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Volume I

2005 Site Environmental Report

BROOKHAVEN NATIONAL LABORATORY

2005 Site Environmental Report Team

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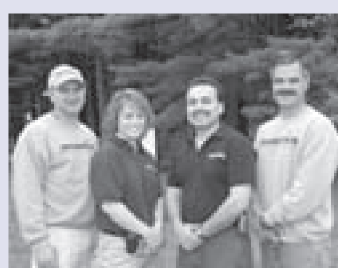

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A MESSAGE FROM THE LABORATORY DIRECTOR

Although I was just named Director of Brookhaven Lab in August 2006, I've worked here for 28 years in several scientific and management positions. During that time, I've witnessed first-hand how important it is for the Laboratory to not only conduct great science, but to back it up with excellence in our operations and openness in our relationships with the many, many communities we serve.

Our environmental performance is, in many ways, key to our success. I am well aware of the tremendous progress we have made in this area in recent years, and I am fully committed to the programs we have in place to help us maintain environmental excellence here at the Laboratory.

In 2005, Brookhaven Lab celebrated a major milestone marking the successful completion of several high-priority cleanup projects that were part of an interagency agreement reached in 1992. Working closely with the Department of Energy, regulatory agencies, our local government, and our neighbors, we've cleaned up billions of gallons of groundwater, removed hundreds of tons of contaminated soil from the site, and restored the Peconic River, a crucial Long Island resource.

Through the Laboratory's Environmental Management System and our Safety, Security, and Health Policy, our commitments to compliance, pollution prevention, cleanup, community outreach, and continual improvement remain strong. This report captures our performance for 2005, and I believe it documents our continued progress in each of these areas.

Samuel H. Aronson,
Laboratory Director

Executive Summary

Each year, 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 (DOE). The report is written to inform the public, regulators, employees, and other stakeholders of BNL's environmental performance during the calendar year in review. The SER summarizes environmental data; environmental management performance; compliance with applicable DOE, federal, state, and local regulations; and compliance, restoration, and surveillance monitoring program performance. BNL has prepared annual SERs since 1971 and has documented nearly all of its environmental history since the Laboratory's inception in 1947.

The report is available in print and as a downloadable file on the BNL web page at http://www.bnl.gov/ewms/ser/. A summary of the SER is also prepared each year to provide a general overview of the report, and is distributed with a CD of the full report.

BNL is operated and managed for DOE's Office of Science by Brookhaven Science Associates, a nonprofit limited-liability company formed as a 50–50 partnership between Battelle Memorial Institute and The Research Foundation of State University of New York (SUNY) on behalf of Stony Brook University. For more than 50 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 Environmental, Safety, Security and Health Policy reflect BNL's management philosophy to fully integrate environmental stewardship into all facets of its missions and operations.

BNL'S ENVIRONMENTAL MANAGEMENT SYSTEM

One of BNL's highest priorities is ensuring that the Laboratory's environmental performance measures up to its world-class status in science. In 2001, an Environmental Management System (EMS) was established at the Laboratory 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 BNL's EMS is the Laboratory's Environment, Safety, Security, and Health (ESSH) Policy. This policy makes clear BNL's commitments to environmental stewardship, the safety of its employees, and the security of the site. Specific environmental commitments in the policy include compliance, pollution prevention, cleanup, 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 and is 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 International Organization for Standardization (ISO) 14001 Environmental Management Standard. BNL was the first laboratory under the DOE Office of Science to become officially registered to this standard in 2001. Annual independent audits, which are required to maintain the registration, are conducted to validate that the EMS is being maintained and to identify evidence of continual improvement. In 2005, an EMS Surveillance Audit determined that BNL continues to conform to the Standard, which was upgraded in 2004. The Laboratory was also the first DOE facility to be certified to the 2004 Standard. During the 2005 EMS audit, seven examples of BNL's continual improvement were highlighted and three minor nonconformances and four opportunities for improvement were identified. A corrective action plan was prepared to track the minor nonconformances to closure.

A strong Pollution Prevention (P2) Program is an essential element for the successful implementation of BNL's EMS. The Laboratory's 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 BNL operating philosophy. Pollution prevention and waste reduction goals have been incorporated into the DOE contract with BSA, into BNL's ESSH Policy, and into critical outcomes associated with the Laboratory's operating contract with BSA. 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. Nineteen P2 proposals were submitted by employees to BNL's P2 Council for funding in 2005. Nine proposals were funded, in addition to four special projects, for a combined investment of approximately $101,000. The anticipated annual savings from these projects is estimated at $102,000, for an average payback period of 1.4 years. Initiatives to reduce, recycle, and reuse 2.8 million pounds of industrial, sanitary, hazardous, and radiological waste through the P2 Program saved over $1 million in 2005.

The completion of the Peconic River cleanup in 2005 resulted in the removal of approximately 6,000 tons of non-hazardous sediment. In addition, remedial activities conducted at the Former Hazardous Waste Management Facility, Waste Concentration Facility, and the Chemical/Glass Holes Projects resulted in the removal of the greatest amount of radiological waste in any single year.

BNL was accepted into the EPA's Performance Track Program in 2004. This program recognizes top environmental performance among participating U.S. facilities of all types and is considered the "gold standard" for facility-based environmental performance. The program requires that facilities commit to several improvement goals for a 3-year period and report on the progress of these goals annually. In 2005, the Laboratory made significant progress in: increasing BNL's land and habitat conservation, reducing radioactive air emissions, and reducing BNL's use of ozone-depleting substances and hazardous materials.

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 2005 follows.

Compliance Monitoring Program

BNL has an extensive program in place to ensure compliance with all applicable environmental regulatory and permit requirements. BNL must comply with more than 100 sets of federal, state, and local environmental regulations, numerous site-specific permits, equivalency permits for the operation of 12 groundwater remediation systems, and several other binding agreements. In 2005, BNL fully complied with the majority of these requirements; the Laboratory reported instances of noncompliance to the regulatory agencies and corrected them expeditiously.

Eleven external environmental audits were conducted by regulatory agencies in 2005, including inspections of petroleum and chemical storage, air emissions from the Central Steam Facility (CSF), Sewage Treatment Plant (STP) operations, other regulated outfalls and recharge basins, and the potable water system. No formal notices of violation or enforcement actions were issued, and BNL took immediate corrective actions to address the issues that were identified. Three conditions requiring corrective action were identified during an annual inspection of the Major Petroleum Facility (MPF) and three conditions were found during an inspection of the Chemical Bulk Storage Facilities; all six conditions were corrected in accordance with New York State Department of Environmental Conservation (NYSDEC) directives.

Compliance monitoring in 2005 showed that emissions of nitrogen oxides, carbon monoxide, and sulfur dioxide were all within permit limits. There were 107 periods of excess opacity emissions at the CSF exhaust stack during routine "soot blowing" operations in the first three quarters of 2005. BNL resequenced the soot blowing cycle and the excursions were eliminated in the fourth quarter.

Approximately 873 pounds of ozone-depleting refrigerants were recovered for recycling on site or offered for use by other DOE or federal facilities. In addition, 125 17-pound Halon 1211 extinguishers were removed from service and have been made available to other DOE facilities.

Monitoring of the potable water supply showed that all drinking water requirements were met. Groundwater monitoring at the MPF continued to demonstrate that current oil storage and transfer operations are not affecting groundwater quality. With the exception of eight minor permit excursions at the STP and two at recharge basins, liquid effluents discharged to surface water and groundwater met all applicable New York State Pollutant Discharge Elimination System (SPDES) permit requirements. The 10 SPDES excursions included two each for total nitrogen and ammonia, and one each for iron, zinc, methylene chloride, pH, copper, and oil and grease. These excursions were investigated by BNL staff, corrected where possible, and reported to NYSDEC and the Suffolk County Department of Health Services (SCDHS).

There were 14 reportable spills of antifreeze, fuel oil, or other small-volume chemical releases in 2005. All releases were cleaned up or addressed to the satisfaction of NYSDEC. The Laboratory has been very successful in reducing the number and severity of spills on site with the implementation of a spill awareness program. In 2005, the total incidence was reduced by 55 percent, compared with 2004.

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 2005, BNL facilities released a total of 3,266 curies of radioactive gases with short half-lives (less than 30 minutes). 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. Although not required, the Brookhaven Linac 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 99.4 percent of radiological air emissions on site in 2005. Facilities capable of delivering radiation doses require periodic, confirmatory monitoring. At BNL, this monitoring is conducted at one active facility, the Target Processing Laboratory (TPL), and one inactive facility, the High Flux Beam Reactor (HFBR). Releases from the TPL in 2005 continued to be very small (0.0771 µCi). Tritium releases from the HFBR in 2005 increased to 17.9 Ci, following the previous downward trend in 2004 to 3.94 Ci. An investigation determined that the probable source for the rise was the evaporation of residual heavy water through a breached vent line, which was immediately repaired. In 2004, BNL filed a petition with EPA to discontinue emissions monitoring at the Brookhaven Medical Research Reactor (BMRR) because sampling has consistently shown no detectable emissions of radionuclides. The petition was approved in 2005.

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 measured in 2005 demonstrated that on-site 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 emission monitoring to demonstrate compliance with emission limits. The CSF is the only BNL facility that requires this monitoring. Two of the four boilers at the CSF are equipped with continuous emission monitors to measure nitrogen oxides and opacity. In 2005, these monitors measured no exceedances of nitrogen oxide. The Laboratory reported all opacity exceedances to NYSDEC; all but one occurred during boiler startup or soot blowing operations—times when opacity exceedances are most likely. After the maintenance schedule was resequenced, there were no additional opacity exceedances.

Because natural gas prices were higher than residual fuel prices throughout 2005, BNL used residual fuel for most heating and cooling. As a result, annual facility emissions of particulate matter, nitrogen oxides, and sulfur dioxide were considerably higher than in years when natural gas was the primary fuel.

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 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 impact of discharges on the quality of the Peconic River, surface water monitoring is conducted at several locations upstream and downstream of the STP effluent. 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 2005, 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. Tritium releases to the Peconic River continued to decline and were the lowest ever recorded; this was a result of the decommissioning and decontaminating at the HFBR. There were no detections of cesium-137 (Cs-137) or other gamma-emitting nuclides in the effluent, and only one detection of strontium-90 (Sr-90) in the STP influent. The Sr-90 detected in a single sample of influent was at levels similar to upstream and other background locations. Very low concentrations of tritium were detected at the STP outfall, most of which were well below the New York State Drinking Water Standard (DWS). Tritium was detected above the minimum detection level (MDL) in samples collected from June through August, when discharges increase due to air conditioning condensate at the HFBR, which contain detectable levels of tritium. Additionally, residual moisture within the HFBR piping systems may have contributed to slightly higher summertime releases of tritium. These levels are expected to continue to decrease even further, provided no additional work is conducted that could expose tritium contained in reactor components.

On-site recharge basins are used for the discharge of "clean" wastewater streams, including once-through cooling water, stormwater runoff, and cooling tower blowdown, and are suitable for direct replenishment of the groundwater aquifer. Radiological analyses in 2005 showed that the low levels of alpha and beta activity detected in most of the basins were attributable to very low levels of naturally occurring radionuclides, such as potassium-40, and not to BNL operations. A very low level of tritium, detected in a single sample, was attributed to inaccuracies of the analytical method.

In 2005, nonradiological analyses of the recharge basins showed low concentrations of volatile organic compounds (VOCs), including disinfection byproducts generated by the use of chlorine used to control algae, acetone, and methylene chloride. In most instances, the detection of acetone and methylene chloride was due to cross-contamination of the samples at the contract analytical laboratory.

Along the Peconic River, several locations are monitored for radiological and nonradiological parameters to access overall water quality. Radiological data from Peconic River surface water sampling in 2005 showed that gross alpha and beta activity was detected at most locations; the highest detection was located downstream and off the Laboratory site. The average concentrations from off-site and control locations were indistinguishable from BNL on-site locations. Monitoring for Sr-90 showed low-level detections, which are consistent with historical levels. All tritium samples collected were below detectable levels except for one sample taken downstream of the STP discharge. All levels were well below the New York State DWS. No VOCs were detected above the MDL in river water samples in 2005.

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 BNL'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 the Laboratory. 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 BNL procedures or into specific program 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 Peconic River cleanup project, initiated in 2004 and completed in 2005, required dewatering both the on- and off-site portions of the river. Banded sunfish were captured from the Peconic River and relocated to a protected pond. In 2005, several hundred sunfish were returned to the Peconic River to ensure the species' continued presence there.

BNL also monitors and manages other wildlife populations, such as white-tailed deer and wild turkey, to ensure that they are sustained. In order to better understand the distribution of deer on site, a model of deer density was developed in 2005. This model enables resource managers to track changes in deer density over time. It is also used to detect interactions between components of the ecosystem, and to identify locations for management activities.

BNL conducts routine monitoring of flora and fauna to assess the impact, if any, of past and present activities on the Laboratory's natural resources. In 2005, deer and fish sampling results were consistent with previous years. Deer sampled on the BNL 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. Removal of areas of contaminated soil at BNL began in 2000, and all major areas were remediated by the end of 2005. The New York State Department of Health has reviewed the potential public health risk associated with the low levels of Cs-137 in on-site deer and determined that neither hunting restrictions or formal health advisories are warranted.

Because of the Peconic River cleanup project and drought conditions in 2005, on-site fish were not sampled. Off-site sampling of fish found low levels of Cs-137; all levels of Cs-137 appear to be declining, compared with historic values. Low levels of mercury and pesticides were also detected in off-site fish samples, but did not exceed any standards and do not present a health impact to consumers of such fish. With completion of the Peconic River cleanup project, all of these levels are expected to drop. On- and off-site aquatic vegetation and sediments contained low levels of Cs-137, metals, pesticides, and PCBs, in amounts that were consistent with levels detected in previous years.

In June and August 2005, “water column” sampling for mercury and methlymercury was performed in support of the post clean-up monitoring of the Peconic River. Samples taken in June were higher in either mercury or methylmercury, or both, compared to values taken at the same location prior to cleanup. This was most likely due to disturbed sediments that did not have sufficient time to settle and consolidate, and vegetation that had not had time to reestablish. Sediment disturbance may also have occurred during sampling. Long-term post remediation monitoring of the Peconic River cleanup will include annual water column and sediment sampling.

Precipitation samples were collected quarterly at two air monitoring stations and analyzed for radiological content. Samples collected at both stations in 2005 showed gross beta measurements above the MDL, although the values were within the range of those historically reported.

2005 marked the final year of the agreement between DOE and the U.S. Fish and Wildlife Service (FWS) for managing the Upton Ecological and Research Reserve, established on site in 2000. The management transition from FWS to BNL and the Foundation for Ecological Research in the Northeast (FERN) began with FERN setting up 50 permanent monitoring plots to assess the current health of the pine barrens. Educational programs, which were a significant part of the Upton Reserve research, also continued in 2005.

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. BNL’s Cultural Resource Management Plan (CRMP), submitted to DOE for approval in 2003, was finalized in 2005. The plan will guide the management of all of the Laboratory’s cultural resources. In 2005, the CRMP focused primarily on outreach activities, including a drive-by tour of historic Laboratory structures and a Summer Sunday devoted to BNL history.

Chapter 6 of this report describes BNL’s Natural and Cultural Resource Management Programs 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 entering and leaving the site. In 2005, the Laboratory collected groundwater samples from 864 on- and off-site monitoring wells during 2,567 individual sampling events. BNL has not detected any new impacts to groundwater quality since 2001.

Under the environmental surveillance program, 125 groundwater wells at 10 active research and support facilities were monitored during 285 individual sampling events. Although no new impacts to groundwater quality were discovered in 2005, groundwater quality continues to be impacted from past releases at four facilities. Low levels of tritium continue to be routinely detected at concentrations above the 20,000 pCi/L drinking water standard in wells immediately downgradient of the g-2/VQ-12 source area in the Alternating Gradient Synchrotron facility, and periodically above the standard in monitoring wells at the BLIP. Monitoring data suggest that the continued release of tritium from these areas is due to residual tritium being flushed out of the unsaturated zone close to the water table by natural water table fluctuations.

As in previous years, VOCs associated with historical petroleum and solvent spills were detected in several monitoring wells directly downgradient of the Motor Pool and Service Station areas. Monitoring of the leak detection systems at both vehicle maintenance facilities indicated that gasoline storage tanks and associated distribution lines were not leaking. Furthermore, BNL's ongoing evaluation of vehicle maintenance operations indicated that all waste oils and used solvents are being properly stored and recycled.

Under the Environmental Restoration Program, on- and off-site contaminant plumes are monitored to track the progress that the groundwater treatment systems are making toward plume remediation. In 2005, 739 groundwater wells were monitored during 2,282 individual sampling events. The peak tritium concentration during 2005, directly downgradient from the HFBR, was 243,000 pCi/L. This concentration was significantly less than the historical peak of 5,034,561 pCi/L, observed in 1999 in this area. Data indicated that the plume had shifted to the east of much of the western downgradient portion of the monitoring well network. The remnants of the high concentration area of the plume (addressed by low-flow pumping remediation in 1999–2000) is currently in the vicinity of the Chilled Water Plant Road. Additional characterization has been scheduled. Monitoring in the Building 96 area indicated that concentrations of VOCs continued to persist in the "silt zone" source area north of treatment well RTW-1. Potassium permanganate injections were implemented in an effort to treat the contamination, and the area will continue to be monitored. Declining carbon tetrachloride concentrations continued in 2005 in samples from wells that monitor the carbon tetrachloride plume and the associated remediation system, which is now in standby mode. Ethylene dibromide (EDB) data from off-site monitoring wells in 2005 indicated that the EDB plume had reached the remediation system extraction wells. VOC concentrations remained stable or declined slightly for the Operable Unit (OU) V VOC plume. Similarly, Sr-90 concentrations remained stable or declined in monitoring wells located at and downgradient from the former Building 650 sump outfall.

The Laboratory's groundwater cleanup goals include minimizing plume growth and reducing contaminant concentrations in the Upper Glacial aquifer to below NYS Maximum Contaminant Level (MCL) standards by 2030. In 2004, BNL prepared a report that identified changes to the Laboratory's OU III cleanup goal time frames for several projects. The report was submitted for public review in December 2004 and was approved by EPA in 2005. For the Sr-90 plumes associated with the Brookhaven Graphite Research Reactor/Waste Concentration Facility and Chemical Holes areas, MCLs must be reached within 70 years and 40 years, respectively. Cleanup of the Magothy aquifer VOC contamination must meet MCLs within 65 years.

The Laboratory continues to make significant progress in restoring groundwater quality on site, with 14 groundwater remediation systems in active operation. During 2005, 472 pounds of VOCs and 4.72 mCi of Sr-90 were removed from the groundwater, and more than 1.7 billion gallons of treated groundwater were returned to the aquifer. To date, approximately 5,280 of the estimated 25,000 to 30,000 pounds of VOCs in the aquifer have been removed.

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

Radiological Dose Assessment Program

BNL routinely assesses its operations to ensure that any potential radiological dose to members of the public, BNL workers, 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 2005 was found to be insignificantly above natural background radiation levels.

To measure direct radiation from Laboratory operations, thermoluminescent dosimeters (TLDs) are installed on site and in surrounding communities. In 2005, the average doses from 55 TLDs showed there was no additional contribution to dose from BNL operations above natural background radiation. The annual on-site external dose from all potential sources, including cosmic and terrestrial radiation, was 66 ± 12 mrem (670 ± 120 µSv), and the annual off-site external dose was 64 ± 9 mrem (640 ± 90 µSv).

The effective dose to the MEI from air emissions was 5.30E-2 mrem (0.53 µSv). The ingestion pathway dose was estimated as 0.32 mrem (3.2 µSv) from consumption of deer meat and 0.08 mrem (0.8 µSv) from consumption of fish caught on site. The total annual dose to the MEI from all pathways was estimated as 0.45 mrem (4.5 µSv). The BNL dose from the air inhalation pathway was less than 10 percent of EPA's annual regulatory dose limit of 10 mrem (100 µSv), and the total dose was less than 1 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 2005, several NESHAPs compliance reviews were performed. The 200-MeV laser electron stripping experiment conducted in the Radiation Effects Facility complied with regulations for emissions; tritium emissions during the pre-cooling of the Alternate Gradient Synchrotron snake magnet were insignificant and in compliance; and BLIP emissions met all compliance requirements and have been significantly reduced due to the installation of a sealed Lucite cover to enclose the cooling water surface and the target holder mechanisms.

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 2005, the Laboratory used five off-site contract analytical laboratories to analyze environmental samples: General Engineering Lab (GEL), H2M Lab, Severn-Trent Lab (STL), Chemtex Lab, and Brooks Rand. All analytical laboratories were certified by New York State 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.

Four of the contract analytical laboratories participated in several national and state PE testing programs in 2005. Results of the tests provide information on the quality of a laboratory's analytical capabilities. The two contract analytical laboratories performing radiological analyses had "average overall satisfactory" scores (as defined by the independent testing organizations) of 98 and 88 percent. The overall satisfactory scores for nonradiological testing ranged from 93.1 to 99.4 percent. The contract analytical laboratories received an "acceptable" rating for a combined average overall satisfactory score of 93.9 percent on the radiological and nonradiological PE tests performed.

In 2005, STL and GEL were audited as part of DOE's Integrated Contract Procurement Team Program. There were no Priority I ("serious") findings for either laboratory. The STL audit resulted in 15 Priority II findings and the GEL audit resulted in two Priority II findings. Corrective actions plans were submitted to DOE by the contract analytical laboratories to document that procedures were put in place to correct the findings.

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 (BNL) is a multi-program national laboratory operated by Brookhaven Science Associates (BSA) for the U.S. Department of Energy (DOE). BSA, a nonprofit, limited-liability company formed as a 50-50 partnership between Battelle Memorial Institute and The Research Foundation of State University of New York (SUNY) on behalf of SUNY-Stony Brook (USB), is the legal entity responsible for leading BNL successfully through the 21st century. Stony Brook University and Battelle have 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 50 years, Laboratory researchers have successfully worked to visualize, construct, and operate large and unique scientific facilities and use the data generated to make advances in many fields. Under BSA's management, new programs in place at BNL emphasize improved environmental, safety, 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 appropriate 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, design, construct, and operate complex, leading-edge, user-oriented research facilities in response to the needs of DOE and the international community of users
- To carry out basic and applied research in long-term, high-risk programs at the frontier of science.
- To develop advanced technologies that address national needs and 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 provide a safe, secure, and healthy workplace, strive to prevent injuries and illnesses, promote healthy lifestyles, and encourage respect for the environment. The Laboratory has been registered under the prestigious International ISO 14001 environmental management standard since 2001. In addition, the Laboratory's Environmental and Waste Management Services Division was registered under the Occupational Health and Safety Assessment Series (OHSAS) 18001 standard in November 2005. These programs are described in detail in Chapter 2 of this report.

1.2 HISTORY

BNL was founded in 1947 by the Atomic Energy Commission (AEC), which was the predecessor to the present DOE. AEC provided the initial funding for BNL's research into the 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 goal was to build 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 peace-time 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 now being decommissioned. The BGRR's capacity was replaced and surpassed in 1965 by the High Flux Beam Reactor (HFBR), which provided neutrons to researchers in diverse subjects ranging from solid state physics to art history. For more than 30 years, the HFBR was one of the premier neutron beam reactors in the world. During a scheduled maintenance shutdown in 1997, workers discovered a leak in the HFBR's spent fuel storage pool. In November 1999, the Secretary of Energy decided that the HFBR would be permanently shut down and decommissioned. All spent fuel from the HFBR has been removed and transported off site.

Medical research at BNL began in 1950 with the opening of one of the first hospitals devoted to nuclear medicine. It was followed by the Medical Research Center in 1958 and the Brookhaven Medical Research Reactor (BMRR) in 1959. The BMRR was the first nuclear reactor in the nation to be constructed specifically for medical research. Due to a reduction of research funding, the BMRR was shut down in December 2000. All spent fuel from the BMRR has been removed and transported off site. The Brookhaven Linac Isotope Producer (BLIP) was built in 1973. The BLIP 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 for research into treatments for brain diseases such as drug addiction, eating disorders, attention deficit disorder, and neurodegenerative disorders. The development of these powerful imaging methods has given scientists a unique opportunity to reveal the molecular mechanisms of human disease and to facilitate the development of new drugs for doctors worldwide to treat patients for cancer and heart disease. Except for the BMRR, all of the above medical facilities are currently operating.

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 Noble Prize in 1957. After 14 years of service, the Cosmotron ceased operation and was dismantled due to design limitations that restricted the energies that 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). The Linac was designed and built in the late 1960s as a major upgrade to the AGS complex. Its 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, heavy metals, and protons for experiments at the Relativistic Heavy Ion Collider (RHIC).

RHIC began operation in 2000. Inside the 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. 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, would 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 and 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 those that would be encountered by astronauts on long missions. Studies are conducted to help 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 x-rays, ultraviolet, and infrared light. These beams allow scientists to study the structure of proteins, to investigate the properties of new materials, and to understand the fate of chemicals in our environment. Although the current NSLS has been continually updated since its commissioning in 1982, today the practical limits of its performance have been reached. A proposal is in place to build a new synchrotron, the NSLS-II. Producing x-rays 10,000 times brighter than the current NSLS, the NSLS-II would be the highest-resolution light source in the world. Planned research at the NSLS-II would focus on important challenges at the nanoscale, such as clean and affordable energy, molecular electronics, and high-temperature superconductors.

The Center for Functional Nanomaterials (CFN) began construction in 2005. The CFN will provide researchers the ability to fabricate and study materials on the order of billionths of a meter, with the potential to bring about and accelerate new technologies in energy distribution, drug delivery, sensors, and industrial processes. The possible benefits of nanoscience include faster computers, improved solar energy conversion, stronger and lighter materials, improved chemical and biological sensing, efficient and rapid detection and remediation of pollutants and pathogens in the environment, more efficient catalysts to speed chemical processes, molecular motors, as well as new drugs.

Past operations at the Laboratory have resulted in environmental contamination dating back to the early 1940s when it was Camp Upton. As a result, BNL was added to the federal Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) National Priorities List of contaminated sites in 1989. One of 27 such sites on Long Island identified for priority cleanup, BNL has made significant progress toward improving environmental operations and remediating past contamination. DOE continues to fund cleanup projects and will until such time that the Laboratory is restored and removed from the National Priorities List.

1.3 RESEARCH AND DISCOVERIES

BNL conducts research in nuclear and high-energy physics, the physics and chemistry of materials, environmental and energy research, nonproliferation, neurosciences and medical imaging, and structural biology. Approximately 2,700 scientists, engineers, technicians, and support staff work at the Laboratory, and more than 4,000 guest researchers from around the world visit the site each year to participate in scientific collaborations. BNL's major world-class research facilities are also available to university, industrial, and government personnel.

To date, six Nobel Prizes have been awarded for discoveries made wholly or partly at BNL. Some important discoveries and developments made at the Laboratory include L-dopa, used to treat Parkinson's disease; magnetically-levitated (maglev) trains; 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; and research on solar neutrinos and how they change form on the way to earth.

Examples of current research being conducted at the Laboratory include the investigation of new nanostructures and nanoparticles; high-temperature superconductors; new state of matter being produced 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; production of advanced radiation detectors for homeland security applications; and research into how infections begin. Further information regarding research and discoveries at BNL can be found at www.bnl.gov.

1.4 FACILITIES AND OPERATIONS

Most of the Laboratory's principal facilities are located near the center of the site. The developed area is approximately 1,650 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. The three former research reactors, no longer operational, are discussed in Section 1.2. 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 facility 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 plant 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. The Fire Rescue Group responds within 5 minutes to emergencies in the core area of the Laboratory and within 8 minutes to emergencies in the outer areas (RHIC and eastern portions of the site).
- *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 the 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 facility 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.
- *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 facility 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 with a lime softening process to remove naturally occurring iron. 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 with carbon to ensure that VOC levels meet the drinking water standards. BNL's water met all drinking water standards in 2005.

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 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 their families, as well as students, reside in apartments and dormitories on site or in surrounding communities. More than 75 percent of BNL employees live in Suffolk County.

The Laboratory is one of five large, high-technology employers on Long Island. An independent Suffolk County Planning Commission concluded that BNL's spending for operations, procurement, payroll, construction, medical benefits, and technology transfer spreads throughout Long Island's economy, making BNL vital to the local economic health (Kamer 1995). In addition, Laboratory employees do most of their shopping locally, further enhancing the local economy. Several of the Laboratory's currently planned projects, which include the Research Support Center and the Center for Functional Nanomaterials (both currently under construction) and the proposed building of a new synchrotron light source, are expected to significantly enhance BNL's economic value to Long Island and New York State.

In 2005, BNL's total procurement budget was approximately $465 million, of which $280 million was spent on employees' salaries, wages, and fringe benefits. In addition, BNL purchased $26.7 million worth of supplies and services from Long Island businesses. Out of that amount, approximately $22.4 million was spent on 3,000 purchases in Suffolk County and approximately $4.3 million went toward 507 purchases made in Nassau County.

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 sole source aquifer system beneath Long Island. 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. These

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, an experiment based on the premise that when new collisions occur, new physics will be readily identified.

2. Alternating Gradient Synchrotron (AGS)
The AGS is a particle accelerator used to propel protons and heavy ions to high energies for physics research. The AGS is capable of accelerating protons and heavy ions, such as gold and iron. 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. Construction is planned for spring 2005. This new facility will be 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. 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.

10. 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.

11. 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 (PET) and Magnetic Resonance Imaging (MRI) studies.

12. Brookhaven Graphite Research Reactor (BGRR)
The BGRR was the first peace-time 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.

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 deep Magothy and Lloyd aquifer systems lying below the Upper Glacial aquifer. Experts estimate 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 (EPA).

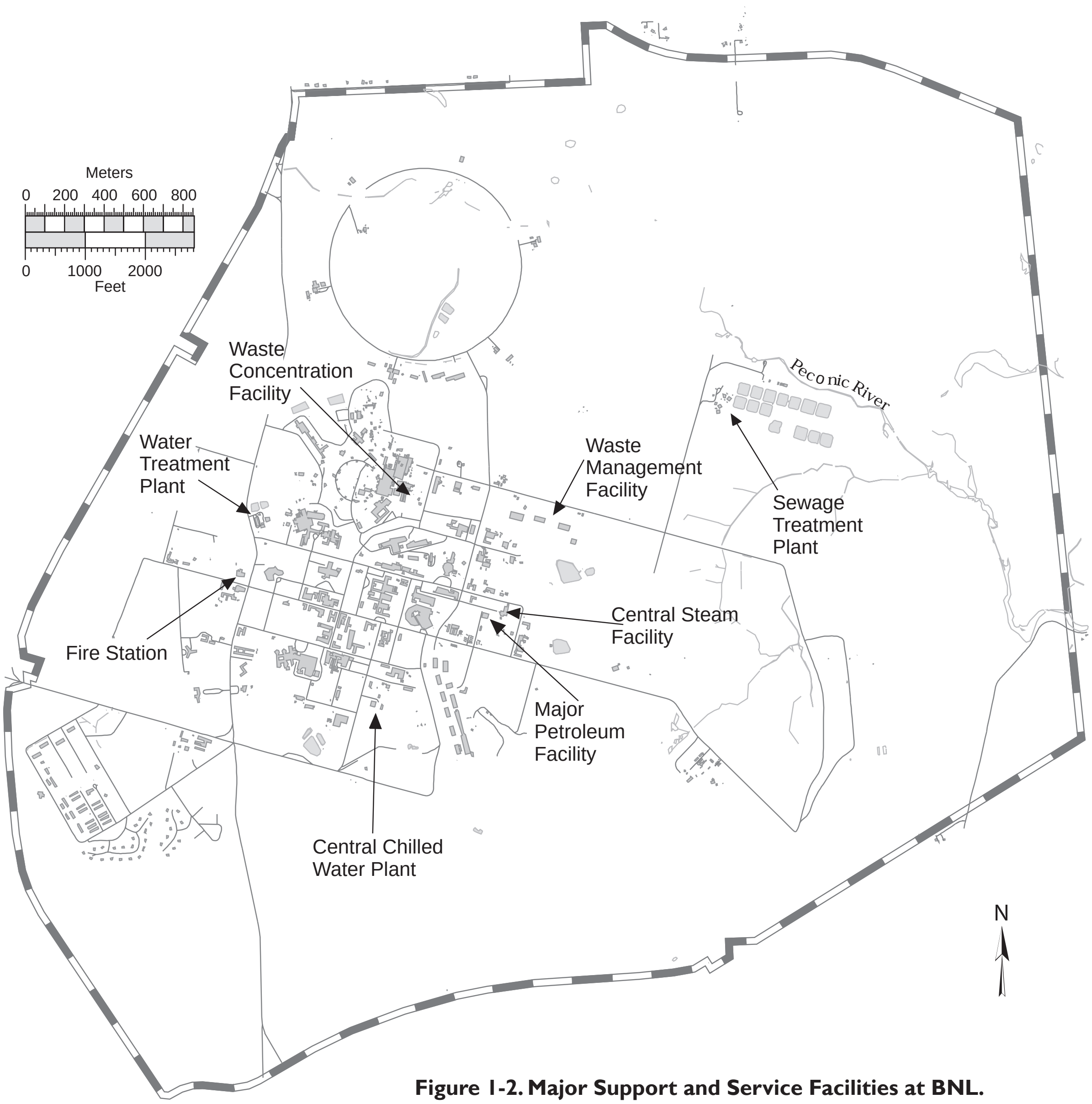


Figure 1-2. Major Support and Service Facilities at BNL.

During 2005, the Laboratory used approximately 1.4 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 BNL site. Human consumption, evaporation (cooling tower and wind losses), and sewer line losses account for the remaining 25 percent. An additional 4.4 million gallons of groundwater are pumped each day from remediation wells for treatment and then returned to the aquifer by way of recharge basins.

Groundwater flow direction across the BNL site is influenced by natural drainage systems flowing 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

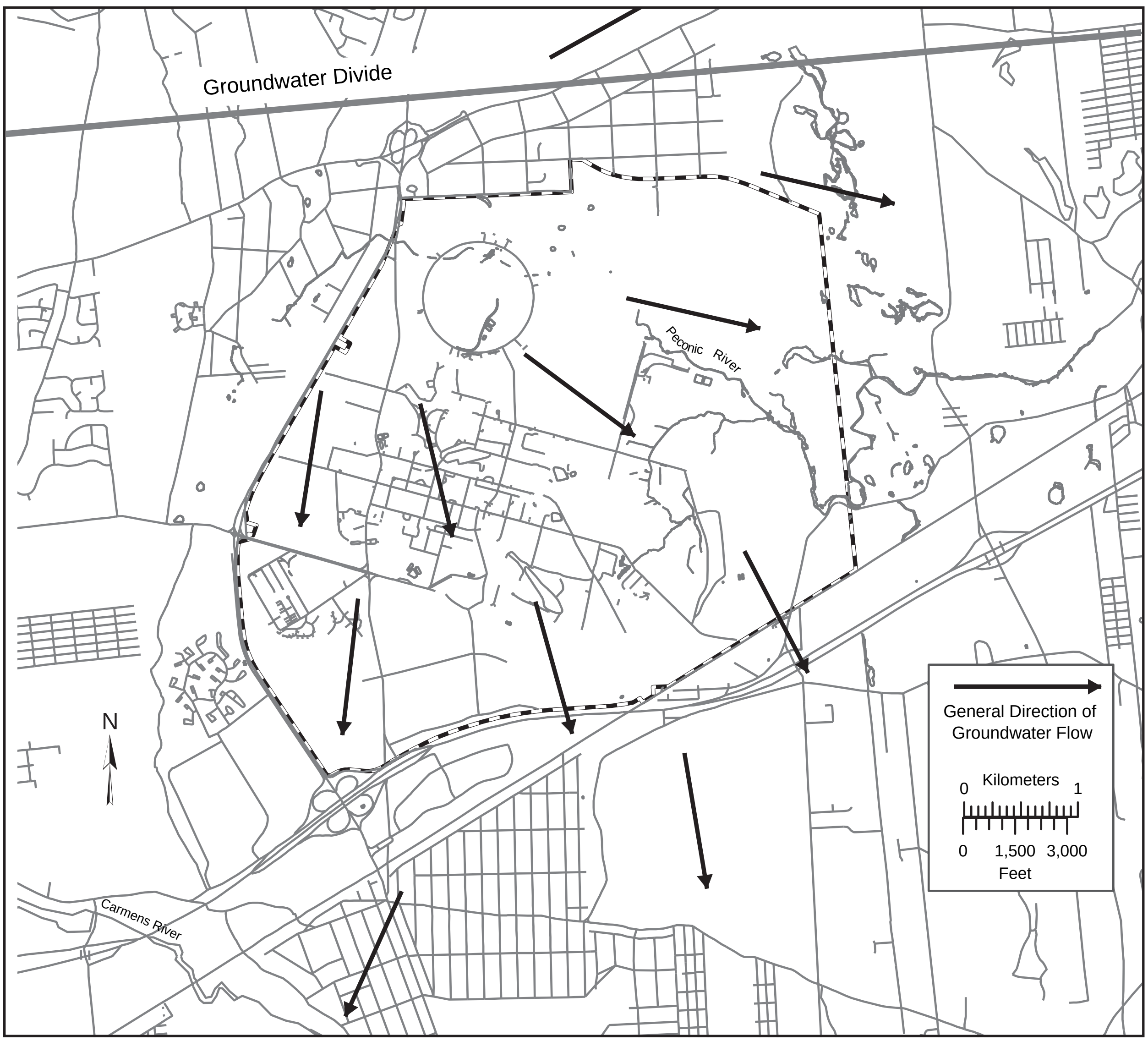
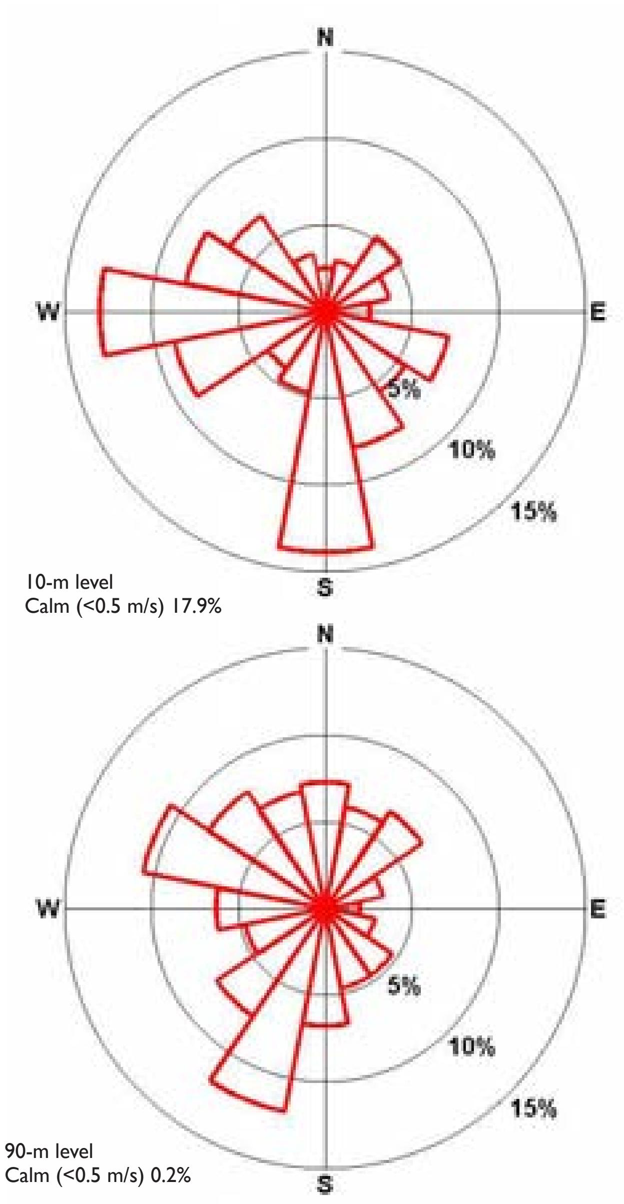


Figure 1-3. BNL Groundwater Flow Map.



Explanation: The arrows formed by the wedges indicate wind direction. Each concentric circle represents a 5 percent frequency, that is, how often the wind came from that direction. The wind direction was measured at heights of 10 and 90 meters. This diagram indicates that the predominant wind direction was from the south at the 10-m level and south-southwest at the 90-m level.

Figure 1-4. BNL 2005 Wind Rose.

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 to 1.2 feet per day (Geraghty and 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 1948. 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 these two directions during the spring and fall (Nagle 1975, 1978). Figure 1-4 shows the 2005 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 (90 meters).

The average yearly snowfall in the area is 31.2 inches. The total snowfall in 2005 was 78.3 inches, the second snowiest season recorded at the Laboratory, with a record snowfall of 29 inches in January. The average yearly precipitation is 48.5 inches. The total annual precipitation for 2005 was 50.1 inches. October was the wettest month ever recorded since the Laboratory has been keeping weather statistics, with 22.14 inches of rain. Figures 1-5 and 1-6 show the 2005 monthly and the 57-year annual precipitation data.

