96 Remediation System	1-52-009	09-Mar-13	NA	NA
NYSDEC - Hazardous Substance	BNL	Bulk Storage Registration Certificate	1-000263	27-Jul-11	NA	NA
NYSDEC - LI Well Permit	BNL	Domestic Potable/Process Wells	1-4722-00032/00113	13-Sep-18	NA	NA
NYSDEC - Air Quality	197	Lithographic Printing Presses	1-4722-00032/00115	29-Jun-13	U-LITHO	19709-10
NYSDEC - Air Quality	423	Metal Parts Cleaning Tanks	1-4722-00032/00115	29-Jun-13	U-METAL	42308
NYSDEC - Air Quality	423	Gasoline Storage and Fuel Pumps	1-4722-00032/00115	29-Jun-13	U-FUELS	42309-10
NYSDEC - Air Quality	423	Motor Vehicle A/C Servicing	1-4722-00032/00115	29-Jun-13	U-MVACS	MVAC1- 4
NYSDEC - Air Quality	244	Paint Spray Booth	1-4722-00032/00115	29-Jun-13	U-PAINT	244-02
NYSDEC - Air Quality	244	Flammable Liquid Storage Cabinet	1-4722-00032/00115	29-Jun-13	U-PAINT	244 AE
NYSDEC - Air Quality	479	Metal Parts Cleaning Tank	1-4722-00032/00115	29-Jun-13	U-METAL	47908
NYSDEC - Air Quality	510	Spin Coating Operation	1-4722-00032/00115	29-Jun-13	U-INSIG	510 AR
NYSDEC - Air Quality	801	Target Processing Laboratory	1-4722-00032/00115	29-Jun-13	U-INSIG	80101
NYSDEC - Air Quality	Site	Aerosol Can Processing Units	1-4722-00032/00115	29-Jun-13	U-INSIG	AEROS
NYSDEC - Air Quality	498	Aqueous Cleaning Facility	1-4722-00032/00115	29-Jun-13	U-METAL	49801
NYSDEC - Air Quality	535B	Plating Tanks	1-4722-00032/00115	29-Jun-13	U-INSIG	53501
NYSDEC - Air Quality	535B	Etching Machine	1-4722-00032/00115	29-Jun-13	U-INSIG	53502
NYSDEC - Air Quality	535B	Printed Circuit Board Process	1-4722-00032/00115	29-Jun-13	U-INSIG	53503
NYSDEC - Air Quality	610	Combustion Unit	1-4722-00032/00115	29-Jun-13	U-61005	61005
NYSDEC - Air Quality	610	Combustion Unit	1-4722-00032/00115	29-Jun-13	U-61006	61006
NYSDEC - Air Quality	610	Combustion Unit	1-4722-00032/00115	29-Jun-13	U-61007	61007
NYSDEC - Air Quality	610	Metal Parts Cleaning Tray	1-4722-00032/00115	29-Jun-13	U-METAL	61008
NYSDEC - Air Quality	610	Combustion Unit	1-4722-00032/00115	29-Jun-13	U-61005	6101A

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

Issuing Agency	Bldg. or Facility	Process/Permit Description	Permit ID No.	Expiration or Completion	Emission Unit ID	Source ID
NYSDEC - Air Quality	630	Gasoline Storage and Fuel Pumps	1-4722-00032/00115	29-Jun-13	U-FUELS	63001-03
NYSDEC - Air Quality	630	Parts Cleaning Tray	1-4722-00032/00115	29-Jun-13	U-METAL	630 AB
NYSDEC - Air Quality	902	Epoxy Coating/Curing Exhaust	1-4722-00032/00115	29-Jun-13	U-COILS	90206
NYSDEC - Air Quality	903	Metal Parts Cleaning Tank	1-4722-00032/00115	29-Jun-13	U-METAL	90304
NYSDEC - Air Quality	919B	Electroplating Operation	1-4722-00032/00115	29-Jun-13	U-INSIG	91904
NYSDEC - Air Quality	630	Parts Cleaning Tray	1-4722-00032/00115	29-Jun-13	U-METAL	630 AD
NYSDEC - Air Quality	922	Electroplating Operation	1-4722-00032/00115	29-Jun-13	U-INSIG	92204
NYSDEC - Air Quality	923	Electronic Equipment Cleaning	1-4722-00032/00115	29-Jun-13	U-METAL	9231A
NYSDEC - Air Quality	923	Parts Drying Oven	1-4722-00032/00115	29-Jun-13	U-METAL	9231B
NYSDEC - Air Quality	924	Magnet Coil Production Press	1-4722-00032/00115	29-Jun-13	U-INSIG	92402
NYSDEC - Air Quality	924	Vapor/Ultrasonic Degreasing Unit	1-4722-00032/00115	29-Jun-13	U-METAL	92404
NYSDEC - Air Quality	Site	Halon 1211 Portable Extinguishers	1-4722-00032/00115	29-Jun-13	U-HALON	H1211
NYSDEC - Air Quality	Site	Halon 1301 Fire Suppression Systems	1-4722-00032/00115	29-Jun-13	U-HALON	H1301
NYSDEC - Air Quality	Site	Packaged A/C Units	1-4722-00032/00115	29-Jun-13	U-RFRIG	PKG01-02
NYSDEC - Air Quality	Site	Reciprocating Chillers	1-4722-00032/00115	29-Jun-13	U-RFRIG	REC01-53
NYSDEC - Air Quality	Site	Rotary Screw Chillers	1-4722-00032/00115	29-Jun-13	U-RFRIG	ROTO1-11
NYSDEC - Air Quality	Site	Split A/C Units	1-4722-00032/00115	29-Jun-13	U-RFRIG	SPL01-02
NYSDEC - Air Quality	Site	Centrifugal Chillers	1-4722-00032/00115	29-Jun-13	U-RFRIG	CEN01-24
NYSDEC - Hazardous Waste	WMF	Waste Management	1-4722-00032/00102	19-Nov-16	NA	NA
NYSDEC - NESHAPs	REF	Radiation Effects/Neutral Beam	BNL-789-01	None	NA	NA
NYSDEC - NESHAPs	RTF	Radiation Therapy Facility	BNL-489-01	None	NA	NA
NYSDEC - Water Quality	CSF	Major Petroleum Facility	1-1700	31-Mar-12	NA	NA
NYSDEC - Water Quality	STP	STP and Recharge Basins	NY-0005835	01-Mar-10	NA	NA
NYSDEC - Water Quality	1010	Install A/C @ 1010A and 1012A	1-4722-00032/00139	30-Jun-09	NA	NA
NYSDEC - Water Quality	1004	Installation of Blockhouse	1-4722-00032/00140	29-Jan-13	NA	NA

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

operation of groundwater remediation systems under CERCLA, or as changes to the BNL Title V operating permit. During 2009, no CERCLA air equivalency permits were issued or revised.

3.2.2.2 SPDES Permits

In June 2009, NYSDEC finalized a major modification to BNL's SPDES permit. This modification was initiated in 2007 as a comprehensive review of the Laboratory's waste water treatment facility and evaluation of point source discharges from BNL operations. The modified permit seeks significant reductions in the concentration of six metals (copper, iron, lead, mercury, nickel, and zinc) discharged from BNL's wastewater treatment facility to the Peconic River. While the target effluent limits are significantly less than the former limits, an interim period is provided to allow studies to be completed to identify controllable sources of metal-bearing waste waters, evaluate alterna-

tive treatment or disposal options, and propose effluent limits attainable through these alternatives. The studies commenced in September and continued through the end of 2009. A report detailing the results of these evaluations is due to NYSDEC by July 1, 2010.

3.2.2.3 NESHAPs Authorization

In April 2009, an authorization application was submitted to EPA to construct and modify the existing stationary stack at the Brookhaven Linear Isotope Production (BLIP) facility. After the authorization was approved in August 2009, the stack was modified before the start of BLIP facility operations for 2010. The modification entailed the removal of an existing 12-inch diameter duct just after the HEPA and charcoal filtration system and the installation of a new 6-inch diameter galvanized steel duct within the building. Outside the building, an 8-inch diameter duct was installed, 10 feet away from the adjacent roof of the BLIP facility, to a total height of 39 feet above local grade (15 feet above the adjacent structure). The exit nozzle size of the duct was reduced to a 4-inch diameter to increase the exit velocity and enhance the momentum rise of the exhaust stream. The total exhaust volume is 375 cubic feet per minute. A new emission sampling system that is compliant with the ANSI N13 Standard was installed as part of the upgrade, which includes sampling for particulates, tritium, and short-lived gases. The new stack and sampling system will be operational and tested in 2010.

3.3 NEPA ASSESSMENTS

The National Environmental Policy Act (NEPA) regulations require federal agencies to evaluate the environmental effects of proposed major federal activities. The prescribed evaluation process ensures that the proper level of environmental review is performed before an irreversible commitment of resources is made.

During 2009, environmental evaluations were completed for 110 proposed projects at BNL. Of those, 98 were considered minor actions requiring no additional documentation. Eleven projects were addressed by submitting notification forms to DOE, which determined that the projects were covered by existing "Categorical Exclusions" per 10 CFR 1021, or fell within the scope of a previous environmental assessment.

Also in 2009, the Laboratory prepared an Environmental Assessment (EA) for a proposed BP solar array project on site. The evaluation of the construction and operation of this proposed facility found that there would be no significant environmental impacts. The project involves DOE granting an easement to BP Solar to construct a large-scale commercial solar photovoltaic array of approximately 37 megawatts (MW) each that would cover approximately 200 acres. Electricity generated by these arrays would be connected into the regional utility power grid. The EA analyzed the potential environmental consequences of the facility and compared them to the consequences of a No Action alternative. The assessment included detailed analysis of all potential environmental, safety, and health hazards anticipated as the design, construction, and operation of the facility progresses. The EA for the BP Solar Array Project (DOE/EA-1663), and the Finding of No Significant Impact (FONSI) are available on the BNL web site.

3.4 PRESERVATION LEGISLATION

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

BNL has three structures or sites that are eligible for listing on the National Register of Historic Places: the Brookhaven Graphite Research Reactor complex, the High Flux Beam Reactor complex, and the World War I Army training trenches associated with Camp Upton. An annual Department of Interior questionnaire regarding historic and cultural resources is prepared. Additional activities associated with historic preservation compliance are described in Chapter 6.

3.5 CLEAN AIR ACT

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

3.5.1 Conventional Air Pollutants

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

3.5.1.1 Boiler Emissions

BNL has four boilers (Nos. 1A, 5, 6, and 7) at the Central Steam Facility (CSF) that are subject to NYSDEC "Reasonably Available Control Technology" requirements. Three of the boilers can burn either residual fuel oil or natural gas; Boiler 1A burns fuel oil only. In 2009, natural gas was the predominant fuel burned at the CSF. For boilers with maximum operating heat inputs greater than or equal to 50 MMBtu/hr (14.6 MW), the requirements establish emission standards for oxides of nitrogen (NO_x). Boilers with a maximum operating heat input between 50 and 250 MMBtu/hr (14.6 and 73.2 MW) can demonstrate compliance with the NO_x standard using periodic emission tests or by using continuous emission monitoring equipment. Emission tests conducted in 1995 and again in 2006 confirmed that boilers 1A and 5, both in this size category, met the NO_x emission standards when burning residual fuel oil with low nitrogen content. To ensure continued compliance, an outside contract analytical laboratory analyzes composite samples (collected quarterly) of fuel deliveries. The analyses conducted in 2009 confirmed that the fuel-bound nitrogen content met these requirements. Compliance with the 0.30 lbs/MMBtu NO_x emission standards for boilers 6 and 7 was demonstrated by continuous emission monitoring of the flue gas. In 2009, NO_x emissions from Boilers 6 and 7 averaged 0.119 lbs/MMBtu and 0.105 lbs/MMBtu, respectively. There were no known exceedances of the NO_x emission standard for either boiler.

The Laboratory also maintains continuous opacity monitors for boilers 6 and 7. These monitors measure the transmittance of light through the exhaust gas and report this measurement in percent attenuated. Opacity limitations state that no facility may emit particulates such that the opacity exceeds 20 percent, calculated in 6-minute averages, except for one period not to exceed 27 percent in any one hour. To maintain boiler efficiency, soot that accumulates on the boiler tubes must be removed. This is accomplished by passing a mixture of high-pressure steam and air through the boiler using a series of blowers. In 2009, BNL reported one period during the first quarter, sixteen periods during the second quarter, and five periods during the fourth quarter when opacity measurements for Boiler 6 exceeded the 6-minute 20 percent average. The first twelve second-quarter excess opacity readings occurred during the initial soot blowing cycle after the boiler was brought on line while combusting natural gas. Since opacity levels began to rise immediately after the boiler came on line, it appears the combination of soot blowing and the cleansing effect of natural gas combustion was the cause of these excess readings. The remaining four excess opacity readings recorded during the second quarter were the result of dust build-up on the optical head assembly; levels dropped after the assembly was cleaned. There were no discernable causes for the excess opacity reading recorded during the first quarter and the remaining five periods in the fourth quarter. Two excess opacity readings for Boiler 7 that were recorded in February during a soot blowing cycle appear to have been isolated incidents.

3.5.1.2 Ozone-Depleting Substances

Refrigerant: The Laboratory's preventative maintenance program requires regular inspection and maintenance of refrigeration and air conditioning equipment that contains ozone-depleting substances such as R-11, R-12, and R-22. All refrigerant recovery and recycling equipment is certified to meet refrigerant evacuation levels specified by 40 CFR 82.158. As a

matter of standard practice at BNL, if a refrigerant leak is found, technicians will either immediately repair the leak or isolate it and prepare a work order for the needed repairs. This practice exceeds the leak repair provisions of 40 CFR 82.156. In 2009, one pound of R-12, 2.3 pounds of R-115, 100 pounds of R-22, and approximately 200 pounds of R-134a were recovered and recycled from refrigeration equipment that was serviced.

Halon: Halon 1211 and 1301 are extremely efficient fire suppressants, but are being phased out due to their effect on the earth's ozone layer. In 1998, the Laboratory purchased equipment to comply with the halon recovery and recycling requirements of the CAA, 40 CFR 82 Subpart H. When portable fire extinguishers or fixed systems are removed from service and when halon cylinders are periodically tested, BNL technicians use halon recovery and recycling devices to comply with CAA provisions. In 2009, eight tanks containing 1,036 pounds of Halon 1301 associated with fixed fire suppression systems were declared excess property because the mission-critical or mission-essential equipment and facilities they protected from damage or loss due to fire have been removed or shut down. Two cylinders containing 94 pounds of Halon 1211 previously used to recharge Halon 1211 portable extinguishers and six 17-pound Halon 1211 extinguishers were also declared excess property and transferred to a storage trailer adjacent to the fire house. The portable extinguishers became excess property due to changes in operations or when they were replaced by ABC dry-chemical or clean agent FE-36 extinguishers. In 2010, the Halon 1301 tanks, Halon 1211 cylinders, and the portable extinguishers will be transferred to the Department of Defense ODS Reserve in accordance with the Class I Ozone Depleting Substances Disposition Guidelines prepared by the DOE Office of Environmental Policy and Guidance.

3.5.2 Hazardous Air Pollutants

In 1970, the CAA established standards to protect the general public from hazardous air pollutants that may lead to death or an increase in irreversible or incapacitating illnesses. The NESHAPs program was established in 1977 and the governing regulations were updated significantly in 1990. EPA developed NESHAPs to limit the emission of 189 toxic air pollutants. The program includes a list of regulated contaminants, a schedule for implementing control requirements, aggressive technology-based emission standards, industry-specific requirements, special permitting provisions, and a program to address accidental releases. The following subsections describe BNL's compliance with NESHAPs regulations.

3.5.2.1 Maximum Available Control Technology

In 2009, the Laboratory determined that Maximum Available Control Technology (MACT) standard 40 CFR 63 Subpart H NESHAPs for Paint Stripping and Miscellaneous Surface Coating Operations at Area Sources would be applicable to BNL's paint spray operations. This rule establishes best management requirements for spray coating operations that are intended to minimize volatile organic compound (VOC) emissions associated with preparation, application of coatings, and with the clean-up of spray coating equipment. An initial notice of applicability was subsequently transmitted to the NYSDEC office in Albany on January 7, 2010. Compliance with the best management practice requirements for surface coating operations is documented via the submittal of a notice of compliance to NYSDEC on or before January 11, 2011. The notice of compliance must include a description of how the Laboratory complied with each of the best management practices.

3.5.2.2 Asbestos

In 2009, the Laboratory notified the EPA Region II office regarding removal of materials containing asbestos. During the year, 4,640 linear feet of pipe insulation, 2,032 square feet of floor tile and roofing material, 23,254 square feet of siding material, and 128 cubic yards of asbestos-containing debris were removed and disposed of according to EPA requirements. In addition, during site preparation for construction of the National Synchrotron Light Source II, approximately 5,000 lineal feet of transite piping

were removed and disposed of by the construction contractor.

3.5.2.3 Radioactive Airborne Emissions

Emissions of radiological contaminants are evaluated and, if necessary, monitored to ensure that they do not impact the environment or people working or residing at or near the Laboratory. A full description of radiological emissions monitoring conducted in 2009 is provided in Chapter 4. BNL transmitted all data pertaining to radioactive air emissions and dose calculations to EPA in fulfillment of the June 30 annual reporting requirement. As in past years, the maximum off-site dose due to airborne radioactive emissions from the Laboratory continued to be far below the 10 mrem (100 μSv) annual dose limit specified in 40 CFR 61 Subpart H (see Chapters 4 and 8 for more information on the estimated air dose). Using EPA modeling software, the dose to the hypothetical maximally exposed individual resulting from BNL's airborne emissions was 0.072 mrem (0.72 μSv) in 2009.

3.6 CLEAN WATER ACT

The disposal of wastewater generated by Laboratory operations is regulated under the Clean Water Act (CWA) as implemented by NYSDEC and under DOE Order 5400.5, Radiation Protection of the Public and the Environment. The goals of the CWA are to achieve a level of water quality that promotes the propagation of fish, shellfish, and wildlife; to provide waters suitable for recreational purposes; and to eliminate the discharge of pollutants into surface waters. New York State was delegated CWA authority in 1975. NYSDEC has issued a SPDES permit to regulate wastewater effluents at the Laboratory. The permit was renewed in May 2005 and significantly modified in June 2009. The permit specifies monitoring requirements and effluent limits for nine of 12 outfalls, as described below. See Figure 5-7 in Chapter 5 for the locations of BNL outfalls.

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

Each month, the Laboratory prepares Discharge Monitoring Reports that describe monitoring results, evaluate compliance with permit limitations, and identify corrective measures taken to address permit excursions. These reports are submitted to the NYSDEC central and regional offices and the Suffolk County Department of Health Services (SCDHS). Details of the monitoring program conducted for the groundwater treatment systems and of SPDES equivalency permit performance are provided in SER Volume II, Groundwater Status Report.

The modifications to the BNL SPDES permit finalized in June 2009 require that BNL perform several additional studies in order to characterize contributing sources of wastewater to the BNL STP and recharge basins. These studies include a Short-Term Monitoring Program to monitor waste waters discharged to BNL's permitted outfalls for specific contaminants identified by NYSDEC during the permit review, a Quantification and Removal Study to identify and quantify controllable sources of metals being discharged to the BNL STP, and a Mercury Minimization Program to document past and proposed practices to reduce potential sources of mercury to the STP. Work commenced in September 2009 and continued through the end of the year.

3.6.1 Sewage Treatment Plant

Sanitary and process wastewater generated by BNL operations is conveyed to the STP for

processing before discharge to the Peconic River. The STP provides tertiary treatment of the wastewater and includes the following processes: settling/sedimentation, biological reduction of organic matter and nitrogen, sand filtration, and UV disinfection. Chapter 5 provides a detailed description of the treatment process.

A summary of SPDES monitoring results for the STP discharge at Outfall 001 is provided in Table 3-3. The relevant SPDES permit limits are also shown. The Laboratory monitors the STP discharge for more than 100 parameters monthly and more than 200 parameters quarterly. BNL's overall compliance with effluent limits was greater than 99 percent in 2009. One excursion of the SPDES permit limit for total iron occurred in May. The concentration in the wastewater effluent sample was measured at 0.39 mg/L, just slightly above the SPDES limit of 0.37 mg/L. All other parameters were within permit limits.

The cause of the increased iron concentration was investigated and historical data evaluated to determine if there were any trends associated with this observation. The most probable cause for the increased concentration of iron was the accumulation of sediment and iron oxide (rust) on the exterior of the sample collection probe. The sample collection team has been reminded to check the collection probe periodically for accumulation of sediment on the probe to prevent future recurrence of the problem.

In follow-up to prior excursions for nitrogen, in March 2008 BNL started adding cafeteria waste as a supplemental food source to support bacterial populations within the treatment process necessary to provide waste denitrification. Since the addition of this alternative food source, all nitrogen values have been within SPDES permit limits. BNL continues to add waste cafeteria food scraps to the STP process daily.

Figures 3-1 through 3-7 plot the 5-year trends for the monthly concentrations of copper, iron, lead, mercury, nickel, silver, and zinc in the STP discharge.

3.6.1.1 Chronic Toxicity Testing

The Laboratory's SPDES permit requires that "whole effluent toxicity" (WET) tests be conducted to ensure that chemicals present in the STP effluent are not toxic to aquatic organisms. BNL continued to perform quarterly chronic toxicity testing using water fleas (*Ceriodaphnia*

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

Analyte	Low Report	High Report	Min. Monitoring. Freq.	SPDES Limit	Exceedances	% Compliance*
Max. temperature (°F)	43	81	Daily	90	0	100
pH (SU)	6.2	8.0	Continuous Recorder	Min 5.8, Max. 9.0	0	100
Avg. 5-Day BOD (mg/L)	<2	<2	Twice Monthly	10	0	100
Max. 5-Day BOD (mg/L)	<2	<2	Twice Monthly	5 (b)	0	100
% BOD Removal	86	96	Monthly	85	0	100
Avg. TSS (mg/L)	<0.6	<1.1	Twice Monthly	10	0	100
Max. TSS (mg/L)	<0.6	1.4	Twice Monthly	20	0	100
% TSS Removal	93	99	Monthly	85	0	100
Settleable solids (ml/L)	0	0	Daily	0.1	0	100
Ammonia nitrogen (mg/L)	< 0.1	0.35	Twice Monthly	1.5 (c)	0	100
Total nitrogen (mg/L)	0.48	9.27	Twice Monthly	10	0	100
Total nitrogen (lbs./day)	10	17	(May – October)	20 (e)	0	100
Total phosphorus (mg/L)	0.23	1.64	Twice Monthly	NA	0	100
Cyanide (mcg/L)	< 1.5	2.6	Twice Monthly	100	0	100
Copper (mg/L)	< 0.003	0.132	Twice Monthly	0.15	0	100
Iron (mg/L)	0.099	0.388 (a)	Twice Monthly	0.37	1	96

(continued on next page)

Table 3-3. Analytical Results for Wastewater Discharges to Sewage Treatment Plant Outfall 001 *(concluded).*

Analyte	Low Report	High Report	Min. Monitoring. Freq.	SPDES Limit	Exceedances	% Compliance*
Lead (mg/L)	0.001	0.005	Twice Monthly	0.019	0	100
Mercury (ng/L)	53	104	Twice Monthly	200 (d)	0	100
Methylene chloride (ug/L)	< 2	< 2	Twice Monthly	5	0	100
Nickel (mg/L)	0.002	0.015	Twice Monthly	0.11	0	100
Silver (mg/L)	< 0.001	0.003	Twice Monthly	0.015	0	100
Toluene (ug/L)	< 1	< 1	Twice Monthly	5	0	100
Zinc (mg/L)	0.006	0.126	Twice Monthly	0.1	0	100
1,1,1-trichloroethane (ug/L)	< 1	< 1	Twice Monthly	5	0	100
2-butanone (ug/L)	< 5	< 5	Twice Monthly	50	0	100
PCBs (ug/L)	< 0.5	< 0.5	Quarterly	NA	0	100
Max. Flow (MGD)	0.29	0.79	Continuous Recorder	2.3	0	100
Avg. Flow (MGD)	0.21	0.33	Continuous Recorder	NA	0	100
Avg. Fecal Coliform (MPN/100 ml)	<2	81	Twice Monthly	200	0	100
Max. Fecal Coliform (MPN/100 ml)	<2	240	Twice Monthly	400	0	100
HEDP (mg/L)	<0.05	<0.05	Monthly	NA (e)	0	100
Tolytriazole (mg/L)	<0.005	<0.005	Monthly	NA (e)	0	100

Notes:
See Chapter 5, Figure 5-6, for location of Outfall 001.
* % Compliance = total no. samples – total no. exceedances/total no. of samples x 100
BOD = Biological Oxygen Demand
HEDP = 1-Hydroxyethylidene
MGD = Million Gallons per Day
MPN = Most Probable Number
NA = Not Applicable
SPDES = State Pollutant Discharge Elimination System
SU = Standard Unit
TSS = Total Suspended Solids

(a) One permit exceedance of the total iron limit was reported in May 2009. See Section 3.6.1 for explanation of this permit exceedance.
(b) Permit limit for maximum 5-day BOD was changed from 20 to 5.0 mg/L in July 2009.
(c) Permit limit for ammonia nitrogen was changed from 2.0 to 1.5 mg/L in July 2009.
(d) Permit limit for mercury was changed from 800 to 200 ng/L in July 2009.
(e) These analytes and associated SPDES limits were added to the SPDES permit in July 2009.

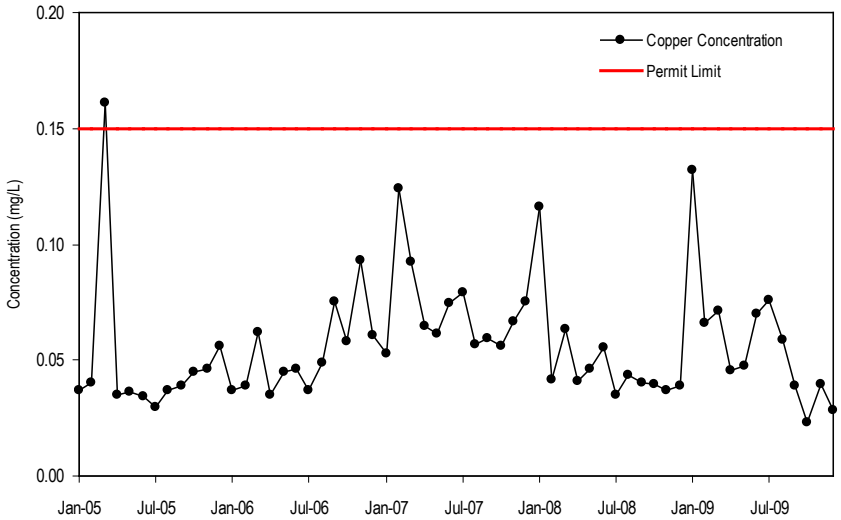


Figure 3-1. Maximum Concentrations of Copper Discharged from the BNL Sewage Treatment Plant, 2005–2009.

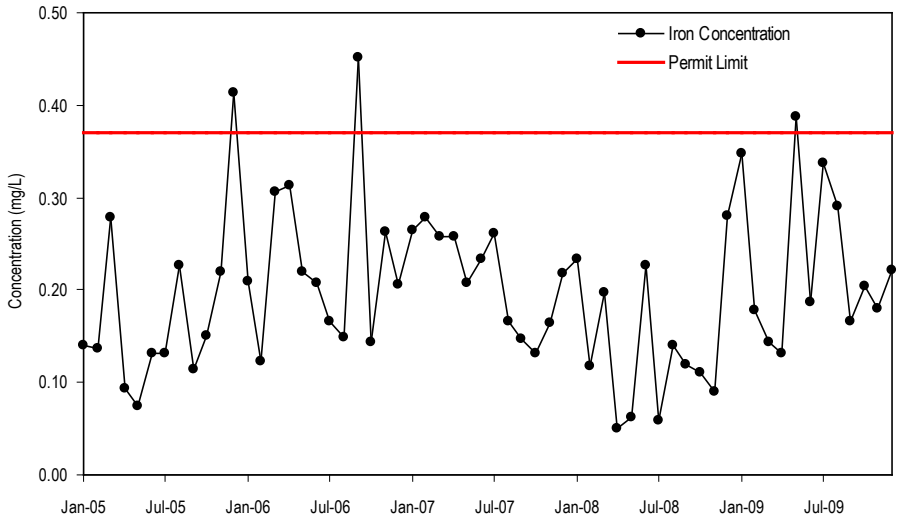


Figure 3-2. Maximum Concentrations of Iron Discharged from the BNL Sewage Treatment Plant, 2005–2009.

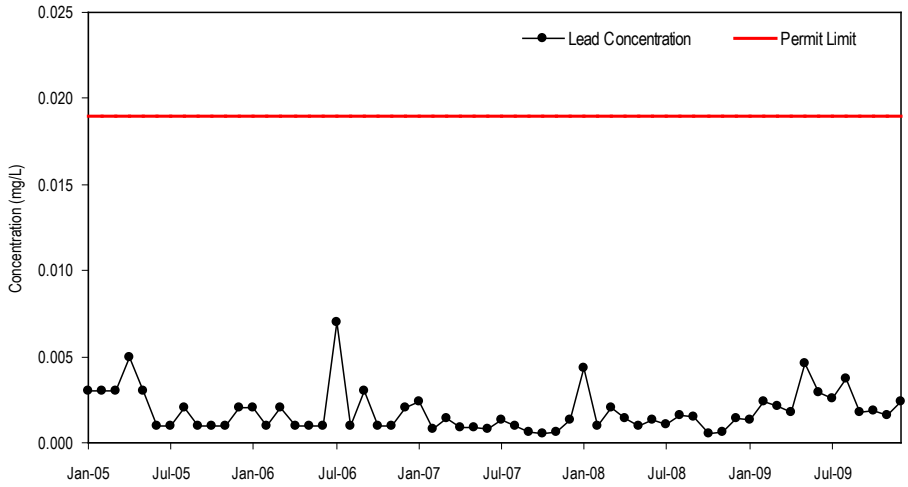


Figure 3-3. Maximum Concentrations of Lead Discharged from the BNL Sewage Treatment Plant, 2005–2009.

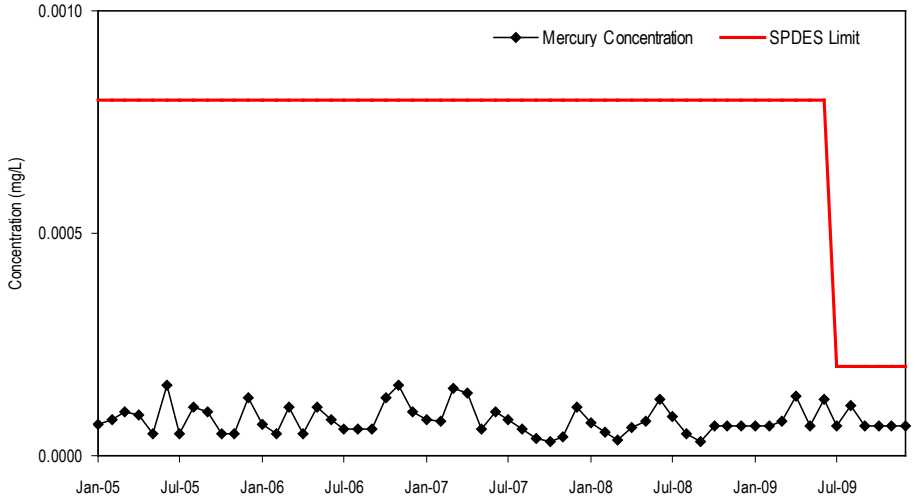


Figure 3-4. Maximum Concentrations of Mercury Discharged from the BNL Sewage Treatment Plant, 2005–2009.

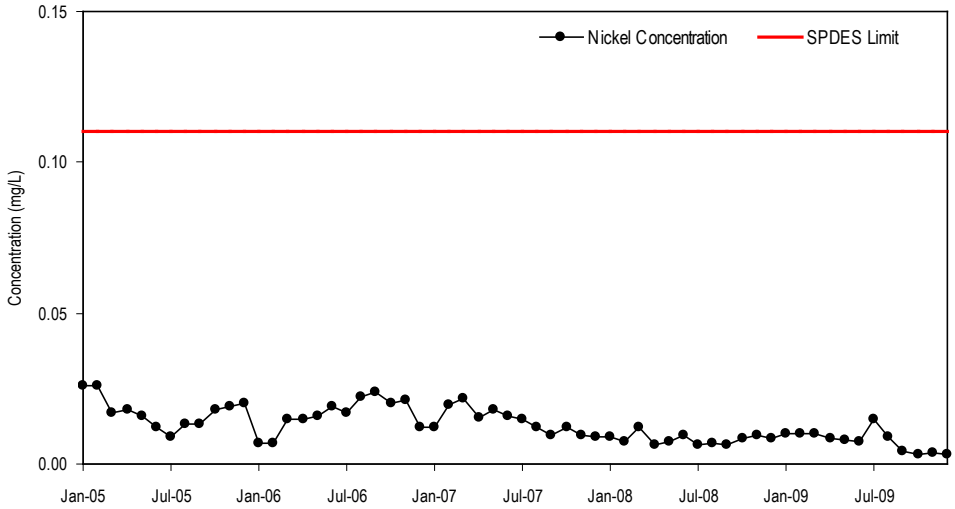


Figure 3-5. Maximum Concentrations of Nickel Discharged from the BNL Sewage Treatment Plant, 2005–2009.

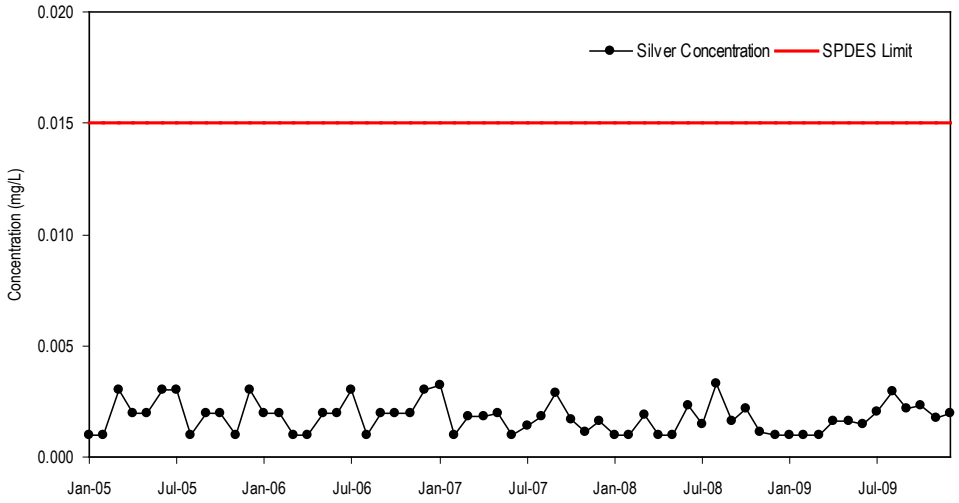
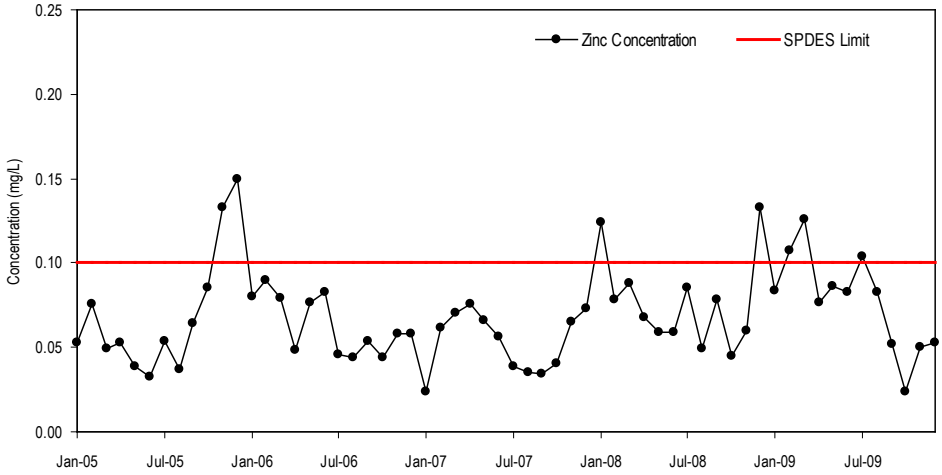


Figure 3-6. Maximum Concentrations of Silver Discharged from the BNL Sewage Treatment Plant, 2005–2009.



Note: Per New York State Department of Environmental Conservation guidance, the concentrations of zinc exhibited in the effluent during November 2005 and January and December 2008 were not considered in violation of the State Pollutant Discharge Elimination System effluent limit of 0.1 mg/L, due to rounding off of significant figures.

Figure 3-7. Maximum Concentrations of Zinc Discharged from the BNL Sewage Treatment Plant, 2005–2009.

dubia) in 2009. Under the WET testing provisions, samples are collected and tested quarterly. In each test, sets of 10 organisms are exposed to varying concentrations of the STP effluent (100, 75, 50, 25, and 12.5 percent) for 7 days. During testing, the rate of reproduction for the water flea is measured and compared to untreated organisms (i.e., controls). The test results are submitted to NYSDEC for review.

Testing in 2009 showed that during one test period in June, the rate of reproduction in the water flea was "significantly different" (less) than the controls. During the test, water fleas in the control had an average reproduction rate of 18.9 neonates per adult, whereas the water fleas in the pure effluent only had 14.9. The exact cause of the decreased reproduction rate was not evident based on chemical analysis of the wastewater. Comparison of the statistics with past tests showed that differences greater than 4 neonates were not significant. During past tests, the cause for reduced water flea reproduction rates has been linked to water hardness and alkalinity levels; consequently, the alkalinity and hardness of the dilution water used in the tests is adjusted to mimic that of the Peconic River. Tests performed in March, September, and December showed no impact on the organisms. Because the observed impacts in the June test were minor and all other tests showed no impact, no further toxicity reduction evaluation was required. Under the terms of the modified SPDES permit, testing is required throughout the term of the permit; consequently, testing will continue in 2010.

3.6.2 Recharge Basins and Stormwater

Water discharged to Outfalls 002 through 008 and Outfalls 010 through 012 recharges to groundwater, replenishing the underlying aquifer. Monitoring requirements for each of these discharges vary, depending on the type of wastewater received and the type of cooling water treatment reagents used. Table 3-4 summarizes the monitoring requirements and performance results for 2009. Review of the data shows that with the exception of a single excursion for tolytriazole in Outfall 006B, all discharges were in full compliance with SPDES requirements. In March, routine monitoring of the discharge to Outfall 006B showed the tolytriazole concentration of the discharge to be 1.5 mg/L, which exceeded the permit limit of 0.2 mg/L. Investigation into the cause of the noncompliant discharge showed the source to be an overdose

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

Analyte		Outfall 002	Outfall 002B	Outfall 005	Outfall 006A	Outfall 006B	Outfall 007	Outfall 008	Outfall 010	SPDES Limit	No. of Exceedances	% Compliance*
Flow (MGD)	N	CR	CR	CR	CR	CR	CR	CR	CR			
	Min.	0.03	0.008	0.11	0.08	0.008	0.12	0.0007	0.009	NA		
	Max.	1.2	0.09	0.59	0.27	0.17	0.32	0.93	1.91	NA	NA	NA
pH (SU)	Min.	6.9	6.1	6.4	6.9	7.4	6.6	6.8	6.9	NA		
	Max.	8.1	8.6	8.4	8.8	8.5	8.9	8.4	8.3	8.5, 9.0 (a)	0	100
Oil and grease (mg/L)	N	12	12	12	12	12	NR	8	8			
	Min.	< 1.4	1.4	1.4	1.8	< 1.4	NR	1.8	1.7	NA		
	Max.	6.7	6.2	7.0	7.0	6.0	NR	5.2	5.1	15	0	100
Copper (mg/L)	N	NR	NR	4	NR	NR	NR	NR	4			
	Min.	NR	NR	< 0.003 (T)	NR	NR	NR	NR	< 0.003 (D)	NA		
	Max.	NR	NR	0.004	NR	NR	NR	NR	0.09 (D)	1.0	0	100
Aluminum (mg/L)	N	4	NR	NR	NR	NR	NR	4	4			
	Min.	< 0.07 (T)	NR	NR	NR	NR	NR	0.09 (D)	< 0.07 (D)	NA		
	Max	0.07	NR	NR	NR	NR	NR	0.6 (D)	0.1 (D)	2.0	0	100

(continued on next page)

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

Analyte		Outfall 002	Outfall 002B	Outfall 005	Outfall 006A	Outfall 006B	Outfall 007	Outfall 008	Outfall 010	SPDES Limit	No. of Exceedances	% Compliance*
Lead, Dissolved (mg/L)	N	NR	NR	NR	NR	NR	NR	NR	4			
	Min.	NR	NR	NR	NR	NR	NR	NR	< 0.0005	NA		
	Max	NR	NR	NR	NR	NR	NR	NR	0.0006	0.05	0	100
Vanadium, Dissolved (mg/L)	N	NR	NR	NR	NR	NR	NR	NR	4			
	Min.	NR	NR	NR	NR	NR	NR	NR	0.002	NA		
	Max	NR	NR	NR	NR	NR	NR	NR	0.006	NPL	NA	NA
Chloroform (mg/L)	N	4	NR	NR	NR	NR	NR	NR	NR			
	Min.	0.6	NR	NR	NR	NR	NR	NR	NR	NA		
	Max.	1.6	NR	NR	NR	NR	NR	NR	NR	7	0	100
Bromodichloromethane (µg/L)	N	4	NR	NR	NR	NR	NR	NR	NR			
	Min.	1.0	NR	NR	NR	NR	NR	NR	NR	NA		
	Max.	3.9	NR	NR	NR	NR	NR	NR	NR	50	0	100
1,1,1-trichloroethane (mg/L)	N	4	NR	NR	NR	NR	NR	8	NR			
	Min.	< 1	NR	NR	NR	NR	NR	< 1	NR	NA		
	Max.	< 1	NR	NR	NR	NR	NR	< 1	NR	5	0	100
1,1-dicloroethylene (mg/L)	N	NR	NR	NR	NR	NR	NR	8	NR			
	Min.	NR	NR	NR	NR	NR	NR	< 1	NR	NA		
	Max.	NR	NR	NR	NR	NR	NR	< 1	NR	5	0	100
Hydroxyethylidene-diphosphonic acid (mg/L)	N	4	4	4	4	4	NR	NR	NR			
	Min.	<0.05	<0.05	<0.05	<0.05	<0.05	NR	NR	NR	NA		
	Max.	<0.05	0.1	<0.05	<0.05	<0.05	NR	NR	NR	0.5	0	100
Tolyltriazole (mg/L)	N	4	4	4	4	4	NR	NR	NR			
	Min.	<0.005	<0.005	<0.005	<0.005	<0.005	NR	NR	NR	NA		
	Max.	<0.005	<0.005	<0.005	<0.005	1.5	NR	NR	NR	0.2 (b)	1	95

Notes:
See Chapter 5, Figure 5-6, for location of outfalls.
There are no monitoring requirements for Outfalls 009, 011, and 012.
* % Compliance = total no. samples – total no. exceedances/total no. of samples x 100
CR = Continuous Recorder
D = Dissolved
MGD = Million Gallons per Day
Max. = Maximum value
Min. = Minimum value
N = Number of samples

NA = Not Applicable
NPL = No permit limit, monitoring only
NR = Analysis Not Required
SU = Standard Unit
T = Total Recoverable
(a) pH limit is 8.5 for Outfalls 005, 008, and 010 and pH limit is 9.0 for Outfalls 002, 002B, 006A, 006B, and 007. There was a single pH excursion at Outfall 002B in August 2008.
(b) There was a single tolytriazole excursion in March 2009.

of corrosion control agent to the cooling tower located at Building 919, which was not adequately monitored by the Ashland Chemical technician responsible for maintaining these systems. The overdose, in combination with low once-through cooling water and stormwater discharges, resulted in the higher effluent concentration. Ashland Chemical has committed to reviewing all changes to chemical dosing closely to ensure future discharges remain within permit limits. In addition, in coordination with the Collider Accelerator Department, Ashland Chemical is evaluating replacing the products used, to eliminate tolytriazole from the cooling tower formulations.

3.7 SAFE DRINKING WATER ACT

The extraction and distribution of drinking water is regulated under the federal Safe Drinking Water Act (SDWA). In New York State, implementation of the SDWA is delegated to the New York State Department of Health (NYSDOH) and administered locally by SCDHS. Because BNL provides potable water to more than 25 full-time residents, it is subject to the same requirements as a municipal water supplier. Monitoring requirements are prescribed annually by SCDHS, and a Potable Water Sampling and Analysis Plan (Chaloupka 2009) is prepared by BNL to comply with these requirements.

3.7.1 Potable Water

The Laboratory maintains six water supply wells for on-site distribution of potable water. As required by NYSDOH regulations, BNL monitors the potable wells regularly for bacteria, inorganics, organics, and pesticides. The Laboratory also voluntarily monitors drinking water supplies for radiological contaminants yearly. Tables 3-5 and 3-6 provide potable water supply monitoring data. In 2009, only iron and color exceeded New York State Drinking Water Standards (NYS DWS) in samples collected from three of the wells (wells 4, 6, and 7) before distribution. Groundwater from these three wells is treated to reduce naturally occurring iron and reduce the color index of the water. Treatment at BNL's Water Treatment Plant effectively reduces these levels to below NYS DWS limits. To ensure that the Laboratory's water supply continually meets NYS DWS, groundwater is also treated with air stripping to remove VOCs. At the point of consumption, drinking water complied with all NYS DWS during 2009. In addition to the compliance sampling program, all wells are also sampled and analyzed quarterly under the BNL environmental surveillance program. Data collected under this program are consistent with the data reported in Tables 3-5 and 3-6. This additional testing goes beyond the minimum SDWA testing requirements.

In 2009, BNL continued its investigation into the cause of the explosion of Wellhouse 12 that occurred in October 2008. As discussed in the 2008 Site Environmental Report, a leak of propane from the auxiliary drive for the well supplied the fuel for the explosion. The cause of the leak was determined to be the propane solenoid valve that accidentally became energized during a maintenance procedure. There were no personnel present during the explosion; consequently, there were no injuries. Environmental impacts from the explosion were negligible, and there were no impacts to the well or groundwater. Well 12, however, remained out of service in 2009. Plans are to replace the wellhouse enclosure in 2011.

To ensure that BNL drinking-water consumers are informed about the quality of Laboratory-produced potable water, BNL annually publishes a Consumer Confidence Report (CCR) by the end of May, a deadline required by the SDWA. This report provides information regarding BNL's source water, supply system, the analytical tests conducted, and the detected contaminants as compared to federal drinking water standards. The CCR also describes the measures the Laboratory takes to protect its water source and limit consumer exposure to contaminants. The CCR is distributed as a special edition of the Laboratory's weekly newsletter to all BNL employees and on-site residents, and is also available electronically at http://www.bnl.gov/bnlweb/pubaf/water/reports.htm and http://www.bnl.gov/bnlweb/pubaf/bulletin.asp.

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

Compound	Well No. 4	Well No. 6	Well No. 7	Well No. 10	Well No. 11	Well No. 12	Potable Distribution Sample	NYS DWS
Water Quality Indicators								
Ammonia (mg/L)	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	NS	< 0.10	SNS
Chlorides (mg/L)	44	30	33	30	33	NS	34	250
Color (units)	< 5	< 5	< 5	< 5	< 5	NS	< 5	15
Conductivity (μmhos/cm)	143	148	154	226	212	NS	280	SNS
Cyanide (μg/L)	< 20	< 20	< 20	< 20	< 20	NS	< 10	SNS
MBAS (mg/L)	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	NS	< 0.04	SNS
Nitrates (mg/L)	< 0.5	< 0.5	< 0.5	0.7	0.7	NS	0.7	10
Nitrites (mg/L)	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	NS	< 0.10	1.0
Odor (units)	0	0	0	0	0	NS	0	3
pH (Standard Units)	5.0	5.6	5.3	5.7	5.3	NS	7.5	SNS
Sulfates (mg/L)	9	10	11	9.5	10	NS	12.1	250
Total coliform	ND	ND	ND	ND	ND	NS	1***	Negative
Metals								
Antimony (μg/L)	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	NS	0.18	6.0
Arsenic (μg/L)	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	NS	< 5.0	50
Barium (mg/L)	0.038	0.023	0.022	0.029	0.027	NS	0.031	2.0
Beryllium (μg/L)	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	NS	< 1.0	4.0
Cadmium (μg/L)	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	NS	< 1.0	5.0
Chromium (mg/L)	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	NS	< 0.005	0.1
Fluoride (mg/L)	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	NS	< 0.2	2.2
Iron (mg/L)	1.1*	2.8*	2.1*	0.01	< 0.01	NS	0.085	0.3
Lead (μg/L)	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	NS	< 1.0	15
Manganese (mg/L)	0.25	0.08	0.07	< 0.01	< 0.01	NS	0.01	0.3
Mercury (μg/L)	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	NS	< 0.25	2.0
Nickel (mg/L)	< 0.01	0.05	< 0.01	< 0.01	< 0.01	NS	< 0.01	SNS
Selenium (μg/L)	< 2.00	< 2.00	< 2.00	< 2.00	< 2.00	NS	< 0.7	50.0
Sodium (mg/L)	24	17	18	17	20	NS	37	SNS

(continued on next page)

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

Compound	Well No. 4	Well No. 6	Well No. 7	Well No. 10	Well No. 11	Well No. 12	Potable Distribution Sample	NYS DWS
Silver (μg/L)	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	NS	< 0.1	100
Thallium (μg/L)	< 2	< 2	< 2	< 2	< 2	NS	< 2	2.0
Zinc (mg/L)	0.03	0.02	0.02	0.02	0.01	NS	0.02	5.0
Radioactivity								
Gross alpha activity (pCi/L)	< 1.85	2.28 ± 0.8	< 1.77	< 2.61	< 1.52	NS	NR	15.0
Gross beta activity (pCi/L)	3.61 ± 1.28	< 1.77	2.03 ± 1.1	< 3.64	2.18 ± 1.07	NS	NR	(a)
Radium-228 (pCi/L)	1.85	< 1.96	< 1.43	1.36	< 1.35	NS	NR	5.0
Strontium-90 (pCi/L)	< 0.55	< 0.61	< 0.55	< 0.61	< 0.59	NS	NR	8.0
Tritium (pCi/L)	< 297	< 320	< 320	< 320	< 320	NS	NR	20,000
Other								
Alkalinity (mg/L)	18	18	20	42	26	NS	54	SNS
Asbestos (M. fibers/L)	NR	NR	NR	NR	NR	NR	< 0.15	7
Calcium (mg/L)	5.5	5.3	5.8	9.8	7.1	NS	13	SNS
HAA5 (mg/L)	NR	NR	NR	NR	NR	NR	0.003	0.06**
Residual chlorine - MRDL (mg/L)	NR	NR	NR	NR	NR	NR	0.6	4.0
TTHM (mg/L)	NR	NR	NR	NR	NR	NR	0.013	0.08**

Notes:
See Figure 7-3 for well locations.
HAA5 = Five Haloacetic Acids
MBAS = Methylene Blue Active Substances
MRDL = Maximum Residual Disinfectant Level
ND = Not Detected
NR = Analysis Not Required
NYS DWS = New York State Drinking Water Standard
SNS = Drinking Water Standard Not Specified
TTHM = Total Trihalomethanes

* Water from these wells is treated at the Water Treatment Plant for color and iron reduction prior to site distribution.
** Limit imposed on distribution samples only.
*** A single sample tested positive for coliform. Upon retesting, all samples were negative.
(a) The drinking water standard was changed from 50 pCi/L (concentration based) to 4 mrem/yr (dose based) in late 2003. Gross beta activity does not identify specific radionuclides; therefore, a dose equivalent cannot be calculated. No specific nuclides were detected; therefore, compliance with the requirement is demonstrated.

3.7.2 Cross-Connection Control

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

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

Compound	WTP Effluent	Well No. 4	Well No. 6	Well No. 7	Well No. 10	Well No. 11	Well No. 12	NYS DWS
	µg/L							
Dichlorodifluoromethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
Chloromethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
Vinyl Chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	2
Bromomethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
Chloroethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
Trichlorofluoromethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
1,1-dichloroethene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
Methylene Chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
trans-1,2-dichloroethene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
1,1-dichloroethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
cis-1,2-dichloroethene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
2,2-dichloropropane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
Bromochloromethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
1,1,1-trichloroethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
Carbon Tetrachloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
1,1-dichloropropene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
1,2-dichloroethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
Trichloroethene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
1,2-dichloropropane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
Dibromomethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
trans-1,3-dichloropropene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
cis-1,3-dichloropropene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
1,1,2-trichloroethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
1,3-dichloropropane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
Chlorobenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
1,1,1,2-tetrachloroethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
Bromobenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
1,2,3-trichloropropane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
2-chlorotoluene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
4-chlorotoluene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
1,3-dichlorobenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
1,4-dichlorobenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
1,2-dichlorobenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
1,2,4-trichlorobenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
Hexachlorobutadiene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
Tetrachloroethene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
1,1,2,2-Tetrachloroethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
1,2,3-trichlorobenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
Benzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5

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

Compound	WTP Effluent	Well No. 4	Well No. 6	Well No. 7	Well No. 10	Well No. 11	Well No. 12	NYS DWS
	µg/L							
Toluene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
Ethylbenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
m,p-xylene	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	NR	5
o-xylene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
Styrene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
Isopropylbenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
n-propylbenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
1,3,5-trimethylbenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
tert-butylbenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
1,2,4-trimethylbenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
sec-butylbenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
4-Isopropyltoluene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
n-butylbenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	5
Chloroform	2.7	12	17.0	0.7	1.1	< 0.5	NR	50
Bromodichloromethane	3.3	5	1.4	< 0.5	0.9	< 0.5	NR	50
Dibromochloromethane	< 0.5	3.6	< 0.5	< 0.5	1	< 0.5	NR	50
Bromoform	0.5	1.1	< 0.5	< 0.5	0.7	< 0.5	NR	50
Methyl tert-butyl ether	< 0.5	< 0.5	< 0.5	0.6	< 0.5	< 0.5	NR	50
Lindane	NR	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	NR	0.2
Heptachlor	NR	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	NR	0.4
Aldrin	NR	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	NR	5
Heptachlor Epoxide	NR	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	NR	0.2
Dieldrin	NR	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	NR	5
Endrin	NR	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	NR	0.2
Methoxychlor	NR	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	NR	40
Toxaphene	NR	< 1	< 1	< 1	< 1	< 1	NR	3
Chlordane	NR	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	NR	2
Total PCB's	NR	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	NR	0.5
2,4,5,-TP (Silvex)	NR	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	NR	10
Dinoseb	NR	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	NR	50
Dalapon	NR	< 1	< 1	< 1	< 1	< 1	NR	50
Picloram	NR	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	NR	50
Dicamba	NR	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	NR	50
Pentachlorophenol	NR	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	NR	1
Hexachlorocyclopentadiene	NR	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	NR	5
Bis(2-ethylhexyl)Phthalate	NR	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	NR	50
Bis(2-ethylhexyl)Adipate	NR	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	NR	50
Hexachlorobenzene	NR	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	NR	5

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

Compound	WTP Effluent	Well No. 4	Well No. 6	Well No. 7	Well No. 10	Well No. 11	Well No. 12	NYS DWS
	µg/L							
Benzo(A)Pyrene	NR	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	NR	50
Aldicarb Sulfone	NR	< 1	< 1	< 1	< 1	< 1	NR	SNS
Aldicarb Sulfoxide	NR	< 1	< 1	< 1	< 1	< 1	NR	SNS
Aldicarb	NR	< 1	< 1	< 1	< 1	< 1	NR	SNS
Oxamyl	NR	< 1	< 1	< 1	< 1	< 1	NR	50
3-Hydroxycarbofuran	NR	< 1	< 1	< 1	< 1	< 1	NR	50
Carbofuran	NR	< 1	< 1	< 1	< 1	< 1	NR	40
Carbaryl	NR	< 1	< 1	< 1	< 1	< 1	NR	50
Methomyl	NR	< 1	< 1	< 1	< 1	< 1	NR	50
Glyphosate	NR	< 6	< 6	< 6	< 6	< 6	NR	50
Diquat	NR	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	NR	50
1,2-dibromoethane (EDB)	NR	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	NR	0.05
1,2-dibromo-3-chloropropane	NR	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	NR	0.2
2,4,-D	NR	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	NR	50
Alachlor	NR	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	NR	2
Simazine	NR	< 0.07	< 0.07	< 0.07	< 0.07	< 0.07	NR	50
Atrazine	NR	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	NR	3
Metolachlor	NR	< 0.75	< 0.75	< 0.75	< 0.75	< 0.75	NR	50
Metribuzin	NR	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	NR	50
Butachlor	NR	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	NR	50
Endothall	NR	< 9	< 9	< 9	< 9	< 9	NR	100
Propachlor	NR	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NR	50

Notes:
See Chapter 7, Figure 7-3, for well locations.
For compliance determination with New York State Department of Health standards, potable water samples were analyzed quarterly for Principal Organic Compounds and annually for other organics by H2M Labs Inc., a New York State-certified contractor laboratory.
The minimum detection limits for principal organic compound analytes are 0.5 mg/L. Minimum detection limits for synthetic organic chemicals and micro-extractables are compound-specific, and, in all cases, are less than the New York State Department of Health drinking water standard.

NA = Not available
NR = Analysis Not Required
SNS = Drinking Water Standard Not Specified
NYS DWS = New York State Drinking Water Standard
WTP = Water Treatment Plant

The Laboratory maintains approximately 200 cross-connection control devices, including primary devices installed at interfaces to the potable water main, and secondary control devices at the point of use. In 2009, 190 cross-connection control units were tested at BNL, including primary and secondary devices. If a problem with a cross-connection device is encountered during testing, the device is repaired and retested to ensure proper function. Copies of the cross-connection device test reports are filed with SCDHS annually.

3.7.3 Underground Injection Control

Underground Injection Control (UIC) wells are regulated under the SDWA. At the Laboratory, UICs include drywells, cesspools, septic tanks, and leaching pools, all of which are classified by EPA as Class V injection wells. Proper management of UIC devices is vital for protecting underground sources of drinking water. In New York State, the UIC program is implemented through EPA because NYSDEC has not adopted UIC regulatory requirements. (Note: New York State regulates the discharges

of pollutants to cesspools under the SPDES program.) Under EPA's UIC program, all Class V injection wells must be included in an inventory maintained with the agency. In 2009, seven stormwater drywells were closed due to site preparation for the construction of the National Synchrotron Light Source II (NSLS-II); three formerly located near Building T-100, three near former Building T-89, and the last found during site preparation for the NSLS-II project. All drywells were tested and found to meet Suffolk County Action Levels for contaminants in soils. In order to alleviate flooding and moisture problems at several BNL facilities, 16 new drywells were installed in 2009. These included four new drywells in the parking lot for Building 464 and 12 around the perimeter of Building 134. Applications detailing the installation of these devices were submitted to the EPA.

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

3.8 PREVENTING AND REPORTING SPILLS

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

3.8.1 Preventing Oil Pollution and Spills

As required by the Oil Pollution Act, BNL maintains a Spill Prevention Control and Countermeasures (SPCC) Plan as a condition of its license to store petroleum fuel. The SPCC Plan is part of the Laboratory's emergency preparedness program and outlines mitigating and remedial actions that would be taken in the event of a major petroleum release. The plan also provides information regarding release prevention measures, the design of storage facilities, and maps detailing storage facility locations. The SPCC Plan is filed with NYSDEC, EPA, and DOE, and was updated in October 2007 (Chaloupka 2007). BNL remained in full compliance with SPCC requirements in 2009.

In July 2002, EPA adopted significant changes to the SPCC regulations that extended the requirements to previously unregulated facilities and provided some relief to existing covered facilities. These changes, among others, included extending the plan update deadline from 3 to 5 years, and specifying that containers smaller than 55 gallons need not be counted toward reaching SPCC applicability. In November 2009, EPA again extended the deadlines for implementing the 2002 revisions to the SPCC requirements. Facilities must be incompliance with the provisions by November 10, 2010. Although the Laboratory has recently updated its SPCC Plan ahead of schedule, the plan will be reviewed again prior to the November 2010 deadline to ensure it complies with all SPCC requirements.

BNL also maintains a Facility Response Plan (FRP) (Lee 2006) that outlines emergency response procedures to be implemented in the event of a worst-case discharge of oil. The BNL FRP was approved by EPA in September 2006. In March 2008, EPA conducted an unannounced government-initiated oil spill response exercise and field inspection at the Laboratory. The objective of the unannounced exercise was to test notification procedures, equipment deployment, and other actions associated with a response to an oil spill scenario identified within BNL's FRP. The exercise revealed that BNL's response procedures were effective and satisfactorily addressed the requirements of the FRP regulation (40 CFR Part 112). The Laboratory fully met the objectives of the government-initiated unannounced exercise and field inspection.

3.8.2 Emergency Reporting Requirements

The Emergency Planning and Community Right-to-Know Act (EPCRA) and Title III of the Superfund Amendments and Reauthorization Act (SARA) require that facilities report inventories (i.e., Tier II Report) and releases (i.e., Tier III Report) of certain chemicals that exceed specific release thresholds. These reports are submitted to the local emergency planning committee and the state emergency response commission. Community Right-to-Know requirements are codified under 40 CFR Parts 355, 370, and 372. The table below summarizes the applicability of the regulations to BNL. The Laboratory complied with these requirements in 2009 through the submittal of reports under EPCRA Sections 302, 303, 311, and 312 for calendar year 2008. In 2009, through the Tier III report, BNL reported releases of lead (~110,255 pounds), mercury (~162 pounds), PCBs (~100 pounds), benzo(g,h,i)perylene (<1 pound), and polycyclic aromatic compounds (<1 pound) for calendar year 2008. Releases of lead, PCBs, and mercury were predominantly in the form of shipments of waste for off-site recycling or disposal. Releases of benzo(g,h,i)perylene and polycyclic aromatic compounds were as by-products of the combustion of fuel oils. In 2009, there were no releases of "extremely hazardous substances" reportable under Part 304.

3.8.3 Spills and Releases

When a spill of hazardous material occurs, Laboratory and contractor personnel are required to immediately notify the on-site Fire Rescue Group, whose members are trained to respond to such releases. Fire Rescue's initial response is to contain and control any release and to notify additional response personnel (i.e., BNL environmental professionals, industrial hygienists, etc.). Environmental professionals reporting to the scene assess the spill for environmental impact and determine if it is reportable to regulatory agencies. Any release of petroleum products to soil must be reported to both NYSDEC and SCDHS, and any release affecting surface water is also reported to the EPA National Response Center. In addition, a release of more than 5 gallons of petroleum product to impermeable surfaces or containment areas must be reported to NYSDEC and SCDHS. Spills of chemicals in quantities greater than the CERCLA-reportable limits must be reported to the EPA National Response Center, NYSDEC, and SCDHS. Remediation of the spill is conducted, as necessary, to prevent impacts to the environment, minimize human health exposures, and restore the site.

During 2009, there were 33 spills, 12 of which met regulatory agency reporting criteria. The remaining 21 spills were small-volume releases either to containment areas or to other impermeable surfaces that did not exceed a reportable quantity. Table 3-7 summarizes each of the 12 reportable events, including a description of the cause and corrective actions taken. There were no long-term effects from these releases and no significant impact on the environment. Eight of the reported events were 5 gallons or less in volume, one was of 5-6 gallons, and two were more than 50 gallons and associated with hydraulic lift or elevator replacements. The twelfth spill was associated with the discovery of an unidentified petroleum storage tank located within the construction area for NSLS-II. Due to the volume of contaminated soils discovered, this incident was reported to DOE through BNL's Occurrence Report Processing System (ORPS), a system for identifying, categorizing, notifying, investigating, analyzing, and reporting to DOE events or conditions discovered on site. In all instances, any recoverable material

Applicability of EPCRA to BNL

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

Table 3-7. Summary of Chemical and Oil Spill Reports.