The average monthy temperature for 2005 was 51.9°F. Eight new daily high temperatures were recorded during the months of January, July, August, and September. August beat a pre-

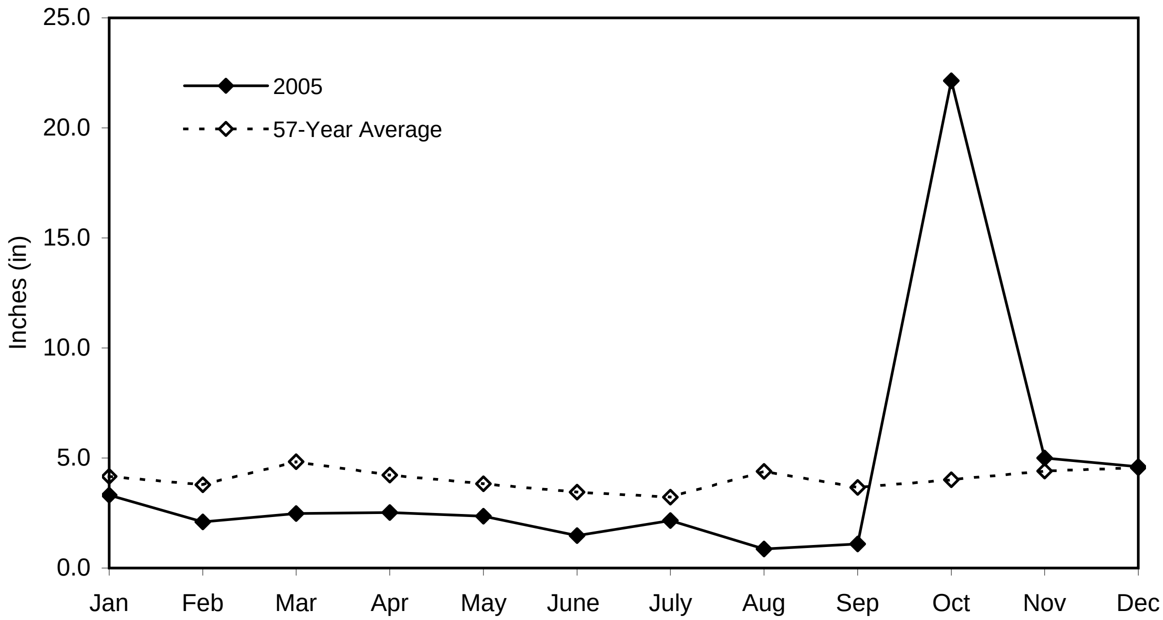


Figure 1-5. BNL 2005 Monthly Precipitation versus 57-Year Monthly Average.

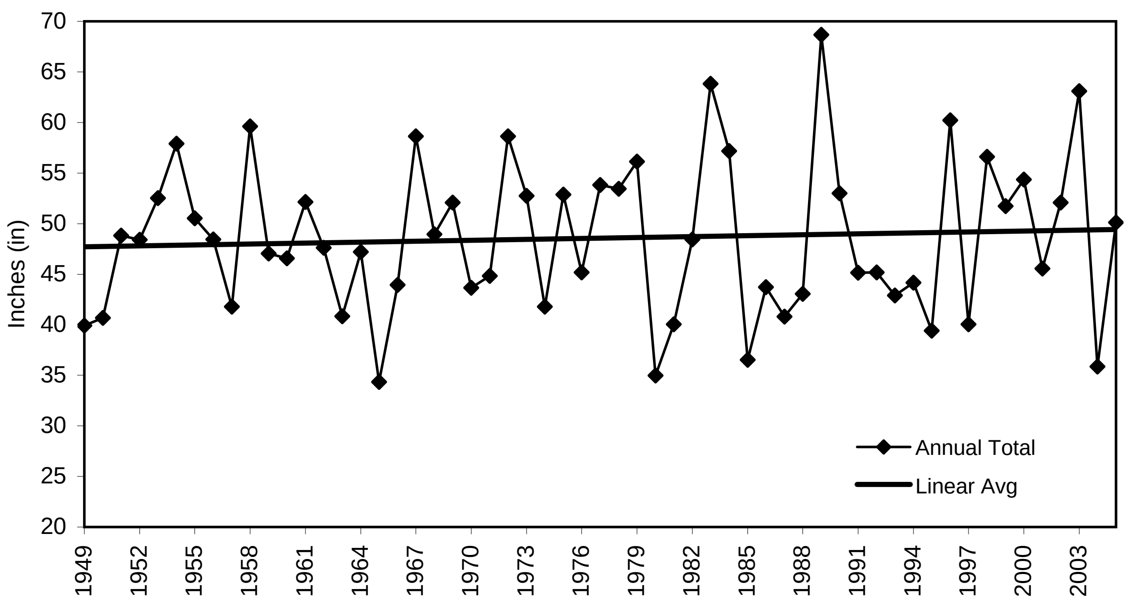


Figure 1-6. BNL Annual Precipitation Trend (57 Years).

vious record set in 2003 as the hottest month, with an average temperature of 76.2°F. Although January was the coldest month recorded, with an average temperature of 28.7°F, it also beat a record for warmest January day by one degree, when the temperature reached 57°F. Figures 1-7 and 1-8 show the 2005 monthly mean temperatures and the historical annual mean temperatures, respectively.

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

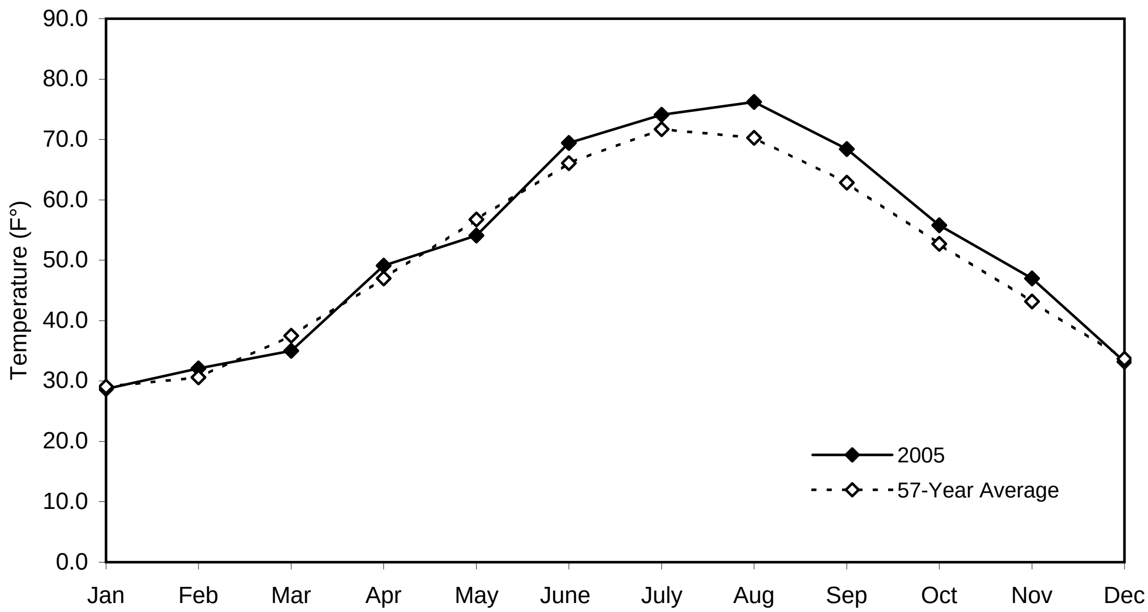


Figure 1-7. BNL 2005 Monthly Mean Temperature versus 57-Year Monthly Average.

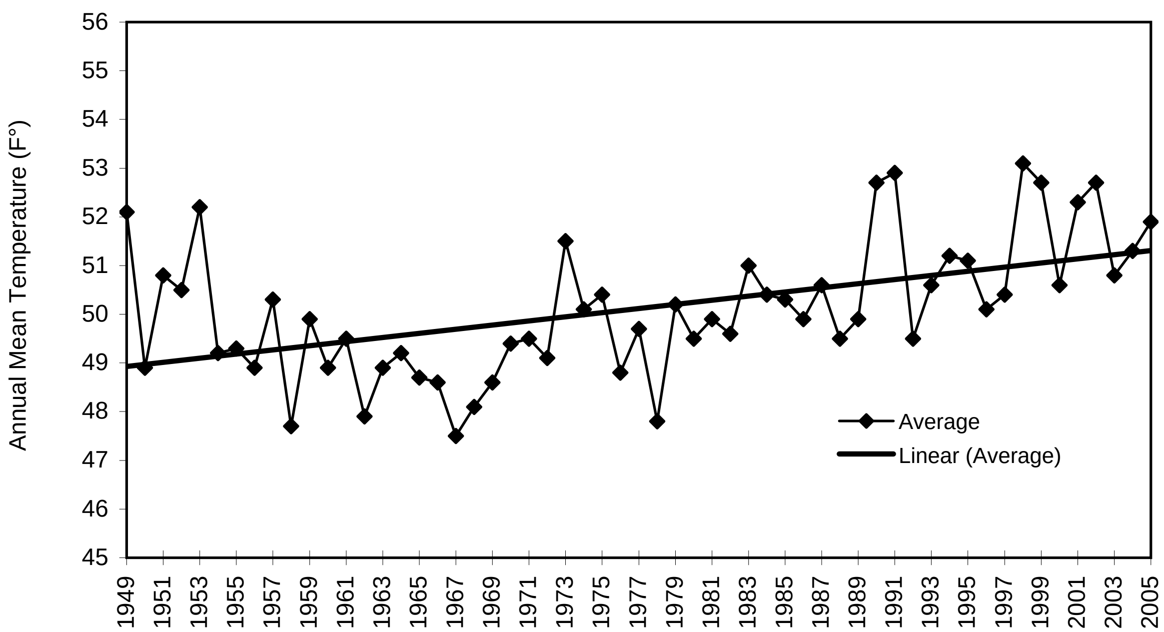


Figure 1-8. BNL Annual Mean Temperature Trend (57 Years).

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. Portions were then cleared again in 1940 when Camp Upton was reactivated. 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 New York State threatened species and two that are 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 as a result of BNL's location within the Atlantic Flyway, and the 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 New York State threatened species. Two types of butterflies that are protected in New York State are believed to breed on site due to 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 habitat 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. Funding provided by DOE under an Inter-Agency Agreement between DOE and the U.S. Fish & Wildlife Services (FWS) expired in fiscal year 2004. FWS conducted resource management programs for the conservation, enhancement, and restoration of wildlife and habitat in the reserve through mid-year 2005, while transitioning research efforts to the Foundation for Ecological Research in the Northeast (FERN). FERN now coordinates research within the Central Pine Barrens and the Upton Reserve. The Laboratory continues to utilize the Upton Reserve Technical Advisory Group, made up of local land management agencies, to assist BNL and FWS with technical expertise and help determine natural resource management policy for the Laboratory and the Upton Reserve. Management of the Upton Reserve falls within the scope of BNL's Natural Resource Management Plan, and the area will continue to be managed for its key ecological values and as an area for ecological research. 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. A *Cultural Resource Management Plan* was developed to identify, assess, and document BNL'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 the Laboratory. BNL currently has three facilities that have been determined as eligible for listing on the National Register of Historic Places. These historical facilities include the Brookhaven Graphite Research Reactor complex, the High Flux Beam Reactor complex, and the World War I training trenches associated with Camp Upton.

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Environmental Management System 2

One of Brookhaven National Laboratory's highest priorities is ensuring that its environmental performance measures up to its world-class status in science. Brookhaven Science Associates (BSA), the contractor operating the Laboratory on behalf of DOE, takes environmental stewardship very seriously. As part of BSA's 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 2005, BNL operations led to a DOE Noticeable Practice Award for a conference entitled "Fleet Managers Pollution Prevention Workshop." This workshop, held at BNL, allowed local organizations that manage vehicle fleets to interact and share pollution prevention ideas.

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 2005, an EMS Surveillance Audit determined that BNL remains in conformance with the ISO 14001: 2004 Standard. The Laboratory was the first DOE facility certified to the 2004 Standard.

BNL continued its strong support of the Pollution Prevention Program in 2005. This program seeks ways to eliminate waste and toxic materials and is the preferred approach to resolving environmental issues at the Laboratory. In 2005, pollution prevention projects saved more than $1 million and resulted in the reduction or reuse of approximately 2.8 million pounds of waste. Also in 2005, the BNL Pollution Prevention Council funded 13 new proposals or special projects, investing approximately $101,000. Anticipated annual savings from the projects are estimated at approximately $102,000, for an average payback period of 1.4 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 also continues to address legacy issues under the Environmental Restoration Program and openly communicates with neighbors, regulators, employees, and other interested parties on environmental issues and cleanup progress on site.

2.1 BNL'S ISO 14001 STANDARD

The ISO 14001 Standard is globally recognized and defines the structure of an organization's EMS for purposes of improving environmental performance. The process-based structure of the ISO 14001 Standard is based on the "Plan-Do-Check-Act" improvement cycle. The standard requires an organization to develop an environmental policy, create plans to implement the policy, implement the plans, check progress and take corrective actions, and review the system annually to ensure its continuing suitability, adequacy, and effectiveness. To gain registration to the ISO 14001 Standard, an organization must comply with a set of 17 requirements that are listed and described in Table 2-1.

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 globally recognized environmental standard. To achieve registration, the Laboratory underwent an independent audit of its EMS to verify that the system conformed to all ISO 14001 requirements and that it was effectively implemented. The certification also requires BNL to undergo annual audits by an accredited registrar to assure that the system is maintained.

In 2005, an EMS Surveillance Audit determined that BNL remains in conformance with the ISO 14001 Standard, which was upgraded in 2004. In its recommendation for continued certification, NSF-International Strategic Registrations, Ltd. highlighted seven examples of BNL's continual improvement, some of which include BNL's improved methods for presenting objectives and targets. The auditors also identified three minor nonconformances and four opportunities for improvement. A corrective action plan was prepared to track the minor nonconformances 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. This policy, issued and signed by the Laboratory director, makes clear BNL's commitments to environmental stewardship, the safety of the public and BNL employees, and the security of the site. To help achieve the goal of providing a healthy and safe work environment, BNL has implemented the OHSAS 18001 (Occupational Health and Safety Assessment Series) specifications to develop a comprehensive Occupational Safety and Health management system. The OHSAS was developed to be compatible with the ISO 14001 Standard to facilitate the integration of environmental and occupational health and safety management systems. The Laboratory is committed to achieving OHSAS registration sitewide by 2006. 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. Within the policy, goals and commitments that focus on compliance, pollution prevention, cleanup, community outreach, and continual improvement include:

- Meet all applicable ESSH laws and BNL Standards Based Management System, Integrated Safety Management, and Integrated Safeguards and Security Management requirements. (The environmental requirements include more than 100 local, state, and federal laws and regulations; DOE Directives; Executive Orders; and numerous operating permits.)
- Integrate hazard prevention/reduction, pollution prevention/waste minimization, resource conservation, security, and compliance into all of our planning and decisionmaking and adopt cost-effective practices that eliminate, minimize, or mitigate environmental impacts and control safety, security, and health risks and vulnerabilities. (This commitment includes conserving natural resources and adhering to the policy known as "E-ALARA" by ensuring that emissions, effluents, and waste generation are As Low As Reasonably Achievable.)
- Strive to conserve resources and minimize or eliminate adverse ESSH effects and risks that may be associated with research and operations, and manage programs in

Table 2-1. Elements of the Environmental Management System (EMS): Implementation of ISO 14001 at BNL.

Environmental Policy	The Environmental, Safety, Security, and Health Policy is a statement of BNL's intentions and principles regarding overall environmental, safety, security, and health performance. It provides a framework for planning and action. In the policy, the Laboratory has reaffirmed its commitment to compliance, pollution prevention, cleanup, community outreach, and continual improvement.
Environmental Aspects and Impacts	When operations have an environmental aspect, BNL implements the EMS to minimize or eliminate any potential impact. As required by the ISO 14001 Standard, the Laboratory evaluates its operations, identifies the aspects of operations that can impact the environment, and determines which of those potential impacts are significant. BNL has determined that the following aspects of its operations have the potential to affect the environment: ▪ Waste generation ▪ Atmospheric emissions ▪ Liquid effluents ▪ Storage or use of chemicals and radioactive materials ▪ Natural resource usage — power and water consumption ▪ Historical and cultural resources ▪ Environmental noise ▪ Disturbances to endangered species/protected habitats ▪ Soil activation ▪ Historical contamination ▪ Other facility-specific compliance aspects
Legal and Other Requirements	BNL has implemented and continues to improve the Standards Based Management System (SBMS), a BNL web-based system designed to deliver Laboratory-level requirements and guidance to all staff. New or revised requirements (e.g., new regulations) are analyzed to determine their applicability, and to identify any actions required to achieve compliance. This may involve developing or revising BNL documents or operating procedures, implementing administrative controls, providing training, installing engineered controls, or increasing monitoring.
Objectives, Targets, and Programs	The Performance Based Management System is designed to develop, align, balance, and implement the Laboratory's strategic objectives, including environmental objectives. Objectives and targets are developed by Fiscal Year (FY). The following were the objectives and targets in FY 2005: ▪ Maintain and improve the EMS ▪ Achieve full compliance with applicable environmental requirements ▪ Invest in specific pollution prevention projects ▪ Improve communications, trust, and relationships with stakeholders on environmental programs ▪ Fully implement the BNL Groundwater Protection Program ▪ Ensure responsible stewardship of natural and historical resources on site ▪ Implement Environmental Restoration projects efficiently Organizations within BNL develop action plans detailing how they will achieve their objectives and targets and commit the necessary resources to successfully implement both Laboratory-wide programs and facility-specific programs. The Laboratory has implemented a Pollution Prevention Program to conserve resources and minimize waste generation. BNL also has a budgeting system designed to ensure that priorities are balanced and that resources essential to the implementation and control of the EMS are provided.
Resources, Roles, Responsibilities, and Authorities	All employees at the Laboratory have specific roles and responsibilities in key areas, including environmental protection. Environmental and waste management technical support personnel assist the line organizations with developing and meeting their environmental responsibilities. Every BNL employee is required to develop a Roles, Responsibilities, Accountabilities, and Authorities document signed by the employee, their supervisor, and the supervisor's manager. Specifics on environment, safety, and health performance expectations are included in these documents.
Competence, Training, and Awareness	Extensive training on EMS requirements has been provided to staff whose responsibilities include environmental protection. The training program includes general environmental awareness for all employees, regulatory compliance training for selected staff, and specific courses for managers, internal assessors, EMS implementation teams, and operations personnel whose work can impact the environment.
Communication	BNL continues to improve processes for internal and external communications on environmental issues. The Laboratory solicits input from interested parties such as community members, activists, civic organizations, elected officials, and regulators. This is accomplished primarily through the Citizens Advisory Committee and the Brookhaven Executive Roundtable. At the core of the communication and community involvement programs are the Environmental Safety, Security, and Health Policy and the Community Involvement Plan.

(continued on next page)

Table 2-1. Elements of the Environmental Management System (EMS): Implementation of ISO 14001 at BNL.

Documentation	BNL has a comprehensive, set of Laboratory-wide environmental documents describing the EMS. Using the SBMS, staff can access detailed information on regulatory requirements, Laboratory-wide procedures, and manuals on how to control processes and perform their work in a way that protects the environment. The SBMS has improved the quality, usability, and communication of Laboratory-level requirements.
Control of Documents	The SBMS includes a comprehensive document control system to ensure effective management of procedures and other requirements documents. When facilities require additional procedures to control their work, document control protocols are implemented to ensure that workers have access to the most current versions of procedures.
Operational Control	Operations at the Laboratory are evaluated for the adequacy of current controls to prevent impact to the environment. As needed, additional administrative or engineered controls are identified, and plans for upgrades and improvements are developed and implemented.
Emergency Preparedness and Response	BNL has an Emergency Preparedness and Response Program and specialized staff to provide timely response to hazardous materials or other environmental emergencies. This program includes procedures for preventing, as well as responding to, emergencies
Monitoring and Measurement	Effluent and emission monitoring helps ensure the effectiveness of controls, adherence to regulatory requirements, and timely identification and implementation of corrective measures. BNL has a comprehensive, sitewide Environmental Monitoring Program. Monitoring results are reported to regulatory agencies and are summarized annually in the Site Environmental Report. In addition, BNL tracks and trends its progress and performance in achieving environmental objectives and performance measures
Evaluation of Compliance	Specific environmental legislation and regulations are evaluated and assessed on a program- or facility-specific basis. BNL has established a documented procedure for periodically evaluating its compliance with relevant environmental regulations. This procedure is often integrated in an organization's environmental, safety, and health inspection process, which is performed in a prioritized fashion by a team of experts, including one on environmental regulatory issues. Periodically, the environmental support organizations will perform a regulatory assessment in a particular topical area to verify the compliance status of multiple organizations throughout the Laboratory. Lastly, external regulatory agencies and/or technical experts may conduct independent audits of compliance.
Nonconformity, and Corrective and Preventive Actions	BNL continues to improve processes that identify and correct problems. A Lessons Learned Program to prevent recurrences, a sitewide Self-Assessment Program, and an electronic web-based assessment and action tracking system have been implemented
Control of Records	EMS-related records, including audit and training records, are maintained to ensure integrity, facilitate retrieval, and protect them from loss.
Internal Audit	To periodically verify that the EMS is operating as intended, audits are conducted. These audits, which are part of the sitewide Self-Assessment Program, are designed to ensure that any nonconformance to the ISO 14001 Standard is identified and addressed. An independent accredited registrar also conducts ISO 14001 registration audits. In addition, compliance with regulatory requirements is verified through routine inspections, operational evaluations, and periodic audits.
Management Review	In addition to audits, a management review process has been established to involve top management in the overall assessment of environmental performance, the EMS, and progress toward achieving environmental goals. This review also identifies, as necessary, the need for changes to, and continual improvement of, the EMS.

a manner that protects the ecosystem and employee/public health. (This commitment includes continually improving the EMS and the Laboratory's environmental performance by establishing appropriate environmental objectives and performance indicators to guide these efforts and measure progress; maintaining certification by employing proactive measures to prevent problems; and taking corrective actions, as appropriate, if problems do occur.)

- Work with stakeholders to help them address their ESSH needs; maintain a positive, proactive, and constructive relationship with neighbors in the community, regulators, DOE, and other stakeholders;

and openly communicate with stakeholders on our progress and performance (see Section 2.4.2).

- Define, prioritize, and aggressively prevent, correct, and/or clean up existing environmental, security, and occupational safety and health problems. (This commitment encompasses removal or treatment of contamination caused by historical practices; strengthening the BNL Environmental Monitoring Program as discussed in Section 2.4.3 to ensure that controls designed to protect the environment are working; and providing early detection of potential threats to the environment.)

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. BNL'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 the significant aspects and potential impacts continue to reflect stakeholder concerns and changes in regulatory requirements. BNL's list of aspects and significance criteria remained unchanged in 2005.

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 SBMS subject areas.

2.3.3 Objectives and Targets

The establishment of environmental objectives and targets is accomplished through BNL's 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. The Laboratory and BSA work with DOE 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 FY 2005 (October 1, 2004 through September 30, 2005), BNL's environmental objectives included:

- Maintaining and improving the EMS
- Achieving full compliance with applicable environmental requirements
- Integrating pollution prevention into work planning and expanding participation within the Laboratory
- Improving communications, trust, and relationships with stakeholders on environmental programs and issues
- Fully implementing the BNL Groundwater Protection Management Program
- Ensuring responsible stewardship of natural and cultural resources on site
- Implementing environmental restoration projects efficiently

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 has developed and funded several important environmental programs to further integrate environmental stewardship into all facets of BNL's missions.

2.3.4.1 Compliance

BNL has an extensive system to help ensure full compliance with all applicable environmental regulatory requirements and permits. Legislated compliance is outlined by the National Emission Standards for Hazardous Air Pollutants (NESHAPs), State Pollutant Discharge Elimination System (SPDES), and Resource Conservation and Recovery Act (RCRA). Other compliance at BNL involves special projects or initiatives, 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 waste. See Chapter 3 for 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. BNL 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 the full and timely disclosure of any off-normal occurrences and regular communication on the performance of the program. In 2005, the Laboratory completed construction of the Strontium-90 Groundwater Treatment System, the last major system scheduled for construction. Chapter 7 and the SER Volume II, Groundwater Status Report, provide additional details about this program, its performance, and monitoring results for 2005.

2.3.4.3 Waste Management

As a byproduct of the world-class research it conducts, BNL generates a large range of waste. This includes 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.

BNL's Waste Management Facility (WMF) is responsible for the collection, transportation, storage, and off-site disposal of waste generated at the Laboratory. 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. In 2005, BNL generated the following types and quantities of waste from routine operations:

- Hazardous waste: 5.9 tons
- Mixed waste: 66 ft^3
- Radioactive waste: 1,402 ft^3

Hazardous and mixed waste amounts from routine operations in 2005 were approximately the same as in 2004 (Figures 2-1a and 2-1b). The radioactive waste quantity for routine operations represents a reduction from previous years, as shown in Figure 2-1c. This reduction is attributed to a limited high-energy nuclear physics fixed-target program in 2005. Waste generated from nonroutine or one-time events and waste generated from environmental restoration activities are not included in the figures.

Routine operations are defined as ongoing industrial and experimental operations. BNL is currently cleaning up facilities and areas containing radioactive and chemical contamination resulting from historical operations. Waste recovered through restoration and decommissioning activities is managed by the Environmental Restoration (ER) group, with oversight by BNL's Environmental and Waste Management Services Division (EWMSD). In 2005, the EWMSD assumed surveillance and maintenance operations for the Brookhaven Medical Research Reactor (BMRR). Waste generation activity associated with the BMRR is reflected in the nonroutine waste values. Nonroutine waste includes construction and demolition waste, environmental restoration waste, legacy waste, lead-painted debris, lead shielding, and polychlorinated biphenyl (PCB) waste. Figures 2-1d through 2-1f show wastes generated under the ER Program, as well as nonroutine operations. Waste generation from these activities has varied significantly from year to year. This was expected, as environmental restoration activities moved from remedial investigations and feasibility studies to remedial actions, which have changed annually based on the progress of BNL's cleanup schedule. In 2005, large-scale remedial operations of the Peconic River were completed resulting in the removal of approximately 6,000 tons of non-hazardous sediment. In addition, ER removed the greatest amount of radiological waste in any single year, with the completion of remedial activities at the Former Hazardous Waste Management Facility, Chemical/Glass Holes Project, and Waste Concentration Facility This was a significant achievement for BNL.

2.3.4.4 Pollution Prevention and Minimization

The Laboratory's Pollution Prevention (P2) Program is an essential element for the successful accomplishment of BNL's broad mission. It 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 BNL 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 critical outcomes associated with the Laboratory's operating contract with BSA. 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
- Identify funding mechanisms for evaluating and implementing P2 opportunities
- Implement P2 projects
- Improve employee and community awareness of P2 goals, plans, and progress

Nineteen P2 proposals were submitted to the BNL P2 Council for funding in FY 2005. Nine proposals were funded, in addition to four special projects, for a combined investment of approximately $101,000. The anticipated an-

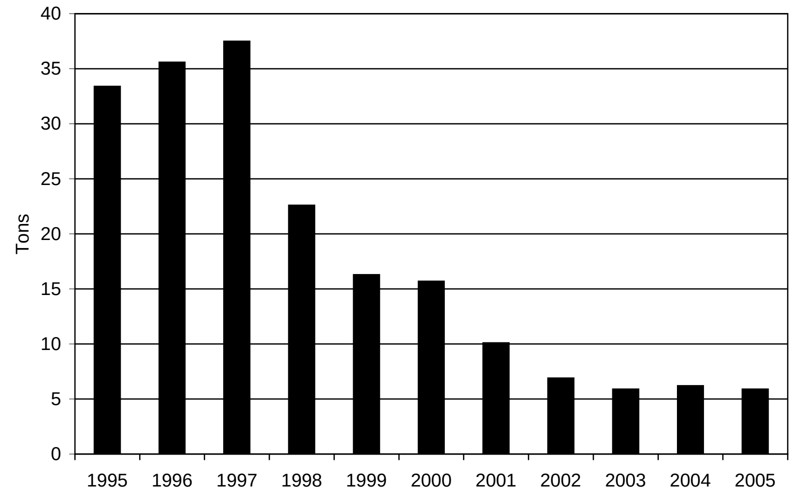

Figure 2-1a.
Hazardous Waste Generation from Routine Operations, 1994 – 2005.

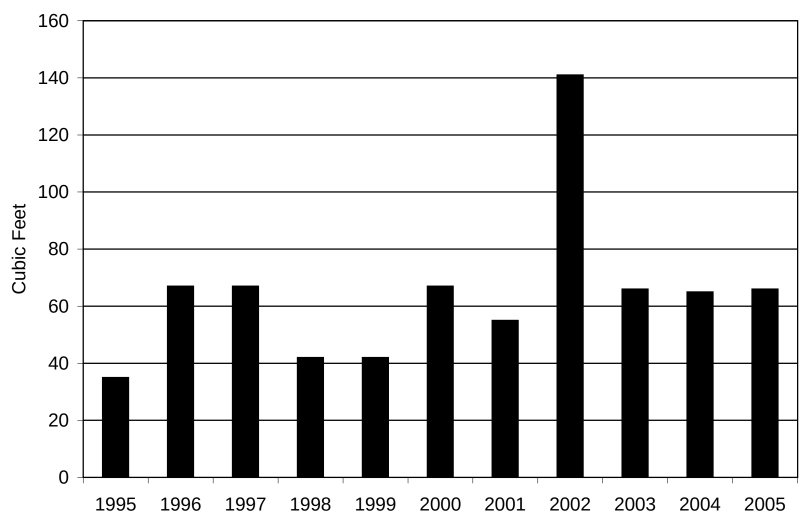

Figure 2-1b.
Mixed Waste Generation from Routine Operations, 1994 – 2005.

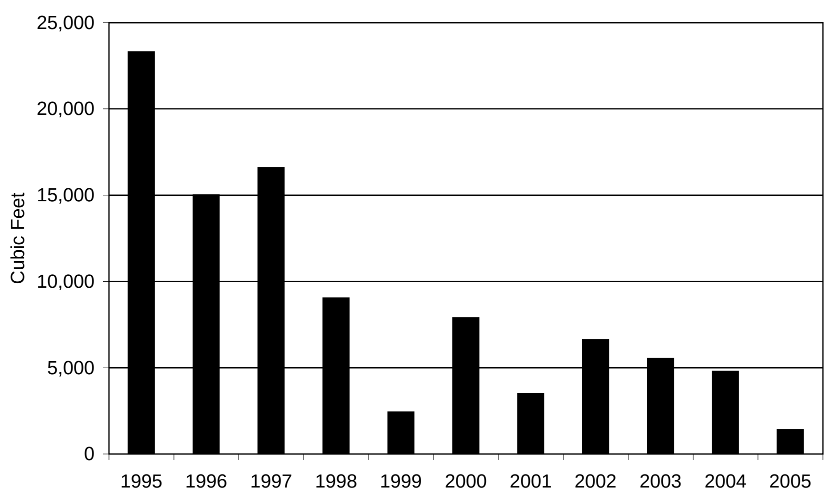

Figure 2-1c.
Radioactive Waste Generation from Routine Operations, 1994 – 2005.

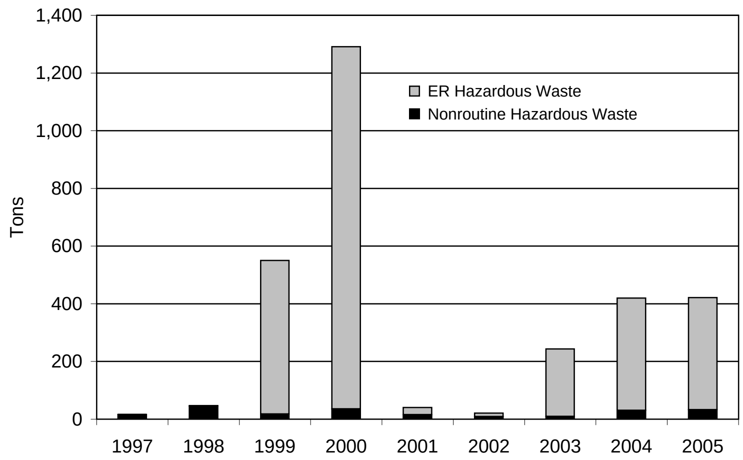

Figure 2-1d.
Hazardous Waste Generation from ER and Nonroutine Operations, 1997 – 2005.

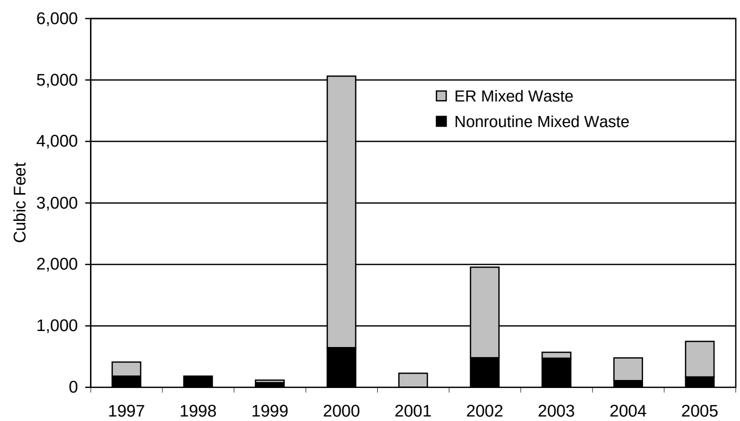

Figure 2-1e.
Mixed Waste Generation from ER and Nonroutine Operations, 1997 – 2005.

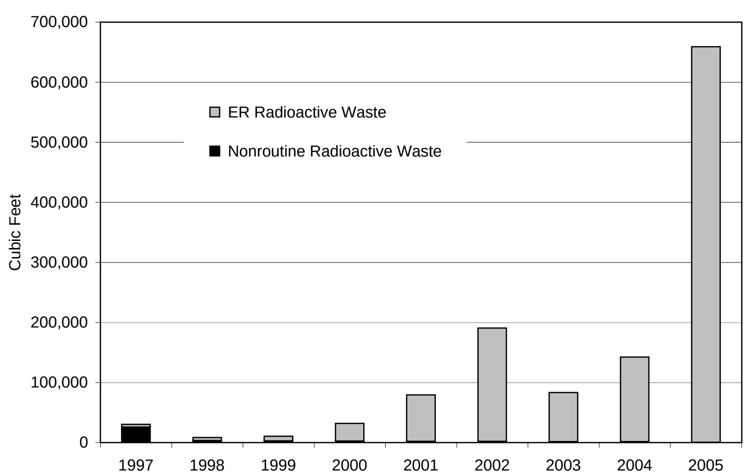

Figure 2-1f.
Radioactive Waste Generation from ER and Nonroutine Operations, 1997 – 2005.

nual savings from these projects is estimated at $102,000, for an average payback period of 1.4 years. The four special projects were jointly funded with other BNL divisions and significantly limited future environmental and worker safety risks.

The efforts of 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.

Examples of some of BNL's 2005 P2 accomplishments include:

- Since 2002, the hydraulic lift bays in the motor pool have been using a biobased hydraulic oil as part of a P2-funded initiative, after an underground hydraulic line leaked petroleum-based oil, which required excavation and remediation. During 2005, a leak involving biobased oil developed in one of the underground hydraulic lines of an adjacent bay. Samples were collected and the impacted soil was found to be as much as 10 feet below grade (yet well above groundwater levels). The authorizing regulatory agencies approved a plan to allow the oil to biodegrade in place. The underground pipes were abandoned and replaced with aboveground piping. The permission to use biodegradation and "abandonment in place" saved the Laboratory approximately $20,000 in excavation, manpower, and waste management costs.
- Several jointly funded P2 projects greatly decreased both environmental and safety risks to the Laboratory. These projects included:
  - Removing the PCB rectifier and transformer from Building 901
  - Dismantling the Animal Bedding Facility Disposal System in Building 490
  - Demolishing and removing the Building 208 Hopper
  - Installing oil/water separators for the Vehicle Wash Facility at Building 649
  - The Collider Accelerator Department submitted a P2 proposal for an aerosol can disposal system. The disposal system punctures aerosol cans and collects the contents, allowing the cans to be recycled as scrap metal and avoiding the generation of hazardous waste. Due to the success of this disposal system, seven additional systems were purchased and distributed throughout the Laboratory.

Table 2-2 describes the P2 projects implemented through 2005 and indicates the number of pounds of materials reduced, reused, or recycled and the estimated cost benefit of each project. Also included in the table are additional recycling and waste reduction projects.

Implementation of pollution prevention opportunities, recycling programs, and conservation initiatives has significantly reduced both waste volumes and management costs. In 2005, these efforts resulted in more than $1 million in cost avoidance or savings and approximately 2.8 million pounds of materials being reduced, recycled, or reused.

BNL also has an active and successful solid waste recycling program, which involves all employees. In 2005, BNL collected more than 190 tons of office paper for recycling. Cardboard, bottles and cans, construction debris, motor oil, scrap metals, lead, automotive batteries, printer and toner cartridges, fluorescent light bulbs, drill press machine coolant, and antifreeze were also recycled. Table 2-3 shows the total number of tons (or units) of the materials recycled in 2005.

2.3.4.5 Water Conservation

BNL has a strong water conservation program in place that 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 cool-

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

Waste Description	Type of Project	Pounds Reduced, Reused, Recycled, or Conserved in 2005	Waste Type	Potential Cost for Treatment and Disposal	Cost of Recycle, Prevention	Estimated Cost Savings	Project Description Details
Aerosol Can Disposal System	Recycling	66	Hazardous Waste	$991	$1,700	$991	Allows spent aerosol cans to be recycled scrap metal rather than sent to Waste Management Division as hazardous waste.
Formaldetox	Source Reduction	128	Industrial Waste - Lab Pack	$2,120	$1,040	$2,120	Neutralizes nonhazardous para-formaldehyde, bleach, and rat blood.
Replacement of IO Mercury Thermometers	Substitution	20	Mercury	$2,350	$250	$2,350	Approximately 20 lbs of mercury-containing thermometers were removed from 10 laboratories during 2005. Savings are based on the cost of one mercury spill and cleanup.
Replacement of PO Mercury Thermometers	Substitution	30	Mercury	$2,350	$450	$2,350	Approximately 30 lbs of mercury-containing thermometers were removed from Physics laboratories during 2005. Savings are based on the cost of one mercury spill and cleanup.
Photon Counting Spectroflurometer	Substitution	54	2 ft^3 of Mixed Waste and 1000 Man-hours	$10,540	$46,350	$25,540	Eliminated the need for radioactive assays and the subsequent generated radioactive waste. Cost savings include 1,000 man-hours and savings on material costs.
Replacement of Mercury Utility Devices	Substitution	120	Mercury		$12,000	$2,350	Approximately 120 lbs of mercury-containing devices were removed from utility devices during 2005. Savings are based on the cost of one mercury spill and cleanup.
Animal Bedding Conveying System Dismantling*	Recycling	2,000	250 ft^3 of Low-Level Radioactive Waste	$38,974	$5,000	$38,974	Multi-year/multiple department-funded initiative that will eliminate low-level radioactive waste and provide a safer work environment in the Medical Department.
PCB Transformer Carcuss Removal	Removal	4,000	High-Level Risk to the Laboratory		$6,251	$6,000	Final stage of a multi-year/multiple department-funded initiative to eliminate electrical components which were PCB contaminated.
Recovery of CFC R-113 from Building 511 Chiller	Substitution	490	Class 1 Ozone Depleting Substances (ODS)	$4,250	$500	$3,750	Recovery and reuse by another DOE facility of 490 lbs of R-113 (a Class 1 ODS).
Halogen 1211 Fire Extinguisher Substitution*	Substitution	1,700	Halogenated Ozone Depleting Substances (ODS)		$10,000	$6,250	Halogen 1211 removed from service and replaced with non-ozone depleting substances.

(continued on next page)

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

Waste Description	Type of Project	Pounds Reduced, Reused, Recycled, or Conserved in 2005	Waste Type	Potential Cost for Treatment and Disposal	Cost of Recycle, Prevention	Estimated Cost Savings	Project Description Details
EP Grounds Vehicle Wash*	Waste Minimization	8,000	Oils/Grease to Soils	$16,000	$3,000	$16,000	Multi-year/multiple department-funded initiative that will eliminate the potential of oil and grease being released to soil.
208 Hopper Demolition	Recycling	12,000	Legacy Waste and Safety Risk to Laboratory	$12,000	$8,100	$4,000	Multiple department-funded initiative that eliminated a potential legacy waste and a severe safety concern.
Laboratory-Wide Earth Day Mercury Disposal Amnesty	Removal	30	Mercury		$6,000	$2,350	Approximately 30 lbs of mercury-containing waste were removed from use during this 2005 amnesty program. Savings are based on the cost of one mercury spill and cleanup.
Automotive Waste	Substitution	510	Hazardous Waste	$1,061	$0	$1,000	In 2004, solvent-based brake cleaners were replaced, reducing the hazards associated with their use and disposal.
Mercury Utility Devices	Substitution	60	Mercury	$1,750	$0	$1,750	Approximately 60 lbs of mercury-containing devices were removed from Buildings 463 and 490 in 2004. Savings are based on the cost of one mercury spill and cleanup in 2004.
PCB Oils	Retrofill	1,200	Hazardous Waste	$2,850	$0	$2,850	Approximately 150 gal of PCB-laden oil were removed from the ATF Klystron in 2004. Savings are based on the cost of one PCB spill and cleanup.
Organic Solvents	Substitution	678	Hazardous Waste	$1,410	$0	$26,000	Life Sciences purchased a Microwave Peptide Synthesizer in 2004 to significantly reduce the amount of hazardous wastes generated. Saves approximately 1,000 work hours/year (reflected in cost savings).
Organic Solvents	Purification/ Reuse	480	Hazardous Waste	$998	$0	$10,915	The implementation of the BES solvent purification system in 2004 replaces the need to purchase new solvent.
Cooling Water	Reuse	80,000	Deionized water	$0	$0	$10,000	A closed-cycle water recycling system for the Building 480 melt spinner was purchased in 2004. This saves a minimium of 10,000 gal of ultra-pure water and extends the life expentancy of equipment worth $100,000.
PCB Oils	Removal	3,110	Hazardous Waste	$6,469	$0	$2,850	In 2004, approximately 300 gal of pure PCB oil were drained from the transformer and rectifier in Building 901 (former PET Facility). Also removed were 30 PCB capacators and 11 PCB transformers. Savings are based on the cost of one PCB spill and cleanup.
Mercury Utility Devices	Substitution	40	Mercury	$2,350	$0	$2,350	The Occupational Medical Center replaced mercury-containing equipment with non mercury-containing equipment in 2004. Savings are based on the cost of one mercury spill and cleanup.
Radioactive Waste	Source Reduction	1,500	Radioactive Waste	$6,000	$0	$6,000	A sorting table was purchased in 2003 for the Waste Yard to sort clean waste from radioactive waste.

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

Waste Description	Type of Project	Pounds Reduced, Reused, Recycled, or Conserved in 2005	Waste Type	Potential Cost for Treatment and Disposal	Cost of Recycle, Prevention	Estimated Cost Savings	Project Description Details
Radioactive Emissions	Emission Reduction	0	Radioactive Emissions			$0	A shroud was installed over the 16-inch diameter shaft in the Hot Cell of the BLIP, isolating cooling water from the rapidly moving air of the exhaust system and allowing radiological decay within the water system. Slowing the diffusion into the hot cell air will effectively reduce gaseous emissions into the exhaust stack, as these radionuclides have very short half lives.
Radioactive Waste generated through wet chemistry	Waste Minimization	30	Mixed Waste and Liquid Radioactive Waste	$17,600	$0	$22,500	The purchase of a Kinetic Phosphorescence Analyzer (KPA) system for uranium analysis eliminated mixed waste generation in this chemistry laboratory, reduced the volume of liquid waste by 90 percent, reduced the amount of radioactive material handled by 90 percent, minimized exposure to uranium by laboratory personnel, and decreased labor time by 75 percent.
Radioactive Waste from labeled chemicals	Waste Minimization/ Volume Reduction	0	Solid Radioactive Waste	$2,168	$0	$2,168	A vial crusher for glass vials, pipettes, and other glassware was purchased to reduce volume of radioactive waste.
Radioactive and Mixed Wastes from radio-labeled chemicals	Waste Minimization	112	Mixed Waste	$27,690	$0	$27,690	A microplate scintillation counter was purchased to to reduce mixed waste generation.
Pump Oil	Substitution	51	Hazardous Waste and Industrial Waste	$3,520	$0	$3,520	Oil-displacement pumps were replaced with dry pumps for both laboratory and aircraft missions.
Photographic Waste	Substitution	3,840	Hazardous Waste and Industrial Waste	$7,600	$0	$16,489	A photographic processor reduced the amount of chemicals used and waste generated by up to 80 percent.
Electrophoretic Mini-Gels	Microscale Chemical Use	2,200	Hazardous Waste - Lab Pack	$10,576	$0	$10,576	This system minimizes silver waste from silver-staining electrophoretic mini-gels. Savings reflect avoided waste disposal costs and lower material purchase costs ($6,000).
Hydraulic Oil	Product Substitution	3,000	Industrial Waste	$26,000	$0	$26,000	Hydraulic lift bays in the Motor Pool Shop were retrofitted to vegetable-based hydraulic oil in 2002. During 2005, an underground hydraulic pipe leak occured. The hydraulics were re-piped above ground and the oil was allowed to biodegrade in place.

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

Waste Description	Type of Project	Pounds Reduced, Reused, Recycled, or Conserved in 2005	Waste Type	Potential Cost for Treatment and Disposal	Cost of Recycle, Prevention	Estimated Cost Savings	Project Description Details
Sewage Sludge	Volume Reduction	122,570	Radioactive Waste	$232,080	$0	$226,480	Disposal of radioactive Sewage Treatment Plant liquid waste would cost $15.16/gal. Instead, the waste is dried using rolloffs, absorbent, and lime realizing a 96 percent volume reduction. The waste is then shipped to a disposal facility in drums or rail cars.
Film and other radioisotopic imaging	Substitution	300	Hazardous Waste and Industrial Waste	$22,000	$0	$22,000	Replacement of film-based autoradiography and other radioisotopic imaging with a Phosphor Imager reduced hazardous waste generation by 200 lbs and industrial waste generation by 100 lbs. Additional projected savings are in annual supply costs and labor reduction.
Digital Imaging System	Substitution	282	Hazardous Waste, Radioactive Waste, and Industrial Waste	$25,000	$0	$25,000	Reduction of hazardous (134 lbs), radioactive (80 lbs), and industrial (68 lbs) waste with installation of a digital imaging system. Additional projected savings are in annual supply costs and labor reduction.
Fluorescence-Based Assay	Substitution	200	Mixed Waste	$30,550	$0	$30,550	Development of a fluorescence-based assay for the DNA-dependent protein kinase (DNA-PKcs), replacing the 32P assay.
Lead Acid Batteries	Recycled	9,200	Hazardous Waste	$19,136	$0	$19,136	Estimate 40 lbs/battery and avoided disposal costs as hazardous waste.
Ion Exchange Wastewater	Source Reduction	1250	Hazardous and Sanitary Wastewater	$2,600	$100	$2,500	Prefilters, added to the deionization system, polish makeup water entering the ion exchange system. This extends the useful life of the ion exchange resins, requiring less frequent regeneration. The regeneration process generates hazardous and sanitary waste. There is a small annual cost for replacement supplies.
Smoke Detectors	Source Reduction	513	Mixed Waste	$112,039	$10,650	$101,389	In 2005, 171 Americium smoke detectors were removed from service, returned to the manufacturer, and replaced with non-rad detectors. This ongoing project reduces the risk of americium being released to the environment and avoids eventual disposal as mixed waste.
Cooling Water	Reuse	6,800	Radioactive Waste	$16,266	$0	$16,266	Approximately 850 gal (6,800 lbs) of cooling water were reused in the main magnet cooling water system, avoiding disposal as radioactive waste water.
Short Half-life Waste	Decay in Storage	25	Radioactive Waste	$2,308	$0	$2,308	Short half-life isotopes, particularly phosphorus-32 and phosphorus-33, are frequently used in Life Sciences Department experiments. In 2005, wastes from these operations (6 ft^3) were managed in accordance with BNL decay-in-storage requirements, rendering the wastes eligible for volumetric release.

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

Waste Description	Type of Project	Pounds Reduced, Reused, Recycled, or Conserved in 2005	Waste Type	Potential Cost for Treatment and Disposal	Cost of Recycle, Prevention	Estimated Cost Savings	Project Description Details
Lubricating Oil	Energy Recovery	4,000	Industrial Waste	$8,320	$500	$8,000	In 2005, approximately 4,000 lbs (500 gal) of lubricating oils were collected, tested for suitable use as waste oil fuel, and used for energy production at the Central Steam Facility. Avoided disposal cost was $8,000. Cost of testing ($500) was offset by fuel use savings ($1.00/gal).
Cooling Tower Chemicals	Source Reduction	6,375	Industrial Waste	$15,000	$0	$15,000	In 2001, ozone water treatment units were installed on cooling towers at two RHIC experiments to provide 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/ Reused	31,120	Industrial Waste	$68,630	$0	$75,030	Central Shops Division operates a recycling system that reclaims Blasocut machining coolant and supplies it Laboratory-wide. In 2005, 3,890 gal (31,120 lbs) of Blasocut lubricant were recycled. Recycling involves aeration, centrifuge, and filtration. This avoids cost of disposal as industrial waste, plus an avoided cost of the procurement of 8 drums of concentrate ($800/drum) and 78 drums for waste ($50/drum).
Used Motor Oil	Energy Recovery	34,560	Industrial Waste	$75,785	$0	$83,370	Used motor oil from the motor pool and the on-site gas station is picked up by Strebel's Laundry Service free-of-charge and used to fire their waste oil dryers. In 2005, 4,320 gal of oil were picked up, avoiding cost for disposal and 87 drums for shipping ($50/drum).
Office Paper	Recycling	388,000	Sanitary Waste	$19,400	$0	$19,400	Estimate $100/ton for disposal as trash.
Cardboard	Recycling	314,000	Sanitary Waste	$15,700	$0	$15,700	Estimate $100/ton for disposal as trash.
Scrap Metal	Recycling	1,122,000	Sanitary Waste	$56,100	$0	$56,100	Estimate $100/ton for disposal as trash.
Bottles/Cans	Recycling	42,000	Sanitary Waste	$2,100	$0	$2,100	Estimate $100/ton for disposal as trash.
Construction Debris	Recycling	578,000	Sanitary Waste	$13,005	$0	$13,005	Estimate $45/ton for avoiding disposal as trash.
	TOTAL	2,786,644		$943,584	$111,891	$1,018,966	

* Cost savings of projects funded by the BNL Pollution Prevention Council are tracked for three years.

Table 2-3. BNL Recycling Program Summary.

Recycled Material	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Mixed paper	220	106	196	204	370	336	246	209	182	185	193
Cardboard	85	101	103	97	124	132	127	157	176	179	143
Bottles/Cans	11	15	21	22	21	20	29	19	23	22	22.1
Tires	11	17	18.6	11.5	15.2	0	0	3.5	12.3	11	12.8
Construction debris	627	837	799	527	352	243	289	304	334	367	350
Used motor oil (gallons)	3,350	4,275	4,600	3,810	3,570	3,295	3,335	1,920	3,920	3,860	4,590
Metals	153	158	266	64	47	534	38	48	193	128	559
Lead	–	–	4.4	3.7	0.7	2.5	0	0	–	5	0
Automotive batteries	0.72	6.8	4.3	2.1	1.1	2.2	4.8	6.3	4.6	5	4.6
Printer/Toner cartridges (units)	–	–	–	1,480/175	1,575/510	–	363	449	187	105	0
Fluorescent bulbs (units)	–	13,664	12,846	867	25,291	5,874	17,112	25,067	13,611	12,592	7,930
Blasocut coolant (gallons)	–	–	–	–	3,575	7,500	10,660	8,180	5,030	6,450	3890
Antifreeze (gallons)	–	55	276	448	145	110	200	0	165	325	0
Tritium exit signs (each)	–	–	–	–	–	185	190	28	181	142	0
Smoke detectors	–	–	–	–	–	–	171	40	0	0	0
Road base	–	–	–	–	–	–	–	2,016	0	2,666	0
Scrap electronics	–	–	–	–	–	–	–	–	–	–	6.1

Notes:
All units are tons unless otherwise noted.
– Denotes not recycled in that year or data not available.

ing towers. The goal is to reduce the consumption of potable water and reduce the possible impact of clean water discharges on Sewage Treatment Plant operations. Figure 2-2 shows the 10-year trend of water consumption. As of 2005, BNL has used less than half as much water as was used in 1996—over 700 million gallons less.

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 possible. The group is responsible for developing, implementing, and coordinating BNL's Energy Management Plan (2003a).

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 2005, the Laboratory used approximately 289 million kilowatt hours (kWh) of electricity, 4.4 million gallons of fuel oil, 40 thousand gallons of propane, and 40 thousand ft^3 of natural gas. Fuel oil and natural gas produce steam at the Central Steam Facility (CSF). Due to market conditions, fuel oil was predominately used in 2005, resulting in a cost savings of approximately $1,144,000. See additional information on natural gas and fuel oil use in Chapter 4.

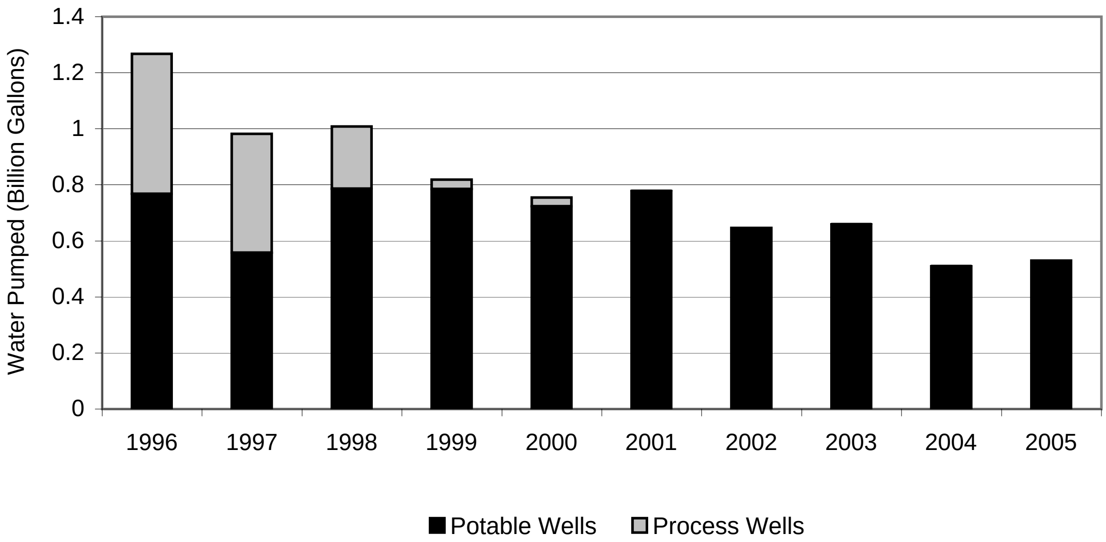

Figure 2-2. BNL Water Consumption Trend.

BNL is a participant in the Long Island Power Authority's (LIPA) Peak Load Reduction Curtailment Program. Through this program, the Laboratory has agreed to reduce electrical demand during critical days throughout the summer when LIPA expects customer demand to meet or exceed the company's available supply. In return, BNL receives a rebate for each megawatt reduced on each critical day. In 2005, participation in this program produced a rebate of $4,000 even though LIPA did not need to call a critical day in 2005. The Laboratory's participation is significant to LIPA: BNL's portion represents more than 10 percent of the 95+ MW load-curtailment program total, making the Laboratory one of the larger program contributors. BNL also agreed to keep electric loads at a minimum during the summer, in part by curtailing operations at the Relativistic Heavy Ion Collider (RHIC). This scheduling allowed the Laboratory to save more than $2 million in electric costs.

BNL also maintains a contract with New York Power Authority (NYPA) that resulted in an overall cost avoidance of $16 million in 2005. Participation in NYPA's 2005 load curtailment effort produced savings of over $2 million. BNL will continue to seek alternative energy sources to meet its future energy needs, support federally required "green" initiatives, and reduce energy costs.

In 2005, a project to install a solar heating system for the BNL swimming pool was initiated. This small project is a first step toward meeting the Laboratory's energy needs with renewable sources. Also in 2005, several other energy related accomplishments included:

- Several activities were undertaken to reduce energy use at non-research facilities (e.g., replacement of inefficient chiller, demand control, lighting upgrades, etc.).
- Obtained the Energy Star designation for the DOE Brookhaven Site Office. To qualify, a building must meet specific standards for thermal comfort, indoor air quality, and lighting. In addition, a building must be in the top 25 percent for energy performance of similar existing buildings of its type and size.
- BNL is evaluating several buildings on site to determine if they meet the qualification criteria of use, size, and metering for Energy Star Buildings consideration as well as Leadership in Energy and Environmental Design (LEED) certification, the recognized standard for measuring building sustainability. The LEED "green" building rating system is designed to promote design and construction practices that increase profitability while reducing negative environmental impacts and improving occupant health and well-being. The Laboratory's Research

Support Building and the Center for Functional Nanomaterials, both under construction, were registered for LEED certification.

- BNL participated in LIPA's Peak Load Reduction Curtailment Program during the summer, as previously discussed. This was the 17th consecutive year of participation.
- Nearly 34,000 gge (gas gallon equivalents) of natural gas were used in place of gasoline for the Laboratory's vehicle fleet.

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. These are very aggressive goals, and go significantly beyond the previously set goals of the 30 percent reduction by 2005 compared to 1985. BNL's energy use per square foot in 2005 was 27.6 percent less than in 1985 (see Figure 2-3) and 6 percent less than 2003. It is important to note that energy use for buildings and facilities at BNL 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 U.S. Fish & Wildlife Service, the Upton Ecological and Research Reserve Technical Advisory Group, and the Foundation for Ecological Research in the Northeast. 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. For more information about these programs, see Chapter 6.

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 (see http://www.epa.gov/superfund/sites/npl/ny.htm).

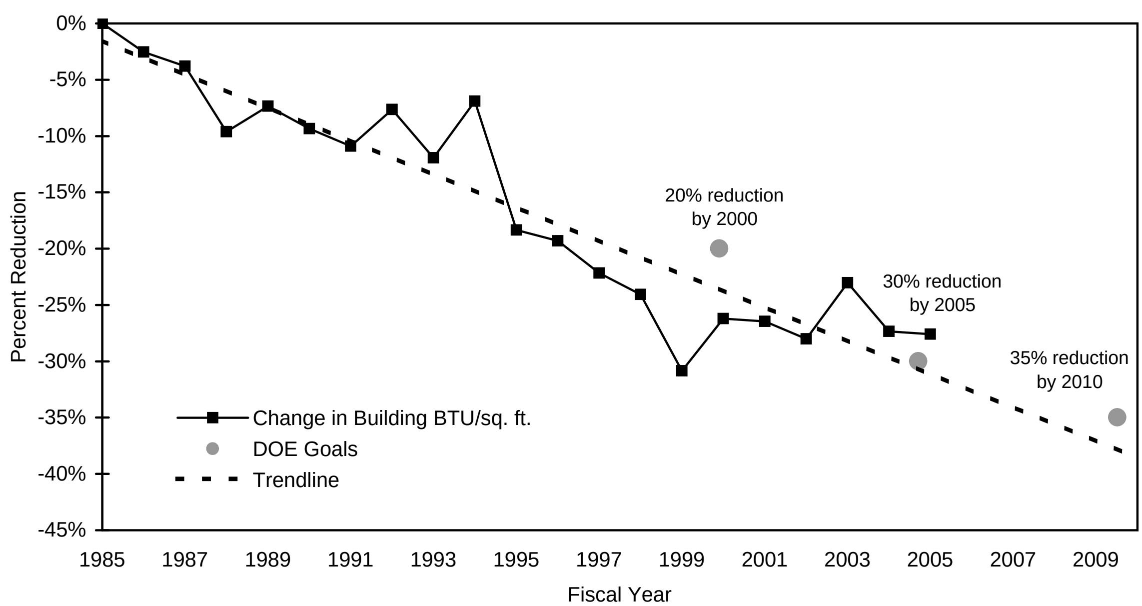

Figure 2-3. BNL Building Energy Performance, 1985 – 2010.

Each step of the CERCLA cleanup process is reviewed and approved by DOE, EPA, and NYSDEC, under an Interagency Agreement contract. This agreement was formalized in 1992. 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 list and evaluate Remedial Action alternatives and present the proposed best alternative
- Issue a Record of Decision (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

Significant progress was made in environmental restoration in 2005, highlighted by the completion of remedial activities at the Peconic River, Former Hazardous Waste Management Facility, and Waste Concentration Facility. Construction of the Strontium-90 Groundwater Treatment System, the last major groundwater treatment system scheduled for construction, was also completed. In addition, the final record of decision for the end state of the BGRR was completed. The success of the accomplishments was recognized with a celebration attended by community and political stakeholders, and marked a turning point for BNL into its planned operation, maintenance, and monitoring program. Table 2-4 provides a description of each operable unit and a summary of environmental restoration actions taken. See Chapter 7 and SER Volume II, Groundwater Status Report, for further details.

2.3.4.9 EPA Performance Track Program

BNL was accepted into the EPA's Performance Track (PTrack) Program in 2004. The 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 program currently has approximately 400 members nationwide.

The PTrack Program requires that sites commit to several improvement goals for a 3-year period and report on the progress of these goals annually. Below is a brief description of the goals and the progress for 2005.

- *Increase BNL's land and habitat conservation.* To date, the Laboratory has recovered a total of 26 acres of land, including 10 acres restored to native vegetation in 2005. This was accomplished by recovering areas where World War II structures had been demolished, and identifying additional acreage to be placed in "no mow" situations, to enable the gradual recovery to native forest vegetation. Additionally, BNL environmental biologists identified a 15-acre plot to be treated with prescribed fire to improve the health of the forest. The prescription for the burn was approved and all preparations were completed. However, due to poor weather conditions, the burn could not be carried out as scheduled. The prescription will be attempted again in 2006.
- *Reduce Radioactive Air Emissions*. In 2005, the Laboratory made significant progress in achieving a PTrack commitment to reduce radioactive air emissions from the Brookhaven Linac Isotope Producer (BLIP) 30 percent by 2006. Construction and testing of a Lucite enclosure was completed in 2005. The objective of the enclosure was to minimize evaporative and gaseous losses from the beam interactions with the target cooling water. A performance test was conducted in March 2005 to evaluate the enclosure's effectiveness. The emissions data confirmed that the overall reduction in emissions ranged between 29 and 35 percent under normal operating conditions.

Table 2-4. Summary of BNL 2005 Environmental Restoration Activities.

Project	Description	Environmental Restoration Program Actions
Soil Projects	OU I OU II OU VII	▪ Mobilized contractor and completed the soil remediation at the former Hazardous Waste Management Facility. ▪ Mobilized the contractor and completed the underground storage tank removal and soil remediation at the Waste Concentration Facility. ▪ Submitted the Operable Unit (OU) I Soils and OU V Long-Term Monitoring and Maintenance Plan to the regulators for review.
Groundwater Projects	OU III	▪ Began operations of an on-site strontium-90 (Sr-90) groundwater treatment system for the Brookhaven Graphite Research Reactor (BGRR)/Waste Concentration Facility groundwater plume. This is the last of the treatment systems to be constructed. ▪ Continued operations of all groundwater treatment systems on and off site that treat volatile organic compounds (VOCs) and Sr-90. ▪ Three groundwater treatment systems began pulse pumping due to low VOC concentrations in the groundwater near the pumping wells. Two systems remained in standby mode. ▪ Performed two applications of the oxidizer potassium permanganate to degrade VOC contamination at the Building 96 groundwater plume. The regulators approved a Petition for Shutdown of the fourth Building 96 groundwater treatment system extraction well. The well was placed on standby in June; however, it was restarted in October due to a rebound in VOC concentrations. Alternative remediation methods may be evaluated. ▪ Continued monitoring of the High Flux Beam Reactor (HFBR) tritium plume. ▪ An Explanation of Significant Differences (ESD) to the OU III Record of Decision (ROD) was signed by DOE and the regulators. The ESD selected active treatment of the Magothy aquifer VOC contamination, changes to the overall cleanup timeframe for the Sr-90 plumes, and documented the need for no further action for Building 96 anomalies. ▪ Began preparation of a Focused Feasibility Study for submittal to the regulators in 2006. ▪ During 2005, 1.8 billion gallons of groundwater were treated and 472 pounds of VOCs were removed. Since the first groundwater treatment system started operating in December 1996, approximately 5,280 pounds of VOCs have been removed from more than 10.1 billion gallons of groundwater.
	OU IV	▪ Continued groundwater monitoring.
	OU VI	▪ Continued operation of a groundwater treatment system to treat ethylene dibromide that has migrated beyond BNL property in Manorville.
	Groundwater Monitoring	▪ Completed the BNL 2004 Groundwater Status Report. ▪ Collected and analyzed 2,282 groundwater samples from 739 monitoring wells. ▪ Updated the Environmental Monitoring Plan. ▪ Submitted the draft sitewide Five-Year Review Report to the regulators for review.
Peconic River	OU V	▪ Completed the Phase 1 on-site remediation of the Peconic River. ▪ DOE and EPA signed the ROD. ▪ Completed the Phase 2 off-site remediation of the Peconic River. ▪ Began long-term post-cleanup monitoring.
Reactors	BGRR	▪ DOE and EPA signed the ROD. ▪ Completed the partial removal of the belowground-duct primary liner. ▪ Completed the removal of the BGRR canal. ▪ Completed the remediation of accessible pockets of deep soil contamination.
	HFBR	▪ Continued long-term surveillance and maintenance activities. ▪ Continued legacy waste disposal.
	BMRR	▪ The surveillance and maintenance activities at the Brookhaven Medical Research Reactor (BMRR) was transitioned from the Environmental Restoration Group to to Environmental and Waste Management Services Division in 2005. ▪ Continued surveillance and maintenance activities at the BMRR. ▪ Disposed of 12 plates (Janus Plates) of low-enriched uranium. ▪ Removed and disposed of approximately 2,000 gallons of tritiated primary coolant water.

- *Reduce BNL's use of ozone-depleting substances (ODS), specifically Class I ODS.* In 2005, BNL continued its commitment to reduce the amount of ODS used at the Laboratory. The 2003 baseline inventory of Class I ODS was revised by BNL in 2005 to include Halon 1211. In 2003, there were 455 portable extinguishers on site, containing 7,707 pounds of Halon 1211; another 50 pounds of Halon 1211 were held in stock to replenish discharged extinguishers.

  Because Halon 1211 has an ozone depletion potential of 3.0, the 2003 baseline inventory was increased to 147,717 pounds of CFC-11 equivalent. By the end of 2005, BNL had reduced its ODS inventory by approximately 65,000 pounds (32.5 tons), exceeding the original proposed reduction of 30 tons. BNL will continue to reduce its reliance on Class I and II ODS in 2006.

  ODS reduction activities in 2005 also included: the recovery/reclamation of residual refrigerant from two chillers, one containing 490 pounds of CFC-113 and one containing 800 pounds of CFC-11, and the removal of 125 Halon 1211 portable extinguishers from service.

  BNL's long-term goal is to replace all of the Halon 1211 portable extinguishers by the end of 2010 with ABC dry-chemical or with clean agent FE-36 extinguishers.
- *Reduce BNL's hazardous materials use.* BNL continued to revise its baseline inventory of mercury and mercury-containing devices in 2005 as new devices were located or identified. The total inventory subject to this commitment in 2005 was 499 pounds. Of the 499 pounds, 194 pounds were determined to be essential and 305 pounds nonessential. By the end of 2005, BNL had removed and recycled approximately 185 pounds of elemental mercury from the nonessential inventory, resulting in a remaining total inventory of 314 pounds. The removed devices included: 87 pounds of elemental mercury from a mercury vacuum pump, more than 450 mercury bulb thermometers, and numerous mercury-wetted relays—some with up to 0.5 pounds of mercury each.

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 a Roles, Responsibilities, Accountabilities, and Authorities document signed by the employee, his or her supervisor, and the supervisor's manager. BSA has clearly defined expectations for management and staff which must be included in this document. Under the BSA performance-based management model, senior management 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 the BNL's science and operations, including environmental stewardship and restoration activities, and to incorporate community input in the Laboratory's decision making.

BNL staff participate in on- and off-site meetings, which include discussions, talks, presentations, roundtables, workshops, canvassing, tours, informal information sessions, and formal public meetings held during public comment periods.

2.4.2.1 Communication Forums

To facilitate effective dialogue between BNL 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 with BNL and DOE. These meetings enable Laboratory and DOE representatives to update local, state, and federal elected officials and regulatory agencies regarding BNL's environmental and operational issues, as well as scientific discoveries and initiatives. The Community Advisory Council (CAC), established by BNL in 1998, advises the Laboratory Director on issues related to the Laboratory that are of importance to the community. The CAC is composed of approximately 30 member organizations representing business, civic, education, employee, community, and environmental and health organizations. The CAC meets monthly in sessions open to the public, and sets its own agenda in cooperation with the Laboratory.

BNL's Envoy Program educates employee volunteers regarding Laboratory issues and provides a link to local community organizations. Feedback shared by envoys helps the Laboratory gain a better understanding of local community concerns. The Speakers' Bureau provides speakers for educational and other organizations interested in BNL, and the Volunteers in Partnership Program supports employee volunteer efforts for charitable organizations. The Laboratory's Summer Sunday tours enable BNL to educate the public by featuring different facilities and program areas each week. In addition, the Laboratory hosts various events annually in celebration of Earth Day.

To keep employees and the community informed about the Laboratory's research, activities, and issues, including those related to the environment, BNL issues press releases; publishes *Laboratory Link*, a monthly update on BNL science and events; *the Bulletin*, a weekly employee newsletter; and *discover Brookhaven*, BNL's quarterly science magazine. The Laboratory maintains an informative website at http://www.bnl.gov, where these publications are posted, as well as information about BNL's science and operations, past and present. In addition, employees and the community can subscribe to the Laboratory's e-mail update service at http://lists.bnl.gov/mailman/listinfo/bnl-announce-1.

2.4.2.2 Community Involvement in Cleanup Projects

In 2005, significant progress was made toward completing several cleanup projects of importance to BNL stakeholders, as a result of their involvement in the decision making.

- A decision among DOE, EPA, and NYSDEC to remove more than 90 percent of the mercury and PCBs in the Peconic River sediment, both on and off site, was reached following extensive public participation. The plan included appropriate methods to clean up the river, measures for protecting environmentally sensitive areas of the river and sensitive species within the river, and measures for reestablishing river vegetation after the cleanup. Final cleanup plans incorporated much of the community's input on each of these issues, and all comments and concerns were responded to and made a part of the written public record.
- DOE, EPA, and NYSDEC agreed on a cleanup plan for the Brookhaven Graphite Research Reactor (BGRR). The plan includes the removal of the reactor pile and contaminated biological shield, accessible pockets of contaminated soil, and the fuel canal structure. The goal is to eliminate more than 99 percent of the radioactive contamination found in the complex. A long-term monitoring program will also be implemented. Stakeholders, including the CAC and a working group of community members, provided substantial input in the final decisions of the cleanup plan.
- Following extensive review by regulators and the public, a final decision was reached regarding the cleanup of strontium-90 (Sr-90) in groundwater on site and contamination in off-site portions of the Magothy aquifer. The primary concern of the community was adequate protection of human health and the environment, given

the length of time required for the cleanup process. The final document formalizing the decision was revised to include wording, suggested by community members, that requires DOE to continue searching for more effective and efficient cleanup methods, and to keep the community informed of the results through regular reviews and published reports.

The cleanup plans reached in 2005 put in place the systems to ensure the completion of high-priority environmental restoration projects on and around the Laboratory site, as required by a 1992 agreement among DOE, EPA, and NYSDEC. Working closely with elected officials, regulatory agency representatives, and community members, DOE and BNL openly shared information, extensively solicited input, and immediately provided feedback on how and when that input was used. To acknowledge these achievements, a community-wide cleanup celebration was held at the Laboratory in the fall of 2005.

2.4.3 Monitoring and Measurement

Effluents and emissions are monitored 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 what 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 450.1, Environmental Protection Program, BNL prepares an Environmental Monitoring Plan, Triennial Update (BNL 2003e), which outlines annual sampling goals by media and frequency. The plan uses the EPA Data Quality Objective approach for documenting the decisions assoc-iated with the monitoring program. In addition to the required triennial update, an annual electronic update is also prepared.

In 2005, there were 9,307 sampling events of groundwater, potable water, precipitation, air, plants and animals, soil, sediment, and discharges under the Environmental Monitoring Program, as shown in Table 2-5. Specific sampling programs for the various media are described further in Chapters 3 through 8.

There are three components to the Environmental Monitoring Program: 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 BNL'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.

Table 2-5. Summary of BNL 2005 Sampling Program Sorted by Media.

Environmental Media	No. of Sampling Events*	Purpose
Groundwater	2,282 ER 503 ES/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.
On-Site Recharge Basins	72	Recharge basins used for wastewater and stormwater disposal are monitored in accordance with discharge permit requirements and for environmental surveillance purposes. See discussion in Chapter 5.
Potable Water	41 ES 181 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 discussion in Chapters 3 and 7.
Sewage Treatment Plant (STP)	453	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 discussion in Chapters 3 and 5.
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 discussion in Chapter 4.
Air – Tritium	305	Silica gel cartridges are used to collect atmospheric moisture for subsequent tritium analysis. These data are used to assess environmental tritium levels. See discussion in Chapter 4.
Air – Particulate	461 ES/C 52 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 discussion in Chapter 4.
Air – Charcoal	53	Samples are collected to assess impacts from BNL operations and to facilitate reporting of emissions to regulatory agencies. See discussion in Chapter 4.
Fauna	65	Fish, deer, and small mammals are monitored to assess impacts on wildlife associated with past or current BNL operations. See discussion in Chapter 6.
Flora	12	Vegetation is sampled to assess possible uptake of contaminants by plants and fauna, since the primary pathway from soil contamination to fauna is via ingestion. See discussion in Chapter 6.
Soils	207	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	431	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	2,032	Samples are collected from groundwater treatment systems and as long-term monitoring after remediation completion under the Comprehensive Environmental Response, Compensation, and Liability Act program. The Laboratory had 14 operating groundwater treatment systems in 2005. See discussion in Chapter 7.
Vehicle Monitor Checks	250	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)	237	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 Sewage Treatment Plant (STP), recharge basins, and four process discharge sub-outfalls to the STP.
Flow Charts	555	Flowcharts are exchanged weekly as part of the Laboratory's SPDES permit requirements to report discharge flow at the recharge basin outfalls.
Floating Petroleum Checks	101	This test is performed on select petroleum storage facility monitoring wells to determine if floating petroleum products are present. The number of wells and frequency of this 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.

(continued on next page)

Table 2-5. Summary of BNL 2005 Sampling Program Sorted by Media *(concluded).*

Environmental Media	No. of Sampling Events*	Purpose
Radiological Monitor Checks	689	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)	317	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	9,307	This number includes all samples identified in the Environmental Monitoring Plan, as well as samples collected to monitor Environmental Restoration projects, air and water treatment system processes, and by the Environmental and Waste Management Services 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 sampling event is the collection of samples from a single georeferenced location. Multiple samples for different analyses (i.e., tritium, gross alpha, gross beta, and volatile organic compounds) can be collected during a single sample event.
C = Compliance
ER = Environmental Restoration
ES = Environmental Surveillance

- *Groundwater monitoring* is also performed in accordance with permit requirements. 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 ER Program, as required under the Records of Decision for many of the OUs or Areas of Concern (see Chapter 7 and SER Volume II, Groundwater Status Report, for details). Additionally, to ensure that the Laboratory maintains a viable potable water supply, groundwater is monitored as required by 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 and RCRA.

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. Followup monitoring of groundwater is conducted in accordance with a Record of Decision with regulatory agencies.

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 that 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 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. BNL 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 unprecedented knowledge of its potential environmental vulnerabilities and current operations due to programs such as the Facility Review Disposition Project, 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 BNL's compliance status, and pollution prevention projects have reduced costs, minimized waste generation, and reused and recycled significant quantities of materials.

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

BNL's EMS is viewed as exemplary within DOE. Due to external recognition of the Laboratory's knowledge and unique experience implementing the EMS program, several DOE facilities and private universities have invited BNL to extend its outreach activities and share its experiences, lessons learned, and successes. BNL'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 the Laboratory:

- The EMS has been strengthened, integrated with other BNL 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.
- BNL 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.

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 BNL's desire to balance world-class research with environmentally responsible operations.

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3

Compliance Status

Brookhaven National Laboratory is subject to more than 100 sets of federal, state, and local environmental regulations; numerous site-specific permits; 15 equivalency permits for operation of 12 groundwater remediation systems; and several other binding agreements. In 2005, 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, minor deficiencies were noted during inspections conducted by the New York State Department of Environmental Conservation.

Emissions of nitrogen oxides, carbon monoxide, and sulfur dioxide were all within permit limits. Numerous opacity excursions due to routine soot blowing occurred in the first three quarters of 2005. Efforts to eliminate these excursions were successful in the fourth quarter. Approximately 873 pounds of ozone-depleting refrigerants were recovered for recycling on site or made available for use by other DOE facilities or other federal agencies. In addition, one hundred twenty-five 17-pound Halon 1211 extinguishers were removed from service and will be made available to other DOE facilities. Monitoring of the Laboratory's potable water system showed that it met all drinking water requirements. During 2005, most of the liquid effluents discharged to surface water and groundwater met applicable New York State Pollutant Discharge Elimination System permit requirements. Ten minor excursions of these permit limits were reported for the year, eight at the Sewage Treatment Plant and two at recharge basins. The permit excursions were reported to the New York State Department of Environmental Conservation 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.

Fourteen reportable spills of petroleum products, antifreeze, or chemicals occurred on site in 2005. There were eight petroleum releases less than 5 gallons, one small-volume antifreeze spill, one 20-gallon release of No. 6 fuel oil from a delivery vehicle, two small-volume chemical releases, one outdoor release of a custodial chemical, and one finding of excrement in buckets along a road adjacent to the Laboratory boundary. All releases were cleaned up or addressed to the satisfaction of the New York State Department of Environmental Conservation.

The Laboratory underwent 11 environmental audits by external regulatory agencies in 2005. These audits included inspections of petroleum and chemical storage, air emissions from the Central Steam Facility, Sewage Treatment Plant operations, other regulated outfalls and recharge basins, and the potable water system. Immediate corrective actions were taken to address all issues raised during these inspections, and no formal violations or enforcement actions were issued.

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 regard to each requirement. 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 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
- Registration certificate from NYSDEC for tanks storing bulk quantities of hazardous substances
- Seven radiological emission authorizations issued by 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 39 facilities
- Three 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
- Fifteen equivalency permits for the operation of 12 groundwater remediation

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

Regulator: **Codified** Regulation	Regulatory Program Description	Compliance Status	SER 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 of inactive hazardous waste disposal sites.	In 1989, BNL entered into a tri-party agreement with EPA, New York State Department of Environmental Conservation (NYSDEC), and DOE. BNL site remediation is conducted by the Environmental Restoration Program in accordance with milestones established under this agreement.	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, that is the 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 decontaminating and decommissioning 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

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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	SER Report Sections
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.	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 10 excursions, these discharges met the SPDES permit limits in 2005.	3.6
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 & 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, BNL 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. SCDHS has safety codes that are more stringent than the 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. While almost all wastes are handled and disposed in accordance with federal and state requirements, two NYSDEC audits conducted in 2004 identified several concerns. These were immediately addressed by corrective actions. There were no inspections in 2005.	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(f) NYSDEC: 6 NYCRR 320 6 NYCRR 325–329	The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and corresponding NY State regulations govern the manufacture, use, storage, and disposal of pesticides 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

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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	SER Report Sections
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. During 2005, three projects were permitted under New York State programs.	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.	Eight additional species on the NYS list have been found at BNL, for a total of 38. In the "endangered" category are one insect, one amphibian, and one plant. In the "threatened" category are one insect, two fish, one bird, and two plants. Of "special concern" are one insect, two amphibians, four reptiles, and five birds. The remaining 16 species are vulnerable or rare plants. BNL's *Natural Resource Management Plan* outlines activities to protect species and protect their habitats.	3.13
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 DOE. Included in the order are the requirements for the Occurrence Reporting and Processing of Operations Program, known as ORPS.	BNL prepares an annual Site Environmental Report and provides data for DOE to prepare annual NEPA summaries and other Safety, Fire Protection, and OSHA reports. BNL 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 these additional documents: 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 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. DOE 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 radioactive wastes, both routine and nonroutine.	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. BNL'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

(continued on next page)

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

Regulator: **Codified** Regulation	Regulatory Program Description	Compliance Status	SER Report Sections
DOE: Order 450.1 (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 and 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.	BNL's EMS was officially registered to the ISO 14001:1996 Standard in 2001. Annual audits to maintain certification were done in 2002, 2003, and 2005. In June 2004, a recertification audit was conducted and BNL was found to conform to the ISO 14001: 2004 Standard. The BNL ISMS program description presents the Laboratory's approach to integrating environment, safety, and health requirements into the processes for planning and conducting work at BNL. It describes BNL's programs, including the Standards-Based Management System (SBMS), for accomplishing work safely and provides a road map of the systems and processes.	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

systems installed under the Inter-Agency Agreement (Federal Facility Agreement under the Comprehensive Environmental Response, Compensation and Liability Act [CERCLA] 120, Administrative Docket No. II-CERCLA-FFA-00201)

3.2.2 New or Modified Permits

3.2.2.1 SPDES Permits

The State Pollutant Discharge Elimination System permit authorizes discharges from the BNL Sewage Treatment Plant (STP) to the Peconic River, and discharges of cooling water and stormwater to recharge basins. A permit renewal was filed with NYSDEC in August 2004 and the renewal was approved in May 2005. The expiration date for the renewed permit is March 1, 2010. Most of the permit requirements are identical to those issued in February 2004. Chronic Toxicity Testing of the STP effluent at Outfall 001 (Figure 5-6) was also renewed in the permit.

Discharges of treated groundwater under the CERCLA program are also overseen by NYSDEC through the issuance of "SPDES equivalency" permits. The SPDES permits and equivalency permits that authorize the operation of the groundwater remediation systems are discussed in SER Volume II, Groundwater Status Report.

3.2.2.2 Air Emissions Permits

Air emissions permits are granted by NYSDEC. Permits are issued as "equivalency" permits for the installation and operation of groundwater remediation systems under CERCLA, or as changes to the BNL Title V operating permit. During 2005, no CERCLA air-equivalency permits were issued and no changes were made to the Laboratory's Title V operating permit.

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 BNL to comply with the applicable regulatory requirements.