Spill No. and Date	Material and Quantity	ORPS Report	Source/Cause and Corrective Actions
09-01 01/05/09	Hydraulic (vegetable) oil 70 gallons	No	One of the pistons associated with a vehicle lift at Bldg. 423 failed, resulting in the release of 70 gallons of oil to the containment beneath the lift. All oil was recovered and sent for disposal as "used oil." The oil is vegetable based and therefore not considered a hazardous material. The lift was replaced.
09-12 05/06/09	20% Ethylene Glycol Solution 1 gallon	No	During site preparation for the NSLS-II project, land graders unearthed an abandoned solar heat experiment that used ethylene glycol solutions as a heat transfer fluid. Polyethylene tubing was encountered by the graders and cut during the grading process, releasing approximately 1 gallon of glycol solution to the ground. An investigation ensued which revealed a complex arrangement of piping and tanks for storing solutions and studying the effects of the ground as a heat storage media. The piping systems were uncovered and the glycol solutions recovered. In total ~ 240 gallons of glycol was removed from the systems.
09-15 05/13/09	Hydraulic Oil 0.5 gallons	No	While mowing the lawn by Apartment #22, the driver noticed the mower was leaking hydraulic fluid. He stopped mowing and parked the vehicle on the pavement. Speedi-dri was used to absorb the oil from the pavement and visibly impacted soil was removed and containerized for off-site disposal.
09-16 05/19/09	Water/Diesel Fuel > 10 gallons	Yes	During site preparation of the NSLS-II project site, land graders unearthed a previously unidentified fuel storage tank. While the tank was mostly empty, residual diesel fuel and water was released to the soil due to the impact of the grader on the tank. The tank was removed from the ground and contaminated soils were excavated and containerized for offsite disposal. Examination of the tank showed several corrosion holes indicating that the contaminated soils were likely the result of past leakage.
09-18 05/29/09	Gasoline 4 gallons	No	After refueling, the gasoline tank on a BNL pick-up truck began to leak. The tank was pumped out and the gasoline reused in another vehicle. Approximately 4 gallons of gasoline leaked from the vehicle and onto the parking lot and adjacent soil before being discovered. Spill absorbents were used to recover the gasoline and impacted soils were removed for off-site disposal.
09-22 06/22/09	Transmission Fluid 2 gallons	No	A rubber transmission fluid line on a large lawnmower dislodged from its fitting, resulting in a release of 2 gallons of fluid to pavement and a small area of grass. Spill absorbents were used to recover the fluid from the asphalt and impacted soils were removed for off-site disposal.
09-24 07/22/09	Hydraulic Fluid 1 gallon	No	While clearing brush, a hydraulic line on a backhoe failed, resulting in the release of hydraulic oil to the ground. Spill absorbent pads were used to remove oil from the machine and impacted soils were excavated and containerized for off-site disposal. The backhoe was repaired prior to returning to service.
09-26 08/14/09	Hydraulic Fluid 1 gallon	No	While moving rail cars, a hydraulic fitting on a Track Mobil loosened, resulting in the release of ~1 gallon of hydraulic oil to the railroad tracks and rock ballast. Impacted rocks were removed and containerized for off-site disposal and the Track Mobil was repaired and returned to service.
09-28 09/17/09	Hydraulic Fluid 1 gallon	No	A hydraulic hose on a payloader failed, resulting in the release of 1 gallon of oil to soil. Impacted soil was excavated and containerized for off-site disposal. The payloader was returned to the heavy equipment shop for repairs.
09-29 10/19/09	Ethylene Glycol 1 gallon	No	A radiator hose on a BNL pickup truck failed, resulting in the release of 1 gallon of ethylene glycol solution to the ground. All spillage was contained on asphalt. Spill absorbent was used to clean up the release. All contaminated spill absorbent was collected and disposed of off site.
09-32 11/16/09	Diesel Fuel 5 – 6 gallons	No	A bulldozer had been parked at the compost area for a period of time. When inspected, diesel fuel was noticed leaking from the vehicle. The bulldozer was trailered and transported to the heavy equipment shop for repairs. Examination of the soi beneath the vehicle showed extensive contamination with diesel fuel. Approximately 3 – 4 cubic yards of contaminated soil were excavated and containerized for off-site disposal.
09-33 11/19/09	Hydraulic Fluid 60 gallons	No	During a retrofit of the elevator in Bldg. 725, oil was discovered in the casing enclosing the elevator ram. Miller Environmental Group, an EPA recognized Oil Spill Response Organization, was retained to clean the oil and any contaminated water from the elevator casing. Approximately 60 gallons of oil and 35 gallons of water were recovered. Once the casing was cleaned out, the elevator contractor completed installation of the new cylinder and ram. A small-diameter PVC monitoring device was installed to monitor for the presence of additional leakage.

Note:
* Release is reportable to DOE under the requirements of DOE Order 231.1A, Occurrence Reporting and Processing.

was removed and spill absorbents were used to remove residual product. For releases to soil, contaminated soils were removed to the satisfaction of the State or local inspector. All contaminated absorbents and impacted soils were containerized for off-site disposal. With the exception of the soils associated with the discovery of the tank within the NSLS-II construction site, these releases had limited environmental impact; consequently, none of the spills were reportable through ORPS. There were no other incidents reportable through ORPS in 2009.

3.8.4 Major Petroleum Facility License

The storage and transfer of 2.3 million gallons of fuel oil (principally No. 6 oil) subjects the Laboratory to MPF licensing by NYSDEC. The fuel is used at the CSF to produce high-pressure steam to heat and cool BNL facilities, and is stored in six tanks with capacities ranging from 300,000 to 600,000 gallons. During 2009, BNL remained in full compliance with MPF license requirements, which include monitoring groundwater in the vicinity of the six aboveground storage tanks. The license also requires the Laboratory to inspect the storage facilities monthly and test the tank leak detection systems, high-level monitoring, and secondary containment. Tank integrity is also checked periodically. Groundwater monitoring consists of monthly checks for the presence of floating products and twice-yearly analyses for VOCs and semi-volatile organic compounds (SVOCs). In 2009, no VOCs, SVOCs, or floating products attributable to MPF activities were detected. See SER Volume II, Groundwater Status Report, for additional information on groundwater monitoring results.

In December 2009, NYSDEC conducted its annual inspection of the Major Oil Storage Facility. Four conditions that required corrective action were identified: the need to properly prepare and paint some sections of Tank 611-06 and associated piping; provide confirmation that all tell-tails associated with each tank are inspected and documented properly; registration and followup inspection of a new 1,000 gallon aboveground bio-diesel tank that was installed in the transfer facility; and evaluation of the Cathodic Protection System servicing tanks 3, 5, and 6 to ensure that it is adequately protecting the tanks. In addition, an inspection of the Laboratory's underground storage facilities and other smaller satellite fuel storage tanks identified one condition that required corrective action. This included the need to conduct and document testing of the automatic line-leak detectors for the tanks located at the on-site service station. Most conditions were corrected in accordance with NYSDEC directives prior to the end of calendar year 2009. With NYSDEC approval, the remaining conditions will be addressed in 2010.

3.8.5 Chemical Bulk Storage

Title 6 of the Official Compilation of the Codes, Rules and Regulations of the State of New York (NYCRR) Part 597 requires that all aboveground tanks larger than 185 gallons and all underground tanks that store specific chemicals be registered with NYSDEC. The Laboratory holds a Hazardous Substance Bulk Storage Registration Certificate for six tanks that store treatment chemicals for potable water (sodium hydroxide and sodium hypochlorite). The tanks range in capacity from 200 to 1,000 gallons. These tanks are also regulated under Suffolk County Sanitary Code (SCSC) Article 12 (SCDHS 1993) and are managed in accordance with BNL procedures designed to conform to Suffolk County requirements.

In May 2009, BNL renewed its Chemical Bulk Storage Registration in accordance with NYSDEC directives and received a Hazardous Substance Bulk Storage Registration Certificate in June 2009, which will not expire until July 2011. NYSDEC conducted an inspection of the Chemical Bulk Storage (CBS) facilities in December 2009. During this inspection, three issues were identified that required corrective action: the need to properly prepare and paint a small section on the west side of Tank 635-01; recalibration or replacement of remote level gauges associated with Tanks 624-05 thru -08; and properly terminating the atmospheric vent associated with Tank 634-02 within the tank containment area. These issues were corrected in accordance with the NYSDEC request.

3.8.6 County Storage Requirements

Article 12 of the Suffolk County Sanitary Code regulates the storage and handling of toxic and hazardous materials in aboveground or underground storage tanks, drum storage facilities, piping systems, and transfer areas. Article 12 specifies design criteria to prevent environmental impacts resulting from spills or leaks, and specifies administrative requirements such as identification, registration, and spill reporting procedures. In 1987, the Laboratory entered into a voluntary Memorandum of Agreement with SCDHS, in which DOE and BNL agreed to conform to the environmental requirements of Article 12.

Currently, there are 336 active storage facilities at BNL for wastewater, chemicals, and fuel (some fuel facilities are regulated under the MPF license), as well as storage facilities used to support BNL research. An additional 17 storage facilities are temporarily out of service. The Laboratory has one active storage facility associated with environmental restoration activities conducted under the CERCLA program; this facility is not regulated under Article 12.

BNL has an ongoing program to upgrade or replace existing storage facilities, to ensure that the information provided to SCDHS for all registered storage facilities is accurate, and to ensure that new or modified storage facilities are designed and reviewed for full conformance with Article 12 regulations. In 2009, the Laboratory continued to provide SCDHS with updated information regarding several registered tanks, and coordinated several field inspections that resulted in BNL receiving "Permits to Operate" for ten existing registered storage facilities. In addition, the design plans and specifications for a new drum storage area at Building 835 and aboveground bio-diesel tank at Building 639 were approved and construction was completed. Both systems were designed and constructed to fully conform to SCSC Article 12 requirements for aboveground storage.

3.9 RCRA REQUIREMENTS

The Resource Conservation and Recovery Act regulates hazardous wastes that, if mismanaged, could present risks to human health or the environment. The regulations are designed to ensure that hazardous wastes are managed from the point of generation to final disposal. In New York State, EPA delegates the RCRA program to NYSDEC, with EPA retaining an oversight role. Because the Laboratory may generate greater than 1,000 Kg (2,200 pounds) of hazardous waste in a month, it is considered a large-quantity generator and has a RCRA permit to store hazardous wastes for up to 1 year before shipping the wastes off site to licensed treatment and disposal facilities. As noted in Chapter 2, BNL also has a number of satellite accumulation and 90-day waste storage areas.

Mixed wastes are materials that are both hazardous (under RCRA guidelines) and radioactive. The Federal Facilities Compliance Act (1992) requires that DOE work with local regulators to develop a site treatment plan to manage mixed waste. Development of the plan has two purposes: to identify available treatment technologies and disposal facilities (federal or commercial) that are able to manage mixed waste produced at federal facilities, and to develop a schedule for treating and disposing of these waste streams.

BNL's Site Treatment Plan is updated annually and submitted to NYSDEC for review. The updated plan documents the current mixed waste inventory and describes efforts undertaken to seek new commercial treatment and disposal outlets for various waste streams. Treatment options for all of the mixed waste now in storage have been identified. BNL expects to continue managing future mixed wastes within the permitted 1-year storage limitation and will continue to maintain and update its Site Treatment Plan as a reporting mechanism, should waste types or treatment facility availability change in the future.

3.10 POLYCHLORINATED BIPHENYLS

The storage, handling, and use of polychlorinated biphenyls (PCBs) are regulated under the Toxic Substance and Control Act. Capacitors manufactured before 1970 that are believed to be oil filled are handled as if they contain PCBs, even when that cannot be verified from the manufacturer's records. All equipment containing

PCBs must be inventoried, except for capacitors containing less than 3 pounds of dielectric fluid and items with a concentration of PCB source material of less than 50 parts per million. Certain PCB-containing articles or PCB containers must be labeled. The inventory is updated by July 1 of each year. The Laboratory responds to any PCB spill in accordance with standard emergency response procedures. BNL was in compliance with the regulatory requirements in 2009.

The Laboratory has aggressively approached reductions in its PCB inventory. By replacing and disposing of the last large capacitor and more than 300 small capacitors from the Collider-Accelerator Department in 2008, the inventory was reduced an additional 9 percent. Since 2003, BNL has reduced its PCB inventory by more than 99 percent. The only known regulated PCB-contaminated piece of electrical equipment remaining on site is a one-of-a-kind klystron located in the Chemistry Department.

3.11 PESTICIDES

The storage and application of pesticides (insecticides, rodenticides, herbicides, and algicides) are regulated under the Federal Insecticide, Fungicide and Rodenticide Act. Pesticides are used at the Laboratory to control undesirable insects, mice, and rats; bacteria in cooling towers; and to maintain certain areas free of vegetation (e.g., around fire hydrants and inside secondary containment berms). Insecticides are also applied to agricultural research fields and in greenhouses on site. Herbicide use is minimized wherever possible (e.g., through spot treatment of weeds). All pesticides are applied by BNL-employed, New York State–certified applicators. By February 1, each applicator files an annual report with NYSDEC detailing insecticide, rodenticide, algicide, and herbicide use for the previous year. The Laboratory was in full compliance with the legislated requirements in 2009.

3.12 WETLANDS AND RIVER PERMITS

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

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

In 2009, one project remained permitted under this program, one was closed-out, and a third project was reviewed and determined not to require a permit. The permit for construction of a block house at the 4 o’clock area at RHIC remained open in 2009 and will likely be closed in 2010. The installation of air conditioning upgrades was completed in 2008 and close-out documents were submitted in 2009. Also in 2009, the placement of an equipment trailer on top of the RHIC berm at the 12 o’clock position was submitted for permit review to NYSDEC and a determination of “no permit necessary” was provided by NYSDEC to DOE. Finally, a permit application was being developed by BNL on behalf of BP Solar for the construction of the approved Long Island Solar Farm, a 32 MW 200-acre facility proposed for the southeast portion of the Laboratory.

3.13 PROTECTION OF WILDLIFE

3.13.1 Endangered Species Act

In 2006, the Laboratory updated its list of endangered, threatened, and species of special concern (see Table 6-1 in Chapter 6). Although the tiger salamander is no longer the only state endangered species found at BNL, it is the most notable and best-studied species on site. Tiger salamanders are listed as endangered in New

York State because populations have declined due to habitat loss through development, road mortality during breeding migration, introduction of predatory fish into breeding sites, historical collection for the bait and pet trade, water level fluctuations, pollution, and general disturbance of breeding sites. The Laboratory adopted and implemented the BNL Natural Resource Management Plan (NRMP) in December 2003. One component of the plan formalizes the strategy and actions needed to protect 26 confirmed tiger salamander breeding locations on site. The strategy includes identifying and mapping habitats, monitoring breeding conditions, improving breeding sites, and controlling activities that could negatively affect breeding. A multi-year study of three ponds began in 2004 to gain a better understanding of salamander habitat requirements and migration patterns.

The banded sunfish and swamp darter are found in the Peconic River drainage areas at BNL. Both species are listed as threatened within New York State, with eastern Long Island having the only known remaining populations of these fish in New York. Measures taken or being taken by the Laboratory to protect the banded sunfish and swamp darter and their habitats include: eliminating, reducing, or controlling pollutant discharges; reducing nitrogen loading in the Peconic River; monitoring populations and water quality to ensure that habitat remains viable; and minimizing disturbances to the river and adjacent banks.

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

Surveys for damselflies and dragonflies conducted annually during the summer months confirmed the presence of one of the three threatened species of damselflies expected to be found on site. In June 2005, the pine-barrens bluet (*Enallagma recurvatum*), a threatened species, was documented at one of the many coastal plain ponds located at BNL.

The Laboratory is also home to 14 species that are listed as species of special concern. Such species have no protection under the state endangered species laws, but may be protected under other state and federal laws (e.g., Migratory Bird Treaty Act). New York State monitors species of special concern and manages their populations and habitats, where practical, to ensure that they do not become threatened or endangered. Species of special concern found at BNL include the mottled duskywing butterfly, marbled salamander, eastern spadefoot toad, spotted turtle, eastern box turtle, eastern hognose snake, worm snake, horned lark, whip-poor-will, vesper sparrow, grasshopper sparrow, and Cooper's hawk. The management efforts for the tiger salamander also benefit the marbled salamander. At present, no additional protective measures are planned for the eastern box turtle or spotted turtle, as little activity occurs within their known habitat at the Laboratory. BNL continues to evaluate bird populations as part of the management strategy outlined in the NRMP. In addition to the bird species mentioned above, 18 other bird species listed as species of special concern and two federally threatened species have been observed during spring and fall migrations.

The Laboratory has 20 plant species that are protected under state law. One is an endangered plant, the crested fringed orchid; two are threatened plants, the stiff goldenrod and stargrass; and two are rare plants, the narrow-leafed bush clover and long-beaked bald-rush. The other 15 species are considered to be "exploitably vulnerable," meaning that they may become threatened or endangered if factors that result in population declines continue. These plants are currently sheltered at BNL due to the large areas of undeveloped pine-barren habitat on site. As outlined in the NMRP, locations of these rare plants must be determined, populations estimated, and management requirements established. In an effort to locate and document rare plants, BNL is working with a botanist to assess the flora found on site. See Chapter 6 for further details.

3.13.2 Migratory Bird Treaty Act

As mentioned in Chapter 1, the Laboratory has identified more than 185 species of migratory birds since 1948; of those, approximately 85 species nest on site. Migratory birds are protected under the Migratory Bird Treaty Act. This protection includes protection from take, harassment, and destruction or disturbance of nests without permits issued by the U.S. Fish and Wildlife Service. In the past, migratory birds have caused health and safety issues, especially through the deposition of fecal matter and the bird's assertive protection of nesting sites. When this occurs, proper procedures are followed to allow the birds to nest, and then preventive measures are taken to ensure that they do not cause problems in the future. Canada geese (*Branta canadensis*) are managed under an annual permit from the U.S. Fish and Wildlife Services goose nest management program. Occasionally, nesting migratory birds come in conflict with construction and the conflict must be resolved. When this occurs, the USDA-APHIS-Wildlife Services division is called for consultation and resolution, if possible. Each incident is handled on a case-by-case basis to ensure protection of migratory birds, as well as maintain fiscal responsibility. See Chapter 6 for more information on migratory birds.

3.13.3 Bald and Golden Eagle Protection Act

While BNL does not have bald or golden eagles nesting on site, they do occasionally visit the area during migration. At times, immature golden eagles have spent several weeks in the area of the Laboratory. Bald eagles are known to spend long periods of time on the north and south shores of Long Island. In general, the Laboratory has no concerns with eagles and has no specific management needs concerning them.

3.14 EXTERNAL AUDITS AND OVERSIGHT

3.14.1 Regulatory Agency Oversight

A number of federal, state, and local agencies oversee BNL activities. In addition to external audits and oversight, the Laboratory has a comprehensive self-assessment program, as described in Chapter 2. In 2009, BNL was inspected by federal, state, or local regulators on nine occasions and SCDHS continued to maintain an on-site office for an inspector who provided periodic oversight of BNL activities. These inspections included:

- *Air Compliance*. NYSDEC conducted its formal inspection of the Laboratory's air compliance program in August 2009; there were no violations noted at the time of inspection.
- *Potable Water*. In July, SCDHS collected samples and conducted its annual inspection of the BNL potable water system. No issues were identified.
- *Sewage Treatment Plant.* SCDHS conducts quarterly inspections of the Laboratory's STP, to evaluate operations and sample the effluent. In 2009, no performance or operational issues were identified. NYSDEC did not perform its annual surveillance inspection in 2009.
- *Recharge Basins.* SCDHS inspected several of the SPDES-regulated outfalls and collected samples. No issues were identified.
- *Major Petroleum Facility.* The annual NYSDEC inspection of the MPF was conducted in December. See Section 3.8.4 for a discussion of the issues identified.
- *Chemical Bulk Storage Facilities.* The CBS facilities are inspected periodically by NYSDEC. The inspection was conducted in December (see Section 3.8.5).

NYSDEC did not perform annual hazardous waste or SPDES inspections in 2009.

3.14.2 DOE Assessments/Inspections

The DOE Brookhaven Site Office (BHSO) conducts several environmentally related assessments each year, some of which are supported by the DOE Chicago Office. In December 2008, BHSO, with assistance from the Chicago Office, evaluated BNL's readiness to declare conformance to DOE Order 450.1A. This order, along with its companion DOE Order 430.2B, established new requirements for DOE facilities in the areas of energy and water conservation, improved fleet management, and other sustainable practices. Order 450.1A requires DOE facilities to have an Environmental Management System (EMS) that includes objectives and targets sup-

porting the sustainability goals of the Order, and the energy, water, fleet, and other goals of Order 430.2B. Overall, the assessment found that the EMS culture at BNL was strong due to the prior long-term establishment of an ISO 14001-registered EMS, and is clearly in conformance with DOE O 450.1A. BNL formally declared its conformance to these new requirements in April 2009.

The Chicago Office conducted an assessment of BNL's Environmentally Preferable Purchasing (EPP) program in June 2009 as part of the BHSO independent oversight program. The findings of this assessment were rolled-up into one Finding. The results indicated that, although an improvement plan was prepared with actions to comply with the requirements related to the EPP requirements of DOE O 450.1A, BNL was behind schedule on implementation of the actions. While the Laboratory committed to have all actions completed by early October 2009, one action remained opened of the end of 2009. This action, to revise and issue the Procurement subject area which includes requirements for EPP, will be completed in 2010.

3.14.2.1 Environmental Multi-Topic Assessment

In 2009, BNL conducted a programmatic self-assessment on several aspects of the Laboratory's environmental management program. Topics for this assessment were determined based on institutional risk, DOE and regulatory agency expectations, and to ensure that key environmental requirements are being implemented as designed. The self-assessment focused on requirements related to properly managing wastes generated at BNL, including hazardous, industrial, mixed, radioactive, radioactive-regulated medical waste, and regulated medical waste.

During the self-assessment, two Noteworthy practices, seven Nonconformances, and three Observations were noted. A causal analysis was performed and a corrective action plan prepared for the identified nonconformances to address the issues. Progress on the actions is being tracked to closure in BNL's Institutional Assessment Tracking System.

3.14.2.2 Nevada Test Site Inspection

The Laboratory continues to be a certified Nevada Test Site (NTS) waste generator. As part

Table 3-8. Existing Agreements and Enforcement Actions Issued to BNL, with Status.

Number Agreements	Title	Parties	Effective Date	Status
No Number	Suffolk County Agreement	SCDHS, DOE, and BNL	Originally signed on 09/23/87	This Agreement was developed to ensure that the storage and handling of toxic and hazardous materials at BNL conform to the environmental and technical requirements of Suffolk County codes.
No Number	Federal Facilities Compliance Agreement on Mixed Wastes	NYSDEC and DOE	1992 (updated annually)	The Federal Facilities Compliance Act (FFCA) requires that a site treatment plan to manage mixed wastes be written and updated annually. BNL is in compliance with this requirement.
II-CERCLA-FFA-00201	Federal Facility Agreement under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Section 120 (also known as the Interagency Agreement or "IAG" of the Environmental Restoration Program)	EPA, DOE, and NYSDEC	05/26/92	Provides the framework, including schedules, for assessing the extent of contamination and conducting the BNL cleanup. Work is performed either as an Operable Unit or a Removal Action. The IAG integrates the requirements of CERCLA, Resource Conservation and Recovery Act (RCRA), and the National Environmental Policy Act (NEPA). While all clean-up actions were completed in 2005, BNL continues to perform surveillance and maintenance of operating remediation systems. All systems operated as required in 2009.
Notices of Violation/Enforcement Actions				
None				

Notes:
EPA = Environmental Protection Agency
NYSDEC = New York State Department of Environmental Conservation
SCDHS = Suffolk County Department of Health Services

of the NTS waste certification process, the NTS Maintenance and Operations Contractor conducts random unannounced inspections. NTS performed an unannounced inspection at BNL in May 2009. There were no findings noted.

3.15 ENFORCEMENT ACTIONS AND AGREEMENTS

There were no formal or informal enforcement actions taken against BNL operations in 2009. A "Warning Notice" was received in October 2009 for failing to report violations of the opacity standards for emissions from the CSF within 2 days of the date of occurrence. The 2-day reporting requirement was added to the revised BNL Title V permit in 2008 and was not recognized as a new enforceable action. Corrective measures have been taken to ensure that appropriate Laboratory staff is notified immediately of an opacity excursion. In addition to the rules and regulations discussed throughout this chapter, Table 3-8 lists the existing agreements with regulatory agencies that oversee BNL operations.

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Air Quality 4

Brookhaven National Laboratory (BNL) monitors both radioactive and nonradioactive emissions at several facilities on site to ensure compliance with the requirements of the Clean Air Act. In addition, the Laboratory conducts ambient air monitoring to verify local air quality and assess possible environmental impacts from Laboratory operations.

During 2009, BNL facilities released a total of 1,833 curies of short-lived radioactive gases. Oxygen-15 and carbon-11 emitted from the Brookhaven Linac Isotope Producer constituted 97.9 percent of the site's radiological air emissions.

Since natural gas prices were comparatively lower than residual fuel prices from May through December of 2009, the Central Steam Facility used natural gas to meet most of the heating and cooling needs of the Laboratory's major facilities during this period. As a result, annual facility emissions of particulate matter, sulfur dioxide, and oxides of nitrogen were considerably lower in 2009 than in the years 2003 to 2005, when residual fuel satisfied more than 91 percent of BNL's major facility heating and cooling needs.

4.1 RADIOLOGICAL EMISSIONS

Federal air quality laws and DOE regulations that govern the release of airborne radioactive material include 40 CFR 61 Subpart H: National Emission Standards for Hazardous Air Pollutants (NESHAPs)—part of the Clean Air Act (CAA), and DOE Order 5400.5, Radiation Protection of the Public and the Environment. Under NESHAPs Subpart H, facilities that have the potential to deliver an annual radiation dose of greater than 0.1 mrem (1 µSv) to a member of the public must be continuously monitored for emissions. Facilities capable of delivering radiation doses below that limit require periodic, confirmatory monitoring. BNL has one facility that is continuously monitored, the Brookhaven Linac Isotope Producer (BLIP). Periodic monitoring is conducted at one active facility, the Target Processing Laboratory (TPL), and one inactive facility, the High Flux Beam Reactor (HFBR). Figure 4-1 indicates the locations of these monitored facilities, and Table 4-1 presents the airborne release data from each of these facilities during 2009. Annual emissions from monitored facilities are discussed in the following sections of this chapter. Also discussed is a fourth inactive facility, the Evaporator Facility, which was periodically monitored in past years. The associated radiation dose estimates are presented in Chapter 8, Table 8-4.

4.1.1 Brookhaven Medical Research Reactor

In August 2000, DOE announced that the Brookhaven Medical Research Reactor (BMRR) would be permanently shut down due to a reduction of research funding. Until it stopped operating in late December 2000, the BMRR was fueled with enriched uranium, moderated and cooled by "light" (ordinary) water, and was operated intermittently at power levels up to 3 MW, thermal. Air from the interior of the containment building was used to cool the neutron reflector surrounding the core of the reactor vessel. As air was drawn through the reflector, it was exposed to a neutron field, resulting in activation of the argon fraction of the air. This produced argon-41 (Ar-41), an inert, radioactive gas (half-life 1.8 hours). After passage through the reflector, the air was routed through a roughing filter and a high-efficiency

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

particulate air (HEPA) filter to remove any particulate matter. Charcoal filters were also used to remove radioiodines produced during the fission process. Following filtration, the air was exhausted to the atmosphere through a 150-foot stack adjacent to the reactor containment building. This air was continuously monitored for Ar-41 emissions.

After the BMRR stopped operating, continuous Ar-41 monitoring was reduced to periodic, semi-annual monitoring to confirm that radionuclide concentrations remained below detection limits. In January 2003, the remaining fuel was removed from the BMRR reactor vessel, eliminating the last significant source for radionuclide emissions. The sole remaining BMRR emission source was evaporation of the cooling water, which contained the radioactive isotope tritium (H-3, half-life 12.3 years), produced by neutron activation when the BMRR operated. In January 2005, EPA approved BNL's petition to discontinue emissions monitoring at the BMRR. As a result, sample collection was stopped in 2006 and all removable radioactive materials were shipped off site to a disposal facility.

The BMRR remained closed as a radiological facility with continued surveillance and maintenance. In 2009, the primary and overflow resin vessels were removed and disposed at a licensed facility.

4.1.2 High Flux Beam Reactor

When the HFBR operated, "heavy" water was used as a neutron moderator and fuel coolant. Heavy water, or D_2O, is water composed of a nonradioactive isotope of hydrogen known as deuterium. When exposed to neutron fields generated inside a reactor vessel, deuterium becomes activated and produces radioactive tritium. As a result of the transfer of fuel elements from the reactor, the spent fuel storage pool contained tritiated heavy water (HTO) from the HFBR system. In 1997, a plume of tritiated groundwater was traced back to a leak in the pool. Consequently, the HFBR was put in standby mode, the pool was pumped out, and the HTO from the pool was properly disposed of as radioactive waste. The pool was repaired and double lined in accordance with Suffolk County Article 12 regulations (SCDHS 1993) and remained empty while the facility was in a standby mode.

The HFBR continued in standby mode until November 1999, when DOE declared that it was to be permanently shut down. Residual tritium in water in the reactor vessel and piping systems continues to diffuse into the building's air through valve seals and other system penetrations, though emission rates are much lower than during the years of operation (Figure 4-2).

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

Facility	Nuclide	Half-Life	Ci Released
HFBR	Tritium	12.3 years	3.82E+01
BLIP	Carbon-11	20.4 minutes	6.70E+02
	Oxygen-15	122 seconds	1.13E+03
	Tritium	12.3 years	2.75E-02
TPL - Bldg. 801	Germanium-68	270.8 days	6.92E-09
	Selenium-75	119.8 days	5.89E-10
Total			**1.83E+03**

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

As shown in Figure 4-2, the increase in emissions in 2003 was attributed to evaporative losses when HTO remaining in the reactor core was pumped out for approved disposal. In 2004, the downward trend in emissions resumed: the level dropped from 9.0 Ci (the 2003 value) to 3.94 Ci. In 2005, tritium emissions climbed to 17.9 Ci, apparently due to evaporation of residual heavy water through an open drain-tank vent line. In 2006, tritium emissions dropped to 4.03 Ci, a level consistent with 2004 emissions. In 2007,

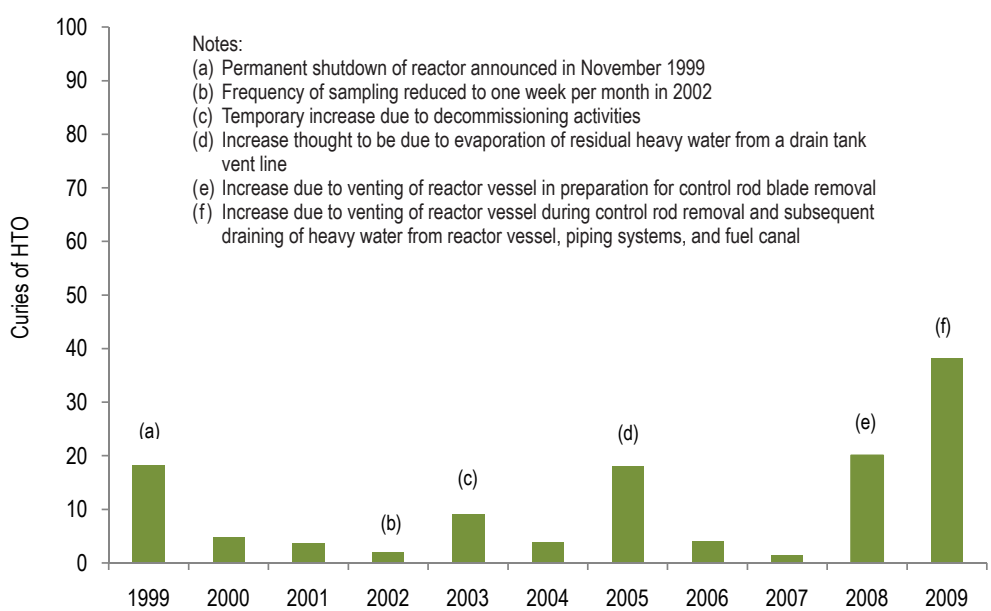

Figure 4-2. High Flux Beam Reactor Tritium Emissions, (1999–2009).

the downward trend continued, as tritium emissions fell to 1.33 Ci. The rise in tritium emissions in 2008 to 20.06 Ci was due to periodic venting of the reactor vessel when domestic water was added to the reactor vessel in preparation for the removal of the HFBR control rod blades. Observed tritium emission increases in 2009 were due to HFBR decontamination and dismantlement (D&D) activities that included the removal of control rod blades from January through March; draining and properly disposing of tritiated heavy water from the reactor vessel, piping systems, and the fuel canal from late spring into the summer; and the opening of contaminated piping systems to allow for the removal of residual volumes of tritiated heavy water. From 2002 through 2008, emissions from the HFBR facility were monitored via air sampling of the building at a frequency of one week per month. In 2009, the frequency of monitoring was increased to bi-weekly to better account for changes in tritium emissions during planned D&D activities.

4.1.3 Brookhaven Linac Isotope Producer

Protons from the Linear Accelerator (Linac) are sent via an underground beam tunnel to the BLIP, where they strike various metal targets to produce new radionuclides for medical diagnostics. The activated metal targets are transferred to the TPL in Building 801 for separation and shipment to various radiopharmaceutical research laboratories. During irradiation, the targets become hot and are cooled by a continuously recirculating water system. The cooling water also becomes activated during the process, producing secondary radionuclides. The most significant of these radionuclides are oxygen-15 (O-15, half-life 122 seconds) and carbon-11 (C-11, half-life 20.4 minutes). Both of these isotopes are released as gaseous, airborne emissions through the facility's 33-foot stack. Emissions of these radionuclides are dependent on the current and energy of the proton beam used to manufacture the radioisotopes.

In 2009, BLIP operated over a period of 24 weeks, during which 670 Ci of C-11 and 1,125 Ci of O-15 were released. Tritium produced from activation of the target cooling water was also released, but in a much smaller quantity, 2.75 E-2 Ci. Combined emissions of C-11 and O-15 were approximately 31 percent lower than 2008 emissions, primarily due to operation at lower energy levels in 2009.

4.1.4 Evaporator Facility

In the past, liquid waste generated on site that contained residual radioactivity was accumulated at the Waste Concentration Facility (WCF) in Building 811. At this facility, reverse osmosis was used to remove suspended solids and a high percentage of radionuclides from the liquid. Because tritium is an isotope of hydrogen, it could not be removed from aqueous wastes. The tritiated water that remained following waste concentration was transferred to the Evaporator Facility in Building 802B, where it was converted to steam and released as an airborne emission. The Evaporator Facility was constructed primarily to reduce the amount of tritiated water released to the Peconic River through the BNL Sewage Treatment Plant (STP). Emissions from the Evaporator Facility were previously directed to the same stack used by the HFBR to exhaust building air. This method was preferable to releases to surface water because there was virtually no potential for the airborne emissions to influence groundwater (the primary drinking water source on Long Island), and the potential for the released tritium to contribute to an off-site dose was minimized by atmospheric dispersion.

No aqueous waste has been processed at the WCF since 2001. As a result, the Evaporator Facility has not been used and has produced no emissions of tritiated water vapor. Because generation rates of aqueous wastes containing residual radioactivity are expected to remain low, it is no longer cost effective to process the waste in the same manner. Wastes are now solidified and sent to an approved off-site disposal facility. Under the Environmental Restoration project, D&D of the WCF is planned for 2011.

4.1.5 Target Processing Laboratory

As mentioned in Section 4.1.3, metal targets irradiated at the BLIP are transported to the TPL in Building 801, where isotopes are chemically

extracted for radiopharmaceutical production. Airborne radionuclides released during the extraction process are drawn through multistage HEPA and charcoal filters and then vented to the HFBR stack. The types of radionuclides that are released depend on the isotopes chemically extracted from the irradiated metal targets, which may change from year to year. Annual radionuclide quantities released from this facility are very small, typically in the µCi to mCi range. In 2009, the total release from the TPL was 0.0075 µCi (see Table 4-1 for details).

4.1.6 Additional Minor Sources

Several research departments at BNL use designated fume hoods for work that involves small quantities of radioactive materials (in the µCi to mCi range). The work typically involves labeling chemical compounds and transferring material between containers using pipettes. Due to the use of HEPA filters and activated charcoal filters, the nature of the work conducted, and the small quantities involved, these operations have a very low potential for atmospheric releases of any significant quantities of radioactive materials. Compliance with NESHAPs Subpart H is demonstrated through the use of an inventory system that allows an upper estimate of potential releases to be calculated. Facilities that demonstrate compliance in this way include Buildings 463, 490, 490A, 510, 535, 555, 725, 801, and 830, where research is conducted in the fields of biology, medicine, high energy physics, chemistry, applied and materials science, advanced technology, and environmental sciences. See Table 8-4 in Chapter 8 for the calculated dose from these facility emissions.

4.1.7 Nonpoint Radiological Emission Sources

Nonpoint radiological emissions from a variety of diffuse sources were evaluated in 2009 for compliance with NESHAPs Subpart H. Diffuse sources evaluated included planned research, environmental restoration, and waste management activities. The EPA-approved CAP88-PC dose modeling computer program was used to calculate the possible dose to members of the public from each of the planned activities. The evaluations determined whether NESHAPs permitting and continuous monitoring requirements were applicable, or whether periodic confirmatory sampling was needed to ensure compliance with Subpart H standards for radionuclide emissions. Chapter 8 discusses the NESHAPs evaluations of the research, environmental restoration, and waste management activities that occurred in 2009.

4.2 FACILITY MONITORING

In the past, potential sources of radioactive emissions have been monitored at the BMRR, HFBR, Evaporator Facility, TPL, and BLIP. Because the BMRR and HFBR are permanently shut down and the Evaporator Facility has not processed any aqueous wastes since 2001, no particulate sampling was conducted at these facilities in 2009.

The samplers in the TPL exhaust duct and the exhaust stack for BLIP are equipped with glass-fiber filters that capture samples of airborne particulate matter generated at these facilities (see Figure 4-3 for locations). The filters are collected and analyzed weekly for gross alpha and beta activity. Particulate filter analytical results for gross alpha and beta activity in 2009 are reported in Table 4-2. The average gross alpha and beta airborne activity

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

Facility Monitor		Gross Alpha	Gross Beta
		(pCi/m^3)	
BLIP	N	35	35
	Max.	0.4400 ± 0.1800	3.2700 ± 0.3480
	Avg.	0.1275 ± 0.1185	1.2422 ± 0.2285
	MDL	0.1722*	0.2241*
TPL-Bldg. 801	N	50	50
	Max.	0.0289 ± 0.0056	0.3870 ± 0.0237
	Avg.	0.0043 ± 0.0032	0.0514 ± 0.0065
	MDL	0.0044*	0.0053*

Notes:
See Figure 4-3 for sample station locations.
All values shown with a 95% confidence interval.
BLIP = Brookhaven Linac Isotope Producer
MDL = Minimum Detection Limit
N = Number of validated samples collected
TPL = Target Processing Laboratory
*Average MDL for all validated samples taken at this location

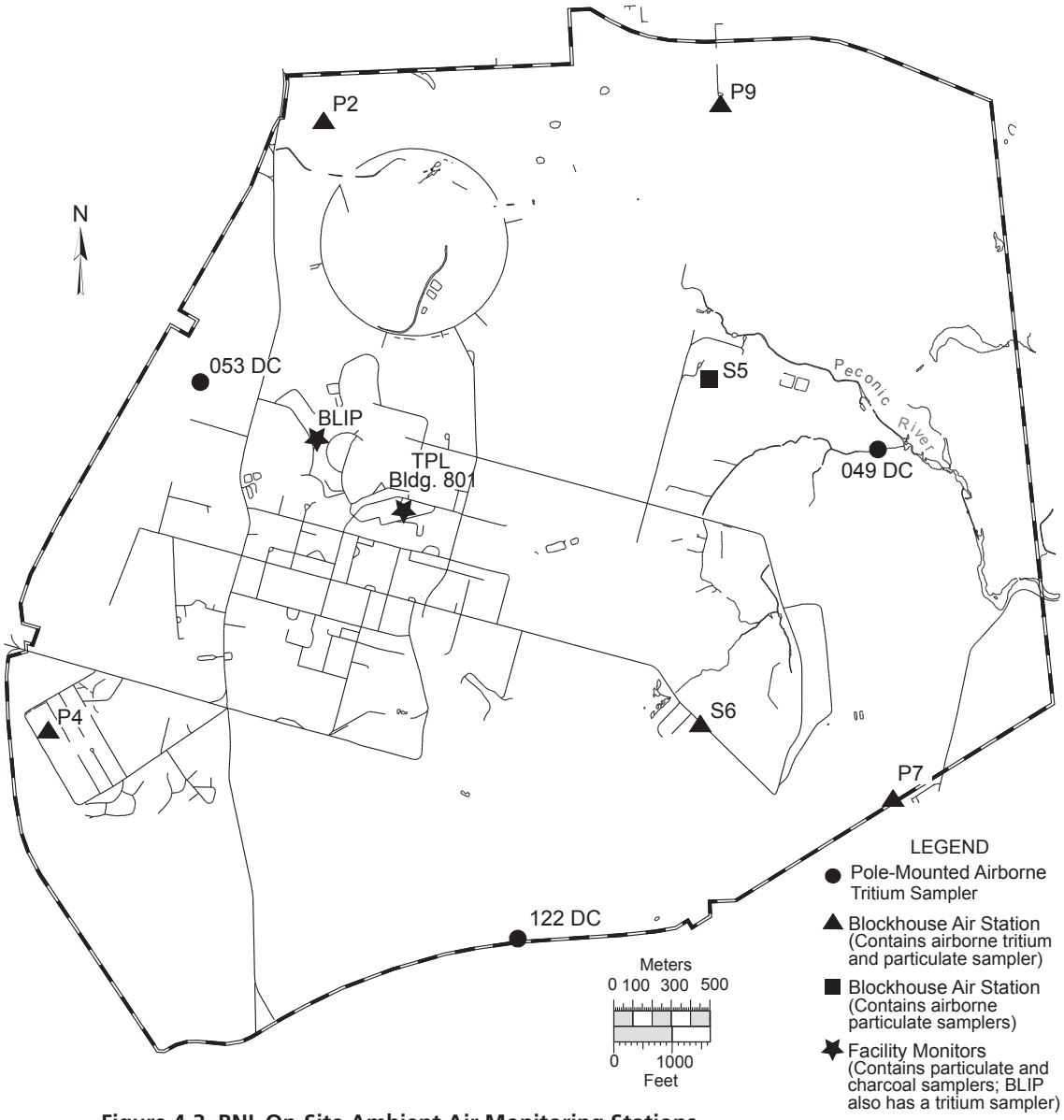

Figure 4-3. BNL On-Site Ambient Air Monitoring Stations.

levels for samples collected from the BLIP exhaust stack were 0.1275 and 1.2422 pCi/m^3, respectively. Annual average gross alpha and beta airborne activity levels for samples collected from the TPL were 0.0043 and 0.0514 pCi/m^3, respectively.

4.3 AMBIENT AIR MONITORING

As part of the Environmental Monitoring Program, air monitoring stations are in place around the perimeter of the BNL site (see Figure 4-3 for locations). Samples are collected using equipment at six blockhouse stations and three pole-mounted, battery-powered silica-gel samplers. The blockhouses are fenced to control access and protect costly sampling equipment. In 2003, the number of pole-mounted samplers used for airborne tritium monitoring was reduced from 16 to 3 because historical air surveillance data revealed that tritium concentrations at most sampling stations were below minimum detection limits (MDLs).

At each blockhouse, vacuum pumps draw air through columns where particulate matter is captured on a glass-fiber filter. Particulate filters are collected weekly and are analyzed for

gross alpha and beta activity using a gas-flow proportional counter. Also, water vapor for tritium analysis is collected on silica-gel absorbent material for processing by liquid scintillation analysis. In 2009, silica-gel samples were collected every two weeks.

4.3.1 Gross Alpha and Beta Airborne Activity

Particulate filter analytical results for gross alpha and beta airborne activity are reported in Table 4-3. Validated samples are those not rejected due to equipment malfunction or other factors (e.g., sample air volumes were not acceptable). The annual average gross alpha and beta airborne activity levels for the six monitoring stations were 0.0017 and 0.0142 pCi/m^3, respectively. Annual gross beta activity trends recorded at Station P7 are plotted in Figure 4-4. The results for this location are typical for the site. The trend shows seasonal variation in activity within a range that is representative of natural background levels. The New York State Department of Health (NYSDOH) received duplicate filter samples that were collected at Station P7 using a sampler they provided. These samples were collected weekly and analyzed by the NYSDOH laboratory for gross beta activity only. The analytical results found were comparable to the Station P7 samples analyzed by General Engineering Lab, an analytical laboratory contracted by BNL. New York State's analytical results for gross beta activity at the Laboratory were between 0.0024 and 0.0152 pCi/m^3, with an average concentration of 0.0083 pCi/m^3. BNL results ranged from 0.0041 to 0.0153 pCi/m^3, with an average concentration of 0.0043 pCi/m^3. As part of a statewide monitoring program, NYSDOH also collects air samples in Albany, New York, a control location with no potential to be influenced by nuclear facility emissions. In 2009, NYSDOH reported that airborne gross beta activity at that location varied between 0.0010 and 0.0230 pCi/m^3, and the average concentration was 0.0118 pCi/m^3. Sample results measured at the Laboratory 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.

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

Sample Station		Gross Alpha	Gross Beta
		(pCi/m^3)	
P2	N	39	39
	Max	0.0034 ± 0.0010	0.0254 ± 0.0017
	Avg.	0.0020 ± 0.0007	0.0155 ± 0.0014
	MDL	0.0006*	0.0008*
P4	N	50	50
	Max	0.0030 ± 0.0011	0.0295 ± 0.0024
	Avg.	0.0015 ± 0.0006	0.0141 ± 0.0012
	MDL	0.0005*	0.0007*
P7	N	49	49
	Max	0.0018 ± 0.0005	0.0153 ± 0.0013
	Avg.	0.0010 ± 0.0004	0.0084 ± 0.0008
	MDL	0.0004*	0.0005*
P9	N	49	49
	Max	0.0035 ± 0.0011	0.0280 ± 0.0022
	Avg.	0.0019 ± 0.0007	0.0159 ± 0.0014
	MDL	0.0006*	0.0008*
S5	N	24	24
	Max	0.0042 ± 0.0010	0.0290 ± 0.0023
	Avg.	0.0019 ± 0.0007	0.0173 ± 0.0015
	MDL	0.0006*	0.0009*
S6	N	47	47
	Max	0.0056 ± 0.0014	0.0304 ± 0.0023
	Avg.	0.0019 ± 0.0008	0.0159 ± 0.0015
	MDL	0.0007*	0.0009*
Grand Average		**0.0017 ± 0.0007**	**0.0142 ± 0.0013**

Notes:
See Figure 4-3 for sample station locations.
All values shown with a 95% confidence interval.
MDL = Minimum Detection Limit
N = Number of validated samples collected
*Average MDL for all validated samples taken at this location

4.3.2 Airborne Tritium

Airborne tritium in the form of HTO is monitored throughout the BNL site. In addition to the five blockhouses containing tritium samplers, three pole-mounted monitors used for tritium sampling are located at or near the Laboratory's property boundary (see Figure 4-3 for sample locations). On average, observed concentrations of tritium at the sampling stations in 2009 were lower than concentrations observed in 2008.

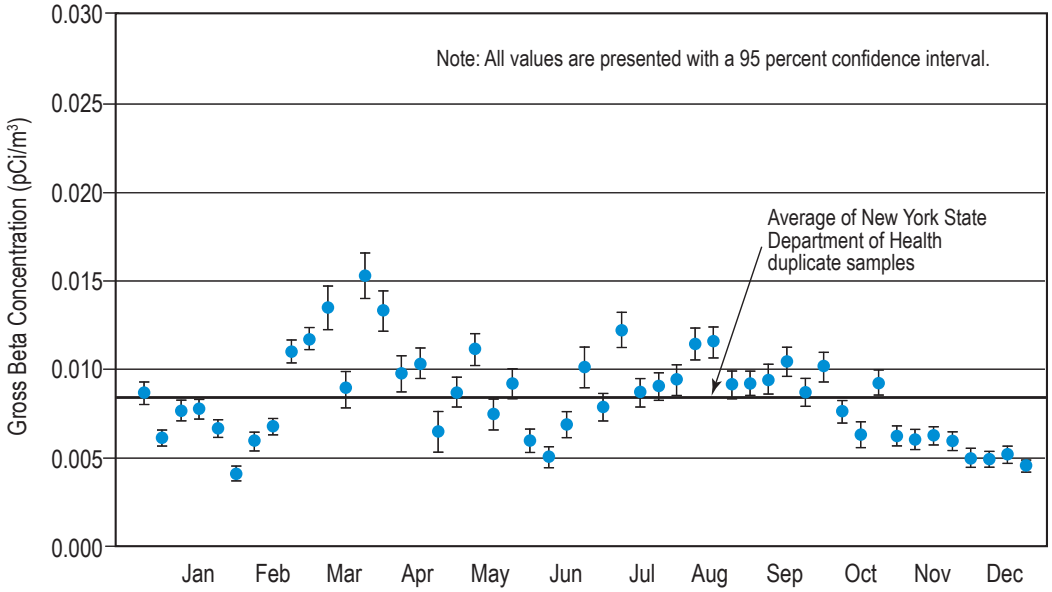

Figure 4-4. Airborne Gross Beta Concentration Trend Recorded at Station P7.

Table 4-4 lists the number of validated samples collected at each location, the maximum value observed, and the annual average concentration. Validated samples are those not rejected due to equipment malfunction or other factors (e.g., a battery failure in the sampler, frozen or supersaturated silica gel, insufficient sample volumes, or the loss of sample during preparation at the contract analytical laboratory). Airborne tritium samples were collected every two weeks from each sampling station during 2009; however, the contract laboratory rejected numerous samples because moisture captured on silica gel was insufficient for analysis. The average tritium concentrations at all of the sampling locations were less than the typical MDL, which ranged from 2.0 to 13.0 pCi/m^3.

4.4 NONRADIOLOGICAL AIRBORNE EMISSIONS

Various state and federal regulations governing nonradiological releases require facilities to conduct periodic or continuous emission monitoring to demonstrate compliance with emission limits. The Central Steam Facility (CSF) is the only BNL facility that requires monitoring for nonradiological emissions. The Laboratory has several other emission sources subject to state and federal regulatory requirements that do not require emission monitoring (see Chapter 3 for more details). The CSF supplies steam for heating and cooling to major BNL facilities through an underground steam distribution and condensate grid. The location of the CSF is shown in Figure 4-1. The combustion units at the CSF are designated as Boilers 1A, 5, 6, and 7. Boiler 1A, which was installed in 1962, has a heat input

Table 4-4. Ambient Airborne Tritium Measurements in 2009.

Sample Station	Wind Sector	Validated Samples	Maximum (pCi/m^3)	Average (pCi/m^3)
049	E	20	9.0 ± 3.4	1.0 ± 4.0
053	NW	17	3.6 ± 1.9	-0.2 ± 3.5
122	SSE	18	3.9 ± 2.1	-1.7 ± 5.4
P2	NNW	13	19.6 ± 19.8	2.0 ± 11.4
P4	WSW	7	3.3 ± 5.6	0.8 ± 2.2
P7	ESE	13	1.8 ± 1.6	0.2 ± 1.2
P9	NE	24	27.0 ± 4.3	1.8 ± 2.2
S6	SE	24	8.2 ± 1.3	0.3 ± 4.1
Grand Average				**0.5 ± 0.8**

Notes:
See Figure 4-3 for station locations.
Wind sector is the downwind direction of the sample station from the HFBR stack.
All values reported with a 95% confidence interval.
Typical minimum detection limit for tritium is between 2.0 and 13.0 pCi/m^3.
DOE Order 5400.5 Air Derived Concentration Guide is 100,000 pCi/m^3.

of 16.4 MW (56.7 million British thermal units [MMBtu] per hour). Boiler 5, installed in 1965, has a heat input of 65.3 MW (225 MMBtu/hr). The newest units, Boilers 6 and 7, were installed in 1984 and 1996, and each has a heat input of 42.6 MW (147 MMBtu/hr). For perspective, National Grid's Northport, New York, power station has four utility-sized turbine/generator boilers, each with a maximum rated heat input of 1,082 MW (3,695 MMBtu/hr).

Because of their design, heat inputs, and dates of installation, Boilers 6 and 7 are subject to Title 6 of the New York Code, Rules, and Regulations (NYCRR) Part 227-2, and the Federal New Source Performance Standard (40 CFR 60 Subpart Db: Standards of Performance for Industrial-Commercial-Institutional Steam Boilers). These boilers are equipped with continuous emission monitors to measure nitrogen oxides (NO_x), and Boiler 7 is equipped with a continuous opacity monitor to comply with Subpart Db opacity monitoring requirements. After a new continuous opacity monitor for Boiler 6 was voluntarily brought online in 2004, emissions on both boilers are now continuously monitored for opacity. To measure combustion efficiency, the boilers are also monitored for carbon dioxide (CO_2). Continuous emission monitoring results from the two boilers are reported quarterly to EPA and the New York State Department of Environmental Conservation (NYSDEC).

From May 1 to September 15 (the peak ozone period), compliance with the 0.30 lbs/MMBtu (129 ng/J) NO_x emission standard for No. 6 oil and the 0.20 lbs/MMBtu (86 ng/J) NO_x emission standard for No. 2 oil and natural gas is demonstrated by calculating the 24-hour average emission rate from continuous emission monitoring system readings and comparing the value to the emission standard. During the remainder of the year, the calculated 30-day rolling average emission rate is used to establish compliance. Boiler 6 and 7 opacity levels are recorded as 6-minute averages. Measured opacity levels cannot exceed 20 percent opacity, except for one 6-minute period per hour of not more than 27 percent opacity. In 2009, there were no measured exceedances of the NO_x emission standards for either boiler.

In 2009, there were 16 periods during the second quarter and 5 periods during the fourth quarter when opacity measurements for Boiler 6 exceeded the opacity limit. The first 12 second quarter excess opacity readings occurred during the initial soot blowing cycle after the boiler was brought on line while combusting natural gas. Since opacity readings began to rise immediately after the boiler was fired with natural gas, it appears that the natural cleansing affect of natural gas caused these opacity excursions. The other four excess opacity readings recorded during the second quarter were the result of dust build-up on the optical head assembly. Subsequent cleaning of the assembly returned opacity readings back to normal. There was no apparent cause for the five excess opacity readings recorded during the fourth quarter. Two excess opacity readings for Boiler 7 recorded in February during a soot blowing cycle appear to have been an isolated incident. Changes in the sequence of the soot blowing cycle for Boiler 6 that were made in August 2005 have proven effective in eliminating most opacity exceedances due to soot blowing. Similar changes made to the soot blowing cycle on Boiler 7 after the installation of a new soot blowing controller in March 2006 have also been successful in eliminating most soot blowing opacity exceedances from this boiler. 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, with opacity levels lower than the regulatory limits established for these boilers.

To satisfy quality assurance requirements for the continuous emissions monitoring system of the Laboratory's Title V operating permit, a relative accuracy test audit (RATA) of the Boilers 6 and 7 continuous emissions monitoring systems for NO_x and CO_2 was conducted in December 2009. The results of the RATA demonstrated that the Boiler 6 and 7 NO_x and CO_2 continuous emissions monitoring systems met RATA acceptance criteria, which are defined in 40 CFR 60, Appendix B, Specifications 2 and 3.

Table 4-5. Central Steam Facility Fuel Use and Emissions (2000 – 2009).

Annual Fuel Use and Fuel Heating Values							Emissions			
Year	No. 6 Oil (10^3 gals)	Heating Value (MMBtu)	No. 2 Oil (10^3 gals)	Heating Value (MMBtu)	Natural Gas (10^6 ft^3)	Heating Value (MMBtu)	TSP (tons)	NO_x (tons)	SO_2 (tons)	VOCs (tons)
2000	2,097.32	309,317	0.82	115	342.40	349,248	9.5	81.6	45.0	1.2
2001	3,645.10	538,847	3.40	476	103.96	106,039	17.5	80.4	77.8	0.8
2002	2,785.04	407,518	0.29	41	220.62	225,030	15.4	62.4	53.8	1.0
2003	4,290.95	628,765	402.06	56,288	0.98	1,000	22.8	75.3	107.1	0.6
2004	4,288.76	628,063	2.45	343	0.11	109	16.4	81.9	104.7	2.4
2005	4,206.12	618,590	0.87	122	0.00	0	15.2	80.4	93.1	2.4
2006	2,933.00	432,430	0.22	30	191.35	195,177	11.8	66.9	66.3	2.2
2007	2,542.85	374,432	0.00	0	263.04	268,301	9.7	77.3	59.3	2.2
2008	1,007.49	148,939	0.10	736	496.48	506,406	5.7	46.7	23.0	1.9
2009	1,904.32	283,734	0.00	0	375.03	382,529	9.0	53.4	44.9	2.1
Permit Limit (in tons)							113.3	159.0	445.0	39.7

Notes:
NO_x = Oxides of Nitrogen
SO_2 = Sulfur Dioxide
TSP = Total Suspended Particulates
VOCs = Volatile Organic Compounds

In 2009, residual fuel prices from May through December exceeded those of natural gas. As a result, natural gas was used to supply more than 98 percent of the heating and cooling needs of BNL's major facilities during these months. Natural gas supplied approximately 57 percent of major facility heating and cooling needs for the year. By comparison, in 2005, residual fuel satisfied more than 99.9 percent of the major facility heating and cooling needs. Consequently, 2009 emissions of particulates, NO_x, and sulfur dioxide (SO_2) were 6.2, 27.0, and 48.2 tons less than the respective totals for 2005. All emissions were well below the respective permit limits of 113.3, 159, and 445 tons. Table 4-5 shows fuel use and emissions since 2000.

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5 Water Quality

Wastewater generated from Brookhaven National Laboratory (BNL) operations is discharged to surface waters via the Sewage Treatment Plant (STP) and to groundwater via 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 requirements and that the public, employees, and environment are protected.

Analytical data for 2009 show that the average gross alpha and beta activity levels in the STP discharge were within the typical range of historical levels and were well below drinking water standards. During 2009, tritium was detected in the STP effluent only once at a concentration above the minimum detectable activity (490 pCi/L), which is less than 3 percent of the drinking water standard. Tritium was also detected twice in the influent, but at levels just above the minimum detectable activity. Analysis of the STP effluent continued to show no detection of cesium-137, strontium-90, or other gamma-emitting nuclides attributable to BNL operations. Similarly, there were no radionuclides detected along the Peconic River in 2009 that were attributable to BNL operations.

Nonradiological monitoring of the STP effluent showed that, except for isolated incidents of noncompliance, organic and inorganic parameters were within State Pollutant Discharge Elimination System effluent limitations or other applicable standards.

Examination of analytical data for discharges to recharge basins shows that the average concentrations of gross alpha and beta activity were within typical ranges and no gamma-emitting radionuclides were detected in 2009. Tritium was detected in a single sample collected at Basin HT-W at a very low level (400 ± 220 pCi/L), and with high uncertainty. Review of organic data shows that disinfection byproducts are detected 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) are also detected in these discharges, primarily from sediment run-off in stormwater discharges. Inorganic data from Peconic River samples collected upstream, downstream, and at control locations demonstrated that elevated amounts of aluminum and iron detected in the river are associated with natural sources.

5.1 SURFACE WATER MONITORING PROGRAM

Treated wastewater from the BNL STP is discharged into the headwaters of the Peconic River. This discharge is permitted under the New York State Department of Environmental Conservation (NYSDEC) State Pollutant Discharge Elimination System (SPDES) Program. Effluent limits are based on the water quality standards established by NYSDEC, as well as historical operational data. To assess the impact of wastewater discharge on the quality of the river, surface water is monitored at several locations upstream and downstream of the discharge point. Monitoring Station HY (see Fig-

ure 5-8), on site but upstream of all Laboratory operations, provides information on the background water quality of the Peconic River. The Carmans River is monitored as a geographic control location for comparative purposes, as it is not affected by operations at BNL or within the Peconic River watershed.

On the Laboratory site, the Peconic River is an intermittent stream. Off-site flow occurs only during periods of sustained precipitation, typically in the spring. Off-site flow in 2009 was only persistent through late July, and then started flowing again in mid-November. When flow ceased, standing water was continuous throughout the year in several of the deeper sections of the river. The following sections describe BNL's surface water monitoring and surveillance program.

5.2 SANITARY SYSTEM EFFLUENTS

The STP effluent (Outfall 001) is a discharge point authorized under a SPDES permit issued by NYSDEC. Figure 5-1 shows a schematic of the STP and its sampling locations. The Laboratory's STP treatment process includes four principal steps: 1) aerobic oxidation for secondary removal of biological matter and nitrification of ammonia, 2) secondary clarification, 3) sand filtration for final solids removal, and 4) ultraviolet disinfection for bacterial control prior to discharge to the Peconic River. Tertiary treatment for nitrogen removal is also provided by controlling the oxygen levels in the aeration tanks. During the aeration process (Step 1), the oxygen levels are allowed to drop to the point where microorganisms use nitrate-bound oxygen for respiration; this liberates nitrogen gas and consequently reduces the concentration of nitrogen in the STP discharge.

Nitrogen is an essential nutrient in biological systems that, in high concentrations, can cause excessive aquatic vegetation growth. During the night (when photosynthesis does not occur), aquatic plants use oxygen in the water. Too much oxygen uptake by aquatic vegetation deprives a water system of oxygen needed by fish

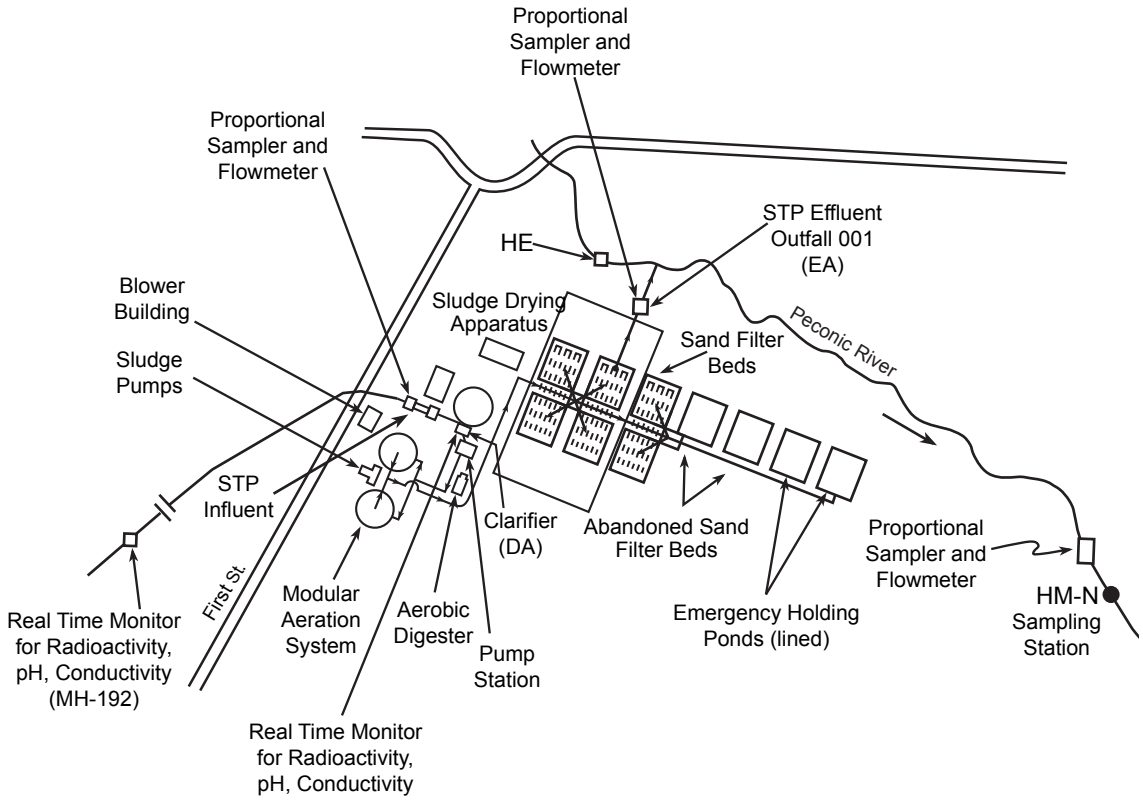


Figure 5-1. Schematic of BNL's Sewage Treatment Plant (STP).

and other aquatic organisms for survival. Limiting the concentration of nitrogen in the STP discharge helps keep plant growth in the Peconic River in balance with the nutrients provided by natural sources.