3.2.2.3 Underground Injection Control Permit

Under the Safe Drinking Water Act (SDWA), BNL is required to maintain an Area Permit for

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	NA	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	W. South Boundary System	1-52-009	NA	NA	NA
NYSDEC - SPDES Equivalency	598	OU I Remediation System	1-52-009	31-Oct-06	NA	NA
NYSDEC - SPDES Equivalency	598	Tritium Remediation System	1-52-009	NA	NA	NA
NYSDEC - SPDES Equivalency	670	Sr-90 Treatment System	None	NA	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	1-Aug-09	NA	NA
NYSDEC - SPDES Equivalency	855	Sr-90 Treatment System-BGRR/WCF	None	1-Jan-10	NA	NA
NYSDEC - LI Well Permit	BNL	Domestic Potable/Process Wells	1-4722-00032/00113	13-Sep-08	NA	NA
NYSDEC - Air Quality	197	Lithographic Printing Presses	1-4722-00032/00115	06-Jan-07	U-LITHO	19709-10
NYSDEC - Air Quality	423	Metal Parts Cleaning Tanks	1-4722-00032/00115	06-Jan-07	U-METAL	42306-08
NYSDEC - Air Quality	423	Gasoline Storage & Fuel Pumps	1-4722-00032/00115	06-Jan-07	U-FUELS	42309-10
NYSDEC - Air Quality	423	Motor Vehicle A/C Servicing	1-4722-00032/00115	06-Jan-07	U-MVACS	MVAC1&2
NYSDEC - Air Quality	458	Paint Spray Booth	1-4722-00032/00115	06-Jan-07	U-45801	45801
NYSDEC - Air Quality	458	Flammable Liquid Storage Cabinet	1-4722-00032/00115	06-Jan-07	U-45801	458AA
NYSDEC - Air Quality	473	Metal Parts Cleaning Tank	1-4722-00032/00115	06-Jan-07	U-METAL	47302
NYSDEC - Air Quality	479	Metal Parts Cleaning Tank	1-4722-00032/00115	06-Jan-07	U-METAL	47906
NYSDEC - Air Quality	490	Milling Machine/Block Cutter	1-4722-00032/00115	06-Jan-07	U-49003	49003
NYSDEC - Air Quality	490	Lead Alloy Melting	1-4722-00032/00115	06-Jan-07	U-49003	49004
NYSDEC - Air Quality	498	Aqueous Cleaning Facility	1-4722-00032/00115	06-Jan-07	U-METAL	49801
NYSDEC - Air Quality	535B	Plating Tanks	1-4722-00032/00115	06-Jan-07	U-INSIG	53501
NYSDEC - Air Quality	535B	Etching Machine	1-4722-00032/00115	06-Jan-07	U-INSIG	53502
NYSDEC - Air Quality	535B	Printed Circuit Board Process	1-4722-00032/00115	06-Jan-07	U-INSIG	53503
NYSDEC - Air Quality	610	Combustion Unit	1-4722-00032/00115	06-Jan-07	U-61005	61005
NYSDEC - Air Quality	610	Combustion Unit	1-4722-00032/00115	06-Jan-07	U-61006	61006
NYSDEC - Air Quality	610	Combustion Unit	1-4722-00032/00115	06-Jan-07	U-61007	61007
NYSDEC - Air Quality	610	Metal Parts Cleaning Tray	1-4722-00032/00115	06-Jan-07	U-METAL	61008

(continued on next page)

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

Issuing Agency	Bldg or Facility	Process/Permit Description	Permit ID No.	Expiration or Completion	Emission Unit ID	Source ID
NYSDEC - Air Quality	610	Combustion Unit	1-4722-00032/00115	06-Jan-07	U-61005	6101A
NYSDEC - Air Quality	630	Gasoline Storage and Fuel Pumps	1-4722-00032/00115	06-Jan-07	U-FUELS	63001-03
NYSDEC - Air Quality	820	Metal Parts Cleaning Tank	1-4722-00032/00115	06-Jan-07	U-METAL	82001
NYSDEC - Air Quality	902	Epoxy Coating/Curing Exhaust	1-4722-00032/00115	06-Jan-07	U-COILS	90206
NYSDEC - Air Quality	903	Metal Parts Cleaning Tank	1-4722-00032/00115	06-Jan-07	U-METAL	90304
NYSDEC - Air Quality	919B	Electroplating Operation	1-4722-00032/00115	06-Jan-07	U-INSIG	91904
NYSDEC - Air Quality	922	Metal Parts Cleaning Tank	1-4722-00032/00115	06-Jan-07	U-METAL	92202-03
NYSDEC - Air Quality	922	Electroplating Operation	1-4722-00032/00115	06-Jan-07	U-INSIG	92204
NYSDEC - Air Quality	923	Electronic Equipment Cleaning	1-4722-00032/00115	06-Jan-07	U-METAL	9231A
NYSDEC - Air Quality	923	Parts Drying Oven	1-4722-00032/00115	06-Jan-07	U-METAL	9231B
NYSDEC - Air Quality	924	Magnet Coil Production Press	1-4722-00032/00115	06-Jan-07	U-INSIG	92402
NYSDEC - Air Quality	924	Vapor/Ultrasonic Degreasing Unit	1-4722-00032/00115	06-Jan-07	U-METAL	92404
NYSDEC - Air Quality	Site	Halon 1211 Portable Extinguishers	1-4722-00032/00115	06-Jan-07	U-HALON	H1211
NYSDEC - Air Quality	Site	Halon 1301 Fire Suppression Systems	1-4722-00032/00115	06-Jan-07	U-HALON	H1301
NYSDEC - Air Quality	Site	Packaged A/C Units	1-4722-00032/00115	06-Jan-07	U-RFRIG	PKG01-02
NYSDEC - Air Quality	Site	Reciprocating Chillers	1-4722-00032/00115	06-Jan-07	U-RFRIG	REC01-41
NYSDEC - Air Quality	Site	Rotary Screw Chillers	1-4722-00032/00115	06-Jan-07	U-RFRIG	ROTO1-07
NYSDEC - Air Quality	Site	Split A/C Units	1-4722-00032/00115	06-Jan-07	U-RFRIG	SPL01-02
NYSDEC - Air Quality	Site	Centrifugal Chillers	1-4722-00032/00115	06-Jan-07	U-RFRIG	CEN01-22
NYSDEC - Hazardous Waste	WMF	Waste Management	1-4722-00032/00102	12-Jul-05	NA	NA
NYSDEC - Natural Resources	AGS	Construction of AGS Storage Facility	1-4722-00032/00133	03-Jun-06	NA	NA
NYSDEC - Natural Resources	RHIC	Construction of New Recharge Basin	1-4722-00032/00129	17-May-04	NA	NA
NYSDEC - Natural Resources	RHIC	Construct 9C/7C Alcove Building	1-4722-00032/00137	08-Sep-08	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-07	NA	NA
NYSDEC - Water Quality	STP	Sewage Plant and Recharge Basins	NY-0005835	01-Mar-05	NA	NA

Notes:
AGS = Alternating Gradient Synchrotron
CSF = Central Steam Facility
EPA = Environmental Protection Agency
LIPA = Long Island Power Authority
NESHAPs = National Emission Standards for Hazardous Air Pollutants
NYSDEC = New York State Department of Environmental Conservation
NA = Not Applicable
OU = Operable Unit
REF = Radiation Effects Facility
RTF = Radiation Therapy Facility
RHIC = Relativistic Heavy Ion Collider
SDWA = Safe Drinking Water Act
STP = Sewage Treatment Plant
WMF = Waste Management Facility

underground injection control wells (e.g., drywells, cesspools, and leaching pools). The Laboratory received a final permit in January 2001, authorizing the operation of 90 UICs, including 86 stormwater drywells and four small sanitary systems. The only change to the UIC inventory in 2005 was the completed closure of a sanitary wastewater disposal system at Building 445, part of the former Hazardous Waste Management Facility.

UICs also are used to recharge treated groundwater. The Laboratory has 34 of these UICs, which are authorized by rule rather than permit. In 2005, BNL's inventory, on record with EPA, was unchanged.

3.2.2.4 RCRA Permit

In January of 2005, the Laboratory submitted to NYSDEC a RCRA permit renewal application for hazardous waste storage at the Waste

Management Facility. In accordance with regulations, the application was submitted at least 180 days before the existing permit expired. Until NYSDEC completes its review of the application, BNL continues to operate under the conditions of the existing permit, as allowed by the State Administrative Procedure Act.

3.3 NEPA ASSESSMENTS

The National Environmental Policy Act (NEPA) regulations require federal agencies to evaluate the effects of proposed major federal activities on the environment. The prescribed evaluation process ensures that the proper level of environmental review is performed before an irreversible commitment of resources is made. During 2005, environmental evaluations were completed for 186 proposed projects. Of these, 177 were considered minor actions requiring no additional documentation. The remaining nine projects were addressed by submitting notification forms to DOE, which determined that they were covered by existing Categorical Exclusions as per 10 CFR 1021 or fell within the scope of a previous environmental assessment. No new environmental assessments were required.

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 acts 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 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. In 2005, the Cultural Resource Management Plan for BNL was approved by DOE and submitted to the New York State Historic Preservation Officer.

The annual Department of Interior questionnaire regarding historic and cultural resources was completed and submitted in March 2005. Additional activities associated with legislated 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 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 2005, low nitrogen residual fuel oil (i.e., below 0.3 percent) was the predominant fuel burned in all four boilers. For boilers with maximum operating heat inputs greater than or equal to 50 MMBtu/hr (14.6 MW), the requirements establish emissions 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 using periodic emission tests or by using continuous emission monitoring equipment. Emission tests conducted in 1995 confirmed that BNL 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 2005 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 2005, NO_x emissions from Boilers 6 and 7 averaged 0.245 lbs/MMBtu and 0.180 lbs/MMBtu, respectively, and 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 2005, BNL reported 107 periods where opacity exceeded the 6-minute, 20 percent average due to soot blowing operations. In past years, soot blowing was considered by BNL to be a required maintenance activity and, as such, was understood to be allowed. However, a 2005 review of these operations by NYSDEC determined that each excursion was a deviation from the opacity limitation. The Laboratory approached the issue aggressively and by August had developed a procedure to prevent these excursions by resequencing the soot blowing cycle. From October to December 2005, the automatic monitoring equipment reported no opacity excursions due to soot blowing. During the year, other deviations from the opacity standard occurred during boiler startup and shutdown. Both EPA and NYSDEC recognize these periods as permissible.

3.5.1.2 Ozone-Depleting Substances

Refrigerants. 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 2005, approximately 400 pounds of R-11, 238 pounds of R-113, and 235 pounds of R-22 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 the CAA provisions.

In 2005, BNL declared one hundred twenty-five 17-pound Halon 1211 portable fire extinguishers as excess property. The Laboratory is making arrangements for their transfer to another DOE facility or to another federal agency, in accordance with the Class I Ozone Depleting Substances Disposition Guidelines of the DOE Office of Environmental Policy and Guidance. The portable extinguishers became excess property after they were removed from areas they served, due to changes in operations, or when they were replaced with ABC dry-chemical or with clean agent FE-36 extinguishers.

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 National Emission Standards for Hazardous Air Pollutants (NESHAPs) program was established in 1977 and the governing regulations were updated significantly in 1990. EPA developed this program to limit the emission of 189 toxic air pollutants. This 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

No proposed or promulgated Maximum Available Control Technology (MACT) standards apply to BNL operations, according to the Laboratory's review of existing state and federal CAA regulations during preparation of the Title V Phase II application. Additional evaluations conducted in 2005 determined that no MACT standards apply to the anticipated emissions from proposed activities or operations.

3.5.2.2 Asbestos

In 2005, the Laboratory notified the EPA Region II office regarding removal of materials containing asbestos. During the year, 1,015 linear ft of asbestos-containing pipe insulation, 8,355 ft^2 of asbestos-containing surface material (siding, roofing, and vinyl asbestos floor tile removed during demolition or renovation), and 160 yd^3 of bulk asbestos waste (generated during demolition of facilities) were removed and disposed of in accordance with EPA requirements.

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 residing at or near BNL. A full description of the monitoring conducted by BNL in 2005 is provided in Chapter 4. The Laboratory 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, in 2005 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. The dose to the hypothetical maximally exposed individual resulting from airborne emissions, calculated using EPA's modeling software, was 0.053 mrem (0.53 µSv).

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 and renewed that permit in May 2005. This permit provides monitoring requirements and specifies 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 for the discharge of the treated effluent from the 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. NYSDEC does not require BNL to monitor Outfalls 003, 011, and 012.
- 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. Reports are submitted directly to the NYSDEC central and regional offices and the Suffolk County Department of Health Services. Details of the monitoring program conducted for the groundwater treatment systems and SPDES equivalency permit performance are provided in SER Volume II, Groundwater Status Report.

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 this wastewater (settlement/sedimentation, biological reduction of organic matter, and reduction of nitrogen). Chapter 5 provides a detailed description of the treatment process.

A summary of the 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 2005, there were eight excursions of the SPDES permit limits: two each for total nitrogen and ammonia, and one each for iron, zinc, methylene chloride, and copper. Each of these excursions was investigated, as follows.

The Laboratory's SPDES limits were exceeded in February for ammonia and in February and March for total nitrogen. In March, copper was found in the effluent at a concentration of 0.16 mg/L, exceeding the permit limit of 0.15 mg/L. Investigation revealed that an out-of-service bypass valve had separated from the concrete wall of the primary clarifier effluent chamber, allowing untreated waste to bypass secondary treatment. The valve was removed and the penetration was sealed with concrete.

Methylene chloride was detected in the STP discharge in one of the two August samples.

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)	50	88	Daily	90	0	100
pH (SU)	6.2	7.8	Continuous Recorder	Min. 5.8	0	100
Avg. 5-day BOD (mg/L)	< 1	2.5	Twice Monthly	10	0	100
Max. 5-day BOD (mg/L)	< 2	4	Twice Monthly	20	0	100
% BOD removal	> 95	> 98	Monthly	85	0	100
Avg. TSS (mg/L)	< 0.3	< 1.7	Twice Monthly	10	0	100
Max. TSS (mg/L)	< 0.6	< 5.7	Twice Monthly	20	0	100
% TSS removal	> 95	> 99	Monthly	85	0	100
Settleable solids (ml/L)	0.0	0.0	Daily	0.1	0	100
Ammonia nitrogen (mg/L)	< 0.10	3.68 (a)	Twice Monthly	2	2	94
Total nitrogen (mg/L)	2.0	13.1 (b)	Twice Monthly	10	2	94
Total phosphorus (mg/L)	1.1	1.7	Twice Monthly	NA	0	100
Cyanide (mg/L)	< 2.5	< 5.0	Twice Monthly	100	0	100
Copper (mg/L)	0.017	0.16 (c)	Twice Monthly	0.15	1	97
Iron (mg/L)	0.06	0.41 (d)	Twice Monthly	0.37	1	97
Lead (mg/L)	< 0.001	0.005	Twice Monthly	0.019	0	100
Nickel (mg/L)	0.005	0.026	Twice Monthly	0.11	0	100
Silver (mg/L)	0.001	0.003	Twice Monthly	0.015	0	100
Zinc (mg/L)	0.019	0.15 (e)	Twice Monthly	0.1	1	97
Mercury (mg/L)	< 0.00005	0.0005	Twice Monthly	0.0008	0	100

(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*
Toluene (mg/L)	< 1.0	< 1.0	Twice Monthly	5	0	100
Methylene chloride (mg/L)	< 1.0	9.2 (f)	Twice Monthly	5	1	97
1,1,1-trichloroethane (µg/L)	< 1.0	< 1.0	Twice Monthly	5	0	100
2-butanone (µg/L)	< 2.0	< 5.0	Twice Monthly	50	0	100
PCBs (µg/L)	< 0.065	< 1.0	Quarterly	NA	0	100
Max. flow (MGD)	0.33	0.83	Continuous Recorder	2.3	0	100
Avg. flow (MGD)	0.24	0.57	Continuous Recorder	NA	0	100
Avg. fecal coliform (MPN/100 mL)	< 1	< 1	Twice Monthly	200	0	100
Max. fecal coliform (MPN/100 mL)	< 2	< 2	Twice Monthly	400	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
MGD = Million Gallons per Day
MPN = Most Probable Number
NA = Not Applicable
SU = Standard Unit
TSS = Total Suspended Solids
(a) Two composite samples, one collected in February and one in December, had concentrations of ammonia that exceeded permit limits.
(b) Two permit exceedances of the total nitrogen limits were reported, one in February and one in March.
(c) A single sample collected in March exhibited a copper concentration of 0.16 ppm, which exceeded the permit limit of 0.15 ppm.
(d) A single sample of iron collected in December exhibited a concentration of 0.41 ppm, which exceeded the permit limit of 0.37 ppm.
(e) A single sample of zinc collected in December exceeded the permit limit of 0.1 ppm, with a concentration of 0.15 ppm.
(f) A single sample of methylene chloride collected in August exhibited a concentration of 9.2 ppb, which exceeded the permit limit of 5.0 ppb

Please refer to Section 3.6.1 for an explanation of these permit exceedances.

No direct cause could be found; the detection may have been the result of error at the contract analytical laboratory. Methylene chloride is frequently detected in wastewater samples at concentrations up to 10 ppb, but in many cases the results are accompanied by notations indicating that methylene chloride was also detected in the analytical laboratory's control samples, or that the detection is estimated.

In December, deviations were recorded for zinc, ammonia, and iron. This release was the result of decanting more than typical volumes of water from the aerobic digesters. Although water is routinely released from the digesters back to the head of the treatment plant, the volume released in December was approximately 25 percent higher than usual. Testing of the digester showed the water to contain very high levels of iron and zinc. Figures 3-1 through 3-7 plot 5-year trends for the maximum 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's chronic toxicity testing program began in 1993 and continued through 2003. Toxicity testing was postponed in 2004, but was restarted in March 2005 as stipulated in the 2005 SPDES permit renewal. Under the WET testing provisions, samples are collected and tested quarterly. The program consists of 7-day chronic toxicity testing on two freshwater organisms, water fleas and fathead minnows. In each test, sets of 10 of these organisms are exposed to varying concentrations of the STP effluent (100, 50, 25, 12.5, and 6.25 percent) for 7 days. During testing, the growth rate of the fish and/or 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.

In 2005, toxicity tests were conducted in March, April, June, September, and December. During the test conducted in March, there was no toxicity exhibited in the minnow, but a high mortality in the water fleas, due to the

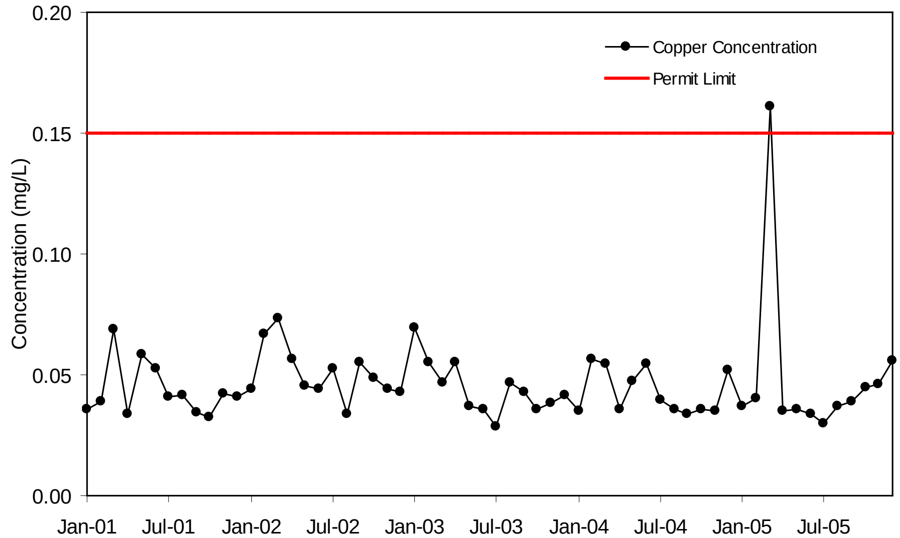

Figure 3-1. Maximum Concentrations of Copper Discharged from the BNL Sewage Treatment Plant, 2001–2005.

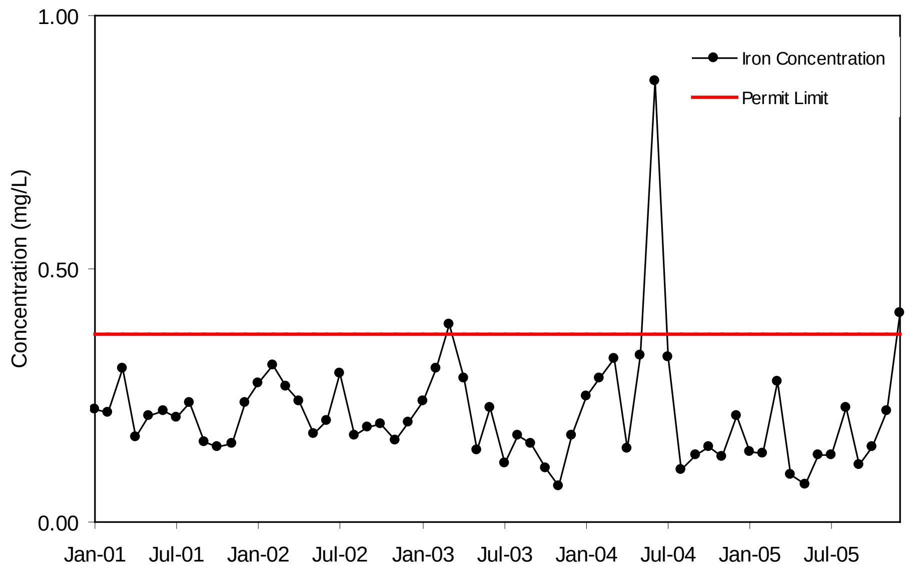

Figure 3-2. Maximum Concentrations of Iron Discharged from the BNL Sewage Treatment Plant, 2001–2005.

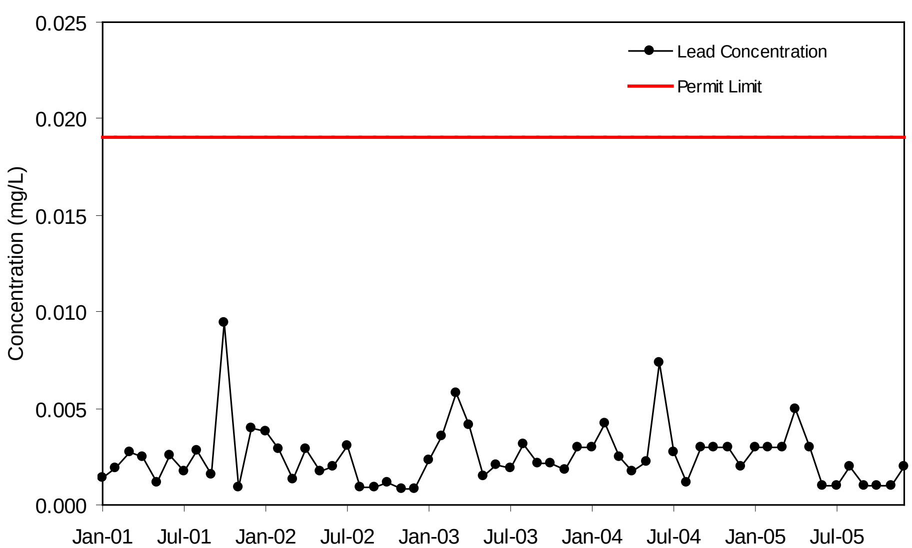

Figure 3-3. Maximum Concentrations of Lead Discharged from the BNL Sewage Treatment Plant, 2001–2005.

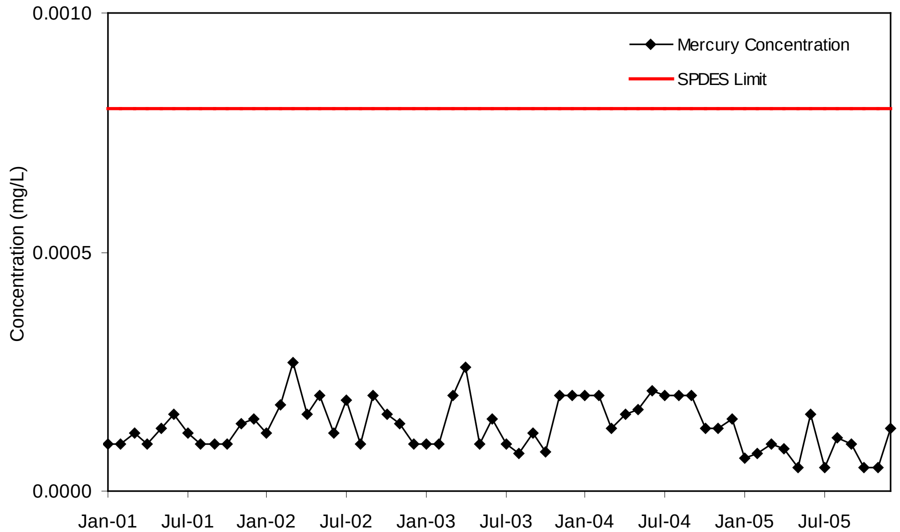

Figure 3-4. Maximum Concentrations of Mercury Discharged from the BNL Sewage Treatment Plant, 2001–2005.

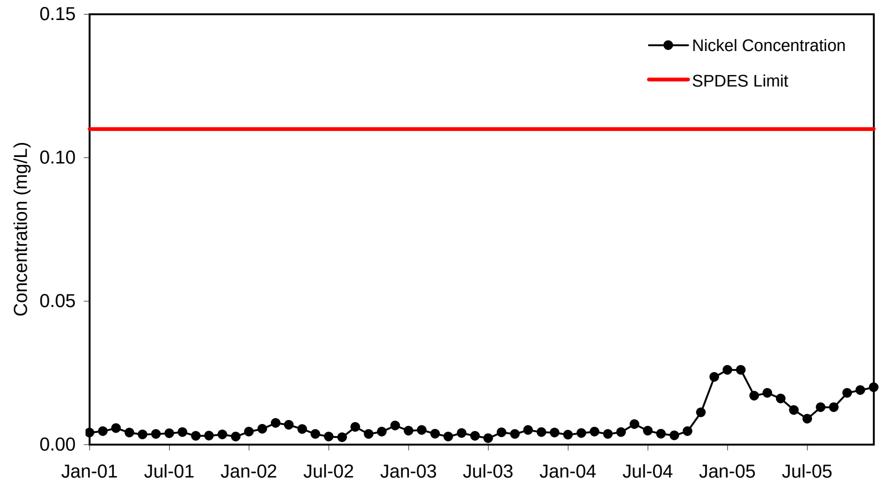

Figure 3-5. Maximum Concentrations of Nickel Discharged from the BNL Sewage Treatment Plant, 2001–2005.

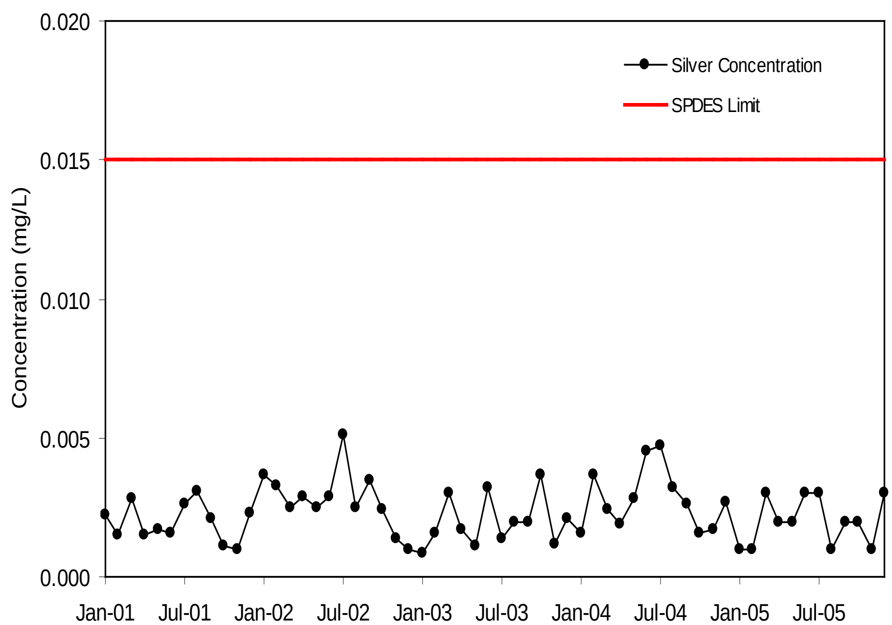

Figure 3-6. Maximum Concentrations of Silver Discharged from the BNL Sewage Treatment Plant, 2001–2005.

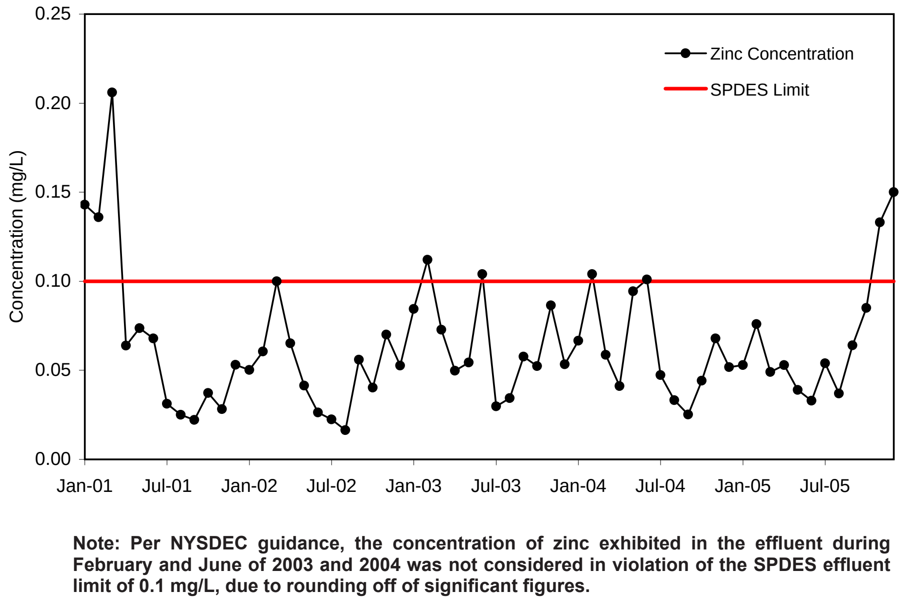

Figure 3-7. Maximum Concentrations of Zinc Discharged from the BNL Sewage Treatment Plant, 2001–2005.

elevated copper levels discussed above. Review of the results of tests conducted in April, June, and September showed minor impacts on the water flea reproduction rates. Tests conducted in December showed no impact. In December, water used in the test as a dilution and control source was collected from the Water Treatment Plant (WTP) rather than from Well 12, which had been used in the four earlier tests. Water from the WTP is treated with lime to remove iron and is aerated to remove volatile organic compounds (VOCs), whereas water from Well 12 is naturally low in iron and is only treated by pH adjustment and carbon filtration. It is possible that water from Well 12 may be too void of ions for optimal water flea health, in which case the test organisms may not have been healthy at the onset of the test. The addition of lime at the WTP may provide enough calcium to overcome the effects of low ion content. Testing will continue in 2006 using water from the WTP to evaluate this theory. Minnows exhibited no acute or chronic toxicity in all tests conducted in 2005.

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 2005. Two deviations were recorded at Outfall 006. The concentration of oil and grease (16.1 mg/L) in February slightly exceeded the permit limit of 15 mg/L. This was attributed to a low volume of snow melt run-off from parking lots. The second was a deviation of the pH limit of 9.0 SU at Basin 006A. The cause of this excursion was tracked to high pH in the potable water serving Building 930. The pH of water measured at the bathroom tap was 9.5 SU. The direct cause for the elevated pH was an overdose of sodium hydroxide to the potable water system. The system was flushed and the pH returned to typical levels of 7 – 8 SU.

3.7 SAFE DRINKING WATER ACT

The distribution and supply of drinking water is regulated under the federal SDWA. In New York State, implementation of the SDWA is delegated to the New York State Department of Health (NYSDOH) and administered by the Suffolk County Department of Health Services (SCDHS). Because BNL provides potable water to "more than 25 full-time residents," it is subject to the same requirements as a public water supplier. Monitoring requirements are prescribed annually by SCDHS, and a Potable Water Sampling and Analysis Plan (Chaloupka

Table 3-4. Analytical Results for Wastewater Discharges to Outfalls 002–008 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	11	10			
	Min.	0.04	0.001	0.01	0.04	0.01	0.10	0.001	0.000	NA		
	Max.	0.36	0.14	0.75	0.65	0.38	0.44	1.1	0.3	NA	NA	NA
pH (SU)	Min.	6.3	7.1	6.6	6.4	6.5	6.6	6.7	6.4	NA		
	Max.	8.3	8.9	9.4	9.4	8.8	7.8	8.4	8.0	8.5, 9.0 (a)	1	98
Oil and grease (mg/L)	N	12	10	12	12	12	NR	11	10			
	Min.	< 0.94	< 1.0	0.95	< 0.94	< 0.97	NR	< 0.93	< 0.9	NA		
	Max.	6.4	8.5	7.4	6.3	16.1	NR	6.5	6	15	1	92
Copper (mg/L)	N	NR	NR	4	NR	NR	NR	NR	4			
	Min.	NR	NR	< 0.003	NR	NR	NR	NR	< 0.003	NA		
	Max.	NR	NR	0.01	NR	NR	NR	NR	0.01	1.0	0	100
Aluminum (mg/L)	N	4	NR	NR	NR	NR	NR	4	4			
	Min.	< 0.07	NR	NR	NR	NR	NR	< 0.07	< 0.07	NA		
	Max	0.4	NR	NR	NR	NR	NR	0.2	0.1	2.0	0	100
Lead (mg/L)	N	NR	NR	NR	NR	NR	NR	NR	4			
	Min.	NR	NR	NR	NR	NR	NR	NR	< 0.0005	NA		
	Max	NR	NR	NR	NR	NR	NR	NR	0.001	0.05	0	100
Vanadium (mg/L)	N	NR	NR	NR	NR	NR	NR	NR	4			
	Min.	NR	NR	NR	NR	NR	NR	NR	0.004	NA		
	Max	NR	NR	NR	NR	NR	NR	NR	0.019	NPL	NA	NA
Chloroform (µg/L)	N	4	NR	NR	NR	NR	NR	NR	NR			
	Min.	0.1	NR	NR	NR	NR	NR	NR	NR	NA	NA	
	Max.	0.5	NR	NR	NR	NR	NR	NR	NR	7	0	100
Bromo-dichloromethane (µg/L)	N	4	NR	NR	NR	NR	NR	NR	NR			
	Min.	< 1.0	NR	NR	NR	NR	NR	NR	NR	NA	NA	
	Max.	0.26	NR	NR	NR	NR	NR	NR	NR	5	0	100

(continued on next page)

Table 3-4. Analytical Results for Wastewater Discharges to Outfalls 002–008 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*
1,1,1-trichloroethane (µg/L)	N	4	NR	NR	NR	NR	NR	11	NR			
	Min.	< 0.5	NR	NR	NR	NR	NR	< 0.5	NR	NA	NA	
	Max.	< 1.0	NR	NR	NR	NR	NR	< 5.0	NR	5	0	100
1,1-dicloroethylene (µg/L)	N	NR	NR	NR	NR	NR	NR	11	NR			
	Min.	NR	NR	NR	NR	NR	NR	< 0.5	NR	NA	NA	
	Max.	NR	NR	NR	NR	NR	NR	< 5.0	NR	5	0	100
Hydroxyethylidene-diphosphonic acid (mg/L)	N	4	3	4	4	4	NR	NR	NR			
	Min.	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	NR	NR	NR	NA	NA	
	Max.	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	NR	NR	NR	0.5	0	100
Tolyltriazole (mg/L)	N	4	3	4	4	4	NR	NR	NR			
	Min.	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	NR	NR	NR	NA	NA	
	Max.	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	NR	NR	NR	0.2	0	100

Notes:
See Chapter 5, Figure 5-6 for locations 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
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
(a) pH limit is 8.5 for Outfalls 005, 008, and 010. pH limit is 9.0 for Outfalls 002, 002B, 003, 006A, 006B, and 007.

2005) is prepared to comply with these requirements.

3.7.1 Potable Water

The Laboratory maintains six groundwater wells for on-site distribution of potable water. To meet New York State Drinking Water Standards (DWS), groundwater is treated with activated carbon or air stripping to remove VOCs. Groundwater from three of the six wells is also treated to reduce naturally occurring iron. 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. Tables 3-5 and 3-6 provide the potable water supply monitoring data for 2005. Color and iron exceeded DWS in samples collected from two of the wells (wells 6 and 7) before distribution. Treatment at the Water Treatment Plant effectively reduced these levels to below DWS. At the point of consumption, drinking water complied with all DWS during 2005. Chapter 7 provides additional data on environmental surveillance tests performed on potable wells. This additional testing goes beyond the minimum SDWA testing requirements.

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 connections between the potable water supply and connections to systems containing hazardous substances ("cross connections"). 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, sec-

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

Compound	Well No. 6	Well No. 7	Well No. 10	Well No. 11	Well No. 12	Potable Distribution Sample	NYS DWS
Water Quality Indicators							
Total coliform	ND	ND	ND	ND	ND	ND	Negative
Color (units)	30*	10	< 5	< 5	< 5	30	15
Odor (units)	0	0	0	0	0	0	3
Cyanide (µg/L)	< 10	< 10	< 10	< 10	< 10	< 10	SNS
Conductivity (µmhos/cm)	129	139	111	307	247	189	SNS
Chlorides (mg/L)	22.4	25.5	14.4	20.5	22.8	28.7	250
Sulfates (mg/L)	7.1	11.2	6.9	8.8	7.6	11.2	250
Nitrates (mg/L)	0.22	0.28	0.3	0.58	0.52	0.31	10
Nitrites (mg/L)	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	1.0
Ammonia (mg/L)	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	SNS
pH (Standard Units)	6.1	6.1	6.3	6.0	6.0	6.9	SNS
MBAS (mg/L)	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	SNS
Metals							
Antimony (µg/L)	< 5.90	< 5.90	< 5.90	< 5.90	< 5.90	< 5.90	6.0
Arsenic (µg/L)	< 3.00	< 3.00	< 3.00	< 3.00	< 3.00	< 3.00	50
Barium (mg/L)	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	2.0
Beryllium (µg/L)	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	4.0
Cadmium (µg/L)	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	5.0
Chromium (mg/L)	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.1
Fluoride (mg/L)	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	2.2
Iron (mg/L)	2.69*	2.15*	< 0.02	< 0.02	< 0.02	0.856	0.3
Lead (µg/L)	< 1.0	< 1.0	< 1.0	< 1.0	1.9	< 1.0	15
Manganese (mg/L)	0.079	0.0741	< 0.010	< 0.010	< 0.010	0.031	0.3
Mercury (µg/L)	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	2.0
Nickel (mg/L)	< 0.040	< 0.040	< 0.040	< 0.040	< 0.040	< 0.040	SNS
Selenium (µg/L)	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	50.0
Sodium (mg/L)	12.4	14.0	8.54	13.6	12.5	17.0	SNS
Silver (µg/L)	< 10	< 10	< 10	< 10	< 10	< 10	100
Thallium (µg/L)	< 1.90	< 1.90	< 1.90	< 1.90	< 1.90	< 1.90	2.0
Zinc (mg/L)	0.037	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	5.0
Radioactivity							
Gross alpha activity (pCi/L)	< 1.6	< 1.2	< 1.1	< 1.2	< 1.4	NR	15.0
Gross beta activity (pCi/L)	< 1.9	< 1.9	< 1.9	< 1.8	< 1.81	NR	(a)
Tritium (pCi/L)	< 394	< 378	< 300	< 393	<352	NR	20,000
Strontium-90 (pCi/L)	< 0.59	< 0.67	< 0.56	< 0.65	< 0.61	NR	8.0

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

Compound	Well No. 6	Well No. 7	Well No. 10	Well No. 11	Well No. 12	Potable Distribution Sample	NYS DWS
Other							
Asbestos (M. fibers/L)	NR	NR	NR	NR	NR	< 0.13	7
Calcium (mg/L)	4.1	5.99	5.96	6.27	8.19	11	SNS
Alkalinity (mg/L)	12.4	24	31.3	16.4	21.7	28.9	SNS
Residual chlorine - MRDL (mg/L)	NR	NR	NR	NR	NR	0.7	4.0
TTHM (mg/L)	NR	NR	NR	NR	NR	<0.005	0.08**
HAA5 (mg/L)	NR	NR	NR	NR	NR	<0.002	0.06**

Notes:
See Figure 7-3 for well locations.
HAA5 = Five Haloacetic Acids
MBAS = Methylene Blue Active Substances
MRDL = Maximum Residual Disinfectant Level
NA = Not Analyzed due to well shutdown in April 2004
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) The drinking water standard was changed from 50 pCi/L (concentration based) to 4 mrem/yr (dose based) in late 2003. Since gross beta activity does not identify specific radionuclides, a dose equivalent can not be calculated for the values in the table

ondary cross-connection controls at the point of use are recommended, to protect users within a specific facility from hazards that might be posed by intra-facility operations.

The Laboratory has installed and maintains approximately 200 cross-connection control devices at interfaces to the potable water main, and secondary control devices at the point of use. If a problem is encountered during testing, the device is repaired and retested to ensure proper function. Approximately 160 cross-connection control units were tested at BNL in 2005, including primary and secondary devices; no cross-contamination problems were found.

3.7.3 Underground Injection Control

UIC wells are regulated under the SDWA. At BNL, 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 did not adopt UIC regulatory requirements. (New York State regulates 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 2005, The Laboratory completed the closure of a UIC device formerly serving Building 445.

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 UICs are regulated by EPA, and a separate inventory is maintained for these treatment facilities.

3.8 PREVENTING AND REPORTING SPILLS

Several federal, state, and local regulations 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. The following subsections describe BNL's compliance with these regulations.

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

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

(continued on next page)

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. 6	Well No. 7	Well No. 10	Well No. 11	Well No. 12	NYS DWS
	μg/L						
1,2,3-trichlorobenzene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Benzene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Toluene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Ethylbenzene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
m,p-xylene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
o-xylene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Styrene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Isopropylbenzene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
n-propylbenzene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,3,5-trimethylbenzene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
tert-butylbenzene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,2,4-trimethylbenzene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
sec-butylbenzene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
4-Isopropyltoluene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
n-butylbenzene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Chloroform	1.2	2.1	0.8	0.5	0.6	< MDL	50
Bromodichloromethane	2	< MDL	< MDL	< MDL	< MDL	< MDL	50
Dibromochloromethane	1.4	< MDL	< MDL	< MDL	< MDL	< MDL	50
Bromoform	< MDL	< MDL	< MDL	0.6	< MDL	< MDL	50
Methyl tert-butyl ether	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	50
Lindane	NR	< MDL	< MDL	< MDL	< MDL	< MDL	0.2
Heptachlor	NR	< MDL	< MDL	< MDL	< MDL	< MDL	0.4
Aldrin	NR	< MDL	< MDL	< MDL	< MDL	< MDL	5
Heptachlor Epoxide	NR	< MDL	< MDL	< MDL	< MDL	< MDL	0.2
Dieldrin	NR	< MDL	< MDL	< MDL	< MDL	< MDL	5
Endrin	NR	< MDL	< MDL	< MDL	< MDL	< MDL	0.2
Methoxychlor	NR	< MDL	< MDL	< MDL	< MDL	< MDL	40
Toxaphene	NR	< MDL	< MDL	< MDL	< MDL	< MDL	3
Chlordane	NR	< MDL	< MDL	< MDL	< MDL	< MDL	2
Total PCB's	NR	< MDL	< MDL	< MDL	< MDL	< MDL	0.5
2,4,5,-TP (Silvex)	NR	< MDL	< MDL	< MDL	< MDL	< MDL	10
Dinoseb	NR	< MDL	< MDL	< MDL	< MDL	< MDL	50
Dalapon	NR	< MDL	< MDL	< MDL	< MDL	< MDL	50
Picloram	NR	< MDL	< MDL	< MDL	< MDL	< MDL	50
Dicamba	NR	< MDL	< MDL	< MDL	< MDL	< MDL	50
Pentachlorophenol	NR	< MDL	< MDL	< MDL	< MDL	< MDL	1
Hexachlorocyclopentadiene	NR	< MDL	< MDL	< MDL	< MDL	< MDL	5

(continued on next page)

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. 6	Well No. 7	Well No. 10	Well No. 11	Well No. 12	NYS DWS
	µg/L						
Bis(2-ethylhexyl)Phthalate	NR	< MDL	< MDL	< MDL	< MDL	< MDL	50
Bis(2-ethylhexyl)Adipate	NR	< MDL	< MDL	< MDL	< MDL	< MDL	50
Hexachlorobenzene	NR	< MDL	< MDL	< MDL	< MDL	< MDL	5
Benzo(A)Pyrene	NR	< MDL	< MDL	< MDL	< MDL	< MDL	50
Aldicarb Sulfone	NR	< MDL	< MDL	< MDL	< MDL	< MDL	SNS
Aldicarb Sulfoxide	NR	< MDL	< MDL	< MDL	< MDL	< MDL	SNS
Aldicarb	NR	< MDL	< MDL	< MDL	< MDL	< MDL	SNS
Oxamyl	NR	< MDL	< MDL	< MDL	< MDL	< MDL	50
3-Hydroxycarbofuran	NR	< MDL	< MDL	< MDL	< MDL	< MDL	50
Carbofuran	NR	< MDL	< MDL	< MDL	< MDL	< MDL	40
Carbaryl	NR	< MDL	< MDL	< MDL	< MDL	< MDL	50
Methomyl	NR	< MDL	< MDL	< MDL	< MDL	< MDL	50
Glyphosate	NR	< MDL	< MDL	< MDL	< MDL	< MDL	50
Diquat	NR	< MDL	< MDL	< MDL	< MDL	< MDL	50
1,2-dibromoethane (EDB)	NR	< MDL	< MDL	< MDL	< MDL	< MDL	0.05
1,2-dibromo-3-chloropropane	NR	< MDL	< MDL	< MDL	< MDL	< MDL	0.2
2,4,-D	NR	< MDL	< MDL	< MDL	< MDL	< MDL	50
Alachlor	NR	< MDL	< MDL	< MDL	< MDL	< MDL	2
Simazine	NR	< MDL	< MDL	< MDL	< MDL	< MDL	50
Atrazine	NR	< MDL	< MDL	< MDL	< MDL	< MDL	3
Metolachlor	NR	< MDL	< MDL	< MDL	< MDL	< MDL	50
Metribuzin	NR	< MDL	< MDL	< MDL	< MDL	< MDL	50
Butachlor	NR	< MDL	< MDL	< MDL	< MDL	< MDL	50
Endothall	NR	< MDL	< MDL	< MDL	< MDL	< MDL	100
Propachlor	NR	< MDL	< MDL	< MDL	< MDL	< MDL	50

Notes:
See Chapter 7, Figure 7-3 for well locations.
Well 4 not used in 2005.
For compliance determination with New York State Department of Health standards, potable water samples were analyzed quarterly or annually, depending on the analyte, by H2M Labs Inc., a New York State-certified contract analytical laboratory.
The minimum detection limits for principal organic compound analytes are 0.5 µg/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.

< MDL = less than the Minimum Detection Limit for the analyte in question
NR = Analysis Not Required
SNS = Drinking Water Standard Not Specified
NYS DWS = New York State Drinking Water Standard
WTP = Water Treatment Plant

3.8.1 Preventing Oil Pollution and Spills

The Laboratory must maintain a Spill Prevention Control and Countermeasures (SPCC) Plan as a condition of its license to store petroleum fuel and as required by the Oil Pollution Act. This plan is part of BNL'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 their locations. The SPCC Plan is filed with NYSDEC, EPA, and DOE, and was last updated in December 2000 (Chaloupka 2000). The Laboratory remained in full compliance with the SPCC requirements in 2005.

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 < 55 gallons need not be counted toward reaching SPCC applicability. The timeline for updating and implementing BNL's SPCC plan to incorporate these changes has been extended until October 2007, although the Laboratory is proceeding with changes to the plan and expects the changes to be completed before that date.

BNL also maintains a Facility Response Plan (FRP) (Lee 2002) that outlines emergency response procedures to be implemented in the event of a worst-case discharge of oil. The Laboratory received notification from EPA in October that the FRP was deficient in several areas, mostly for missing or inadequate information. The plan was revised accordingly and will be resubmitted in early February 2006.

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 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 2005 through the submittal of reports under EPCRA Sections 302, 303, 311, and 312. In 2005, through the Tier III report, BNL reported releases of lead (~ 2,355 pounds), mercury (~ 140 pounds), PCBs (~ 3,200 pounds), benzo(g,h,i) perylene (< 1 pound), and polycyclic aromatic compounds (< 1 pound). Releases of lead, PCBs, and mercurywere predominantly in the form of shipments of waste for off-site recycling or disposal. Releases of benzo(g,h,i)perylene and polycyclic aromatic compounds were as byproducts of combustion of fuel oils. In 2005, there were no releases of "extremely hazardous substances" that were reportable under Part 304.

3.8.3 Spills and Releases

When a spill of hazardous material occurs, Laboratory personnel are required to immediately notify the on-site Fire Rescue Group, whose members are trained to respond to such releases. The initial step in spill 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 impacting surface water must also be 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 con-

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 [ ]

ducted as necessary to restore the site.

During 2005, there were 34 spills, of which 14 met external agency reporting criteria. The remaining 20 spills were small-volume releases either to containment areas or to other impermeable surfaces that did not exceed a reportable quantity. Eight of the 14 reported releases involved very small volumes (< 5 gallons) of petroleum products that reached soil. New York State has a "zero tolerance" level for releases of petroleum products to soil or water; consequently, spills of any amount to soil are reportable. There was one spill of antifreeze from a piece of machinery, one 20-gallon release of No. 6 fuel oil from a delivery vehicle, two small-volume chemical releases, one outdoor release of a custodial chemical, and one finding of human excrement in buckets along a road adjacent to the BNL boundary. Table 3-7 contains a summary of each of these incidents, including a description of the cause, corrective actions taken, and whether the spill was reportable to DOE through the Occurrence Reporting and Processing System (ORPS).

The Laboratory has been very successful in reducing the number and severity of spills. In 2005, the total incidence of spills was reduced by 55 percent, from 76 spills in 2004 to 34 for 2005. Measures employed to achieve this reduction included: changing petroleum-based lubricants and fluids with vegetable-based products, installing stainless steel-reinforced hydraulic lines on various pieces of grounds equipment and heavy equipment, and training staff in

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

Spill No. and Date	Material and Quantity	ORPS Report	Source/Cause and Corrective Actions
05-01 Jan 26	Solvent Mixture 1 gallon	Yes SC-CH-BH-BNL-BNL-2005-0001	The 490 Building Manager requested that plumbing work be performed in Room 907. For access to the work area, a researcher was asked to move a full, 1-gallon glass bottle of a solvent mixture containing acetone (40%), hexane (38%), methylene chloride (20%), ethyl acetate (1%), ethanol (1%), and porphyrin. The manager placed the container on a cart and during transport the cart hit a bump (possibly a door sill). The container fell to the floor and broke. The incident was reported to the fire and police groups and a cleanup response began. More than 90 percent of the mixture evaporated prior to the response team arrival. The small amount of liquid remaining was removed with absorbent pads. The pads, personal protective equipment, and broken glass container were placed in a plastic bucket and were properly disposed. The spill was reported to regulatory agencies, as > 1 pound of hexane was released to the air.
05-03 Feb 8	Hydraulic Fluid < 1 gallon	No	During repairs to the railroad siding, a hose failed on a backhoe and released hydraulic fluid to the railroad tracks, ballast, and ties. All visually impacted soils and ballast were removed for disposal. Waste was sent to an approved disposal facility.
05-04 Mar 14	Hydraulic Fluid 1 pint	No	While working on the Peconic River cleanup, an Envirocon worker noticed a hydraulic leak from a Bobcat working on the temporary plastic mat road. Approximately 1 pint of hydraulic oil leaked from the plastic mat onto surrounding soil. The spill was immediately contained and cleaned up.
05-08 Mar 31	Human Excrement < 1 gal	No	Numerous 5-gallon plastic buckets in garbage bags were found on BNL property along a road adjacent to the BNL east boundary. The Emergency Services Division HAZMAT Team packaged the waste into DOT-approved containers (three 55-gal drums) and then transferred it to the Waste Management area. The containers were opened on April 7 by a BNL vendor (Onyx) and human excrement was found. The waste was re-packaged and disposed of as Regulated Medical Waste through the Medical Department.
05-10 April 12	Compressor Oil 2 ounces	No	A dewatering pump on the Peconic River remediation project blew compressor oil out of the discharge hose, to the plastic containment below and adjacent soil. The discharge was apparently due to failure of the compressor rings. The oil released to the containment pad and the affected soil was removed for proper disposal.
05-13 May 18	Diesel Fuel ½ gallon	No	Oil-stained grass was discovered in an area where a portable emergency generator had been parked, behind Bldg. 610. The stained area was approximately 2 ft in diameter. Diesel fuel is believed to have leaked from the fill cap of the generator fuel storage tank as a result of thermal expansion of the fuel. Buildings and Grounds personnel removed all visibly contaminated grass and underlying soil for off-site disposal.

(continued on next page)

Table 3-7. Summary of Chemical and Oil Spill Reports *(concluded).*

Spill No. and Date	Material and Quantity	ORPS Report	Source/Cause and Corrective Actions
05-17 Jun 20	Slaked Lime 15 pounds	No	BNL personnel discovered a white-chalky, alkaline solid material on soil along a concrete headwall near an on-site drinking water wellhouse and reported it to the Emergency Services Division as an unknown material spill. The material was collected and put in a plastic 15-gallon waste container. During the clean-up, samples were collected for chemical identification/ fingerprinting. Samples of similar material on site, including Quick Lime and ice melt, were compared with the unknown substance using field fingerprinting methods: reaction with acids, precipitation of solids, and pH. Based on these tests (high pH and calcium content), the unknown material was identified as slaked lime (calcium hydroxide). It was characterized and sent off site for disposal.
05-20 Aug 15	Motor Oil ½ cup	No	A locomotive owned and operated by New York & Atlantic Railway leaked motor oil on the tracks along Power Line Road, just before the Laboratory exit. The locomotive had recently dropped off a load of empty rail cars for BNL to use for transporting remediation waste. The leak was not discovered until after the locomotive left the site. Most of the leaked motor oil was on top of a railroad tie, although some spilled over onto the soil on either side. Spill absorbent was used to remediate the spill, and the impacted spoil and contaminated absorbent were removed and containerized for off-site disposal.
05-22 Aug 17	Ethylene Glycol 7 gallons	No	A radiator hose ruptured on the "Trackmobile" being used to transport rail cars in support of the Former Hazardous Waste Management Facility cleanup. The operator realized there was a problem and immediately stopped the vehicle and workers placed drip pans and absorbent material under the radiator. Impacted soils, gravel, and debris were removed and placed in a 55-gallon drum for off-site disposal.
05-23 Oct 8	Hydraulic Fluid 5 gallons	No	As concrete blocks were being moved from Bldg. 912 to Bldg. 933 along E. Fifth Avenue, a hydraulic line burst, resulting in a spill of approximately 5 gallons of hydraulic oil along a 1-mile stretch of road. It was raining heavily throughout the day and there was evidence of discharge of the oil into two of the storm sewer drains near Bldg. 912. Fire and Rescue personnel were notified as soon as the spill was discovered. It was contained to the asphalt road and did not come into contact with the soil. Absorbents were placed along the spill areas and along the storm drains. Booms were also placed at the weir (SPDES Outfall #002) to prevent discharge into the recharge basins located near the RHIC Ring. Visual inspection of the weir leading to the recharge basins showed no evidence of discharge of oil into the environment. All contaminated absorbents were collected and disposed off site.
05-27 Nov 4	Gasoline < 1 gallon	No	During routine surveillance of BNL property along North Street, a BNL employee noticed a closed 10-gallon carboy on the east side of North Street approximately 250 yards north of the east gate. The carboy was about 2/3 full and contained what appeared to be waste engine oil. Another 250 yards north, he found an open 5-gallon pail filled with rainwater that had overflowed onto the ground below. The rain water in the pail had a visible sheen and a noticeable gasoline odor. Fire Rescue was notified and placed the 5-gallon pail in an overpak container with contaminated soil they recovered from below the container. The abandoned containers were transported to a waste storage area for characterization and disposal.
05-28 Nov 5	Floor Stripper 1 gallon	Yes SC-BHSO-BNL-PE-2005-0002	Weekend custodial staff dumped floor stripper into the courtyard of Bldg. 911. Stripper, which is highly caustic, was dumped on the bricks and migrated to the side gravel. A field pH reading on litmus paper showed a very high pH. Custodial staff and grounds crew cleaned up the spill and collected all waste for proper disposal.
05-32 Dec 12	Hydraulic Fluid < 1 gallon	No	During the planned decommissioning of an outdoor lift behind Bldg. 480, it was discovered that one of the hydraulic lines had rusted and leaked within the pit of the lift. The piping was removed and the line was capped. The accumulated debris at the bottom of the pit (leaves and sand) was discolored from the oil. The pit had a concrete floor and a drain to prevent water accumulation. All impacted material was removed and containerized for off-site disposal.
05-33 Dec 17	No. 6 Fuel Oil 20 gallons	Yes SC-BHSO-BNL-PE-2005-0003	At approximately 2:30 a.m., a Metro fuel oil tanker came on site to deliver a load of #6 fuel oil, but did not deliver the fuel. In the process, the tanker leaked oil in a trail that was discovered on the northbound William Floyd Parkway, through its route on BNL property, and off site as it traveled southbound on William Floyd Parkway. On the parkway, as well as for most of its route on site, the tanker left one to two thin lines of #6 fuel along its route. Where the tanker slowed or stopped, it left a heavier deposit. This was particularly true at the entrance gate, weigh station, fuel transfer bay, and where the truck took corners. Most significantly, the truck leaked 20 to 25 gallons on the ground and in a catch basin shortly after it pulled out of the transfer bay. The roads, transfer bay, impacted soils, and drywell were cleaned and all spill residue was disposed of off site.

Notes:
*Release is reportable to DOE under the requirements of DOE Order 231.1A, Occurrence Reporting and Processing.
DOT = Department of Transportation

proper spill-response techniques.

In 2005, six incidents reported through ORPS were environmental in nature. Three of these reports were spill-related and have been summarized in Table 3-7; the remaining three are summarized in Table 3-8. All incidents were addressed through the identification and implementation of corrective actions geared toward the root cause. No off-site or on-site permanent environmental impacts arose from the ORPS-reported incidents.

3.8.4 Major Petroleum Facility License

The storage of 2.3 million gallons of fuel oil (principally No. 6 oil) subjects BNL to Major Petroleum Facility licensing by NYSDEC. The Laboratory maintains an MPF License for storing and transferring oil at the Central Steam Facility (CSF). During 2005, BNL remained in full compliance with license requirements, which include monitoring groundwater in the vicinity of the six active, aboveground storage tanks. These tanks range in size from 300,000 to 600,000 gallons. The license also requires the Laboratory to inspect storage facilities monthly and test the systems for leak detection, high-level monitoring, and secondary containment. Tank integrity is also checked periodically. Groundwater monitoring consists of monthly checks for floating products and twice-yearly analyses for volatile organic compounds and semivolatile organic compounds. In 2005, no contaminants or floating products attributable to MPF activities were detected. See SER Volume II, Groundwater Status Report, for additional information on groundwater monitoring results.

The following upgrades and/or inspections were performed at the MPF in 2005:

- The roof plates and product piping for Tanks No. 5 and 6 were sandblasted, primed, and painted in June 2005.
- Five 60,000-gallon tanks, four of which were never used, were cut into manageable pieces and removed for recycling in May 2005.
- The 2005 NYSDEC annual inspection was conducted in August. Three conditions that required corrective action were noted: the management of vegetative growth in the secondary containment berms at Building 610; peeling and blistering paint causing corrosion to large segments of the product pip-

Table 3-8. Summary of Other Environmental Occurrence Reports.

ORPS* ID: EM-CH-BH-BNL-BNL-2005-0002 Stormwater runoff from a soil contamination area breached a berm constructed to retain the water and prevent cross contamination. Analysis of the water showed it contained between 3,600 and 17,450 pCi/L of cesium-137. The berm was repaired and reinforced with a geomembrane.	Date: 2/10/05 Status: Closed. All corrective actions have been completed.
ORPS ID: EM-CH-BH-BNL-BNL-2005-0003 Flooding occurred at the strontium-90 Groundwater Treatment Pilot System. Evaluation of the incident revealed that the extraction pump was placed in manual-mode "On," which caused the pump to overflow the equalization tank. (In manual mode, the high-level cutout is inoperable.) Approximately 3,500 gallons of water collected on the floor and sumps of the building. Since the facility was designed with secondary containment curbing, there was little run-off outside the building. All water was collected and re-treated prior to disposal.	Date: 2/11/05 Status: Closed. All corrective actions have been completed.
ORPS ID: EM-CH-BH-BNL-BNL-2005-0005 Several rail cars of contaminated soil being shipped from BNL were found to be leaking water upon arrival at Envirocare of Utah. All rail shipments were halted and cars en route were returned to BNL for repackaging. The cause of the leaks was determined to be snow melt and rain water that accumulated between the package containing the waste and the rail car body. Excess moisture was also evident in the waste. Soils were reworked to absorb excess moisture and repackaged for shipment.	Date: 3/21/05 Status: Closed. All corrective actions have been completed.

Notes:
*Reportable under the Occurrence Reporting and Processing System (ORPS), established by the requirements of DOE Order 231.1A.

ing that serves Tanks 651-02, -03, and -04; and heavy staining and product observed near transfer pumps associated with the diesel off-loading station (designated 651-01).

All conditions were corrected in accordance with NYSDEC directives.

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 chemical substances be registered with NYSDEC. The Laboratory holds a Hazardous Substance Bulk Storage Registration Certificate for eight tanks. Seven of the tanks store potable water treatment chemicals (sodium hydroxide and sodium hypochlorite) and one tank stores gallium trichloride, formerly required in physics experiments. The tanks range in size from 200 to 1,200 gallons. These tanks are also regulated under Suffolk County Sanitary Code Article 12 (SCDHS 1993) and are managed in accordance with BNL procedures designed to conform to Suffolk County requirements.

NYSDEC conducted an inspection of the Chemical Bulk Storage (CBS) facilities in August 2005. During this inspection, three issues were identified that required corrective action: peeling and blistering paint observed on Tanks 634-02, 635-01, and 637-01, causing corrosion to sections of the affected tanks; the need to install a level gauge near the fill port location of Tank 634-02; and the need for a 5-year inspection report for Tanks 624-05 and 624-06. All of these issues were corrected in accordance with the NYSDEC directive.

3.8.6 County Storage Requirements

Article 12 of the Suffolk County Sanitary Code, administered by SCDHS, regulates storing and handling 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. It also 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 366 active storage facilities listed in the BNL tanks database. An additional 36 storage facilities are temporarily out of service. Also included in the BNL database are another seven active storage facilities associated with environmental restoration activities conducted under the CERCLA program; these facilities are not regulated under Article 12. Laboratory storage facilities listed in the database include those storing fuel (some of which are also regulated under the MPF license), wastewater, and chemicals, as well as storage facilities used to support BNL research.

In 2005, the Laboratory provided SCDHS with updated registrations for more than 35 storage facilities. In addition, SCDHS conducted an inspection of BNL's Motor Pool and Site Service Station underground storage tanks in June 2005 to verify compliance with SCDHS requirements. During this inspection, two minor deficiencies were identified that required corrective action: one related to improper inspection of the interstitial space alarm probes, and the other for deficiencies in the inspection records and scheduled repairs. All deficiencies identified were addressed to Suffolk County's satisfaction.

The Laboratory has an ongoing program to upgrade or replace existing storage facilities and to meet with representatives of SCDHS to ensure that the information provided for all registered storage facilities is accurate and that new or modified storage facilities are designed and reviewed for full conformance with Article 12 regulations.

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. The Laboratory is considered a large-quantity generator because it may generate greater than 1,000 Kg of hazardous waste in a month, and has a RCRA permit to store hazardous wastes for one year before shipping them off site to licensed treatment and disposal facilities. As noted in Chapter 2, BNL also has a number of 90-day accumulation and storage areas.

Mixed wastes are materials that are both hazardous (under RCRA guidelines) and radioactive. The Federal Facilities Compliance Act, issued in 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.

The Laboratory updates the BNL Site Treatment Plan annually and submits it 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 anticipates that it will continue to manage mixed wastes within its permitted one-year time frame. However, the Laboratory 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 legislated requirements in 2005.

The Laboratory has aggressively approached significant reductions in its PCB inventory. In 2005, the inventory was reduced by approximately 84 percent, by replacing and disposing of 250 large capacitors from the Collider-Accelerator Department. Since 2003, BNL has reduced its PCB inventory by more than 90 percent.

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 at BNL are used to control undesirable insects, mice, and rats; to control 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 2005.

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 2005, three projects were permitted under this program, all ongoing from 2003/2004. These projects included constructing a new recharge basin, a storage facility at the Alternating Gradient Synchrotron, and ancillary structures at Buildings 1007 and 1009. All projects have been completed except for new structures at Buildings 1007 and 1009, which are no longer planned; the permit will be cancelled in 2006. Final photos and completed project notifications for the finished projects will be filed with NYSDEC in 2006 to close the relevant permits.

3.13 ENDANGERED SPECIES ACT

In 2005, 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 Natural Resource Management Plan (NRMP) in December 2003. One component of the plan formalizes the strategy and actions needed to protect 22 confirmed tiger salamander breeding locations at BNL. 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 was begun in 2004 to gain a better understanding of the habitat requirements and salamander movement.

The banded sunfish and swamp darter are found in the Peconic River drainage areas at BNL. Both are listed as threatened species within New York State. Eastern Long Island has 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 habitat include the following:

- Eliminating, reducing, or controlling pollutant discharges
- Reducing nitrogen loading in the Peconic River
- Monitoring populations and water quality to ensure that habitat remains viable
- Maintaining adequate flow to the river to enable the fish to survive drought
- 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 mottled duskywing. None have been documented in recent surveys. Habitat for the frosted elfin and persius duskywing exists on Laboratory property and mottled duskywing is likely to exist on site; therefore, the management of habitat and surveys for the three butterflies has been added to the management plan.

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 the Laboratory 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 12 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. Radio telemetry work on the spotted turtle was carried out in 2004 – 2005, and a basic understanding of their movement and habitat needs was developed. A radio telemetry study on the eastern hognose snake continued in 2005, resulting in greater understanding of this species' habitat needs and its movement between habitats. 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 management plan, the locations of these rare plants must be determined, populations estimated, and management requirements established. See Chapter 6 for more information.

3.14 EXTERNAL AUDITS AND OVERSIGHT

A number of federal, state, and local agencies oversee Laboratory activities. In 2005, BNL was inspected by federal, state, or local regulators on 11 occasions. In 2005, SCDHS maintained a part-time, on-site staffer who provided periodic oversight of BNL activities. In addition to external audits and oversight, the Laboratory has a comprehensive self-assessment program, as described in Chapter 2.

3.14.1 Regulatory Agency Inspections

- *Air Compliance*. NYSDEC conducted an annual inspection of the CSF in March. No issues were identified during this inspection.
- *Potable Water*. In October 2005, SCDHS collected samples and conducted its annual inspections of the BNL potable water system to ensure that facilities are maintained. No issues were identified. All sample results were within DWS, except for iron, which occurs naturally in some of the wells. As noted in Section 3.7.1, the Laboratory treats the water from certain supply wells to remove iron before distribution.
- *Sewage Treatment Plant.* SCDHS conducts quarterly inspections of the Laboratory's Sewage Treatment Plant, to evaluate operations and sample the effluent. In 2005, no performance or operational issues were identified. NYSDEC also conducts annual inspections of the STP, and identified no issues in 2005.
- *Recharge Basins.* As part of SCDHS oversight, recharge basins and other SPDES outfalls are inspected periodically. In March 2005, SCDHS inspected several of the outfalls and collected samples. Sediment collected at Outfall 010 contained elevated levels of lead. This issue is discussed further in Chapter 5. NYSDEC also conducted inspections of the recharge basin outfalls in March; no issues were identified.
- *Major Petroleum Facility*. The annual NYSDEC inspection of the MPF was conducted in August 2005 (see Section 3.8.4).
- *Chemical Bulk Storage Facilities*. The CBS facilities are inspected periodically by NYSDEC. This inspection was conducted in August 2005 (see Section 3.8.5).

3.14.2 DOE Inspections

DOE Headquarters (EH-10) and the Chicago Support Center did not conduct assessments of the Laboratory's environmental programs in 2005. However, the DOE Brookhaven Site Office (DOE-BHSO) continued to oversee BNL programs and observed programmatic assessments of the environmental monitoring, NEPA programs, and the hazardous waste characterization process. The results of these assessments are summarized below. In all cases, corrective actions were implemented to correct the deficiencies identified.

3.14.2.1 Environmental Monitoring

The Environmental and Waste Management Services Division (EWMSD) conducted a self-assessment to ensure that sample collection meets regulatory requirements and the BNL Environmental Monitoring Plan, and that past monitoring issues had been adequately addressed. The assessment was conducted between March 7 and April 8, as part of the EWMSD self-assessment program, and included DOE-BHSO observation. While prior assessments have looked at some aspects of monitoring, this was the first full-scale review of the environmental monitoring program. Specifically, the assessment focused on:

- Documentation of environmental monitoring requirements
- Adequacy of sample collection programs
- Adequacy of collection procedures
- Followup to previously identified monitoring concerns

Sample collection activities were reviewed in the EWMSD and the Plant Engineering (PE) and Environmental Restoration (ER) divisions. In addition, a review was held of the processes used by the Collider–Accelerator Department and the PE Division to determine if environmental monitoring is required for new facilities and operations. The assessment involved documentation review, including SPDES permits, ER SPDES and Air permit equivalencies, ER operations manuals, environmental monitoring standard operating procedures, and the BNL Environmental Monitoring Plan. The review also involved field observations of sample collections (radiation sensors, liquid effluents, surface water, groundwater, and air) and interviews with subject-matter experts, sampling technicians, and line personnel. Whenever possible, representatives from DOE's on-site office participated in the review.

The assessment found three noteworthy practices, two nonconformances, four observations, and five opportunities for improvement. Overall, the assessment concluded that the environmental monitoring program is well documented and is effective for measuring compliance with regulatory requirements and impacts of Laboratory operations on the environment. There were no regulatory noncompliances identified during the assessment (Lee 2005).

3.14.2.2 NEPA Management

In late 2004, EWMSD conducted a self-assessment, with DOE-BHSO observation, using the SBMS subject area "National Environmental Policy Act and Cultural Resources Evaluations." The report was finalized in January 2005. The audit included examinations of the federal Proposal Information Questionnaire (PIQ) database – 2004, the nonfederal PIQ database – 2004, capital procurements in excess of $25,000 for FY 2004, departmental NEPA reviews, and the prior assessment, conducted during 2001. The assessment also involved interviews with line personnel responsible for implementing NEPA requirements. The review found three noteworthy practices, no nonconformances, one observation, and three opportunities for improvement (Pohlot 2005).

3.14.2.3 Waste Characterization

An assessment of waste characterization methods performed at the generator level was conducted from September 22 to September 29, 2005, to ensure that radioactive and nonradioactive wastes presented to BNL's waste management program for treatment and/or disposal were properly documented. Documentation helps ensure that wastes are managed in compliance with applicable regulations and disposal facility waste acceptance criteria. The assessment found that the methods employed and the documentation/process knowledge used to support

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

Number	Title	Parties	Effective Date	Status
Agreements				
No Number	Suffolk County Agreement	SCDHS, DOE, and BNL	Originally signed on 9/23/87	This Agreement was developed to ensure that the storage and handling of toxic and hazardous materials at BNL conform with the environmental and technical requirements of Suffolk County codes.
No Number	Federal Facilities Compliance Agreement on Mixed Wastes	NYS-DEC 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). All IAG-scheduled milestones were met in 2005.
Enforcement Actions: None				

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

the waste's characterization data were effective. It was noted that of the 20 waste items assessed, supporting information for four of the items was not initially provided with the waste documentation, but was supplied by the originating group when requested.

3.14.3 Enforcement Actions and Memos

No new consent orders nor Notices of Violation were issued to the Laboratory in 2005. All existing enforcement actions and memoranda are listed in Table 3-9, along with a summary of their status. BNL determined that it has fully complied with the terms and conditions listed in these actions and has submitted supporting documentation to the regulatory agencies. When a Notice of Violation is issued, the Laboratory works with the regulators to close these actions as expeditiously as possible. In October, BNL was informed that one such notice was pending with NYSDEC for opacity violations reported in quarterly emission reports. To date, the notice has not been received and the Laboratory continues to address the issue with NYSDEC.

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Air Quality

4

Brookhaven National Laboratory 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 BNL operations.

During 2005, BNL facilities released a total of 3,266 curies of short-lived radioactive gases. Oxygen-15 and carbon-11 emitted from the Brookhaven Linac Isotope Producer constituted more than 99.4 percent of the site's radiological air emissions.

Since natural gas prices were comparatively higher than residual fuel prices throughout 2005, the Central Steam Facility continued to rely on residual fuel to meet the heating and cooling needs of BNL's major facilities. As a result, annual facility emissions of particulate matter, nitrogen oxides, and sulfur dioxide were considerably higher in 2005 than in 1999, when natural gas was the predominant fuel used at the Central Steam Facility.

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, 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. Although not required, 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 2005. 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 particulate air (HEPA) filter to remove any particulate matter.

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

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-ft 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 remain 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, no samples were collected.

In 2005, the facility was in a cold shut-down mode and was downgraded from a nuclear facility to a radiological facility. During the year, the remaining primary cooling water, Janus plates, control rod blades, and activated hydraulic fluid were shipped to a DOE-approved disposal 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, tritiated heavy water (HTO) from the HFBR system was contained in the spent fuel storage pool. In 1997, a leak in the pool was discovered when a plume of tritiated groundwater was traced back to it. 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 then 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).

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. Following an investigation to determine possible sources

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

Facility	Nuclide	Half-Life	Ci Released
HFBR	Tritium	12.3 years	1.79E+01
BLIP	Carbon-11	20.4 minutes	8.16E+02
	Oxygen-15	122 seconds	2.43E+03
	Tritium	12.3 years	5.16E-02
TPL - Bldg. 801	Germanium-68	270.8 days	7.71E-08
Total			3.27E+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 (Bldg. 801)

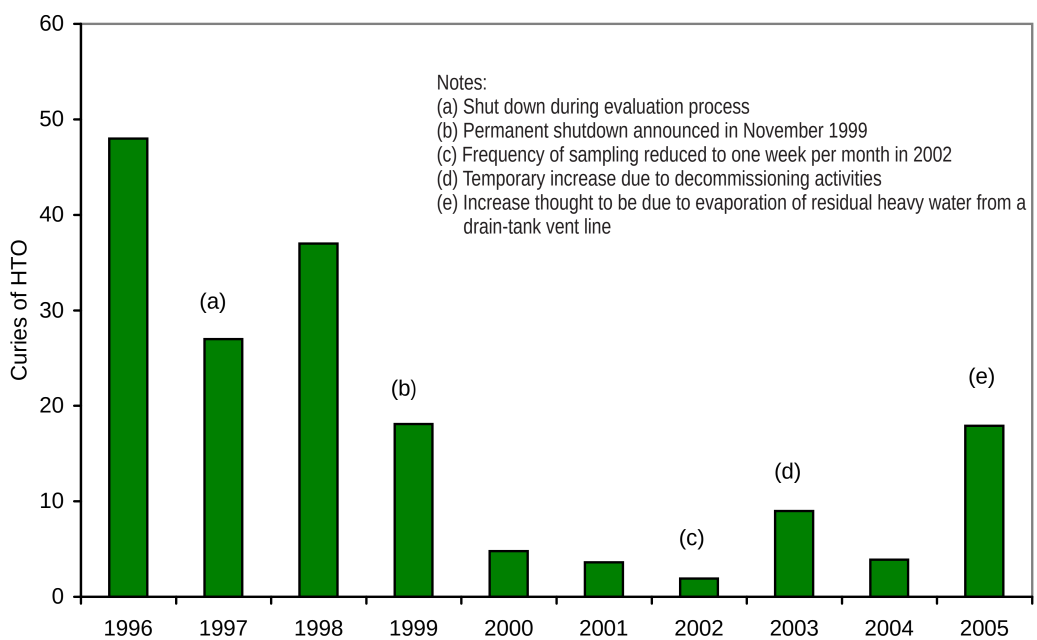

Figure 4-2. High Flux Beam Reactor Tritium Emissions, Ten-Year Trend (1996–2005).

for the rise, evaporation of residual heavy water through an open drain-tank vent line appears to have been the most likely source. The air emissions from the HFBR facility have been monitored since 2002 via air sampling of the building at a frequency of one week per month.

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 20.48 minutes). Both of these isotopes are released as gaseous, airborne emissions through the facility's 33-ft stack.

In 2005, the BLIP operated over a period of 17 weeks. During this period, 816 Ci of C-11 and 2,432 Ci of O-15 were released. Tritium produced from activation of the target cooling water was also released, but in a much smaller quantity, 5.16 E-02 Ci. Combined emissions of C-11 and O-15 were roughly 20 percent higher than in 2004, primarily due to six extra weeks of operation, but the combined emissions were 15 percent lower than the 2003 total. This drop in emissions was facilitated by the installation of a lucite enclosure over the continuously recirculating water system. Section 8.4.1 provides more details on the effectiveness of the shroud enclosure.

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 the WCF, 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. 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 processed through solidification, with off-site disposal. As a result, planning is underway to decommission the WCF reverse osmosis process and the Evaporator Facility. Subject to funding availability, the plans call for demolishing the Building 802B stack and decontaminating the WCF.

4.1.5 Target Processing Laboratory

As mentioned in Section 4.1.3, the metal targets irradiated at the BLIP are transported to the TPL in Building 801, where isotopes are chemically extracted for radiopharmaceutical production. Airborne radionuclides that are 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 can change from year to year. Annual radionuclide quantities released from this facility are very small, typically in the µCi to mCi range. In 2005, the total release from the TPL was 0.0771 µCi. See Table 4-1 for details of all radionuclides released in 2005.

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 transferring material between containers using pipettes, and labeling chemical compounds. 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, and 801, where research is conducted in the fields of biology, medicine, high energy physics, chemistry, applied and materials science, and advanced technology. 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 2005 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 2005.

4.2 FACILITY MONITORING

In the past, potential sources of radioactive emissions that have been monitored included the BMRR, the HFBR, the Evaporator Facility, the TPL, and the BLIP. Since 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.

The samplers in the exhaust duct for the TPL and the exhaust stack for the 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 are reported in Table 4-2. Annual average gross alpha and beta airborne activity levels for samples collected from the TPL were 0.0037 and 0.0365 pCi/m^3, respectively. The average gross alpha and beta airborne activity levels for samples collected from the BLIP exhaust stack were 0.0752 and 1.1776 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. Samples are collected using sampling equipment at six blockhouse stations and three pole-mounted samplers (see Figure 4-3 for locations). The blockhouses are fenced to control access and protect costly sampling equipment. In 2003, the number of pole-mounted, battery-powered silica-gel samplers used for tritium monitoring was reduced from 16 to three. The elimination of redundant samplers was justified on the basis that historical air surveillance data after the shutdown of the HFBR and the BMRR revealed that, at most of the sampling stations, the tritium concentrations were below minimum detection limits (MDL) obtained on the day of analysis.

At each blockhouse, particulate matter is captured on a glass-fiber filter, and water vapor for tritium analysis is collected on silica-gel absorbent material. Particulate filters are collected weekly and are analyzed for gross alpha

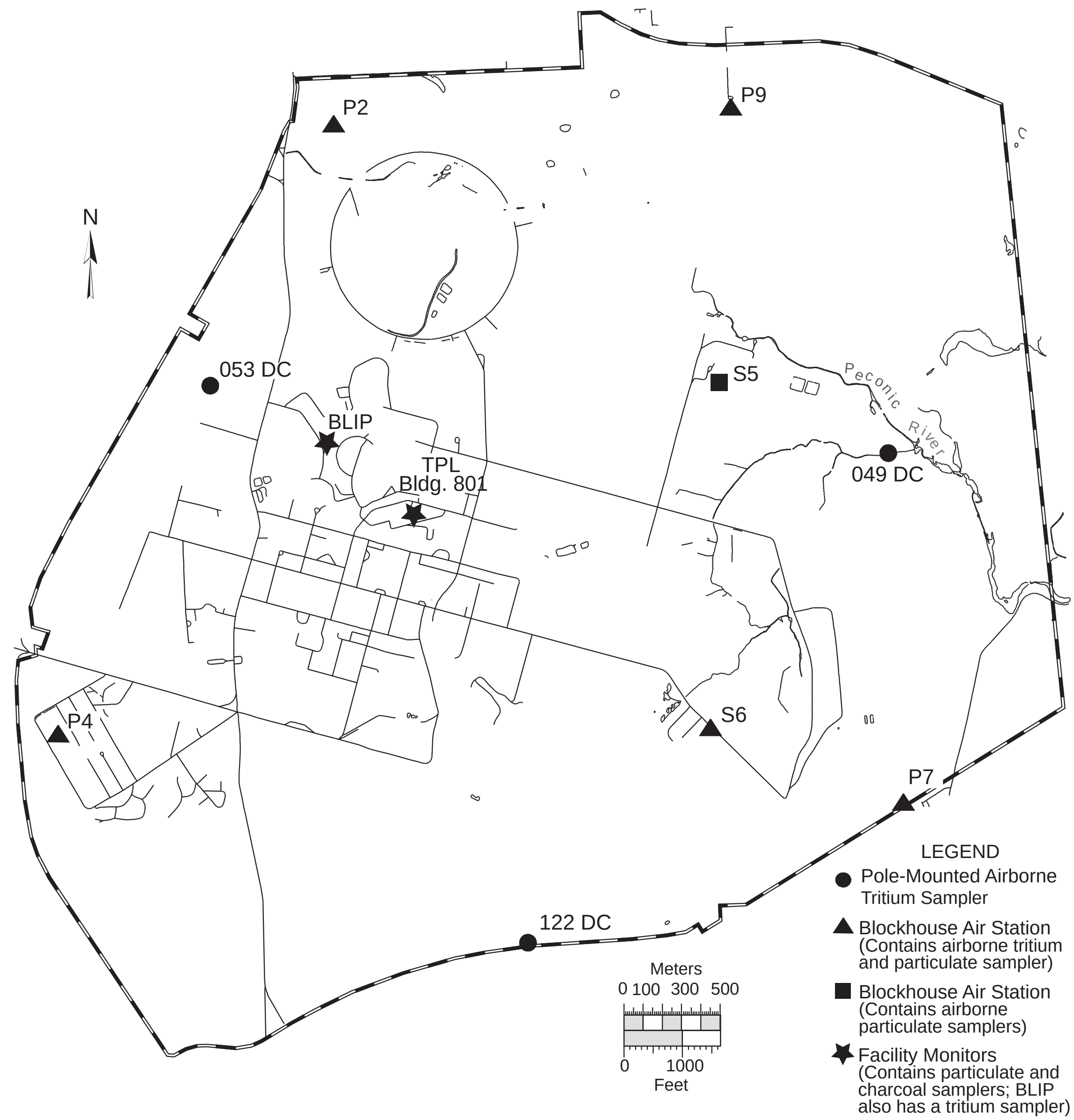

Figure 4-3. BNL On-Site Ambient Air Monitoring Stations.

and beta activity using a gas-flow proportional counter. In 2005, silica-gel samples were collected biweekly for processing by liquid scintillation analysis.