Real-time monitoring of the sanitary waste stream for radioactivity, pH, and conductivity takes place at two locations. The first site (MH-192, see Figure 5-1) is approximately 1.1 miles upstream of the STP, providing at least 30 minutes' warning to the STP operators if wastewater is en route that may exceed SPDES limits or BNL effluent release criteria (which are more stringent than DOE-specified levels). The second site is at the point where the STP influent enters the treatment process, as shown in Figure 5-1.

Based on the data collected by the real-time monitoring systems, any influent to the STP that may not meet SPDES limits or BNL effluent release criteria (whichever is more stringent) is diverted to two double-lined holding ponds. The total combined capacity of the two holding ponds exceeds 6 million gallons, or approximately 18 days of flow. Diversion continues until the effluent's water quality meets the permit limits or release criteria. If wastewater is diverted to the holding ponds, it is tested and evaluated against the requirements for release. If necessary, the wastewater is treated and then reintroduced into the STP at a rate that ensures compliance with SPDES permit limits for non-radiological parameters or BNL effluent release criteria for radiological parameters. In 2009, there were no instances that required diversion of the waste water to the hold-up ponds.

Solids separated in the clarifier are pumped to aerobic digesters for continued biological solids reduction and sludge thickening. Until 2007, the thickened sludge was periodically emptied into solar/heat lamp-powered drying beds, where it was dried to a solid cake. The dried sludge historically contained very low levels (less than 0.5 pCi/g) of radioactivity, such as residual levels of cobalt-60 (Co-60: half-life 5.2 years) from sewage releases. Consequently, the dried sludge was dispositioned as low-level radioactive waste. In an effort to reduce a high inventory of sludge stored in the aerobic digesters, in 2007 the Laboratory retained the services of Mineral Processing Services to process the sludge for drying and eventual off-site disposal. The sludge was processed in late 2007 and placed into Geotubes (large filter bags) and left to dry throughout 2008. In the summer of 2009, the dried sludge was mixed with sand from the sand filter beds and disposed off site at a landfill authorized by NYSDEC. New sand was placed in the filter beds and they were placed back into service. With the clean-out of the digesters, newly generated sludge was analyzed and found to be free of radiological contamination. In 2008, authorization was received from the local County authority to transfer waste sludge directly from the aerobic digester to the County-operated sewage treatment facility. In 2009, two shipments (approximately 50,000 gallons of sludge each) were released to the County sewage works at Bergen Point after waste characterization samples of the sludge were found to be acceptable.

5.2.1 Sanitary System Effluent–Radiological Analyses

Wastewater at the STP is sampled at the inlet to the treatment process, Station DA (see Figure 5-1) and at the Peconic River Outfall (Station EA). At each location, samples are collected on a flow-proportional basis; that is, for every 1,000 gallons of water treated, approximately 4 fluid ounces of sample are collected and composited into a 5-gallon collection container. These samples are analyzed for gross alpha and gross beta activity and for tritium concentrations. In 2009, samples were collected three times weekly. Samples collected from these locations are also composited and analyzed monthly for gamma-emitting radionuclides and strontium-90 (Sr-90: half-life 29 years).

Although the Peconic River is not used as a direct source of potable water, the Laboratory applies the stringent Safe Drinking Water Act (SDWA) standards for comparison purposes when monitoring the effluent, in lieu of DOE wastewater criteria. Under the SDWA, water standards are based on a 4 mrem (40 μSv) dose limit. The SDWA specifies that no individual may receive an annual dose greater than

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

		Flow (a) (Liters)	**Tritium** (pCi/L)		**Gross Alpha** (pCi/L)		**Gross Beta** (pCi/L)	
			max.	avg.	max.	avg.	max.	avg.
January	*influent*	2.50E+7	< 380	-6.2 ± 68.5	< 1.4	0.6 ± 0.2	7.2 ± 1.6	4.6 ± 1.0
	effluent	2.02E+7	< 350	8.1 ± 54.4	< 1.7	0.5 ± 0.3	5.9 ± 1.2	4.1 ± 0.4
February	*influent*	2.21E+7	360 ± 210	80.8 ± 64.3	< 1.3	0.1 ± 0.2	9.2 ± 1.5	5.4 ± 0.8
	effluent	1.74E+7	< 330	100.8 ± 48.5	< 1.4	0.3 ± 0.3	6.1 ± 1.3	4.8 ± 0.5
March	*influent*	2.84E+7	< 250	43.8 ± 45.7	5.5 ± 3.7	0.7 ± 0.8	6.3 ± 1.1	4.4 ± 0.6
	effluent	2.16E+7	< 270	57.7 ± 48.8	< 2.6	0.4 ± 0.3	5.6 ± 1.1	4.4 ± 0.4
April	*influent*	3.66E+7	630 ± 220	92.3 ± 97.4	1.6 ± 1.1	0.7 ± 0.3	6.9 ± 1.2	4.4 ± 0.7
	effluent	3.12E+7	< 310	84.3 ± 56	< 1.3	0.2 ± 0.2	5.6 ± 1.3	3.8 ± 0.4
May	*influent*	2.31E+6	< 330	78.1 ± 66.9	3.5 ± 1.6	0.9 ± 0.5	6.8 ± 1.4	5.6 ± 0.5
	effluent	3.19E+7	< 330	89.9 ± 55.1	< 1.3	0.2 ± 0.3	5.5 ± 1.2	4.1 ± 0.4
June	*influent*	3.57E+7	< 310	14.9 ± 50.6	5.4 ± 2.7	1.4 ± 0.8	10.4 ± 2.2	6.4 ± 1.0
	effluent	2.89E+7	< 310	87.7 ± 30.2	< 1.5	0.0 ± 0.2	6.2 ± 1.2	5.0 ± 0.3
July	*influent*	4.04E+7	< 300	71.6 ± 47.1	3.5 ± 1.8	1.2 ± 0.6	8.0 ± 1.5	5.3 ± 0.8
	effluent	4.14E+7	< 310	103.8 ± 38.5	< 2.6	0.5 ± 0.4	6.5 ± 1.2	4.7 ± 0.7
August	*influent*	3.86E+7	< 420	12.5 ± 49.6	6.4 ± 2.7	2.3 ± 1.0	11.4 ± 1.8	6.4 ± 1.6
	effluent	4.27E+7	< 380	75.5 ± 48.5	< 1.9	0.4 ± 0.3	7.1 ± 1.4	5.3 ± 0.7
September	*influent*	1.91E+7	< 160	23.6 ± 29.4	6.8 ± 3.1	2.3 ± 1.7	12.9 ± 3.4	7.2 ± 2.2
	effluent	1.81E+7	< 170	32.7 ± 30.8	5.0 ± 2.3	1.2 ± 1.3	7.7 ± 1.7	5.4 ± 1.2
October	*influent*	1.22E+7	< 160	23.2 ± 27.7	2.6 ± 1.1	1.0 ± 1.3	5.6 ± 1.1	4.3 ± 1.2
	effluent	1.19E+7	< 190	39.2 ± 44.5	2.1 ± 1.0	0.7 ± 1.0	6.7 ± 1.2	5.3 ± 0.9
November	*influent*	3.44E+7	< 340	39.8 ± 41.9	< 2.2	0.5 ± 0.3	6.1 ± 1.1	4.3 ± 0.8
	effluent	3.37E+7	490 ± 230	83.5 ± 78.6	< 1.5	0.5 ± 0.3	5.2 ± 1.1	4.1 ± 0.3
December	*influent*	3.89E+7	< 120	22.2 ± 31.1	< 1.6	0.4 ± 0.3	6.4 ± 1.2	4.8 ± 0.7
	effluent	3.63E+7	< 120	14 ± 35.2	1.5 ± 1.0	0.5 ± 0.4	6.2 ± 1.3	4.2 ± 0.5
Annual Avg.	*influent*	2.78E+7		43.2 ± 17.6		1.0 ± 0.2		5.3 ± 0.3
	effluent	2.79E+7		67.8 ± 15.3		0.4 ± 0.1		4.5 ± 0.2
Total Release		**3.35E+8**		**22.3 mCi**		**0.1 mCi**		**1.4 mCi**
Average MDL (pCi/L)				**270.7**		**1.6**		**1.2**
SDWA Limit (pCi/L)				**20,000**		**15**		**(b)**

Notes:
All values are reported with a 95% confidence interval.
Negative numbers occur when the measured value is lower than background (see Appendix B for description).
To convert values from pCi to Bq, divide by 27.03.
MDL = Minimum Detection Limit
SDWA = Safe Drinking Water Act
(a) Effluent values greater than influent values occur when water that had been diverted to the holding ponds is tested, treated (if necessary), and released.
(b) The drinking water standards were changed from 50 pCi/L (concentration based) to 4 mrem/yr (dose based) in 2003. As gross beta activity does not identify specific radionuclides, a dose equivalent cannot be calculated for the values in the table.

4 mrem from radionuclides that are beta or photon emitters, which includes up to 168 individual radioisotopes. The Laboratory performs radionuclide-specific gamma analysis to ensure compliance with this standard. The SDWA annual average gross alpha activity limit is 15 pCi/L, including radium-226 (Ra-226: half-life 1,600 years), but excluding radon and uranium.

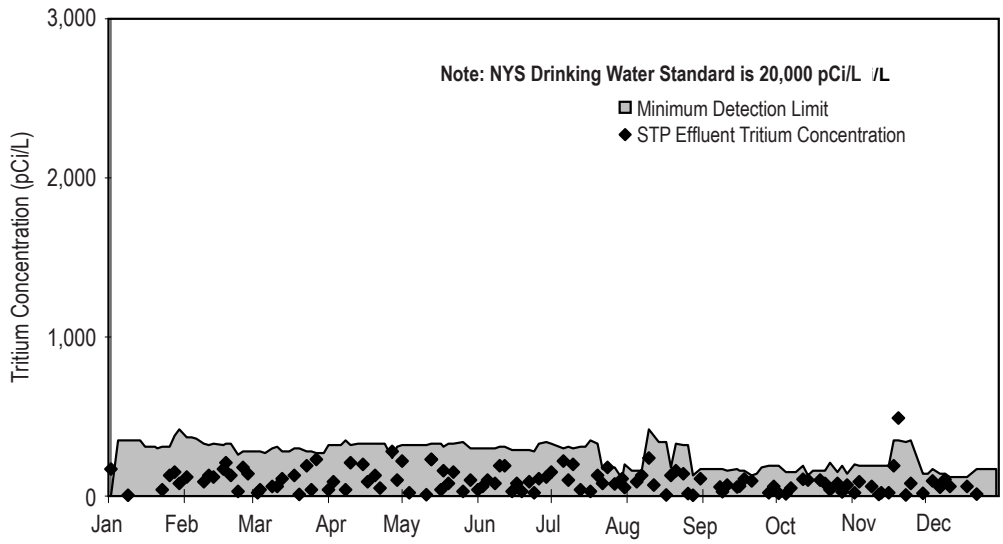


Figure 5-2. Tritium Concentrations in Effluent from the BNL Sewage Treatment Plant (2009).

Other SDWA-specified drinking water limits are 20,000 pCi/L for tritium (H-3: half-life 12.3 years), 8 pCi/L for Sr-90, 5 pCi/L for Ra-226 and radium-228 (Ra-228: half-life 5.75 years), and 30 µg/L for uranium. Gross activity (alpha and beta) measurements are used as a screening tool for detecting the presence of radioactivity. Table 5-1 shows the monthly gross alpha and beta activity data and tritium concentrations for the STP influent and effluent during 2009. Annual average gross alpha and beta activity levels in the STP effluent were 0.4 ± 0.1 pCi/L and 4.5 ± 0.2 pCi/L, respectively. These concentrations remain essentially unchanged from year to year. Control location data (Carmans River Station HH; see Figure 5-8) show average gross alpha and beta levels of 0.22 ± 0.68 pCi/L and 1.45 ± 1.1 pCi/L, respectively (see Table 5-7). The average concentrations of gross alpha and beta activity in Peconic River water samples collected upstream of BNL were 0.49 ± 0.33 pCi/L and 2.48 ± 1.17 pCi/L, respectively.

Tritium detected at the STP originates from either High Flux Beam Reactor (HFBR) sanitary system releases, or from small, infrequent batch releases that meet BNL discharge criteria from other facilities. Although the HFBR is no longer operating, tritium continues to be released from the facility at very low concentrations due to off-gassing. When the HFBR was operating, air within the reactor building contained higher levels of tritium in the form of water vapor. The water was absorbed by many porous surfaces and materials, which slowly liberated the tritiated moisture as it is replaced by untritiated water. Once tritium is in the air stream, it condenses as a component of water vapor in the air conditioning or air compressor units and is discharged in these wastewater streams. To minimize the quantity of tritium released to the STP, efforts have been made to capture most of the air compressor condensate collected in the equipment areas of the structure. A plot of the 2009 tritium concentrations recorded in STP effluent is presented in Figure 5-2. A 15-year trend plot of annual average tritium concentrations measured in the STP discharge is shown in Figure 5-3. The annual average concentration trend has been declining since 1995.

In 2009, with the exception of a single low-level reported value, tritium was not detected in the discharge of the STP (EA, Outfall 001) for the entire year. The concentration measured in the single sample of the STP discharge in November (see Figure 5-2) was 490 ± 230 pCi/L. Although this was a low level of detection with high uncertainty, this concentration may be attributed to work to further ready the HFBR for decommissioning and decontamination (D&D). Residual moisture within the HFBR piping systems may have been exposed during D&D activities and could result in higher tritium releases to the STP. The annual average

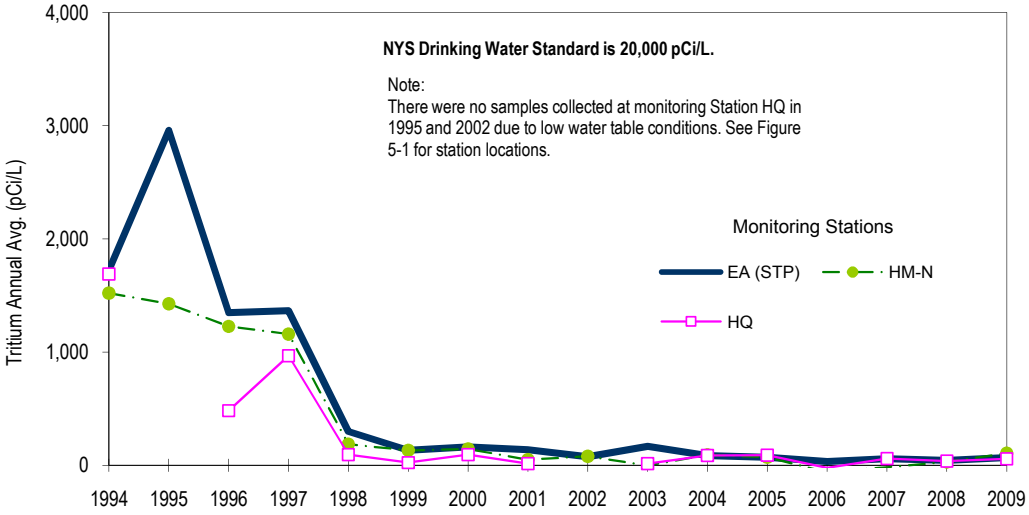


Figure 5-3. Sewage Treatment Plant/Peconic River Annual Average Tritium Concentrations (1994–2009).

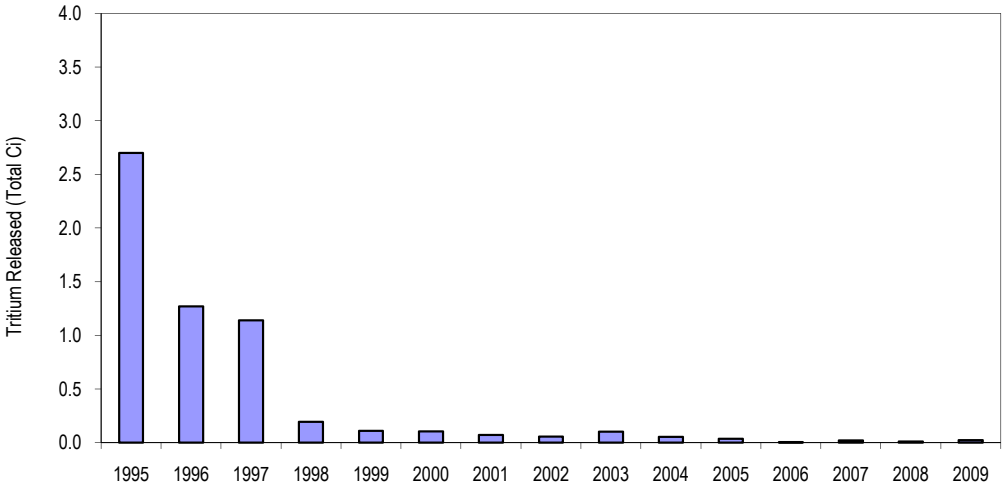


Figure 5-4. Tritum Released to the Peconic River, 15-Year Trend (1995–2009).

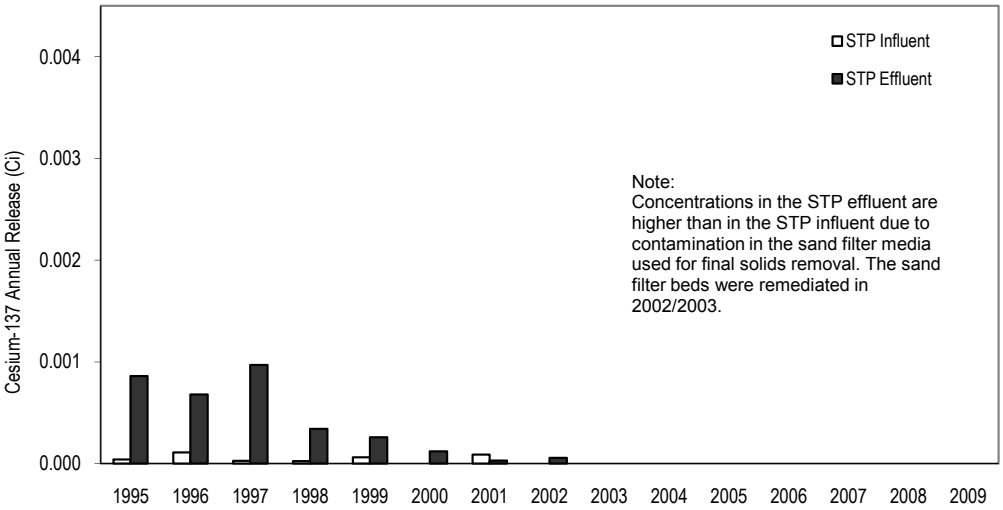


Figure 5-5. Cesium-137 in the BNL Sewage Treatment Plant Influent and Effluent (1995–2009).

tritium concentration, as measured in the STP effluent, was 67.8 ± 15.3 pCi/L, which is only 25 percent of the average MDL, 270 pCi/L, and well below the drinking water standard (DWS) of 20,000 pCi/L. Using the annual average concentration and the flow recorded for the year, a total of 0.022 Ci (22.3 mCi) of tritium was released during the year, which is consistent with total releases of tritium over the last five years (see Figure 5-4). Low levels of tritium were also detected in two influent samples collected in February and April 2009 (360 ± 210 pCi/L and 630 ± 220 pCi/L, respectively) and were also most likely attributed to D&D work at the HFBR.

Table 5-2 presents the gamma spectroscopy data for anthropogenic radionuclides historically detected in the monthly STP wastewater composite samples. In 2009, there were no gamma-emitting nuclides detected in the STP effluent, which is consistent with data reported for 2003–2008 (see Figure 5-5). Sr-90 was detected (0.83 pCi/L) in a single sample of influent collected in July but was not detectable in the effluent.

Table 5-2. Gamma-Emitting Radionuclides and Strontim-90 in Water at the BNL Sewage Treatment Plant.

		Flow (Liters)	Co-60	Cs-137	Be-7	Na-22	Sr-90
			(pCi/L)				
January	*influent*	2.50E+7	ND	ND	ND	ND	ND
	effluent	2.02E+7	ND	ND	ND	ND	ND
February	*influent*	2.21E+7	ND	ND	ND	ND	ND
	effluent	1.74E+7	ND	ND	ND	ND	ND
March	*influent*	2.84E+7	ND	ND	ND	ND	ND
	effluent	2.16E+7	ND	ND	ND	ND	ND
April	*influent*	3.66E+7	ND	ND	ND	ND	ND
	effluent	3.12E+7	ND	ND	ND	ND	ND
May	*influent*	2.31E+6	ND	ND	ND	ND	ND
	effluent	3.19E+7	ND	ND	ND	ND	ND
June	*influent*	3.57E+7	ND	ND	ND	ND	ND
	effluent	2.89E+7	ND	ND	ND	ND	ND
July	*influent*	4.04E+7	ND	ND	ND	ND	0.83
	effluent	4.14E+7	ND	ND	ND	ND	ND
August	*influent*	3.86E+7	ND	ND	ND	ND	ND
	effluent	4.27E+7	ND	ND	ND	ND	ND
September	*influent*	1.91E+7	ND	ND	ND	ND	ND
	effluent	1.81E+7	ND	ND	ND	ND	ND
October	*influent*	1.22E+7	ND	ND	ND	ND	ND
	effluent	1.19E+7	ND	ND	ND	ND	ND
November	*influent*	3.44E+7	ND	ND	ND	ND	ND
	effluent	3.37E+7	ND	ND	ND	ND	ND
December	*influent*	3.89E+7	ND	ND	ND	ND	ND
	effluent	3.63E+7	ND	ND	ND	ND	ND
Total Release to the Peconic River (mCi)			**0**	**0**	**0**	**0**	**0**
DOE Order 5400.5 DCG (pCi/L)			**5,000**	**3,000**	**50,000**	**10,000**	**1,000**
Dose limit of 4 mrem EDE (pCi/L)			**100**	**200**	**6,000**	**400**	**8**

Notes:
No BNL-derived radionuclides were detected in the effluent to the Peconic River for 2009.
To convert values from pCi to Bq, divide by 27.03.
DCG = Derived Concentration Guide
EDE = Effective Dose Equivalent
ND = Not Detected

5.2.2 Sanitary System Effluent – Nonradiological Analyses

In addition to the compliance monitoring discussed in Chapter 3, effluent from the STP is also monitored for nonradiological contaminants under the BNL Environmental Surveillance Program. Data are collected for field-measured parameters such as temperature, specific conductivity, pH, and dissolved oxygen, as well as inorganic parameters such as chlorides, nitrates, sulfates, and metals. Composite samples of the STP effluent are collected using a flow-proportional refrigerated sampling device (ISCO Model 3700RF) and are then analyzed by contract analytical laboratories. Samples are analyzed for 23 inorganic elements and for anions, semivolatile organic compounds (SVOCs), pesticides, and herbicides. In addition, grab samples are collected monthly from the STP effluent and analyzed for 38 different volatile organic compounds (VOCs). Daily influent and effluent logs are maintained by the STP operators for flow, pH, temperature, and settleable solids, as part of routine monitoring of STP operations.

Table 5-3 summarizes the water quality and inorganic analytical results for the STP samples. Comparing the effluent data to the SPDES effluent limits (or New York State Ambient Water Quality Standards [NYS AWQS], as appropriate) shows that most of the analytical parameters were within effluent permit limits (see also the compliance data in Chapter 3). Only total aluminum, iron, and zinc were detected in the effluent at concentrations exceeding the SPDES permit limits or ambient water quality standards. Aluminum was detected in a single sample in July at a concentration of 107 µg/L, which is just above the NYS AWQS limit of 100 µg/L. Iron was detected in a single sample in April at a concentration of 0.8 mg/L, approximately two times the SPDES limit of 0.37 mg/L, and zinc was detected in May at a concentration of 134 µg/L, which is just above the SPDES limit of 100 µg/L. Review of the STP monthly reports for each of these months indicate that all of these excursions were likely associated with the decant of water from the aerobic digesters that occurred prior to collecting effluent samples. Samples of decant collected in the past have shown high concentrations of aluminum, iron, and zinc. Aluminum is also regulated in the ionic (i.e., dissolved) form. All data reported in Table 5-3 are for "total recoverable," which includes suspended and dissolved fractions; consequently, the data are conservative (err on the side of caution). The iron concentration is consistent with the compliance data reported in Chapter 3, and since the SPDES permit limit for zinc is represented as 0.1 mg/L, with standard rounding, the measured value would not constitute a violation of the limit.

In 2009, two VOCs were detected in the STP effluent, but at very low concentrations. Methyl chloride was detected on one occasion with a concentration estimated at less than 1 µg/L, and much less than the NYS AWQS of 5 µg/L. Acetone was also detected, at concentrations ranging from 1.5 µg/L to a maximum of 6.8 µg/L. Acetone is a common solvent used in the contract analytical laboratory and is routinely detected due to cross-contamination within the contract analytical laboratory.

5.3 PROCESS-SPECIFIC WASTEWATER

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

The Laboratory's SPDES permit includes requirements for quarterly sampling and analysis of process-specific wastewater discharged from printed-circuit-board fabrication operations conducted in Building 535B, metal cleaning operations in Building 498, and cooling tower discharges from Building 902. These operations are monitored for contaminants such as metals, cyanide, VOCs, and SVOCs. In 2009, analyses of these waste streams showed that, although

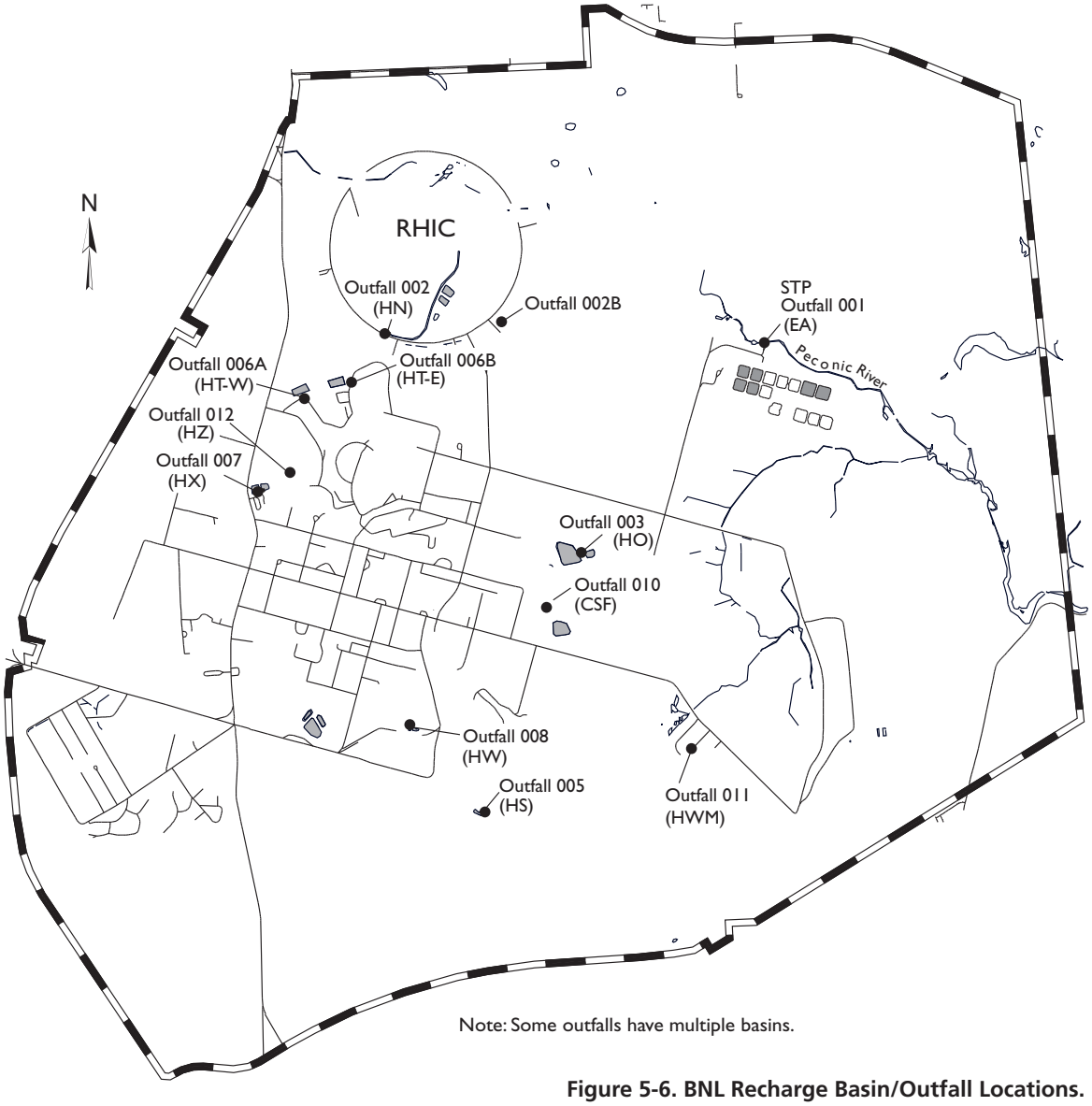
Table 5-3. BNL Sewage Treatment Plant (STP) Water Quality and Metals Analytical Results.

		STP Influent				STP Effluent				SPDES Limit or AWQS (1)	Comment or Qualifier
ANALYTE	*Units*	N	Min.	Max.	Avg.	N	Min.	Max.	Avg.		
pH	SU	CM	6.8	7.9	NA	CM	6.1	8.0	NA	5.8 - 9.0	
Conductivity	µS/cm	CM	NR	NR	NR	172(a)	136	746	361.4	SNS	
Temperature	°C	CM	NR	NR	NR	172(a)	3.5	26.2	14.3	SNS	
Dissolved Oxygen	mg/L	NM	NM	NM	NM	172(a)	6.1	14.3	9.9	SNS	
Chlorides	mg/L	12	48.7	118.0	66.1	12	39.6	136.0	64.1	SNS	
Nitrate (as N)	mg/L	11	0.1	3.1	1.7	11	0.7	6.7	3.7	10	Total N
Sulfates	mg/L	12	1.8	19.8	15.1	12	11.7	19.9	17.3	250	GA
Aluminum	µg/L	12	116.0	5950.0	849.1	12	17.1	107.0	60.9	100	Ionic
Antimony	µg/L	12	0.5	13.9	< 10	12	0.3	< 10	< 10	3	GA
Arsenic	µg/L	12	0.8	23.7	< 10	12	1.2	< 10	< 10	150	Dissolved
Barium	µg/L	12	29.7	915.0	173.9	12	14.4	28.6	19.3	1000	GA
Beryllium	µg/L	12	0.1	< 4	< 4	12	0.1	< 4	< 4	11	Acid Soluble
Cadmium	µg/L	12	0.4	8.2	< 2	12	0.2	0.6	0.4	1.1	Dissolved
Calcium	mg/L	12	10.9	23.8	14.9	12	10.1	18.1	13.1	SNS	
Chromium	µg/L	12	3.5	57.1	< 20	12	3.0	< 20	< 20	34.4	Dissolved
Cobalt	µg/L	12	0.3	21.1	3.2	12	0.3	1.1	0.7	5	Acid Soluble
Copper	µg/L	12	49.7	5720.0	750.9	12	25.8	69.8	45.8	150	SPDES
Iron	mg/L	12	0.6	20.4	3.2	12	0.1	0.8	0.3	0.37	SPDES
Lead	µg/L	12	3.1	550.0	64.2	12	1.0	5.5	3.2	19	SPDES
Magnesium	mg/L	12	2.9	6.7	4.3	12	2.7	5.4	3.8	SNS	
Manganese	µg/L	12	19.1	194.0	62.1	12	2.5	11.9	6.5	300	GA
Mercury	µg/L	12	0.1	5.2	0.9	12	0.1	0.2	< 0.2	0.2	SPDES
Nickle	µg/L	12	2.7	224.0	32.0	12	3.2	13.7	7.3	110	SPDES
Potassium	mg/L	12	3.8	10.5	6.4	12	3.2	7.5	4.7	SNS	
Selenium	µg/L	12	0.4	7.4	< 5	12	0.2	< 10	< 10	4.6	Dissolved
Silver	µg/L	12	0.4	34.2	4.3	12	0.7	3.9	2.0	15	SPDES
Sodium	mg/L	12	30.8	91.6	47.1	12	25.5	78.3	43.0	SNS	
Thallium	µg/L	12	0.1	< 10	< 10	12	0.2	< 10	< 10	8	Acid Soluble
Vanadium	µg/L	12	3.2	115.0	12.7	12	3.3	< 10	< 10	14	Acid Soluble
Zinc	µg/L	12	46.2	4790.0	589.6	12	30.5	134.0	72.7	100	SPDES

Notes:
See Figure 5-1 for locations of the STP influent and effluent monitoring locations.
All analytical results were generated using total recoverable analytical techniques.
For Class C Ambient Water Quality Standards (AWQS), the solubility state for the metal is provided.
(1) Unless otherwise provided, the reference standard is NYSDEC Class C Surface Water Ambient Water Quality Standards (AWQS).
(a) The conductivity, temperature, and dissolved oxygen values reported are based on analyses of daily grab samples.
AWQS = Ambient Water Qualty Standards
NR = Not Recorded
CM = Continuously monitored
NYSDEC = New York State Department of Environmental Conservation
GA = Class GA (groundwater) AWQS
SNS = Standard Not Specified
N = Number of samples
SPDES = State Pollutant Discharge Elimination System
NA = Not Applicable
SU = Standard Units
NM = Not Monitored

several operations contributed contaminants (principally metals) to the STP influent in concentrations exceeding SPDES-permitted levels, these discharges did not affect the quality of the STP effluent.

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



Note: Some outfalls have multiple basins.

Figure 5-6. BNL Recharge Basin/Outfall Locations.

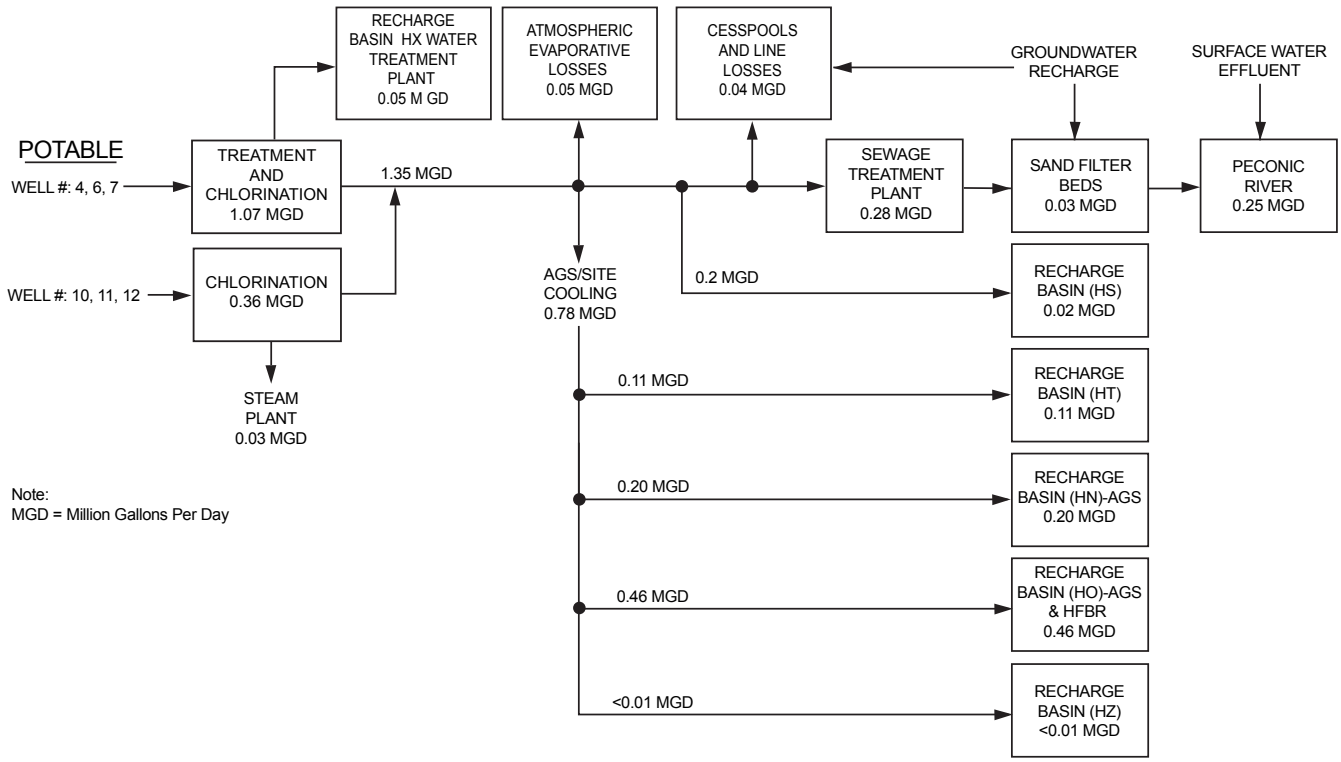


Figure 5-7. Schematic of Potable Water Use and Flow at BNL.

5.4 RECHARGE BASINS

Recharge basins are used for the discharge of "clean" wastewater streams, including once-through cooling water, stormwater runoff, and cooling tower blowdown. With the exception of elevated temperature and increased natural sediment content, these wastewaters are suitable for direct replenishment of the groundwater aquifer. Figure 5-6 shows the locations of the Laboratory's discharges to recharge basins (also called "outfalls" under BNL's SPDES permit). Figure 5-7 presents an overall schematic of potable water use at the Laboratory. Eleven recharge basins are used for managing once-through cooling water, cooling tower blowdown, and stormwater runoff:

- Basins HN, HT-W, and HT-E receive once-through cooling water discharges generated at the Alternating Gradient Synchrotron (AGS) and Relativistic Heavy Ion Collider (RHIC), as well as cooling tower blowdown and stormwater runoff.
- Basin HS receives predominantly stormwater runoff, once-through cooling water from Building 555 (Chemistry Department), and minimal cooling tower blowdown from the National Synchrotron Light Source (NSLS).
- Basin HX receives Water Treatment Plant filter backwash water.
- Basin HO receives cooling water discharges from the AGS and stormwater runoff from the area surrounding the HFBR.
- Several other recharge areas are used exclusively for discharging stormwater runoff. These areas include Basin HW in the former warehouse area, Basin CSF at the Central Steam Facility (CSF), Basin HW-M at the former Hazardous Waste Management Facility (HWMF), and Basin HZ near Building 902.

Each of the recharge basins is a permitted point-source discharge under the Laboratory's SPDES permit. Where required by the permit, the discharge to the basin is equipped with a flow monitoring station; weekly recordings of flow are collected, along with measurements of pH. The specifics of the SPDES compliance monitoring program are provided in Chapter 3. To supplement the monitoring program, sam-

Table 5-4. Radiological Analysis of Samples from On-Site Recharge Basins at BNL.

Basin		Gross Alpha	Gross Beta	Tritium
		(pCi/L)		
No. of samples		4	4	4
HN	*max.*	< 1.3	< 1.5	< 310
	avg.	-0.03 ± 1.04	0.31 ± 1.17	80.5 ± 62.5
HO	*max.*	< 1.2	5.3 ± 1	< 290
	avg.	-0.03 ± 0.47	2.42 ± 2.01	36 ± 28.07
HS	*max.*	4.2 ± 1.5	7.1 ± 1.2	< 300
	avg.	1.34 ± 1.88	3.95 ± 2.4	91 ± 114.25
HT-E	*max.*	< 3.9	64 ± 62	< 310
	avg.	-11.95 ± 24.86	20.12 ± 28.99	130 ± 104.02
HT-W	*max.*	< 1.6	< 1.2	400 ± 220
	avg.	0.57 ± 0.51	0.62 ± 0.24	186.5 ± 143.26
HW	*max.*	72 ± 19	81 ± 15	< 300
	avg.	35.35 ± 28.62	22.24 ± 23.33	87 ± 65.17
HZ	*max.*	< 1	1.7 ± 1	< 320
	avg.	0.09 ± 0.25	1.12 ± 0.47	-2.5 ± 84.82
SDWA Limit		15	(a)	20,000

Notes:
See Figure 5-6 for the locations of recharge basins/outfalls.
All values reported with a 95% confidence interval.
Negative numbers occur when the measured value is lower than background (see Appendix B for description).
To convert values from pCi to Bq, divide by 27.03.
(a) The drinking water standard was changed from 50 pCi/L (concentration based) to 4 mrem/yr (dose based) in 2003. As gross beta activity does not identify specific radionuclides, a dose equivalent of this value cannot be calculated.
MDL = Minimum Detection Limit
SDWA = Safe Drinking Water Act
* Samples typically collected 4x per year. HW was sampled 5x in 2009.

ples are also routinely collected and analyzed under BNL's Environmental Surveillance Program for radioactivity, VOCs, metals, and anions. During 2009, water samples were collected from all basins listed above except recharge basin HX at the Water Treatment Plant (exempted by NYSDEC from sampling due to documented non-impact to groundwater) and the recharge basin at the former HWMF, as there are no longer any operations that could lead to the contamination of runoff.

5.4.1 Recharge Basins – Radiological Analyses

Discharges to the recharge basins were sampled throughout the year for subsequent analyses for gross alpha and beta activity, gamma-emitting radionuclides, and tritium. These results are presented in Table 5-4 and show that low levels of alpha and beta activity were detected in most of the basins. Typically, low-level detections of gross alpha and beta activity are attributable to very low levels of naturally occurring radionuclides, such as potassium-40 (K-40: half-life 1.3E+09 years). Surface samples collected from Basin HW in September 2009 exhibited much higher than normal gross alpha/beta results (72 ± 19 pCi/L and 81 ± 15 pCi/L, respectively) with increased uncertainty and minimum detection limit. These elevated results were due to the presence of high residual sediments and dissolved solids in the water sample. Significant clearing and other soil disturbance activities associated with the construction of the NSLS-II Project have contributed to much higher than normal sediment content in the stormwater runoff reaching Basin HW, resulting in false positive results for gross alpha/beta activity. To confirm the elevated results were due to mass loading, a filtered water sample collected during the same time and location was analyzed for gross alpha/beta and the results were within normal ranges.

The contract analytical laboratory reported no gamma-emitting nuclides attributable to BNL operations in any discharges to recharge basins in 2009. Tritium was detected in a single sample collected at Basin HT-W at a very low level (400 ± 220 pCi/L) and with high uncertainty. This basin receives discharges from the Collider-Accelerator complex.

5.4.2 Recharge Basins – Nonradiological Analyses

To determine the overall impact on the environment of discharges to the recharge basins, the nonradiological analytical results were compared to groundwater discharge standards promulgated under Title 6 of the New York Codes, Rules, and Regulations (NYCRR), Part 703.6. Samples were collected quarterly for water quality parameters, metals, and VOCs, and were analyzed by a contract analytical laboratory.

Table 5-5. Water Quality Data for BNL On-Site Recharge Basin Samples.

ANALYTE		Recharge Basin HN (RHIC)	HO (AGS)	HS (s)	HT-W (Linac)	HT-E (AGS)	HW (s)	CSF (s)	HZ (s)	NYSDEC Effluent Standard	Typical MDL
No. of samples		4	4	4	4	4	4	4	4		
pH (SU)	*min.*	7.6	7.5	7.4	7.4	7.9	7.2	7.2	7.4	6.5 - 8.5	NA
	max.	8.1	7.9	8.1	8.7 (a)	8.5	8.4	8.3	8.0		
Conductivity (µS/cm)	*min.*	200	53	177	183	126	79	71	86	SNS	NA
	max.	260	217	355	293	4051	202	153	274		
	avg.	222	163	284	225	1381	153	109	193		
Temperature (°C)	*min.*	5.0	14.5	4.0	5.8	5.0	9.2	8.4	4.0	SNS	NA
	max.	8.7	27.9	11.0	8.9	11.7	19.0	18.8	19.4		
	avg.	7.2	19.1	7.0	7.5	7.9	14.2	13.9	14.2		
Dissolved oxygen (mg/L)	*min.*	10.7	7.6	10.0	11.8	9.5	8.1	9.2	8.4	SNS	NA
	max.	11.7	10.3	12.6	13.3	12.2	11.6	11.6	11.0		
	avg.	11.2	9.0	11.5	12.4	10.5	10.0	10.3	9.6		
Chlorides (mg/L)	*min.*	33.7	29.2	24.6	27.3	10.2	10.2	6.2	21.6	500	4
	max.	42.9	37.5	82.4	36.2	22500.0	26.6	17.9	38.1		
	avg.	36.7	32.1	54.9	33.3	5681.3	17.7	10.2	33.3		
Sulfates (mg/L)	*min.*	10.4	9.9	3.7	10.1	3.6	4.1	2.2	7.2	500	4
	max.	12.5	10.6	13.3	11.6	161.0	13.7	5.8	11.2		
	avg.	11.1	10.3	9.3	10.8	54.4	10.4	4.6	9.8		
Nitrate as nitrogen (mg/L)	*min.*	0.2	0.3	0.06	0.2	0.02	0.3	0.1	0.2	10	1
	max.	0.5	0.7	0.4	0.7	0.5	4.5	0.4	0.2		
	avg.	0.3	0.4	0.3	0.4	0.3	1.5	0.2	0.2		

Notes:
See Figure 5-6 for the locations of recharge basins/outfalls.
(a) = The New York State-granted SPDES permit for BNL allows a maximum discharge pH limit of 9.0 SU for this recharge basin.
(s) = stormwater
AGS/HFBR = Alternating Gradient Synchrotron/High Flux Beam Reactor
CSF = Central Steam Facility
Linac = Linear Accelerator
MDL = Minimum Detection Limit
NA = Not Applicable
NYSDEC = New York State Department of Environmental
RHIC = Relativistic Heavy Ion Collider
SNS = Effluent Standard Not Specified

Field-measured parameters (pH, conductivity, and temperature) were routinely monitored and recorded. The water quality and metals analytical results are summarized in Tables 5-5 and 5-6, respectively.

Low concentrations of disinfection byproducts were periodically detected in discharges to several of the basins throughout the year. Sodium hypochlorite and bromine, used to control bacteria in the drinking water and algae in cooling towers, led to the formation of VOCs, including bromoform, chloroform, dibromochloromethane, and dichlorobromomethane. The maximum concentration detected in any of the recharge basins was 11.0 µg/L of bromoform in basin HT-E. Acetone was the only other analyte detected above the MDL for most recharge basins. The concentration of acetone ranged from nondetectable to a maximum of 8.4 µg/L. In most instances, acetone was also found as a contaminant in the contract analytical laboratory, as evidenced by detections in blank samples.

The analytical data in Table 5-5 show that for 2009, the concentrations of all analytes were within effluent standards, except for one high detection of chlorides in Basin HT-E. Chlorides are found to be higher in the discharge samples collected during the winter and are attributed to

road salt used to control snow and ice buildup. This particular sample was collected from HT-E after a rain event, which likely washed out a buildup of road salt in the area that had been left over from previous snow events. High concentrations of sodium confirm road salt as the source of chlorides. The data in Table 5-6 show that almost all of the parameters above respective water quality or groundwater discharge standards (aluminum, arsenic, cobalt, chromium, iron, mercury, manganese, lead, and antimony) were associated with recharge basin HW, which, as described in Section 5.4.1, has received higher than normal amounts of residual sediments and suspended solids in the water samples from NSLS-II construction activities. Due to the prevalence of metals in soils, the presence of these elements is likely due to suspended soil in the samples at the time of collection. Acidification of the samples (part of the analytical process) results in the dissolution of the element and its detection during analysis. This is supported by the observation that the concentrations of metals in all filtered samples except for cobalt were significantly less, and well below the discharge standard or NYS AWQS. Cobalt is found in all filtered water samples and is most likely a result of the filtration and not an indicator of water quality. As these metals are in particulate form in the discharge water, they pose no threat to groundwater quality because the recharge basin acts as a natural filter, trapping particles before they reach the groundwater.

5.4.3 Stormwater Assessment

All recharge basins receive stormwater runoff. Stormwater at BNL is managed by collecting runoff from paved surfaces, roofs, and other impermeable surfaces and directing it to recharge basins via underground piping and above-grade vegetated swales. Recharge basin HS receives most of the stormwater runoff from the central, developed portion of the Laboratory site. Basins HN, HZ, HT-W, and HT-E receive runoff from the Collider–Accelerator complex. Basin HO receives runoff from the Brookhaven Graphite Research Reactor (BGRR) and High Flux Beam Reactor (HFBR) areas. Basin CSF receives runoff from the CSF area and along Cornell Avenue east of Railroad Avenue on site. Basin HW receives runoff from the former warehouse area, and HW-M receives runoff from the fenced area at the former HWMF.

Stormwater runoff at the Laboratory typically has elevated levels of inorganics, and low pH. The inorganics are attributable to high sediment content in stormwater (inorganics occur naturally in native soil). In an effort to further improve the quality of stormwater runoff, BNL has finalized formal procedures for managing and maintaining outdoor work and storage areas. The requirements include covering areas to prevent contact with stormwater, conducting an aggressive maintenance and inspection program, implementing erosion control measures during soil disturbance activities, and restoring these areas when operations cease. Basin sediment sampling is conducted on a 5-year testing cycle to ensure these discharges are not compromising the quality of the basins. Samples were collected in 2007 and results presented in the 2007 Site Environmental Report in Chapter 6. The next sampling event will occur in 2012.

5.5 PECONIC RIVER SURVEILLANCE

Several locations are monitored along the Peconic River to assess the overall water quality of the river and assess any impact from BNL discharges. Sampling points along the Peconic River are identified in Figure 5-8. In total, 10 stations (three upstream and seven downstream of the STP) were regularly sampled in 2009. A sampling station along the Carmans River (HH) was also monitored as a geographic control location, not affected by Laboratory operations or within the Peconic River watershed. All locations were routinely monitored for radiological and nonradiological parameters. The sampling stations are located as follows:

Upstream sampling stations

- HY, on site immediately east of the William Floyd Parkway
- HV, on site just east of the 10:00 o'clock Experimental Hall in the RHIC Ring
- HE, on site approximately 20 feet upstream of the STP outfall (EA)

Table 5-6. Metals Analysis of Water Samples from BNL On-Site Recharge Basins.

METAL		Recharge Basin																NYSDEC Effluent Limit or AWQS	Typical MDL
		HN (RHIC)		HO (AGS)		HS (stormwater)		HT-E (AGS)		HT-W (Linac)		HW (stormwater)		CSF (stormwater)		HZ (stormwater)			
Total (T) or Filtered (F)		T	F	T	F	T	F	T	F	T	F	T	F	T	F	T	F		
No. of samples		4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3		
Ag Silver (µg/L)	*min.*	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	50	2.0
	max.	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	2.6	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0		
	avg.	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0		
Al Aluminum (µg/L)	*min.*	< 50.0	< 50.0	< 50.0	< 50.0	< 50.0	< 50.0	< 50.0	< 50.0	< 50.0	< 50.0	564.0	313.0	358.0	< 50.0	< 50.0	< 50.0	2,000	50
	max.	< 50.0	< 50.0	< 50.0	< 50.0	1450.0	< 50.0	127.0	< 50.0	< 50.0	< 50.0	288000	886.0	1030.0	< 50.0	< 50.0	< 50.0		
	avg.	< 50.0	< 50.0	< 50.0	< 50.0	589.9	< 50.0	59.1	< 50.0	< 50.0	< 50.0	122669	608.3	797.6	< 50.0	< 50.0	< 50.0		
As Arsenic (µg/L)	*min.*	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	0.6	50	5.0
	max.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	23.6	22.8	< 5.0	< 5.0	131.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	7.1	8.2	< 5.0	< 5.0	41.4	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
Ba Barium (µg/L)	*min.*	<20	<20	22.0	24.9	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	2,000	20
	max.	31.5	31.2	33.6	33.9	37.4	32.8	188.0	53.6	33.6	32.7	1360.0	<20	<20	<20	26.5	24.3		
	avg.	24.4	23.7	26.2	30.2	31.0	22.5	70.3	25.9	25.8	23.5	462.1	<20	<20	<20	<20	<20		
Be Beryllium (µg/L)	*min.*	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	SNS	2.0
	max.	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	6.2	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0		
	avg.	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	3.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0		
Cd Cadmium (µg/L)	*min.*	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	10	2.0
	max.	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	14.6	4.2	< 2.0	< 2.0	4.2	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0		
	avg.	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	4.9	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0		
Co Cobalt (µg/L)	*min.*	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	5	0.1
	max.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	6.2	< 5.0	< 5.0	< 5.0	< 5.0	74.8	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	31.1	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
Cr Chromium (µg/L)	*min.*	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	100	10.0
	max.	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	10.1	< 50.0	< 10.0	< 10.0	< 10.0	311.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0		
	avg.	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 50.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0		
Cu Copper (µg/L)	*min.*	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	12.6	10.1	1,000	10.0
	max.	22.5	<10.0	12.4	11.1	<10.0	<10.0	125.0	52.5	23.8	19.6	155.0	<10.0	14.3	<10.0	36.9	20.1		
	avg.	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	53.2	22.3	15.0	10.3	70.8	<10.0	<10.0	<10.0	24.3	14.4		

(continued on next page)

Table 5-6. Metals Analysis of Water Samples from BNL On-Site Recharge Basins *(continued).*

METAL		Recharge Basin																NYSDEC Effluent Limit or AWQS	Typical MDL
		HN (RHIC)		HO (AGS)		HS (stormwater)		HT-E (AGS)		HT-W (Linac)		HW (stormwater)		CSF (stormwater)		HZ (stormwater)			
Total (T) or Filtered (F)		T	F	T	F	T	F	T	F	T	F	T	F	T	F	T	F		
No. of samples		4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3		
Fe Iron (mg/L)	*min.*	0.07	<0.05	0.06	<0.05	0.05	<0.05	0.15	<0.05	<0.05	<0.05	0.52	0.22	0.36	<0.05	<0.05	<0.05	0.6	0.05
	max.	0.18	0.07	0.11	<0.05	1.43	0.06	1.03	0.44	0.06	<0.05	228.00	0.66	1.43	<0.05	0.19	0.05		
	avg.	0.12	0.05	0.07	<0.05	0.64	0.05	0.51	0.17	<0.05	<0.05	90.80	0.40	0.96	<0.05	0.12	<0.05		
Hg Mercury (µg/L)	*min.*	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	1.4	0.2
	max.	< 0.2	< 0.2	< 0.2	< 0.2	0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	1.9	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2		
	avg.	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	0.8	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2		
Mn Manganese (µg/L)	*min.*	7.7	6.1	<5.0	<5.0	<5.0	6.9	5.0	5.9	<5.0	<5.0	8.5	10.2	8.3	<5.0	<5.0	5.6	600	5.0
	max.	24.5	18.2	10.4	<5.0	17.5	10.0	232.0	67.5	5.9	4.2	1880.0	36.2	40.2	15.5	14.6	6.5		
	avg.	16.3	10.2	6.2	<5.0	12.3	8.5	101.1	28.5	<5.0	<5.0	856.0	24.5	21.3	7.8	7.4	6.1		
Na Sodium (mg/L)	*min.*	18.4	18.9	15.8	15.0	15.9	16.0	8.9	8.6	15.6	17.8	8.4	7.2	5.5	5.4	12.5	11.9	SNS	0.25
	max.	34.7	33.9	22.7	22.2	37.8	35.1	13500.0	191.0	35.6	35.3	22.3	19.2	14.7	5.8	24.8	22.2		
	avg.	23.2	24.7	18.4	18.6	28.9	26.2	3431.6	72.7	22.9	25.0	14.9	11.6	7.9	5.6	19.8	18.1		
Ni Nickel (µg/L)	*min.*	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	200	10
	max.	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	22.7	< 10.0	< 10.0	< 10.0	141.0	< 10.0	11.7	< 10.0	< 10.0	< 10.0		
	avg.	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	60.6	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0		
Pb Lead (µg/L)	*min.*	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	4.6	< 3.0	3.6	< 3.0	< 3.0	3.9	50	3.0
	max.	< 3.0	< 3.0	< 3.0	< 3.0	6.1	< 3.0	< 15.0	< 3.0	< 3.0	< 3.0	776.0	< 3.0	17.2	< 3.0	34.0	21.3		
	avg.	< 3.0	< 3.0	< 3.0	< 3.0	3.0	< 3.0	< 15.0	< 3.0	< 3.0	< 3.0	248.1	< 3.0	8.6	< 3.0	15.2	9.7		
Sb Antimony (µg/L)	*min.*	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	6	5.0
	max.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 25.0	< 5.0	< 5.0	< 5.0	13.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 25.0	< 5.0	< 5.0	< 5.0	6.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
Se Selenium (µg/L)	*min.*	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	20	5.0
	max.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 25.0	14.7	< 5.0	< 5.0	13.6	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 25.0	5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
Tl Thallium (µg/L)	*min.*	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	SNS	5.0
	max.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 25.0	< 5.0	< 5.0	< 5.0	6.3	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 25.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		

(continued on next page)

Table 5-6. Metals Analysis of Water Samples from BNL On-Site Recharge Basins *(concluded).*

METAL		Recharge Basin																						NYSDEC Effluent Limit or AWQS	Typical MDL
		HN (RHIC)		HO (AGS)		HS (stormwater)		HT-E (AGS)		HT-W (Linac)		HW (stormwater)		CSF (stormwater)		HZ (stormwater)			
Total (T) or Filtered (F)		T	F	T	F	T	F	T	F	T	F	T	F	T	F	T	F		
No. of samples		4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3		
V Vanadium (µg/L)	*min.*	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	SNS	5.0
	max.	< 5.0	< 5.0	8.0	5.3	< 5.0	< 5.0	< 25.0	< 5.0	< 5.0	< 5.0	262.0	< 5.0	9.5	5.2	6.4	6.1		
	avg.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 25.0	< 5.0	< 5.0	< 5.0	128.0	< 5.0	6.1	< 5.0	< 5.0	< 5.0		
Zn Zinc (µg/L)	*min.*	11.0	10.8	1.9	<10.0	13.2	<10.0	14.8	23.6	<10.0	<10.0	16.4	<10.0	13.4	<10.0	25.7	28.2	5000	10
	max.	38.1	20.4	14.6	23.0	30.4	<10.0	64.2	36.8	15.4	17.3	540.0	11.4	65.3	21.7	70.4	67.5		
	avg.	20.3	14.5	<10.0	13.5	20.4	<10.0	34.1	30.3	11.0	10.8	229.1	<10.0	36.3	14.8	48.0	42.1		

Notes:
See Figure 5-6 for the locations of recharge basins/outfalls.
AGS = Alternating Gradient Synchrotron
AWQS = Ambient Water Quality Standards
CSF = Central Steam Facility
Linac = Linear Accelerator
MDL = Minimum Detection Limit
NYSDEC = New York State Department of Environmental Conservation
RHIC = Relativistic Heavy Ion Collider
SNS = Effluent Standard Not Specified

- *Downstream sampling stations*
- HM-N, on site 0.5 mile downstream of the STP outfall
- HM-S, on site on a typically dry tributary of the Peconic River
- HQ, on site 1.2 miles downstream of the STP outfall at the site boundary
- HA, first station downstream of the BNL boundary, 3.1 miles from the STP outfall
- Donahue's Pond, off site, 4.3 miles downstream of the STP outfall.
- Forge Pond, off site
- Swan Pond, off site, not within the influence of BNL discharges

Control location

- HH, Carmans River

5.5.1 Peconic River – Radiological Analyses

Radionuclide measurements were performed on surface water samples collected from the Peconic River at all 10 sampling locations. Routine samples at Stations HM-N and HQ were collected once per month, as flow allowed. All other stations were sampled quarterly unless conditions (such as no water flow) prevented collection. Stations HE, HM-N, and HQ have been equipped with Parshall flumes that allow automated flow-proportional sampling and volume measurements. All other sites were sampled by collecting instantaneous grab samples, as flow allowed.

The radiological data from Peconic River surface water sampling in 2009 are summarized in Table 5-7. Radiological analysis of water samples collected both upstream and downstream of the STP discharge and from background locations had very low concentrations of gross alpha and gross beta activity. The maximum concentration of gross alpha activity was found in the sections of the Peconic River upstream of the STP, and the maximum gross beta was found at the off-site location (Donahue's Pond). The average concentrations from off-site and control locations were indistinguishable from BNL on-site levels. The beta activity for all locations is

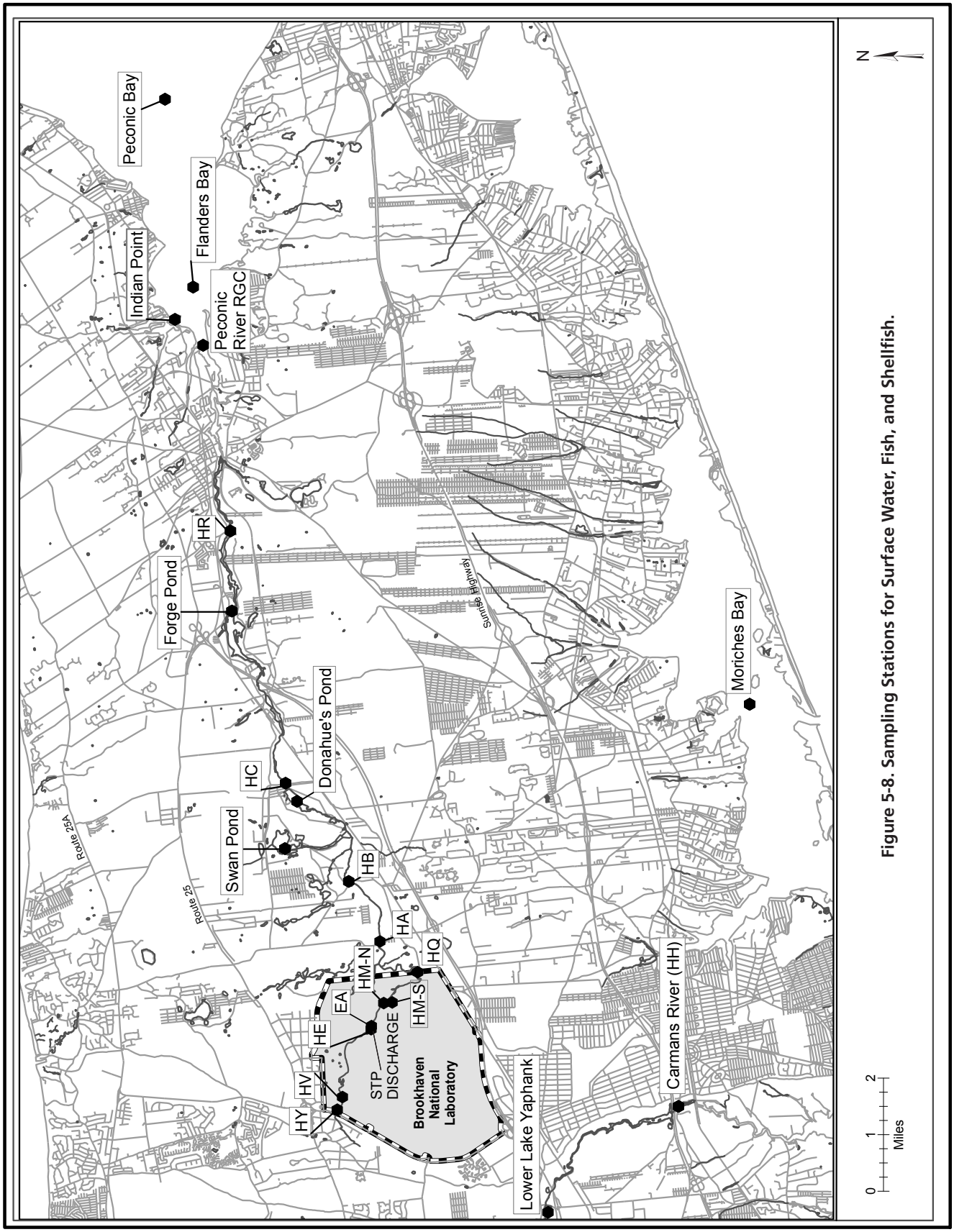


Figure 5-8. Sampling Stations for Surface Water, Fish, and Shellfish.

therefore attributed to natural sources. All detected levels were below the applicable New York State Drinking Water Standards (NYS DWS). No gamma-emitting radionuclides attributable to Laboratory operations were detected either upstream or downstream of the STP. Very low concentrations of tritium were detected at three locations, including Basin HE (390 ± 200 pCi/L) immediately upstream of the STP outfall, Basin HM-N (570 ± 240 pCi/L) downstream of the STP outfall, and HQ (480 ± 230 pCi/L) at the BNL site boundary. All three results were reported by the contract analytical laboratory as "estimated," since the results were greater than the instrument detection limit but less than stated reporting limit. Due to the low level of detection and the high uncertainty, the data may be false-positive. The NYS DWS for tritium is 20,000 pCi/L.

Monitoring for strontium-90 (Sr-90) was performed at all Peconic River and Carmans River stations in 2009. Low-level detections were found at Stations HE, HM-N, HA, Donahue's Pond, and the control location HH (Carmans River) at very consistent levels of 0.38 ± 0.24, 0.75 ± 0.38, 0.32 ± 0.2, 0.35 ± 0.19, and 0.37 ± 0.17 pCi/L, respectively. All concentrations detected were much less than the NYS DWS of 8 pCi/L, are consistent with historical levels, and can be attributed to worldwide fallout.

5.5.2 Peconic River – Nonradiological Analyses

River water samples collected in 2009 were analyzed for water quality parameters (pH, temperature, conductivity, and dissolved oxygen), anions (chlorides, sulfates, and nitrates), metals, and VOCs. Acetone and toluene were the only organic contaminants detected at concentrations above the MDL in 2009. Acetone was detected (14 µg/L) in a single sample collected at location HY (upstream of the STP discharge) but was also found as a contaminant in the contract analytical

Table 5-7. Radiological Results for Surface Water Samples from the Peconic and Carmans Rivers.

Sampling Station		Gross Alpha	Gross Beta	Tritium	Sr-90
		(pCi/L)			
Peconic River					
HY (headwaters) on site, west of the RHIC ring	*N*	4	4	4	4
	max	3.4 ± 1.8	4.3 ± 1.1	< 270	< 0.57
	avg	1.4 ± 1.32	2.18 ± 1.67	9.75 ± 61.52	0.01 ± 0.08
HV (headwaters) on site, inside the RHIC ring	*N*	4	4	4	NS
	max	2 ± 0.95	2.45 ± 0.87	< 340	
	avg	1.16 ± 0.55	1.59 ± 0.56	47 ± 54.23	
HE upstream of STP outfall	*N*	4	4	4	4
	max	< 1.4	4 ± 1.2	390 ± 200	0.38 ± 0.24
	avg	0.49 ± 0.33	2.48 ± 1.17	130.75 ± 173.99	0.15 ± 0.29
HM-N downstream of STP, on site	*N*	12	12	12	4
	max	1.9 ± 1	6.4 ± 1.2	570 ± 240	0.75 ± 0.38
	avg	0.63 ± 0.28	4.04 ± 0.61	105.34 ± 96.52	0.21 ± 0.36
HM-S tributary, on site	*N*	1	1	1	1
	max	< 0.93	< 1.2	< 310	< 0.3
	avg	NA	NA	NA	NA
HQ downstream of STP, at BNL site boundary	*N*	10	10	10	3
	max	2.4 ± 1.1	5.1 ± 1.2	480 ± 230	< 0.59
	avg	0.67 ± 0.45	3.56 ± 0.61	55.7 ± 103.31	0.38 ± 0.21
HA off site	*N*	4	4	4	4
	max	< 1.1	1.62 ± 0.75	< 420	0.32 ± 0.2
	avg	0.26 ± 0.4	0.93 ± 0.76	23.5 ± 100.37	0.29 ± 0.1
Donahue's Pond off site	*N*	4	4	4	4
	max	< 1.1	9.8 ± 1.4	< 220	0.35 ± 0.19
	avg	0.4 ± 0.21	2.98 ± 4.48	34.5 ± 77.5	0.24 ± 0.12
Forge Pond off site	*N*	4	4	4	4
	max	1.7 ± 0.99	1.32 ± 0.67	< 140	< 0.36
	avg	0.59 ± 0.74	1.13 ± 0.2	16.25 ± 63.97	0.17 ± 0.08
Carmans River HH control location, off site	*N*	5	5	5	5
	max	< 1.5	2.75 ± 0.94	< 140	0.37 ± 0.17
	avg	0.22 ± 0.68	1.45 ± 1.1	-17.5 ± 35.57	0.16 ± 0.27
Swan Pond control location, off site	*N*	4	4	4	4
	max	< 1.7	2.7 ± 1	< 140	< 0.5
	avg	0.66 ± 0.38	1.97 ± 0.7	69.75 ± 59.02	0.22 ± 0.13
SDWA Limit (pCi/L)		**15**	**(a)**	**20,000**	**8**

Notes:
See Figure 5-8 for the locations of sampling stations.
All values reported with a 95% confidence interval.
Negative numbers occur when the measured values are lower than background (see Appendix B).
To convert values from pCi to Bq, divide by 27.03.
(a) The drinking water standard was changed from 50 pCi/L (concentration based) to 4 mrem/yr (dose based) in 2003. Because gross beta activity does not identify specific radionuclides, a dose equivalent cannot be calculated for the values in the table.
N = Number of samples analyzed
NS = Not Sampled for this analyte
RHIC = Relativistic Heavy Ion Collider
SDWA = Safe Drinking Water Act
STP = Sewage Treatment Plant

Table 5-8. Water Quality Data for Surface Water Samples Collected along the Peconic and Carmans Rivers.

Analyte		Peconic River Station Locations						Donahue's Pond	Forge Pond	Swan Pond	(Control) HH	NYSDEC Effluent Standard	Typical MDL
		HY	HE	HM-N	HM-S	HQ	HA						
No. of samples		4	4	12	1	10	4	4	4	4	4		
pH (SU)	*min.*	4.4	5.8	6.1	4.3	6.3	6.1	6.1	6.9	6.3	6.7	6.5-8.5	NA
	max.	8.8	7.4	7.9	4.3	7.9	7.0	7.2	7.2	7.3	7.6		
Conductivity (µS/cm)	*min.*	103	67	140	56	105	45	55	79	77	178	SNS	NA
	max.	285	114	387	56	306	71	71	133	95	199		
	avg.	156	90	262	56	207	57	63	109	85	188		
Temperature (°C)	*min.*	5.6	2.3	1.3	9.6	3.3	3.3	5.0	4.4	3.9	6.0	SNS	NA
	max.	20.1	11.8	23.3	9.6	24.3	24.2	24.8	28.1	26.0	22.0		
	avg.	13.2	7.8	10.2	9.6	13.0	14.4	15.6	16.8	15.3	14.2		
Dissolved oxygen (mg/L)	*min.*	6.6	5.3	5.2	6.9	1.0	2.8	4.8	8.6	6.8	8.6	>4.0	NA
	max.	10.9	9.5	14	6.9	15.4	13.3	11.7	14.1	9.8	13.4		
	avg.	8.2	7.9	11.1	6.9	8.9	7.9	8.6	10.2	8.7	10.8		
Chlorides (mg/L)	*min.*	14.7	9.0	25.2	4.7	20.6	6.5	8.3	15.1	8.6	28.5	250(a)	4.0
	max.	51.2	15.5	66.2	4.7	61.2	9.7	15.1	20.4	11.1	30.5		
	avg.	27.8	12.7	46.32	4.7	36.2	7.8	10.4	17.7	9.9	29.4		
Sulfates (mg/L)	*min.*	<4.0	<4.0	7.9	<4.0	6.2	<4.0	<4.0	7.0	4.3	11.8	250(a)	4.0
	max.	12.1	7.0	19.8	<4.0	14.2	4.3	5.4	13.2	9.8	12.3		
	avg.	5.1	5.2	14.8	<4.0	10.6	<4.0	<4.0	9.7	7.5	12.0		
Nitrate as nitrogen (mg/L)	*min.*	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.43	10(a)	1.0
	max.	1.16	<1.0	4.76	<1.0	1.69	<1.0	<1.0	<1.0	<1.0	1.80		
	avg.	<1.0	<1.0	2.59	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.57		

Notes:
See Figure 5-6 for the locations of recharge basins/outfalls.
(a) Since there are no NYSDEC Class C surface Ambient Water Quality Standards (AWQS) for these compounds, the AWQS for groundwater is provided, if specified.
Donahue's Pond = Peconic River, off site
Forge Pond = Peconic River, off site
HA = Peconic River, off site
HE = Peconic River, upstream of STP Outfall
HH = Carmans River control location, off site
HM-N = Peconic River on site, downstream of STP
HM-S = Peconic River tributary, on site
HQ = Peconic River, downstream of STP at BNL site boundary
HY = Peconic River headwaters, on site, east of Wm Floyd Pkwy.
MDL = Minimum Detection Limit
NA = Not Applicable
NYSDEC = New York State Department of Environmental Conservation
SNS = Effluent Standard Not Specified

laboratory, as evidenced by a similar detection in the trip blank sample. Toluene was detected (7.3 µg/L) in a single sample collected at location HQ (on site but near the BNL site boundary). Roadway runoff is the most likely source of this contaminant. The inorganic analytical data for the Peconic River and Carmans River samples are summarized in Tables 5-8 (water quality) and 5-9 (metals).

Peconic River water quality data collected upstream and downstream showed that water quality was consistent throughout the river system. The data were also consistent with water samples collected from the Carmans River control location (HH). Sulfates and nitrates tend to be slightly higher in samples collected immediately downstream of the STP discharge (Stations HM-N and HQ) and were consistent with the concentrations in the STP discharge. Chlorides and sodium were highest at Station HM-N, which is immediately downstream of the STP outfall and likely a result of road salting operations at the Laboratory. There are no NYS AWQS imposed for chloride or sulfates in discharges to surface water; however, NYSDEC imposes a limit of 500 mg/L for discharges to groundwater.

The pH measured at some locations was very low, due to the low pH of precipitation, ground-

Table 5-9. Metals Analysis in Surface Water Samples Collected along the Peconic and Carmans Rivers.

METAL		Peconic River Locations														Swan Pond		Forge Pond		Control HH		NYSDEC AWQS	Typical MDL
		HY		HE		HM-N		HM-S		HQ		HA		DP									
Total or Dissolved		T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D		
No. of samples		4	3	4	3	12	5	1	1	10	5	4	3	4	3	4	3	4	3	4	3		
Ag (I) Silver (µg/L)	*min.*	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	0.1	2
	max.	< 4.0	< 2.0	< 2.0	< 2.0	3.9	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0		
	avg.	< 4.0	< 2.0	< 2.0	< 2.0	2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0		
Al (I) Aluminum (µg/L)	*min.*	457.0	167.0	182.0	112.0	<50.0	<50.0	815.0	705.0	80.9	60.2	83.1	64.1	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	100	50
	max.	1390.0	606.0	535.0	325.0	585.0	116.0	815.0	705.0	443.0	227.0	135.0	108.0	78.1	61.4	150.0	<50.0	61.1	<50.0	<50.0	<50.0		
	avg.	741.5	410.7	362.5	208.7	283.4	73.3	815.0	705.0	286.6	138.2	109.0	80.1	61.0	<50.0	60.3	<50.0	<50.0	<50.0	<50.0	<50.0		
As (D) Arsenic (µg/L)	*min.*	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	150	5
	max.	< 5.0	< 5.0	< 5.0	< 5.0	< 10.0	< 10.0	< 5.0	< 5.0	< 10.0	< 10.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	< 5.0	< 5.0	< 5.0	< 5.0	< 10.0	< 10.0	< 5.0	< 5.0	< 10.0	< 10.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
Ba Barium (µg/L)	*min.*	10.1	8.4	16.9	16.5	13.5	10.4	10.9	9.2	8.5	6.0	7.4	6.7	8.0	7.9	4.8	4.4	15.1	14.1	26.4	5.7	SNS	1.8
	max.	52.1	14.8	21.2	18.4	23.8	19.4	10.9	9.2	15.5	11.9	15.4	8.4	21.1	10.3	11.5	20.7	22.2	32.8	36.6	34.7		
	avg.	22.7	11.9	18.9	17.5	19.7	15.3	10.9	9.2	11.4	9.7	10.2	7.7	12.4	8.9	7.1	10.8	19.7	21.7	32.0	22.7		
Be (AS) Beryllium (µg/L)	*min.*	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	11	2
	max.	< 2.0	< 2.0	< 2.0	< 2.0	< 4.0	< 4.0	< 2.0	< 2.0	< 4.0	< 4.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0		
	avg.	< 2.0	< 2.0	< 2.0	< 2.0	< 4.0	< 4.0	< 2.0	< 2.0	< 4.0	< 4.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0		
Cd (D) Cadmium (µg/L)	*min.*	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	1.1	2
	max.	< 4.0	< 2.0	< 2.0	< 2.0	< 4.0	< 4.0	< 2.0	< 2.0	< 4.0	< 4.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0		
	avg.	< 4.0	< 2.0	< 2.0	< 2.0	< 4.0	< 4.0	< 2.0	< 2.0	< 4.0	< 4.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0		
Co (AS) Cobalt (µg/L)	*min.*	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	5	5
	max.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
Cr (I) Chromium (µg/L)	*min.*	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	34	10
	max.	< 20.0	< 10.0	< 10.0	< 10.0	< 20.0	< 20.0	< 10.0	< 10.0	< 20.0	< 20.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0		
	avg.	< 20.0	< 10.0	< 10.0	< 10.0	< 20.0	< 20.0	< 10.0	< 10.0	< 20.0	< 20.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0		
Cu (D) Copper (µg/L)	*min.*	< 10.0	< 10.0	< 10.0	< 10.0	16.4	24.5	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	4	10
	max.	47.4	< 10.0	< 10.0	< 10.0	70.9	56.2	< 10.0	< 10.0	27.1	24.9	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0		
	avg.	14.2	< 10.0	< 10.0	< 10.0	38.8	38.3	< 10.0	< 10.0	12.9	14.8	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0		
Fe (AS) Iron (mg/L)	*min.*	0.3	0.2	1.0	0.4	0.2	0.11	0.4	0.3	0.2	0.1	0.5	0.3	0.4	0.3	0.1	<0.075	0.6	0.2	0.3	<0.075	0.3	0.075
	max.	1.3	0.5	4.4	1.2	1.3	0.4	0.4	0.3	0.8	0.5	4.0	0.8	3.9	0.9	0.2	0.3	2.5	1.0	0.5	0.3		
	avg.	0.6	0.3	2.6	0.9	0.6	0.2	0.4	0.3	0.4	0.3	1.6	0.5	1.7	0.6	0.1	0.1	1.2	0.5	0.3	0.2		

(continued on next page)

Table 5-9. Metals Analysis in Surface Water Samples Collected along the Peconic and Carmans Rivers *(concluded).*

METAL		Peconic River Locations														Swan Pond		Forge Pond		Control HH		NYSDEC AWQS	Typical MDL
		HY		HE		HM-N		HM-S		HQ		HA		DP									
Total or Dissolved		T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D		
No. of samples		4	3	4	3	12	5	1	1	10	5	4	3	4	3	4	3	4	3	4	3		
Hg (D) Mercury (µg/L)	*min.*	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	0.2	0.2
	max.	< 0.2	< 0.2	< 0.2	0.2	0.3	0.3	0.3	< 0.2	0.3	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	0.2	< 0.2	< 0.2	0.3	< 0.2	0.2		
	avg.	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	0.3	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2		
Mn Manganese (µg/L)	min.	10.4	7.4	109.0	80.6	4.9	12.7	20.1	22.1	8.0	4.5	14.2	18.3	25.6	29.7	43.3	42.8	56.0	47.6	44.6	28.2	SNS	2
	max.	106.0	56.1	156.0	218.0	197.0	33.9	20.1	22.1	42.1	44.2	189.0	33.9	270.0	56.2	103.0	67.6	102.0	95.4	68.6	76.8		
	avg.	53.8	37.4	128.8	131.8	48.6	21.5	20.1	22.1	24.6	22.3	63.6	24.6	96.8	39.1	68.7	54.5	79.6	66.0	58.6	56.7		
Na Sodium (mg/L)	min.	10.2	10.7	5.9	6.4	16.5	21.6	3.3	3.0	12.4	20.7	3.9	4.1	4.8	4.8	5.1	6.0	9.5	8.8	15.5	7.4	SNS	1
	max.	65.0	18.6	9.3	9.2	42.5	41.9	3.3	3.0	38.7	39.3	5.7	5.5	6.2	6.4	7.2	12.2	11.9	19.0	18.0	17.3		
	avg.	26.5	14.2	7.7	7.4	32.4	34.0	3.3	3.0	25.7	28.4	5.1	4.9	5.7	5.7	6.2	8.1	10.6	12.8	16.7	13.6		
Ni (D) Nickel (µg/L)	min.	1.2	1.4	< 1.1	1.3	3.1	5.3	1.3	1.2	2.3	4.1	< 1.1	< 1.1	< 1.1	< 1.1	< 1.1	< 1.1	< 1.1	< 1.1	< 1.1	< 1.1	23	1.1
	max.	10.2	2.4	2.9	2.2	8.8	8.3	1.3	1.2	8.4	6.5	< 10.0	1.4	< 10.0	< 10.0	< 10.0	1.3	< 10.0	1.4	< 10.0	1.4		
	avg.	3.7	1.8	1.8	1.7	6.0	6.4	1.3	1.2	4.8	5.3	< 10.0	1.1	< 10.0	< 10.0	< 10.0	0.9	< 10.0	1.1	< 10.0	1.1		
Pb (D) Lead (µg/L)	min.	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	1.4	3
	max.	5.4	3.2	< 3.0	< 3.0	5.4	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	3.1	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0		
	avg.	3.3	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0		
Sb Antimony (µg/L)	min.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	SNS	5
	max.	< 5.0	< 5.0	< 5.0	< 5.0	< 10.0	< 10.0	< 5.0	< 5.0	< 10.0	< 10.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	< 5.0	< 5.0	< 5.0	< 5.0	< 10.0	< 10.0	< 5.0	< 5.0	< 10.0	< 10.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
Se (D) Selenium (µg/L)	min.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	4.6	5
	max.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
Tl (AS) Thallium (µg/L)	min.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	8	5
	max.	< 5.0	< 5.0	< 5.0	< 5.0	< 10.0	< 10.0	< 5.0	< 5.0	< 10.0	< 10.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	< 5.0	< 5.0	< 5.0	< 5.0	< 10.0	< 10.0	< 5.0	< 5.0	< 10.0	< 10.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
V (AS) Vanadium (µg/L)	min.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	14	5
	max.	65.1	< 5.0	< 5.0	< 5.0	< 10.0	< 10.0	< 5.0	< 5.0	< 10.0	< 10.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	17.2	< 5.0	< 5.0	< 5.0	< 10.0	< 10.0	< 5.0	< 5.0	< 10.0	< 10.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
Zn (D) Zinc (µg/L)	min.	15.9	11.2	< 10.0	10.2	21.8	42.7	14.5	13.6	< 10.0	< 10.0	< 10.0	10.1	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	34	10
	max.	280.0	18.4	19.7	17.1	106.0	92.1	14.5	13.6	47.1	45.7	< 10.0	11.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	10.9	< 10.0	15.4		
	avg.	83.2	15.6	14.8	13.5	63.2	65.7	14.5	13.6	26.4	32.2	< 10.0	10.6	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	11.2		

Notes:
See Figure 5-8 for the locations of sampling stations.
AWQS = Ambient Water Quality Standards
AS = Acid Soluble
AS = Acid Soluble
D = Dissolved
DP = Donahue's Pond
SNS = Effluent Standard Not Specified for these elements in Class C Surface Waters
T = Total

water, and the formation of humic acids from decaying organic matter. As spring rains mix with decaying matter, these acids decrease the already low pH of precipitation, resulting in a pH as low as 4.3 Standard Units. A discussion of precipitation monitoring is provided in Chapter 6 (see Section 6.7 for more detail).

Ambient water quality standards for metallic elements are based on their solubility state. Certain metals are only biologically available to aquatic organisms if they are in a dissolved or ionic state, whereas other metals are toxic in any form (i.e., dissolved and particulate combined). In 2009, the BNL monitoring program continued to assess water samples for both the dissolved and particulate form. Dissolved concentrations were determined by filtering the samples prior to acid preservation and analysis. Examination of the metals data showed that silver, aluminum, copper, iron, mercury, lead, vanadium, and zinc were present in concentrations at some locations that exceeded NYS AWQS. With the exception of silver, copper, and mercury, the highest concentrations were found at upstream locations, indicating a natural source of contamination. Aluminum and iron are detected throughout the Peconic and Carmans Rivers at concentrations that exceed the NYS AWQS in both the filtered and unfiltered fractions. Iron and aluminum are found in high concentrations in native Long Island soil and, for iron, at high levels in groundwater. The highest levels for silver, copper, and mercury were found in samples collected immediately downstream of the STP discharge (Station HM-N) at concentrations greater than the NYS AWQS. The concentrations detected were consistent with the concentrations found in the STP discharge and, in most instances, were within the BNL SPDES permit limits. The NYS AWQS limits for silver, copper, and mercury are very restrictive; consequently, the NYS-granted SPDES permit allows higher limits, provided toxicity testing shows no impact to aquatic organisms. Filtration of the samples reduced concentrations of most metals to below the NYS AWQS, indicating that most detections were due to sediment carryover. Mercury was detected in some samples collected downstream of the STP at concentrations greater than the MDL. Since the concentrations in the Peconic River were typically higher than the levels detected in the STP discharge (see Table 5-3), the river is a contributor of mercury. Further discussion of mercury in the Peconic River sediment, water, and fish samples is found in Chapter 6.

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6 Natural and Cultural Resources

The Brookhaven National Laboratory 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 on maintaining compliance with applicable regulations. The goals of the program include protecting and monitoring the ecosystem, conducting research, and communicating with staff and the public on ecological issues. BNL focuses on protecting 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 this program. In 2009, deer and fish sampling results were consistent with previous years. Vegetables grown in the BNL garden plot continue to support historical analyses that there are no Laboratory-generated radionuclides in produce.

The overriding goal of the Cultural Resource Management Program is to ensure that proper stewardship of BNL and DOE 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 to on-site personnel and the public for research and interpretation.

6.1 NATURAL RESOURCE MANAGEMENT PROGRAM

The purpose of the Natural Resource Management Program at BNL is to promote stewardship of the natural resources found at the Laboratory, as well as to integrate natural resource management and protection with BNL's scientific mission. To meet this purpose, the Laboratory prepared a Natural Resource Management Plan (NRMP) (BNL 2003a). This plan describes the program strategy, elements, and planned activities for managing the various resources found on site.

6.1.1 Identification and Mapping

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

In 2009, BNL developed an Environmental Assessment (EA) under the National Environmental Policy Act of 1969 for the proposed BP Solar Long Island Solar Farm (LISF) on site. This project will encompass an area of approximately 200 acres. The GIS and natural resource data were utilized in the development of the EA (DOE 2009) and are routinely updated through surveys, observations, and research.

A wide variety of vegetation, birds, reptiles, amphibians, and mammals inhabit the site. Through implementation of the NRMP, additional endangered, threatened, and species of special concern have been identified as having been resident at BNL during the past 30 years.

Table 6-1. New York State Threatened, Endangered, Exploitably Vulnerable, and Species of Special Concern at BNL.

Common Name	Scientific Name	State Status	BNL Status
Insects			
Frosted elfin	*Callophrys iris*	T	Likely
Mottled duskywing	*Erynnis martialis*	SC	Likely
Persius duskywing	*Erynnis persius persius*	E	Likely
Pine Barrens bluet	*Enallagma recurvatum*	T	Confirmed
Fish			
Banded sunfish	*Enniacanthus obesus*	T	Confirmed
Swamp darter	*Etheostoma fusiforme*	T	Confirmed
Amphibians			
Eastern tiger salamander	*Ambystoma tigrinum tigrinum*	E	Confirmed
Marbled salamander	*Ambystoma opacum*	SC	Confirmed
Eastern spadefoot toad	*Scaphiopus holbrookii*	SC	Confirmed
Reptiles			
Spotted turtle	*Clemmys guttata*	SC	Confirmed
Eastern hognose snake	*Heterodon platyrhinos*	SC	Confirmed
Eastern box turtle	*Terrapene carolina*	SC	Confirmed
Eastern worm snake	*Carphophis amoenus*	SC	Confirmed
Birds (nesting, transient, or potentially present)			
Horned lark	*Eremophila alpestris*	SC	Likely
Whip-poor-will	*Caprimulgus vociferus*	SC	Likely
Vesper sparrow	*Pooecetes gramineus*	SC	Likely
Grasshopper sparrow	*Ammodramus savannarum*	SC	Confirmed
Northern harrier	*Circus cyaneus*	T	Confirmed
Cooper's hawk	*Accipiter cooperii*	SC	Confirmed
Osprey	*Pandion haliaetus*	SC	Confirmed
Sharp-shinned hawk	*Accipiter striatus*	SC	Confirmed
Plants			
Stargrass	*Aletris farinosa*	T	Confirmed
Butterfly weed	*Asclepias tuberosa*	V	Confirmed
Spotted wintergreen	*Chimaphila maculata*	V	Confirmed
Flowering dogwood	*Cornus florida*	V	Confirmed
Pink lady's slipper	*Cypripedium acaule*	V	Confirmed
Winterberry	*Ilex verticillata*	V	Confirmed
Sheep laurel	*Kalmia angustifolia*	V	Confirmed
Narrow-leafed bush clover	*Lespedeza augustifolia*	R	Confirmed
Ground pine	*Lycopodium obscurum*	V	Confirmed
Bayberry	*Myrica pensylvanica*	V	Confirmed
Cinnamon fern	*Osmunda cinnamomera*	V	Confirmed
Clayton's fern	*Osmunda claytoniana*	V	Confirmed
Royal fern	*Osmunda regalis*	V	Confirmed
Crested fringed orchid	*Plantathera cristata*	E	Likely
Swamp azalea	*Rhododendron viscosum*	V	Confirmed
Long-beaked bald-rush	*Rhynchospora scirpoides*	R	Confirmed
Stiff goldenrod	*Solidago rigida*	T	Confirmed
New York fern	*Thelypteris novaboracensis*	V	Confirmed
Marsh fern	*Thelypteris palustris*	V	Confirmed
Virginia chain-fern	*Woodwardia virginica*	V	Confirmed

Notes:
* Table information is based on 6 NYCRR Part 182, 6 NYCRR Part 193, and BNL survey data.
No federally listed Threatened or Endangered Species are known to inhabit the BNL site.
E = Endangered
R = Rare
SC = Species of Special Concern
T = Threatened
V = Exploitably Vulnerable

The only New York State endangered species confirmed as now inhabiting Laboratory property is the eastern tiger salamander (*Ambystoma t. tigrinum*). Additionally, the New York State endangered Persius duskywing butterfly (*Erynnis p. persius*) and the crested fringed orchid (*Plantathera cristata*) have been identified on site in the past. Five New York State threatened species have been positively identified on site and two other species are considered likely to be present. The banded sunfish (*Enneacanthus obesus*), the swamp darter fish (*Etheostoma fusiforme*), and the stiff goldenrod plant (*Solidago rigida*) have been previously reported (BNL 2000). The northern harrier (*Circus cyaneus*) was seen hunting over open fields in November 2003. In 2005, the Pine Barrens bluet (*Enallagma recurvatum*) damselfly was confirmed at one of the many coastal plain ponds located on site. The frosted elfin butterfly (*Callophrys irus*) has been identified as possibly being at BNL, based on historic documentation and the presence of its preferred habitat and host plant (wild lupine). In addition, stargrass (*Aletris farinosa*) was reconfirmed to exist at BNL. A number of other species that are listed as rare, of special concern, or exploitably vulnerable by New York State either currently inhabit the site, visit during migration, or have been identified historically (see Table 6-1).

6.1.2 Habitat Protection and Enhancement

BNL has precautions in place to protect onsite habitats and natural resources. Activities to eliminate or minimize negative effects on sensitive or critical species are either incorporated into Laboratory procedures or into specific program or project plans. Environmental restoration projects remove pollutant sources that could contaminate habitats. Human access to critical habitats is limited. In some cases, habitats are enhanced to improve survival or increase populations. Even routine activities such as road maintenance are not performed until they have been duly evaluated and determined to be unlikely to affect habitat.

6.1.2.1 Salamander Protection Efforts

To safeguard eastern tiger salamander breeding areas, a map of the locations is reviewed

when new projects are proposed. Distribution of the map is limited, to protect the salamander from exploitation by collectors and the pet trade. The map is routinely updated as new information concerning the salamanders is generated through research and monitoring. The most recent update extends the buffer area around tiger salamander habitat from 800 feet to 1,000 feet. Other efforts to protect this state-endangered species include determining when adult salamanders are migrating toward breeding locations, when metamorphosis has been completed, and when juveniles are migrating after metamorphosis. During these times, construction and maintenance activities near their habitats are postponed or closely monitored. BNL environmental protection staff must review any project planned near eastern tiger salamander habitats, and every effort is made to minimize impacts.

Water quality testing is conducted as part of the routine monitoring of recharge basins, as discussed in Chapter 5. In cooperation with the New York State Department of Environmental Conservation (NYSDEC), habitat surveys have been routinely conducted since 1999. Biologists conducting egg mass and larval surveys have confirmed 26 on-site ponds that are used by eastern tiger salamanders. Egg mass surveys of ponds and additional flooded depressions at the Laboratory were not conducted in 2009. The monitoring procedure calls for all ponds that had egg masses during the spring surveys to be surveyed again in June and July to check for the presence of larval salamanders. A PhD candidate and student interns have conducted surveys of tiger salamander ponds, drift fence surveys, and radio telemetry tracking around four ponds. The results of these studies have shown the extent of egg mass production, the importance of precipitation as a trigger for metamorphic salamanders leaving ponds, and the extent of movements by both adults and metamorphic tiger salamanders. Work toward a comprehensive understanding of eastern tiger salamander movements and habitat requirements began in 2004, with funding provided to SUNY Binghamton by NYSDEC. Continued research adds to the understanding of the needs of this state-endangered species. Information acquired from all research is entered into a database, and portions of the data are linked to a GIS. These data are used to visualize distributions, track reproductive success, and identify areas for focused management or study.

Protection of the eastern tiger salamander was a key component of the EA for the LISF project in 2009. The unique shape of the project, in part, came about due to the need to provide sufficient, viable habitat for the salamander within the area to be developed. Additionally, the LISF agreed to habitat enhancement to improve one of BNL's tiger salamander ponds that was determined to be a population sink area (i.e. breeding occurred in the pond, but has not been successful).

6.1.2.2 Other Species

As part of the eastern tiger salamander and herpetological surveys, information is being gathered on other species found on site. Including the tiger salamander, sightings of 26 species of reptiles and amphibians have been recorded over the past several years. The species include the northern red-back salamander (*Plethodon c. cinereus*), marbled salamander (*Ambystoma opacum*), four-toed salamander (*Hemidactylium scutatum*), red-spotted newt (*Notophthalmus viridescens*), spring peeper (*Pseudacris crucifer*), wood frog (*Rana sylvatica*), gray tree frog (*Hyla versicolor*), bullfrog (*Rana catesbiana*), green frog (*Rana clamitans*), pickerel frog (*Rana palustris*), Fowler's toad (*Bufo woodhousei fowleri*), eastern spadefoot toad (*Scaphiopus holbrooki*), snapping turtle (*Chelydra serpentine*), painted turtle (*Chrysemys p. picta)*, musk turtle (*Sternotherus odoratus*), spotted turtle (*Clemmys guttata*), eastern box turtle (*Terrapene c. Carolina*), northern black racer (*Coluber constrictor*), eastern ribbon snake (*Thamnophis s. sauritus*), eastern garter snake (*Thamnophis s. sirtalis*), northern water snake (*Nerodia s. sipedon*), northern ring-necked snake (*Diadophis puctatus edwardsi*), brown snake (*Storeria d. dekayi*), northern red-bellied snake (*Storeria occiptiomaculata*), and eastern wormsnake (*Carphophis amoenus*). This list indicates that BNL has one of the most diverse herpetofaunal assemblages on Long Island.

Banded sunfish protection efforts include observing whether adequate flow in the Peconic River is maintained within areas currently identified as sunfish habitat, ensuring that existing vegetation in their habitat is not disturbed, and evaluating all activities taking place on the river for potential impacts on these habitats. Population estimates are periodically conducted within various waters on site to determine the current health of the banded sunfish. The last estimate was conducted in 2007, with a population of approximately 4,000 fish.

6.1.2.3 Migratory Birds

A total of 216 species of birds have been identified at BNL since 1948; at least 85 species are known to nest on site. Some of these nesting birds have shown declines in their populations nationwide over the past 30 years. The Laboratory conducts routine monitoring of songbirds along six permanent bird survey routes in various habitats on site. In 2009, monthly surveys were conducted starting at the end of March and extending through the end of September. These surveys identified 71 songbird species, compared to 70 species in 2008 and 69 species during 2007. One of the species identified during the 2009 surveys had not been reported previously. A total of 114 songbird species have been identified during surveys in the past 10 years; 45 of these species were present each year. Variations in the number and species identified reflect the time of sampling, variations in weather patterns between years, or actual changes in the environment. The two most diverse transects pass near wetlands by the Biology Fields and the Peconic River. The four transects passing through the various forest types (white pine, moist pine barrens, and dry pine barrens) showed a less diverse bird community. Data are stored in an electronic database that is linked to the Laboratory's GIS.

The eastern bluebird (*Sialia sialis*) has been identified as one of the declining species of migratory birds in North America. This decline is due to loss of habitat and to nest site competition from European starlings (*Sturnus vulgaris*) and house sparrows (*Passer domesticus*). BNL's NRMP includes habitat enhancement for the eastern bluebird. Since 2000, the Laboratory has installed more than 56 nest boxes around open grassland areas on site to enhance their population.

Migratory birds occasionally cause safety and health concerns. Birds that typically are of concern include Canada geese (*Branta canadensis*) and several species of migratory birds that occasionally nest on buildings or in construction areas. Over the past several years, the resident Canada goose population began increasing with the potential to reach large numbers that could result in health and safety issues for the Laboratory. In 2007, under a permit from the U.S. Fish & Wildlife Service (FWS), the Laboratory began managing the resident goose population. In the first year, the goose population was estimated at approximately 120 birds and nests were only managed if they posed a health or safety issue; eggs were treated in ten nests, or the nests were removed. At the end of the 2007 nesting season, the goose population reached an estimated 157 birds. Therefore, in 2008, nest management became more aggressive and eggs in 30 nests that were found were oiled to prevent development. Even with a more aggressive approach to nest management, 15 goslings were hatched and survived. However, with attrition and mortality associated with off-site hunting, the resident population was estimated at 148 birds at the end of 2008. In 2009, the goose population was estimated at 120 birds prior to treating 30 nests. By the end of 2009, the local resident goose population was estimated at 105 birds.

In 2009, the Laboratory began construction of the National Synchrotron Light Source II. This involved extensive grading of the site, creating favorable habitat for killdeer (*Charadrius vociferous*), a ground-nesting plover. The area was known to be suitable for this species as determined in the EA for the NSLS-II (BNL 2005). When nests were identified, all work around the nests was halted and the United States Department of Agriculture Animal and Plant Health Inspection Service – Wildlife Services (USDA-WS) division was called to assess and remove nests, as determined necessary. USDA-WS personnel were called on two separate occasions, removing three nests. A fourth nest, away from the construction site, produced four chicks,

which were relocated to the NSLS-II site by the parents. These birds were coaxed away from the construction site by natural resource staff.

6.1.3 Population Management

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

6.1.3.1 Wild Turkey

The forested areas of BNL provide good nesting and foraging habitat for wild turkey *(Meleagris gallapavo)*. The on-site population was estimated at 60 to 80 birds in 1999 and had grown to approximately 500 birds in 2004. Since 2004, the population appears to have stabilized at approximately 300 birds. The population across Suffolk County, Long Island, was determined to be of sufficient size to support hunting in 2009. Biologists from NYSDEC, USDA-WS, and the Wild Turkey Federation attempted to band turkeys on site prior to the hunt, but were unsuccessful. Hunting is not currently allowed at the Laboratory. However, turkeys do not limit their movements to BNL and often move great distances. Banding turkeys taken in the hunt would have provided valuable information on patterns of movement. The first fall hunt (5 days) resulted in over 100 birds taken in Suffolk County, with little or no evidence of effects on the BNL turkey population.

6.1.3.2 White-Tailed Deer

BNL consistently updates information on the resident population of white-tailed deer (*Odocoileus virginianus*). As there are no natural predators on site and hunting is not permitted at the Laboratory, there are no significant pressures on the population to migrate beyond their typical home range of approximately 1 square mile. Normally, a population density of 10 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 normal circumstances. This was the approximate density in 1966, when the Laboratory reported an estimate of 267 deer on site (Dwyer 1966). The Laboratory has been conducting population surveys of the white-tailed deer since 2000. In 2004, based on results of aerial infrared surveys, BNL adjusted the methods for estimating the deer population. The method utilizes GIS data layers for vegetation to adjust deer counts based on habitat. The deer population increased to an estimate of 800 deer in December 2008. In 2009, the deer population increased to an estimated 893 animals in the spring and began declining in the fall. By December 2009, the population estimate was 731. This decrease is, in part, supported by the increased number of car–deer accidents reported on site during October and November.

To gain additional information on deer populations, an aerial deer survey is being planned during the winter months in early 2010. This survey is very similar to the aerial surveys conducted in February and March 2004. The Spring 2009 estimate of 893 animals is equivalent to 109 deer per square mile and reflects an approximate increase of ten percent over December 2008 numbers.

Deer overpopulation can affect animal and human health (e.g., animal starvation, Lyme disease from deer ticks, collision injuries to both human and animal), species diversity (songbird species reduction due to selective grazing and destruction of habitat by deer), and property values (collision damage to autos and browsing damage to ornamental plantings). In 2009, 13 deer-related collisions occurred on site, compared to 3 accidents in 2007 and 2008. Only in 2006 were there 10 or more deer-related collisions. The increased number of accidents appears to be due to an increase in deer population. While the winter of 2008-2009 was harsh on the BNL deer, many of them survived. This resulted in a significant increase in accidents. While the population was high, winter conditions were such that significant population reduction was likely to occur. Several cold rains occurred in November and December 2009, stressing the population, even though there was significant food available from the 2009 acorn crop.

Because the high deer population is a regional problem, the Laboratory is working on the is-

sue with other local jurisdictions. As part of this regional approach, an issue and decision paper was prepared for BNL management consideration late in 2007. Options for deer management are limited, and most are controversial. While a single regional approach would benefit the community, land managers, and the health of the deer population, multiple land managing organizations like the Laboratory must implement a regional approach. In 2008, the BNL Policy Council approved moving forward with deer management planning. Several meetings were held with employees during the spring months, resulting in the development of an employee survey. The survey was sent out to approximately 2,800 individuals; 829 individuals responded. Most respondents believe that deer management is needed, but the survey was unclear on the method of deer management to be used. In the fall months, several informational sessions were held to further explain the various options available in order to begin moving forward with management. The first step is for BNL to prepare an EA under the requirements of NEPA. The EA process was scheduled to begin sometime in 2009, but was delayed due to the higher priority development of an EA for the LISF.

6.1.4 Compliance Assurance and Potential Impact Assessment

The NEPA review process at BNL is a key to ensuring that environmental impacts of a proposed action or activity are adequately evaluated and addressed. The Laboratory will continue to use NEPA (or NEPA-like) processes under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Environmental Restoration Program when identifying potential environmental impacts associated with site activities—especially with physical alterations. As appropriate, stakeholders such as EPA, NYSDEC, Suffolk County Department of Health Services (SCDHS), BNL's Community Advisory Council, and the BNL Brookhaven Executive Roundtable are involved in reviewing major projects that have the potential for significant environmental impacts. Formal NEPA reviews are coordinated with the State of New York. As discussed previously, in 2009 BNL completed an EA for the proposed LISF. A summary of NEPA reviews is provided in Chapter 3.

6.2 UPTON ECOLOGICAL AND RESEARCH RESERVE

On November 9, 2000, then-Secretary of Energy Bill Richardson and Susan MacMahon, Acting Regional Director of Region 5 FWS, dedicated 530 acres of Laboratory property as an ecological research reserve. The property was designated by DOE as the Upton Ecological and Research Reserve (Upton Reserve) and was managed by FWS under an Interagency Agreement (DOE–FWS 2000). The Upton Reserve, on the eastern boundary of BNL, is home to a wide variety of flora and fauna. It contains wetlands and is largely within the core preservation area of the Long Island Central Pine Barrens. Based on information from a 1994–1995 biological survey of the Laboratory, experts believe the reserve is home to more than 200 plant species and at least 162 species of mammals, birds, fish, reptiles, and amphibians (LMS 1995).

A transition from FWS management of the Upton Reserve to management by BNL and the Foundation for Ecological Research in the Northeast (FERN) occurred in 2005. During that year, FERN initiated its first pine barrens–wide monitoring program to assess the health of the various forest types within the Pine Barrens, followed by a continuation of the effort in 2006. FERN established 91 permanent plots over the 2-year period of the monitoring program. One significant finding from the monitoring is the lack of forest regeneration. In virtually every forest type, there is a lack of survival of trees from seedlings through to saplings. This is likely a result of either deer over-abundance or lack of sunlight penetrating to the understory. Further information on the forest health initiative, as well as other activities of FERN, is available on the FERN website at www.fern-li.org. In 2008, FERN finalized protocols for monitoring wetland health throughout the Pine Barrens. These protocols, when implemented, will provide baseline information on the current health of the wetlands found within the Central Pine Barrens.

Research supported by FERN in 2009 included continued investigation into the microbial world of soils located within a number of the Forest Health Plots and experimental areas at BNL. Microbial research carried out by a scientist at Dowling College in 2007 identified several new species of fungus and bacteria that had not previously been known. In 2008, the work was expanded to develop a microbial community profile of the Pine Barrens. This work has resulted in a small National Science Foundation Grant to further investigate and isolate new bacteria. Research was conducted in conjunction with a Faculty and Student Team from Southern University at New Orleans, who have submitted their results for publication. The work is expected to continue in 2010, with genetic analysis of the microbes to further refine the microbial community structure. Additional work funded by FERN included an aquatic invertebrate survey of the Carmans River and the development of a DVD documenting the various sampling protocols used within the Open Space Stewardship Program (OSSP) sponsored by the Office of Education at BNL. Additional information on these projects is provided in Section 6.5.

6.3 MONITORING FLORA AND FAUNA

The Laboratory routinely monitors flora and fauna to determine the effects of past and present Laboratory activities. Because soil contaminated with a radioactive isotope of cesium (Cs-137) was used in some BNL landscaping projects in the past, traces have now been found in deer and in other animals and plants. At the cellular level, Cs-137 takes the place of potassium (K), an essential nutrient.

Most radionuclide tables in this chapter list data for both Cs-137 and potassium-40 (K-40), a naturally occurring radioisotope of potassium. Because K-40 is naturally in the environment, it is commonly found in flora and fauna. (In general, K-40 values do not receive significant discussion in the scientific literature because K-40 occurs naturally.) Studies indicate that Cs-137 out-competes K and K-40 when potassium salts are limited in the environment, which is typical on Long Island.

The results of the annual sampling conducted under the flora and fauna monitoring program follow.

6.3.1 Deer Sampling

White-tailed deer in New York State typically are large, with males weighing, on average, about 150 pounds; females typically weigh one-third less, approximately 100 pounds. However, white-tailed deer on Long Island tend to be much smaller, weighing an average of 80 pounds. The available meat on local deer ranges from 20 to 40 pounds per deer. This fact has implications for calculating the potential radiation dose to consumers of deer meat containing Cs-137, because smaller deer do not provide sufficient amounts of venison to support the necessary calculations.

In 2009, as in recent years, an off-site deer-sampling program was conducted with the NYSDEC Wildlife Branch. While most off-site samples are from road-killed deer near the Laboratory, NYSDEC provides a few samples from hunters beyond BNL boundaries, yielding control data on deer living 1 mile or more from BNL. In addition, Laboratory employees occasionally inform Laboratory staff of deer that have died in various areas of Long Island. In all, 14 deer were obtained on site and 18 were from off-site locations, ranging from adjacent to BNL along the William Floyd Parkway, to approximately 5 miles away (Baiting Hollow, New York).

BNL sampling technicians collect the samples and process them for analysis. Samples of meat, liver, and bone are taken from each deer, when possible. The meat and liver are analyzed for Cs-137, and the bone is analyzed for strontium-90 (Sr-90).

6.3.1.1 Cesium-137 in White-Tailed Deer

White-tailed deer sampled at the Laboratory contain higher concentrations of Cs-137 than deer from greater than 1 mile off site (BNL 2000), probably because they graze on vegetation growing in soil where elevated Cs-137 levels are known to exist. Cs-137 in soil can be transferred to aboveground plant matter via root uptake, where it then becomes available to browsing animals.

Removal of contaminated soil areas at BNL has occurred under the Laboratory's Environmental Restoration (ER) Project. All major areas of contaminated soil were remediated by September 2005. In addition, all buildings at the former Hazardous Waste Management Facility (HWMF) were removed in 2003, and the cleanup of the remainder of the facility was completed by fall 2005. Subsequent to the completion of cleanup at the former HWMF, additional minor contamination outside that facility was found and characterized, and the majority of the contamination was removed in 2009. Further characterization of the area surrounding the former HWMF was performed in late 2009, with work scheduled to continue into 2010.

The number of deer obtained for sampling steadily increased between 1996 and 2004. However, the numbers of deer obtained from 2005 to 2008 were significantly lower. In 2009, increased number of deer–car collisions resulted in a larger number of samples than in the recent past. In 1998, a statistical analysis based on existing data suggested that 40 deer from off site and 25 deer from on site were needed to achieve a statistically sound data set. Since that analysis was completed, BNL has attempted to obtain the required number of deer. The number obtained each year has varied due to the sampling method, which depends on vehicle and deer accidents and people reporting dead deer. The number of deer hit by vehicles varies widely from year to year, depending on the population of deer present near major roadways and the traffic density. Figure 6-1 shows the location of all deer samples taken within a 5-mile radius of the Laboratory since 2004. Most of the off-site samples are concentrated along the William Floyd Parkway on the west boundary of BNL, whereas the concentration on site is near the front gate area and the constructed portions of the Laboratory. This distribution is most likely due to the fact that people on their way to work see and report dead deer. Vehicle collisions with deer on site occur primarily early or late in the day, when deer are more active and traffic to and from the front gate are greatest.

In 2009, Cs-137 concentrations in deer muscle ("meat") samples taken at BNL ranged from non-detectable to 2.97 pCi/g wet weight. The wet weight concentration is before a sample is dried for analysis, and is the form most likely to be consumed. Dry weight concentrations are typically higher than wet weight values. The maximum 2009 on-site concentration (2.97 pCi/g wet weight) was 1.8 times higher than the highest level reported in 2008 (1.67 pCi/g wet weight), but continues to be much lower than the highest level ever reported (11.74 pCi/g wet weight, in 1996). The arithmetic average concentration in on-site meat samples was 0.80 pCi/g, wet weight (see Table 6-2), which was comparable to the arithmetic average in 2008, 0.89 pCi/g wet weight.

Cs-137 concentrations in off-site deer meat samples were separated into two groups: samples taken within 1 mile of BNL (nine samples) and samples taken farther away (nine samples) as shown in Table 6-2. Concentrations in meat samples taken within 1 mile ranged from 0.03 to 4.89 pCi/g wet weight, with an arithmetic average of 1.66 pCi/g wet weight; concentrations in meat taken from greater than 1 mile ranged from non-detectable to 1.39 pCi/g wet weight, with an arithmetic average of 0.43 pCi/g wet weight. Because deer on site may routinely travel up to 1 mile off site, the arithmetic average for deer taken on site and within 1 mile of the Laboratory is also calculated; for 2009, this was 1.14 pCi/g wet weight.

Figure 6-2 compares the average values of Cs-137 concentrations in meat samples collected in 2009 from four different location groupings. Although the figure does not show this, 72 percent of all meat samples taken both on and off site are below 1 pCi/g wet weight (Table 6-2).

Figure 6-3 presents the 10-year trend of on-site and near-off-site Cs-137 averages in deer meat. While similar in number to the samples taken in 2001, samples from 2009 indicate a similar range of error and continue to indicate the effectiveness of cleanup actions across the Laboratory; approximately 0.5 pCi lower average than in 2001. In 2003, a seasonal pattern in Cs-137 concentrations in deer meat was noticed. This seasonality was present in data from earlier years and occurred again in 2009 (see Table

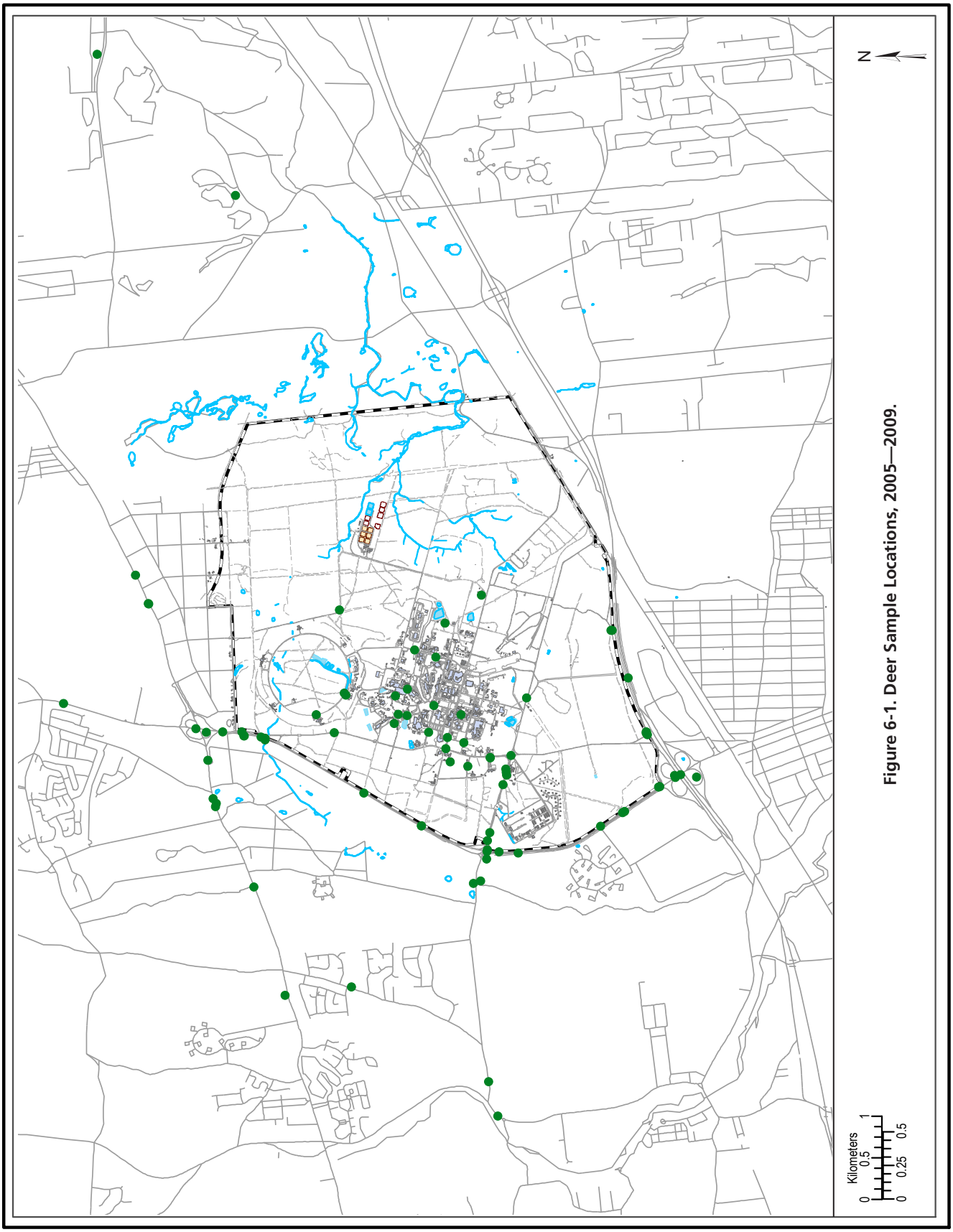

Figure 6-1. Deer Sample Locations, 2005—2009.

Table 6-2. Radiological Analyses of Deer Tissue (Flesh, Liver, Bone).

Sample Location	Collection Date	Tissue Type	K-40 pCi/g (Wet Weight)	Cs-137 pCi/g (Wet Weight)	Sr-90 pCi/g (Dry Weight)
BNL, On Site					
Bldg 1070	01/06/09	Hind	3.19 ± 0.35	0.41 ± 0.04	
		Bone			0.23 ± 0.55
Between Bldgs. 460 and 461	02/09/09	Hind*	2.89 ± 0.33	0.04 ± 0.01	
		Liver*	2.21 ± 0.47	0.06 ± 0.02	
		Bone			0.63 ± 0.50
National Weather Service	03/09/09	Hind	2.87 ± 0.36	0.03 ± 0.01	
		Bone**			0.96 ± 0.59
Bldg. 488	04/04/09	Hind*	3.26 ± 0.38	0.02 ± 0.01	
		Liver	2.42 ± 0.32	0.01 ± 0.01	
		Bone			0.70 ± 0.45
Bldg 258	04/20/09	Hind	2.10 ± 0.46	ND	
		Liver	2.96 ± 0.76	ND	
		Bone**			0.83 ± 0.52
Near P-2 area	06/22/09	Hind*	3.19 ± 0.37	0.02 ± 0.01	
		Liver*	1.84 ± 0.26	0.01 ± 0.01	
		Bone			ND
P-2 area, Bldg. 488	09/04/09	Hind*	3.62 ± 0.41	0.08 ± 0.01	
		Liver*	2.33 ± 0.41	0.03 ± 0.02	
		Bone			1.60 ± 0.52
Fence between Bldgs. 908 and 941	11/17/09	Hind	3.75 ± 0.54	0.73 ± 0.07	
		Liver	2.93 ± 0.31	0.29 ± 0.03	
		Bone			1.13 ± 0.35
Intersection, Bell Ave. and Columbia St.	11/20/09	Hind	3.11 ± 0.36	0.76 ± 0.05	
		Bone			1.49 ± 0.39
Intersection, Upton Rd. and Princeton Ave.	11/20/09	Hind	3.36 ± 0.38	2.97 ± 0.30	
		Bone			ND
Corner, Upton Rd. and Bell Ave.	12/11/09	Hind	2.61 ± 0.38	0.66 ± 0.07	
		Liver*	2.21 ± 0.31	0.12 ± 0.02	
		Bone			ND
Princeton Ave., across from Motorpool	12/11/09	Hind	3.41 ± 0.40	2.81 ± 0.28	
		Bone			2.75 ± 0.45
North Gate Rd.	12/11/09	Hind	3.40 ± 0.39	1.00 ± 0.09	
		Liver*	2.26 ± 0.55	0.13 ± 0.04	
		Bone			ND
Inner RHIC Rd., across from Bldg. 1007	12/19/09	Hind	3.28 ± 0.35	1.71 ± 0.11	
		Liver	2.22 ± 0.29	0.42 ± 0.04	
		Bone			4.66 ± 0.57
Offsite < 1 mile					
LIE and WFP NE cloverleaf	05/20/2009	Hind	3.02 ± 0.34	0.24 ± 0.03	
		Liver*	1.66 ± 0.37	0.12 ± 0.03	
		Bone			1.00 ± 0.59
LIE and WFP	07/17/2009	Hind	3.25 ± 0.34	0.60 ± 0.05	
		Bone			1.96 ± 0.58

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Table 6-2. Radiological Analyses of Deer Tissue (Flesh, Liver, Bone) *(continued).*

Sample Location	Collection Date	Tissue Type	K-40 pCi/g (Wet Weight)	Cs-137 pCi/g (Wet Weight)	Sr-90 pCi/g (Dry Weight)
Red Deer from Sandy Pond	10/02/2009	Hind*	2.66 ± 0.34	0.03 ± 0.01	
		Bone			1.53 ± 0.57
WFP and Main Gate	10/02/2009	Hind	3.14 ± 0.37	1.79 ± 0.10	
		Bone			1.31 ± 0.58
WFP, 0.5 miles S of Main Gate	10/31/2009	Hind	3.10 ± 0.37	1.70 ± 0.09	
		Bone			ND
WFP at North Gate	11/05/2009	Hind	3.17 ± 0.38	0.52 ± 0.05	
		Bone			ND
WFP	11/20/2009	Hind	3.49 ± 0.40	4.07 ± 0.36	
		Bone			1.91 ± 0.47
LIE, Exit 68 at South Gate	11/23/2009	Hind	3.15 ± 0.36	4.89 ± 0.42	
		Bone			7.82 ± 0.73
LIE, Exit 68 at South Gate	11/23/2009	Hind	3.04 ± 0.34	1.13 ± 0.09	
		Bone			ND
Offsite > 1 mile					
WFP, 1 mile N of Rte 25	01/06/2009	Hind	2.65 ± 0.30	1.39 ± 0.09	
		Bone			2.76 ± 0.76
Rt. 25, 0.25 mile W of WFP	01/06/2009	Hind	3.06 ± 0.33	0.40 ± 0.04	
		Liver*	2.06 ± 0.28	0.09 ± 0.02	
		Bone			1.58 ± 0.62
3186 Sound Ave., Riverhead	10/02/2009	Hind	2.79 ± 0.32	0.02 ± 0.01	
		Liver	2.85 ± 0.32	ND	
		Bone			ND
3186a Sound Ave., Riverhead	10/02/2009	Hind*	3.11 ± 0.34	0.01 ± 0.01	
		Liver*	3.05 ± 0.35	0.02 ± 0.01	
		Bone			ND
3186b Sound Ave., Riverhead	10/03/2009	Hind	3.02 ± 0.33	0.66 ± 0.05	
		Liver	2.48 ± 0.31	0.38 ± 0.03	
		Bone			1.44 ± 0.55
3186c Sound Ave., Riverhead	10/04/2009	Hind*	2.66 ± 0.33	0.02 ± 0.01	
		Liver*	2.69 ± 0.32	0.01 ± 0.01	
		Bone			ND
3186d Sound Ave., Riverhead	10/05/2009	Hind	2.77 ± 0.34	0.87 ± 0.08	
		Liver	2.80 ± 0.35	0.37 ± 0.04	
		Bone			ND
4603 Rt. 25, Calverton	11/04/2009	Hind	3.00 ± 0.44	0.52 ± 0.05	
		Liver	3.64 ± 0.39	0.98 ± 0.08	
		Bone			1.42 ± 0.40
Tanner Neck Rd., Westhampton	12/10/2009	Hind	3.50 ± 0.43	ND	
		Liver	3.36 ± 0.49	ND	
		Bone			ND

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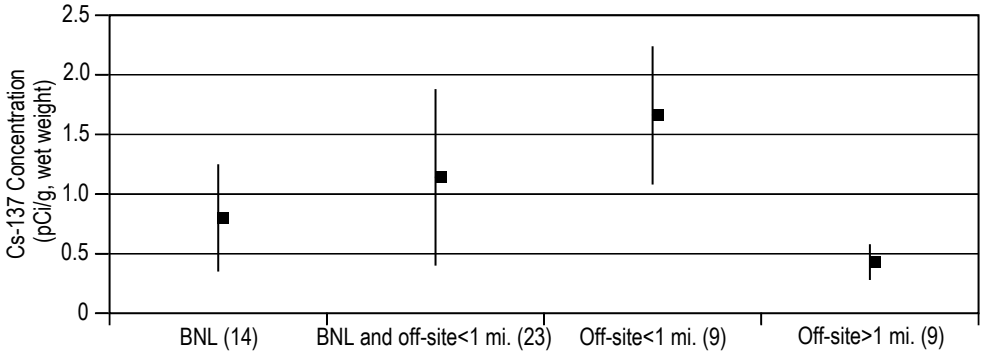
Table 6-2. Radiological Analyses of Deer Tissue (Flesh, Liver, Bone) *(concluded).*

Sample Location	Collection Date	Tissue Type	K-40 pCi/g (Wet Weight)	Cs-137 pCi/g (Wet Weight)	Sr-90 pCi/g (Dry Weight)
Averages by Tissue					
Flesh					
Average for all Samples (32 samples)			3.08 ± 2.11	0.94 ± 0.75	
BNL on-site average (14 samples)			3.15 ± 1.47	0.80 ± 0.45	
BNL on- and off-site < 1 mile avg. (23 samples)			3.13 ± 1.82	1.14 ± 0.74	
Off-site average (18 samples)			3.03 ± 1.52	1.05 ± 0.60	
Off-site < 1 mile average (9 samples)			3.11 ± 1.08	1.66 ± 0.58	
Off-site > 1 mile average (9 samples)			2.95 ± 1.07	0.43 ± 0.15	
Liver					
Average for all samples (18 samples)			2.55 ± 1.69	0.17 ± 0.13	
BNL on-site average (9 samples)			2.38 ± 1.30	0.12 ± 0.08	
BNL on- and off-site < 1 mile avg. (10 samples)			2.30 ± 1.35	0.12 ± 0.08	
Off-site average (9 samples)			2.73 ± 1.07	0.22 ± 0.10	
Off-site < 1 mile average (1 sample)*			1.66 ± 0.37	0.12 ± 0.03	
Off-site > 1 mile average (8 samples)			2.87 ± 1.01	0.23 ± 0.10	
Bone					
Average for all samples (32 samples)					1.39 ± 3.29
BNL on-site average (14 samples)					1.25 ± 1.98
BNL on- and off-site < 1 mile avg. (23 samples)					1.55 ± 2.79
Off-site average (18 samples)					1.51 ± 2.62
Off-site < 1 mile average (9 samples)					2.01 ± 1.96
Off-site > 1 mile average (9 samples)					1.00 ± 1.74

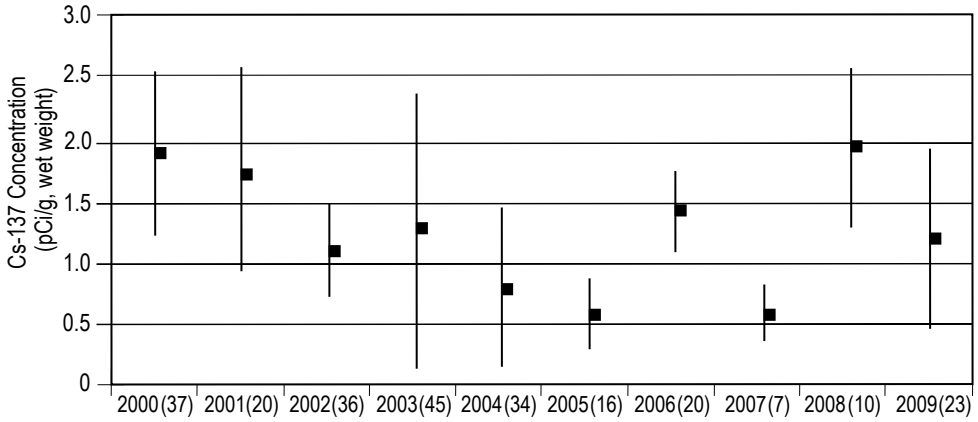
Notes:
All values are shown with a 95% confidence interval.
K-40 occurs naturally in the environment and is presented as a comparison to Cs-137.
All averages are the arithmetic average.
Confidence limits are 2σ signma (95%) propogated error.
Cs-137 = cesium-137
K-40 = potassium-40
LIE = Long Island Expressway
Sr-90 = strontium-90
WPF = William Floyd Parkway
* = estimated value for Cs-137
** = estimated value for Sr-90

6-2); deer sampled from October to December typically have higher Cs-137 values than those obtained in the spring. During the summer of 2004, a student in the Community College Intern Program reviewed all data from 2000–2003, analyzed the data statistically, and determined that there was a statistical seasonal variation in values for deer both on site as well as far off site (Florendo 2004). This seasonality is likely due to diet and the biological processing of Cs-137. From January through May, deer have a limited food supply—mostly dry vegetation from the previous year's growth (with a fixed concentration of Cs-137 because plants are dormant). In the summer and fall, deer eat more and the vegetation is constantly growing, taking up nutrients and contaminants from the soil. In summer and fall, deer feeding on vegetation growing in soil



Notes: Averages are shown for samples collected at BNL, on site and off site within 1 mile, off site but within 1 mile of the boundary, and off site greater than 1 mile from the boundary.
Numbers in parentheses indicate the number of samples in that data set.
All values are presented with a 95% confidence interval.
Cs-137 = cesium-137

Figure 6-2. Comparison of Cs-137 Average Concentrations in Deer, 2009.