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 0.0014 and 0.0147 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 received were

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

Facility Monitor		Gross Alpha (pCi/m^3)	Gross Beta (pCi/m^3)
BLIP	N	48	48
	Max.	0.2100 ± 0.1960	2.6700 ± 0.4000
	Avg.	0.0752 ± 0.0233	1.1776 ± 0.0313
	MDL	0.1703*	0.3138*
TPL - Bldg. 801	N	49	49
	Max.	0.0115 ± 0.0029	0.1560 ± 0.0108
	Avg.	0.0037 ± 0.0005	0.0365 ± 0.0007
	MDL	0.0028*	0.0049*

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 (Bldg. 801)
*Average MDL for all samples taken at this location

comparable to the Station P7 samples analyzed by Severn Trent Lab, a contract analytical laboratory. Analytical results for gross beta activity were between 0.0072 and 0.0264 pCi/m^3, with an average concentration of 0.0144 pCi/m^3, whereas the BNL results ranged from 0.0039 to 0.022 pCi/m^3, with an average concentration of 0.0100 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 2005, NYSDOH reported that airborne gross beta activity at that location varied between 0.0037 and 0.0187 pCi/m^3 and the average concentration was 0.0093 pCi/m^3. Sample results measured at BNL generally 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.

4.3.2 Airborne Tritium

Airborne tritium in the form of HTO is monitored throughout the Laboratory site. In addition to the five blockhouses containing tritium samplers, three pole-mounted monitors used for tritium sampling are located at or near the property boundary (see Figure 4-3 for locations). A pump is used to draw air through a column of silica gel, a water-absorbent medium, to capture airborne tritium. The absorbed HTO is recovered by distillation and analyzed using liquid scintillation counting techniques.

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

Sample Station		Gross Alpha (pCi/m^3)	Gross Beta (pCi/m^3)
P2	N	50	50
	Max	0.0036 ± 0.0009	0.0233 ± 0.0017
	Avg.	0.0012 ± 0.0001	0.0138 ± 0.0002
	MDL	0.0006*	0.0011*
P4	N	52	52
	Max	0.0036 ± 0.0009	0.0308 ± 0.0020
	Avg.	0.0014 ± 0.0001	0.0167 ± 0.0002
	MDL	0.0006*	0.0011*
P7	N	50	50
	Max	0.0035 ± 0.0008	0.0220 ± 0.0024
	Avg.	0.0010 ± 0.0001	0.0100 ± 0.0002
	MDL	0.0005*	0.0008*
P9	N	50	50
	Max	0.0056 ± 0.0012	0.0337 ± 0.0020
	Avg.	0.0016 ± 0.0001	0.0154 ± 0.0002
	MDL	0.0006*	0.0011*
S5	N	50	50
	Max	0.0034 ± 0.0007	0.0327 ± 0.0019
	Avg.	0.0014 ± 0.0001	0.0166 ± 0.0002
	MDL	0.0007*	0.0012*
S6	N	50	49
	Max	0.0038 ± 0.0012	0.0284 ± 0.0017
	Avg.	0.0016 ± 0.0001	0.0162 ± 0.0002
	MDL	0.0006*	0.0012*
Grand Average		0.0014 ± 0.0001	0.0147 ± 0.0006

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 samples taken at this location

Table 4-4 lists the number of validated samples collected at each location, the maximum value observed, and the annual average concen-

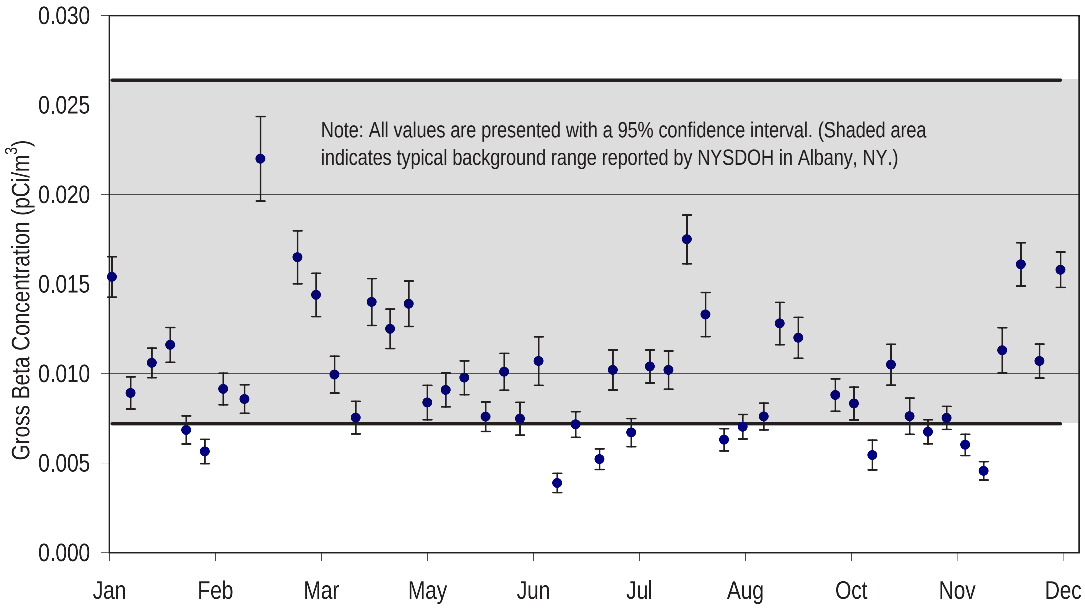

Figure 4-4. Airborne Gross Beta Concentration Trend Recorded at Station P7.

tration. 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, or the loss of sample during preparation at the contract analytical laboratory). Airborne tritium samples were collected biweekly from each sampling station during 2005. The average tritium concentrations at all of the sampling locations were less than the typical MDL, which ranged from 1.0 to 6.0 pCi/m^3. The collected data demonstrate that there were no significant differences in ambient tritium concentrations on site or at the site boundary. Observed concentrations of tritium at the sampling stations in 2005 were comparable to concentrations observed in 2004.

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 facilities at BNL 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

Table 4-4. Ambient Airborne Tritium Measurements in 2005.

Sample Station	Wind Sector	Validated Samples	Maximum (pCi/m^3)	Average (pCi/m^3)
049	E	21	13.5 ± 3.9	2.0 ± 1.3
053	NW	24	2.9 ± 3.1	0.5 ± 0.4
122	SSE	21	5.0 ± 4.7	0.8 ± 0.7
P2	NNW	22	4.1 ± 3.6	0.6 ± 0.5
P4	WSW	23	62.1 ± 4.5	2.9 ± 5.2
P7	ESE	21	14.4 ± 4.0	1.5 ± 1.6
P9	NE	22	4.7 ± 1.2	1.0 ± 0.6
S6	SE	23	5.0 ± 0.6	0.7 ± 0.6
Grand Average				1.2 ± 0.7
DOE Order 5400.5 Air Derived Concentration Guide				100,000 pCi/m^3

Notes:
See Figure 4-3 for sample station locations.
All values reported with a 95% confidence interval.
Wind sector is the downwind direction of the sample station from the HFBR stack.
Typical minimum detection limit for tritium is between 1.0 and 6.0 pCi/m^3.

heat input of 16.4 MW (56.7 MMBtu/hr). 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, Keyspan's Northport, New York power station has four utility-sized turbine/generator boilers, each with a maximum rated heat input of 1,004 MW (3,435 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). Therefore, these boilers are equipped with continuous emission monitors to measure nitrogen oxides (NO_x). Boiler 7 was already equipped with a continuous opacity monitor to comply with Subpart Db opacity monitoring requirements, and 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.

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 (86ng/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. The remainder of the year, the calculated 30-day rolling average emission rate is used to establish compliance. Boiler 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 2005, there were no measured exceedances of the NO_x emission standards for either boiler. During the year, all but one of the Boiler 6 opacity measurements and all of the Boiler 7 opacity measurements that exceeded the opac-

Table 4-5. Central Steam Facility Fuel Use and Emissions (1996 – 2005).

	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)
1996	4,782.55	703,991	52.77	7,388	0.00	0	14.0	104.9	109.0	0.7
1997	3,303.43	484,613	10.23	1,432	190.65	194,463	13.7	83.5	75.1	1.0
1998	354.28	52,283	9.44	1,322	596.17	608,093	2.7	75.1	8.9	1.7
1999	682.76	78,335	2.77	388	614.98	627,280	5.1	53.5	16.7	1.8
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	4,290.94	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
Permit Limit (in tons)							113.3	159	445	39.7

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

ity limit occurred during boiler startups, routine boiler tube soot blowing operations, and necessary calibrations of the monitoring system. Changing the sequence of the soot blowing cycle on Boiler 6 has virtually eliminated opacity exceedances due to soot blowing. Similar changes will be made to the soot blowing cycle on Boiler 7. 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 exceeding the regulatory limits established for these boilers.

Although several boilers have the ability to burn natural gas, natural gas prices exceeded those for residual fuel oil throughout 2005. As a result, residual fuel supplied 100 percent of the heating and cooling needs of BNL's major facilities in 2005. By comparison, in 1999 natural gas satisfied more than 88 percent of the major facility heating and cooling needs. Consequently, 2005 emissions of particulates, NO_x, and sulphur dioxide (SO_2) were 10.1, 26.9, and 76.4 tons higher than the respective totals for 1999. 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 1996.

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Water Quality

5

Wastewater generated from Brookhaven National Laboratory 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 2005 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. Tritium releases to the Peconic River continued to decline and were the lowest ever recorded. The maximum concentration of tritium released was approximately 3.5 percent of the drinking water standard. Analysis of the STP effluent continued to show no detection of cesium-137 or other gamma-emitting nuclides attributable to BNL operations. Strontium-90 detected in a single sample of influent was at a level similar to upstream and other background locations, and was not detected in the effluent. Very low concentrations of tritium were occasionally detected at the STP outfall, but tritium was only detected once at the first downstream monitoring station (HM-N). No other nuclides were detected downstream of the STP discharge.

Nonradiological monitoring of 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. 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 were a result of natural sources.

5.1 SURFACE WATER MONITORING PROGRAM

Treated wastewater from the BNL Sewage Treatment Plant 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 Figure 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.

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 was recorded from January through June, then again from October through December. October was the wettest month recorded on site, with 22 inches of rain; this resulted in high off-site flows dur-

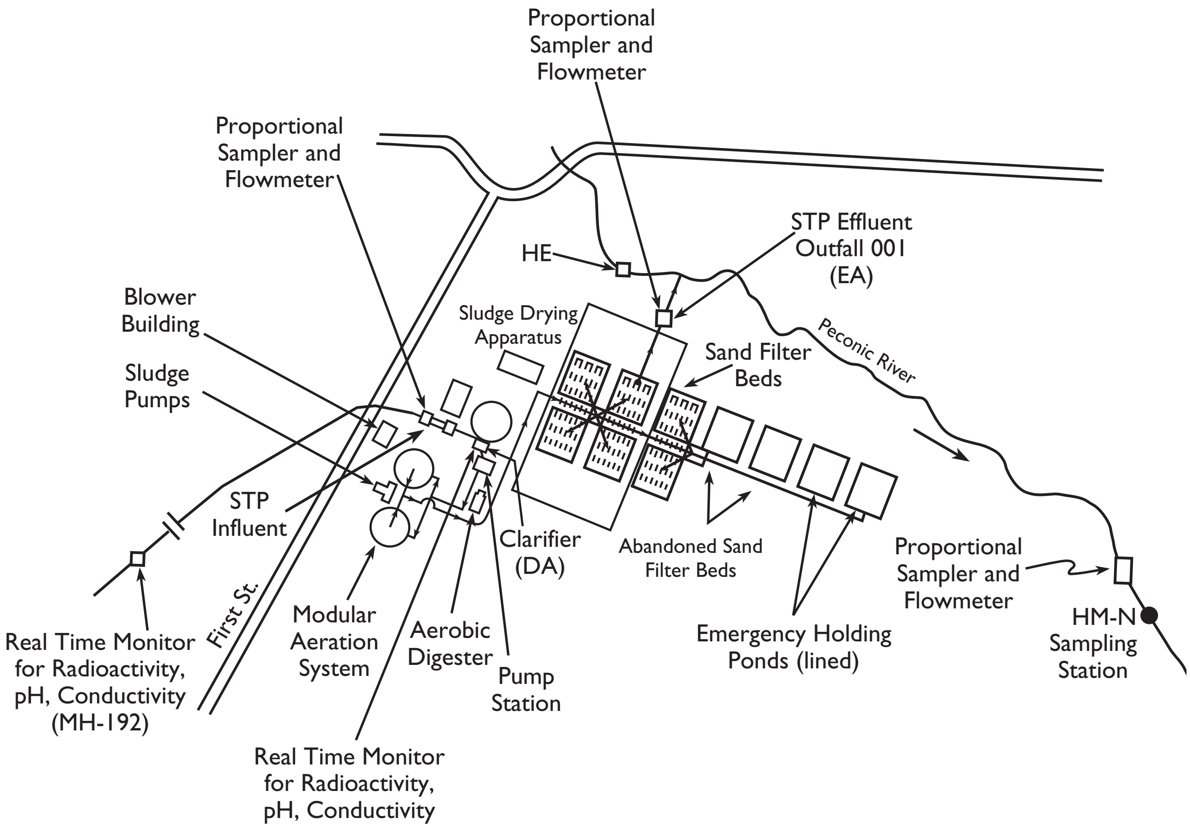

Figure 5-1. Schematic of BNL's Sewage Treatment Plant (STP).

ing the latter part of the year. The following sections describe the Laboratory's surface water monitoring and surveillance program.

5.2 SANITARY SYSTEM EFFLUENTS

The STP effluent (Outfall 001) is a discharge point operated 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 five steps: 1) primary clarification to remove settleable solids and floatable materials, 2) aerobic oxidation for secondary removal of biological matter and nitrification of ammonia, 3) secondary clarification, 4) sand filtration for final solids removal, and 5) ultraviolet disinfection for bacterial control prior to discharge to the Peconic River. Tertiary treatment for nitrogen removal also is provided by controlling the oxygen levels in the aeration tanks. During the aeration process (i.e., Step 2), 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 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 primary clarifier, as shown in Figure 5-1. In addition to the monitoring that occurs at these two stations, as effluent leaves the primary clarifier it is also monitored for radioactivity.

Based on the data collected by the real-time monitoring systems, any influent to the clarifier 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 7 million gallons, or approximately 21 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, then reintroduced into the STP at a rate that ensures compliance with SPDES permit limits for nonradiological parameters or BNL effluent release criteria for radiological parameters. In 2005, the STP influent was diverted in October due to increased flow that occurred during very heavy rains. Influent flow rates, that peaked at 2.8 million gallons per day, could have resulted in inadequately treated waste, violating the Laboratory's SPDES permit. The excess flow was bypassed to the holding ponds and held for treatment after the peak flow period subsided.

Solids separated in the clarifiers are pumped to an aerobic digester for solids reduction. Sludge is periodically emptied into solar/heat lamp-powered drying beds, where it is dried to a semisolid cake. The dried sludge contains 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 historic sewage releases. The dried sludge is put into containers for off-site disposal at an authorized facility.

5.2.1 Sanitary System Effluent–Radiological Analyses

Wastewater at the STP is sampled at the output of the primary clarifier, Station DA (see Figure 5-2) 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. During 2005, 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. EPA revised the SDWA limits for radionuclides in 2003. Under the revisions, the gross activity limit for beta emitters (50 pCi/L) was replaced with a 4 mrem (40 μSv) dose limit. The SDWA specifies that no individual may receive an annual dose greater than 4 mrem from radionuclides that are beta or photon emitters. Beta/photon emitters include 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. 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 2005. Annual average gross alpha and beta activity levels in the STP effluent were 0.3 ± 0.1 pCi/L and 4.6 ± 0.3 pCi/L, respectively. Control location data (Carmans River Station HH; see Figure 5-8 for location) show average gross alpha and beta levels of 0.4 ± 0.2 pCi/L and 1.9 ± 1.2 pCi/L, respectively (see Table 5-7).

Tritium detected at the STP originates from either High Flux Beam Reactor (HFBR) sanitary system releases, or from small, infrequent batch releases from other facilities that meet BNL dis-

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

		Flow (a) (Liters)	Tritium (pCi/L)		Gross Alpha (pCi/L)		Gross Beta (pCi/L)	
			max.	*avg.*	*max.*	*avg.*	*max.*	*avg.*
January	*influent*	2.94E+7	470 ± 190	88 ± 88.9	3.7 ± 2.0	0.9 ± 0.6	15.1 ± 2.2	6.4 ± 1.7
	effluent	2.83E+7	< 240	57.9 ± 62	< 1.4	0.2 ± 0.2	6.9 ± 1.6	5.3 ± 0.7
February	*influent*	2.62E+7	1180 ± 310	153.3 ± 192.3	2.1 ± 1.2	0.3 ± 0.4	8.7 ± 1.3	6.3 ± 0.6
	effluent	2.81E+7	< 270	1.7 ± 62.6	2.8 ± 1.7	0.7 ± 0.5	6.9 ± 1.6	5.8 ± 0.4
March	*influent*	3.33E+7	340 ± 180	94.6 ± 59.3	< 1.9	0.4 ± 0.3	6.7 ± 1.6	5.7 ± 0.5
	effluent	3.37E+7	290 ± 180	91.1 ± 68.4	< 1.6	0.3 ± 0.2	7.8 ± 1.6	5.6 ± 0.7
April	*influent*	3.72E+7	< 300	-12.2 ± 57.4	< 2.1	0.5 ± 0.2	7.1 ± 1.6	5.3 ± 0.6
	effluent	3.96E+7	< 300	-30.6 ± 28.9	< 1.6	0.3 ± 0.2	6.7 ± 1.5	4.9 ± 0.4
May	*influent*	3.96E+7	< 220	-45.4 ± 51.6	< 2.0	0.5 ± 0.3	5.9 ± 1.4	4.7 ± 0.4
	effluent	4.33E+7	< 220	-9.3 ± 51	< 1.5	0.2 ± 0.2	5.3 ± 1.4	4.5 ± 0.3
June	*influent*	5.16E+7	< 350	69.2 ± 67.3	6.9 ± 1.4	1.0 ± 1.0	5.5 ± 1.0	4.2 ± 0.5
	effluent	5.13E+7	< 240	79.8 ± 30	1.7 ± 1.2	0.3 ± 0.3	4.9 ± 1.4	4.2 ± 0.2
July	*influent*	5.43E+7	730 ± 240	256.7 ± 132.4	1.3 ± 0.9	0.3 ± 0.3	6.0 ± 1.2	4.4 ± 0.4
	effluent	5.14E+7	730 ± 210	249.2 ± 158.2	< 1.7	0.2 ± 0.2	5.1 ± 1.3	4.0 ± 0.6
August	*influent*	6.47E+7	650 ± 240	118.9 ± 119.7	< 1.9	0.6 ± 0.1	8.7 ± 1.6	4.7 ± 0.8
	effluent	5.59E+7	600 ± 240	112.9 ± 111.6	2.1 ± 1.4	0.4 ± 0.3	7.3 ± 1.2	4.9 ± 0.5
September	*influent*	5.11E+7	< 320	88.3 ± 60.8	2.2 ± 1.2	0.4 ± 0.3	5.2 ± 1.4	4.4 ± 0.4
	effluent	4.21E+7	< 300	121.3 ± 65.1	< 1.5	0.1 ± 0.2	5.0 ± 1.5	4.0 ± 0.4
October	*influent*	5.12E+7	< 430	48.2 ± 64.3	3.1 ± 1.4	0.9 ± 0.4	5.4 ± 1.5	4.1 ± 0.4
	effluent	6.07E+7	< 360	51.5 ± 34.9	5.1 ± 1.8	0.9 ± 0.7	7.0 ± 2.4	4.3 ± 0.7
November	*influent*	4.08E+7	< 350	-76.7 ± 112.8	1.5 ± 1.0	0.6 ± 0.3	7.0 ± 1.5	5.0 ± 0.9
	effluent	3.38E+7	< 380	0.5 ± 72.1	< 1.6	0.1 ± 0.2	11.3 ± 1.6	5.0 ± 1.4
December	*influent*	3.94E+7	2490 ± 400	245.3 ± 369.6	< 2.6	0.5 ± 0.2	7.1 ± 1.6	3.9 ± 1.0
	effluent	3.90E+7	< 340	109.5 ± 65.1	< 1.5	0.0 ± 0.6	6.4 ± 1.5	2.4 ± 3.2
Annual Avg.	*influent*			85.5 ± 42.9		0.6 ± 0.1		4.9 ± 0.2
	effluent			69.6 ± 24		0.3 ± 0.1		4.6 ± 0.3
Total Release		5.07E+8		35.8 mCi		0.2 mCi		2.1 mCi
Average MDL (pCi/L)				307.5		1.7		1.9
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 late 2003. As gross beta activity does not identify specific radionuclides, a dose equivalent cannot be calculated for the values in the table.

charge criteria. 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 liberate 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 conditioning condensate collected on the equipment level of the HFBR. A plot of the 2005 tritium concentrations recorded in the 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 2005, a total of 0.04 Ci of tritium was released during the year (see Figure 5-4). The annual average tritium concentration as measured in the STP effluent (EA, Outfall 001) was 70 ± 24 pCi/L, which is approximately 20 percent less than that recorded for 2004 and well below the drinking water standard (DWS) of 20,000 pCi/L. The 2005 value is approximately one-quarter the average minimum detection limit (MDL) of 307 pCi/L. The maximum concentration detected in the STP discharge (see Figure 5-2) was 730 ± 210 pCi/L. Evaporative losses are expected to be greatest during the warmer months; consequently, tritium was detected above the MDL in samples collected from June through August, when discharges increase due to HFBR air conditioning condensate. Additionally, work to further ready the HFBR for decommissioning and decontamination, which may have exposed residual moisture within the HFBR piping system, may have contributed to slightly higher summertime tritium releases. These levels should continue to decrease, provided no additional work is conducted that could expose tritium contained in reactor components.

Table 5-2 presents the gamma spectroscopy analytical data for anthropogenic radionuclides historically detected in the monthly STP wastewater composite samples. During 2005, there were no gamma-emitting nuclides detected in the STP effluent, which is consistent with the data reported for 2003 and 2004 (see Figure 5-5). Sr -90 was detected in a single sample of influent collected in May but was not detectable in the effluent. The concentration detected (0.87 pCi/L) was very similar to levels found in upstream portions of the Peconic River.

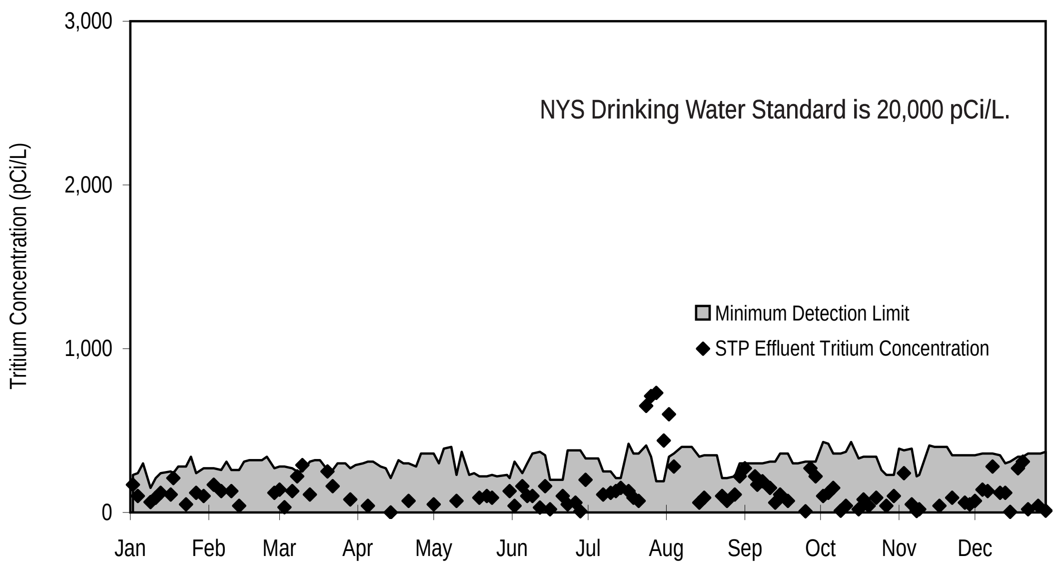

Figure 5-2. Tritium Concentrations in Effluent from the BNL Sewage Treatment Plant (2005).

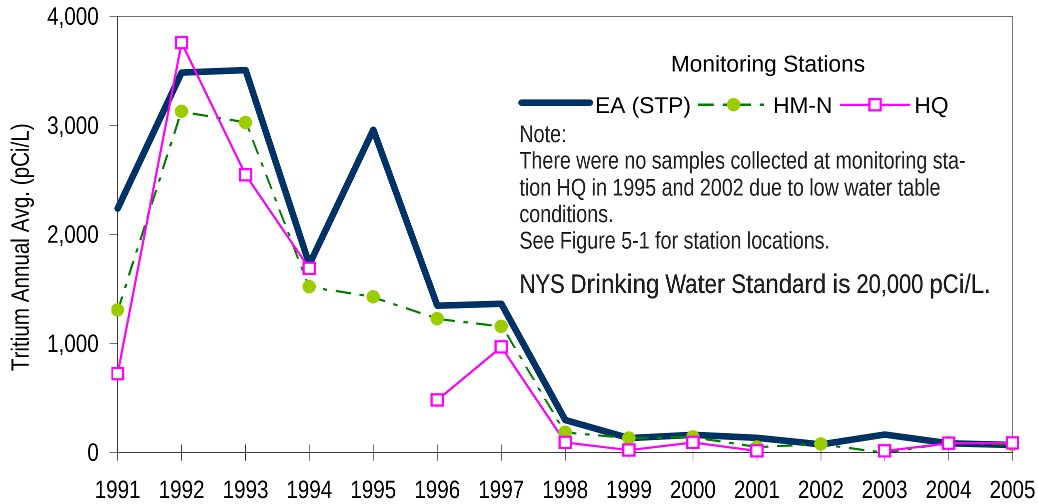

Figure 5-3. Sewage Treatment Plant/Peconic River Annual Average Tritium Concentrations (1991-2005)

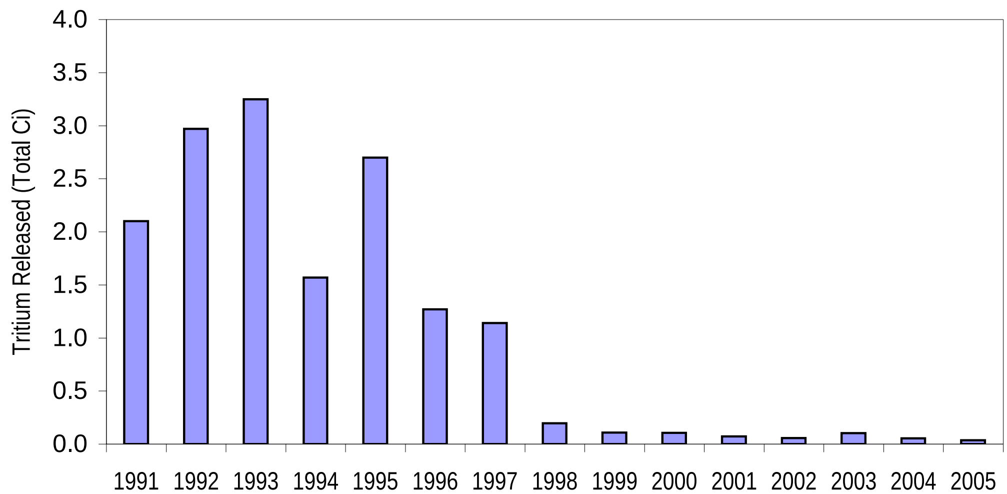

Figure 5-4. Tritum Released to the Peconic River, 15-Year Trend (1991–2005).

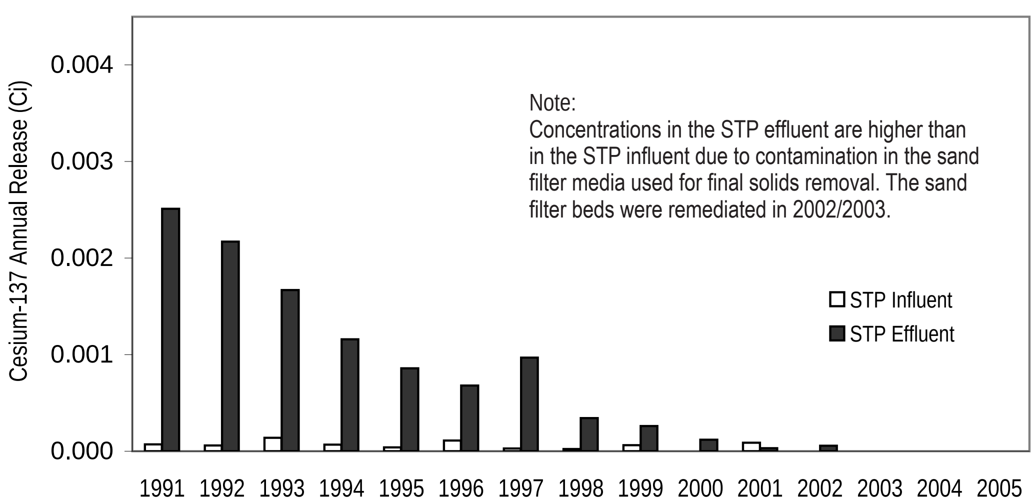

Figure 5-5. Cesium-137 in the BNL Sewage Treatment Plant Influent and Effluent (1991–2005).

Table 5-2. Gamma-Emitting Radionuclides and Sr-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*	2.94E+7	ND	ND	ND	ND	ND
	effluent	2.83E+7	ND	ND	ND	ND	ND
	influent	2.62E+7	ND	ND	ND	ND	ND
	effluent	2.81E+7	ND	ND	ND	ND	ND
March	*influent*	3.33E+7	ND	ND	ND	ND	ND
	effluent	3.37E+7	ND	ND	ND	ND	ND
April	*influent*	3.72E+7	ND	ND	ND	ND	ND
	effluent	3.96E+7	ND	ND	ND	ND	ND
May	*influent*	3.96E+7	ND	ND	ND	ND	0.87± 0.38
	effluent	4.33E+7	ND	ND	ND	ND	ND
June	*influent*	5.16E+7	ND	ND	ND	ND	ND
	effluent	5.13E+7	ND	ND	ND	ND	ND
July	*influent*	5.43E+7	ND	ND	ND	ND	ND
	effluent	5.14E+7	ND	ND	ND	ND	ND
August	*influent*	6.47E+7	ND	ND	ND	ND	ND
	effluent	5.59E+7	ND	ND	ND	ND	ND
September	*influent*	5.11E+7	ND	ND	ND	ND	ND
	effluent	4.21E+7	ND	ND	ND	ND	ND
October	*influent*	5.12E+7	ND	ND	ND	ND	ND
	effluent	6.07E+7	ND	ND	ND	ND	ND
November	*influent*	4.08E+7	ND	ND	ND	ND	ND
	effluent	3.38E+7	ND	ND	ND	ND	ND
December	*influent*	3.94E+7	ND	ND	ND	ND	ND
	effluent	3.90E+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 2005.
To convert values from pCi to Bq, divide by 27.03.
DCG = Derived Concentration Guide
EDE = Effective Dose Equivalent
ND = Not Detected
Sr-90 = Strontium-90

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, 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 SPDES effluent permit limits (see also the compliance data in Chapter 3). There was one detection of a parameter above its SPDES limit: in November, zinc was detected at 113 ppb, exceeding the permit limit of 100 ppb.

There were single instances, both in February, when aluminum and vanadium exceeded the NYS AWQS. Review of the analytical data report showed that several inorganics were higher than typical levels. The contract analytical laboratory indicated that there was a problem with the analysis (matrix interference); consequently, the results were questionable. All other results were below the applicable limit or guidance value. See Section 5.5 for further discussion of the Peconic River and other surface waters.

Acetone and methylene chloride are periodically detected in the effluent. Both are common solvents and are typically found in background levels in laboratories. The maximum concentrations detected were 4.1 µg/L and 5.0 µg/L, respectively. No other organic compounds were detected above the MDL in 2005. Although there are no SPDES limits or ambient water quality standards specified for acetone, NYSDEC imposes a generic limit of 50 µg/L for unlisted organic compounds. The amounts detected in BNL samples were approximately 10 percent of that generic limit.

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, cooling tower discharges from Building 902, and boiler blowdown from satellite boilers in Buildings 244 and 423. These operations are monitored for contaminants such as metals, cyanide, VOCs, and SVOCs. Analyses of these waste streams in 2005 showed that, although several operations contributed contaminants to the STP 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 primary closed-loop cooling water, heat exchanger cleaning wastewater, 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 the Laboratory's effluent release criteria. If the concentrations were within limits, authorization for sewer system discharge was granted; if not, alternate means of disposal were pursued. 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 offsite disposal.

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	5.3	10.7	NA	CM	5.8	7.4	NA	5.8 - 9.0	
Conductivity	µS/cm	CM	NR	NR	NR	172 (a)	140	467	302	SNS	
Temperature	°C	CM	NR	NR	NR	172 (a)	1.8	26.6	14.9	SNS	
Dissolved Oxygen	mg/L	NM	NM	NM	NM	172 (a)	6.3	15.4	9.8	SNS	
Chlorides	mg/L	12	37.7	77.0	52.3	12	27.2	62.0	44.1	SNS	
Nitrate (as N)	mg/L	12	0.1	4.4	2.4	6	1.9	8.1	5.6	10	Total N
Sulfates	mg/L	12	12.3	26.9	17.0	12	12.1	17.9	15.9	250	GA
Aluminum	µg/L	12	49.8	295.0	186.5	12	9.3	128.0	49.6	100	Ionic
Antimony	µg/L	12	0.6	< 5	< 5	12	0.7	< 12.5	< 12.5	3	GA
Arsenic	µg/L	12	2.3	5.2	< 5	12	2.5	< 12.5	< 12.5	150	Dissolved
Barium	µg/L	12	9.0	58.1	38.3	12	2.9	33.0	18.5	1000	GA
Beryllium	µg/L	12	< 2	< 2	< 2	12	< 2	< 5	< 5	11	Acid Soluble
Cadmium	µg/L	12	0.1	0.8	0.4	12	0.2	< 2	< 2	1.1	Dissolved
Calcium	mg/L	12	9.2	15.0	11.9	12	9.3	13.0	10.9	SNS	
Chromium	µg/L	12	1.9	8.4	< 5	12	4.1	11.8	< 5	34.4	Dissolved
Cobalt	µg/L	12	0.5	1.7	1.1	12	0.6	< 5	< 5	5	Acid Soluble
Copper	µg/L	12	19.8	151.0	93.9	12	4.9	76.3	34.9	150	SPDES
Iron	mg/L	12	1.1	2.9	1.9	12	0.1	0.3	0.2	0.37	SPDES
Mercury	µg/L	12	0.1	0.6	< 0.2	12	0.1	< 0.2	< 0.2	0.8	SPDES
Manganese	µg/L	12	12.3	59.8	33.5	12	2.8	11.4	5.0	300	GA
Magnesium	mg/L	12	3.0	5.1	4.1	12	2.9	4.0	3.5	SNS	
Nickel	µg/L	12	6.0	20.1	< 0.2	12	2.5	41.1	15.1	110	SPDES
Lead	µg/L	12	1.8	22.5	12.1	12	0.9	5.1	< 3	19	SPDES
Potassium	mg/L	12	2.1	5.8	4.6	12	1.1	10.7	4.4	SNS	
Selenium	µg/L	12	0.6	< 5	< 5	12	0.7	< 12.5	< 12.5	4.6	Dissolved
Silver	µg/L	12	0.2	< 2	< 2	12	2.0	5.8	2.3	15	SPDES
Sodium	mg/L	12	23.3	62.2	41.9	12	16.7	52.6	36.4	SNS	
Thallium	µg/L	12	0.3	< 5	< 5	12	0.5	< 12.5	< 12.5	8	Acid Soluble
Vanadium	µg/L	12	2.6	17.5	7.1	12	1.9	21.0	6.0	14	Acid Soluble
Zinc	µg/L	12	40.2	116.0	78.1	12	30.1	113.0	58.6	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 AWQS, the solubility state for the metal is provided.
(1) Unless otherwise provided, the reference standard is NYSDEC Class C Surface Water AWQS.
(a) The conductivity, temperature, and dissolved oxygen values reported are based on analyses of daily grab samples.
AWQS = Ambient Water Qualty Standards
CM = Continuously monitored
GA = Class GA (groundwater) Ambient Water Quality Standard
N = Number of Samples
NA = Not Applicable
NM = Not Monitored
NR = Not Recorded
NYSDEC = New York State Department of Environmental Conservation
SNS = Standard Not Specified
SPDES = State Pollutant Discharge Elimination System
SU = Standard Units

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. Ten 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.

Note: Some outfalls have multiple basins.

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

- Several other recharge areas are used exclusively for discharging stormwater runoff. These areas include Basin HW in the warehouse area, Basin CSF at the Central Steam Facility, Basin HW-M at the former Hazardous Waste Management Facility (HWMF), and Basin HZ near Building 902. In late 2004, the basin identified as HW-M was removed as remediation of the former HWMF began. This facility was remediated in accordance with its Record of Decision, and the former discharge point was restored through the installation of geotextile topped with rocks to prevent erosion. The remainder of the area was restored to a natural state.

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 that monitoring program, samples are also routinely collected and analyzed under BNL's Environmental Monitoring Program for radioactivity, VOCs, metals, and anions. During 2005, water samples were collected from all the basins listed above except basin HX (at the Water Treatment Plant; exempted by NYSDEC from sampling due to documented non-impact to groundwater) and basin HW-M, which is being monitored as part of the remediation of the former HWMF.

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. The data show that low levels of alpha and beta activity were detected in most of the basins. Activities ranged from nondetectable to 4.2 ± 1.4 pCi/L for gross alpha activity, and from nondetectable

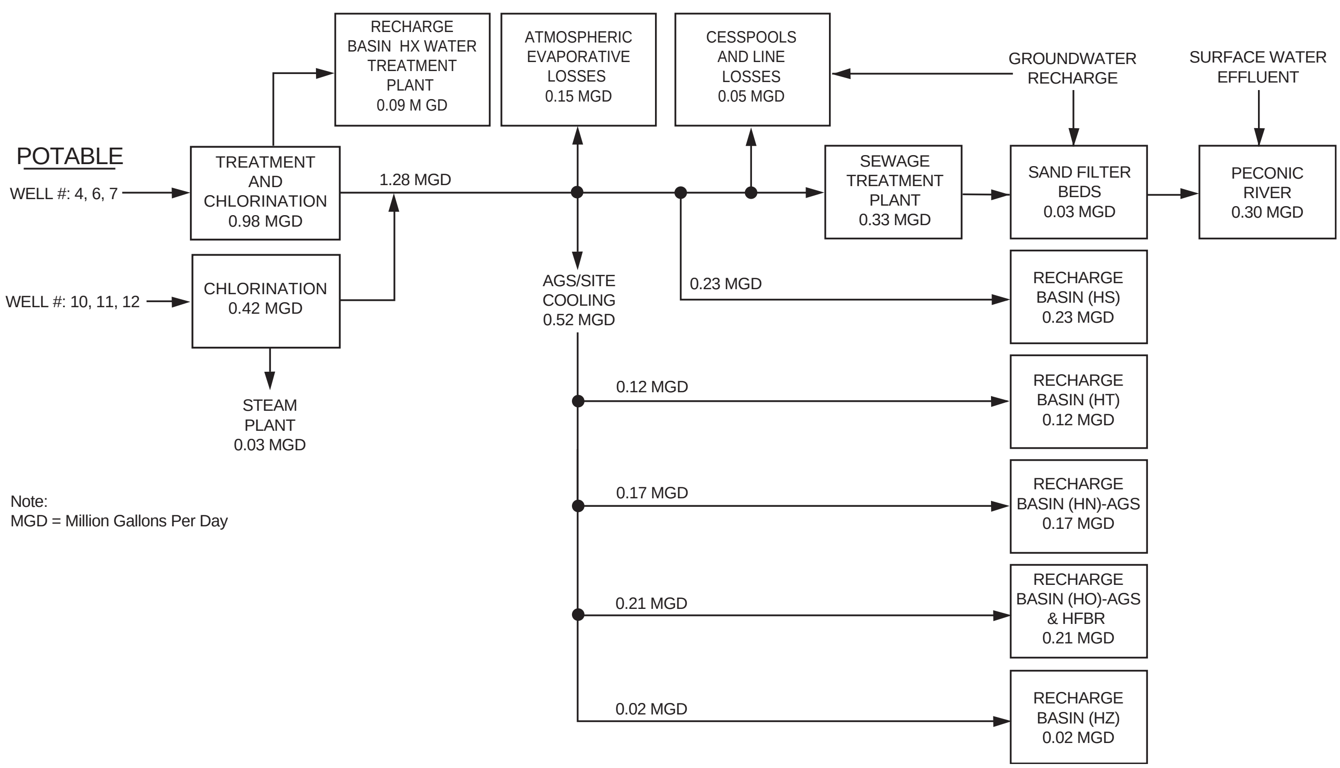

Figure 5-7. Schematic of Potable Water Use and Flow at BNL.

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.*	< 1.9	5.1 ± 1.4	< 400
	avg.	0.5 ± 0.5	3.0 ± 1.4	52.5 ± 95.5
HO	*max.*	1.3 ± 0.8	3.2 ± 1.3	640 ± 230
	avg.	0.5 ± 0.6	1.9 ± 0.9	120 ± 359.4
HS	*max.*	< 1.4	3.5 ± 1.2	< 390
	avg.	0.5 ± 0.5	2.7 ± 0.9	-25 ± 101.4
HT-E	*max.*	< 39*	< 36*	< 260
	avg.	3.7 ± 4.2	12.2 ± 8.8	-40 ± 157.4
HT-W	*max.*	< 1.1	4.5 ± 1.1	< 260
	avg.	0.2 ± 0.5	2.8 ± 1.5	10 ± 173.3
HW	*max.*	4.2 ± 1.4	6.6 ± 1.5	< 220
	avg.	1.8 ± 1.8	4.5 ± 2.17	27.5 ± 37
HZ	*max.*	< 5.3	13.1 ± 2.8	< 390
	avg.	1.2 ± 1.3	6.4 ± 4.9	-80 ± 142.0
SDWA Limit		15	(a)	20,000

Notes:
See Figure 5-6 for the locations of recharge basins.
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.
MDL = Minimum Detection Limit
SDWA = Safe Drinking Water Act
*A lower MDL could not be acheived due to high solids content of the sample.
(a) The drinking water standard was changed from 50 pCi/L (concentration based) to 4 mrem/yr (dose based) in late 2003. As gross beta activity does not identify specific

to 13.1 ± 2.8 pCi/L for gross beta activity. 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 1.3 E9 years). The contract analytical laboratory reported no gamma-emitting nuclides attributable to BNL operations in any discharges to recharge basins in 2005. Tritium was detected in a single sample collected at Basin HO at very low levels (i.e., 640 ± 230 pCi/L). This basin receives discharges from the Collider–Accelerator complex and the HFBR.

5.4.2 Recharge Basins–Nonradiological Analyses

To determine the overall impact of the recharge basin discharges on the environment, 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 analyzed by a contract analytical laboratory. 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 are periodically detected. Sodium hypochlorite and bromine, used to control algae in cooling towers, lead to the formation of VOCs including bromoform, chloroform, dibromochloromethane, and dichlorobromomethane. In 2005, concentrations ranged from nondetectable to a maximum of 5 µg/L. Acetone and methylene chloride were the only other analytes detected above minimum detection limits for most recharge basins, ranging from nondetectable to a maximum of 20 µg/L. In most instances, acetone and methylene chloride were also found as contaminants in the contract analytical laboratory, as evidenced by detections in blank samples.

The analytical data in Tables 5-5 and 5-6 show that all parameters, except for aluminum, iron, and lead, complied with the respective groundwater discharge or water quality standards. Chlorides were found to be higher in discharge samples collected during the winter and are attributed to road salt used to control snow and ice buildup. Iron and aluminum are natural components of soil and readily dissolve when water samples are acidified for preservation. Iron is also naturally present in Long Island groundwater at concentrations that exceed the New York State groundwater discharge standard (GDS). Filtration of samples resulted in aluminum and iron concentrations that were less than the NYS AWQS or GDS, as appropriate. As the aluminum and iron are in particulate form, they pose no threat to groundwater quality, because the recharge basin acts as a natural filter, trap-

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

ANALYTE	No. of samples	Recharge Basin HN (RHIC) 4	HO (AGS) 4	HS (s) 4	HT-W (Linac) 4	HT-E (AGS/HFBR) 4	HW (s) 4	CSF (s) 4	HZ (s) 4	NYSDEC **Effluent** Standard	Typical MDL
pH (SU)	*min.*	6.9	6.3	7.4	7.2	7.6	7.5	7.1	7.5	6.5 - 8.5	NA
	max.	7.9	7.5	8.0	7.8	7.8	7.8	7.5	7.7		
Conductivity (µS/cm)	*min.*	177	141	170	136	171	41	59	168	SNS	NA
	max.	362	199	284	191	1006	340	294	782		
	avg.	226	166	216	170	542	132	170	409		
Temperature (ºC)	*min.*	7.3	12.2	2.4	7.1	3.4	4.0	4.5	4.6	SNS	NA
	max.	110.2	19.0	10.9	17.1	12.2	24.9	25.6	21.2		
	avg.	34.3	16.2	7.8	13.5	7.8	12.6	13.8	13.3		
Dissolved oxygen (mg/L)	*min.*	10.6	9.7	10.7	9.1	9.3	8.3	8.2	8.9	SNS	NA
	max.	11.4	10.8	13.7	11.8	15.1	13.4	12.7	13.6		
	avg.	11.1	10.2	12.2	10.5	12.3	11.4	11.0	11.1		
Chlorides (mg/L)	*min.*	22.1	19.5	21.0	20.5	31.2	2.4	2.2	29.6	500	4
	max.	62.4	28.7	51.9	40.5	3260.0	22.5	131.0	101.0		
	avg.	37.8	25.1	36.5	29.3	883.2	9.5	46.9	55.8		
Sulfates (mg/L)	*min.*	10.8	8.0	8.9	10.8	11.6	2.1	2.4	9.7	500	4
	max.	23.4	11.0	15.6	15.9	48.5	7.2	27.4	49.1		
	avg.	14.7	9.8	12.2	12.3	36.7	4.2	9.7	23.8		
Nitrate as nitrogen (mg/L)	*min.*	0.7	0.3	0.4	0.4	0.5	0.3	0.2	0.2	10	1
	max.	1.3	0.9	1.3	1.2	0.9	1.4	0.7	2.3		
	avg.	0.9	0.6	0.8	0.7	0.8	0.7	0.5	0.9		

Notes:
See Figure 5-6 for the locations of recharge basins.
(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 Conservation
RHIC = Relativistic Heavy Ion Collider
SNS = Effluent Standard Not Specified
SU = Standard Units

ping the particles before they reach groundwater. Lead was detected in a sample collected at Basin HZ in both the filtered and unfiltered samples. This was an isolated instance and could not be repeated in subsequent samples. Lead is present in native soils and is identified in soil sample analyses. Contamination of the water samples with very low levels of soil could be the cause of this finding.

Lead at the CSF outfall continued to be evaluated in 2005. In 2005, the Laboratory cleaned out several upstream manholes that contained sediment found to have high concentrations of lead. During heavy rain events, these sediments were being washed downstream and were collecting on the surface of the geotextile. Cleaning out the manholes precluded future movement and deposits of lead-contaminated soils.

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 or Filtered	T	F	T	F	T	F	T	F	T	F	T	F	T	F	T	F		
	No. of samples	4	3	5	2	4	3	4	3	4	3	4	3	3	3	5	2		
Ag Silver (µg/L)	*min.*	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<0.6	<2.0	<2.0	<2.0	0.06	<2.0	<2.0	<2.0	<0.1	<2.0		
	max.	<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	1.0
	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.*	40.3	13.1	10.9	<50.0	26.7	9	19.8	20	19.4	13	217	31.3	214	29.1	10.2	27.1		
	max.	434	<50.0	508	<50.0	733	23.8	215	<50.0	67.1	<50.0	2580	54.2	3030	202	238	58.1	2000	2.2
	avg.	247.7	<50.0	106.6	<50.0	280.4	15.2	92.9	<50.0	43.1	<50.0	1352.5	41.3	2074.7	88	73.5	42.6		
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	0.8	<5.0	<5.0	<5.0	1.6	3.4		
	max.	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	24.5	22.1	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	6.6	9.2	50	3.0
	avg.	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	10.9	13.9	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	6.3		
Ba Barium (µg/L)	*min.*	21.7	21.3	19.4	19.7	15.6	18.8	23.6	21.8	24.3	22.1	5	3.6	4.7	3	16.7	36.5	2000	1.8
	max.	44.6	37.3	23.5	21.8	37.3	35.4	135	58.8	30.3	26.8	24.7	8.8	45	21.6	51	46.8		
	avg.	29.1	27.9	20.5	20.8	25.1	26.4	69.9	42.7	26.5	24.7	13.8	6.4	21.2	9.3	30.2	41.7		
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	0.1	<2.0	<2.0	<2.0	SNS	0.7
	max.	<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		
	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		
Cd Cadmium (µg/L)	*min.*	0.1	0.3	0.1	<2.0	0.1	<2.0	1.3	<2.0	0.2	1.7	0.3	0.2	0.1	0.3	0.1	0.7	10	1.1
	max.	1.4	<2.0	<2.0	<2.0	<2.0	<2.0	3.8	3.8	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	2.4	1.5		
	avg.	0.6	<2.0	<2.0	<2.0	<2.0	<2.0	2	2.2	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	1.1		
Co Cobalt (µg/L)	*min.*	0.3	1.7	0.5	1.1	0.43	1.4	1.1	1.8	0.2	3	1.5	0.7	1.4	1.9	0.5	2.5	5	0.1
	max.	<5.0	2.5	<5.0	2.3	<5.0	4.9	<5.0	2.8	<5.0	5.3	<5.0	1.9	7.5	4.7	<5.0	<5.0		
	avg.	<5.0	2.2	<5.0	1.7	<5.0	2.8	<5.0	2.2	<5.0	<5.0	<5.0	1.3	<5.0	2.9	<5.0	<5.0		

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

METAL		Recharge Basin: HN (RHIC)		HO (AGS)		HS (stormwater)		HT-E (AGS)		HT-W (Linac)		HW (stormwater)		CSF (stormwater)		HZ (stormwater)		NYSDEC **Effluent** Limit or AWQS	Typical MDL
Total or Filtered		T	F	T	F	T	F	T	F	T	F	T	F	T	F	T	F		
No. of samples		4	3	5	2	4	3	4	3	4	3	4	3	3	3	5	2		
Cr Chromium (µg/L)	*min.*	5	<5.0	4.1	4	<5.0	<5.0	4.5	<5.0	4.4	<5.0	3.9	<5.0	<5.0	<5.0	2.9	3.9	100	1.0
	max.	7.2	7.3	8.2	<5.0	6.4	6.1	8.2	8.7	6.7	6	12.1	<5.0	8.2	<5.0	7.1	<5.0		
	avg.	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	6.4	<5.0	<5.0	<5.0	<5.0	<5.0		
Cu Copper (µg/L)	*min.*	13	9.4	1.4	2.4	2.7	1.6	5.8	3.5	47.5	43.6	3.9	2.2	4.4	3	16.9	68.2	1000	2.0
	max.	54.9	33.8	8.8	5.9	9.2	8.4	86.7	62.5	307	260	28	13	28.6	12.1	133	108		
	avg.	27.3	17.9	5	4.2	6.4	4.3	45.5	37.4	127.1	131.2	13.2	6.3	16	6.1	56.6	88.1		
Fe Iron (mg/L)	*min.*	0.12	0.06	0.03	0.03	0.07	0.02	0.14	0.06	0.04	0.01	0.27	0.03	0.39	0.04	0.09	0.1	0.6	0.015
	max.	0.92	0.13	0.82	0.04	0.99	0.07	1.22	0.74	0.14	0.09	3.89	0.09	4.64	0.14	1.17	0.33		
	avg.	0.53	0.1	0.22	0.04	0.4	0.05	0.68	0.43	0.09	0.04	2.01	0.06	2.71	0.09	0.4	0.22		
Hg Mercury (µg/L)	*min.*	0.1	0.1	0.1	<0.2	<0.2	0.1	0.1	0.1	0.1	<0.2	0.1	0.1	<0.2	0.1	0.1	0.1	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	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2		
	avg.	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2		
Mn Manganese (µg/L)	*min.*	5	6.1	4.4	3.7	6.3	3.7	16.2	7.8	5	2.5	5	4.1	13.3	7	5.7	14.7	600	2.0
	max.	27.2	10.5	23.3	4.3	22.7	14.2	120	51.3	21.1	26.3	54.1	20.5	91.8	41	48.6	25.4		
	avg.	19.6	8.27	11.1	4	12.1	8.5	79.3	36.5	11.4	11.9	29.8	11.2	48.1	18.8	23.5	20.1		
Na Sodium (mg/L)	*min.*	19.6	20.3	18.6	18.6	19.1	19.5	23	22.5	21.6	22.2	1.62	1.61	4.38	4.09	20.5	47.4	SNS	1.0
	max.	51.8	51.7	32.8	32.4	32.9	30.7	1490	167	30.5	27.6	19.1	5.35	5.48	5.43	122	47.7		
	avg.	31.3	32.3	22.5	25.5	28.6	26.9	452.8	108.2	25.9	25.5	7.8	3.9	5	4.8	52	47.6		
Ni Nickel (µg/L)	*min.*	2.5	1.7	2	1.5	1.4	1.4	3.5	1.5	1.7	1.4	1.6	1.4	5.1	3.7	1.6	3.2	200	1.1
	max.	<10.0	3.8	<10.0	<10.0	2.6	2.6	10.3	4	<10.0	2.7	12.9	5.1	96.5	62.1	<10.0	5.1		
	avg.	<10.0	2.6	<10.0	<10.0	2	2.1	<10.0	3	<10.0	2.1	5.7	3.2	36	23.5	<10.0	4.2		

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

METAL		Recharge Basin: HN (RHIC)		HO (AGS)		HS (stormwater)		HT-E (AGS)		HT-W (Linac)		HW (stormwater)		CSF (stormwater)		HZ (stormwater)		NYSDEC **Effluent** Limit or AWQS	Typical MDL
	Total or Filtered	T	F	T	F	T	F	T	F	T	F	T	F	T	F	T	F		
	No. of samples	4	3	5	2	4	3	4	3	4	3	4	3	3	3	5	2		
Pb Lead (µg/L)	*min.*	0.8	<3.0	3	<3.0	0.6	0.7	1.8	1.7	<3.0	<3.0	2.7	0.9	2.3	1.5	0.7	6.7	50	1.3
	max.	2.9	<3.0	3	<3.0	5	<3.0	3.4	<3.0	<3.0	<3.0	26.8	<3.0	30.3	<3.0	73	58.2		
	avg.	2.3	<3.0	<3.0	<3.0	2.2	<3.0	<3.0	<3.0	<3.0	<3.0	14.4	<3.0	12.8	<3.0	18.4	32.5		
Sb Antimony (µg/L)	*min.*	0.9	0.7	0.8	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	0.8	0.7	0.7	1.3	<5.0	<5.0	6	0.9
	max.	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	5.9	2	<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	1.2	<5.0	<5.0	<5.0	<5.0		
Se Selenium (µg/L)	*min.*	0.8	0.6	<5.0	<5.0	0.7	0.6	1.4	2	0.7	0.8	<5.0	1.1	0.7	<5.0	1.3	3.3	20	5
	max.	<5.0	0.8	<5.0	<5.0	<5.0	<5.0	17.7	14.7	<5.0	<5.0	<5.0	<5.0	1.3	<5.0	5.8	5.1		
	avg.	<5.0	0.7	<5.0	<5.0	<5.0	<5.0	5.9	5.6	<5.0	<5.0	<5.0	<5.0	0.9	<5.0	<5.0	4.2		
Tl Thallium (µg/L)	*min.*	<5.0	0.5	0.5	0.4	0.2	0.3	0.4	1.2	0.4	0.58	0.3	0.3	0.6	0.5	0.5	0.3	SNS	0.7
	max.	<5.0	1	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	1.8	<5.0	<5.0	<5.0		
	avg.	<5.0	0.8	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	1.3	<5.0	<5.0	<5.0		
V Vanadium (µg/L)	*min.*	4.2	<5.0	3.4	<5.0	<5.0	<5.0	<5.0	<5.0	4.7	2.9	<5.0	4.7	5.9	3.2	2	<5.0	SNS	5.5
	max.	<5.0	<5.0	<5.0	5.4	5.1	7.2	7.5	6.3	<5.0	<5.0	14.4	<5.0	63.2	30.9	<5.0	6.3		
	avg.	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	6.1	<5.0	26.3	12.8	<5.0	<5.0		
Zn Zinc (µg/L)	*min.*	23.4	20.3	1.2	2.7	5.7	6.3	8.5	7.1	6.9	5.7	20.2	18.8	21.8	13	26.1	49.2	5000	4
	max.	75.7	47.2	46.4	5.1	63	7.8	61.5	45.5	198	246	150	46.4	293	133	142	108		
	avg.	59	37	12.6	3.9	24.6	7.3	45.5	28.6	61.1	88.6	69.9	29.4	115.4	54.2	73.9	78.6		

Notes:
See Figure 5-7 for the locations of recharge basins.
CSF = Central Steam Facility
NYSDEC = New York State Department of Environmental Conservation
AGS = Alternating Gradient Synchrotron
Linac = Linear Accelerator
RHIC = Relativistic Heavy Ion Collider
AWQS = Ambient Water Quality Standards
MDL = Minimum Detection Limit
SNS = Effluent Standard Not Specified

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 abovegrade 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 HFBR areas. Basin CSF receives runoff from the Central Steam Facility area and along Cornell Avenue east of Railroad Avenue. Basin HW receives runoff from the 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 and the natural occurrence of these elements in native soil. In an effort to further protect 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, and restoring these areas when operations cease.

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 2005. A sampling station along the Carmans River (HH) was also monitored as a geographic control location, not affected by Laboratory operations. 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 ft upstream of the STP outfall (EA)

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. (Note: In 2005, some samples were collected at former station HC, due to access problems at Donahue's Pond. The two sites are very near one another, one within the pond and the other at the outflow from the pond.)
- 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 locations. Routine samples at Stations HM-N and HQ were collected once per month; 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 2005 are summarized in Table 5-7. Radiological analysis of upstream water samples showed that gross alpha and beta activity was detected at most Peconic River and Carmans River locations. The highest concentrations of gross beta activity were detected at Station HA, located downstream and off the Laboratory site. The average concentrations

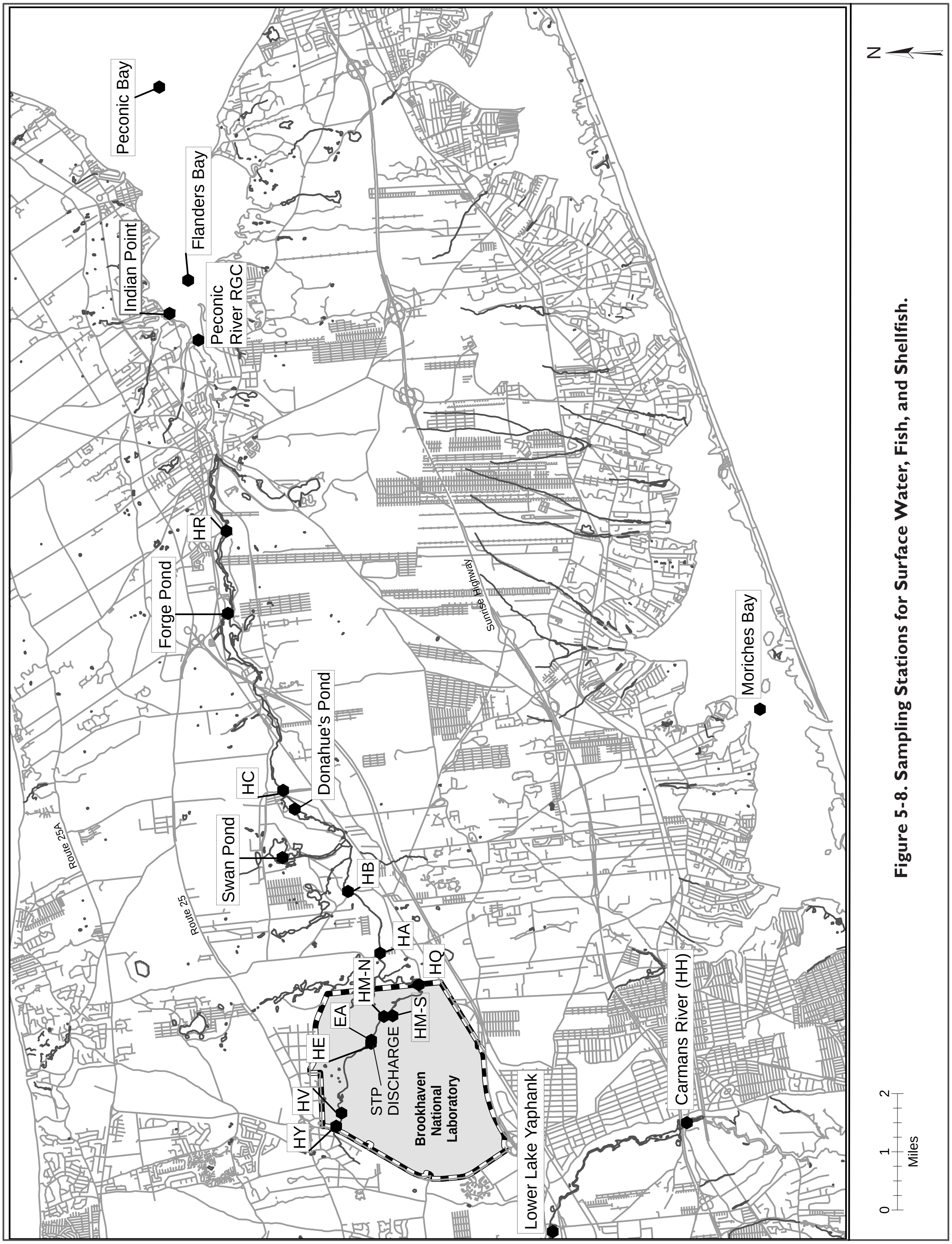

Figure 5-8. Sampling Stations for Surface Water, Fish, and Shellfish.

from off-site and control locations were indistinguishable from BNL on-site levels. The beta activity for all locations is therefore attributed to natural sources. Samples collected downstream of the STP discharge showed concentrations typical of STP releases and historical values. All detected levels were below the applicable DWS. Swan Pond, a station along a Peconic River tributary but uninfluenced by BNL discharges, had the highest detection of gross alpha activity, 4.2 ± 1.5 pCi/L. Again, the average alpha concentrations between upstream, downstream, and background locations were indistinguishable. No gamma-emitting radionuclides attributable to Laboratory operations were detected either upstream or downstream of the STP.

Tritium results for water samples collected upstream and downstream of the STP discharge were below detectable levels at all stations, except for a single detection of 290 ± 180 pCi/L at station HM-N, downstream of the STP discharge. The New York State DWS for tritium is 20,000 pCi/L.

Monitoring for Sr-90 was performed at nine of the 10 stations sampled in 2005. Low-level detections were found at Stations HE, HM-N, and HM-S, at very consistent levels of 0.9, 0.6, and 0.5 pCi/L. These concentrations are consistent with historical levels and are attributed to worldwide fallout.

5.5.2 Peconic River–Nonradiological Analyses

Peconic River samples collected in 2005 were analyzed for water quality parameters (pH, temperature, conductivity, and dissolved oxygen), anions (chlorides, sulfates, and nitrates), metals, and VOCs. No VOCs above the MDL were detected in river water samples. 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. These data were also consistent with those from the Carmans River control location (HH). Sulfates, chlorides, and nitrates tend to be slightly higher in samples collected imme-

Table 5-7. Radiological Results for Surface Water Samples Collected along 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.	< 1.2	3.6 ± 1.3	< 260	< 1.6
	avg.	0.8 ± 0.4	2.6 ± 1.3	-4.5 ± 59.1	0.2 ± 0.1
HV (headwaters) on site, inside the RHIC ring	*N*	4	4	5	NS
	max.	1.71 ± 0.87	8.8 ± 1.7	< 260	
	avg.	1.0 ± 0.5	4.8 ± 3.1	-63.4 ± 72	
HE upstream of STP outfall	*N*	4	4	4	3
	max.	1.7 ± 1.1	2.6 ± 1	< 260	0.9 ± 0.4
	avg.	1 ± 0.5	1.9 ± 0.8	42.5 ± 104.8	0.5 ± 0.4
HM-N downstream of STP, on site	*N*	12	12	12	6
	max.	2.6 ± 1.2	6.6 ± 1.5	290 ± 180	0.6 ± 0.51
	avg.	0.6 ± 0.5	4.1 ± 0.9	71.8 ± 56.8	0.1 ± 0.4
HM-S tributary, on site	*N*	3	3	3	3
	max.	< 1.2	3 ± 1.2	< 270	0.5 ± 0.3
	avg.	0.4 ± 0.2	2.4 ± 0.7	-96.7 ± 169.9	0.3 ± 0.3
HQ downstream of STP, at BNL site boundary	*N*	9	9	9	4
	max.	< 1.2	5.6 ± 1.1	< 340	< 0.77
	avg.	0.01 ± 0.3	3.7 ± 0.8	88.9 ± 68.1	0.3 ± 0.1
HA off site	*N*	4	4	4	4
	max.	< 1.2	36.8 ± 4.3	< 230	< 0.54
	avg.	0.2 ± 0.5	10 ± 17.5	-60 ± 109.4	0.2 ± 0.1
HC off site	*N*	2	2	2	2
	max.	< 1	3.3 ± 0.99	< 220	< 0.54
	avg.	0.4 ± 0.6	2.4 ± 1.9	-80 ± 39.2	0.2 ± 0.1
Donahue's Pond off site	*N*	2	2	2	2
	max.	< 1.2	< 2.2	< 310	< 0.67
	avg.	0.7 ± 0.2	1.8 ± 0.5	-60 ± 58.8	0.2 ± 0.2
Forge Pond off site	*N*	4	4	4	4
	max.	< 0.95	13.6 ± 2.1	< 230	< 0.50
	avg.	0.3 ± 0.5	4.7 ± 5.8	-27.5 ± 108.7	0.2 ± 0.2
Swan Pond control location, off site	*N*	4	4	4	4
	max.	4.2 ± 1.5	6.4 ± 1.4	< 390	< 0.69
	avg.	1.6 ± 1.7	4.9 ± 1.6	25 ± 99.5	0.2 ± 0.3
HH Carmans River control location, off site	*N*	4	4	4	4
	max.	< 1.4	3.6 ± 1	< 390	< 0.62
	avg.	0.4 ± 0.2	1.9 ± 1.2	-12.5 ± 35.2	0.1 ± 0.2
SDWA Limit (pCi/L)		15	(a)	20,000	8

Notes:
See Figure 5-8 for 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.
N = Number of samples analyzed
NS = Not Sampled for this analyte
SDWA = Safe Drinking Water Act
(a) The drinking water standard was changed from 50 pCi/L (concentration based) to 4 mrem/yr (dose based) in late 2003. Because gross beta activity does not identify specific radionuclides, a dose equivalent cannot be calculated for the values in the table.

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

		Recharge Basin												
ANALYTE		HY	HE	HM-N	HM-S	HQ	HA	HC	Donahue's Pond	Forge Pond	Swan Pond	HH	NYSDEC **Effluent** Standard	Typical MDL
	No. of samples	4	4	12	3	9	4	2	2	4	4	4		
pH (SU)	*min*	4.2	5.0	5.2	4.0	5.2	6.0	6.0	6.2	6.6	5.9	6.4	6.5 – 8.5	NA
	max.	7.3	6.5	7.0	4.0	9.6	6.6	6.5	6.4	6.4	7.0	7.1		
Conductivity (µS/cm)	*min.*	78.0	50.0	153.0	67.0	55.0	58.0	64.0	74.0	101.0	69.0	158.0	SNS	NA
	max.	225.0	130.0	660.0	117.0	293.0	74.0	79.0	79.0	148.0	105.0	174.0		
	avg.	137.2	86.0	271.1	88.0	185.7	66.8	71.5	76.5	119.0	92.5	167.8		
Temperature (ºC)	*min.*	1.1	4.2	0.6	0.0	2.2	1.3	12.3	1.7	3.5	1.8	5.8	SNS	NA
	max.	14.9	8.6	26.2	16.5	25.2	22.1	13.9	21.5	27.4	22.2	19.0		
	avg.	10.2	7.0	13.0	9.7	11.2	10.9	13.1	11.6	14.7	12.0	10.9		
Dissolved oxygen (mg/L)	*min.*	7.7	8.3	4.9	5.0	4.7	4.5	9.5	4.0	7.8	4.2	7.0	>4.0	NA
	max.	10.8	13.0	13.6	11.8	15.1	10.5	10.4	8.5	11.1	10.0	11.6		
	avg.	9.1	11.2	9.8	7.9	10.7	8.0	10.0	6.2	9.8	7.7	9.9		
Chlorides (mg/L)	*min.*	6.3	5.8	6.8	0.9	5.1	6.7	9.3	10.4	14.1	8.8	25.7	250(b)	4.0
	max.	33.5	11.6	68.7	5.4	48.3	9.3	11.2	12.2	24.6	15.7	29.7		
	avg.	17.0	8.2	39.1	3.7	27.8	8.4	10.3	11.3	17.8	11.2	27.6		
Sulfates (mg/L)	*min.*	0.4	3.7	7.9	0.3	6.3	3.2	5.2	3.3	8.0	2.8	11.0	250(b)	4.0
	max.	4.2	36.1	22.0	17.8	23.6	6.5	9.8	7.1	13.0	10.8	11.4		
	avg.	2.2	12.7	14.3	7.6	13.5	4.9	7.5	5.2	11.2	8.2	11.2		
Nitrate as nitrogen (mg/L)	*min.*	<0.02	<0.02	0.8	<0.02	<0.02	0.1	<0.02	<0.02	<0.02	<0.02	1.3	10(b)	1.0
	max.	1.0	0.7	7.8	1.3	4.1	1.0	1.0	0.1	0.8	0.8	2.4		
	avg.	0.4	0.3	4.1	0.6	1.4	0.2	0.5	0.1	0.3	0.2	1.6		

Notes:
(a) See Figure 5-6 for the locations of recharge basins. Verbal descriptions are provided below.
(b) 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
HC = 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

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

METAL		Peconic River Locations																				Control			
		HY		HE		HM-N		HM-S		HQ		HA		HC		D. P.	Swan Pond		Forge Pond		HH		NYSDEC AWQS	Typical MDL
	Total or Dissolved	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	T	D	T	D	T	D		
	No. of samples	4	2	5	1	13	6	3	1	9	5	4	2	2	2	2	4	2	4	2	4	2		
Ag (I) Silver (µg/L)	*min.*	<2.0	<2.0	<2.0	<2.0	1.4	0.53	<2.0	<2.0	<2.0	<2.0	0.1	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	0.1	2
	max.	<2.0	<2.0	<2.0	*	18.4	<2.0	<2.0	*	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<5.0	<2.0	<2.0	<2.0	<2.0	<2.0		
	avg.	<2.0	<2.0	<2.0	*	3.2	<2.0	<2.0	*	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<5.0	<2.0	<2.0	<2.0	<2.0	<2.0		
Al (I) Aluminum (µg/L)	*min.*	552	282	165	186	116	19	558	855	119	87.1	103	109	76.5	67.7	48.7	34.6	28.6	24.5	44.1	43.7	19.3	100	50
	max.	1040	668	857	*	2890	338	942	*	469	361	218	188	122	110	51.8	579	61.6	125	80.2	195	21.1		
	avg.	726.5	475	494	*	603.4	89.9	792	*	285	197	146.3	148.5	99.3	88.9	50.25	239.9	45.1	66.35	62.15	103	20.2		
As (D) Arsenic (µg/L)	*min.*	<5.0	<5.0	3	<5.0	2.8	1.9	<5.0	<5.0	<5.0	<5.0	2.9	<5.0	<5.0	<5.0	2.1	3.2	<5.0	2.1	<5.0	<5.0	<5.0	150	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		
	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		
Ba Barium (µg/L)	*min.*	7.7	8.7	11.1	<9.7	12.8	10.4	12.4	15.4	5.1	2.8	7.8	8.1	10.6	9.4	10.1	10.3	9.8	15.4	14.1	23.3	20.5	SNS	1.8
	max.	14.3	12.8	45.9	*	67.1	20.9	24.1	*	15.4	12.7	12.7	11	14.6	13.9	16.2	25.5	11.2	23.7	17.4	35.4	33.2		
	avg.	11.8	10.8	20.9	*	26.2	14.7	17.5	*	10	8.3	10.4	9.6	12.6	11.7	13.15	14.48	10.5	18.9	15.8	31	26.85		
Be (AS) Beryllium (µg/L)	*min.*	<2.0	<2.0	0.2	<2.0	0.2	0.2	<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	<2.0	<2.0	*	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<5.0	<2.0	<2.0	<2.0	<2.0	<2.0		
	avg.	<2.0	<2.0	<2.0	*	<2.0	<2.0	<2.0	*	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<5.0	<2.0	<2.0	<2.0	<2.0	<2.0		
Cd (D) Cadmium (µg/L)	*min.*	0.1	0.1	0.1	<2.0	0.1	0.1	0.1	0.1	0.1	0.11	0.1	0.1	<2.0	<2.0	<2.0	0.08	<2.0	<2.0	<2.0	<2.0	<2.0	1.1	2
	max.	<2.0	<2.0	<2.0	*	1	0.26	<2.0	*	0.3	0.22	<2.0	<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	*	0.4	0.2	<2.0	*	0.2	0.16	<2.0	<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.*	0.5	2.5	0.5	3.4	0.6	0.8	0.4	1.7	<5.0	<5.0	0.1	1.8	<5.0	1.8	0.2	0.3	2.3	0.27	0.76	0.18	1.7	5	5
	max.	<5.0	4.5	4.3	*	<5.0	3.2	<5.0	*	<5.0	<5.0	<5.0	2	<5.0	2.5	<5.0	<5.0	2.7	<5.0	3.2	<5.0	2.1		
	avg.	<5.0	3.5	1.8	*	<5.0	1.8	<5.0	*	<5.0	<5.0	<5.0	1.9	<5.0	2.2	<5.0	<5.0	2.5	<5.0	1.98	<5.0	1.9		

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

METAL		Peconic River Locations																			Control		NYSDEC AWQS	Typical MDL
		HY		HE		HM-N		HM-S		HQ		HA		HC		D. P.	Swan Pond		Forge Pond		HH			
	Total or Dissolved	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	T	D	T	D	T	D		
	No. of samples	4	2	5	1	13	6	3	1	9	5	4	2	2	2	2	4	2	4	2	4	2		
Cr (I) Chromium (µg/L)	*min.*	3.9	<5.0	<5.0	5.8	4.7	4.3	4.6	<5.0	3.8	4.4	3.9	3.8	<5.0	3.8	4	<5.0	<5.0	4	<5.0	4.2	<5.0	34	5
	max.	9.9	<5.0	5.3	*	21.8	6.4	<5.0	*	6.4	6	<5.0	<5.0	<5.0	<5.0	<5.0	<12.5	<5.0	<5.0	<5.0	<5.0	<5.0		
	avg.	5.2	<5.0	<5.0	*	5.3	<5.0	<5.0	*	5.1	5.2	<5.0	<5.0	<5.0	<5.0	<5.0	<12.5	<5.0	<5.0	<5.0	<5.0	<5.0		
Cu (D) Copper (µg/L)	*min.*	1.7	1.7	1.1	0.95	16.1	9.7	1.1	2.2	7	6.7	0.8	1.9	0.87	1	<10.0	1.1	1	0.5	0.85	0.38	1.1	4	10
	max.	20.2	4.7	13.5	*	144	58.1	1.6	*	27	14.5	2.8	2.5	0.98	1.1	15.9	6.4	1.3	<10.0	1.2	<10.0	<10.0		
	avg.	7.2	3.2	4.4	*	44.3	22.7	1.3	*	13.1	9.7	1.7	2.2	0.92	1.1	<10.0	2.9	1.15	<10.0	1.02	<10.0	<10.0		
Fe (AS) Iron (mg/L)	*min.*	0.4	0.4	0.3	0.64	0.3	0.1	0.2	0.7	0.3	0.1	0.5	0.6	0.9	0.65	0.69	0.11	0.07	0.64	0.5	0.36	0.19	0.3	0.075
	max.	0.8	0.5	5.9	*	2.4	0.4	0.7	*	0.5	0.3	3.02	0.7	0.96	0.66	2.66	0.8	0.12	1.1	0.83	0.58	0.24		
	avg.	0.6	0.5	3.2	*	0.9	0.2	0.5	*	0.4	0.2	1.27	0.6	0.93	0.66	1.67	0.4	0.1	0.84	0.67	0.45	0.21		
Hg (D) Mercury (µg/L)	*min.*	0.1	0.1	<0.2	55.3	0.1	0.1	<0.2	<0.2	<0.2	<0.2	0.01	0.1	<0.2	0.06	<0.2	0.1	0.06	0.07	0.08	0.06	0.06	0.2	0.2
	max.	<0.2	<0.2	<0.2	*	1.2	<0.2	<0.2	*	0.3	<0.2	<2.0	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2		
	avg.	<0.2	<0.2	<0.2	*	<0.2	<0.2	<0.2	*	<0.2	<0.2	<2.0	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.21		
Mn Manganese (µg/L)	*min.*	9.2	32.7	55.8	55.3	13.3	13.9	34.4	37.3	9.9	2.2	17.7	20.5	30.3	30.4	66.8	48.6	32.2	58.8	73.1	57.1	0.06	SNS	2
	max.	56.1	40.7	265	*	80.7	77.3	52.1	*	77.2	69.1	81.9	59.6	219	215	247	546	88.9	161	147	90.8	<0.2		
	avg.	33.9	36.7	174.4	*	45.1	31.8	40.8	*	32.9	25.1	49.1	40.1	124.7	122.7	156.9	275.9	60.6	112.7	110.1	68	<0.2		
Na Sodium (mg/L)	*min.*	8.8	9.3	5.1	5.3	5.4	5.5	3.1	3.29	3.89	3.9	5.2	6.18	7.1	6.95	7.89	6.4	6.49	9.63	9.49	17	60.2	SNS	1
	max.	33.8	34.7	8.8	*	54	54	3.3	*	39.3	35.4	7.5	7.51	7.2	7.1	8.12	9.9	7.09	14.7	10.2	19.3	60.8		
	avg.	20.8	22	6.2	*	29.9	31.2	3.2	*	24.3	23.86	6.3	6.84	7.1	7.02	8.01	7.5	6.79	12.01	9.85	18.15	60.5		
Ni (D) Nickel (µg/L)	*min.*	1.4	1.5	1.3	1.7	6.5	4.5	1.2	1.7	<10.0	<10.0	0.6	1.5	<10.0	1.3	0.51	1.5	1.3	0.59	1.2	0.55	17.1	23	1.1
	max.	<10.0	2.4	<10.0	*	28.9	20.9	1.8	*	13	<10.0	<10.0	1.9	<10.0	1.7	10	<10.0	1.4	<10.0	1.3	<10.0	18.4		
	avg.	<10.0	2	<10.0	*	14	10.7	1.47	*	<10.0	<10.0	<10.0	1.7	<10.0	1.5	<10.0	<10.0	1.35	<10.0	1.3	<10.0	17.6		

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

METAL		Peconic River Locations																			Control			
		HY		HE		HM-N		HM-S		HQ		HA		HC		D. P.	Swan Pond		Forge Pond		HH			
Total or Dissolved		T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	T	D	T	D	T	D	NYSDEC AWQS	Typical MDL
No. of samples		4	2	5	1	13	6	3	1	9	5	4	2	2	2	2	4	2	4	2	4	2		
Pb (D) Lead (µg/L)	*min.*	2.4	2.4	1.3	<3.0	0.7	1.2	1.1	1.2	<3.0	<3.0	1	0.6	0.65	0.62	1.1	1.2	0.81	0.58	<3.0	0.58	1.2	1.4	3
	max.	4.3	2.5	<3.0	*	15.7	<3.0	<3.0	*	<3.0	<3.0	<3.0	1.1	0.98	0.71	<3.0	13.2	<3.0	<3.0	<3.0	<3.0	1.7		
	avg.	3.4	2.5	<3.0	*	3.1	<3.0	<3.0	*	<3.0	<3.0	<3.0	0.8	0.82	0.66	<3.0	4.45	<3.0	<3.0	<3.0	<3.0	1.5		
Sb Antimony (µg/L)	*min.*	1.1	0.8	<5.0	<5.0	0.9	1.9	<5.0	<5.0	<5.0	0.8	<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	1	<5.0	*	<5.0	<5.0	<5.0	*	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<12.5	<5.0	<5.0	<5.0	<5.0	<5.0		
	avg.	<5.0	0.8	<5.0	*	<5.0	<5.0	<5.0	*	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<12.5	<5.0	<5.0	<5.0	<5.0	<5.0		
Se (D) Selenium (µg/L)	*min.*	0.7	0.8	0.7	<5.0	0.64	0.8	0.8	<5.0	<5.0	<5.0	1	0.8	<5.0	<5.0	<5.0	0.81	<5.0	0.57	0.88	0.76	0.73	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	<12.5	<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	<12.5	<5.0	<5.0	<5.0	<5.0	<5.0		
Tl (AS) Thallium (µg/L)	*min.*	0.6	0.7	0.3	<5.0	0.23	<5.0	0.31	<5.0	<5.0	<5.0	0.5	0.5	<5.0	<5.0	<5.0	0.26	0.64	0.38	<5.0	<5.0	0.73	8	5
	max.	<5.0	<5.0	<5.0	*	<5.0	<5.0	<5.0	*	<5.0	<5.0	1.3	<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	0.8	<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	4.8	<5.0	1.7	1.9	1.6	<5.0	<5.0	<5.0	1.8	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	0.28	14	5
	max.	<5.0	<5.0	7.3	*	13.7	8.3	2.4	*	<5.0	<5.0	7	<5.0	<5.0	<5.0	6.2	<12.5	<5.0	5.4	<5.0	5.8	<5.0		
	avg.	<5.0	<5.0	<5.0	*	<5.0	<5.0	1.9	*	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<12.5	<5.0	<5.0	<5.0	<5.0	<5.0		
Zn (D) Zinc (µg/L)	*min.*	15.4	16	6	14.1	25	19.7	17.1	36.6	12.5	14.2	4.1	6.9	1.8	7.8	6.1	3.8	5.7	2.7	4.7	2.3	6.9	34	10
	max.	49.7	42.9	117	*	177	79	32.9	*	65.4	33.6	11.6	12.6	8.5	13.1	<10.0	24.3	7.8	<10.0	14.6	<10.0	6.9		
	avg.	27.4	29.5	38.9	*	70.4	38	25.87	*	29.3	24.5	7.6	9.8	5.2	10.5	<10.0	10.15	6.8	<10.0	9.65	<10.0	6.9		

Notes:
See Figure 5-8 for the locations of sample statons.
*Only one sample taken; no min/max, no average
AWQS = Ambient Water Quality Standards
AS = Acid Soluble
D = Dissolved
D. P. = Donahue's Pond
I = Ionic
MDL = Minimum Detection Limit
NYSDEC = New York State Department of Environmental Conservation
RHIC = Relativistic Heavy Ion Collider
SNS = Effluent Standard Not Specified for these elements in Class C Surface Waters

diately downstream of the STP discharge (Stations HM-N and HQ) and were consistent with the concentrations in the STP discharge. All nitrate levels were less than 10 mg/L. There are no 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 several locations was very low, due to the low pH of precipitation, groundwater, 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 4.2 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 2005, 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 aluminum, copper, iron, lead, nickel, silver, and zinc were present in concentrations at some locations that exceeded AWQS both upstream and downstream of the STP discharge. 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. Both are found in high concentrations in native Long Island soil and, for iron, at high levels in groundwater. The low pH of groundwater and precipitation contribute to the dissolution of these elements. Although most metals were detected in upstream samples (indicating a natural presence), the highest levels for silver, copper, lead, nickel, and zinc were detected in samples collected immediately downstream of the Laboratory's STP discharge (HM-N). 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 copper, silver, and zinc are extremely restrictive (for silver and copper, less than the typical MDL); 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 single samples collected from Stations HM-N and HQ, both downstream of the Laboratory's STP discharge. Metals such as mercury can pose a risk for human consumption when they enter the food chain. In 2005, BNL completed an extensive project to remove contaminants from the Peconic River by excavating 6 to 12 inches of sediment from the river bottom. Remediation began immediately downstream of the STP discharge and continued off site into the County Parks east of the Laboratory's boundary. Once remediation was completed, monitoring of river water, sediment, vegetation, and fish samples was performed to determine the project's effectiveness. Mercury levels in the water initially rose, most likely due to disturbances of mercury deposits within the buried sediments. The mercury levels in the water are expected to drop as the sediments settle and are covered with fresh silt from stormwater runoff. The mercury levels in the sediments were lower than the pre-cleanup levels.