Notes: Averages are shown for samples collected at BNL, and within 1 mile.
Numbers in parentheses indicate the number of samples in that data set.
All values are presented with a 95% confidence interval.
Cs-137 = cesium-137

Figure 6-3. Ten-Year Trend of Cs-137 Concentrations in Deer Meat at BNL and Within 1 Mile of BNL.

containing Cs-137 are more likely to obtain a continuous supply, which is incorporated into their tissues. This increased concentration of Cs-137 in tissues is evidenced by the three highest values seen in deer in 2009 (2.81, 4.07, and 4.89 pCi/g wet weight) from samples taken in October through December. By January or February, the Cs-137 in their tissues has been eliminated through biological processes. The levels of Cs-137 in deer tissue during June through early August are not well known, as there are few vehicle–deer accidents at this time of year.

When possible, liver samples are taken concurrently with meat samples. Liver generally accumulates Cs-137 at a lower rate than muscle tissue. The typically lower values in liver allow the results to be used as a validity check for meat values (i.e., if liver values are higher than meat values, results can be considered questionable and should be confirmed). In liver samples collected on site in 2009, Cs-137 concentrations ranged from non-detectable to 0.42 pCi/g wet weight, with an arithmetic average of 0.12 pCi/g wet weight. The off-site Cs-137 concentration in liver ranged from non-detectable to 0.98 pCi/g wet weight, with an arithmetic average for all off-site liver samples of 0.22 pCi/g wet weight.

The potential radiological dose resulting from deer meat consumption is discussed in Chapter 8. The New York State Department of Health (NYSDOH) has formally considered the potential public health risk associated with elevated Cs-137 levels in on-site deer and determined that neither hunting restrictions nor formal health advisories are warranted (NYSDOH 1999).

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

6.3.1.2 Strontium-90 in Deer Bone

BNL began testing deer bones for Sr-90 content in 2000. In 2009, Sr-90 content ranged from non-detectable to 4.66 pCi/g dry weight in on-site samples. Sr-90 in off-site samples ranged from non-detectable to 7.82 pCi/g dry weight in samples taken within 1 mile of BNL, and non-detectable to 2.76 pCi/g dry weight in samples taken more than a mile from BNL. This overlap in values between all samples suggests that Sr-90 is present in the environment at background levels, probably as a result of worldwide fallout from nuclear weapons testing. Sr-90 is present at very low levels in the environment, is readily incorporated into bone tissue, and may concentrate over time. The Laboratory will continue to test for Sr-90 in bone to maintain baseline information on this radionuclide and its presence in local white-tailed deer.

6.3.2 Other Animals Sampled

When other animals, such as wild turkey or Canada geese, are found dead along the roads of BNL and the immediate vicinity due to road mortality, they are tested for Cs-137 and Sr-90 content. In 2009 as in 2008, there were no samples taken from geese or turkeys. Data taken over the past several years indicate that both species do not readily uptake radionuclides from their diet.

6.3.4 Fish Sampling

In collaboration with the NYSDEC Fisheries Division, BNL maintains an ongoing program for collecting and analyzing fish from the Peconic River and surrounding freshwater bodies. Routine annual on-site sampling of fish resumed in 2007. Large areas of open water on site resulting from the cleanup of the Peconic River have resulted in sufficient habitat to support larger fish. During sampling activities in 2007, numerous schools of fry of bass and sunfish were noticed. While low dissolved oxygen levels continue to be a problem for fish, the deeper pools provide areas of cooler, more highly oxygenated water for long-term survival. Fish were sampled early in 2009 to take advantage of periods when dissolved oxygen levels are higher, supporting the presence of fish.

As in the past, off-site fish sampling continued in 2009. All samples were analyzed for edible (fillet) content of each of the analytes reported. In 2009, various species of fish were collected off site from Swan Pond, Donahue's Pond, Forge Pond, Manor Road, Schultz Road, and Lower Lake on the Carmans River (see Figure 5-8 for sampling stations). Swan Pond is a semi-control location on the Peconic River system (a tributary of the Peconic not connected to the BNL branch), and Lower Lake on the Carmans River is the non-Peconic control site. Sampling is carried out in cooperation with NYSDEC and through a contract with the Cold Spring Harbor Fish Hatchery and Museum. Sampling is also separated into samples taken as part of the routine surveillance monitoring program, and those taken as part of the post cleanup monitoring for the Peconic River Cleanup project (primarily for mercury analysis).

6.3.4.1 Radiological Analysis of Fish

The species collected for radiological analysis in 2009 by the Laboratory, NYSDEC, and through contract labor included brown bullhead (*Ictalurus nebulosus*), chain pickerel (*Esox niger*), largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), pumpkinseed (*Lepomis gibbosus*), brown trout (*Salmo trutta*), and yellow perch (*Perca flavescens*). Gamma spectroscopy analysis was performed on all samples. When fish were not of sufficient mass to conduct all non-radiological and radiological analyses, samples of the same species were composited to gain sufficient volume for radiological analysis. Table 6-3 presents specific information on the sampling location, species collected, and analytical results. All sample results are presented as wet weight concentrations. Information on the natural radioisotope K-40 is included as a comparison.

Cs-137 was detected at low levels in all but two samples from the Peconic River system, ranging from non-detectable for a largemouth bass and brown bullhead from Forge Pond and Swan Pond, respectively, to 0.51 pCi/g wet weight in a composite sample of largemouth bass taken from Area C on site. In 2009, fish taken from Lower Lake on the Carmans River (the non-Peconic control location) had no measurable values of Cs-137.

To account for the different feeding habits and weights of various species, it is important to compare species with similar feeding habits (i.e., bottom feeders such as brown bullhead should be compared to other bottom feeders). Cs-137 concentrations in brown bullhead collected at all locations along the Peconic River had values less than 0.30 pCi/g wet weight. Largemouth bass from the Peconic River showed Cs-137 levels of 0.51 pCi/g wet weight or less. Levels of Cs-137 in all fish species appear to be declining, compared to historic values.

Though it is clear from discharge records and sediment sampling that past BNL operations have contributed to anthropogenic (human-caused) radionuclide levels in the Peconic River system, most of these radionuclides were released between the late 1950s and early 1970s. Concentrations continue to decline over time through natural decay. Cs-137 has a half-life of 30 years. No Cs-137 was released from the BNL Sewage Treatment Plant (STP) to the Peconic River between 2003 and 2009 (see Figure 5-4 for a trend of Cs-137 discharges). Additionally, the cleanup of both on- and off-site portions of the Peconic River in 2004 and 2005 removed approximately 88 percent of Cs-137 in the sediment that was co-located with mercury. Removal of this contamination is expected to result in further decreases in Cs-137 levels in fish.

6.3.4.2 Fish Population Assessment

BNL suspended fish sampling on site in 2001 because prior fish sampling had depleted the population and limited the remaining fish to smaller sizes. Sampling resumed in 2007 when multiple schools of small fish were observed throughout the on-site portions of the river. The relative sizes of fish caught during annual sampling events will be tracked, and modifications to future sampling events will be made, as necessary, to ensure long-term health of the on-site fish populations. Successful sampling of sufficiently large fish for analysis in 2008 and 2009 indicated that populations are maintaining themselves and can support annual sampling.

6.3.4.3 Nonradiological Analysis of Fish

In 1997, under BNL's Environmental Restoration Program Operable Unit (OU) V Remediation Project, fish from the Peconic River on site were analyzed for metals, pesticides, and PCBs. From 2002 through 2006, analysis was limited to off-site fish. The timing of sampling has varied from year to year, as well as the sample preparation (whole-body, tissue separation, composite sampling). In 1997, sampling was performed during April through May; in 1999, sampling was performed during September through December. From 2000 through 2006, sampling was performed from July through August. Additionally, there has been a wide variation in fish size; therefore, samples have had to be composite whole-body to obtain significant mass for analysis. These variables make the comparisons from year to year difficult, as there can be significant seasonal variations in

Table 6-3. Radiological Analysis of Fish from the Peconic River System and Carmens River, Lower Lake.

Location/Species	K-40	Cs-137
	pCi/g, wet weight	
BNL, On Site		
Area A		
Brown Bullhead (composite)	NR	0.23 ± 0.03
Brown Bullhead (composite)	NR	0.22 ± 0.03
Brown Bullhead (composite)	NR	0.30 ± 0.04
Brown Bullhead (composite)	NR	0.23 ± 0.03
Brown Bullhead (composite)	NR	0.20 ± 0.03
Brown Bullhead (composite)	NR	0.26 ± 0.03
Brown Bullhead (composite)	NR	0.21 ± 0.03
Brown Bullhead (composite)	NR	0.25 ± 0.03
Brown Bullhead (composite)	NR	0.20 ± 0.04
Largemouth Bass	NR	0.19 ± 0.02
Pumpkinseed (composite)	NR	0.26 ± 0.04
Pumpkinseed (composite)	NR	0.20 ± 0.02
Pumpkinseed (composite)	NR	0.26 ± 0.03
Area C		
Bluegill (composite)	NR	0.19 ± 0.04
Bluegill (composite)	NR	0.18 ± 0.04
Brown Bullhead (composite)	NR	0.21 ± 0.03
Largemouth Bass (composite)	NR	0.51 ± 0.06
Pumpkinseed (composite)	NR	0.28 ± 0.08
Pumpkinseed (composite)	NR	0.22 ± 0.04
Pumpkinseed (composite)	NR	0.21 ± 0.04
Area D		
Brown Bullhead	NR	0.24 ± 0.03

(continued)

Table 6-3. Radiological Analysis of Fish from the Peconic River System and Carmens River, Lower Lake *(continued).*

Location/Species	K-40	Cs-137
	pCi/g, wet weight	
Brown Bullhead (composite)	4.12 ± 0.52	0.30 ± 0.05
Brown Bullhead (composite)	3.10 ± 0.36	0.23 ± 0.03
Brown Bullhead (composite)	3.92 ± 0.42	0.22 ± 0.03
Brown Bullhead (composite)	NR	0.22 ± 0.03
Brown Bullhead (composite)	NR	0.24 ± 0.03
Brown Bullhead (composite)	3.04 ± 0.50	0.09 ± 0.03
Brown Bullhead (composite)	3.54 ± 0.48	0.15 ± 0.03
Largemouth Bass	3.39 ± 0.45	0.43 ± 0.04
Pumpkinseed	NR	0.24 ± 0.04
Pumpkinseed (composite)	2.94 ± 0.47	0.14 ± 0.03
Schultz Road		
Chain Pickerel	3.19 ± 0.44	0.14 ± 0.03
Largemouth Bass	2.74 ± 0.43	0.08 ± 0.02
Manor Road		
Brown Bullhead	3.43 ± 0.51	0.12 ± 0.03
Brown Bullhead	2.90 ± 0.42	0.19 ± 0.02
Brown Bullhead	3.17 ± 0.47	0.24 ± 0.03
Brown Bullhead	3.13 ± 0.44	0.12 ± 0.02
Brown Bullhead (composite)	2.10 ± 0.36	0.09 ± 0.02
Brown Bullhead (composite)	2.90 ± 0.40	0.19 ± 0.02
Brown Bullhead (composite)	2.95 ± 0.40	0.08 ± 0.03
Brown Bullhead (composite)	3.49 ± 0.54	0.14 ± 0.03
Chain Pickerel	3.61 ± 0.43	0.11 ± 0.02
Largemouth Bass	2.66 ± 0.45	0.07 ± 0.02
Largemouth Bass	3.43 ± 0.42	0.09 ± 0.02
Swan Pond (Peconic River control location)		
Brown Bullhead	2.34 ± 0.50	ND
Brown Bullhead*	4.09 ± 0.70	0.07 ± 0.03

(continued)

Table 6-3. Radiological Analysis of Fish from the Peconic River System and Carmens River, Lower Lake *(continued).*

Location/Species	K-40	Cs-137
	pCi/g, wet weight	
Brown Bullhead*	3.33 ± 0.72	0.08 ± 0.04
Brown Bullhead*	2.85 ± 0.67	0.05 ± 0.03
Chain Pickerel*	3.76 ± 0.88	0.12 ± 0.06
Largemouth Bass*	3.90 ± 0.63	0.08 ± 0.03
Largemouth Bass*	4.63 ± 0.66	0.11 ± 0.03
Largemouth Bass*	2.45 ± 0.67	0.09 ± 0.03
Largemouth Bass*	3.69 ± 0.57	0.11 ± 0.04
Yellow Perch*	2.36 ± 0.70	0.10 ± 0.04
Yellow Perch*	3.60 ± 0.79	0.06 ± 0.05
Yellow Perch*	2.91 ± 0.65	0.09 ± 0.04
Yellow Perch*	3.29 ± 0.80	0.07 ± 0.05
Yellow Perch*	3.29 ± 0.93	0.09 ± 0.07
Yellow Perch*	2.20 ± 0.66	0.05 ± 0.04
Yellow Perch*	2.89 ± 0.78	0.08 ± 0.05
Donahue's Pond		
Bluegill (composite)	2.63 ± 0.51	0.05 ± 0.03
Bluegill (composite)	2.00 ± 0.47	0.05 ± 0.03
Bluegill (composite)	1.78 ± 0.38	0.05 ± 0.02
Bluegill (composite)	2.43 ± 0.41	0.09 ± 0.02
Bluegill (composite)	1.63 ± 0.58	0.07 ± 0.03
Bluegill (composite)	2.09 ± 0.42	0.07 ± 0.03
Brown Bullhead	2.87 ± 0.45	0.07 ± 0.02
Brown Bullhead	3.33 ± 0.49	0.07 ± 0.02
Brown Bullhead	3.06 ± 0.52	0.09 ± 0.02
Brown Bullhead	2.59 ± 0.52	0.10 ± 0.02
Brown Bullhead	3.03 ± 0.45	0.05 ± 0.02
Brown Bullhead (composite)	2.65 ± 0.52	0.06 ± 0.02
Chain Pickerel	3.05 ± 0.41	0.15 ± 0.02
Chain Pickerel	2.35 ± 0.37	0.26 ± 0.03
Chain Pickerel	3.35 ± 0.43	0.13 ± 0.02
Chain Pickerel	2.52 ± 0.37	0.10 ± 0.02
Pumpkinseed (composite)	2.02 ± 0.36	0.02 ± 0.02
Forge Pond		
Brown Bullhead*	3.27 ± 0.50	0.04 ± 0.02
Chain Pickerel*	2.84 ± 0.83	0.10 ± 0.05

(continued)

Table 6-3. Radiological Analysis of Fish from the Peconic River System and Carmens River, Lower Lake *(concluded).*

Location/Species	K-40	Cs-137
	pCi/g, wet weight	
Chain Pickerel*	3.33 ± 0.76	0.19 ± 0.05
Chain Pickerel*	2.95 ± 0.58	0.08 ± 0.03
Chain Pickerel*	3.27 ± 0.70	0.09 ± 0.04
Largemouth Bass*	3.32 ± 0.84	0.08 ± 0.05
Largemouth Bass*	2.86 ± 0.90	0.12 ± 0.06
Largemouth Bass	4.91 ± 1.13	ND
Largemouth Bass*	4.65 ± 0.94	0.11 ± 0.06
Largemouth Bass*	2.88 ± 0.92	0.11 ± 0.06
Largemouth Bass*	3.82 ± 0.91	0.08 ± 0.05
Yellow Perch*	3.39 ± 0.68	0.07 ± 0.03
Yellow Perch*	2.83 ± 0.68	0.11 ± 0.04
Yellow Perch*	3.42 ± 0.62	0.08 ± 0.03
Yellow Perch*	4.09 ± 0.74	0.07 ± 0.03
Yellow Perch*	3.96 ± 0.86	0.09 ± 0.05
Yellow Perch*	2.79 ± 0.71	0.11 ± 0.03
Lower Lake, Carmans River		
Brown Bullhead	NR	ND
Brown Bullhead	NR	ND
Brown Bullhead	NR	ND
Brown Trout	NR	ND
Brown Trout	NR	ND
Brown Trout (composite)	NR	ND
Brown Trout (composite)	NR	ND
Largemouth Bass	NR	ND
Largemouth Bass	NR	ND
Largemouth Bass	NR	ND
Largemouth Bass	NR	ND
Largemouth Bass	NR	ND
Largemouth Bass	NR	ND

Notes:
All samples analyzed as edible portions (fillets).
K-40 occurs naturally in the environment and is presented as a comparison to Cs-137.
Cs-137 = cesium-137
K-40 = potassium-40
* = estimated value for Cs-137 based on analytical laboratory qualifiers.
ND = not detected, based on analytical laboratory qualifiers.
NR = data not reported by analytical laboratory.

feeding, energy consumption, and incorporation of nutrients into various tissues. Beginning in 2005, all fish of sufficient size were analyzed as edible portions (fillets). Smaller fish, such as golden shiners, were composited for whole-body analysis. In 2007, fish sampling was moved to the spring months to lessen the effect of low oxygen levels on fish distributions. Nearly all samples were obtained between April and mid-June.

Table 6-4 shows the 2009 concentration of metals in fish taken for surveillance monitoring within the Peconic River and Lower Lake on the Carmans River. Due to the fact that values for arsenic, beryllium, cadmium, cobalt, silver, thallium, selenium, and vanadium were near or less than the minimum detection level (MDL) for the analytical procedure, they were not included in Table 6-4. Other metals tested but not included in the table include aluminum, antimony, and nickel, as most values reported for these metals were less than the MDL. Values that were above the MDL are discussed below. Fish taken on site are important to the post cleanup monitoring program; they are analyzed for mercury and the data are presented in Table 6-5.

Values for metals not shown in Table 6-4 because they were at or near MDL were as follows: aluminum was found in a composite sample of brown trout from the Carmans River at a level of 32.7 mg/kg; antimony was found in a single yellow perch from Swan Pond at a level of 0.383 mg/kg; arsenic was detected in several brown trout samples from Lower Lake on the Carmans River and ranged from 0.27 to 0.34 mg/kg, and was present in a single yellow perch from Forge Pond at a level of 0.28 mg/kg; cadmium, nickel, and selenium were not detected in any samples taken; and silver was found in two fish taken from the Peconic River, a yellow perch taken at Forge Pond and a largemouth bass from Swan Pond. Both fish had a value of 0.10 mg/kg. These reported values and those presented in Table 6-4 are not considered to pose any health risks to humans or other animals that may consume fish.

Due to its known health effects, mercury is the metal of highest concern. Peconic River samples taken for surveillance were inadvertently not analyzed for mercury content in 2009. This error in analytical testing does not include fish taken for post cleanup monitoring related to the Peconic River Cleanup.

Table 6-4. Surveillance Monitoring Metals Analysis of Fish from the Peconic River System and Carmans River, Lower Lake.

Location/Species	Barium	Chromium	Copper	Iron	Lead	Manganese	Mercury	Zinc
	mg/kg							
Forge Pond								
Chain Pickerel	< MDL	< MDL	< MDL	< MDL	< MDL	0.472	NT	4.450
Chain Pickerel	< MDL	< MDL	< MDL	< MDL	< MDL	0.873	NT	6.310
Chain Pickerel	< MDL	< MDL	< MDL	< MDL	< MDL	0.206	NT	3.530
Chain Pickerel	< MDL	< MDL	< MDL	< MDL	< MDL	0.226	NT	3.120
Brown Bullhead	0.154	< MDL	< MDL	< MDL	< MDL	0.258	NT	2.480
Yellow Perch	< MDL	< MDL	< MDL	< MDL	< MDL	0.442	NT	3.660
Yellow Perch	< MDL	< MDL	< MDL	< MDL	< MDL	0.584	NT	5.850
Yellow Perch	0.343	< MDL	< MDL	< MDL	< MDL	2.020	NT	10.900
Yellow Perch	< MDL	< MDL	< MDL	< MDL	< MDL	0.575	NT	4.330
Yellow Perch	< MDL	< MDL	< MDL	< MDL	< MDL	0.396	NT	4.000
Yellow Perch	< MDL	< MDL	< MDL	< MDL	< MDL	0.620	NT	4.610
Yellow Perch	0.101	< MDL	< MDL	< MDL	0.121	0.199	NT	4.610
Yellow Perch	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	NT	5.510

(continued on next page)

Table 6-4. Surveillance Monitoring Metals Analysis of Fish from the Peconic River System and Carmans River, Lower Lake *(concluded).*

Location/Species	Barium	Chromium	Copper	Iron	Lead	Manganese	Mercury	Zinc
	mg/kg							
Yellow Perch	0.156	1.910	< MDL	14.000	< MDL	0.453	NT	7.780
Yellow Perch	0.184	< MDL	< MDL	< MDL	< MDL	0.240	NT	5.670
Yellow Perch	< MDL	< MDL	< MDL	< MDL	< MDL	0.274	NT	5.820
Yellow Perch	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	NT	5.440
Swan Pond (Peconic River control location)								
Largemouth Bass	0.170	0.157	< MDL	< MDL	< MDL	0.437	NT	5.580
Largemouth Bass	< MDL	< MDL	< MDL	< MDL	< MDL	0.211	NT	7.220
Largemouth Bass	0.110	< MDL	< MDL	< MDL	< MDL	0.281	NT	5.070
Largemouth Bass	0.142	< MDL	< MDL	< MDL	< MDL	0.271	NT	5.460
Chain Pickerel	< MDL	< MDL	< MDL	< MDL	< MDL	0.260	NT	6.220
Yellow Perch	0.218	< MDL	< MDL	< MDL	< MDL	2.660	NT	6.090
Yellow Perch	< MDL	< MDL	< MDL	< MDL	< MDL	0.318	NT	5.230
Yellow Perch	0.159	0.407	< MDL	< MDL	< MDL	0.406	NT	6.870
Yellow Perch	0.152	< MDL	< MDL	< MDL	< MDL	1.790	NT	4.530
Yellow Perch	< MDL	< MDL	< MDL	< MDL	< MDL	0.250	NT	4.210
Yellow Perch	0.112	< MDL	< MDL	< MDL	< MDL	0.317	NT	6.250
Yellow Perch	0.418	< MDL	< MDL	< MDL	< MDL	2.070	NT	8.160
Brown Bullhead	0.291	< MDL	< MDL	< MDL	< MDL	0.322	NT	4.910
Brown Bullhead	0.395	< MDL	< MDL	< MDL	< MDL	0.348	NT	4.590
Brown Bullhead	0.212	< MDL	< MDL	< MDL	< MDL	0.830	NT	4.400
Brown Bullhead	0.291	< MDL	< MDL	< MDL	< MDL	0.290	NT	4.100
Lower Lake, Carmans River (control location)								
Brown Bullhead	0.328	0.125	< MDL	5.190	< MDL	0.449	0.035	5.440
Brown Bullhead	0.222	0.124	< MDL	6.340	< MDL	0.305	0.018	4.760
Brown Bullhead	0.191	0.101	< MDL	2.800	< MDL	< MDL	0.029	3.290
Largemouth Bass	< MDL	0.128	< MDL	< MDL	< MDL	< MDL	0.055	4.670
Largemouth Bass	0.338	0.126	< MDL	< MDL	< MDL	0.690	0.047	4.480
Largemouth Bass	< MDL	0.122	< MDL	< MDL	< MDL	0.271	0.066	6.470
Largemouth Bass	0.172	0.153	< MDL	< MDL	< MDL	0.332	0.055	5.850
Largemouth Bass	0.124	0.114	< MDL	< MDL	< MDL	< MDL	0.051	5.410
Largemouth Bass	< MDL	0.102	< MDL	< MDL	< MDL	0.223	0.395	7.150
Brown Trout composite(3)	< MDL	0.119	< MDL	3.510	< MDL	0.213	0.004	3.950
Brown Trout composite(4)	0.411	0.152	< MDL	< MDL	< MDL	0.322	0.004	4.010
Brown Trout	0.131	0.150	< MDL	< MDL	< MDL	0.387	0.004	5.260
Brown Trout	< MDL	0.126	< MDL	< MDL	< MDL	0.204	0.004	3.760

Notes:
See Figure 5-8 for sampling locations.
All fish were analyzed as edible portions (fillets).
NT = No Test
MDL = Minimum Detection Limit

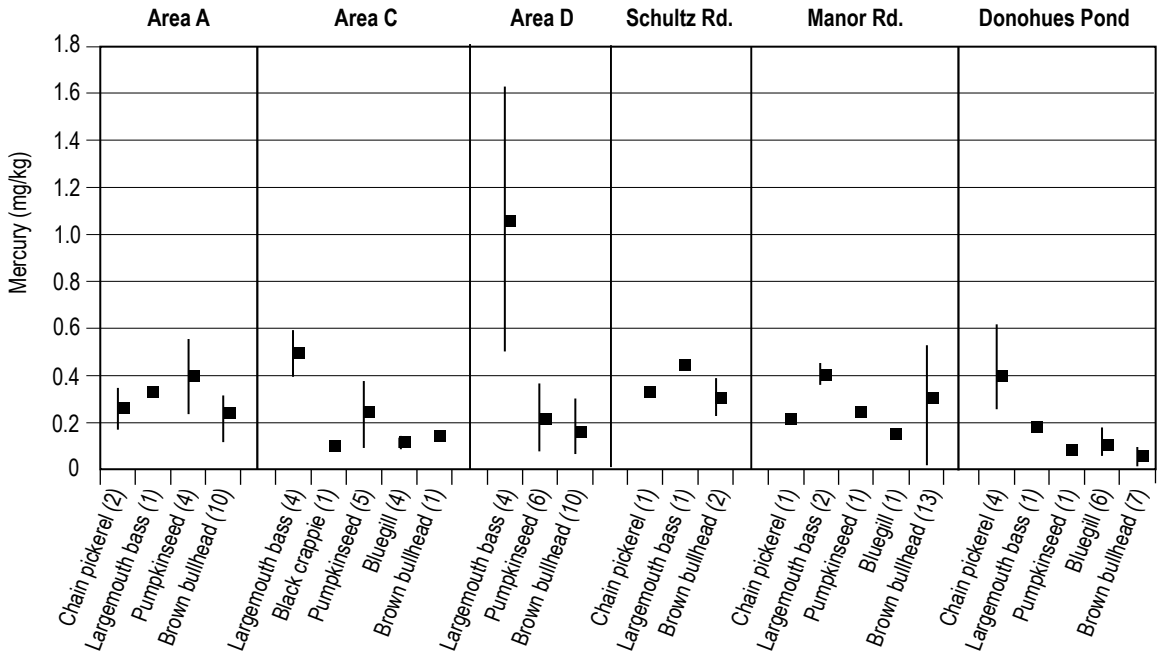
Table 6-5. Mercury Analysis of Fish from the Peconic River System Post Cleanup Monitoring.

Location/Species	Mercury mg/kg Min	Max	Avg
BNL, On Site			
Area A			
Chain pickerel (2)	0.167	0.349	0.258
Largemouth bass (1)	0.328	0.328	0.328
Pumpkinseed (4)	0.236	0.557	0.396
Brown bullhead (10 with composites)	0.116	0.319	0.241
Area C			
Largemouth bass (4 with composites)	0.393	0.593	0.496
Black Crappie (1)	0.100	0.100	0.100
Pumpkinseed (5 with composites)	0.088	0.383	0.248
Bluegill (4 with composites)	0.093	0.135	0.121
Brown bullhead (1 with composites)	0.145	0.145	0.145
Area D			
Largemouth bass (4)	0.507	1.630	1.056
Pumpkinseed (6 with composites)	0.081	0.367	0.211
Brown bullhead (10 with composites)	0.066	0.304	0.161
Schultz Road			
Chain pickerel (1)	0.329	0.329	0.329
Largemouth bass(1)	0.445	0.445	0.445
Brown bullhead (2)	0.228	0.386	0.307
Manor Road			
Chain pickerel (1)	0.214	0.214	0.214
Largemouth bass (2)	0.356	0.451	0.404
Pumpkinseed (1)	0.245	0.245	0.245
Bluegill (1)	0.152	0.152	0.152
Brown bullhead (13 with composites)	0.022	0.534	0.304
Donahue's Pond			
Chain pickerel (4)	0.262	0.624	0.399
Largemouth bass (1)	0.186	0.186	0.186
Pumpkinseed (1)	0.085	0.085	0.085
Bluegill (6 with composites)	0.065	0.177	0.106
Brown bullhead (7 with composites)	0.025	0.091	0.057

Notes:
Area letter designation refers to Peconic River cleanup areas on site.
All samples were analyzed as edible portions (fillets), including composite samples.
Full data sets are available in 2009 Peconic River Monitoring Report.

The post cleanup monitoring data for mercury analysis in fish is presented in Table 6-5 and is shown as a range of results by species and area sampled, to reduce the size of the table. The data is presented graphically in Figure 6-4. Mercury values in Area A of the Peconic River (area nearest the Sewage Treatment Plant [STP] outfall) ranged from 0.116 mg/kg in brown bullheads to 0.0.557 mk/kg in a pumpkinseed. At Area C, mercury ranged from 0.088 mg/kg in pumpkinseed to 0.593 mg/kg in largemouth bass. Fish taken from Area D near the boundary of the Laboratory had mercury content ranging from 0.066 mg/kg in brown bullhead to 1.630 mg/kg in largemouth bass. At Schultz Road, mercury ranged from 0.228 mg/kg in brown bullhead to 0.445 mg/kg in largemouth bass. At Manor Road, mercury content ranged from 0.022 mg/kg to 0.534 mg/kg in brown bullhead. The last location sampled as a part of the Peconic River Cleanup monitoring was Donahue's Pond, where mercury content in fish ranged from 0.025 mg/kg in brown bullhead to 0.624 mg/kg in chain pickerel. In general, from the rough data presented, a trend of decreasing mercury content going downstream from BNL's STP is evident. A more detailed review of the data is covered in the Annual Report on Peconic River Sampling for 2009 (BNL 2010).

Pesticide analyses in fish were discontinued in 2008, since several years of sampling detected pesticides in only a few fish far off site. PCB analyses in fish was also discontinued from surveillance monitoring, but continued to be completed on fish collected on site. Two fish samples taken from within Area A tested positive for Aroclor 1254: a 4-year-old brown bullhead containing 18.9 µg/kg and a composite sample of pumpkinseed containing 13.7 µg/kg. Historically, PCBs have been found in both fish and sediment at BNL and periodically at other locations in the Peconic River. The cleanup of the Peconic River that was completed in 2005 removed most PCBs within the sediments. Although BNL has discontinued most pesticide and PCB monitoring, the Laboratory may periodically test for PCBs and pesticides in fish to verify the presence/absence in fish tissue.



Note: Number in parentheses indicate the number of samples included

Figure 6-4. Peconic River Post Cleanup Mercury Distribution in Fish Species (Minimum, Maximum, and Average Values).

6.3.5 Aquatic Sampling

6.3.5.1 Radiological Analysis

Annual sampling of sediment and vegetation in the Peconic River and a control location on the Carmans River was conducted in 2009. (See Chapter 5 for a discussion on water quality and monitoring, and Figure 5-8 for the locations of sampling stations. Additionally, refer to Section 6.3.6 for a discussion of sediment and water analysis related to monitoring post-cleanup of the Peconic River.) Because significant numbers of samples are now taken under this monitoring program, fewer samples are being taken through routine surveillance monitoring, to reduce duplication of effort and lessen the impact on the fish populations.

Table 6-6 summarizes the radiological data. Cs-137 was not detected in any aquatic vegetation samples in 2009. Low levels of Cs-137 were detected in sediments at Swan Pond, Forge Pond, and Lower Lake on the Carmans River.

6.3.5.2 Metals in Aquatic Samples

Metals analyses (Table 6-7) were conducted on aquatic vegetation and sediments from the Peconic River and Lower Lake on the Carmans River. Most of the data indicate metals at background levels. The standard used for comparison of sediments is the SCDHS soil cleanup objectives for heavy metals. Vegetation results are compared to soil cleanup standards, because metals in vegetation may accumulate via uptake from sediment. In general, metals are seen in vegetation at levels lower than in associated sediment.

Other metals analyzed for, but not listed in Table 6-7, include antimony, arsenic, beryllium, cadmium, magnesium, potassium, selenium, sodium, and thalium. In general, levels of these metals are either below detection limits, below action levels or cleanup objectives, or, like sodium, are common in the environment. In the past, both arsenic and cadmium were detected in either Donahue's Pond and Lower Lake or in both. Neither of these metals were detected in sediments taken in 2009. Arsenic was detected above SCDHS cleanup objectives of 7.5 mg/kg in sediments at Donahue's Pond and Lower Lake (11 and 8.7 mg/kg, respectively). Cadmium was found in sediments at Lower Lake at a concentration of 1.16 mg/kg, which is above cleanup objectives but well below SCDHS ac-

Table 6-6. Radiological Analysis of Aquatic Vegetaion and Sediment from the Peconic River System and Carmans River, Lower Lake.

Location/Sample Type	K-40	Cs-137
	pCi/g	
BNL, On Site		
Aquatic vegetation	4.53 ± 0.51	ND
Aquatic vegetation	3.27 ± 0.48	ND
Aquatic vegetation	2.99 ± 0.45	ND
Aquatic vegetation	3.35 ± 0.39	ND
Donahue's Pond		
Aquatic vegetation	0.76 ± 0.27	ND
Sediment	1.48 ± 0.52	ND
Forge Pond		
Lilypads	1.7 ± 0.32	ND
Sediment	2.74 ± 0.33	0.07 ± 0.01
Swan Pond (Peconic River control location)		
Lilypads	2.6 ± 0.43	ND
Sediment	3.27 ± 0.63	1.06 ± 0.12
Lower Lake, Carmans River (control location)		
Lilypads	2.54 ± 0.43	ND
Sediment	3.99 ± 0.74	0.48 ± 0.09

Notes:
Cs-137 = cesium-137
K-40 = potassium-40
ND = not detected
Aquatic vegetation values are reported as wet weight.
Sediment values are reported as dry weight.

tion levels. Chromium was found above cleanup objectives of 10 mg/kg in sediment at Swan Pond and Lower Lake. Mercury and nickel were just above SCDHS cleanup objectives of 0.1 and 13 mg/kg, respectively, at Lower Lake.

6.3.5.3 Pesticides and PCBs in Aquatic Samples

Pesticides and PCBs analyses of aquatic samples were discontinued in 2008, corresponding to the discontinuance of this sampling in fish. DDT and its breakdown products have been the primary pesticide observed in sediments due to its long persistence in the environment. BNL will periodically analyze aquatic sediments to track the continued degradation of this pesticide in the environment.

6.3.6 Peconic River Post-Cleanup Monitoring

Sediment from the Peconic River was remediated in 2004 and 2005 to remove mercury and associated contaminants from the river. BNL/DOE must ensure that the cleanup provides adequate protection of human health and the environment by monitoring the sediment, surface water, and fish in the river for five years (2006–2010). A summary of the 2009 sediment, surface water, and fish sampling results for 2009 is described below. Detailed information on 2009 sampling results can be found in the Final 2009 Peconic River Monitoring Report (BNL, 2010).

6.3.6.1 Sediment Sampling

Sediment was sampled in August 2009 at 15 Peconic River routine sampling stations on site and 15 routine sampling stations off site. All of the 30 annual sediment samples collected in 2009 met the mercury cleanup goal of 2.0 mg/kg. Five supplemental samples were collected in the 80–100 square-foot area surrounding one on-site 2008 sediment sample location with a mercury concentration slightly greater than 2.0 mg/kg. The mercury concentrations for these five samples ranged between 0.35 mg/kg and 3.1 mg/kg, respectively, with an average of 1.37 mg/kg and only one sample exceeding 2.0 mg/kg. No further action is required in this area.

Supplemental sediment sampling was also conducted to evaluate elevated water column mercury concentrations at station PR-WC-06. The supplemental 2009 and January 2010 sediment samples identified a small on-site section of the river which will receive supplemental cleanup in the fall of 2010.

6.3.6.2 Water Column Sampling

In 2009, surface water was analyzed in June and July for total mercury and methylmercury at 20 and 17 of 22 Peconic River sampling stations, respectively. Samples at the STP and one reference station on the Connetquot River were also collected. Not all stations could be sampled due to low water tables in June and July. The concentrations of total mercury in the June (120 ng/L maximum) and July (115 ng/L maximum) water samples generally trended down-

Table 6-7. Metals Analysis of Aquatic Vegetation and Sediment from the Peconic River System and Carmens River, Lower Lake.

Location/ Sample Type	Aluminum	Barium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Manganese	Mercury	Nickel	Silver	Vanadium	Zinc
	mg/kg													
BNL, On Site														
Aquatic vegetation	10.2	3.05	1020	< MDL	< MDL	1.73	38.6	0.1	28.7	< MDL	0.204	0.127	0.155	4.83
Aquatic vegetation	54.3	17.6	782	0.309	< MDL	2.27	156	0.38	27	0.018	0.629	1.21	0.292	7.53
Aquatic vegetation	13.6	3.74	1450	< MDL	0.16	1.83	61.5	0.1	67.8	< MDL	0.365	< MDL	0.183	5.84
Aquatic vegetation	9.4	6.27	1750	< MDL	< MDL	1.08	42.1	0.117	46.7	< MDL	0.584	< MDL	0.187	7.1
Donahue's Pond														
Aquatic vegetation	10.2	44.4	4140	< MDL	0.232	< MDL	127	0.22	151	< MDL	< MDL	< MDL	< MDL	5.62
Sediment	78.6	1.67	44.9	0.267	< MDL	< MDL	163	2.03	6.18	< MDL	< MDL	< MDL	0.294	0.968
Forge Pond														
Aquatic vegetation	< MDL	33.2	1830	< MDL	< MDL	0.311	57	0.21	85.5	< MDL	< MDL	< MDL	< MDL	4.6
Sediment	4070	11.9	775	4.15	1.33	2.22	3940	3.39	17.7	< MDL	2.53	< MDL	5.5	23.9
Swan Pond (Peconic River control location)														
Aquatic vegetation	10.7	10.9	1200	< MDL	< MDL	< MDL	10.3	0.22	234	< MDL	< MDL	< MDL	< MDL	3.89
Sediment	3630	58.2	4350	14	2.45	10.7	2850	149	1180	< MDL	6.87	< MDL	27.8	45.3
Carmans River, Lower Lake (control location)														
Aquatic vegetation	7.38	44.9	2390	0.247	< MDL	0.531	71.1	0.2	232	< MDL	0.19	< MDL	0.195	5.95
Sediment	9670	161	5510	41.6	9.48	27.2	16700	131	883	0.235	15	< MDL	39.4	201
SCDHS Action Levels	N/A	N/A	N/A	100	N/A	500	N/A	400	N/A	2	1000	100	N/A	N/A
Cleanup Objectives	N/A	N/A	N/A	10	N/A	25	N/A	100	N/A	0.1	13	5	N/A	N/A

Notes:
MDL = method detection level
N/A = not applicable
SCDHS = Suffolk County Department of Health Services

wards with fluctuations and with increasing distance downstream from the STP until reaching concentrations of 3.17 ng/L to 3.84 ng/L at sample stations east of the cranberry bogs.

Peconic River methylmercury concentrations increased slightly from the STP outfall to the BNL site border. The methylmercury concentrations then decreased gradually with increasing distance downstream of the site border. The June methylmercury concentrations (3.97 ng/L maximum) in Peconic River samples were slightly less than the July samples (8.08 ng/L maximum), and decreased with increasing distance downstream of the site border until reaching the historic range of concentrations for the Connetquot River reference station. The decreasing methylmercury concentrations are associated with flow in downstream sections of the river with lower mercury concentrations in the sediment, and with dilution by flow into the river from ground water and tributaries.

6.3.6.3 Fish Sampling

In 2009, fish were collected from the Peconic River at Area A downstream of the STP, Area C, Area D near North Street, the Schultz Road and Manor Road areas, and Donahue's Pond. The average mercury concentration for all 93 fish samples was 0.27 mg/kg, which is significantly lower than the average pre-cleanup (1996 and 2001) fish mercury concentration (0.58 mg/kg). The EPA criterion for methylmercury concentration in fish tissue is 0.3 mg/kg. For PCBs, 52 fish samples were analyzed for 7 PCB isomers, for a total of 364 PCB analyses. Two (of 364) PCB analyses had concentrations greater than the detection limit (Aroclor 1254 at 13.7 and 18.9 ug/kg). The remaining 362 analyses had PCB concentrations less than the detection limit. The 2009 Cs-137 activity for the 61 fish samples analyzed was between non-detect and 0.51 pCi/g, and had an average of 0.17 pCi/g.

6.3.6.4 Remedial Actions

BNL/DOE recommended to EPA, DEC, and SCDHS that a sediment trap be removed from the river as required by the ROD, and that small sections of the river in the PR-WC-06 and PR-SS-15 areas with elevated sediment mercury concentrations be remediated. The work is planned for the fall of 2010.

6.3.7 Vegetation Sampling

6.3.7.1 Farm and Garden Vegetables

On-site sampling of garden vegetables was completed in 2009. The data on garden vegetables are presented in Table 6-8. Samples of zucchini, cucumber, tomato, pepper, and corn were analyzed for Cs-137 content. This radionuclide was not detected in any vegetables sampled from the on-site garden, but was detected in soils at a very low level (0.23 pCi/g). This value for Cs-137 in soil is consistent with background levels resulting from worldwide fallout from historic above-ground nuclear testing.

6.3.7.2 Grassy Plants

Grassy vegetation sampling around the Laboratory was conducted in 2009. Vegetation was sampled from ten locations around the Laboratory, including on the top and sides of the berms at the BNL Alternating Gradient Synchrotron and the Relativistic Heavy Ion Collider. Samples were also taken along the south and north boundaries of the Lab. All samples were analyzed for Cs-137 content. Data are presented in Table 6-8. None of the grassy vegetation samples had detectable levels of Cs-137, which is consistent with past sampling efforts. Grassy vegetation sampling is utilized for the annual dose to biota analysis reported in Chapter 8.

6.4 OTHER MONITORING

6.4.1 Soil Sampling

Soil sampling was conducted at the same ten locations where grassy vegetation was sampled in 2009. Soil samples were analyzed for Cs-137 and the data are presented in Table 6-8. Cs-137 content in soils ranged from non-detectable to 0.27 pCi/g. These values are consistent with past soil analysis and are indicative of background levels resulting from worldwide fallout from historic above-ground nuclear testing.

6.4.2 Basin Sediments

A 5-year testing cycle for basin sediment samples was established in 2003. Basin sediments were sampled in 2007 and results were

Table 6-8. Radiological Analysis of Farm and Garden Vegetables and Associated Soils.

Location/Sample	K-40	Cs-137
	pCi/g	
BNL Garden		
Green Pepper	1.95 ± 0.20	ND
Cucumber	1.77 ± 0.13	ND
Tomato	2.63 ± 0.24	ND
Corn	2.79 ± 0.23	ND
Zuchini	1.70 ± 0.15	ND
Soil	6.24 ± 0.61	0.23 ± 0.03
BNL grassy vegetation		
RHIC Ring, 10 o'clock beam stop		
Vegetation	3.02 ± 0.74	ND
Soil	6.5 ± 1.05	0.27 ± 0.06
RHIC Ring, 10 o'clock berm side		
Vegetation	2.52 ± 0.56	ND
Soil	3.66 ± 0.65	ND
RHIC Ring, 2 o'clock beam stop		
Vegetation	2.57 ± 0.49	ND
Soil*	4.61 ±0.75	0.09 ± 0.03
RHIC Ring, 2 o'clock berm side		
Vegetation	5.11 ± 0.76	ND
Soil*	4.57 ± 0.68	0.11 ± 0.03
AGS Berm		
Vegetation	4.84 ± 0.68	ND
Soil*	4.81 ± 0.83	0.16 ± 0.05
Tunnel Berm, S of Bldg. 925		
Vegetation	4.12 ± 0.50	ND
Soil*	5.75 ± 0.88	0.08 ± 0.06
South Boundary Rd., SW Corner		
Vegetation	4.16 ± 0.64	ND
Soil*	9.55 ± 1.27	0.12 ± 0.06
Biology Fields, E of Astronomy Way		
Vegetation	6.30 ± 0.70	ND
Soil*	7.27 ± 1.04	0.17 ± 0.07
W of Air Station P7		
Vegetation	6.21 ± 0.77	ND
Soil*	7.81 ± 0.99	0.06 ± 0.04
N of Wooded Wetland		
Vegetation	4.47 ± 0.59	ND
Soil	5.92 ± 0.93	0.24 ± 0.05

Notes:
Vegetables are reported as wet weight values.
Soils are reported as dry weight values.
* = estimated values for Cs-137
K-40 = Potassium-40
Cs-137 = Cesium-137

presented in the 2007 Site Environmental Report. In 2007, at basins HO and HT-E, initial results of sampling identified several compounds above SCDHS action levels. Suffolk County was notified and a co-sampling event was conducted with BNL and Suffolk County's participation. Both sets of results indicated that no issue existed, suggesting an error in the original sample results. Under the 5-year cycle for basin sediments, the next sampling will occur in 2012.

6.4.3 Chronic Toxicity Tests

Under BNL's SPDES discharge permit, the Laboratory conducted chronic toxicity testing of STP effluents. The results of this testing are discussed in Chapter 3, Section 3.6.1.1. Testing will continue in 2010.

6.4.4 Radiological and Mercury Monitoring of Precipitation

As part of the BNL Environmental Monitoring Program, precipitation samples were collected quarterly at air monitoring Stations P4 and S5 (see Figure 4-3 for station locations), and were analyzed for radiological content and total mercury (Table 6-9). Four samples were taken from each of these two stations in 2009. Gross alpha activity measurements were above the MDL at P4 in the first and third quarters of 2009. Values were 7.8 pCi/L in the first quarter and estimated at 1.67 pCi/L in the third quarter.

Gross beta activity was measured in samples for three of the four quarters at both stations in 2009. In general, radioactivity in precipitation comes from naturally occurring radionuclides in dust and from activation products that result from solar radiation. Location P4 had a maximum gross beta activity level of 10.7 pCi/L, with an average of 3.47 pCi/L. Location S5 had a maximum gross beta activity level of 5.6 pCi/L, with an average of 3.36 pCi/L. Gross beta activity values were within the range of values historically observed at these two locations. Beryllium-7 (Be-7) was not detected in any of the quarterly samples at either station. Be-7 is produced in the atmosphere by cosmic radiation and is periodically found in precipitation.

Analysis of mercury in precipitation is completed to document the range of mercury depo-

Table 6-9. Precipitation Monitoring (Radiological and Mercury).

Location/ Period	Be-7	Gross Alpha	Gross Beta	Mercury
	pCi/L			ng/L
P4				
1st Quarter	ND	7.8 ± 1.6	10.7 ± 1.6	10.4
2nd Quarter	ND	ND	2.10 ± 0.74*	5.47
3rd Quarter	ND	1.67 ± 0.84	1.06 ± 0.67*	6.79
4th Quarter	ND	ND	ND	7.57
S5				
1st Quarter	ND	ND	5.6 ± 1.3	10.6
2nd Quarter	ND	ND	2.94 ± 0.93*	5.54
3rd Quarter	ND	ND	ND	7.36
4th Quarter	ND	ND	1.54 ± 0.71*	9.46

Notes:
Method detection limit for mercury is 0.2 ng/L.
* = estimated values based on laboratory qualifiers.
P4 = precipitaion sampler near BNL Apartments area.
S5 = precipitation sampler near BNL Sewage Treatment Plant.

sition that occurs on site. This information is compared to Peconic River monitoring data and aids in understanding the sources of mercury within the Peconic River. Mercury was detected in precipitation samples in each quarter and at both sampling stations. Mercury ranged from 5.54 ng/L at station S5 in the second quarter to 10.6 ng/L at station S5 during the first quarter of 2009.

6.5 WILDLIFE PROGRAMS

BNL sponsors a variety of educational and outreach activities involving natural resources. These programs are designed to help participants understand the ecosystem and to foster interest in science. Wildlife programs are conducted at BNL in collaboration with DOE, 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 2009, the Environmental Protection Division (EPD) and FERN hosted 19 interns and one faculty member. Interns consisted of one high school intern, eleven undergraduate interns, and six school teachers during the summer. Two of the undergraduate interns worked with a faculty member from Southern University at New Orleans, as part of the Faculty and Student Teams (FaST) Program. Interns worked on a variety of projects. The FaST team worked on soil microbial studies of Pine Barrens soils and oak gall maker surveys (galls are unusual plant growths caused by insects). Undergraduate interns worked on invertebrate distribution surveys of the Carmans River, small mammal and flying squirrel surveys, and the quantification of soil nitrogen using the NSLS. The high school student worked on tree selection by flying squirrels. Teachers in the ACTS program worked on bathymetry of a small lake, inventory of Odonate species, mtDNA analysis of Odonates, GIS work, and a survey of night active birds. Teachers also participated in a week-long workshop on environmental monitoring under the OSSP. In addition to intern projects, FERN continued work on video-based instruction for protocols used within OSSP. A limited discussion concerning each project is presented below, and associated papers and posters are available at www.bnl.gov/esd/wildlife/research.asp.

Work on Odonate species continued in 2009 with teachers conducting research including: a comparative study between Odonate diversity and water quality and vegetation of man-made and man-modified ponds and genetic variations of Odonates between ponds at BNL; determining the effects of lunar cycles on night active birds, such as whippoorwill and other nightjars; work to develop and conduct a bathymetric study of Lake Arrowhead on the Baiting Hollow Boy Scout Camp; and a GIS study of BNL's contours and sanitary systems. These studies are designed to help teachers develop out-of-class room experience for their students that meet state curriculum requirements.

Students from the Southern University at New Orleans (SUNO) worked on a variety of projects including: quantification of soil nitrogen within Pine Barrens soils using the NSLS; genetic and nutrient use by microbial flora and fauna to form an analysis of the microbial community within the Gamma Forest soils compared to microbial distributions elsewhere in the Pine Barrens; and a study of the natural history

of scrub oak gall makers, which included the imaging of galls using the NSLS.

Other students worked on a variety of projects associated with the Carmans River, including the effects of water quality parameters on the distribution of aquatic invertebrates and the effects of substrate variations on invertebrate distributions using artificial substrates. These studies may become useful for assisting with management decision associated with efforts to protect the Carmans River watershed, a combined project being undertaken by the Town of Brookhaven, Suffolk County, and the Central Pine Barrens Commission.

Work being conducted on small mammals and flying squirrels was completed within the area proposed for the Long Island Solar Farm. These studies utilized live traps to determine population and diversity of small mammals (mice, shrews, etc.) and flying squirrels. This information is important for assessing the long-term changes and use by small mammals after the facility is constructed. Specific tree species used by flying squirrels were also studied. The flying squirrel studies were particularly successful and raised multiple questions, which warrant further study in 2010. The 2010 study will focus on squirrel movements using radio telemetry.

Members of EPD and other BNL departments volunteered as speakers for schools and civic groups and provided on-site ecology tours. EPD also hosted several environmental events in association with Earth Day and participated in Family Day during BNL's Summer Sunday program. In October, the Laboratory hosted the Fourteenth Annual Pine Barrens Research Forum for ecosystems researchers to share and discuss their results. In addition, BNL and FERN participated in the first Annual Pine Barrens Discovery Day held on the Suffolk County Community College Campus in Riverhead, New York.

The Laboratory also hosted 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 fire fighters in the methods of wildland fire suppression, prescribed fire, and fire analysis. BNL has developed and is implementing a Wildland Fire Management Plan. While plans were prepared for conducting a prescribed fire during the Academy, the conditions did not meet the requirements of the prescription. Post-fire monitoring on previous fires, conducted in 2007, indicated that prescribed fires have been somewhat effective at opening up the understory to allow forest regeneration. BNL intends to continue the use of prescribed fire for fuel and forest management in the future, and is working with NYSDEC to prepare additional prescriptions for a larger portion of the northern and eastern sections of the Laboratory property.

6.6 CULTURAL RESOURCE ACTIVITIES

The BNL Cultural Resource Management (CRM) Program ensures that the Laboratory fully complies with the numerous cultural resource regulations. The Cultural Resource Management Plan for Brookhaven National Laboratory (BNL, 2005) guides the management of all of BNL's historical resources. Along with achieving compliance with applicable regulations, one of the major goals of the CRM program is to fully assess both known and potential cultural resources. The range of the Laboratory's cultural resources includes buildings and structures, World War I (WWI) earthwork features, the Camp Upton Historical Collection, scientific equipment, photo/audio/video archives, and institutional records. As various cultural resources are identified, plans for their long-term stewardship are being developed and implemented. Achieving these goals will ensure that the contributions BNL and the site have made to our history and culture are documented and available for interpretation. The Laboratory has three structures or sites that have been determined to be eligible for listing on the National Register of Historic Places: the Brookhaven Graphite Research Reactor (BGRR) complex, the High Flux Beam Reactor (HFBR) complex, and the WWI training trenches associated with Camp Upton. The BNL trenches are examples of the few surviving WWI earthworks in the United States.

In 2009, two field studies were conducted to evaluate the proposed Long Island Solar Farm project site; Section 106 project reports were subsequently submitted to the New York State

Historic Preservation (SHPO) Officer. An archaeological survey was performed on 33 acres formerly occupied by the World War I Camp Upton Remount Facility (Bernstein, 2009a) in order to assess the overall potential of the area for the presence of cultural resources, including both a surface inspection and subsurface testing. The surface inspection entailed a walkover of the entire project area. Subsurface testing involved the excavation of small-shovel test pits on a closely spaced grid system, in accordance with NY State guidelines.

An architectural and archeological data recovery/assessment of a standing Civilian Conservation Corps (CCC) era privy was conducted on a half-acre site (Bernstein, 2009b). The architectural documentation was designed to meet the standards of the Historic American Buildings Survey (HABS). The survey included excavation of the outhouse pit to document the potential presence of artifacts and required removal of the privy structure from its rotted sill. Once SHPO comments were addressed, SHPO concluded that the project would have no adverse effect upon cultural resources in or eligible for inclusion in the National Registers of Historic Places.

Additional cultural resource management activities primarily focused on identifying and relocating artifacts from the BGRR and HFBR, including items such as scale models, graphite block, operating status board, mock fuel elements, and spare control rods. Outreach activities consisted of providing presentations on Laboratory cultural resources and tours of the WWI trenches to several small groups.

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7 Groundwater Protection

The Brookhaven National Laboratory Groundwater Protection Program is made up of four elements: prevention, monitoring, restoration, and communication. The Laboratory has implemented aggressive pollution prevention measures to protect groundwater resources. An extensive groundwater monitoring well network is used to verify that prevention and restoration activities are effective. In 2009, BNL collected groundwater samples from 806 monitoring wells during 1,800 individual sampling events. Twelve groundwater remediation systems removed 229 pounds of volatile organic compounds and returned approximately 1.6 billion gallons of treated water to the Upper Glacial aquifer. Since the beginning of active groundwater remediation in December 1996, the Laboratory has removed 6,363 pounds of volatile organic compounds by treating 16 billion gallons of groundwater. During 2009, two groundwater treatment systems removed approximately 1.9 millicuries of strontium-90 while remediating nearly 15 million gallons of groundwater. Since 2003, BNL has removed approximately 21.3 millicuries of strontium-90 from the groundwater while remediating 64 million gallons of groundwater.

7.1 THE BNL GROUNDWATER PROTECTION MANAGEMENT PROGRAM

The primary goal of BNL's Groundwater Protection Program is to ensure that plans for groundwater protection, management, monitoring, and restoration are fully defined, integrated, and managed in a manner that is consistent with federal, state, and local regulations. The program helps to fulfill the environmental monitoring requirements outlined in DOE Order 450.1, Environmental Protection Program. The program consists of four interconnecting elements: 1) preventing pollution of the groundwater, 2) monitoring the effectiveness of engineered and administrative controls at operating facilities and groundwater treatment systems, 3) restoring the environment by cleaning up contaminated soil and groundwater, and 4) communicating with stakeholders on groundwater protection issues. The Laboratory is committed to protecting groundwater resources from further chemical and radionuclide releases, and to remediate existing contaminated groundwater.

7.1.1 Prevention

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

or storage). BNL's comprehensive groundwater monitoring program is used to confirm that these controls are working.

7.1.2 Monitoring

The Laboratory's groundwater monitoring network is designed to evaluate the impacts of groundwater contamination from former and current operations and to track cleanup progress. Each year, BNL collects groundwater samples from an extensive network of on- and off-site monitoring wells (see Table 7-1). Results from groundwater monitoring are used to verify that protection and restoration efforts are working. Groundwater monitoring is focused on two general areas: 1) Facility Monitoring (FM), designed to satisfy DOE and New York State monitoring requirements for active research and support facilities, and 2) Comprehensive Environmental Response, Compensation and Liability (CERCLA) monitoring related to the Laboratory's obligations under the Federal Facilities Agreement (FFA). These monitoring programs are coordinated to ensure completeness and to prevent duplication of effort in the installation, monitoring, and decommissioning of wells. The monitoring program elements include data quality objectives; plans and procedures; sampling and analysis; quality assurance; data management; and the installation, maintenance, and decommissioning of wells.

Table 7-1. Summary of BNL Groundwater Monitoring Program, 2009.

	CERCLA Program	Facility Monitoring Program
Number of wells monitored	688	108
Number of sampling events	1,617	183
Number of analyses performed	2,827	331
Number of results	67,472	3,819
Percent of nondetectable analyses	89	88
Number of permanent wells installed	4	0
Number of temporary wells installed	70	26
Number of wells abandoned	64	0

These elements are integrated to create a cost-effective monitoring system and to ensure that water quality data are available for review and interpretation in a timely manner.

7.1.3 Restoration

BNL was added to the National Priorities List in 1989. To help manage the restoration effort, 31 separate Areas of Concern were grouped into six Operable Units (OUs). Remedial Investigation/Feasibility Studies have been conducted for each OU, and the focus is currently on operating and maintaining cleanup systems. Contaminant sources (e.g., contaminated soil and underground storage tanks) are being removed or remediated to prevent further contamination of groundwater. All remediation work is carried out under the FFA involving EPA, the New York State Department of Environmental Conservation (NYSDEC), and DOE.

7.1.4 Communication

BNL's Community Education, Government and Public Affairs Office ensures that the Laboratory communicates with its stakeholders in a consistent, timely, and accurate manner. A number of communication mechanisms are in place, such as press releases, web pages, mailings, public meetings, briefings, and roundtable discussions. Specific examples include routine meetings with the Community Advisory Council and the Brookhaven Executive Roundtable (see Chapter 2, Section 2.4.2). Quarterly and annual technical reports that summarize data, evaluations, and program indices are prepared. In addition, BNL has developed a Groundwater Protection Contingency Plan (BNL 2008) that provides formal processes to promptly communicate off-normal or unusual monitoring results to Laboratory management, DOE, regulatory agencies, and other stakeholders, including the public and employees.

7.2 GROUNDWATER PROTECTION PERFORMANCE

BNL has made significant investments in environmental protection programs, and is making progress in achieving its goal of preventing new groundwater impacts and to remediate previously contaminated groundwater.

No new impacts to groundwater quality have been identified since 2001. A new impact is defined as the detection and confirmation of previously unidentified groundwater contamination. The Groundwater Protection Contingency Plan, mentioned earlier as a communications tool, also is designed to ensure that appropriate and timely actions are taken if unusual or off-normal results are observed. The contingency plan provides guidelines for verifying the data, evaluating the source of the problem, notifying stakeholders, and implementing appropriate corrective actions. The Laboratory will continue efforts to prevent new groundwater impacts, and is vigilant in measuring and communicating its performance.

Since the start of active groundwater remediation in December 1996, BNL has made significant progress in restoring groundwater quality by removing 6,363 pounds of volatile organic compounds (VOCs) and 21.3 millicuries (mCi) of strontium-90 (Sr-90) from the aquifer. Noticeable improvements in groundwater quality are evident in a number of on-site and off-site areas.

7.3 GROUNDWATER MONITORING

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

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

Groundwater quality at BNL is routinely monitored through a network of approximately 800 on- and off-site wells (see SER Volume II, Groundwater Status Report, for details). In addition to water quality assessments, water levels are routinely measured in more than 875 on- and off-site wells to assess variations in the direction and velocity of groundwater flow. Groundwater flow directions in the vicinity of the Laboratory are shown in Figure 7-1.

The following active facilities have groundwater monitoring programs: the Sewage Treatment Plant (STP) area, Waste Management Facility (WMF), Major Petroleum Facility (MPF), Alternating Gradient Synchrotron (AGS), Relativistic Heavy Ion Collider (RHIC), and several vehicle maintenance and petroleum storage facilities. Inactive facilities include the former Hazardous Waste Management Facility (HWMF), two former landfill areas, Waste Concentration Facility (WCF), Brookhaven Graphite Research Reactor (BGRR), High Flux Beam Reactor (HFBR), and Brookhaven Medical Research Reactor (BMRR). As a result of detailed groundwater investigations, six significant VOC plumes and eight radionuclide plumes have been identified (see Figures 7-2 and 7-3).

7.4 FACILITY MONITORING PROGRAM

BNL's Facility Monitoring program includes groundwater monitoring at 10 active research facilities (e.g., accelerator beam stop and target areas) and support facilities (e.g., fuel storage and waste management facilities). During 2009, groundwater samples were collected from 108 wells during 183 individual sampling events. Nine temporary wells were also installed as part of this program. Detailed descriptions and maps

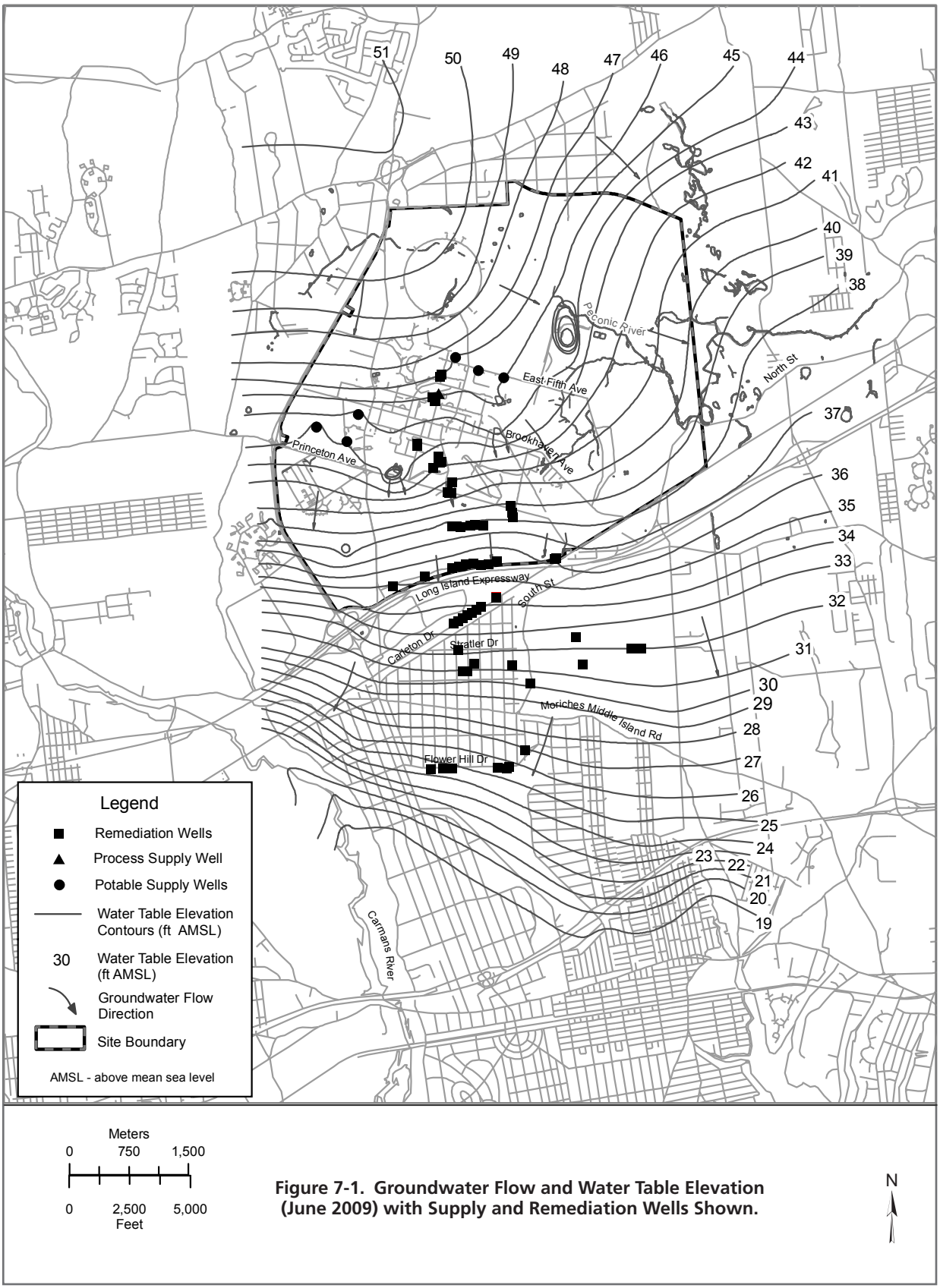

Figure 7-1. Groundwater Flow and Water Table Elevation (June 2009) with Supply and Remediation Wells Shown.

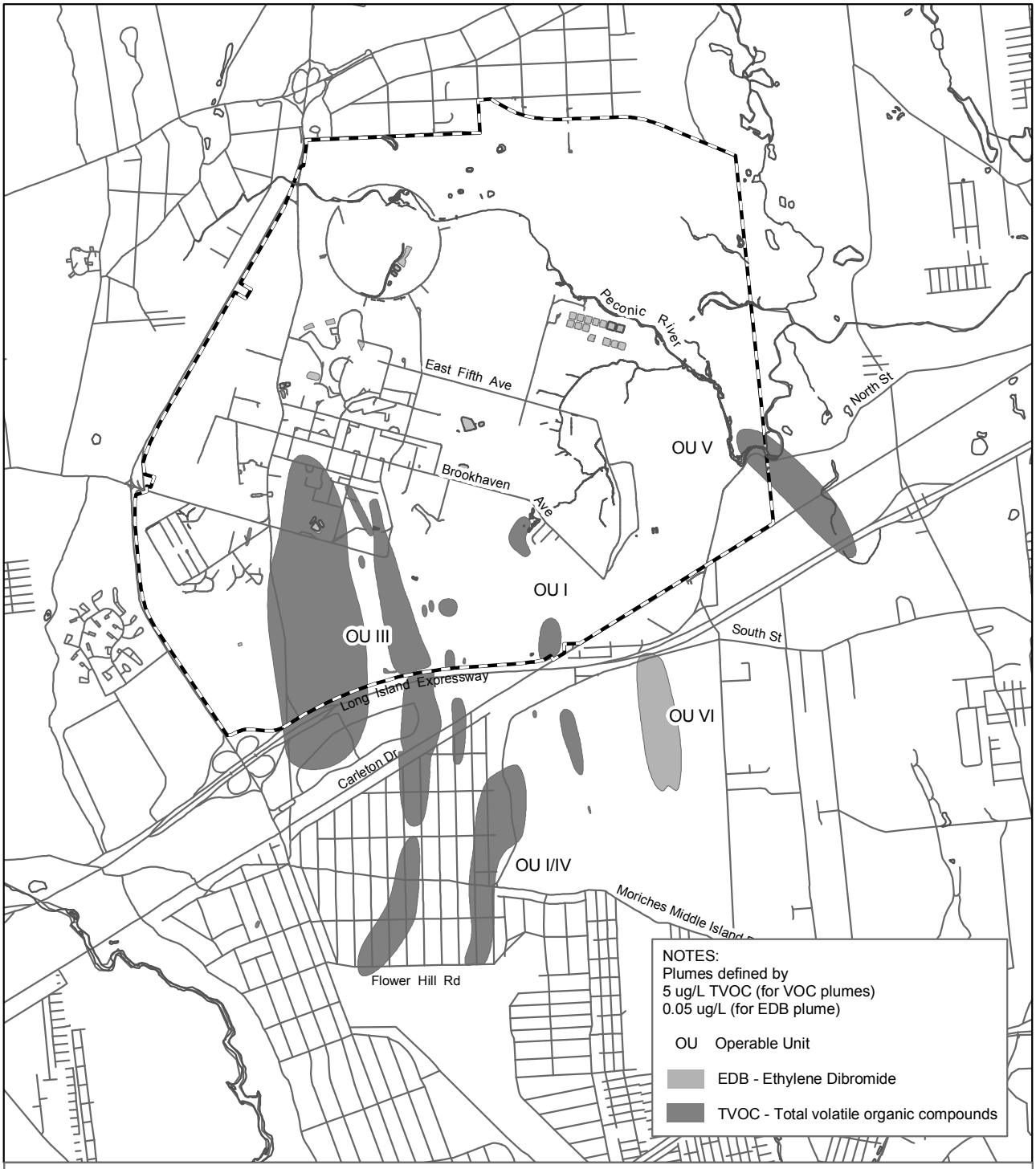

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Figure 7-2. Extent of VOC Plumes.

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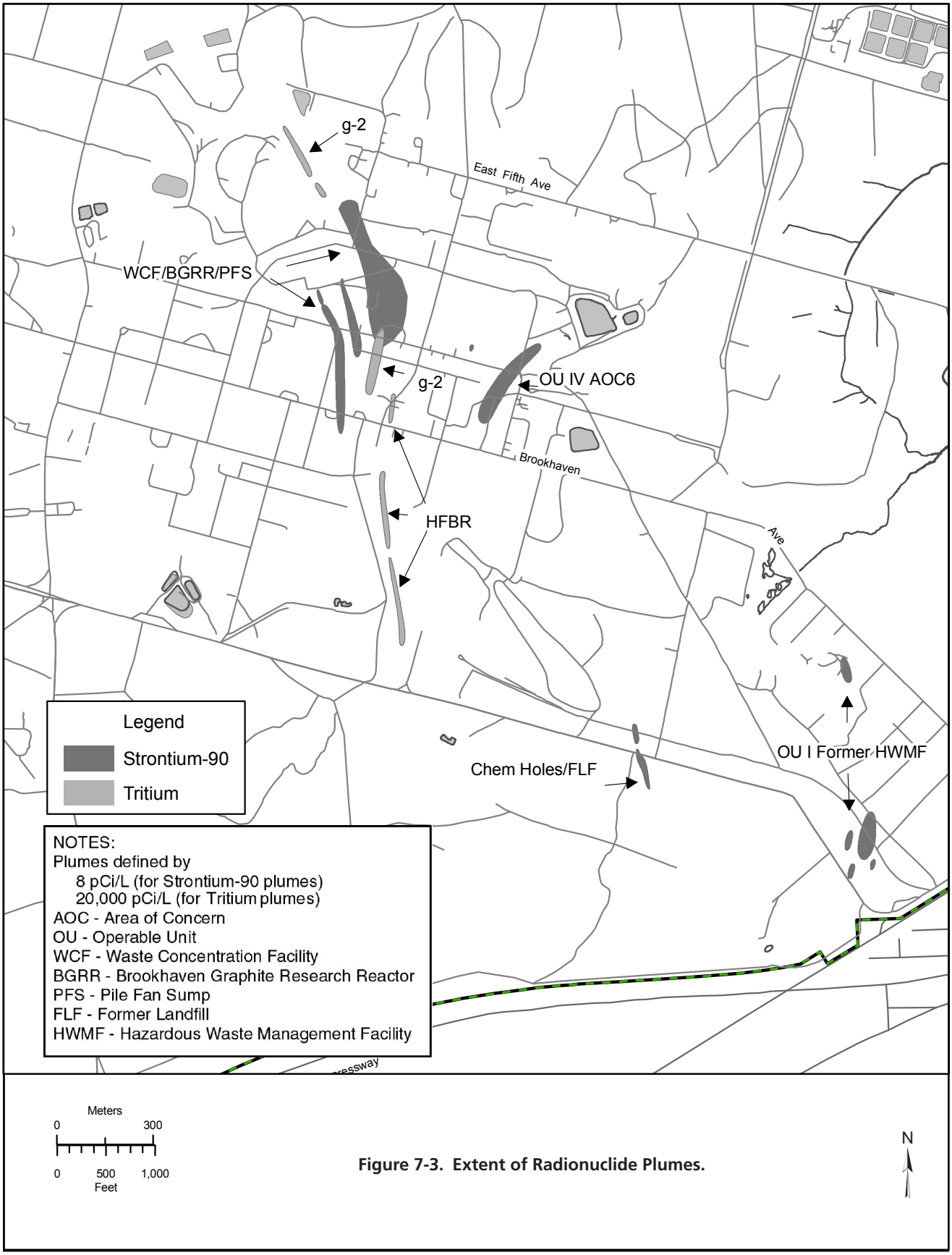

Figure 7-3. Extent of Radionuclide Plumes.

related to the FM groundwater monitoring program can be found in SER Volume II, Groundwater Status Report.

Although no new impacts to groundwater quality have been discovered since 2001, groundwater quality continues to be impacted at two BNL facilities: continued periodic high levels of tritium at the g-2 tritium source area and continued high levels of VOCs at the Upton service station. Highlights of the surveillance program are as follows:

- Tritium continues to be detected in the g-2 source area monitoring wells, at concentrations above the 20,000 pCi/L DWS. A short-term spike in tritium levels was observed in October 2009, with a tritium concentration of 138,000 pCi/L. Although the engineered stormwater controls are effectively protecting the activated soil shielding at the source area, monitoring data indicate that the continued release of tritium appears to be related to the flushing of residual tritium from the deep vadose zone following significant natural periodic fluctuations in the local water table.
- Monitoring of the downgradient areas of the g-2 tritium plume was accomplished using a combination of permanent and temporary wells. The highest tritium concentration in the downgradient segment of the plume was 92,200 pCi/L, observed approximately 400 feet south of the HFBR, along Temple Place road. The southern extent of the plume was tracked to the north side of the National Synchrotron Light Source (NSLS), where a maximum tritium concentration of 78,600 pCi/L was detected. As a result of natural radioactive decay and dispersion in the aquifer, the tritium plume is breaking up into discrete segments.
- Since April 2006, all tritium concentrations in the Brookhaven Linear Isotope Producer (BLIP) facility surveillance wells have been less than the 20,000 pCi/L DWS. The maximum tritium concentration during 2009 was 4,240 pCi/L. These results indicate that the engineered stormwater controls are effectively protecting the activated soil shielding, and that the amount of residual tritium in the deep vadose zone is diminishing.
- At the Upton Service Station, VOCs associated with petroleum products and the solvent PCE continue to be detected in the groundwater directly downgradient of the facility. Total VOC concentrations in one well reached a maximum of 617 µg/L; with the contamination consisting mostly of xylenes, ethylbenzene, and trimethylbenzenes. Groundwater monitoring results indicate that the petroleum-related compounds break down within a short distance from the facility. Monitoring of the leak detection systems at the Upton Service Station indicates that the gasoline storage tanks and associated distribution lines are not leaking, and all waste oils and used solvents are being properly stored and recycled. Therefore, it is believed that the contaminants detected in groundwater originate from historical vehicle maintenance activities and are not related to current operations.

7.5 CERCLA MONITORING PROGRAM

The CERCLA groundwater monitoring program is used to track the progress that groundwater treatment systems are making toward plume remediation (see Section 7.6, below). During 2009, the CERCLA program monitored 698 monitoring wells during 1,617 individual groundwater sampling events. Seventy temporary wells were also installed as part of this program. Detailed descriptions and maps related to the CERCLA groundwater monitoring program can be found in SER Volume II, Groundwater Status Report.

Maps showing the main VOC and radionuclide plumes are provided as Figures 7-2 and 7-3, respectively. Highlights of the program include:

- The HFBR Pump and Recharge system was operational during all of 2009. Monitoring data indicate that the elevated zone of tritium is approaching extraction well EW-16. The system is expected to remain operational for several more years until this elevated concentration zone has been completely captured and tritium concentrations

in the area decrease below the 20,000 pCi/L DWS. Tritium concentrations immediately downgradient of the HFBR remained below the DWS during all of 2009. This indicates that the inventory of tritium remaining in the deep vadose zone beneath the HFBR is diminishing.

- Plans were developed to excavate a small area of VOC contaminated soils south of the former Building 96 and to dispose of the soils off site. The removal of this source area is expected to significantly reduce PCE levels in the groundwater within three to five years, and allow for the groundwater treatment system to be turned off. A temporary plastic cover was placed over the contaminated soils source area until excavation is undertaken. An Explanation of Significant Differences (ESD) documenting the source area excavation was signed by the regulatory agencies in September 2009.
- The BGRR/Waste Concentration Facility Sr-90 Treatment System will be modified in 2010 to incorporate four additional extraction wells to remediate an area of Sr-90 contaminated groundwater near the HFBR. Furthermore, groundwater monitoring and characterization over the five years that this system has been in operation indicates that source area Sr-90 concentrations in the vicinity of both the WCF and the Building 701 areas have not shown marked decreases. This may be due to a continuing source of Sr-90 in these areas. Sr-90 from both of these source areas is presently being captured and treated by source area extraction wells, thereby preventing any plume growth.
- There have been significant improvements to the OU I South Boundary VOC plume over the past 14 years. However, based on the slower than expected migration rate of a small area of elevated VOCs located in a low permeability unit approximately 500 feet north of the south boundary, it does not appear that the Record of Decision (ROD) cleanup goals will be met if the extraction wells are shutdown in 2011, as originally planned. BNL will evaluate extending the operational duration of the existing extraction wells to ensure that the cleanup goal is attained. Furthermore, groundwater modeling using data from temporary wells installed during 2009 indicates that the Sr-90 concentrations within the OU I Sr-90 plume will drop below DWS before the plume reaches the site boundary, which is estimated to be in approximately 12 years.
- Temporary well characterization of the Building 650 and Sump Outfall Sr-90 plume in 2009 showed the area of highest concentrations approximately 500 feet north of Brookhaven Avenue. The new data will be used to update the groundwater model and determine when the plume is expected to attenuate to below DWS.
- As in 2008, elevated concentrations of dichlorodifluoromethane (Freon-12) continued to be detected in several OU III Western South Boundary area wells. Additional characterization will be conducted during 2010 to determine the extent of this contamination.

7.6 GROUNDWATER TREATMENT SYSTEMS

The primary mission of the CERCLA program is to operate and maintain groundwater treatment systems and prevent additional groundwater contamination from migrating off site. The cleanup objectives will be met by a combination of active treatment and natural attenuation. The specific cleanup goals are as follows:

- Achieve maximum contaminant levels (MCLs) for VOCs in the Upper Glacial aquifer by 2030
- Achieve MCLs for VOCs in the Magothy aquifer by 2065
- Achieve MCLs for Sr-90 at the BGRR in the Upper Glacial aquifer by 2070
- Achieve MCLs for Sr-90 at the Chemical Holes in the Upper Glacial aquifer by 2040

During 2009, BNL continued to make significant progress in restoring groundwater quality. Figure 7-4 shows the locations of 14 groundwater treatment systems currently in operation. Table 7-2 provides a summary of the amount of VOCs and Sr-90 removed from the

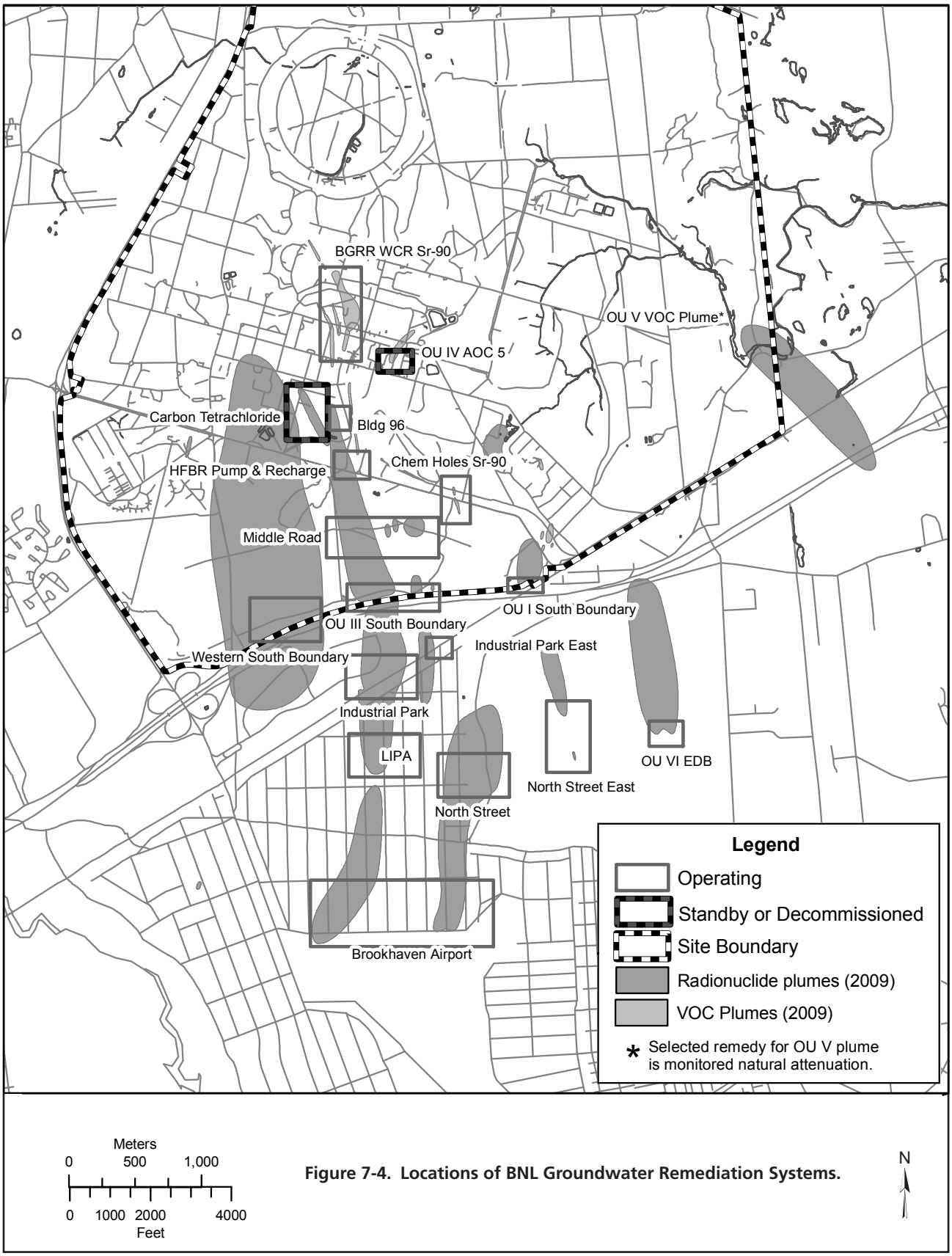

Figure 7-4. Locations of BNL Groundwater Remediation Systems.

Table 7-2. BNL Groundwater Remediation Systems Treatment Summary for 1997 through 2009.

		1997-2008		2009	
Remediation System	**Start Date**	**Water Treated** (Gallons)	**VOCs Removed** (Pounds) (e)	**Water Treated** (Gallons)	**VOCs Removed** (Pounds) (e)
OU I South Boundary	12/1996	3,442,314,000	347	172,000,000	6
OU III HFBR Tritium Plume (a)	05/1997	334,987,000	180	103,000,000	0
OU III Carbon Tetrachloride (d)	10/1999	153,538,075	349	Decommissioned	0
OU III Building 96	01/2001	172,297,416	98	50,000,000	9
OU III Middle Road	10/2001	1,417,411,550	799	177,500,000	63
OU III South Boundary	06/1997	3,319,952,850	2,630	201,000,000	85
OU III Western South Boundary	09/2002	667,647,000	54	115,300,000	12
OU III Industrial Park	09/1999	1,492,478,330	1,033	148,000,000	12
OU III Industrial Park East	06/2004	320,172,000	35	37,000,000	3
OU III North Street	06/2004	869,122,000	290	135,000,000	10
OU III North Street East	06/2004	492,976,000	24	74,000,000	6
OU III LIPA/Airport	08/2004	1,072,887,000	260	266,000,000	23
OU IV AS/SVE (b)	11/1997	(c)	35	Decommissioned	0
OU VI EDB	10/2004	624,711,000	(f)	164,000,000	(f)
Total		**14,380,485,221**	**6,134**	**1,642,800,000**	**229**

		2003–2008		2009	
Remediation System	**Start Date**	**Water Treated** (Gallons)	**Sr-90 Removed** (mCi)	**Water Treated** (Gallons)	**Sr-90 Removed** (mCi)
OU III Chemical Holes Sr-90	02/2003	18,404,826	3.33	6,200,000	0.46
OU III BGRR/WCF Sr-90	06/2005	30,951,000	16.1	8,500,000	1.4
Total		**49,355,826**	**19.43**	**14,700,000**	**1.86**

Notes:
(a) System was reactivated in late 2007 as a contingency action.
(b) System was shut down on January 10, 2001 and decommissioned in 2003.
(c) Air Sparging/Soil Vapor Extraction (AS/SVE) system performance was measured by pounds of VOCs removed per cubic feet ofair treated.
(d) System was shut down and placed in standby mode in August 2004 and decommissioned in 2009.
(e) Values are rounded to the nearest whole number.
(f) Because EDB has only been detected at trace levels in the treatment system influent, no removal of VOCs is reported.

BGRR = Brookhaven Graphite Research Reactor
EDB = ethylene dibromide
HFBR = High Flux Beam Reactor
LIPA = Long Island Power Authority
OU = Operable Unit
VOCs = volitile organic compounds
WCF = Waste Concentration Facility

aquifer since the start of active remediation in December 1996. During 2009, 229 pounds of VOCs and approximately 1.9 mCi of Sr-90 were removed from the groundwater, and more than 1.6 billion gallons of treated groundwater were returned to the aquifer. To date, 6,363 pounds of VOCs have been removed from the aquifer, and noticeable improvements in groundwater quality are evident in the OU I South Boundary, OU III South Boundary, OU III Industrial Park, OU III Industrial Park East, OU III North Street, OU IV, Building 96, and Carbon Tetrachloride areas. Also to date, two of the treatment systems have removed approximately 21 mCi of Sr-90.

Detailed information on the groundwater treatment systems can be found in SER Volume II, Groundwater Status Report.

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8 Radiological Dose Assessment

The Laboratory's routine operations, scientific experiments, and proposed new research projects are all evaluated for safety and radiological dose impact to workers and the environment. Radiological assessments are also performed as necessary, to ensure that radiological dose impact from non-routine activities remain "As Low As Reasonably Achievable" (ALARA) to members of the public, BNL workers, visitors, and the environment. These assessments ensure that facilities and operations are in compliance with federal, state, and local regulations. The potential radiological dose to members of the public is calculated at the site boundary as the maximum dose that could be received by a hypothetical individual defined as the "maximally exposed individual" (MEI). Therefore, all other individual members of the public will receive dose less than the MEI. The dose to the MEI is the sum total from direct and indirect dose pathways to an individual via air immersion, inhalation of particulates and gases, and ingestion of local fish and deer meat. The 2009 Total Effective Dose Equivalent (TEDE) from Laboratory operations was well below the EPA and DOE regulatory dose limits for the public, workers, and the environment.

The average annual on-site external dose from ambient sources was 71 ± 10 mrem (710 ± 100 μSv) and 65 ± 7 mrem (650 ± 70 μSv) at off-site locations. Both on- and off-site dose measurements include the contribution from natural terrestrial and cosmic background radiation. A statistical comparison of the average doses measured using 49 thermoluminescent dosimeters (TLDs) on-site and 14 TLDs off-site showed that there was no external dose contribution from BNL operations distinguishable from the natural background radiation level. An additional nine TLDs were used to measure on-site areas known to have radiation dose slightly elevated above the natural background radiation. The results of these measurements are described in Section 8.1.2.

The effective dose equivalent (EDE) from air emissions was calculated as 7.20E-02 mrem (0.72 μSv) to the MEI. The dose from the ingestion pathway was estimated as 7.10 mrem (71 μSv) from the consumption of deer meat, and 0.17 mrem (1.7 μSv) from the consumption of fish caught in the vicinity of the Laboratory. The total annual dose to the MEI from all the pathways was estimated as 7.34 mrem (73 μSv). The BNL dose from the inhalation pathway was less than 1 percent of EPA's annual regulatory dose limit of 10 mrem (100 μSv). The total dose was less than 8 percent of DOE's annual dose limit of 100 mrem (1,000 μSv) from all environmental pathways.

Doses to aquatic and terrestrial biota were also evaluated and found to be well below DOE regulatory limits. Other short-term projects, such as remediation work and waste management disposal activities, were assessed for radiological emissions; the potential dose impacts from these activities were below regulatory limits and there was no radiological risk to the public, BNL employees, visitors, or the environment. In summary, the overall dose impact from all Laboratory activities in 2009 was comparable to natural background radiation levels.

8.1 DIRECT RADIATION MONITORING

Direct, penetrating beta and gamma radiation is measured using TLDs. The principle of TLD function is that when certain crystals are exposed to radiation, impurities in the crystals' low-temperature trapping sites are excited to higher energy states. These electrons remain in a high-energy state at normal ambient temperature. When the TLDs are heated (annealed), electrons return to the lower energy state, emitting photon energy (light), which is measured with a photomultiplier tube; the light intensity is directly proportional to the absorbed radiation dose. The environmental TLDs used at the Laboratory are composed of calcium fluoride and lithium fluoride crystals. Accuracy is verified by exposing the TLD to a known and characterized radiation source.

A direct radiation-monitoring program is used to measure the external dose contribution to members of the public and workers from radiation sources at the Laboratory. This is achieved by measuring direct penetrating radiation exposures at both on- and off-site locations. The direct measurements taken at the off-site locations are with the premise that off-site exposures represent true natural background radiation (with contribution from both cosmic and terrestrial sources) and represent no contribution from BNL operations. On- and off-site external dose measurements were averaged, and then compared with each other using the statistical t-test to measure any variations in the averages and thus the contribution, if any, from Laboratory operations.

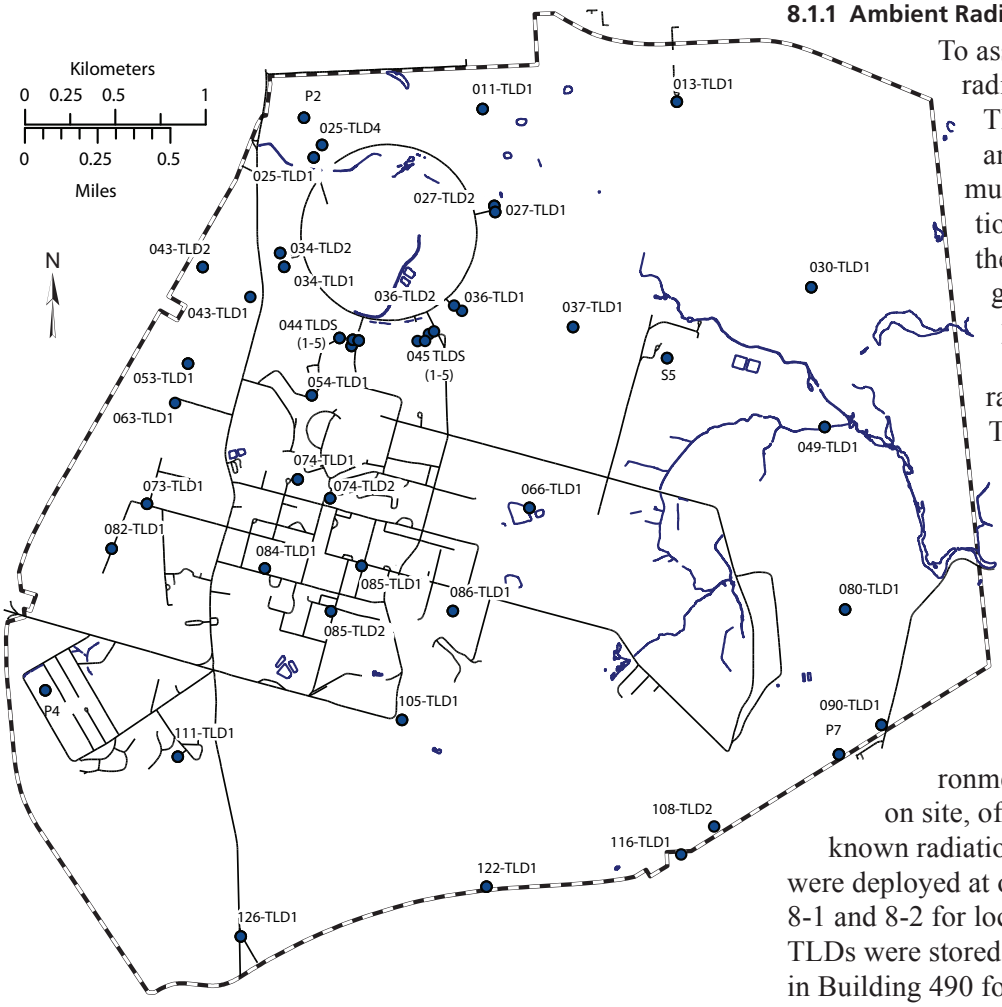

Figure 8-1. On-Site TLD Locations.

8.1.1 Ambient Radiation Monitoring

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

In 2009, a total of 58 environmental TLDs were deployed on site, of which nine were placed in known radiation areas. Another 14 TLDs were deployed at off-site locations (see Figures 8-1 and 8-2 for locations). An additional 30 TLDs were stored in a lead-shielded container in Building 490 for use as reference and control TLDs for comparison purposes. The average of the control TLD values was reported as

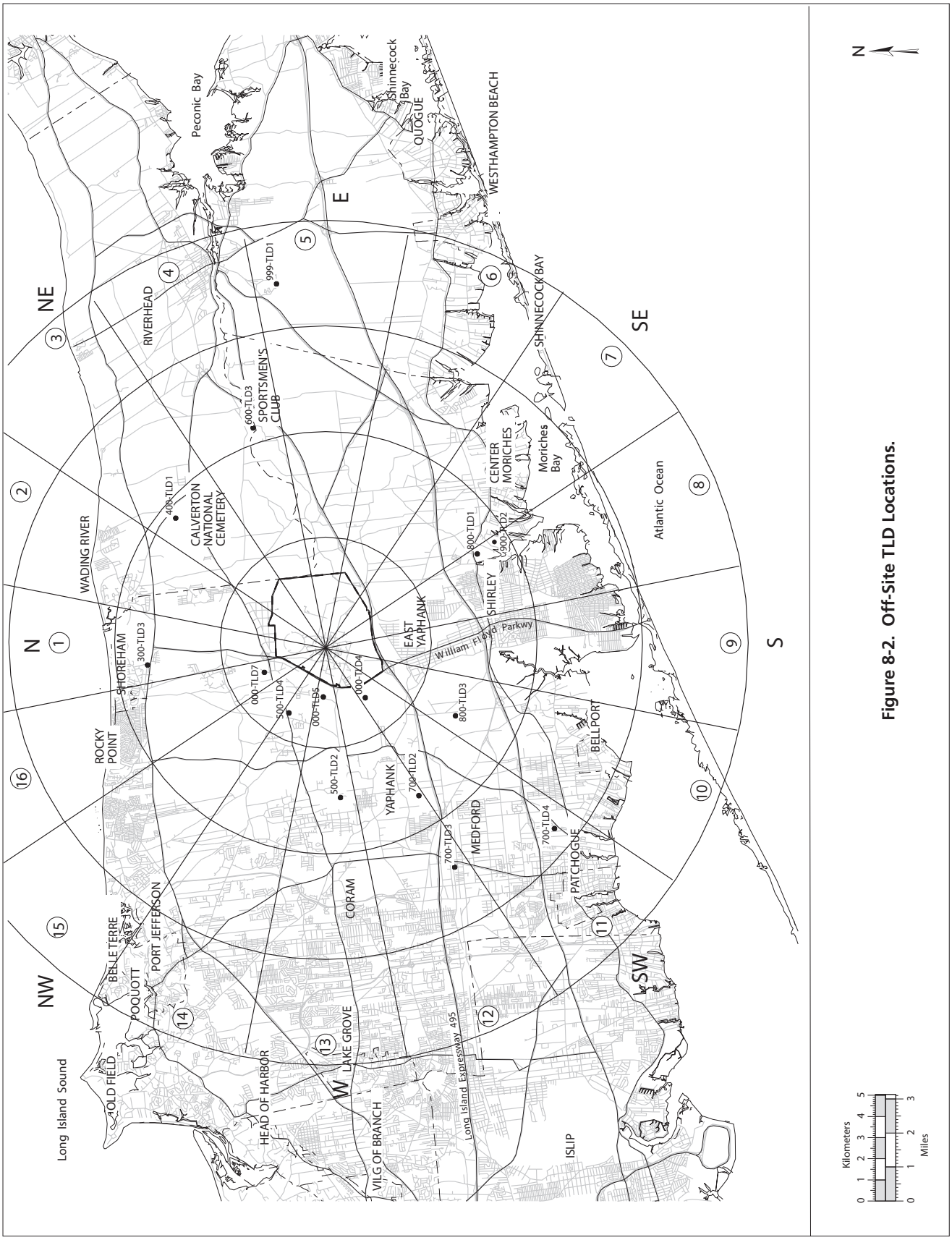

Figure 8-2. Off-Site TLD Locations.

"075-TLD4" in Tables 8-1 and 8-2. Note that a small "residual" dose was reported for the control TLDs when they were annealed, because it is not possible to completely anneal and shield the TLDs from all natural background and cosmic radiation sources. The on- and off-site TLDs were collected and read quarterly to determine the external radiation dose measured.

Table 8-1 shows the quarterly and yearly on-site radiation dose measurements for 2009. The on-site average external doses for the first, second, third, and fourth quarters were 18.6 ± 3.5, 18.1 ± 3.6, 15.5 ± 3.0, and 18.3 ± 3.5 mrem, respectively. The on-site average annual external dose from all potential environmental sources, including cosmic and terrestrial radiation sources, was 71 ± 10 mrem (710 ± 100 μSv).

Table 8-2 shows the quarterly and yearly off-site radiation dose measurements for 2009. The off-site average external doses for the first, second, third, and fourth quarters were 16.7 ± 2.8, 16.2 ± 2.9, 14.6 ± 2.3, and 18.1 ± 2.7 mrem, respectively. The off-site average annual ambient dose from all potential environmental sources, including cosmic and terrestrial radiation sources, was 65 ± 7 mrem (650 ± 70 μSv).

To determine the BNL contribution to the external direct radiation dose, a statistical t-test between the measured on- and off-site external dose averages was conducted. The t-test showed no significant difference between the off-site dose (71 ± 10 mrem) and on-site dose (65 ± 7 mrem) at the 95 percent confidence level. From the measured TLD doses, it can be safely concluded that there was no measurable external dose contribution to on- and off-site locations from Laboratory operations in 2009.

8.1.2 Facility Area Monitoring

Nine on-site TLDs were designated as facility-area monitors (FAMs) because they were posted in known radiation areas (near "facilities"). Table 8-3 shows the external doses measured with the FAM-TLDs. The environmental TLDs 088-TLD1 through 088-TLD4 are posted at the S-6 blockhouse location and on the fence of the former Hazardous Waste Management Facility (HWMF). These TLDs measured external doses that were slightly elevated compared

Table 8-1. On-Site Direct Ambient Radiation Measurements.

TLD#	Location	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Avg./Qtr. ±2σ (95%)	Annual Dose ±2σ (95%)
		(mrem)					
011-TLD1	North firebreak	14.9	16.0	12.8	16.7	15 ± 3	60 ± 13
013-TLD1	North firebreak	20.6	17.7	14.5	15.5	17 ± 5	68 ± 21
025-TLD1	Bldg. 1010, beam stop 1	16.6	19.0	15.1	16.6	17 ± 3	67 ± 13
025-TLD4	Bldg. 1010, beam stop 4	16.5	17.7	15.1	16.5	16 ± 2	66 ± 8
027-TLD1	Bldg. 1002A S	16.8	18.1	13.2	16.6	16 ± 4	65 ± 16
027-TLD2	Bldg. 1002D E	16.5	16.8	13.7	14.8	15 ± 3	62 ± 11
030-TLD1	NE firebreak	18.2	18.8	14.8	17.6	17 ± 3	69 ± 14
034-TLD1	Bldg. 1008, collimator 2	18.2	18.2	15.9	17.1	17 ± 2	69 ± 9
034-TLD2	Bldg. 1008, collimator 4	21.3	19.3	16.7	16.9	19 ± 4	74 ± 17
036-TLD1	Bldg. 1004B, E	19.8	15.6	13.6	17.0	17 ± 5	66 ± 20
036-TLD2	Bldg. 1004, E	19.4	19.4	15.0	19.0	18 ± 4	73 ± 17
037-TLD1	S-13	16.2	17.6	15.5	16.8	17 ± 2	66 ± 7
043-TLD1	N access road	18.4	20.2	16.7	17.7	18 ± 3	73 ± 12
043-TLD2	N of Meteorology Tower	17.0	18.2	16.5	17.3	17 ± 1	69 ± 6
044-TLD1	Bldg. 1006	19.0	16.2	15.5	18.0	17 ± 3	69 ± 13
044-TLD2	S of Bldg. 1000E	19.4	17.7	15.4	16.0	17 ± 4	69 ± 14

(continued on next page)

Table 8-1. On-Site Direct Ambient Radiation Measurements *(concluded).*

TLD#	Location	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Avg./Qtr. ±2σ (95%)	Annual Dose ±2σ (95%)
		(mrem)					
044-TLD3	S of Bldg. 1000P	16.1	15.1	14.4	19.5	16 ± 4	65 ± 18
044-TLD4	NE of Bldg. 1000P	19.2	16.4	14.3	18.4	17 ± 4	68 ± 17
044-TLD5	N of Bldg. 1000P	17.9	16.7	15.6	18.4	17 ± 2	69 ± 10
045-TLD1	Bldg. 1005S	17.7	17.9	17.5	19.0	18 ± 1	72 ± 5
045-TLD2	E of Bldg. 1005S	18.7	18.7	15.0	20.4	18 ± 4	73 ± 18
045-TLD3	SE of Bldg. 1005 S	20.8	16.3	15.3	17.2	17 ± 5	70 ± 19
045-TLD4	SW of Bldg. 1005 S	18.3	16.4	15.1	17.9	17 ± 3	68 ± 11
045-TLD5	WSW of Bldg. 1005 S	16.7	15.2	14.4	16.1	16 ± 2	62 ± 8
049-TLD1	E firebreak	20.5	19.6	14.4	18.1	18 ± 5	73 ± 21
053-TLD1	W firebreak	20.2	17.8	17.0	20.8	19 ± 4	76 ± 14
054- TLD1	Bldg. 914	20.9	20.6	15.0	15.5	18 ± 6	72 ± 25
063-TLD1	W firebreak	19.7	22.3	18.0	19.7	20 ± 3	80 ± 14
066-TLD1	Waste Management Facility	15.2	15.6	15.5	18.6	16 ± 3	65 ± 12
073-TLD1	Meteorology Tower / Bldg. 51	18.4	18.5	18.8	19.4	19 ± 1	75 ± 4
074-TLD1	Bldg. 560	20.0	20.4	15.0	21.1	19 ± 5	77 ± 22
074-TLD2	Bldg. 907	18.6	19.5	15.8	19.7	18 ± 4	74 ± 14
080-TDL1	E firebreak	20.9	20.5	16.1	21.8	20 ± 5	79 ± 20
082-TLD1	W firebreak	19.0	18.7	16.9	18.7	18 ± 2	73 ± 8
084-TLD1	Tennis courts	20.4	16.8	14.7	19.1	18 ± 5	71 ± 20
085-TDL2	Upton gas station	18.3	21.4	16.8	20.4	19 ± 4	77 ± 16
085-TLD1	Diversity Office	20.7	19.6	17.0	18.4	19 ± 3	76 ± 12
086-TLD1	Baseball fields	21.5	15.9	18.3	19.2	19 ± 5	75 ± 18
090-TLD1	North St. gate	17.1	17.6	15.3	19.8	17 ± 4	70 ± 15
105-TLD1	S firebreak	19.3	20.1	13.9	21.7	19 ± 7	75 ± 27
108-TLD1	Water tower	18.4	20.1	15.7	16.8	18 ± 4	71 ± 15
108-TLD2	Tritium pole	23.2	22.5	19.0	22.1	22 ± 4	87 ± 15
111-TLD1	Trailer park	19.1	18.6	16.2	19.1	18 ± 3	73 ± 11
122-TLD1	S firebreak	17.2	17.9	15.3	19.2	17 ± 3	70 ± 13
126-TLD1	S gate	19.8	19.2	19.4	20.7	20 ± 1	79 ± 5
P2		16.9	15.9	12.8	16.2	15 ± 4	62 ± 14
P4		16.8	16.0	14.1	19.0	16 ± 4	66 ± 16
P7		17.3	18.6	15.5	18.4	17 ± 3	70 ± 11
S5		17.7	16.0	13.4	15.6	16 ± 3	63 ± 14
On-site average		**18.6**	**18.1**	**15.5**	**18.3**	**18 ± 3**	**71 ± 10**
Std. dev. (2 σ)		**3.5**	**3.6**	**3.0**	**3.5**		
075-TLD4 Control TLD average		**9.0**	**8.6**	**9.3**	**8.9**	**8.9 ± 1**	**36 ± 2**

Notes:
See Figure 8-1 for TLD locations.
L = TLD lost
NP = TLD not posted

Table 8-2. Off-Site Direct Radiation Measurements.

TLD#	Location	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Avg./Qtr. ± 2 σ (95%)	Annual Dose ± 2 σ (95%)
		(mrem)					
000-TLD4	Private property	15.5	17.5	15.6	19.1	17 ± 3	68 ± 13
000-TLD5	Longwood Estate	16.1	15.2	15.3	16.3	16 ± 1	62 ± 5
000-TLD7	Mid-Island Game Farm	17.4	19.1	14.2	17.5	17 ± 5	68 ± 20
300-TLD3	Private property	17.6	NP	NP	NP	18 ± 0	70 ± 0
400-TLD1	Calverton Nat. Cemetary	19.6	18.3	16.2	19.6	18 ± 3	74 ± 13
500-TLD2	Private property	15.1	14.9	14.0	16.4	15 ± 2	60 ± 8
500-TLD4	Private property	15.3	15.0	14.1	19.9	16 ± 5	64 ± 20
600-TLD3	Sportsmen's Club	16.3	15.3	13.7	NP	15 ± 3	60 ± 10
700-TLD2	Private property	17.3	13.9	NP	NP	16 ± 5	62 ± 19
700-TLD3	Private property	18.5	15.8	13.4	17.4	16 ± 4	65 ± 17
700-TLD4	Private property	16.2	16.8	14.3	18.9	17 ± 4	66 ± 15
800-TLD1	Private property	16.1	15.2	16.7	NP	16 ± 1	64 ± 6
800-TLD3	Suffolk County CD	18.4	16.7	15.4	16.6	17 ± 2	67 ± 10
900-TLD2	Private property	14.7	16.8	12.7	19.2	16 ± 5	63 ± 22
999-TLD1	Private property	NP	NP	NP	NP		
Off-site average		**16.7**	**16.2**	**14.6**	**18.1**	**16 ± 2**	**65 ± 7**
Std. dev. (2 σ)		**2.8**	**2.9**	**2.3**	**2.7**		
075-TLD4	**Control TLD average**	**9.6**	**9.6**	**9.6**	**9.8**	**9.6 ± 0**	**39 ± 1**

Notes:
See Figure 8-2 for TLD locations.
CD = Correctional Department
NP = TLD not posted for the quarter

to the normal natural background radiation doses measured from other areas of BNL. The elevated external dose measured at the former HWMF can be attributed to the presence of small amounts of contamination in soil. However, a comparison of the 2009 dose rates to doses from previous years show that the dose rates have declined significantly since the removal of most of the contaminated soil within the former HWMF. As recorded in Table 8-3, the dose is currently just slightly above natural background levels. The former HWMF is fenced; access is controlled and only radiologically trained BNL employees are allowed inside the fenced area.

Two TLDs (075-TLD3 and 075-TLD5) near Building 356 showed much higher than normal quarterly averages: 25 ± 14 mrem (250 ± 140 µSv) and 25 ± 4 mrem (250 ± 40 µSv), respectively. The yearly doses were measured at 101 ± 56 mrem (1010 ± 560 µSv) for 075-TLD3, and 100 ± 17 mrem (1000 ± 170 µSv) for 075-TLD5. The direct doses are higher than the on-site annual average because Building 356 houses a cobalt-60 (Co-60) source, which is used to irradiate materials, parts, and electronic circuit boards. The elevated dose from Building 356 is attributed to the "sky-shine" phenomenon. Although it is conceivable that individuals who use the parking lot adjacent to Building 356 could receive a dose from this source, the dose would be minimal due to the limited time an individual spends in the parking lot.

Two FAM-TLDs placed on the fence northeast and northwest of Building 913-B (the Alternating Gradient Synchrotron tunnel access) showed slightly higher than average ambient external dose. The first-quarter dose at that site was measured at 22.9 mrem for 054-TLD2 and 21.2 mrem for 054-TLD3 (compared to the site-wide first-quarter dose of 18.6 ± 3.5). The

Table 8-3. Facility Area Monitoring.

TLD#	Location	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Average ± 2σ (95%)	Annual Dose ± 2σ (95%)
		(mrem)					
054-TLD2	NE of Bldg. 913-B	22.9	22.3	16.4	20.6	20 ± 6	82 ± 23
054-TLD3	NW of Bldg. 913-B	21.2	18.1	14.5	16.1	17 ± 6	70 ± 23
S6		18.7	18.7	17.9	20.8	19 ± 2	76 ± 10
088-TLD1	FWMF, 50', E of S-6	18.9	19.3	17.2	18.6	19 ± 2	74 ± 7
088-TLD2	FWMF, 50', W of S-6	21.6	23.5	17.7	20.9	20 ± 5	84 ± 19
088-TLD3	FWMF, 100', W of S-6	21.3	20.5	17.0	26.2	21 ± 7	85 ± 30
088-TLD4	FWMF, 150', W of S-6	18.2	20.4	17.1	20.0	19 ± 3	76 ± 12
075-TLD3	Bldg. 356	23.8	20.3	21.5	35.8	25 ± 14	101 ± 56
075-TLD5	N corner of Bldg. 356	24.7	23.5	24.0	28.2	25 ± 4	100 ± 17

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

second quarter reading for 054-TLD2 was 22.3 mrem, which was slightly elevated. For the remaining quarters, both TLDs showed dose comparable to the natural background radiation.

The Alternating Gradient Synchrotron (AGS) accelerates protons to energies up to 30 GeV and heavy ion beams to 15 GeV/amu. The Relavistic Heavy Ion Collider (RHIC) has two beams circulating in opposite directions and is capable of accepting either protons or heavy ions up to gold. At the RHIC, protons and heavy ions received from the AGS are further accelerated up to final energies of 250 GeV for protons and 100 GeV per nucleon for gold ions. Under these high-energy conditions, facilities such as AGS and RHIC have the potential to generate high-energy neutrons when the charged particles leave the confines of the accelerator and produce nuclear fragments along its path or when they collide with matter. A passive monitoring TLD device provides dose information from the neutron interactions when placed at strategic locations. In 2009, 12 neutron monitoring TLDs (Harshaw Badge 8814) were posted at such strategic locations to measure the dose contribution from the high-energy neutrons (see Figure 8-3 for locations). The technical criteria used for the placement of the neutron TLDs was based on such aspects as the thickness of the berm shielding, location of soil activation areas, beam stop areas and beam collimators, and the proximity to the site boundary. In 2009, the neutron 025-TLD-N2 in the vicinity of building 1010 and 034-TLD-N1 in the vicinity of Building 1008 showed neutron doses of 1 mrem and 2 mrem, respectively.

8.2 DOSE MODELING

EPA regulates radiological emissions from DOE facilities under the requirements set forth in 40 CFR 61, Subpart H, National Emission Standards for Hazardous Air Pollutants (NESHAPs). This regulation specifies the compliance and monitoring requirements for reporting radiation doses received by members of the public from airborne radionuclides. The regulation mandates that no member of the public shall receive a dose from DOE operations that is greater than 10 mrem (100 μSv) in a year. The emission monitoring requirements are set forth in Subpart H, Section 61.93(b) and include the use of a reference method for continuous monitoring at major release points (defined as those with a potential to exceed 1 percent of the 10 mrem standard), and a periodic confirmatory measurement for all other release points. The regulations also require DOE facilities to submit an annual NESHAPs report to EPA that describes the major and minor emission sources and dose to the MEI. The dose estimates from various facilities are given in Table 8-4, and the actual emissions for 2009 are discussed in detail in Chapter 4.

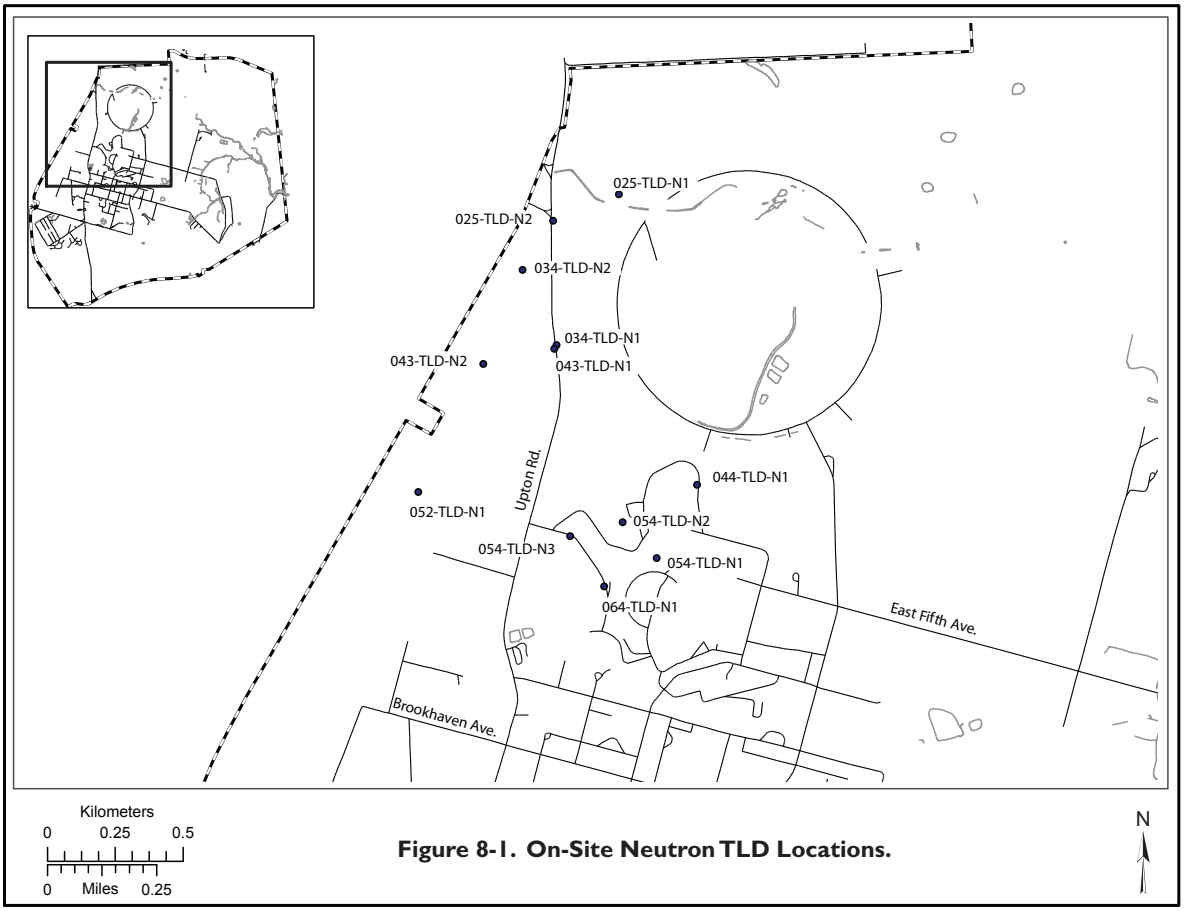

Figure 8-1. On-Site Neutron TLD Locations.

As a part of the NESHAPs review process at BNL, any source that has the potential to emit radioactive materials is evaluated for regulatory compliance. Although the activities conducted under the Environmental Restoration (ER) Program are exempt under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), these activities are also monitored and assessed for any potential to release radioactive materials, and to determine their dose contribution, if any, to the environment. Any new processes or activities are evaluated for compliance with NESHAPs regulations using EPA's approved dose modeling software (see Section 8.2.1 for details). Because this model was designed to treat radioactive emission sources as continuous over the course of a year, it is not well suited for estimating short-term or acute releases. Consequently, it overestimates potential dose contributions from short-term projects and area sources. For that reason, the results are considered to be "conservative"—that is, erring on the side of caution.

8.2.1 Dose Modeling Program

Compliance with NESHAPs regulations is demonstrated through the use of EPA dose modeling software and the Clean Air Act Assessment Package 1988 (CAP88-PC), Version 3.0. This computer program uses a Gaussian plume model to estimate the average dispersion of radionuclides released from elevated stacks or diffuse sources. It calculates a final value of the projected dose at the specified distance from the release point by computing dispersed radionuclide concentrations in air, rate of deposition on ground surfaces, and intake via the food pathway (where applicable). CAP88-PC calculates both the EDE to the MEI and the collective population dose within a 50-mile radius of the emission source. In most cases, the CAP88-PC model provides conservative doses. For the purpose of modeling the dose to the MEI, all

Table 8-4. Maximally Exposed Individial Effective Dose Equivalent From Facilities or Routine Processes.

Building No.	Facility or Process	Construction Permit No.	MEI Dose (mrem) (a)	Notes
348	Radiation Protection	None	ND	(b)
463	Biology Facility	None	ND	(b)
490	Medical Research	BNL-489-01	2.94E-12	(b)
490A	Energy and Environment National Security	None	ND	(b)
491	Brookhaven Medical Research Reactor	None	ND	(e)
510	Calorimeter Enclosure	BNL-689-01	ND	(f)
510A	Physics	None	ND	(b)
535	Instrumentation	None	ND	(b)
555	Chemistry Facility	None	ND	(b)
725	National Synchrotron Light Source	None	ND	(b)
750	High Flux Beam Reactor	None	1.92E-4	(c)
801	Target Processing Lab	None	6.10E-8	(b), (c)
802B	Evaporator Facility	BNL-288-01	NO	(e)
820	Accelerator Test Facility	BNL-589-01	ND	(d)
830	Environmental Science Department	None	ND	(d)
865	Reclamation Building	None	ND	(c)
906	Medical-Chemistry	None	ND	
925	Accelerator Department	None	ND	(b)
931	Brookhaven Linac Isotope Producer	None	7.20E-2	(c)
938	REF/NBTF	BNL-789-01	ND	(g)
942	Alternate Gradient Syncrotron Booster	BNL-188-01	ND	(h)
–	Relativistic Heavy Ion Collider	BNL-389-01	ND	(d)
Total Potential Dose from BNL Operations			**7.22E-2**	
EPA Limit			**10.0 mrem**	

Notes:
Diffuse, Fugitive, and Other sources are not included in this table since they are short-term emissions.
NBTF = Neutron Beam Test Facility
REF = Radiation Effects Facility
(a) "Dose" in this table means effective dose equivalent to MEI.
(b) Dose is based on emissions calculated using 40 CFR 61, Appendix D methodology.
(c) Emissions are monitored at the facility.
(d) ND = No dose from emissions source in 2009.
(e) NO = Not operational in 2009.
(f) This has become a zero-release facility since original permit application.
(g) This facility is no longer in use; it produces no radioactive emissions.
(h) Booster ventilation system prevents air release through continuous air recirculation.

emission points are located at the center of the developed portion of the BNL site. The dose calculations are based on very low concentrations of environmental releases and on chronic, continuous intakes in a year. The input parameters used in the model include radionuclide type, emission rate in curies (Ci) per year, stack parameters such as height and diameter, and emission exhaust velocity. Site-specific weather and population data are factored into the dose assessment. Weather data are supplied by measurements from the Laboratory's meteorological tower. These measurements include wind speed, direction, frequency, and air temperature (see Chapter 1 for details). Population data used in the model are based on the Long Island Power Authority population survey (LIPA 2000). Because visiting researchers and their families may reside at the BNL on-site apartment area for extended periods, these residents are included in the population file used for dose assessment.

8.2.2 Dose Calculation Methods and Pathways

8.2.2.1 Maximally Exposed Individual

The MEI is defined as a hypothetical person who resides at the site boundary and has a lifestyle such that no other member of the public could receive a higher dose than the MEI. This person is assumed to reside 24 hours a day, 365 days a year at the BNL site boundary in the downwind direction, and to consume significant amounts of fish and deer containing radioactivity attributable to Laboratory operations based on projections from the New York State Department of Health (NYSDOH). In reality, it is highly unlikely that such a combination of "maximized dose" to any single individual would occur, but the concept is useful for evaluating maximum potential risk and dose to members of the public.

8.2.2.2 Effective Dose Equivalent

The EDE to the MEI for low levels of radioactive materials dispersed into the environment was calculated using the CAP88-PC dose modeling program, Version 3.0. Site meteorology data were used to calculate annual dispersions for the midpoint of a given wind sector and distance. Facility-specific radionuclide release rates (Ci/yr) were used for continuously monitored facilities. For small sources, the emissions were calculated using the method set forth in 40 CFR 61, Appendix D. The Gaussian dispersion model calculated the EDE at the site boundary and the collective population dose values from immersion, inhalation, and ingestion pathways. These dose and risk calculations to the MEI are based on low emissions and chronic intakes.

8.2.2.3 Dose Calculation: Fish Ingestion

To calculate the EDE from the fish consumption pathway, the intake is estimated. Intake is the average amount of fish consumed by a person engaged in recreational fishing in the Peconic River. Based on a NYSDOH study, the consumption rate is estimated at 15 pounds (7 kg) per year (NYSDOH 1996). For each radionuclide of concern for fish samples, the dry weight activity concentration was converted to picocuries per gram (pCi/g) wet weight, since "wet weight" is the form in which fish are caught and consumed. A dose conversion factor was used for each radionuclide to convert the activity concentration into the EDE. For example, the committed dose equivalent conversion factor for cesium-137 (Cs-137) is 5.0E-02 rem/µCi, as set forth in DOE/EH-0071. The dose was calculated as: dose (rem/yr) = intake (kg/yr) × activity in flesh (µCi/kg) × dose factor (rem/µCi).

8.2.2.4 Dose Calculation: Deer Meat Ingestion

The dose calculation for the deer meat ingestion pathway is similar to that for fish consumption. The Cs-137 radionuclide dose conversion factor was used to estimate dose, based on the U.S. Environmental Protection Agency Exposure Factors Handbook (EPA 1996). The total quantity of deer meat ingested during the course of a year was estimated as 64 pounds (29 kg) (NYSDOH 1999).

8.3 SOURCES: DIFFUSE, FUGITIVE, "OTHER"

Diffuse sources are described as releases of radioactive contaminants to the atmosphere that do not have a well-defined emission point such as a stack or vent. Such sources are also known as nonpoint or area sources. Fugitive sources include releases to the air not through an actively ventilated air stream (i.e., leaks from vents are fugitive sources). As a part of the NESHAPs review process, in addition to stack emissions, any fugitive or diffuse emission source that could potentially emit radioactive materials to the environment is evaluated. Although CERCLA-prompted actions, such as remediation projects, are exempt from the procedural requirements to obtain federal, state, or local permits, any BNL activity or process with the potential to emit radioactive material must be evaluated and assessed for dose impact to members of the public. The following radiological sources were evaluated in 2009 for potential contribution to the overall site dose.

8.3.1 Brookhaven Graphite Research Reactor (BGRR)

The BGRR was the first reactor built in 1950 for the sole purpose of providing neutrons for research projects. The BGRR was an air-cooled,

graphite-moderated research reactor. During reactor operations, filtered outside air was drawn through the reactor pile, cooled in the ductwork, filtered, and then exhausted back out through a 100-meter stack. Until 1958, the reactor was fueled with natural uranium. It was then fueled with enriched uranium; the enriched fuel produced a higher neutron flux and reduced the fuel failure rate. The reactor was shut down in 1969, and all fuel was removed from the BNL site by June 1972.

The BGRR has been identified as Area of Concern (AOC) 9, under an Interagency Agreement and Record of Decision (ROD) among DOE, EPA, and the New York State Department of Environmental Conservation (NYSDEC) under the Federal Facility Agreement of the CERCLA of 1980. There are several BGRR structures that must be removed under this ROD and disposed of at an off-site licensed facility.

The graphite pile and biological shield that surrounds the graphite pile were called out for removal in the ROD and a NESHAP evaluation was performed. The graphite pile, which acted as a neutron moderator for the research reactor, is housed within the biological shield. The graphite pile is a 25-foot cube, made up of 60,000 graphite blocks of various shapes and sizes. There is some debris remaining within the air passages and at the base of the pile. The debris is contaminated with activation products and fission products as a result of past fuel failures. The amount of loose surface contamination on the biological shield is limited to the inner surfaces exposed to the reactor cooling air. The Environmental Remediation Project group analyzed graphite samples and swipes to identify the radiological constituents in the graphite pile. The following radionuclides were identified as major contamination components: H-3, C-14, Co-60, Ni-63, I-129, Cs-137, Sr-90, Eu-152, Eu-154, Am-241, Th-232, Pu-238, Pu-239, and Pu-240.

The removal of the graphite pile and the biological shield is expected to be completed by the end of 2011. Approximately 1.4 million pounds of activated graphite blocks and 5,000 tons of activated concrete and steel from the biological shield will be removed from Building 701 and then packaged, transported, and disposed of at an off-site location. The graphite pile removal work will be performed within a contamination containment enclosure (CCE) with a remotely controlled Gradall manipulator. The remote manipulator will be used to remove the graphite pile blocks starting from the top layer and continuing down to the pile bedplates. The remote manipulator will be fitted with a specially designed end effecter and clamshell bucket to load the graphite blocks into "super sacks" located inside the biological shield cavity. Once a super sack is full, it will be lifted out of the biological shield with a 5-ton crane and transferred to a 144 ft^3 Industrial Package Type 1 (IP-1) box. The IP-1 box will be staged and decontaminated inside the CCE to control the spread of contamination.

Due to the many fuel failures during the operational phase of the reactor and the presence of activation and fission products, multiple barriers to control contamination will be implemented during the remediation to prevent the generation and spread of dispersible contaminants. Special tools will be used with the manipulator and administrative controls will be implemented to restrict the airborne concentrations of radionuclides, both inside the CCE and within Building 701. Continuous air monitors will also be installed to measure air concentrations and any spread of contamination inside Building 701 and adjacent to the biological shield.

The source term was based on the results of waste characterization studies, smear results, and the radiological inventory of the graphite pile and biological shield. The inventory is predominantly composed of activation products resulting from neutron activation of the graphite pile and biological shield materials. Fission products from fuel leakage are present on graphite surfaces and on the innermost section of the biological shield. The effective dose equivalent to the MEI from the graphite pile and biological shield removal project was estimated to be 1.33E-02 mrem/year.

8.3.2 Waste Transfer Lines, Buildings 801 to 811

Underground waste lines were used to transfer radioactive liquid waste from the Hot Laboratory in Building 801 to the Waste Concentra-

tion Facility, Building 811. These underground radioactive waste transfer lines (A, B, D, and a non-acid off-gas pipe) were installed in 1949, modified in 1952, and completely abandoned in-place in 1961. A steam line in the area was also abandoned in 2001. The radioactive waste transfer lines A and B were 2″-diameter shielded stainless steel pipes, which were used to transfer Class A uranium and other fissionable material, and Class B non-fissionable waste materials. The D waste line was a 4″-diameter mild steel pipe used to transfer other radioactive liquid waste. The liquid radioactive waste was generated from the operation of the BGRR, the HFBR, and the Hot Laboratory. A concrete culvert, approximately 700′ long and 3′-8 ½″ wide, was used as a secondary containment for the radioactive waste transfer pipes. The waste lines lead to six waste storage tanks in the Building 811 Waste Concentration Facility, which were removed and documented in 2005 Closeout Report, Operable Unit I, and Area of Concern 10 (AOC 10).

In 2009, remediation work included the removal of the waste transfer lines, steam line, soil below the pipes, a portion of the long concrete culvert and the non-acid off-gas pipe under the HFBR AOC 31 ROD. The pipes and concrete were disposed of as radiological material, and approximately 47 yd^3 (36 m^3) of soil were excavated from the area. Building 811 characterization data was used to estimate the potential source term during the remediation work and was based on a material-at-risk (MAR). An MAR is defined as the maximum amount of radionuclides available to be acted upon by a given physical stress (remediation activities) with certain probability for the radioactive materials to be released into the environment. The effective dose equivalent to the MEI from the underground waste transfer lines A, B, D, and acid off-gas remediation work was estimated to be 1.38E-03 mrem/year at the northwest location.

8.3.3 Waste Management Facility (Building 865)

A NESHAPs compliance review for venting of the radioactive gases used in the gallium trichloride experiment in Building 555 was performed. The residual radioactive gases were released in the fume hood (EF-108) in the Waste Management Building, 865. The source activity was estimated to be carbon dioxide in the form of C-14 at 17.42 μCi, and krypton-85 (Kr-85) at 1.4 μCi.

The source term was based on the information provided on the NESHAPs Assessment Form. Although both gases had long half-lives, their specific activity was very low. A conservative estimate of effective dose equivalent to the MEI was estimated to be 2.37E-08 mrem/year. Based on the radiological dose risk assessment, the venting of the inert gases did not have an adverse impact on the environment or members of public.

8.3.4 Brookhaven Avenue Soil Removal

The former HWMF is located south of Brookhaven Avenue in the southeast wind sector at the Laboratory. In 2005, the cleanup and remediation of the former HWMF was completed under the CERCLA program, Operable Unit (OU) I AOC I. The former HWMF is fenced and categorized as a radiological facility, currently under the surveillance and maintenance program of the Environmental Restoration Project. In 2005, a small area with residual surface contamination was left in place and designated as the Waste Loading Area (WLA) to be used for remedial activities from other facilities. A decision was later made to remediate the WLA and to remove the contaminated soil from the area. Soon after the remedial activity in November 2007, BNL prepared an investigation and characterization of Brookhaven Avenue Cs-137 contamination, which showed additional elevated levels of beta/gamma radiation north/northeast and east of the former HWMF. Due to limited funding in 2008, a few discrete spots were remediated and the remainder of the area contamination was left in place. Stimulus package funding in 2009 allowed additional removal and disposal of the remaining contaminated soil at Brookhaven Avenue.

Survey results showed elevated levels of beta/gamma radiation contamination in an area of 1,433 square meters and at 13 localized spots above natural background radiation levels. Ex-

cavation equipment (i.e., Bobcat, backhoe) were used to scrape the top layers of contaminated soil, and a front-end loader was used to load the contaminated soil into super sacks for transportation to an off-site disposal facility. The residential cleanup level for Cs-137 of 23pCi/g was chosen as the cleanup goal for remediation work. The investigation and characterization of the Brookhaven Avenue Cs-137 contamination was reviewed in order to develop the source term. The effective dose equivalent to the MEI was estimated to be 6.67E-05 mrem/year.

8.3.4 Cyclotron

A NESHAPs dose assessment was performed for the potential release of carbon-11 (half-life: 20 minutes) in an "Accident" scenario for inclusion in the Safety Analysis Report (SAR) of the cyclotron. The worse case (maximal) accident condition was seen as the rupture of a carbon-11 (C-11) gas foil target. As a result of the accident condition, the maximum radioactivity released to the environment would be 500 mCi. Therefore, the source term for the dose assessment was assumed to be 500 mCi of C-11 without decay or dispersion in the 60″ cyclotron vault. Due to the short half-life of carbon-11 and because the adiabatic dispersion of the gas would be very fast in the environment, the result would be a small impact. A conservative estimate of effective dose equivalent to the MEI was estimated to be 2.64E-04 mrem/year.

8.4 DOSE FROM POINT SOURCES

8.4.1 Brookhaven Linac Isotope Producer

Source term descriptions for point sources are given in Chapter 4. The Brookhaven Linac Isotope Producer (BLIP) facility is the only emission source with any potential to contribute dose to members of the public greater than 1 percent of the EPA limit (i.e., 0.1 mrem, or 1.0 µSv). The BLIP facility uses the excess beam capacity of the Linear Accelerator (Linac) to produce short-lived radioisotopes for medical diagnostic procedures, medical imaging, and scientific research. During the irradiation process, the targets are cooled continuously by recirculating water in a 16-inch-diameter shaft. The principal gaseous radionuclides produced as a result of activation of the cooling water are O-15, C-11, and trace amounts of N-13. Because the BLIP facility has the potential to exceed 1 percent of the EPA emission limit, the facility emissions are directly measured using a low-resolution gamma spectrometer with an in-line sampling system connected to the air exhaust, to measure the short-lived gaseous products that cannot be sampled and analyzed by conventional analytical methods. Particulates and radioiodine are monitored with paper and granular activated charcoal filters, which are exchanged weekly for analysis by a contract analytical laboratory. A tritium sampler also operates continuously, with samples collected weekly.

In 2009, the BLIP facility operated over a period of 24 weeks. During the year, 670 Ci of C-11 and 1,125 Ci of O-15 were released from the facility. A small quantity of tritiated water vapor from activation of the targets' cooling water was also released at 2.75E-02 Ci. The EDE to the MEI was calculated to be 7.20E-02 mrem (0.72 µSv) in a year from BLIP operations.

In order to upgrade and make the BLIP stack comply with American National Standards Institute (ANSI) standards, an authorization application was submitted to EPA to construct and modify an existing stationary stack under 40 CFR 61.07 in April 2009; authorization was approved in August 2009. The upgrade and modification required removing an existing 12-inch diameter duct (after removing the existing HEPA and charcoal filtration system) and installing a new 6-inch-diameter galvanized steel duct within the building. On the outside of the building, an 8-inch-diameter duct was installed 10 feet away from the adjacent roof to avoid eddy currents. The total physical stack height above the adjacent structure is 15 feet, and it is 39 feet above normal grade level. The exit duct nozzle size was reduced to a 4-inch-diameter with a discharge velocity of 4,295 feet per minute (fpm). The normal exhaust volume was 375 cubic fpm, variable up to 745 cubic fpm. A new emission sampling system was installed that complies with the ANSI N13.1-1999 standard for particulates, tritium, and short-lived gases. A shroud probe was installed in the 6-inch duct to extract a representative sample for particulates,

and the transport lines were made of non-reactive stainless steel with the shortest distance to the filter collection system. A new sampling system for tritium and short-lived gases was also installed. The stack modifications were completed before the start of BLIP operations in 2010. The new stack sampling system will be tested during operations in 2010.

8.4.2 High Flux Beam Reactor

In 2009, the HFBR reactor vessel, primary cooling water system, and fuel canal which were filled with domestic water, were drained. The water was solidified and disposed of off site. Sixteen control rod blades and nine beam plugs were removed and shipped off site to a licensed disposal facility. The HFBR facility was downgraded to a radiological facility below the hazard category 3 after a Safety Basis Analysis. In 2009, tritium levels in the building were much higher than previous years (38.2 curies) due to the remediation work being performed. Effective dose equivalent to the MEI was calculated to be 1.92E-4 mrem (2 nSv) in a year.

8.4.3 Brookhaven Medical Research Reactor

In 2009, the Brookhaven Medical Research Reactor (BMRR) facility was in a "cold" shutdown mode. There was no dose contribution from the BMRR.

8.4.4 Unplanned Releases

There were no unplanned releases in 2009.

8.5 DOSE FROM INGESTION

Radionuclides in the environment bioaccumulate in deer and fish tissues, bones, and organs; consequently, samples from deer and fish were analyzed to evaluate the dose contribution to humans from the ingestion pathway. As discussed in Chapter 6, deer meat samples collected off site and less than 1 mile from the BNL boundary was used to assess the potential dose impact to the MEI. The maximum tissue concentration in the deer meat (flesh) collected "off site and less than 1 mile" was used to calculate the potential dose to the MEI. Potassium-40 (K-40) and Cs-137 were detected in the tissue samples. K-40 is a naturally occurring radionuclide and is not related to BNL operations. In 2009, the average K-40 concentrations in tissue samples (off site < 1 mile) were 3.11 ± 1.08 pCi/g (wet weight) in the flesh and 1.66 ±0.37 pCi/g (wet weight) in the liver. The maximum Cs-137 concentrations were 4.89 ± 0.47 pCi/g (wet weight) in the flesh and 0.42 ± 0.04 pCi/g (wet weight) in the liver (see Table 6-2). The average Cs-137 concentration was calculated at 1.66 ± 0.58 pCi/g; however, the maximum concentration of 4.89 pCi/g was used for the purpose of MEI dose calculations. The maximum estimated dose to humans from consuming deer meat containing the maximum Cs-137 concentration was estimated to be 7.10 mrem (71 μSv) in a year. The dose was below the health advisory limit of 10 mrem (100 μSv) established by NYSDOH. The maximized estimated dose would not be actualized, as no deer hunting is permitted on the BNL site.

In collaboration with the New York State Department of Environmental Conservation (NYSDEC) Fisheries Division, BNL maintains an ongoing program of collecting and analyzing fish from the Peconic River and surrounding freshwater bodies. In 2009, largemouth bass samples collected from the Peconic River on BNL site had the highest concentration of Cs-137, at 0.51 ± 0.06 pCi/g; this was used to estimate the EDE to the MEI. The potential dose from consuming 15 pounds of bass annually was calculated to be 0.17 mrem (1.7 μSv)—well below the NYSDOH health advisory limit of 10 mrem.

8.6 DOSE TO AQUATIC AND TERRESTRIAL BIOTA

DOE-STD-1153-2002, A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota, provides the guidelines for screening methods to estimate radiological doses to aquatic animals, terrestrial plants, and terrestrial animals, using site-specific environmental surveillance data. The RESRAD-BIOTA 1.21 biota dose level 2 program was used to evaluate compliance with the requirements for protection of biota specified in DOE Order 5400.5 (1990), Radiation Protection of the Public and the Environment, and DOE Order 450.1A, General Environmental Protection Program.

In 2009, the terrestrial animal and plant doses were evaluated based on 0.27 pCi/g of Cs-137

Table 8-5. BNL Site Dose Summary.

Pathway	Dose to Maximally Exposed Individual	Percent of DOE 100 mrem/year Limit	Estimated Population Dose per year
Inhalation			
Air	0.072 mrem (0.72 µSv)	<1%	3.09 person-rem
Ingestion			
Drinking water	None	None	None
Fish	0.17 mrem (1.7µSv)	<1%	Not tracked
Deer Meat	7.10 mrem (71 µSv)	<8%	Not tracked
All Pathways	7.34 mrem (73.4 µSv)	<8%	3.09 person-rem

found in surface soils in the vicinity of the RHIC ring and a Sr-90 concentration of 0.75 pCi/L in the surface waters collected at the HM-N location. The dose to terrestrial animals was calculated to be 0.01 mGy/day, and to plants, 1.22 E-03 mGy/day. The doses to terrestrial plants and animals were well below the biota dose limit of 1 mGy/day.

To calculate the dose to aquatic and riparian animals, Sr-90 radionuclide concentration values for surface water from HM-N location and the Cs-137 in the Carmans River, Lower lake sediments were used. The Cs-137 sediment concentration was 0.48 pCi/g, and the Sr-90 concentration in surface water was 0.75 pCi/L. The calculated dose to aquatic animals was 2.36E-04 Gy/day and to riparian animals was 2.84E-03 Gy/day. Therefore, the dose to aquatic and riparian animals was also well below the 10 mGy/day limit specified by the regulations.

8.7 CUMULATIVE DOSE

Table 8-5 summarizes the potential cumulative dose from the BNL site in 2009. The total dose to the MEI from air and ingestion pathways was estimated to be 7.34 mrem (73 µSv). In comparison, the EPA regulatory limit for the air pathway is 10 mrem (100 µSv) and the DOE limit from all pathways is 100 mrem (1,000 µSv). The cumulative population dose would be 3.09 person-rem (31 person-mSv) in a year. The effective dose was well below the DOE and EPA regulatory limits, and the ambient TLD dose was within normal background levels seen at the Laboratory site. The potential dose from drinking water was not estimated, because most of the residents adjacent to the BNL site get their drinking water from the Suffolk County Water Authority rather than private wells.

To put the potential dose impact into perspective, a comparison was made with other sources of radiation. The annual dose from all natural background sources and radon is approximately 300 mrem (3.0E-3 µSv). A diagnostic chest x-ray would result in a 5 to 20 mrem (50–200 µSv) dose per exposure. Using natural gas in homes yields approximately a 9 mrem (90 µSv) dose per year, cosmic radiation yields 26 mrem (260 µSv), and natural potassium in the body yields approximately 39 mrem (390 µSv) of internal dose. Even with worst-case estimates of dose from the air pathway and ingestion of local deer meat and fish, the cumulative dose from BNL operations was equivalent to the dose that could be received from a single chest x-ray.

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9 Quality Assurance

Quality assurance is an integral part of every activity at Brookhaven National Laboratory. A comprehensive Quality Assurance/Quality Control (QA/QC) Program is in place to ensure that all environmental monitoring samples are representative and that data are reliable and defensible. The QC in the contract analytical laboratories is maintained through daily instrument calibration, 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. The multilayered components of QA monitored at BNL ensure that all analytical data reported for the 2009 Site Environmental Report are reliable and of high quality.

9.1 QUALITY PROGRAM ELEMENTS

As required by DOE Order 450.1, Environmental Protection Program, BNL has established a QA/QC Program to ensure that the accuracy, precision, and reliability of environmental monitoring data are consistent with the requirements of Title 10 of the Code of Federal Regulations, Part 830 (10 CFR 830), Subpart A, Quality Assurance Requirements (2000) and DOE Order 414.1A, Quality Assurance. The responsibility for quality at BNL starts with the Laboratory director, who approves the policies and standards of performance governing work, and extends throughout the entire organization. The purpose of the BNL Quality Management (QM) System is to implement QM methodology throughout the various Laboratory management systems and associated processes, in order to:

- Plan and perform operations in a reliable and effective manner to minimize any impact on the health and safety of the public, employees, and the environment
- Standardize processes and support continual improvement in all aspects of Laboratory operations
- Enable the delivery of products and services that meet customers' requirements and expectations

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

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

Laboratory environmental personnel determine sampling requirements using the EPA Data Quality Objective (DQO) process (EPA 2000) or its equivalent. During this process, the project manager for each environmental program determines the type, amount, and quality of data needed to support decision making, the legal requirements, and stakeholder concerns. An environmental monitoring plan or project-specific sampling plan is then prepared, specifying the location, frequency, type of sample, analytical

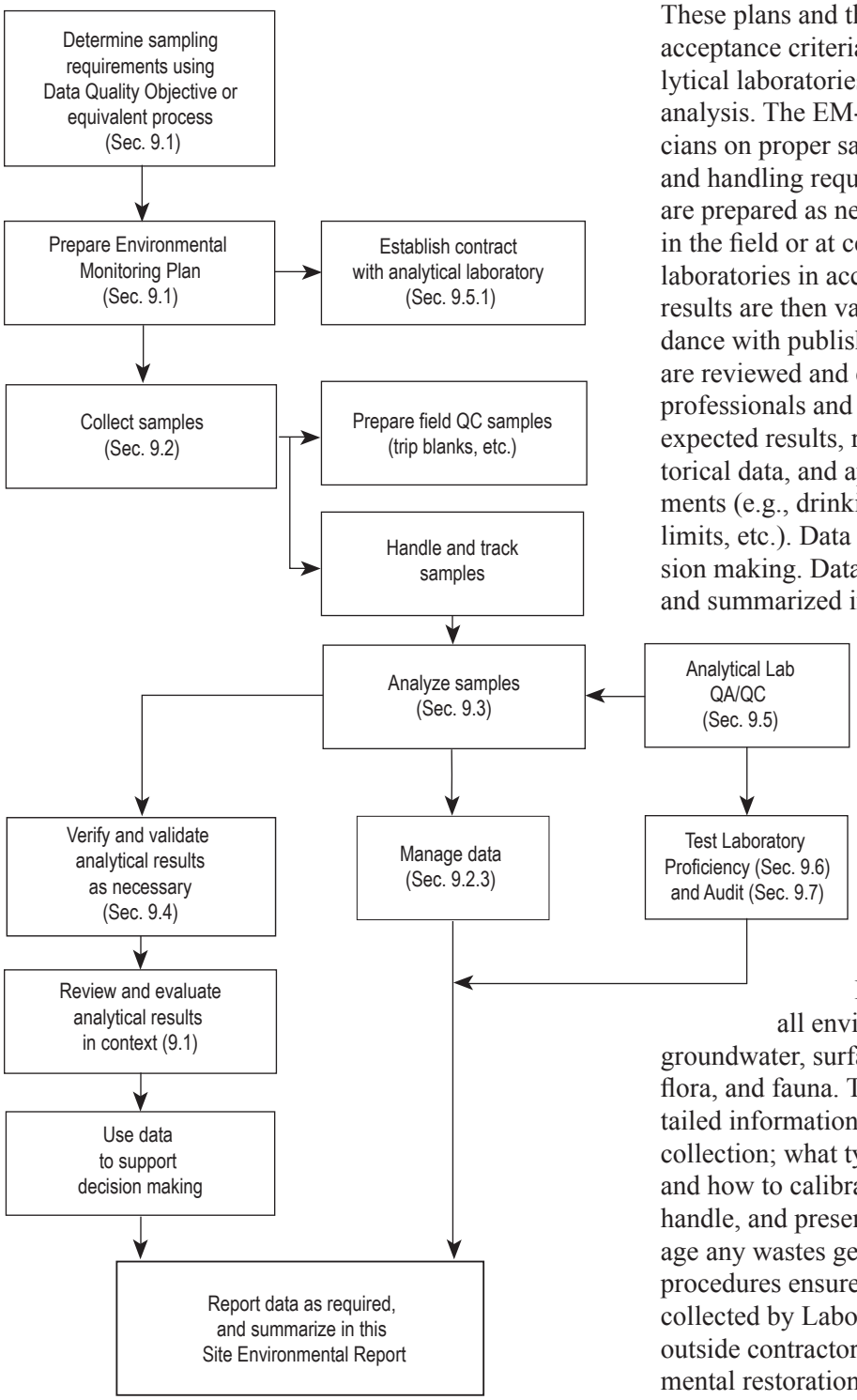


Figure 9-1. Flow of Environmental Monitoring QA/QC Program Elements.

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

9.2 SAMPLE COLLECTION AND HANDLING

In 2009, environmental monitoring samples were collected as specified by EM-SOPs, the BNL Environmental Monitoring Plan Update (BNL 2009), and project-specific work plans, as applicable.

BNL has sampling SOPs for all environmental media, including groundwater, surface water, soil, sediment, air, flora, and fauna. These procedures contain detailed information on how to prepare for sample collection; what type of field equipment to use and how to calibrate it; how to properly collect, handle, and preserve samples; and how to manage any wastes generated during sampling. The procedures ensure consistency between samples collected by Laboratory sampling personnel and outside contractors in support of the environmental restoration, compliance, and surveillance programs.

QC checks of sampling processes include the collection of field duplicates, matrix spike samples, field blanks, trip blanks, and equipment blanks. For example, field readings of water

quality parameters are taken until all parameters are within acceptable limits. Also, specific sampling methodologies include QC checks. An example of this is the low-flow groundwater sampling technique, which includes checks to ensure that monitoring wells are properly purged before readings are taken.

All wastes generated during sampling (contaminated equipment, purge water from wells, etc.) are managed in accordance with applicable requirements. A factor considered during sample collection is minimizing the amount of waste generated, consistent with the Pollution Prevention Program described in Chapter 2.

9.2.1 Field Sample Handling

To ensure the integrity of samples, chain-of-custody (COC) was maintained and documented for all samples collected in 2009. A sample is considered to be in the custody of a person if any of the following rules of custody are met: 1) the person has physical possession of the sample, 2) the sample remains in view of the person after being in possession, 3) the sample is placed in a secure location by the custody holder, or 4) the sample is in a designated secure area. These procedures are outlined in EM-SOP 109, "Chain-of-Custody, Storage, Packaging, and Shipment of Samples" (BNL 2010). All environmental monitoring samples in 2009 maintained a valid COC from the time of sample collection through sample disposal by the contract analytical laboratories.

9.2.1.1 Custody and Documentation

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

As required by EM-SOP-201, "Documentation of Field Activities" (BNL 2007a), the field sampling technician is also required to maintain a bound, weatherproof field logbook, which is used to record sample ID number, collection time, description, collection method, and COC number. Daily weather conditions, field measurements, and other appropriate site-specific observations also are recorded in the logbook.

9.2.1.2 Preservation and Shipment

Before sample collection, the field sampling technicians prepare all bottle labels and affix them to the appropriate containers, as defined in the QA program plan or applicable EM-SOPs. Appropriate preservatives are added to the containers before or immediately after collection; in appropriate cases, samples are refrigerated. For example, samples collected for methyl mercury are cooled immediately and shipped to the contract analytical laboratory on the day of collection. After samples arrive at the laboratory, they are preserved with hydrochloric acid.

Sample preservation is maintained as required throughout shipping. If samples are sent via commercial carrier, a bill-of-lading is used. COC seals are placed on the shipping containers; their intact status upon receipt indicates that custody was maintained during shipment. These procedures are outlined in EM-SOP 109.

9.2.2 Field Quality Control Samples

Field QC samples collected for the environmental monitoring program include equipment blanks, trip blanks, field blanks, field duplicate samples, and matrix spike/matrix spike duplicate samples. The rationale for selecting specific field QC samples, and minimum requirements for their use in the environmental monitoring program, are provided in the BNL EM-SOP 200 series. Equipment blanks and trip blanks (see below) were collected for all appropriate media in 2009.

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

A *trip blank* is provided with each shipping container of samples to be analyzed for volatile organic compounds (VOCs). The use of trip blanks provides a way to determine whether contamination of a sample occurred during shipment from the manufacturer, while in bottle storage, in shipment to a contract analytical laboratory, or during analysis at a lab. Trip blanks consist of an aliquot of laboratory-grade water sealed in a sample bottle, usually prepared by the contract analytical laboratory prior to shipping the sample bottles to BNL. If trip blanks were not provided by the lab, then field sampling technicians prepare trip blanks before they collect the samples. Trip blanks were included with all shipments of aqueous samples for VOC analysis in 2009.

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

In 2009 (as in other years), the most common contaminants detected in the trip, field, and equipment blanks included methylene chloride, methyl chloride, toluene, and chloroform. These compounds are commonly detected in blanks and do not pose significant problems with the reliability of the analytical results. Several other compounds were also detected, such as acetone and strontium-90 (Sr-90), at low levels. When these contaminants are detected, validation or verification procedures are used, where applicable, to qualify the associated data as "nondetects," (see Section 9.4). The results from blank samples collected during 2009 did not indicate any significant impact on the quality of the results.

Field duplicate samples are analyzed to check the reproducibility of sampling and analytical results, based on EPA Region II guidelines (EPA 2006a,b). For example, in the Groundwater Monitoring Program, duplicates are collected for 5 percent of the total number of samples collected for a project per sampling round. During 2009, 66 duplicate samples were collected for nonradiological analyses, and 57 duplicate samples were collected for radiological analyses. All duplicate samples were acceptable for input into BNL's Environmental Information Management System (EIMS) database, which is used to manage the Laboratory's environmental data. Duplicates were analyzed only for the parameters relevant to the program they monitored. Of the 5,091 nonradiological parameters analyzed in 2009, 99 percent of the analyses met QA criteria. Of the 229 radiological parameters monitored, 99 percent met QA criteria.

Matrix spike and *matrix spike duplicates* are performed to determine whether the sample matrix (e.g., water, soil, air, vegetation, bone, or oil) adversely affected the sample analysis. A *spike* is a known amount of analyte added to a sample. Matrix spikes are performed at a rate specified by each environmental program's DQOs. The rate is typically one per 20 samples collected per project. No significant matrix effects were observed in 2009 for routine matrices such as water and soil. Non-routine matrices, such as oil, exhibited the expected matrix issues.

9.2.3 Tracking and Data Management

Most environmental monitoring samples and analytical results were tracked in the EIMS. A small number of environmental samples that were not tracked in the EIMS were from Chemtex Lab, which cannot produce the electronic data deliverables needed to enter the data into the EIMS. Tracking was initiated when a sample was recorded on a COC form. Copies of the COC form and supplemental forms were provided to the project manager or the sample coordinator and forwarded to the data coordinator to be entered into the EIMS. Each contract analytical laboratory also maintained its own internal sample tracking system.

Following sample analysis, the contract analytical laboratory provides the results to the project manager or designee and, when applicable, to the validation subcontractor, in accordance with their contract. Once results of the analyses are entered into the EIMS, reports

can be generated by project personnel and DOE Brookhaven Site Office staff using a web-based data query tool.

9.3 SAMPLE ANALYSIS

In 2009, environmental samples were analyzed by one of six contract laboratories, whose selection is discussed in Section 9.3.1. All samples were analyzed according to EPA-approved methods, where such methods exist, and by standard industry methods where there are no EPA methods. In addition, field sampling technicians performed field monitoring for parameters such as conductivity, dissolved oxygen, pH, temperature, and turbidity.

9.3.1 Qualifications

BNL used the following contract analytical laboratories for analysis of environmental samples in 2009:

- General Engineering Lab (GEL) in Charleston, South Carolina, for radiological and nonradiological analytes
- Ecotest Lab in Babylon, New York, for nonradiological analytes
- Test America (TA), formerly Severn-Trent Lab, based in St. Louis, Missouri, for radiological and nonradiological analytes
- Chemtex Lab in Port Arthur, Texas, for select nonradiological analytes
- Brooks Rand in Seattle, Washington, for mercury and methylmercury analyses
- American Radiation Services (ARS) in port Allen, Louisiana for radiological analyses

The process of selecting off-site contract analytical laboratories involves a number of factors: 1) their record on performance evaluation (PE) tests, 2) their contract with the DOE Integrated Contract Procurement Team, 3) pre-selection bidding, and 4) their adherence to their own QA/QC programs, which must be documented and provided to BNL. Routine QC procedures that laboratories must follow, as discussed in Section 9.5, include daily instrument calibrations, efficiency and background checks, and standard tests for precision and accuracy. All the laboratories contracted by BNL in 2009 were certified by the New York State Department of Health (NYSDOH) for the relevant analytes, where such certification existed. The laboratories also were subject to PE testing and DOE-sponsored audits (see Section 9.7).

9.4 VERIFICATION AND VALIDATION OF ANALYTICAL RESULTS

Environmental monitoring data are subject to data verification and, in certain cases, data validation, when the data quality objectives of the project require this step. For example, groundwater samples collected for the Groundwater Protection Group (GPG) undergo data verification, whereas specific data collected for specific waste streams undergo full validation.

The data *verification* process involves checking for common errors associated with analytical data. The following criteria can cause data to be rejected during the data verification process:

- *Holding time missed* – The analysis is not initiated or the sample is not extracted within the time frame required by EPA or by the contract.
- *Incorrect test method* – The analysis is not performed according to a method required by the contract.
- *Poor recovery* – The compounds or radioisotopes added to the sample before laboratory processing are not recovered at the recovery ratio required by the contract.
- *Insufficient QA/QC data* – Supporting data received from the contract analytical laboratory are insufficient to allow validation of results.
- *Incorrect minimum detection limit (MDL)* – The contract analytical laboratory reports extremely low levels of analytes as "less than minimum detectable," but the contractually required limit is not used.
- *Invalid chain-of-custody* – There is a failure to maintain proper custody of samples, as documented on COC forms.
- *Instrument failure* – The instrument does not perform correctly.
- *Preservation requirements not met* – The requirements identified by the specific analytical method are not met or properly documented.
- *Contamination of samples from outside sources* – These possible sources include

sampling equipment, personnel, and the contract analytical laboratory.

- *Matrix interference* – Analysis is affected by dissolved inorganic/organic materials in the matrix.

Data *validation* involves a more extensive process than data verification. Validation includes all the verification checks as well as checks for less common errors, including instrument calibration that was not conducted as required, internal analyte standard errors, transcription errors, and calculation errors. The amount of data checked varies, depending on the environmental media and on the DQOs for each project. Data for some projects, such as long-term groundwater monitoring, may require only verification. Data from some waste streams receive the more rigorous validation testing, performed on 20 to 100 percent of the analytical results. The results of the verification or validation process are entered into the EIMS.

9.4.1 Checking Results

Nonradiological data analyzed in 2009 were verified and/or validated, when project DQOs required, using BNL EM-SOPs in the 200 Series and EPA contract laboratory program guidelines (EPA 2006a, b). Radiological packages were verified and validated using BNL and DOE guidance documents (BNL 2002, DOE 1994). During 2009, the verifications were conducted using a combination of manually checking the hard copy data packages and the use of a computer program developed at the Laboratory to verify that the information reported electronically is stored in the EIMS.

9.5 CONTRACT ANALYTICAL LABORATORY QA/QC

In 2009, procedures for calibrating instruments, analyzing samples, and assessing QC were consistent with EPA methodology. QC checks performed included: analyzing blanks and instrument background; using Amersham Radiopharmaceutical Company or National Institute for Standards and Technology (NIST) traceable standards; and analyzing reference standards, spiked samples, and duplicate samples. Analytical laboratory contracts specify analytes, methods, required detection limits, and deliverables—which include standard batch QA/QC performance checks. As part of the laboratory selection process, candidate laboratories are required to provide BNL with copies of their QA/QC manuals and QA program plans.

When discrepancies were found in field sampling designs, documented procedures, COC forms, data analyses, data processing systems, and QA software, or when failures in PE testing occurred, nonconformance reports were generated. Following investigation into the root causes, corrective actions were taken and tracked to closure.

9.6 PERFORMANCE OR PROFICIENCY EVALUATIONS

Five of the contract analytical laboratories (GEL, TA, Ecotest, ARS, and Brooks Rand) participated in several national and state PE testing programs in 2009. The fifth contractor, Chemtex Lab, did not participate in PE testing because there is no testing program for the specific analytes Chemtex analyzed: tolytriazole, polypropylene glycol monobutyl ether, and 1,1-hydroxyethylidene diphosphonic acid. Each of the participating laboratories took part in at least one testing program, and several laboratories participated in multiple programs. Results of the tests provide information on the quality of a laboratory's analytical capabilities. The testing was conducted by Environmental Resource Associates (ERA), the voluntary Mixed Analyte Performance Evaluation Program (MAPEP), Resource Technology Corporation (RTC), and NYSDOH Environmental Laboratory Accreditation Program (ELAP). The results from these tests are summarized in Section 9.6.1. Because Brooks Rand only analyzed samples for mercury and methylmercury, their PE results are not summarized.

9.6.1 Summary of Test Results

In Figures 9-2 and 9-3, results are plotted as percentage scores that were "Acceptable," "Warning (But Acceptable)," or "Not Acceptable." A Warning (But Acceptable) is considered by the testing organization to be "satisfactory." An "average overall satisfactory" score is the

sum of results rated as Acceptable and those rated as Warning (But Acceptable), divided by the total number of results reported. A Not Acceptable rating reflects a result that is greater than three standard deviations from the known value—a criterion set by the independent testing organizations.

Figure 9-2 summarizes radiological performance scores in the ERA, MAPEP, and ELAP programs. GEL, TA, and ARS had average overall satisfactory scores of 91, 86, and 90 percent, respectively. More details about the radiological assessments are in Section 9.6.1.1.

Figure 9-3 summarizes the nonradiological performance results of the three participating laboratories (GEL, Ecotest, and TA) in the ERA, RTC, and ELAP tests. For nonradiological tests, the average overall satisfactory results ranged from 96 to 99 percent. Additional details on nonradiological evaluations are in Section 9.6.1.2.

9.6.1.1 Radiological Assessments

GEL, TA, and ARS participated in the ERA radiological PE studies. Of GEL's tests on radiological samples, 95.6 percent were in the Acceptable range; 90.0 percent of TA's tests were Acceptable; and 89.7 percent of ARS' tests were Acceptable.

GEL and TA also participated in the ELAP evaluations: 82.9 percent of GEL's tests on radiological samples were in the Acceptable range and 91.7 percent of TA's ELAP tests on radiological samples were in the Acceptable range.

GEL also participated in the MAPEP evaluations: 93.7 percent of GEL's tests on radiological samples were in the Acceptable range.

9.6.1.2 Nonradiological Assessments

During 2009, Ecotest and GEL participated in the NYSDOH ELAP evaluations of performance on tests of nonpotable water, potable water, and solid wastes. NYSDOH found 98.6 percent of H2M's nonradiological tests to be in the Acceptable range and 96.0 percent of GEL's nonradiological tests to be in the Acceptable range. TA, which is certified through the National Environmental Laboratory Accreditation Conference (NELAC), was not required to participate in ELAP evaluations.

TA and GEL voluntarily participated in the ERA water supply and water pollution studies, although this evaluation is not required for New York State certification. ERA found that 97.6 percent of TA's tests were in the Acceptable range, as were 97.8 percent of GEL's tests.

GEL also voluntarily participated in RTC nonradiological evaluations, which showed that 98.9 percent of GEL's were in the Acceptable range.

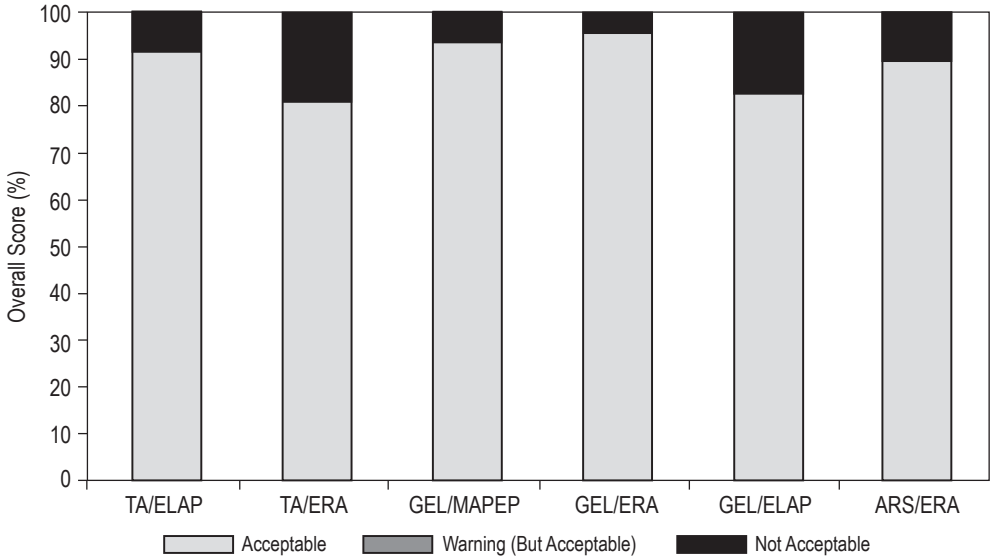
9.7 AUDITS

As part of DOE's Integrated Contract Procurement Team Program, TA, GEL, and ARS were audited during 2009 (DOE 2009a, b, c). During the audits, errors are categorized into Priority I and Priority II findings. Priority I status indicates a problem that can result in unusable data or a finding that the contract analytical laboratory cannot adequately perform services for DOE. Priority II status indicates problems that do not result in unusable data and do not indicate that the contract analytical laboratory cannot adequately perform services for DOE (DOE 2002). There were no Priority I findings for GEL and TA. ARS had one Priority I finding.

The results of the TA audit included 14 Priority II findings. The Priority II findings were in the following departments: eight Priority II findings in the Quality Assurance department, one in the Inorganic and Wet Chemistry department, two in the Radiological department, and three in the Material Handling department. TA submitted a corrective action plan covering these findings, which was accepted by DOE (DOE 2009d)

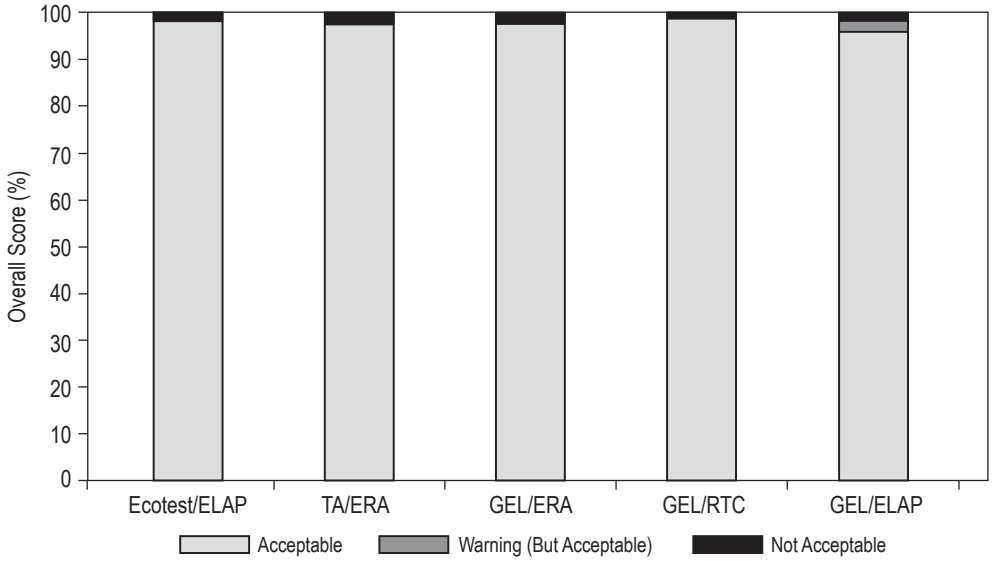
The results of the GEL audit included eight Priority II findings. The Priority II findings were in the following departments: three Priority II findings in the Quality Assurance department, three in the Inorganic and Wet Chemistry department, and two in the Radiological department. DOE has accepted a corrective action plan for these findings (DOE, 2008e).

The results of the ARS audit included four Priority II findings. Prior to the audit, ARS received a Priority I finding for failing to achieve acceptable scores for strontium-90 (Sr-90) in soil in two consecutive performance evaluation (PE) tests (DOE 2009f). ARS did pass their PE tests for Sr-90 in an aqueous matrix. Since ARS



Note that the Acceptable scores and the Warning (But Acceptable) scores combined constitute the "overall satisfactory" category referred to in the text of this chapter.

Figure 9-2. Summary of Scores in the Radiological Proficiency Evaluation Programs.



Note that the Acceptable scores and the Warning (But Acceptable) scores combined constitute the "overall satisfactory" category referred to in the text of this chapter.

Figure 9-3. Summary of Scores in the Nonradiological Proficiency Evaluation Programs.

only received aqueous samples from BNL, this did not affect any results for the Laboratory. The Priority II findings were in the following departments: one Priority II finding in the Quality Assurance department, two in the Radiological department, and one finding pertaining to the Laboratory Information Management System. ARS submitted a corrective action plan, which was accepted by DOE (DOE 2009g). Based on the audits, the analytical data met DOE's criteria for Acceptable status.

9.8 CONCLUSION

Based on the data validations, data verifications, and results of the independent Performance Evaluation assessments, the chemical

and radiological results reported in this 2009 Site Environmental Report are of acceptable quality.

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Acronyms and Abbreviations

These acronyms and abbreviations reflect the typical manner in which terms are used for this specific document and may not apply to all situations. Items with an asterisk (*) are described in the glossary of technical terms, which follows this list.

AEC	Atomic Energy Commission
AGS	Alternating Gradient Synchrotron
ALARA*	"As Low As Reasonably Achievable"
AMSL	above mean sea level
AOC*	area of concern
APG	Analytical Products Group
ARARs	Applicable, Relevant, and Appropriate Requirements
ARPA*	Archeological Resource Protection Act
AS/SVE*	air sparging/soil vapor extraction
AST	aboveground storage tank
AWQS	Ambient Water Quality Standards
BAF	Booster Applications Facility
BGD	belowground duct
BGRR	Brookhaven Graphite Research Reactor
BHSO	DOE Brookhaven Site Office
BLIP	Brookhaven Linac Isotope Producer
BMRR	Brookhaven Medical Research Reactor
BNL	Brookhaven National Laboratory
BOD*	biochemical oxygen demand
Bq*	becquerel
Bq/g	becquerel per gram
Bq/L	becquerel per liter
BRAHMS	Broad Range Hadron Magnetic Spectrometer
BSA	Brookhaven Science Associates
Btu	British thermal units
CAA*	Clean Air Act
CAAA*	CAA Amendments (1990)
CAC	Community Advisory Council
CAP	Clean Air Act Assessment Package
CBS	chemical bulk storage
CCR	Consumer Confidence Report
CEGPA	Community, Education, Government and Public Affairs
CERCLA*	Comprehensive Environmental Response, Compensation and Liability Act
CFC-11	an ozone-depleting refrigerant
cfm, cfs	cubic feet per minute, per second
CFN	Center for Functional Nanomaterials
CFR	U.S. Code of Federal Regulations
Ci*	curie
CO	certificate to operate
COC*	chain-of-custody
CRM	Cultural Resource Management
CRMP	Cultural Resource Management Plan
Cs	cesium
CSF	Central Steam Facility
CTN	Center for Transitional Neuroimaging
CWA*	Clean Water Act
CY	calendar year
D_2O*	heavy water
DAC	Derived Air Concentration
DCA	1,1-dichloroethane
DCE	1,1-dichloroethylene
DCG*	derived concentration guide
D&D	decontamination and decommissioning
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DMR	Discharge Monitoring Report
DOE*	U.S. Department of Energy
DOE CH	DOE Chicago Operations Office
DQO	Data Quality Objective
DSA	Documented Safety Analysis
DSB	Duct Service Building
DUV – FEL	Deep UltraViolet – Free Electron Laser
DWS	Drinking Water Standards
EA*	Environmental Assessment
EDB*	ethylene dibromide
EDE*	Effective Dose Equivalent
EDTA	ethylenediaminetetraacetic acid
EE/CA	Engineering Evaluation/Cost Analysis
EIMS*	Environmental Information Management System
ELAP	Environmental Laboratory Approval Program
EML	Environmental Measurements Laboratory
EMP	Environmental Monitoring Plan
EMS*	Environmental Management System
EO	Executive Order
EPA*	U.S. Environmental Protection Agency
EPCRA*	Emergency Planning and Community Right-to-Know Act
EPD	Environmental Protection Division
EPP	Environmentally Preferable Products
ERP	Environmental Restoration Projects
ERA	Environmental Resource Associates
ERD	Environmental Restoration Division

ES*	environmental surveillance
ESR	Experimental Safety Review
ES&H	Environment, Safety, and Health
ESA*	Endangered Species Act
ESH&Q	Environment, Safety, Health, and Quality Directorate
ESPC	Energy Savings Performance Contract
ESSH	Environmental Safety, Security and Health
FAMS	Facility area monitors
FERN	Foundation for Ecological Research in the Northeast
FFCA*	Federal Facilities Compliance Act
FFA	Federal Facilities Agreement
FIFRA*	Federal Insecticide, Fungicide, and Rodenticide Act
FM	Facility Monitoring
FRP	Facility Response Plan
FWS*	U.S. Fish & Wildlife Service
FY	fiscal year
GBq	giga (billion or E+09) becquerel
GAB	gross alpha and beta
GC/ECD	gas chromatography/electron capture detector
GC/MS	gas chromatography/mass spectrometry
GDS	Groundwater Discharge Standard
GEL	General Engineering Laboratory, LLC
GeV	giga (billion) electron volts
gge	gas gallon equivalent
GIS	Geographical Information System
GWh	gigawatt hour
H2M	H2M Labs, Inc.
HEPA	high efficiency particulate air
HFBR	High Flux Beam Reactor
HITL	Heavy Ion Transfer Line
HPSB	High Performance and Sustainable Buildings
HSS	Health, Safety and Security
HTO	tritiated water (liquid or vapor)
HVAC	heating/ventilation/air conditioning
HWMF	Hazardous Waste Management Facility
I	Iodine
IAEA	International Atomic Energy Agency
IAG	Interagency Agreement
IC	ion chromatography
ICP/MS	inductively coupled plasma/mass spectrometry
ISMS	Integrated Safety Management System
ISO*	International Organization for Standardization
K	potassium
kBq	kilobecquerels (1,000 Bq)
KeV	kilo (thousand) electron volts
Kr	kryptonite
kwH	kilowatt hours
LDR	Land Disposal Restriction
LED	light emitting diode
LEED	Leadership in Energy and Environmental Design
LIE	Long Island Expressway
LIMS	Laboratory Information Management System
Linac	Linear Accelerator
LIPA	Long Island Power Authority
LSTPD	Laboratory Science Teacher Professional Development
LTRA	Long Term Remedial Action
MACT	Maximum Available Control Technology
MAPEP	Mixed Analyte Performance Evaluation Program
MAR	Materials-at-risk
MCL	maximum contaminant level
MDL*	minimum detection limit
MEI*	maximally exposed individual
MeV	million electron volts
MGD	million gallons per day
mg/L	milligrams per liter
MMBtu	million British thermal units
MOA	Memorandum of Agreement
MPF	Major Petroleum Facility
MPN	most probable number
mrem	milli (thousandth of a) rem
MRI	Magnetic Resonance Imaging
MRC	Medical Research Center
MSL*	mean sea level
mSv	millisievert
MTBE	methyl tertiary butyl ether
MW	megawatt
µg/L	micrograms per liter
NA	not analyzed
NCRP	National Council on Radiation Protection and Measurements
ND	not detected
NEAR	Neighbors Expecting Accountability and Remediation
NELAC	National Environmental Laboratory Accreditation Conference
NELAP	National Environmental Laboratory Accreditation Program
NEPA*	National Environmental Policy Act
NESHAPs*	National Emission Standards for Hazardous Air Pollutants
ng/J	nano (one-billionth) gram per Joule
NHPA*	National Historic Preservation Act
NIST	National Institute for Standards and Technology
NO_2	nitrogen dioxide
NOV	Notice of Violation
NO_X*	nitrogen oxides
NOEC	no observable effect concentration
NPDES	National Pollutant Discharge Elimination System

NR	not required
NRMP	Natural Resource Management Plan
NS	not sampled
NSF-ISR	NSF-International Strategic Registrations, Ltd.
NSLS	National Synchrotron Light Source
NSRC	Nanoscale Science Research Centers
NSRL	NASA Space Radiation Laboratory
NT	not tested
NTS	Nevada Test Site
NYCRR*	New York Codes, Rules, and Regulations
NYISO	New York Independent System Operator
NYPA	New York Power Authority
NYS	New York State
NYSDEC	NYS Department of Environmental Conservation
NYSDOH	NYS Department of Health
NYSHPO	NYS Historic Preservation Office
O_3*	ozone
O&M	Operation and Maintenance
ODS	ozone-depleting substances
OHSAS	Occupational Health and Safety Assessment Series
OMC	Occupational Medical Clinic
ORC	oxygen-releasing compound
ORPS*	Occurrence Reporting and Processing System
OSHA	Occupational Health and Safety Administration
OSSP	Open Space Stewardship Program
OU*	operable unit
P2*	pollution prevention
PAAA*	Price-Anderson Act Amendment
PAF	Process Assessment Form
Pb	lead
PBT	persistent, bioaccumulative, and toxic
PCBs*	polychlorinated biphenyls
PCE	tetrachloroethylene (or perchloroethylene)
pCi/g	picocuries per gram
PE	performance evaluation
PET	positron emission tomography
ppb	parts per billion
ppm	parts per million
PRAP	Proposed Remedial Action Plan
QA*	quality assurance
QAPP	Quality Assurance Program Plan
QC*	quality control
QM	Quality Management
R-11 (etc.)	ozone-depleting refrigerant
RA*	removal action
RACT	Reasonably Available Control Technology
RATA	Relatiivistic accuracy test
RCRA*	Resource Conservation and Recovery Act
RD/RA	Remedial Design/Remedial Action
RF	resuspension factor
RHIC	Relativistic Heavy Ion Collider
ROD*	Record of Decision
RPD	relative percent difference
RSB	Research Support Building
RFT	Radiation Therapy Facility
RWMB	Radioactive Waste Management Basis
RWP	Radiological Work Permit
SARA*	Superfund Amendments and Reauthorization Act
SBMS*	Standards Based Management System
SCDHS	Suffolk County Department of Health Services
SCR	Special Case Resource
SCSC	Suffolk County Sanitary Code
SDL	Source Development Laboratory
SDWA*	Safe Drinking Water Act
SER	Site Environmental Report
SI	International System (measurement units)
SNS	standard not specified
SO_2	sulfur dioxide
SOP	standard operating procedure
SPCC	Spill Prevention Control and Countermeasures
SPDES*	State Pollutant Discharge Elimination System
Sr	strontium
SSPP	Strategic Sustainablility Performance Plan
STAR	Solenoid Tracker at RHIC
STEM	Scanning Transmission Electron Microscope
STL	Severn Trent Laboratories, Inc.
STP	Sewage Treatment Plant
SU	standard unit
SUNY	State University of New York
Sv*	sievert; unit for assessing radiation dose risk
SVE*	soil vapor extraction
SVOC*	semivolatile organic compound
$t_{1/2}$*	half-life
TAG	Technical Advisory Group
TBq	tera (trillion, or E+12) becquerel
TCA	1,1,1-trichloroethane
TCAP	Transportation Safety and Operations Compliance Assurance Process
TCE*	trichloroethylene
TCLP	toxicity characteristic leaching procedure
TEAM	Transformational Energy Action Management
TKN	Total Kjeldahl nitrogen
TLD*	thermoluminescent dosimeter
TPL	Target Processing Laboratory
TRE	Toxic Reduction Evaluation
TRI	Toxic Release Inventory
TSCA*	Toxic Substances Control Act
TVDG	Tandem Van de Graaff
TVOC*	total volatile organic compounds

UIC*	underground injection control
UST*	underground storage tank
VOC*	volatile organic compound
VUV*	very ultraviolet
WAC	waste acceptance criteria
WBS	Work Breakdown Structure
WCPP	Waste Certification Program Plan
WCF	Waste Concentration Facility
WET	Whole Effluent Toxicity
WLA	Waste Loading Area
WM	Waste Management
WMF	Waste Management Facility
WTP	Water Treatment Plant

Technical Terms

These definitions reflect the typical manner in which the terms are used for this specific document and may not apply to all situations. Bold-face words in the descriptions are defined in separate entries.

A

AA (atomic absorption) – A spectroscopy method used to determine the elemental composition of a sample. In this method, the sample is vaporized and the amount of light it absorbs is measured.

accuracy – The degree of agreement of a measurement with an accepted reference or true value. It can be expressed as the difference between two values, as a percentage of the reference or true value, or as a ratio of the measured value and the reference or true value.

activation – The process of making a material radioactive by bombardment with neutrons, protons, or other high energy particles.

activation product – A material that has become radioactive by bombardment with neutrons, protons, or other high energy particles.

activity – Synonym for radioactivity.

Administrative Record – A collection of documents established in compliance with **CERCLA**. Consists of information the CERCLA lead agency uses in its decision on the selection of response actions. The Administrative Record file should be established at or near the facility and made available to the public. An Administrative Record can also be the record for any enforcement case.

aerobic – An aerobic organism is one that lives, acts, or occurs only in the presence of oxygen.

aerosol – A gaseous suspension of very small particles of liquid or solid.

ALARA (As Low As Reasonably Achievable) – A phrase that describes an approach to minimize exposures to individuals and minimize releases of radioactive or other harmful material to the **environment** to levels as low as social, technical, economic, practical, and public policy considerations will permit. ALARA is not a dose limit, but a process with a goal to keep dose levels as far below applicable limits as is practicable.

alpha radiation – The emission of alpha particles during radioactive decay. Alpha particles are identical in makeup to the nucleus of a helium atom and have a positive charge. Alpha radiation is easily stopped by materials as thin as a sheet of paper and has a range in air of only an inch or so. Despite its low penetration ability, alpha radiation is densely ionizing and therefore very damaging when ingested or inhaled. Naturally occurring radioactive sources such as radon emit alpha radiation.

air stripping – A process for removing **VOCs** from contaminated water by forcing a stream of air through the water in a vessel. The contaminants evaporate into the air stream. The air may be further treated before it is released into the atmosphere.

ambient air – The surrounding atmosphere, usually the outside air, as it exists around people, animals, plants, and structures. It does not include the air immediately adjacent to emission sources.

analyte – A constituent that is being analyzed.

anneal – To heat a material and then cool it. In the case of thermoluminescent dosimeters (TLDs), this is done to reveal the amount of radiation the material had absorbed.

anion – A negatively charged ion, often written as a superscript negative sign after an element symbol, such as Cl^-.

anthropogenic – Resulting from human activity; anthropogenic radiation is human-made, not naturally occurring.

AOC (area of concern) – Under **CERCLA**, this term refers to an area where releases of hazardous substances may have occurred or a location where there has been a release or threat of a release of a hazardous substance, pollutant, or contaminant (including **radionuclide**s). AOCs may include, but need not be limited to, former spill areas, landfills, surface impoundments, waste piles, land treatment units, transfer stations, wastewater treatment units, incinerators, container storage areas, scrap yards, cesspools, tanks, and associated piping that are known to have caused a release into the environment or whose integrity has not been verified.

aquifer – A water-saturated layer of rock or soil below the ground surface that can supply usable quantities of **groundwater** to wells and springs. Aquifers can be a source of water for domestic, agricultural, and industrial uses.

ARPA (Archaeological Resources Protection Act) This law, passed in 1979, has been amended four times. It protects any material remains of past human life or activities that are of archaeological interest. Known *and potential* sites of interest are protected from uncontrolled excavations and pillage, and artifacts found on public and Indian lands are banned from commercial exchange.

AS/SVE (air sparging/soil vapor extraction) – A method of extracting **volatile organic compounds** from the **groundwater**, in place, using compressed air. (In contrast, air stripping occurs in a vessel.) The vapors are typically collected using a soil vapor extraction system.

B

background – A sample or location used as reference or control to compare BNL analytical results to those in areas that could not have been impacted by BNL operations.

background radiation – **Radiation** present in the environment as a result of naturally occurring radioactive materials in the Earth, cosmic radiation, or human-made radiation sources, including fallout.

beta radiation – Beta radiation is composed of charged particles emitted from a nucleus during radioactive decay. A negatively charged beta particle is identical to an electron. A positively charged beta particle is called a positron. Beta radiation is more penetrating than alpha radiation, but it may be stopped by materials such as aluminum or Lucite™ panels. Naturally occurring radioactive elements such as potassium-40 emit beta radiation.

blank – A sample (usually reagent-grade water) used for quality control of field sampling methods, to demonstrate that cross contamination has not occurred.

blowdown – Water discharged from either a boiler or cooling tower in order to prevent the build-up of inorganic matter within the boiler or tower and to prevent scale formation (i.e., corrosion).

BOD (biochemical oxygen demand) – A measure of the amount of oxygen in biological processes that breaks down organic matter in water; a measure of the organic pollutant load. It is used as an indicator of water quality.

Bq (becquerel) – A quantitative measure of **radioactivity**. This alternate measure of activity is used internationally and with increasing frequency in the United States. One Bq of activity is equal to one nuclear decay per second.

bremsstrahlung – Translates as "fast braking" and refers to electromagnetic radiation produced by the sudden retardation of a charged particle in an intense electric field.

C

CAA (Clean Air Act), CAA Amendments (CAAA) – The original Clean Air Act was passed in 1963, but the U.S. air pollution control program is based on the 1970 version of the law. The 1990 Clean Air Act Amendments (CAAA) are the most far-reaching revisions of the 1970 law. In common usage, references to the CAA typically mean to the 1990 amendments. (*source*: EPA's "Plain English Guide to the Clean Air Act" glossary, accessed 3-7-05)

caisson – A watertight container used in construction work under water or as a foundation.

cap – A layer of natural or synthetic material, such as clay or gunite, used to prevent rainwater from penetrating and spreading contamination. The surface of the cap is generally mounded or sloped so water will drain off.

carbon adsorption/carbon treatment – A treatment system in which contaminants are removed from **groundwater**, surface water, and air by forcing water or air through tanks containing activated carbon (a specially treated material that attracts and holds or retains contaminants).

carbon tetrachloride – A poisonous, nonflammable, colorless liquid, CCl_4.

CERCLA (Comprehensive Environmental Response, Compensation and Liability Act) – Pronounced "sir-klah" and commonly known as Superfund, this law was enacted by Congress on December 11, 1980. It created a tax on the chemical and petroleum industries and provided broad federal authority to respond directly to releases or threatened releases of hazardous substances that may endanger public health or the environment. CERCLA established prohibitions and requirements concerning closed and abandoned hazardous waste sites; provided for liability of persons responsible for releases of hazardous waste at these sites; and established a trust fund to provide for cleanup when no responsible party could be identified

The law authorizes two kinds of response actions: short-term removals, where actions may be taken to address releases or threatened releases requiring prompt response, and long-term remedial response actions that permanently and significantly reduce the dangers associated with releases or threats of releases of hazardous substances that are serious, but not immediately life threatening. These actions can be conducted only at sites listed on **EPA**'s National Priorities List (NPL). CERCLA was amended by the Superfund Amendments and Reauthorization Act (**SARA**) on October 17, 1986, accessed 03-7-05)

CFR (Code of Federal Regulations) – A codification of all regulations developed and finalized by federal agencies in the Federal Register. The CFR is arranged by "title," with Title 10 covering energy- and radiation-related issues, and Title 40 covering protection of the environment. Subparts within the titles are included in citations, as in "40 CFR Subpart H."

characterization – Facility or site sampling, monitoring, and analysis activities to determine the extent and nature of contamination. Characterization provides the basis of necessary technical information to select an appropriate cleanup alternative.

Ci (**curie**) – A quantitative measure of radioactivity. One Ci of activity is equal to 3.7E+10 decays per second. One curie has the approximate activity of 1 gram of radium. It is named after Marie and Pierre Curie, who discovered radium in 1898.

Class GA groundwater – New York State Department of Environmental Conservation classification for high quality groundwater, where the best intended use is as a source of drinking water supply.

closure – Under **RCRA** regulations, this term refers to a hazardous or solid waste management unit that is no longer operating and where potential hazards that it posed have been addressed (through clean up, immobilization, capping, etc.) to the satisfaction of the regulatory agency.

COC (chain-of-custody) – A method for documenting the history and possession of a sample from the time of collection, through analysis and data reporting, to its final disposition.

cocktail – a mixture of chemicals used for **scintillation** counting.

collective Effective Dose Equivalent – A measure of health risk to a population exposed to radiation. It is the sum of the **EDEs** of all individuals within an exposed population, frequently considered to be within 50 miles (80 kilometers) of an environmental release point. It is expressed in person-**rem** or person-**sievert**.

Committed Effective Dose Equivalent – The total **EDE** received over a 50-year period following the internal deposition of a **radionuclide**. It is expressed in **rems** or **sieverts**.

composite sample – A sample of an environmental medium containing a certain number of sample portions collected over a period of time, possibly from different locations. The constituent samples may or may not be collected at equal time intervals over a predefined period of time, such as 24 hours.

confidence interval – A numerical range within which the true value of a measurement or calculated value lies. In the SER, radiological values are shown with a 95 percent confidence interval: there is a 95 percent probability that the true value of a measurement or calculated value lies within the specified range. *See also* "Uncertainty" discussion in Appendix B.

conservative – Estimates that err on the side of caution because all possibly deleterious components are included at generous or high values.

contamination – Unwanted radioactive and/or hazardous material that is dispersed on or in equipment, structures, objects, air, soil, or water.

control – *See* **background**.

cooling water – Water used to cool machinery and equipment. *Contact* cooling water is any wastewater that contacts machinery or equipment to remove heat from the metal; *noncontact* cooling water has no direct contact with any process material or final product. *Process wastewater* cooling water is water used for cooling that may have become contaminated through contact with process raw materials or final products.

cover boards – Sheets of plywood placed on the ground near ponds to serve as attractive habitat for salamanders, as part of a population study.

curie – *See* **Ci**.

CWA (Clean Water Act) – Growing public awareness and concern for controlling water pollution led to enactment of the Federal Water Pollution Control Act Amendments of 1972. As amended in 1977, this law became commonly known as the Clean Water Act. It established the basic structure for regulating discharges of pollutants into the waters of the United States, giving **EPA** the authority to implement pollution control programs such as setting wastewater standards for industry. The CWA also continued requirements to set water quality standards for all contaminants in surface waters and made it unlawful for any person to discharge any pollutant from a **point source** into navigable waters unless a permit was obtained. The CWA also funded the construction of sewage treatment plants and recognized the need for planning to address the critical problems posed by **nonpoint source pollution**.

Revisions in 1981 streamlined the municipal construction grants process. Changes in 1987 phased out the construction grants program. Title I of the Great Lakes Critical Programs Act of 1990 put into place parts of the Great Lakes Water Quality Agreement of 1978, signed by the U.S. and Canada; the two nations agreed to reduce certain toxic pollutants in the Great Lakes. Over the years many other laws have changed parts of the CWA, accessed 03-7-05)

D

D_2O – *See* **heavy water**.

daughter, progeny – A given **nuclide** produced by radioactive decay from another nuclide (the "parent"). *See also* **radioactive series**.

DCG (derived concentration guide) – The concentration of a **radionuclide** in air or water that, under conditions of continuous exposure for one year by a single pathway (e.g., air inhalation, absorption, or ingestion), would result in an effective dose equivalent of 100 mrem (1 mSv). The values were established in **DOE Order 5400.5**.

decay product – A **nuclide** resulting from the radioactive disintegration of a **radionuclide**, being formed either directly or as a result of successive transformations in a radioactive series. A decay product may be either radioactive or stable.

decontamination – The removal or reduction of **radioactive** or hazardous contamination from facilities, equipment, or soils by washing, heating, chemical or electrochemical action, mechanical cleaning, or other techniques to achieve a stated objective or end condition.

disposal – Final placement or destruction of waste.

DOE (Department of Energy) – The federal agency that promotes scientific and technical innovation to support the national, economic, and energy security of the United States. DOE has responsibility for 10 national laboratories and for the science and research conducted at these laboratories, including Brookhaven National Laboratory.

DOE Order 231.1A – This order, Environment, Safety, and Health Reporting, is dated 8/19/03. It replaces the 1995 version, Order 231.1, as well as the "ORPS" order, DOE Order 232.1A, Occurrence Reporting and Processing of Operations Information, dated 7/21/97, and Order 210.1, Performance Indicator…, dated 9/27/95.

DOE Order 450.1 – This order, Environmental Protection Program, is dated 1/15/03. It replaces DOE Order 5400.1, General Environmental Protection Program, dated 11/9/88.

DOE Order 5400.5 – This order, Radiation Protection of the Public and the Environment, was first published by **DOE** in 1990 and was modified in 1993. It established

the standards and requirements for operations of DOE and DOE contractors with respect to protecting the public and the **environment** against undue risk from radiation.

dose – *See* **EDE**.

dosimeter – A portable detection device for measuring exposure to ionizing radiation. See Chapter 8 for details.

downgradient – In the direction of **groundwater** flow from a designated area; analogous to "downstream."

DQO (Data Quality Objective) –The Data Quality Objective (DQO) process was developed by **EPA** for facilities to use when describing their environmental monitoring matrices, sampling methods, locations, frequencies, and measured parameters, as well as methods and procedures for data collection, analysis, maintenance, reporting, and archiving. The DQO process also addresses data that monitor quality assurance and quality control.

drift fence – A stretch of temporary fencing to prevent an animal population from leaving the area, used at BNL as part of a population study.

dry weight – The dry weight concentration of a substance is after a sample is dried for analysis. Dry weight concentrations are typically higher than wet weight values.

D-waste – Liquid waste containing radioactivity.

E

EA (Environmental Assessment) – A report that identifies potentially significant effects from any federally approved or funded project that might change the physical **environment**. If an EA identifies a "significant" potential impact (as defined by **NEPA**), an Environmental Impact Statement (EIS) must be researched and prepared.

EDB (ethylene dibromide) – A colorless, nonflammable, heavy liquid with a sweet odor; slightly soluble in water. Although the U.S. Department of Health and Human Services has determined that ethylene dibromide may reasonably be anticipated to be a carcinogen, it is still used to treat felled logs for bark beetles; to control wax moths in beehives; as a chemical intermediary for dyes, resins, waxes, and gums; to spot-treat milling machinery; and to control Japanese beetles in ornamental plants.

EDE (Effective Dose Equivalent) – A value used to express the health risk from radiation exposure to tissue in terms of an equivalent whole body exposure. It is a "normalized" value that allows the risk from radiation exposure received by a specific organ or part of the body to be compared with the risk due to whole-body exposure. The EDE equals the sum of the doses to different organs of the body multiplied by their respective **weighting factors**. It includes the sum of the EDE due to radiation from sources external to the body and the committed effective dose equivalent due to the internal deposition of **radionuclide**s. EDE is expressed in **rems** or **sieverts**.

effluent – Any liquid discharged to the environment, including stormwater **runoff** at a site or facility.

EIMS (Environmental Information Management System) – A database system used to store, manage, verify, protect, retrieve, and archive BNL's environmental data.

EM (environmental monitoring) – Sampling for contaminants in air, water, sediment, soil, food stuffs, plants, and animals, either by directly measuring or by collecting and analyzing samples.

emissions – Any gaseous or particulate matter discharged to the atmosphere.

EMS (Environmental Management System) – The BNL EMS meets the requirements of the **ISO 14001 EMS standard**, with emphasis on compliance assurance, pollution prevention, and community outreach. An extensive environmental monitoring program is one component of BNL's EMS.

environment – Surroundings (including air, water, land, natural resources, flora, fauna, and humans) in which an organization operates, and the interrelation of the organization and its surroundings.

environmental aspect – Elements of an organization's activities, products, or services that can interact with the surrounding air, water, land, natural resources, flora, fauna, and humans.

environmental impact – Any change to the surrounding air, water, land, natural resources, flora, and fauna, whether adverse or beneficial, wholly or partially resulting from an organization's activities, products, or services.

environmental media – Includes air, **groundwater**, surface water, soil, flora, and fauna.

environmental monitoring or **surveillance** – *See* **EM**.

EPA (U. S. Environmental Protection Agency) – The federal agency responsible for developing and enforcing environmental laws. Although state or local regulatory agencies may be authorized to administer environmental regulatory programs, EPA generally retains oversight authority.

EPCRA (Emergency Planning and Community Right-to-Know Act) – Also known as Title III of SARA, EPCRA was enacted by Congress as the national legislation on community safety, to help local groups protect public health, safety, and the environment from chemical hazards. To implement EPCRA, Congress required each state to appoint a State Emergency Response Commission (SERC). The SERCs were required to divide their states into Emergency Planning Districts and to name a Local Emergency Planning Committee for each district

Broad representation by fire fighters, health officials, government and media representatives, community groups, industrial facilities, and emergency managers ensures that all necessary elements of the planning process are represented.

ES (environmental surveillance) – Sampling for contaminants in air, water, sediment, soil, food stuffs, plants, and animals, either by directly measuring or by collecting and analyzing samples.

ESA (Endangered Species Act) – This provides a program for conserving threatened and endangered plants and animals and their habitats. The **FWS** maintains the list of 632 *endangered* species (326 are plants) and 190 *threatened* species (78 are plants). Species include birds, insects, fish, reptiles, mammals, crustaceans, flowers, grasses, and trees. Anyone can petition FWS to include a species on this list. The law prohibits any action, administrative or real, that results in a "taking" of a listed species *or* adversely affects habitat. Likewise, import, export, interstate, and foreign commerce of listed species are all prohibited. **EPA**'s decision to register pesticides is based in part on the risk of adverse effects on endangered species as well as environmental fate (how a pesticide will affect habitat). Under **FIFRA**, EPA can issue emergency suspensions of certain pesticides to cancel or restrict their use if an endangered species will be adversely affected.

evapotranspiration – A process by which water is transferred from the soil to the air by plants that take the water up through their roots and release it through their leaves and other aboveground tissue.

exposure – A measure of the amount of ionization produced by **x-rays** or **gamma rays** as they travel through air. The unit of radiation exposure is the roentgen (**R**).

F

fallout – Radioactive material, made airborne as a result of aboveground nuclear weapons testing, that has been deposited on the Earth's surface.

FFCA (Federal Facility Compliance Act) – Formerly, the federal government maintained that it was not subject to fines and penalties under solid and hazardous waste law because of the doctrine of "sovereign immunity." The State of Ohio challenged this in *Ohio v. the Department of Energy (1990)*. The U.S. Circuit Court of Appeals found in favor of the State (June 11, 1990), writing that the federal government's sovereign immunity is waived under both the **CWA** sovereign immunity provision and **RCRA**'s citizen suit provision. The Circuit Court decision was overturned by the Supreme Court on April 21, 1992, in *DOE v. Ohio,* which held that the waiver of sovereign immunity in RCRA and CWA is not clear enough to allow states to impose civil penalties directly. After the high court's ruling, the consensus among lawmakers was that a double standard existed: the same government that developed laws to protect human health and the environment and required compliance in the private sector, was itself not assuming the burden of compliance. As a result, Congress enacted the FFCA (October 6, 1992, Pub. Law 102-386), which effectively overturned the Supreme Court's ruling. In the legislation Congress specifically waived sovereign immunity with respect to RCRA for federal facilities.

Under section 102, FFCA amends section 6001 of RCRA to specify that federal facilities are subject to "all civil and administrative penalties and fines, regardless of whether such penalties or fines are punitive or coercive in nature." These penalties and fines can be levied by **EPA** or by authorized states. In addition, FFCA states that "the United States hereby expressly waives any immunity otherwise applicable to the United States." Although federal agents, employees, and officers are not liable for civil penalties, they are subject to criminal sanctions. No departments, agencies, or instrumentalities are subject to criminal sanctions. Section 104 (1) and (2) require EPA to conduct annual RCRA inspections of all federal facilities.

FIFRA (Federal Insecticide, Fungicide, and Rodenticide Act) – The primary focus of this law was to provide federal control of pesticide distribution, sale, and use. **EPA** was given authority under FIFRA not only to study the consequences of pesticide usage but also to require users (farmers, utility companies, and others) to register when purchasing pesticides. Through later amendments to the law, users also must take exams for certification as applicators of pesticides. All pesticides used in the U.S. must be registered (licensed) by EPA. Registration assures that pesticides will be properly labeled and that if used in accordance with specifications, will not cause unreasonable harm to the environment.

FS (feasibility study) – A process for developing and evaluating remedial actions using data gathered during the remedial investigation. The FS defines the objectives of the remedial program for the site and broadly develops remedial action alternatives, performs an initial screening of these alternatives, and performs a detailed analysis of a limited number of alternatives that remain after the initial screening stage.

FWS (U.S. Fish & Wildlife Service) – The U.S. Fish and Wildlife Service is the principal federal agency responsible for conserving, protecting, and enhancing fish, wildlife, plants, and their habitats for the continuing benefit of the people of the United States. FWS manages the 95-million-acre National Wildlife Refuge System, which encompasses 544 national wildlife refuges, thousands of small wetlands, and other special management areas. It also operates 69 national fish hatcheries, 64 fishery resources offices, and 81 ecological services field stations. The agency enforces federal wildlife laws, administers the Endangered Species Act, manages migratory bird populations, restores nationally significant fisheries, conserves and restores wildlife habitat such as wetlands, and helps foreign and Native American tribal governments with their conservation efforts. It also oversees the Federal Assistance Program, which distributes hundreds of millions of dollars in excise taxes on fishing and hunting equipment to state fish and wildlife agencies.

fugitive source – Unanticipated sources of volatile hazardous air pollutants due to leaks from valves, pumps, compressors, relief valves, connectors, flanges, and various other pieces of equipment.

G

gamma radiation – Gamma radiation is a form of electromagnetic radiation, like radio waves or visible light, but with a much shorter wavelength. It is more penetrating than **alpha** or **beta** radiation, capable of passing through dense materials such as concrete.

gamma spectroscopy – This analysis technique identifies specific **radionuclide**s. It measures the particular energy of a radionuclide's gamma radiation emissions. The energy of these emissions is unique for each nuclide, acting as a "fingerprint."

geotextile – A product used as a soil reinforcement agent and as a filter medium. It is made of synthetic fibers manufactured in a woven or loose manner to form a blanket-like product.

grab sample – A single sample collected at one time and place.

Green Building – Construction that adheres to guidelines established by the Green Building Council, a coalition of leaders from across the building industry working to promote structures that are environmentally responsible, profitable, and healthy places to live and work.

groundwater – Water found beneath the surface of the ground (subsurface water). Groundwater usually refers to a zone of complete water saturation containing no air.

gunite – A mixture of cement, sand, and water sprayed over a mold to form a solid, impermeable surface. Formerly a trademarked name, now in general usage.

H

half-life ($t_{1/2}$) – The time required for one-half of the atoms of any given amount of a radioactive substance to disintegrate; the time required for the activity of a radioactive sample to be reduced by one half.

halon – An ozone-depleting fire suppressant; suffixes (-1301, etc.) indicate variants.

hazardous waste – Toxic, corrosive, reactive, or ignitable materials that can injure human health or damage the environment. It can be liquid, solid, or sludge, and include heavy metals, organic solvents, reactive compounds, and corrosive materials. It is defined and regulated by **RCRA**, Subtitle C.

heat input – The heat derived from combustion of fuel in a steam generating unit. It does not include the heat from preheated combustion air, recirculated flue gases, or the exhaust from other sources.

heavy water (D_2O) – A form of water containing deuterium, a nonradioactive isotope of hydrogen.

herpetofaunal – Relating to the study of reptiles.

hot cell – Shielded and air-controlled facility for the remote handling of radioactive material.

hydrology – The science dealing with the properties, distribution, and circulation of natural water systems.

I

inert – Lacking chemical or biological action.

influent – Liquid (such as stormwater runoff or wastewater) flowing into a reservoir, basin, or treatment plant.

intermittent river – A stream that dries up on occasion, usually as a result of seasonal factors or decreased contribution from a source such as a wastewater treatment plant.

ionizing radiation – Any radiation capable of displacing electrons from atoms or molecules, thereby producing ions. High doses of ionizing radiation may produce severe skin or tissue damage. *See also* **alpha, beta, gamma radiation; x-rays**.

ISO 14001 EMS standard – The International Organization for Standardization (ISO) sets standards for a wide range of products and management operations. Following the success of the ISO 9000 Standards for quality management, ISO introduced the 14000 series for environmental management. BNL was the first DOE Office of Science laboratory to obtain third-party registration to this globally recognized environmental standard.

isotope – Two or more forms of a chemical element having the same number of protons in the nucleus (the same atomic number), but having different numbers of neutrons in the nucleus (different atomic weights). Isotopes of a single element possess almost identical chemical properties.

L

leaching – The process by which soluble chemical components are dissolved and carried through soil by water or some other percolating liquid.

light water – As used in this document, tap water, possibly filtered.

liquid scintillation counter – An analytical instrument used to quantify tritium, carbon-14, and other beta-emitting **radionuclide**s. *See also* **scintillation**.

M

matrix, matrices – The natural context (e.g., air, vegetation, soil, water) from which an environmental sample is collected.

MDL (minimum detection limit) – The lowest level to which an analytical parameter can be measured with certainty by the analytical laboratory performing the measurement. While results below the MDL are sometimes measurable, they represent values that have a reduced statistical confidence associated with them (less than 95 percent confidence).

MEI (maximally exposed individual) – The hypothetical individual whose location and habits tend to maximize his/her radiation dose, resulting in a dose higher than that received by other individuals in the general population.

metamorphic – In the state of changing from larval to mature forms.

mixed waste – Waste that contains both a hazardous waste component (regulated under Subtitle C of **RCRA)** and a radioactive component.

monitoring – The collection and analysis of samples or measurements of effluents and emissions for the purpose of characterizing and quantifying contaminants, and demonstrating compliance with applicable standards.

monitoring well – A well that collects **groundwater** for the purposes of evaluating water quality, establishing groundwater flow and elevation, determining the effectiveness of treatment systems, and determining whether administrative or engineered controls designed to protect groundwater are working as intended.

MSL (mean sea level) – The average height of the sea for all stages of the tide. Used as a benchmark for establishing **groundwater** and other elevations.

N

NEPA (National Environmental Policy Act) – Assures that all branches of government give proper consideration to the environment before any land purchase or any construction projects, including airports, buildings, military complexes, and highways. Project planners must assess the likely impacts of the project by completing an Environmental Assessment (EA) and, if necessary, an Environmental Impact Statement (EIS).

NESHAPs (National Emissions Standards for Hazardous Air Pollutants) – Standards that limit emissions from specific sources of air pollutants linked to serious health hazards. NESHAPs are developed by **EPA** under the CAA. Hazardous air pollutants can be chemical or radioactive. Their sources may be human-made, such as vehicles, power plants, and industrial or research processes, or natural, such as radioactive gas in soils.

neutrino – A small, neutral particle created as a result of particle decay. Neutrinos were believed to be massless, but recent studies have indicated that they have small, but finite, mass. Neutrinos interact very weakly.

NHPA (National Historic Preservation Act) – With passage of the National Historic Preservation Act in 1966, Congress made the federal government a full partner and a leader in historic preservation. The role of the federal government is fulfilled through the National Park Service. State participation is through State Historic Preservation Offices. "Before 1966, historic preservation was mainly understood in one-dimensional terms: the proverbial historic shrine or Indian burial mound secured by lock and key—usually in a national park—set aside from modern life as an icon for study and appreciation. NHPA largely changed that approach, signaling a much broader sweep that has led to the breadth and scope of the vastly more complex historic preservation mosaic we know today."

nonpoint source pollution – Nonpoint source pollution occurs when rainfall, snowmelt, or irrigation water runs over land or through the ground, picks up pollutants, and deposits them into rivers, lakes, and coastal waters or introduces them into **groundwater**. Nonpoint source pollution also includes adverse changes to the hydrology of water bodies and their associated aquatic habitats. After Congress passed the Clean Water Act in 1972, the nation's water quality community emphasized **point source** pollution (coming from a discrete conveyance or location, such as industrial and municipal waste discharge pipes). Point sources were the primary contributors to the degradation of water quality then, and the significance of nonpoint source pollution was poorly understood. Today, nonpoint source pollution remains the largest source of water quality problems. It is the main reason that approximately 40 percent of surveyed rivers, lakes, and estuaries are not clean enough to meet basic uses such as fishing or swimming.

NO_X – Nitrogen oxides are gases consisting of one molecule of nitrogen and varying numbers of oxygen molecules. Nitrogen oxides are produced, for example, by the combustion of fossil fuels in vehicles and electric power plants. In the atmosphere, NO_X can contribute to the formation of smog, impair visibility, and have health consequences. NO_X are considered "criteria air pollutants" under the CAA.

nuclide – A species of atom characterized by the number of protons and neutrons in the nucleus.

NYCRR (New York Codes, Rules, and Regulations) The NYCRR primarily contains state agency rules and regulations adopted under the State Administrative Procedure Act. There are 22 Titles: one for each state department, one for miscellaneous agencies and one for the Judiciary. Title 6 addresses environmental conservation, so many references in the SER are to "6 NYCRR."

O

O_3 – *See* ozone.

on site – The area within the boundaries of a site that is controlled with respect to access by the general public.

opacity – Under the Clean Air Act (**CAA**), a measurement of the degree to which smoke (emissions other than water vapor) reduces the transmission of light and obscures the view of an object in the background.

ORPS (Occurrence Reporting and Processing System) A system for identifying, categorizing, notifying, investigating, analyzing, and reporting to DOE events or conditions discovered at the BNL site. It was originally established by DOE Order 232.1, which has been replaced by **DOE Order 231.1A.**

OU (operable unit) – Division of a contaminated site into separate areas based on the complexity of the problems associated with it. Operable units may address geographical portions of a site, specific site problems, or initial phases of an action. They may also consist of any set of actions performed over time, or actions that are concurrent, but located in different parts of a site. An OU can receive specific investigation and a particular remedy may be proposed. A Record of Decision (**ROD**) is prepared for each OU.

outfall – The place where wastewater is discharged.

oxides of nitrogen (NO_X) – *See* **NO_X**.

ozone (O_3) – A very reactive type of oxygen formed naturally in the upper atmosphere which provides a shield for the earth from the sun's ultraviolet rays. At ground level or in the lower atmosphere, it is pollution that forms when oxides of nitrogen and hydrocarbons react with oxygen in the presence of strong sunlight. Ozone at ground level can lead to health effects and cause damage to trees and crops.

P

P2 (pollution prevention) – Preventing or reducing the generation of pollutants, contaminants, hazardous substances, or wastes at the source, or reducing the amount for treatment, storage, and disposal through recycling. Pollution prevention can be achieved through reduction of waste at the source, segregation, recycle/reuse, and the efficient use of resources and material substitution. The potential benefits of pollution prevention include the reduction of adverse environmental impacts, improved efficiency, and reduced costs.

PAAA (Price-Anderson Act Amendments) – The Price-Anderson Act (PAA) was passed in 1957 to provide for prompt compensation in the case of a nuclear accident. The PAA provided broad financial coverage for damage, injury, and costs, and required DOE to indemnify contractors. The amended act of 1988 (PAAA) extended indemnification for 15 years and required DOE to establish and enforce nuclear safety rules. The PAAA Reauthorization, passed in December of 2002, extended current indemnification levels through 2004. 10 CFR 820 and its Appendix A provide DOE enforcement procedure and policy.

Parshall flume – An engineered channel used to measure the flow rate of water. It was named after the inventor, who worked for the U.S. government as an irrigation research engineer.

PCBs (polychlorinated biphenyls) – A family of organic compounds used from 1926 to 1979 (when they were banned by **EPA**) in electrical transformers, lubricants, carbonless copy paper, adhesives, and caulking compounds. PCBs are extremely persistent in the environment because they do not break down into different and less harmful chemicals. PCBs are stored in the fatty tissues of humans and animals through the bioaccumulation process.

percent recovery – For analytical results, the ratio of the measured amount, divided by the known (spiked) amount, multiplied by 100.

permit – An authorization issued by a federal, state, or local regulatory agency. Permits are issued under a number of environmental regulatory programs, including **CAA**, **CWA**, **RCRA**, and **TSCA**. Permits grant permission to operate, to discharge, to construct, and so on. Permit provisions may include emission/effluent limits and other requirements such as the use of pollution control devices, monitoring, record keeping and reporting. Also called a "license" or "certificate" under some regulatory programs.

pH – A measure of hydrogen ion concentration in an aqueous solution. Acidic solutions have a pH less than 7, neutral solutions have a pH of 7, and basic solutions have a pH greater than 7 and up to 14.

plume – A body of contaminated **groundwater** or polluted air flowing from a specific source. The movement of a groundwater plume is influenced by such factors as local groundwater flow patterns, the character of the aquifer in which groundwater is contained, and the density of contaminants. The movement of an air contaminant plume is influenced by the ambient air motion, the temperatures of the ambient air and of the plume, and the density of the contaminants.

point source – Any confined and discrete conveyance (e.g., pipe, ditch, well, or stack) of a discharge.

pollutant – Any hazardous or radioactive material naturally occurring or added to an environmental medium, such as air, soil, water, or vegetation.

potable water – Water of sufficient quality for use as drinking water without endangering the health of people, plants, or animals.

precision – A statistical term describing the dispersion of data around a central value, usually represented as a variance, standard deviation, standard error, or confidence interval.

putrescible waste – Garbage that contains food and other organic biodegradable materials. There are special management requirements for this waste in 6 **NYCRR** Part 360.

Q

QA (quality assurance) – In environmental monitoring, any action to ensure the reliability of monitoring and measurement data. Aspects of QA include procedures, inter-laboratory comparison studies, evaluations, and documentation.

QC (quality control) – In environmental monitoring, the routine application of procedures to obtain the required standards of performance in monitoring and measurement processes. QC procedures include calibration of instruments, control charts, and analysis of replicate and duplicate samples.

qualifier – A letter or series of letter codes in a graph or chart indicating that the associated value did not meet analytical requirements or was estimated.

quenching – Anything that interferes with the conversion of decay energy to electronic signal in the photomultiplier tubes of detection equipment, usually resulting in a reduction in counting efficiency.

R

R (roentgen) – A unit of exposure to ionizing radiation. It is the amount of gamma or x-rays required to produce ions carrying one electrostatic unit of electrical charge in one cubic centimeter of dry air under standard conditions. It is named after the German scientist Wilhelm Roentgen, who discovered x-rays.

RA (removal actions, "removals") – Interim actions that are undertaken to prevent, minimize, or mitigate damage to the public health or environment that may otherwise result from a release or threatened release of hazardous substances, pollutants, or contaminants pursuant to **CERCLA**, and that are not inconsistent with the final remedial action. Under CERCLA, **EPA** may respond to releases or threats of releases of hazardous substances by starting an RA to stabilize or clean up an incident or site that immediately threatens public health or welfare. Removal actions are less comprehensive than *remedial* actions. However, removal actions must contribute to the efficiency of future remedial actions.

radiation – Some atoms possess excess energy, causing them to be physically unstable. Such atoms become stable when the excess energy is released in the form of charged particles or electromagnetic waves, known as radiation.

radiation event – A single detection of a charged particle or electromagnetic wave.

radioactive series – A succession of **nuclide**s, each of which transforms by radioactive disintegration into the next until a stable nuclide results. The first member of the series is called the parent and the intermediate members are called daughters or progeny.

radioactivity – The spontaneous transition of an atomic nucleus from a higher energy to a lower energy state. This transition is accompanied by the release of a charged particle or electromagnetic waves from the atom. Also known as "activity."

radionuclide – A radioactive element characterized by the number of protons and neutrons in the nucleus. There are several hundred known radionuclides, both artificially produced and naturally occurring.

RCRA (Resource Conservation and Recovery Act) Pronounced "rick-rah," this act of Congress gave **EPA** the authority to control the generation, transportation, treatment, storage, and disposal of hazardous waste. RCRA also set forth a framework for the management of nonhazardous wastes. The 1986 amendments to RCRA enabled EPA to address environmental problems that could result from underground tanks storing petroleum and other hazardous substances. RCRA focuses only on active and future facilities and does not address abandoned or historical sites (*see* CERCLA). In 1984, amendments to RCRA called the Hazardous and Solid Waste Amendments (HSWA, pronounced "hiss-wa") required phasing out the land disposal of hazardous waste. Some other mandates of this strict law include increased enforcement authority for EPA, more stringent hazardous waste management standards, and a comprehensive underground storage tank (UST) program.

recharge – The process by which water is added to a zone of saturation (aquifer) from surface infiltration, typically when rainwater soaks through the earth to reach an aquifer.

recharge basin – A basin (natural or artificial) that collects water. The water will infiltrate to the aquifer.

release – Spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing of a hazardous substance, pollutant, or contaminant into the environment. The National Contingency Plan also defines the term to include a threat of release.

rem – Stands for "**roentgen** equivalent man," a unit by which human radiation dose is assessed (*see also* **Sv**). The rem is a risk-based value used to estimate the potential health effects to an exposed individual or population. 100 rem = 1 sievert.

remedial (or **remediation) alternatives** – Options considered under **CERCLA** for decontaminating a site such as an operable unit (**OU**) or area of concern (**AOC**). Remedial actions are long-term activities that prevent the possible release, or stop or substantially reduce the actual release, of substances that are hazardous but not immediately life-threatening. *See also* feasibility study (**FS**) and Record of Decision (**ROD**).

residual fuel – Crude oil, Nos. 1 and 2 fuel oil that have a nitrogen content greater than 0.05 weight percent, and all fuel oil Nos. 4, 5, and 6, as defined by the American Society of Testing and Materials in ASTM D396-78, *Standard Specifications for Fuel Oils,* (c. 2001).

riparian – An organism living on the bank of a river, lake, or tidewater.

ROD (Record of Decision) – A document that records a regulatory agency's decision for the selected remedial action. The ROD also includes a responsiveness summary and a bibliography of documents that were used to reach the remedial decision. When the ROD is finalized, remedial design and implementation can begin.

roentgen – *See* R.

RPD (relative percent difference) – A measure of precision, expressed by the formula: RPD = [(A-B)/(A+B)] x 200, where A equals the concentration of the first analysis and B equals the concentration of the second analysis.

runoff – The movement of water over land. Runoff can carry pollutants from the land into surface waters or uncontaminated land.

S

sampling – The extraction of a prescribed portion of an effluent stream or environmental media for purposes of inspection or analysis.

SARA (Superfund Amendments and Reauthorization Act) – This Act of Congress in 1986 reauthorized CERCLA to continue cleanup activities around the country. Several site-specific amendments, definitions clarifications, and technical requirements were added to the legislation, including additional enforcement authorities. Title III of SARA also authorized EPCRA.

SBMS (Standards-Based Management System) – A document management tool used to develop and integrate

systems, and to demonstrate BNL's conformance to requirements to perform work safely and efficiently.

scintillation – Flashes of light produced in a phosphor by a radioactive material.

SDWA (Safe Drinking Water Act) – The Safe Drinking Water Act was established to protect the quality of drinking water in the United States. It focuses on all waters actually or potentially designed for drinking use, whether from above ground or underground sources. The SDWA authorized **EPA** to establish safe standards of purity and required all owners or operators of public water systems to comply with health-related standards. State governments assume regulatory power from EPA.

sediment – The layer of soil and minerals at the bottom of surface waters, such as streams, lakes, and rivers.

sensitivity – The minimum amount of an analyte that can be repeatedly detected by an instrument.

sievert – *See* **Sv**.

skyshine – Radiation emitted upward from an open-topped, shielded enclosure and reflected downward, resulting in the possibility that flora and fauna (including humans) outside the shielded enclosure can be exposed to radiation.

sludge – Semisolid residue from industrial or water treatment processes.

sole source aquifer – An area defined by **EPA** as being the primary source of drinking water for a particular region. Includes the surface area above the sole source aquifer and its recharge area.

SPDES (State Pollutant Discharge Elimination System) This permit program is delegated to the states, but the effluent limitations and other requirements are set by the federal government. 6 NYCRR Section 750-1.11(a) concerns the provisions of SPDES permits and lists the citations for the various effluent limitations from the Federal Register and the **CFR**.

stable – Nonradioactive.

stakeholder – People or organizations with vested interests in BNL and its environment and operations. Stakeholders include federal, state, and local regulators; the public; DOE; and BNL staff.

stripping – A process used to remove volatile contaminants from a substance (*see also* **air stripping**).

sump – A pit or tank that catches liquid **runoff** for drainage or disposal.

Sv (sievert) – A unit for assessing the risk of human radiation dose, used internationally and with increasing frequency in the United States. One sievert is equal to 100 rem.

SVE (soil vapor extraction) – An *in situ* (in-place) method of extracting **VOCs** from soil by applying a vacuum to the soil and collecting the air, which can be further treated to remove the VOCs, or discharged to the atmosphere.

SVOC – A general term for volatile organic compounds that vaporize relatively slowly at standard temperature and pressure. See also VOC.

synoptic – Relating to or displaying conditions as they occur over a broad area.

T

$t_{1/2}$ (half-life) – The time required for one-half of the atoms of any given amount of a radioactive substance to disintegrate; the time required for the activity of a radioactive sample to be reduced by one half.

TCE (trichloroethylene, also known as **trichloroethene)** A stable, colorless liquid with a low boiling point. TCE has many industrial applications, including use as a solvent and as a metal degreasing agent. TCE may be toxic when inhaled or ingested, or through skin contact, and can damage vital organs, especially the liver. S*ee also* **VOC**.

Tier III reports – Reports, required by **SARA**, that are prepared to document annual emissions of toxic materials to the environment. These are also known as TRI Section 313 reports.

TLD (thermoluminescent dosimeter) – A device used to measure radiation dose to occupational workers or radiation levels in the environment.

tritium – The heaviest and only radioactive nuclide of hydrogen, with a **half-life** of 12.3 years and a very-low-energy radioactive decay (tritium is a **beta** emitter).

TSCA (Toxic Substances Control Act) – Enacted by Congress in1976, TSCA empowers **EPA** to track the 75,000 industrial chemicals produced or imported into the United States. EPA repeatedly screens these chemicals and can require reporting or testing of any that may pose an environmental or human health hazard. EPA can ban the manufacture or import of chemicals that pose an unreasonable risk.

TVOC (total volatile organic compounds) – A sum of all individual **VOC** concentrations detected in a given sample.

U

UIC (underground injection control) – A hole with vertical dimensions greater than its largest horizontal dimensions; used for disposal of wastewater.

UST (underground storage tank) – A stationary device, constructed primarily of nonearthen material, designed to contain petroleum products or hazardous materials. In a UST, 10 percent or more of the volume of the tank system is below the surface of the ground.

upgradient/upslope – A location of higher **groundwater** elevation; analogous to "upstream."

V

vadose – Relating to water in the ground that is above the permanent groundwater level.

vernal pool – A small, isolated, and contained basin that holds water on a temporary basis, most commonly during winter and spring. It has no aboveground outlet for water and is extremely important to the life cycle of many am-

phibians (such as the tiger salamander), as it is too shallow to support fish, a major predator of amphibian larvae.

VOC (volatile organic compound) –A general term for organic compounds capable of a high degree of vaporization at standard temperature and pressure. Because VOCs readily evaporate into the air, the potential for human exposure is greatly increased. Due to widespread industrial use, VOCs are commonly found in soil and groundwater.

VUV – Stands for "very ultraviolet" and refers to a beamline at the NSLS with wavelengths at the far ultraviolet end of the spectrum.

W

waste minimization – Action that avoids or reduces the generation of waste, consistent with the general goal of minimizing current and future threats to human health, safety, and the environment. Waste minimization activities include recycling, improving energy usage, reducing waste at the source, and reducing the toxicity of hazardous waste. This action is associated with pollution prevention, but is more likely to occur after waste has been generated.

water table – The water-level surface below the ground where the unsaturated zone ends and the saturated zone begins. It is the level to which a well that is screened in the unconfined aquifer will fill with water.

watershed – The region draining into a river, a river system, or a body of water.

weighting factor – A factor which, when multiplied by the dose equivalent delivered to a body organ or tissue, yields the equivalent risk due to a uniform radiation exposure of the whole body. *See also* **EDE**.

wet weight – The wet weight concentration of a substance is before a sample is dried for analysis (in other words, in its "natural" state), and is the form most likely to be consumed. Wet weight concentrations are typically lower than dry weight values.

wind rose – A diagram that shows the frequency of wind from different directions at a specific location.

X

x-rays – A form of electromagnetic **radiation** with short wavelength, generated when high-energy electrons strike matter or when lower-energy **beta** radiation is absorbed in matter. **Gamma** radiation and x-rays are identical, except for the source.

Z

zeolite – A naturally occurring group of more than 100 minerals, formed of silicates and aluminum, with unique and diverse crystal properties. Zeolites can perform ion exchange, filtering, odor removal, and chemical sieve and gas absorption tasks. Synthetic zeolites are now used for most applications.

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Understanding Radiation

This section introduces the general reader to some basic concepts of radioactivity and an understanding of the radiation emitted as radioactive materials decay to a stable state. To better comprehend the radiological information in the Site Environmental Report (SER), it is important to remember that not all radiations are the same and that different kinds of radiation affect living beings differently.

This appendix includes discussions on the common sources of radioactivity in the environment, types of radiation, the analyses used to quantify radioactive material, and how radiation sources contribute to radiation dose. Some general statistical concepts are also presented, along with a discussion of radionuclides that are of environmental interest at BNL. The discussion begins with some definitions and background information on scientific notation and numerical prefixes used when measuring dose and radioactivity. The definitions of commonly used radiological terms are found in the Technical Topics section of the glossary, Appendix A, and are indicated in boldface type here only when the definition in the glossary provides additional details.

RADIOACTIVITY AND RADIATION

All substances are composed of atoms that are made of subatomic particles: protons, neutrons, and electrons. The protons and neutrons are tightly bound together in the positively charged nucleus (plural: nuclei) at the center of the atom. The nucleus is surrounded by a cloud of negatively charged electrons. Most nuclei are stable because the forces holding the protons and neutrons together are strong enough to overcome the electrical energy that tries to push them apart. When the number of neutrons in the nucleus exceeds a threshold, then the nucleus becomes unstable and will spontaneously "decay," or emit excess energy ("nuclear" energy) in the form of charged particles or electromagnetic waves. Radiation is the excess energy released by unstable atoms. Radioactivity and radioactive refer to the unstable nuclear property of a substance (e.g., radioactive uranium). When a charged particle or electromagnetic wave is detected by radiation-sensing equipment, this is referred to as a radiation event.

Radiation that has enough energy to remove electrons from atoms within material (a process called ionization) is classified as ionizing radiation. Radiation that does not have enough energy to remove electrons is called nonionizing radiation. Examples of nonionizing radiation include most visible light, infrared light, microwaves, and radio waves. All radiation, whether ionizing or not, may pose health risks. In the SER, radiation refers to ionizing radiation.

Radioactive elements (or radionuclides) are referred to by name followed by a number, such as cesium-137. The number indicates the mass of that element and the total number of neutrons and protons contained in the nucleus of the atom. Another way to specify cesium-137 is Cs-137, where Cs is the chemical symbol for cesium in the Periodic Table of the Elements. This type of abbreviation is used throughout the SER.

SCIENTIFIC NOTATION

Most numbers used for measurement and quantification in the SER are either very large or very small, and many zeroes would be required to express their value. To avoid this, scientific notation is used, with numbers represented in multiples of 10. For example, the number two million five hundred thousand (two and a half million, or 2,500,000) is written in scientific notation as 2.5×10^6, which represents "2.5 multiplied by 10 raised to the power of 6." Since even "2.5×10^6" can be cumbersome, the capital letter E is substituted for the phrase "10 raised to the power of …" Using this format, 2,500,000 is represented as 2.5E+06. The "+06" refers to the number of places the decimal point was moved to the left to create the shorter version. Scientific notation is also used to represent numbers smaller than zero, in which case a

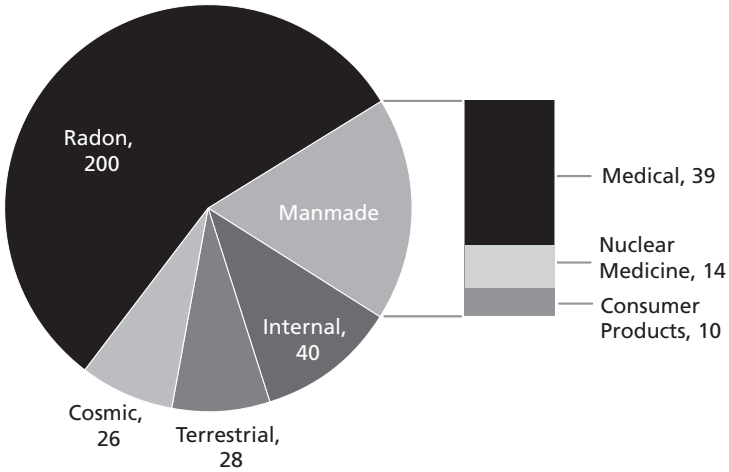

Figure B-1. Typical Annual Radiation Doses from Natural and Man-Made Sources (mrem). *Source: NCRP Report No. 93 (NCRP 1987)*

minus sign follows the E rather than a plus. For example, 0.00025 can be written as 2.5×10^{-4} or 2.5E-04. Here, "-04" indicates the number of places the decimal point was moved to the right.

NUMERICAL PREFIXES

Another method of representing very large or small numbers without using many zeroes is to use prefixes to represent multiples of ten. For example, the prefix *milli* (abbreviated m) means that the value being represented is one-thousandth of a whole unit; 3 mg (milligrams) is 3 thousandths of a gram or E-03. See Appendix C for additional common prefixes, including *pico* (p), which means trillionth or E-12, *giga* (G), which means billion or E+09, and *tera* (T), which means trillion, E+12.

SOURCES OF IONIZING RADIATION

Radiation is energy that has both natural and manmade sources. Some radiation is essential to life, such as heat and light from the sun. Exposure to high-energy (ionizing) radiation has to be managed, as it can pose serious health risks at large doses. Living things are exposed to radiation from natural background sources: the atmosphere, soil, water, food, and even our own bodies. Humans are exposed to ionizing radiation from a variety of common sources, the most significant of which follow.

Background Radiation – Radiation that occurs naturally in the environment is also called background activity. Background radiation consists of cosmic radiation from outer space, radiation from radioactive elements in soil and rocks, and radiation from radon and its decay products in air. Some people use the term background when referring to all non-occupational sources commonly present. Other people use natural to refer only to cosmic and terrestrial sources, and background to refer to common man-made sources such as medical procedures, consumer products, and radioactivity present in the atmosphere from former nuclear testing. In the SER, the term natural background is used to refer to radiation from cosmic and terrestrial radiation.

Cosmic – Cosmic radiation primarily consists of charged particles that originate in space, beyond the earth's atmosphere. This includes ionizing radiation from the sun, and secondary radiation generated by the entry of charged particles into the earth's atmosphere at high speeds and energies. Radioactive elements such as hydrogen-3 (tritium), beryllium-7, carbon-14, and sodium-22 are produced in the atmosphere by cosmic radiation. Exposure to cosmic radiation increases with altitude, because at higher elevations the atmosphere and the earth's magnetic field provide less shielding. Therefore, people who live in the mountains are exposed to more cosmic radiation than people who live at sea level. The average dose from cosmic radiation to a person living in the United States is approximately 26 mrem per year. (For an explanation of dose, see *effective dose equivalent* in Appendix A. The units *rem* and *sieverts* also are explained in Appendix A.)

Terrestrial – Terrestrial radiation is released by radioactive elements that have been present in the soil since the formation of the earth. Common radioactive elements that contribute to terrestrial exposure include isotopes of potassium, thorium, actinium, and uranium. The average dose from terrestrial radiation to a person living in the United States is approximately 28 mrem per year, but may vary considerably depending on the local geology.

Internal – Internal exposure occurs when radionuclides are ingested, inhaled, or absorbed through the skin. Radioactive material may be incorporated into food through the uptake of terrestrial radionuclides by plant roots. People can

ingest radionuclides when they eat contaminated plant matter or meat from animals that have consumed contaminated plants. The average dose from food for a person living in the United States is about 40 mrem per year. A larger exposure, for most people, comes from breathing the decay products of naturally occurring radon gas. The average dose from breathing air with radon byproducts is about 200 mrem per year, but that amount varies depending on geographical location. An Environmental Protection Agency (EPA) map shows that BNL is located in one of the regions with the lowest potential radon risk.

Medical – Every year in the United States, millions of people undergo medical procedures that use ionizing radiation. Such procedures include chest and dental x-rays, mammography, thallium heart stress tests, and tumor irradiation therapies. The average doses from nuclear medicine and x-ray examination procedures are about 14 and 39 mrem per year, respectively.

Anthropogenic – Sources of anthropogenic (man-made) radiation include consumer products such as static eliminators (containing polonium-210), smoke detectors (containing americium-241), cardiac pacemakers (containing plutonium-238), fertilizers (containing isotopes from uranium and thorium decay series), and tobacco products (containing polonium-210 and lead-210). The average dose from consumer products to a person living in the United States is 10 mrem per year (excluding tobacco contributions).

COMMON TYPES OF IONIZING RADIATION

The three most common types of ionizing radiation are described below.

Alpha Radiation – An alpha particle is identical in makeup to the nucleus of a helium atom, consisting of two neutrons and two protons. Alpha particles have a positive charge and have little or no penetrating power in matter. They are easily stopped by materials such as paper and have a range in air of only an inch or so. However, if alpha-emitting material is ingested, alpha particles can pose a health risk inside the body. Naturally occurring radioactive elements such as uranium emit alpha radiation.

Beta Radiation – Beta radiation is composed of particles that are identical to electrons. Therefore, beta particles have a negative charge. Beta radiation is slightly more penetrating than alpha radiation, but most beta radiation can be stopped by materials such as aluminum foil and plexiglass panels. Beta radiation has a range in air of several feet. Naturally occurring radioactive elements such as potassium-40 emit beta radiation. Some beta particles present a hazard to the skin and eyes.

Gamma Radiation – Gamma radiation is a form of electromagnetic radiation, like radio waves or visible light, but with a much shorter wavelength. Gamma rays are emitted from a radioactive nucleus along with alpha or beta particles. Gamma radiation is more penetrating than alpha or beta radiation, capable of passing through dense materials such as concrete. Gamma radiation is identical to x-rays except that x-rays are more energetic. Only a fraction of the total gamma rays a person is exposed to will interact with the human body.

TYPES OF RADIOLOGICAL ANALYSES

The amount of radioactive material in a sample of air, water, soil, or other material can be assessed using several analyses, the most common of which are described below.

Gross alpha – Alpha particles are emitted from radioactive material in a range of different energies. An analysis that measures all alpha particles simultaneously, without regard to their particular energy, is known as a gross alpha activity measurement. This type of measurement is valuable as a screening tool to indicate the total amount but not the type of alpha-emitting radionuclides that may be present in a sample.

Gross beta – This is the same concept as that for gross alpha analysis, except that it applies to the measurement of gross beta particle activity.

Tritium – Tritium radiation consists of low-energy beta particles. It is detected and quantified by liquid scintillation counting. More information on tritium is presented in the section Radionuclides of Environmental Interest, later in this appendix.

Strontium-90 – Due to the properties of the radiation emitted by strontium-90 (Sr-90), a special analysis is required. Samples are chemically processed to separate and collect any

strontium atoms that may be present. The collected atoms are then analyzed separately. More information on Sr-90 is presented in the section Radionuclides of Environmental Interest.

Gamma – This analysis technique identifies specific radionuclides. It measures the particular energy of a radionuclide's gamma radiation emission. The energy of these emissions is unique for each radionuclide, acting as a "fingerprint" to identify it.

STATISTICS

Two important statistical aspects of measuring radioactivity are uncertainty in results, and negative values.

Uncertainty – Because the emission of radiation from an atom is a random process, a sample counted several times usually yields a slightly different result each time; therefore, a single measurement is not definitive. To account for this variability, the concept of uncertainty is applied to radiological data. In the SER, analysis results are presented in an x ± y format, where "x" is the analysis result and "± y" is the 95 percent "confidence interval" of that result. That means there is a 95 percent probability that the true value of x lies between (x + y) and (x – y).

Negative values – There is always a small amount of natural background radiation. The laboratory instruments used to measure radioactivity in samples are sensitive enough to measure the background radiation along with any contaminant radiation in the sample. To obtain a true measure of the contaminant level in a sample, the background radiation level must be subtracted from the total amount of radioactivity measured. Due to the randomness of radioactive emissions and the very low concentrations of some contaminants, it is possible to obtain a background measurement that is larger than the actual contaminant measurement. When the larger background measurement is subtracted from the smaller contaminant measurement, a negative result is generated. The negative results are reported, even though doing so may seem illogical, but they are essential when conducting statistical evaluations of data.

Radiation events occur randomly; if a radioactive sample is counted multiple times, a spread, or distribution, of results will be obtained. This spread, known as a Poisson distribution, is centered about a mean (average) value. Similarly, if background activity (the number of radiation events observed when no sample is present) is counted multiple times, it also will have a Poisson distribution. The goal of a radiological analysis is to determine whether a sample contains activity greater than the background reading detected by the instrument. Because the sample activity and the background activity readings are both Poisson distributed, subtraction of background activity from the measured sample activity may result in values that vary slightly from one analysis to the next. Therefore, the concept of a minimum detection limit (MDL) was established to determine the statistical likelihood that a sample's activity is greater than the background reading recorded by the instrument.

Identifying a sample as containing activity greater than background, when it actually does not have activity present, is known as a Type I error. Most laboratories set their acceptance of a Type I error at 5 percent when calculating the MDL for a given analysis. That is, for any value that is greater than or equal to the MDL, there is 95 percent confidence that it represents the detection of true activity. Values that are less than the MDL may be valid, but they have a reduced confidence associated with them. Therefore, all radiological data are reported, regardless of whether they are positive or negative

At very low sample activity levels that are close to the instrument's background reading, it is possible to obtain a sample result that is less than zero. This occurs when the background activity is subtracted from the sample activity to obtain a net value, and a negative value results. Due to this situation, a single radiation event observed during a counting period could have a significant effect on the mean (average) value result. Subsequent analysis may produce a sample result that is positive. When the annual data for the SER are compiled, results may be averaged; therefore, all negative values are retained for reporting as well. This data handling practice is consistent with the guidance provided in the Handbook of

Radioactivity Measurements Procedures (NCRP 1985) and the Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance (DOE 1991). Average values are calculated using actual analytical results, regardless of whether they are above or below the MDL, or even equal to zero. The uncertainty of the mean, or the 95 percent confidence interval, is determined by multiplying the population standard deviation of the mean by the $t_{(0.05)}$ statistic.

RADIONUCLIDES OF ENVIRONMENTAL INTEREST

Several types of radionuclides are found in the environment at BNL due to historical operations.

Cesium-137 – Cs-137 is a fission-produced radionuclide with a half-life of 30 years (after 30 years, only one half of the original activity level remains). It is found in the worldwide environment as a result of past aboveground nuclear weapons testing and can be observed in near-surface soils at very low concentrations, usually less than 1 pCi/g (0.004 Bq/g). Cs-137 is a beta-emitting radionuclide, but it can be detected by gamma spectroscopy because its decay product, barium-137m, emits gamma radiation.

Cs-137 is found in the environment at BNL mainly as a soil contaminant, from two main sources. The first source is the worldwide deposition from nuclear accidents and fallout from weapons testing programs. The second source is deposition from spills or releases from BNL operations. Nuclear reactor operations produce Cs-137 as a byproduct. In the past, wastewater containing small amounts of Cs-137 generated at the reactor facilities was routinely discharged to the Sewage Treatment Plant (STP), resulting in low-level contamination of the STP and the Peconic River. In 2002/2003, under the Environmental Restoration Program, sand and its debris containing low levels of Cs-137, Sr-90, and heavy metals were removed, assuring that future discharges from the STP are free of these contaminants. Soil contaminated with Cs-137 is associated with the following areas that have been, or are being, addressed as part of the Environmental Remediation Program: former Hazardous Waste Management Facility, Waste Concentration Facility, Building 650 Reclamation Facility and Sump Outfall Area, and the Brookhaven Graphite Research Reactor (BGRR).

Strontium-90 – Sr-90 is a beta-emitting radionuclide with a half-life of 28 years. Sr-90 is found in the environment principally as a result of fallout from aboveground nuclear weapons testing. Sr-90 released by weapons testing in the 1950s and early 1960s is still present in the environment today. Additionally, nations that were not signatories of the Nuclear Test Ban Treaty of 1963 have contributed to the global inventory of fission products (Sr-90 and Cs-137). This radionuclide was also released as a result of the 1986 Chernobyl accident in the former Soviet Union.

Sr-90 is present at BNL in the soil and groundwater. As in the case of Cs-137, some Sr-90 at BNL results from worldwide nuclear testing; the remaining contamination is a byproduct of reactor operations. The following areas with Sr-90 contamination have been or are being addressed as part of the Environmental Remediation Program: former Hazardous Waste Management Facility, Waste Concentration Facility, Building 650 Reclamation Facility and Sump Outfall Area, the BGRR, Former and Interim Landfills, Chemical and Glass Holes Area, and the STP.

The information in SER tables is arranged by method of analysis. Because Sr-90 requires a unique method of analysis, it is reported as a separate entry. Methods for detecting Sr-90 using state-of-the-art equipment are quite sensitive (detecting concentrations less than 1 pCi/L), which makes it possible to detect background levels of Sr-90.

Tritium – Among the radioactive materials that are used or produced at BNL, tritium has received the most public attention. Approximately 4 million Ci (1.5E+5 TBq) per year are produced in the atmosphere naturally (NCRP 1979). As a result of aboveground weapons testing in the 1950s and early 1960s in the United States, the global atmospheric tritium inventory was increased by a factor of approximately 200. Other human activities such as consumer product manufacturing and nuclear power reactor operations have also released tritium into the

environment. Commercially, tritium is used in products such as self-illuminating wristwatches and exit signs (the signs may each contain as much as 25 Ci [925 GBq] of tritium). Tritium also has many uses in medical and biological research as a labeling agent in chemical compounds, and is frequently used in universities and other research settings such as BNL and other national laboratories.

Of the sources mentioned above, the most significant contributor to tritium in the environment has been aboveground nuclear weapons testing. In the early 1960s, the average tritium concentration in surface streams in the United States reached a value of 4,000 pCi/L (148 Bq/L; NCRP 1979). Approximately the same concentration was measured in precipitation. Today, the level of tritium in surface waters in New York State is less than one-twentieth of that amount, below 200 pCi/L (7.4 Bq/L; NYSDOH 1993). This is less than the detection limit of most analytical laboratories.

Tritium has a half-life of 12.3 years. When an atom of tritium decays, it releases a beta particle, causing transformation of the tritium atom into stable (nonradioactive) helium. The beta radiation that tritium releases has a very low energy, compared to the emissions of most other radioactive elements. In humans, the outer layer of dead skin cells easily stops the beta radiation from tritium; therefore, only when tritium is taken into the body can it cause an exposure. Tritium may be taken into the body by inhalation, ingestion, or absorption of tritiated water through the skin. Because of its low energy radiation and short residence time in the body, the health threat posed by tritium is very small for most exposures.

Environmental tritium is found in two forms: gaseous elemental tritium, and tritiated water or water vapor, in which at least one of the hydrogen atoms in the H_2O water molecule has been replaced by a tritium atom (hence, its shorthand notation, HTO). Most of the tritium released from BNL sources is in the form of HTO, none as elemental tritium. Sources of tritium at BNL include the reactor facilities (all now non-operational), where residual water (either heavy or light) is converted to tritium via neutron bombardment; the accelerator facilities, where tritium is produced by secondary radiation interactions with soil and water; and facilities like the Brookhaven Linac Isotope Producer, where tritium is formed from secondary radiation interaction with cooling water. Tritium has been found in the environment at BNL as a groundwater contaminant from operations in the following areas: Current Landfill, BLIP, Alternating Gradient Synchrotron, and the High Flux Beam Reactor. Although small quantities of tritium are still being released to the environment through BNL emissions and effluents, the concentrations and total quantity have been drastically reduced, compared with historical operational releases as discussed in Chapters 4 and 5.

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Units of Measure and Half-Life Periods

UNITS OF RADIATION MEASUREMENT AND CONVERSIONS

U.S. System	International System	Conversion
curie (Ci)	becquerel (Bq)	1 Ci = 3.7×10^{10} Bq
rad	gray (Gy)	1 rad = 0.01 Gy
rem	sievert (Sv)	1 rem = 0.01 Sv

APPROXIMATE METRIC CONVERSIONS

When you know	multiply by	to obtain	When you know	multiply by	to obtain
centimeters (cm)	0.39	inches (in.)	in.	2.54	cm
meters (m)	3.28	feet (ft)	ft	0.305	m
kilometers (km)	0.62	miles (mi)	mi	1.61	km
kilograms (kg)	2.20	pounds (lb)	lb	0.45	kg
liters (L)	0.264	gallons (gal)	gal	3.785	L
cubic meters (m^3)	35.32	cubic feet (ft^3)	ft^3	0.03	m^3
hectares (ha)	2.47	acres	acres	0.40	ha
square kilometers (km^2)	0.39	square miles (mi^2)	mi^2	2.59	km^2
degrees Celcius (°C)	1.8 (°C) + 32	degrees Fahrenheit (°F)	°F	(°F - 32) / 1.8	°C

SCIENTIFIC NOTATION USED FOR MEASUREMENTS

Multiple	Decimal Equivalent	Notation	Prefix	Symbol
1×10^{12}	1,000,000,000,000	E+12	Tera-	T
1×10^{9}	1,000,000,000	E+9	giga-	G
1×10^{3}	1,000	E+03	kilo-	k
1×10^{-2}	0.01	E-02	centi-	c
1×10^{-3}	0.001	E-03	milli-	m
1×10^{-6}	0.000001	E-06	micro-	µ
1×10^{-9}	0.000000001	E-09	nano-	n
1×10^{-12}	0.000000000001	E-12	pico-	p

CONCENTRATION CONVERSIONS

1 ppm	=	1,000 ppb		
1 ppb	=	0.001 ppm	=	1µg/L*
1 ppm	=	1 mg/L	=	1000 µg/L*

* For aqueous fractions only.

HALF-LIFE PERIODS	
Am-241	432.7 yrs
C-11	~20 min
Co-60	5.3 yrs
Cs-137	30.2 yrs
N-13	~10 min
N-22	2.6 yrs
O-15	~2 min
PU-238	87.7 yrs
Pu-239	24,100.0 yrs
Pu-240	6,560.0 yrs
Sr-90	29.1 yrs
tritium	12.3 yrs
U-234	247,000.0 yrs
U-235	~700 million yrs (7.0004E8)
U-238	87.7 yrs

APPENDIX D

Federal, State, and Local Laws and Regulations Pertinent to BNL

DOE DIRECTIVES, REGULATIONS, AND STANDARDS

DOE O 231.1-A	Order: Environment, Safety and Health Reporting 08/19/03
DOE O 414.1	Order: Management Assessment and Independent Assessor's Guide 05/31/2001
DOE O 430.2B	Departmental Energy, Utilities, and Transportation Management 02/27/2008
DOE O 435.1	Order, Change 1: Radioactive Waste Management 08/28/2001
DOE O 450.1A	Order: Environmental Protection Program 06/04/2008
DOE P 450.5	Policy: Line Environment, Safety, and Health Oversight 06/26/1997
DOE O 5400.5	Order: Change 2, Radiological Protection of the Public and the Environment 01/07/1993

FEDERAL LAWS AND REGULATIONS

EO 13148	Greening of the Government Through Leadership in Environmental Management
EO 13514	Federal leadership in Environmental, Energy, and Economic Performance
10 CFR 1021	National Environmental Protection Act, Implementing and Procedures
10 CFR 1022	Compliance with Floodplain/Wetlands Environmental Review Requirements
10 CFR 830	Subpart A: Quality Assurance Requirements
10 CFR 834	Radiation Protection of the Public and the Environment
16 USC 470	National Historic Preservation Act
36 CFR 60	National Register of Historic Places
36 CFR 63	Determination of Eligibility for Inclusion in the National Register of Historic Places
36 CFR 79	Curation of Federally Owned and Administered Archaeological Collections
36 CFR 800	Protection of Historic Properties
40 CFR 50-0	National Primary and Secondary Ambient Air Quality Standards
40 CFR 82	Protection of Stratospheric Ozone
40 CFR 109	Criteria for State, Local and Regional Oil Removal Contingency Plans
40 CFR 110	Discharge of Oil
40 CFR 112	Oil Pollution Prevention Act
40 CFR 113	Liability Limits for Small Onshore Storage Facilities
40 CFR 116	Designation of Hazardous Substances
40 CFR 117	Determination of Reportable Quantities for Hazardous Substances

40 CFR 121	State Certification of Activities Requiring a Federal License or Permit
40 CFR 122	National Pollution Discharge Elimination System (NPDES)
40 CFR 123	State Program Requirements
40 CFR 124	Procedures for Decision-making
40 CFR 125	Criteria and Standards for the National Pollutant Discharge Elimination System
40 CFR 129	Toxic Pollutant Effluent Standards
40 CFR 130	Water Quality Planning and Management
40 CFR 131	Water Quality Standards
40 CFR 132	Water Quality Guidance for the Great Lakes System
40 CFR 133	Secondary Treatment Regulation
40 CFR 135	Prior Notice of Citizen Suits
40 CFR 136	Guidelines Establishing Test Procedures for the Analysis of Pollutants
40 CFR 141	National Primary Drinking Water Regulations
40 CFR 142	National Primary Drinking Water Regulations Implementation
40 CFR 143	National Secondary Drinking Water Regulations
40 CFR 144	Underground Injection Control (UIC) Program
40 CFR 146	Underground Injection Control (UIC) Program: Criteria and Standards
40 CFR 148	Hazardous Waste Injection Restrictions
40 CFR 149	Sole Source Aquifers
40 CFR 167	Submissions of Pesticide Reports
40 CFR 168	Statements of Enforcement Policies and Interpretations
40 CFR 169	Books and Records of Pesticide Production and Distribution
40 CFR 170	Worker Protection Standard
40 CFR 171	Certification of Pesticide Applicators
40 CFR 260	Hazardous Waste Management Systems: General
40 CFR 261	Identification and Listing of Hazardous Waste
40 CFR 262	Standards Applicable to Generators of Hazardous Waste
40 CFR 263	Standards Applicable to Transporters of Hazardous Waste
40 CFR 264	Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities
40 CFR 265	Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities
40 CFR 266	Standards for the Management of Special Hazardous Wastes and Specific Types of Hazardous Waste Management Facilities

40 CFR 268	Land Disposal Restrictions
40 CFR 270	EPA Administered Permit Program: The Hazardous Waste Permit Program
40 CFR 271	Requirements for Authorization of State Hazardous Waste Mgmt Programs
40 CFR 272	Approved State Hazardous Waste Management Programs
40 CFR 273	Standards for Universal Waste Management
40 CFR 279	Standards for the Management of Used Oil
40 CFR 280	Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks (USTs)
40 CFR 300	National Oil and Hazardous Substances Pollution Contingency Plan
40 CFR 302	Designation, Reportable Quantities, and Notification
40 CFR 355	Emergency Planning and Notification
40 CFR 370	Hazardous Chemical Report: Community Right-to-Know
40 CFR 372	Toxic Chemical Release Report: Community Right-to-Know
40 CFR 700	Toxic Substances Control Act [TSCA]
40 CFR 702	Toxic Substances Control Act: General Practices and Procedures
40 CFR 704	Toxic Substances Control Act: Reporting and Recordkeeping Requirements
40 CFR 707	Chemical Imports and Exports
40 CFR 710	Inventory Reporting Regulations
40 CFR 712	Chemical Information Rules
40 CFR 716	Health and Safety Data Reporting
40 CFR 717	Records and Reports of Allegations that Chemical Substances Cause Significant Adverse Reactions to Health or the Environment
40 CFR 720	Premanufacture Notification
40 CFR 721	Significant New Users of Chemical Substances
40 CFR 723	Premanufacture Notification Exemptions
40 CFR 725	Reporting Requirements and Review Processes for Microorganisms
40 CFR 745	Lead-Based Paint Poisoning Prevention in Certain Residential Structures
40 CFR 747	Metalworking Fluids
40 CFR 749	Water Treatment Chemicals
40 CFR 750	Procedures for Rulemaking Under Section 6 of TSCA
40 CFR 761	PCBs Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions
40 CFR 763	Asbestos
40 CFR 1500	Council on Environmental Quality: Purpose, Policy, and Mandate

40 CFR 1501	NEPA and Agency Planning
40 CFR 1502	Environmental Impact Statement
40 CFR 1503	Commenting
40 CFR 1504	Predecision Referrals to the Council of Proposed Federal Actions
40 CFR 1505	NEPA and Agency Decision-making
40 CFR 1506	Other Requirements of NEPA
40 CFR 1507	Agency Compliance
40 CFR 1508	Terminology and Index
50 CFR 17	Endangered and Threatened Wildlife and Plants

NEW YORK STATE LAWS, REGULATIONS, AND STANDARDS

6 NYCRR 182	Endangered and Threatened Species of Fish and Wildlife, Species of Special Concern
6 NYCRR 200	Environmental Conservation Law
6 NYCRR 201	Subpart 201-1: General Provisions
6 NYCRR 202	Subpart 202: Emissions Verification
6 NYCRR 203	Indirect Sources of Air Contamination
6 NYCRR 204	NO_x Budget Training Program
6 NYCRR 205	Architectural and Maintenance (AIM) Coatings
6 NYCRR 207	Control Measures for an Air Pollution Episide
6 NYCRR 208	Landfill Gas Collection and Control System for Certain Municipal Solid Waste Landfills
6 NYCRR 211	General Prohibitions
6 NYCRR 212	General Process Emission Sources
6 NYCRR 215	Open Fires
6 NYCRR 217	Environmental Conservation Rules and Regulations [Exhaust and Emission Standards]
6 NYCRR 218	Subpart 218-1 [More on Vehicle Exhaust]
6 NYCRR 221	Asbestos-Containing Surface Coating Material
6 NYCRR 225	Subpart 225-1: Fuel Composition and Use – Sulfur Limitations
6 NYCRR 227	Solvent Metal Cleaning Processes
6 NYCRR 228	Surface Coating Processes
6 NYCRR 229	Petroleum and Volatile Organic Liquid Storage and Transfer
6 NYCRR 230	Gasoline Dispensing Sites and Transport Vehicles
6 NYCRR 231	New Source Review in Nonattainment Areas and Ozone Transport Regions
6 NYCRR 234	Graphic Arts

6 NYCRR 237	Acid Deposition Reduction NO_x Budget Training Program
6 NYCRR 238	Acid Deposition Reduction SO_2 Budget Training Program
6 NYCRR 239	Portable Fuel Container Spillage Control
6 NYCRR 240	Conformity to State or Federal Implementation Plans
6 NYCRR 250	Miscellaneous Orders
6 NYCRR 256	Air Quality Classification System
6 NYCRR 257	Air Quality Standards
6 NYCRR 307	[Air Quality in] Suffolk County
6 NYCRR 320	Pesticides - General
6 NYCRR 325	Application of Pesticides
6 NYCRR 326	Registration and Certification of Pesticides
6 NYCRR 327	Use of Chemicals for the Control or Elimination of Aquatic Vegetation
6 NYCRR 328	Use of Chemicals for the Extermination of Undesirable Fish
6 NYCRR 329	Use of Chemicals for the Control or Elimination of Aquatic Insects
6 NYCRR 360-1	General Provisions: Solid Waste Management Facilities
6 NYCRR 361	Siting of Industrial Hazardous Waste Facilities
6 NYCRR 364	Waste Transporter Permits
6 NYCRR 370	Hazardous Waste Management Regulations
6 NYCRR 371	Identification and Listing of Hazardous Waste
6 NYCRR 372	Hazardous Waste Manifest System and Related Standards for Generators, Transporters and Facilities
6 NYCRR 373	Hazardous Waste Management Facilities
6 NYCRR 374	Standards for the Management of Specific Hazardous Wastes
6 NYCRR 376	Land Disposal Restrictions
6 NYCRR 595	Release of Hazardous Substances
6 NYCRR 596	Hazardous Substance Bulk Storage Regulations
6 NYCRR 597	List of Hazardous Substances
6 NYCRR 611	Environmental Priorities and Procedures in Petroleum Cleanup and Removal
6 NYCRR 612	Registration of Petroleum Storage Facilities
6 NYCRR 613	Handling and Storage of Petroleum
6 NYCRR 663	Freshwater Wetlands Permit Requirements
6 NYCRR 666	Regulation for Administration and Management of the Wild, Scenic, and Recreational Rivers System in New York State Excepting Private Land in the Adirondack Park

6 NYCRR 700	Part 700 Water Quality Regulations
6 NYCRR 701	Classification – Surface Waters and Groundwaters
6 NYCRR 702	Derivation and Use of Standards and Guidance Values
6 NYCRR 703	Surface Water and Groundwater Quality Standards and Groundwater Effluent Limitations
6 NYCRR 750	Obtaining a SPDES Permit
10 NYCRR 5	State Sanitary Code – Part 5

SUFFOLK COUNTY RULES, REGULATIONS, AND STANDARDS

SCSC Art. 12	Toxic and Hazardous Material Storage, Handling and Control