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Natural and Cultural Resources

6

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 2005, 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.

In its fifth year, Upton Ecological and Research Reserve (Upton Reserve) was transitioned to the Foundation for Ecological Research in the Northeast (FERN). Final research work under the Upton Reserve was provided to the U.S. Fish & Wildlife Service and utilized by FERN to conduct the first phase of forest health monitoring in the Long Island Central Pine Barrens. This work is discussed in greater detail in this chapter.

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. A BNL Cultural Resource Management Plan has been developed to identify, assess, and document BNL's historic and cultural resources.

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 and issued the Natural Resource Management Plan (NRMP) (BNL 2003a). The NRMP 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 the 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 2005, BNL initiated efforts to better understand the distribution of deer on site. A model of deer density was developed (Figure 6-1) using the mapping and spatial analysis tools. This model will enable resource managers to track changes in deer density over time, detect interactions between components of the ecosystem, and identify locations for management activities.

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. 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 the BNL 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 Bar-

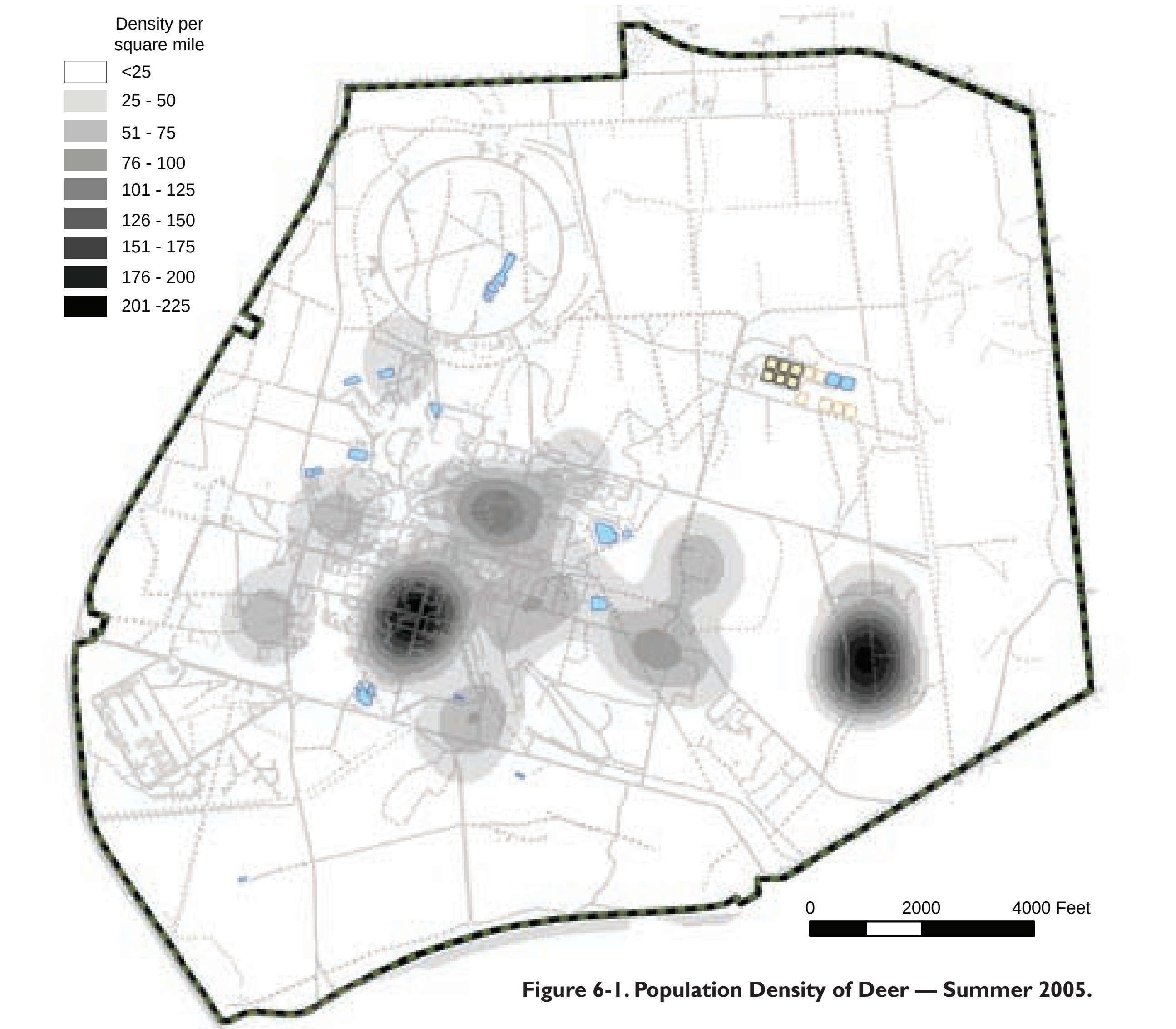


Figure 6-1. Population Density of Deer — Summer 2005.

rens bluet (*Ennalagma recurvatum*) was confirmed at one of the many coastal plain ponds located on the Laboratory 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 farinose*) was reconfirmed to exist at BNL in 2005. Several other species that inhabit the Laboratory site, visit during migration, or have historically been identified, are listed as rare, species of special concern, or exploitably vulnerable by New York State (Table 6-1).

6.1.2 Habitat Protection and Enhancement

The Laboratory has precautions in place to protect on-site habitats and natural resources. Activities to eliminate or minimize negative effects on sensitive or critical species are either incorporated into BNL procedures or into specific program or project plans. Environmental restoration efforts 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 these 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. 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. BNL environmental protection staff must review any project planned near eastern

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

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

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

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 conducted annually since 1999. Biologists conducting egg mass and larval surveys have increased the number of confirmed sites from 17 on-site ponds to 26 ponds that are used by eastern tiger salamanders. The study 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. Egg mass surveys of 26 ponds plus additional flooded depressions at the Laboratory were conducted in 2005. A PhD candidate and students working through the intern programs offered by DOE and BNL's Office of Education conducted surveys of tiger salamander ponds, drift fence surveys, and radio telemetry tracking around four ponds. The results of these studies show 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 needs began in 2004, with funding provided to SUNY Binghamton by NYSDEC. Continued research consistently 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.

6.1.2.2 Eastern Hognose Snake

A radio telemetry study of the eastern hognose snake (*Heterodon platyrhinos*) that was initiated in 2003 continued through 2005. This species of special concern was considered to be very rare on Long Island. Reports of the snake were sporadic through 1995, with no reports from Long Island between 1995 and 2001. In 2002, five sightings of this snake occurred at the Laboratory, with photo documentation for two of the sightings. The presence of the snake at BNL and the radio telemetry work conducted have raised interest about this species. Reports from multiple locations on Long Island have been confirmed. While the snake is not highly common, the various reports indicate that it is not as rare on Long Island as was previously thought.

In 2005, eight snakes were tracked, and the potential for snakes to auto-reject implanted transmitters was documented. This may explain some of the earlier retrieval of transmitters without any clear evidence of predation. Tracking of snakes also documented predation by various animals, including red-tailed hawks and small mammals. At the end of the tracking season, only three snakes remained. The snakes were allowed to hibernate and will be recaptured upon re-emergence in 2006. The transmitters will be removed and the snakes released. Results of this 3-year study will be published in the scientific literature.

6.1.2.3 Other Species

As part of the eastern tiger salamander and herpetological surveys, information is being gathered on other species. Including the salamander (see Section 6.1.2.1), sightings of 26 species of reptiles and amphibians have been recorded over the past several years. The species observed 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*), the northern red-bellied snake (*Storeria occiptiomaculata*), and the eastern wormsnake (*Carphophis amoenus*). This listing 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 river remediation efforts for potential impacts on these habitats. The Peconic River cleanup project was initiated in 2004 and completed in May 2005. Prior to dewatering of both the on- and off-site portions of the river, an effort was made to capture and relocate banded sunfish. A total of 193 fish were relocated to a protected pond, and a study was conducted to determine their breeding success. Approximately 1,200 fish were seined from the pond, measured, and released. The study estimated the number of fish taken per area covered by each seining event. Conservatively, the pond was estimated to contain between 90,000 and 110,000 fish. By October 2005, a severe drought had resulted in the near drying of the pond, and by conservative estimates, 3,000 fish remained. To ensure the continued presence of the banded sunfish in the Peconic River, approximately 250 sunfish were removed from the pond and returned to the river. A population estimate of the pond will again be conducted in 2006 and additional reintroductions of the banded sunfish to the Peconic River will occur, once additional vegetative cover has been re-established.

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 at BNL. In 2005, monthly surveys were conducted, starting at the end of March and extending through the end of September. These surveys identified 67 species, compared to 68 species in 2004 and 79 species during 2003. One new species was identified during the 2005 surveys. A total of 109 species have been identified during surveys in the past 6 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. Trends in the data indicate a slight decline each year in the number of species detected on each transect. Data are stored in an electronic database that is linked to the Laboratory's GIS.

The Laboratory occasionally encounters conflicts with migratory birds. These conflicts are resolved in consultation with NYSDEC, FWS, and the United States Department of Agriculture – Animal Plant Health Inspection Service – Wildlife Services Division (Wildlife Services). In 2005, a pair of Killdeer *(Charadrius vociferous)* nested and laid four eggs in the middle of a contaminated area at the Former Waste Management Facility that was scheduled for cleanup. Due to the high cost of delaying cleanup, Wildlife Services was contacted for consultation. A decision was made to remove the eggs and scan for contamination. Low levels of radiological activity were detected on the surface of the eggs; therefore, they were disposed of along with radiological contaminated soils. Mechanized work in the area and disturbance of the soil in the area of the nest prevented further nesting by the birds.

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 53 nest boxes around open grassland areas on site to enhance their population. In 2005, the boxes were monitored approximately every 3 weeks during the breeding season to determine use and nesting success. Thirty bluebird nests were observed. Other birds using the houses included house wrens (*Troglodytes aedon*), black-capped chickadees (*Poecile atricapilla*), tufted titmouse (*Baeolophus bicolor*), and tree swallows (*Tachycineta bicolor*). Bluebirds have consistently produced 19 broods or more each year for the past 6 years.

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. Due to the wet spring and drought conditions in 2005, there was a dispersal of many of the birds, resulting in a population estimate of 300 birds.

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). BNL has been conducting population surveys of the white-tailed deer since 2000. In February and March 2004, an aerial infrared survey was conducted of three properties, including Wertheim National Wildlife Refuge (south of BNL), Brookhaven National Laboratory, and Rocky Point Wildlife Area (northwest of BNL). The results indicated a population of 412 deer on site and immediately off site. When a correction for survey accuracy was applied, the on-site population was estimated at 446 animals. This value was much lower than a ground-based estimate of 1,302, made at the same time using the existing methodology. Because there was a large discrepancy between methods, a review of the ground-based methodology was conducted and the method of estimating was refined. The new method uses the Laboratory's vegetation map and estimates the deer population based on the habitat in which deer are sighted during surveys. The result of this revised method indicated that the deer population was approximately 497, which is considered to be reasonably comparable to the aerial survey results. The next step taken was to apply the new population model to historic survey data. Most of the data resulted in a much lower estimate, with ranges from approximately 1,000 deer in 2001 to approximately 400 deer in 2005. Note that the revised estimate is still higher than the optimal range of 80 to 250 deer on an area the size of BNL.

Deer overpopulation can affect animal and human health (e.g., animal starvation, Lyme disease from deer ticks, collision injuries—both human and animal), species diversity (songbird species reduction due to selective grazing and destruction of habitat by deer), and property values (auto damage and browsing damage to ornamental plantings). In 2005, there were six deer-related collisions on site, compared to the 25 accidents documented in 2004. This notable decrease in accidents is attributed to a major effort by BNL Safeguards and Security personnel to enforce the 30-mph speed limit on site. Additional emphasis on vehicle–deer safety is also thought to have helped reduce this type of accident. Deer health continues to be affected due to lack of food. Deer damage to vegetation around buildings continues to be a problem, but varies depending on the severity of the winter and the availability of browse in the lawns.

Because the high deer population is a regional problem, BNL is working on the issue with other local jurisdictions. The Laboratory is rep-

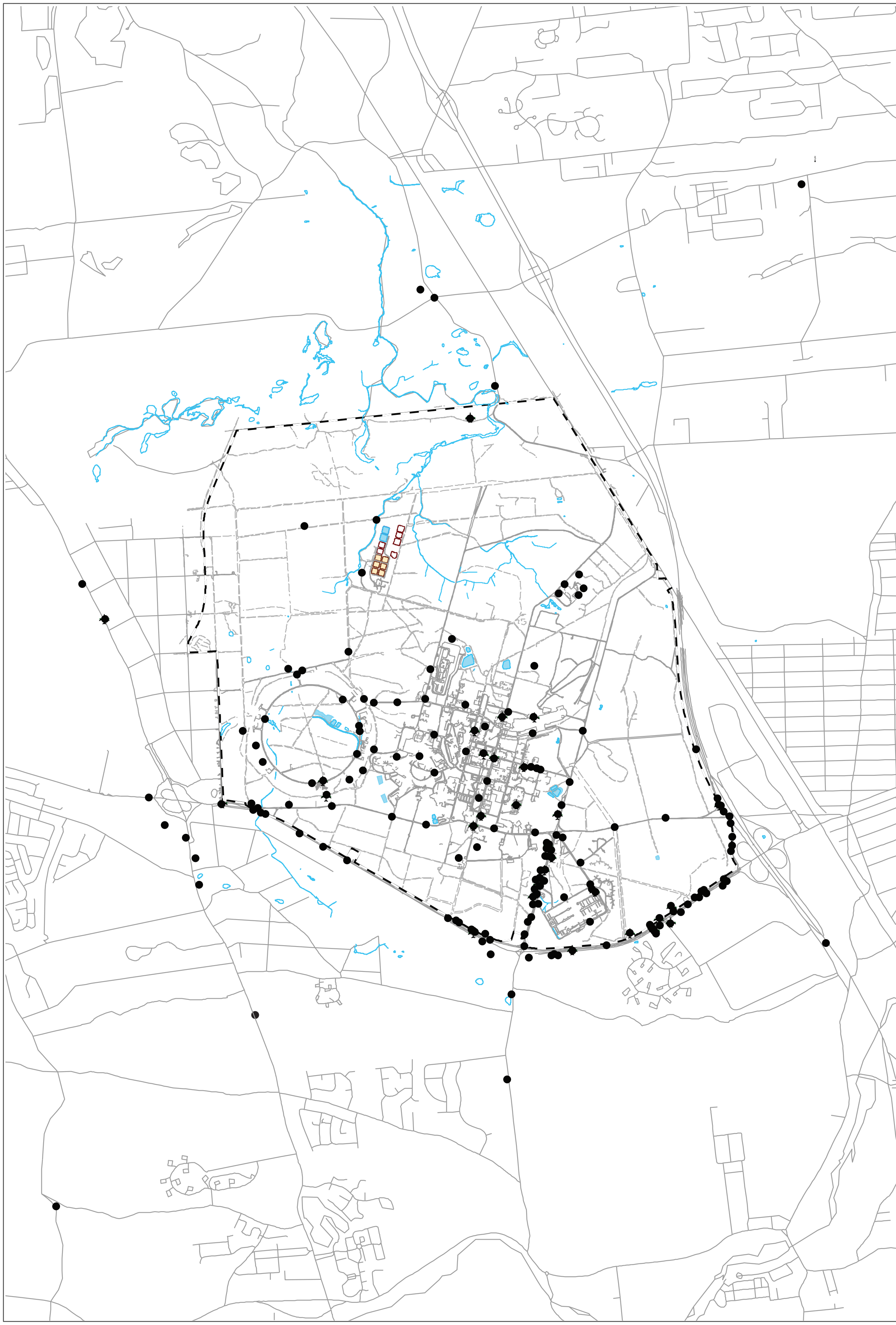


Figure 6-2. Deer Sample Locations, 2001—2005.

resented on a deer advisory panel for the hamlet of Lloyd Harbor. Environmental biologists at BNL would like to see a regional approach to deer management in place before attempting large-scale deer management on site. Options for deer management are limited, and most are controversial. A regional approach would benefit the community, land managers, and the health of the deer population.

6.1.4 Compliance Assurance and Potential Impact Assessment

The National Environmental Policy Act (NEPA) review process at BNL is 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), the Community Advisory Council, and the Brookhaven Roundtable are involved in reviewing major projects that have the potential for significant environmental impacts. Formal NEPA reviews are coordinated with the Stae of New York.

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 Fish & Wildlife Service (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 the 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).

In establishing the Upton Reserve, DOE committed to provide FWS with $1 million to manage the reserve over a 5-year period. 2005 marked the final year of the agreement between DOE and FWS. A planned transition from FWS management of the Upton Reserve to management by BNL and the Foundation for Ecological Research in the Northeast (FERN) occurred, with FERN initiating its first pine barrens-wide monitoring program. The Upton Reserve research efforts concluded with a database of all known pine barrens-related research and forest health monitoring protocols for pine barrens. Both the database and monitoring protocols are available on the FERN website, at www.fern-li.org. The plot-based monitoring protocols were implemented and used by FERN to gather information concerning the health of the Long Island Central Pine Barrens. A total of 50 permanent monitoring plots were established in the summer of 2005; the project will continue in 2006 to fully assess the current health of the forests. Permanent plots will allow the periodic assessment of forest health, to determine whether management actions are having a positive or negative impact.

The Interagency Agreement that established the Upton Reserve specified the formation of a Technical Advisory Group (TAG), which includes the reserve's supervisory FWS biologist and representatives from NYSDEC, Suffolk County Parks Department, Central Pine Barrens Joint Policy and Planning Commission, DOE, BNL's Citizens Advisory Council, Brookhaven Executive Roundtable, Brookhaven Science Associates, and The Nature Conservancy. The TAG's primary responsibility was to develop BNL's comprehensive NRMP. The TAG also developed criteria for soliciting and reviewing proposals and awarding funds for research to be conducted within the Upton Reserve. The multiple research projects over the past few years have greatly improved the understanding of pine barrens ecology. While most of the TAG's responsibilities have been met, the Laboratory intends to periodically ask for assistance in reviewing annual reports required under the NRMP, and to support the 5-year update of the plan.

Educational programs have been a significant part of the Upton Reserve and were continued in 2005. A project was conducted by Longwood High School to determine the preferential use of artificial shelter ("cover") by reptiles and amphibians. Led by a high school science teacher, students established three transects cutting across multiple habitats. At set intervals, two artificial covers (plywood and geotextile material) were placed on the ground to attract reptiles and amphibians. Transects were checked every other week during fall 2005. Results of the project are still pending.

Research on oak tree defoliators that was initiated by FWS and the Upton Reserve is continuing at the Laboratory. Much of the oak forest on site and immediately east of BNL has been subject to repeated defoliation by gypsy moth and orange-striped oak moth. This double defoliation, if it occurs year after year, can kill large sections of oak forest. In 2003, areas of BNL were experiencing oak death due to repeated defoliation. Cooler temperatures in 2004 appeared to set back the oak moth infestation, but much of the damage had already been incurred; between 15 and 25 percent of the red oaks died. In 2005, a new defoliator, a geometrid moth, appeared on oaks throughout the Long Island Central Pine Barrens, and the orange-striped oak moth was again evident, resulting in additional tree mortality.

FWS management activities for the Upton Reserve in 2005 included mapping vernal pools, conducting educational and outreach activities, coordinating researcher access and training requirements, and radio tracking hognose snakes and spotted turtles, as discussed in Section 6.8.

6.3 MONITORING FLORA AND FAUNA

BNL conducts routine monitoring of flora and fauna to determine the impact of past and present Laboratory activities. Because soil contaminated with cesium-137 (Cs-137), a radioactive isotope of cesium, was used in some BNL landscaping projects in the past, traces have now been found in deer and in other animals and plants. Most radionuclide tables in this chapter list data for both potassium-40 (K-40), a naturally occurring radioisotope of potassium, and Cs-137. Because K-40 occurs naturally in the environment, it is not uncommon in flora and fauna. It is presented as a comparison to Cs-137 because Cs-137 competes with potassium at a cellular level. General trends indicate that Cs-137 will out-compete potassium when potassium salts are limited in the environment, which is the typical case on Long Island. In general, K-40 values do not receive significant discussion in the scientific literature due to this relationship and the fact that K-40 occurs naturally. 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, about 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 2005, as in recent years, an off-site deer-sampling program was conducted with the NYSDEC Wildlife Branch and FWS. While most off-site samples are from road-killed deer at and near the Laboratory, NYSDEC provides a few samples that result in data on deer that move beyond BNL boundaries, where they can be legally hunted. The samples provide control data on deer living 1 mile or more from BNL. In addition, FWS informs Laboratory staff of deer that have died in or near the Wertheim National Wildlife Refuge and other FWS properties on Long Island. In all, six deer were obtained on site and 24 were from off-site locations, ranging from adjacent to BNL along the William Floyd Parkway, to approximately 30 miles away (East Islip, 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 Cs-137 in White-Tailed Deer

White-tailed deer sampled at BNL 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) Program. All major areas of contaminated soil were remediated by September 2005. In addition, all buildings at the former Hazardous Waste Management Facility were removed in 2003, and the cleanup of the remainder of the facility was completed by fall 2005.

The number of deer taken for sampling has steadily increased since 1996, with the exception of 2005. 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 taken 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 6-2 shows the location of all deer samples taken within a 5-mile radius of the Laboratory since 2001. 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 BNL. 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.

In 2005, Cs-137 concentrations in deer meat samples taken at BNL ranged from 0.08 to 0.52 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 2005 on-site concentration (0.52 pCi/g wet weight) was much lower than the highest level reported in 2004 (2.93 pCi/g wet weight), and is significantly 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 0.20 pCi/g. The average concentration of all off-site meat samples was 0.40 pCi/g wet weight. In 2004, averages for Cs-137 both on and off site were below 1.0 pCi/g wet weight for the first time since the cleanup of landscape soils was completed in 2000 (see Table 6-2).

Cs-137 concentrations in off-site deer meat samples were separated into two groups: samples taken within 1 mile of BNL and samples taken farther away (see Table 6-2). Concentrations in meat samples taken within 1 mile ranged from 0.03 to 2.75 pCi/g wet weight, with an average of 0.26 pCi/g wet weight; concentrations in meat taken from greater than 1 mile ranged from nondetectable to 0.64 pCi/g wet weight, with an average of 0.13 pCi/g wet weight.

Figure 6-3 compares the average values of Cs-137 concentrations in meat samples collected in 2005 from four different location groupings. Although the figure does not show this, more than 90 percent of all samples taken both on and off site are below 1 pCi/g wet weight (see Table 6-2).

Figure 6-4 presents the 5-year trend of on-site and near off-site Cs-137 averages in deer meat. Although there is no statistical difference between the values across the five years, there is a statistical difference between values in 2001 (before landscape soils were cleaned up) and values in 2002, 2004, and 2005.

In 2003, a seasonal pattern in Cs-137 concentrations in deer meat was noticed. This seasonality was present in earlier years and

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

Sample Location	Collection Date	Tissue Type	K-40 Wet Weight pCi/g	Cs-137 Wet Weight pCi/g	Sr-90 Dry Weight pCi/g
BNL, On Site					
1,000 ft east of main entrance	01/20/05	Flesh	3.83 ± 0.32	0.26 ± 0.02	
		Liver*	2.33 ± 0.25	0.08 ± 0.01	
		Bone			0.67 ± 0.16
Princeton Ave. at Motor Pool Bldg.	02/09/05	Flesh	3.87 ± 0.43	0.52 ± 0.04	
		Liver*	2.07 ± 0.23	0.09 ± 0.01	
Bldg. 912	08/08/05	Flesh*	4.10 ± 0.39	0.02 ± 0.01	
		Liver	2.53 ± 0.43	ND	
		Bone**			0.68 ± 0.25
West side of Bldg. 912	10/31/05	Flesh*	3.60 ± 0.30	0.08 ± 0.01	
		Liver*	2.78 ± 0.25	0.05 ± 0.01	
		Bone**			0.65 ± 0.29
Northeast of Bldg. 463	11/28/05	Flesh*	2.39 ± 0.42	0.09 ± 0.02	
		Bone			1.44 ± 0.37
Back of Bldg. 925 in AGS Ring access road	12/20/05	Flesh	4.03 ± 0.58	0.21 ± 0.04	
		Liver*	2.21 ± 0.53	0.06 ± 0.03	
		Bone			ND
< 1 Mile from BNL					
Outside South Gate	02/07/05	Flesh	4.14 ± 0.37	0.99 ± 0.09	
		Liver*	1.94 ± 0.22	0.13 ± 0.02	
		Bone			3.66 ± 0.61
William Floyd Pkwy., North Gate	02/09/05	Flesh	4.19 ± 0.33	0.34 ± 0.04	
		Liver*	2.89 ± 0.29	0.06 ± 0.01	
		Bone			2.10 ± 0.39
South Gate	03/25/05	Flesh	3.57 ± 0.35	0.12 ± 0.02	
		Liver	2.67 ± 0.28	0.06 ± 0.02	
		Bone			2.51 ± 0.54
Longwood Estate	06/01/05	Flesh	3.44 ± 0.40	0.13 ± 0.02	
		Liver*	3.09 ± 0.48	0.05 ± 0.02	
		Bone			2.32 ± 0.61
William Floyd Pkwy., Main Gate	09/28/05	Flesh	3.70 ± 0.25	0.42 ± 0.03	
		Liver*	2.93 ± 0.25	0.12 ± 0.01	
		Bone			3.55 ± 0.61
William Floyd Pkwy., 1 mile north of Main Gate	10/13/05	Flesh*	4.07 ± 0.29	0.03 ± 0.01	
		Liver	3.13 ± 0.15	ND	
		Bone			1.41 ± 0.41
Longwood Rd., 1/2 mile west of William Floyd Pkwy.	10/27/05	Flesh	4.03 ± 0.30	0.39 ± 0.03	
		Liver	2.63 ± 0.20	0.30 ± 0.03	
Longwood Rd., 1/2 mile west of William Floyd Pkwy.	10/27/05	Bone			1.95 ± 0.40
William Floyd Pkwy., North Gate (deer No. 1)	11/14/05	Flesh	3.54 ± 0.28	0.74 ± 0.05	
		Bone			1.82 ± 0.41

(continued on next page)

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

Sample Location	Collection Date	Tissue Type	K-40 Wet Weight pCi/g	Cs-137 Wet Weight pCi/g	Sr-90 Dry Weight pCi/g
William Floyd Pkwy., North Gate (deer No. 2)	11/14/05	Flesh	4.57 ± 0.32	1.69 ± 0.14	
		Bone			1.19 ± 0.34
Rte. 25 Ridge, east of William Floyd Pkwy.	11/30/05	Flesh	3.45 ± 0.40	2.75 ± 0.22	
		Liver	3.21 ± 0.38	1.32 ± 0.12	
		Bone			1.41 ± 0.37
> 1 Mile from BNL					
Swan Pond Rd. at Grumman main gate	02/09/05	Flesh	3.04 ± 0.28	0.58 ± 0.04	
		Liver*	2.41 ± 0.25	0.09 ± 0.01	
		Bone			1.26 ± 0.40
Calverton, 1 mile north of Rte. 25 on Fresh Pond Rd.	06/27/05	Flesh*	3.61 ± 0.46	0.04 ± 0.01	
		Bone			1.79 ± 0.53
Kaplan Farm in Northville	08/31/05	Flesh*	4.07 ± 0.34	0.01 ± 0.01	
		Liver	3.35 ± 0.36	ND	
		Bone			1.34 ± 0.35
Rte., 25 west of Wading River Hollow Rd.	10/31/05	Flesh	3.68 ± 0.28	0.27 ± 0.02	
		Bone			1.21 ± 0.32
Sunrise Hwy., just west of William Floyd Pkwy.	12/08/05	Flesh	3.38 ± 0.63	0.64 ± 0.03	
		Liver	3.21 ± 0.26	0.22 ± 0.02	
		Bone			ND
Seatuck deer cull (deer No. 1)	12/12/05	Liver	3.03 ± 0.27	ND	
		Bone**			0.52 ± 0.19
Seatuck deer cull (deer No. 2)	12/12/05	Flesh	3.66 ± 0.41	ND	
		Liver	3.11 ± 0.27	ND	
		Bone			ND
Seatuck deer cull (deer No. 3)	12/12/05	Flesh	3.95 ± 0.40	ND	
		Liver	3.42 ± 0.37	ND	
		Bone**			0.97 ± 0.26
Seatuck deer cull (deer No. 4)	12/12/05	Flesh	4.32 ± 0.24	ND	
		Liver	3.22 ± 0.31	ND	
		Bone**			0.46 ± 0.21
Seatuck deer cull (deer No. 5)	12/12/05	Flesh*	4.17 ± 0.41	0.02 ± 0.01	
		Liver	2.62 ± 0.28	ND	
		Bone			ND
Old Stump Road, outside Werthereim	12/13/05	Flesh	3.07 ± 0.30	0.06 ± 0.01	
		Liver*	2.75 ± 0.24	0.01 ± 0.01	
		Bone			1.15 ± 0.34
Seatuck deer cull (deer No. 6)	12/20/05	Flesh*	3.46 ± 0.25	0.01 ± 0.01	
		Liver	2.45 ± 0.14	ND	
		Bone			ND
Seatuck deer cull (deer No. 7)	12/20/05	Flesh*	3.14 ± 2.32	0.02 ± 0.01	
		Liver	3.77 ± 0.34	ND	
		Bone			ND

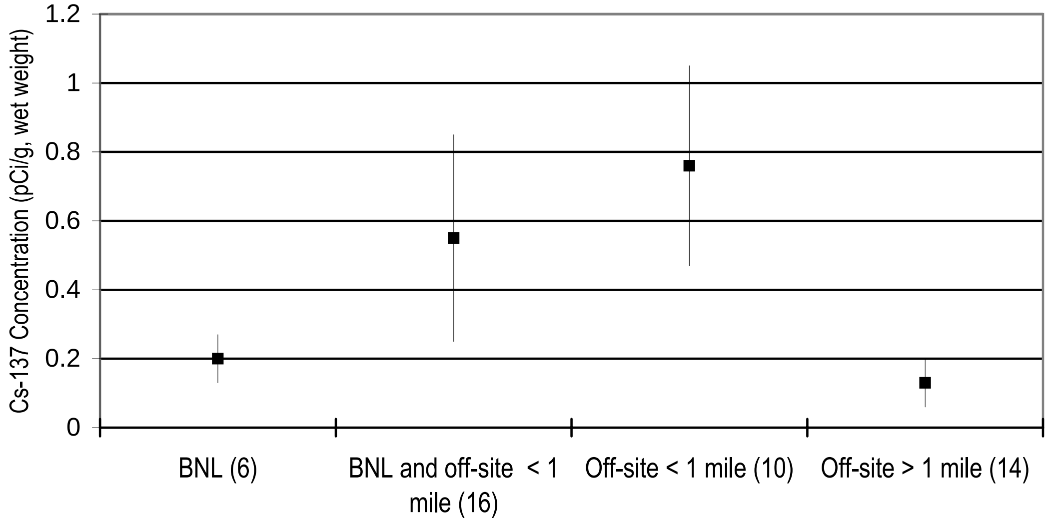
(continued on next page)

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

Sample Location	Collection Date	Tissue Type	K-40 Wet Weight pCi/g	Cs-137 Wet Weight pCi/g	Sr-90 Dry Weight pCi/g
Seatuck deer cull (deer No. 8)	12/20/05	Flesh*	3.47 ± 0.21	0.01 ± 0.01	
		Liver	3.06 ± 0.19	ND	
		Bone			ND
Averages by Tissue					
Flesh					
Average for all samples			3.71 ± 3.03	0.36 ± 0.31	
BNL on-site average			3.64 ± 1.02	0.20 ± 0.07	
BNL on- and off-site < 1 mile average			3.78 ± 1.47	0.55 ± 0.30	
Off-site average			3.73 ± 2.85	0.40 ± 0.30	
Off-site < 1 mile average			3.87 ± 1.06	0.76 ± 0.29	
Off-site > 1 mile average			3.62 ± 2.65	0.13 ± 0.07	
Liver					
Average for all samples			2.83 ± 1.51	0.11 ± 0.14	
BNL on-site average			2.38 ± 0.80	0.06 ± 0.04	
BNL on- and off-site < 1 mile average			2.67 ± 1.14	0.19 ± 0.14	
Off-site average			2.94 ± 1.29	0.12 ± 0.14	
Off-site < 1 mile average			2.81 ± 0.85	0.26 ± 0.13	
Off-site > 1 mile average			3.03 ± 0.97	0.03 ± 0.04	
Bone					
Average for all samples					1.25 ± 2.01
BNL on-site average					0.72 ± 0.59
BNL on- and off-site < 1 mile average					1.70 ± 1.63
Off-site average					1.36 ± 1.92
Off-site < 1 mile average					2.19 ± 1.52
Off-site > 1 mile average					0.75 ± 1.18

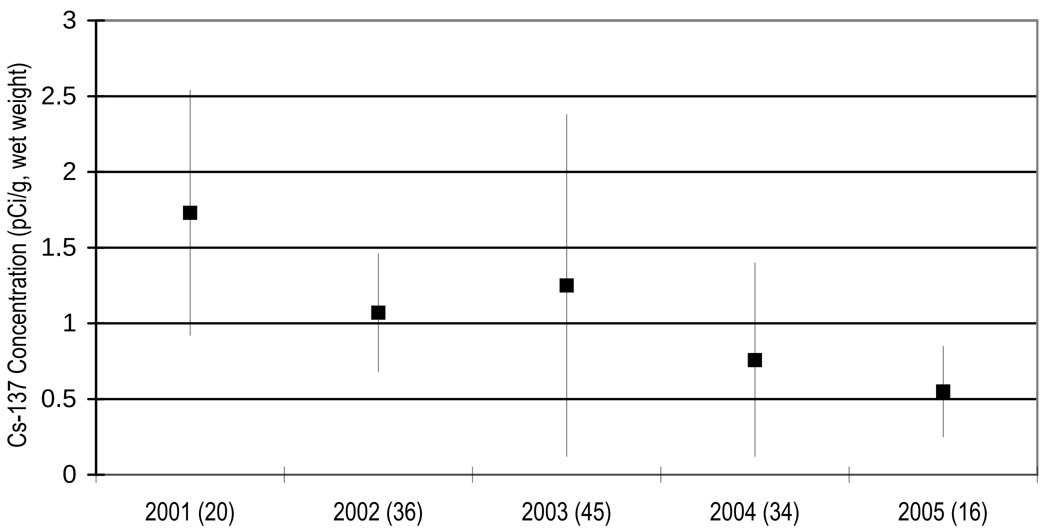
Notes:
All values are shown with a 95% confidence interval.
Potassium-40 (K-40) occurs naturally in the environment and is presented as a comparison to cesium-137 (Cs-137).
All averages are the arithmetic average and utilize estimated values for ND. Confidence limits are 2σ sigma (95%) propogated error.
ND = Not Detected
* = estimated value for Cs-137
** = estimated value for strontium-90 (Sr-90)

occurred again in 2005 (see Table 6-2). During the summer of 2004, a student in the Community College Intern Program reviewed all data from 2000–2003, analyzed it 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 the 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 containing Cs-137, are more likely to obtain a continuous supply, which is incorporated into their tissues. 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.



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

Figure 6-3. Comparison of Cs-137 Average Concentrations in Deer, 2005.



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.

Figure 6-4. Five-Year Cs-137 Concentration Trends in Deer Meat at BNL and Within 1 Mile of BNL, 2001 to 2005.

When possible, liver samples are taken concurrently with meat samples. Liver generally accumulates Cs-137 at a lower rate than muscle tissue (meat). The 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 2005, Cs-137 concentrations ranged from nondetectable to 0.09 pCi/g wet weight, with an average of 0.06 pCi/g wet weight. The off-site Cs-137 concentration in liver ranged from nondetectable to 1.32 pCi/g wet weight, with an average for all off-site liver samples of 0.12 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 about 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 the 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, and continued this analysis in 2005. Sr-90 content ranged from nondetectable to 1.44 pCi/g dry weight in on-site samples. Sr-90 in off-site samples ranged from 1.19 to 3.66 pCi/g dry weight in samples taken within 1 mile of BNL, and nondetectable to 1.79 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. BNL will continue to test for Sr-90 in bone to develop baseline information on this radionuclide and its presence in white-tailed deer.

6.3.2 Small Mammal Sampling

BNL continued small mammal sampling in 2005. The original goal of this sampling was to determine the suitability of small mammals, primarily squirrels, as a surrogate for deer sampling. Squirrels are readily trapped and tend to eat similar food as deer, but have a much more restricted range and therefore can indicate areas where low levels of contamination may be present. Squirrels were sent to an off-site contract

Table 6-3. Radiological Analyses of Small Mammals (Squirrels).

Location	Collection Date	Species	K-40	Cs-137	Sr-90
			pCi/g, Dry Weight		
BNL					
Trailer 96	03/10/05	Squirrel	13.4 ± 1.5	2.68 ± 0.17	0.25 ± 0.06
Cornell Ave. and Rutherford St.	03/18/05	Squirrel	11 ± 1.6	0.13 ± 0.08	0.78 ± 0.10
Trailer 533	03/31/05	Squirrel	9.14 ± 1.6	0.54 ± 0.09	0.50 ± 0.10
Off Site					
Flanders	04/30/05	Squirrel*	12.9 ± 2.1	0.20 ± 0.08	0.19 ± 0.08
Flanders	05/01/05	Squirrel*	12 ± 1.5	0.26 ± 0.06	0.41 ± 0.10
Flanders	05/02/05	Squirrel*	12 ± 2.1	0.40 ± 0.15	0.32 ± 0.09

Notes:
All values are presented with a 95% confidence interval.
* The strontium-90 (Sr-90) concentration was reported as an estimated value by the contract analytical laboratory.

analytical laboratory for dissection and analysis. Meat was separated from the bone and tested for gamma-emitting radionuclides, and the bone was tested for Sr-90. Results of the analyses are presented in Table 6-3. Cs-137 in off-site samples ranged from 0.20 to 0.40 pCi/g dry weight. On-site samples contained Cs-137 ranging from 0.13 to 2.68 pCi/g dry weight. Sr-90 values ranged from 0.19 to 0.41 pCi/g dry weight in off-site squirrels. On-site squirrels had Sr-90 values ranging from 0.25 to 0.78 pCi/g dry weight. Small mammals will continue to be sampled to obtain additional information about their usefulness for environmental surveillance.

6.3.3 Other Animals Sampled

Occasionally, other animals of interest are found dead along the roads of the Laboratory and the immediate vicinity. Generally, BNL tests wild turkey or Canada geese if they are found dead due to road mortality. In 2005, no other animals were tested.

6.3.4 Fish Sampling

In collaboration with the NYSDEC Fisheries Division, the Laboratory maintains an ongoing program for collecting and analyzing fish from the Peconic River and surrounding freshwater bodies. Annual on-site sampling has depleted the number of large fish. To obtain a sample large enough to complete all analyses desired, multiple small fish would be needed. BNL suspended most on-site sampling beginning in 2001, and population surveys indicate that population levels on site are still insufficient to conduct full-scale annual sampling and analysis. On-site fish were sampled in 2004 when the river was de-watered for the Peconic River cleanup project. Flow was returned to the river in the spring of 2005, then the area experienced drought conditions toward the end of summer. Natural flow to the river resumed after heavy rains in October 2005. No fish samples were taken in 2005 directly on-site, but a single sample was taken downstream of gauging station HQ, adjacent to North Street, and is reported as an on-site sample. The on-site population of fish will be assessed in 2006 and samples will be taken if the fish populations have sufficiently recovered.

Off-site fish sampling continued as in the past. All samples were analyzed for edible (fillet) portion content of each of the analytes reported. In 2005, various species of fish were collected off site from Swan Pond, Donahue's Pond, Forge Pond, 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 Cold Spring Harbor Fish Hatchery and Museum. Twenty-seven samples were taken, representing eight species of fish.

6.3.4.1 Radiological Analysis of Fish

The species collected for radiological analysis in 2005 by the Laboratory and through contract labor included brown bullhead (*Ictalurus nebulosus*), chain pickerel (*Esox niger*), largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), pumpkinseed (*Lepomis gibbosus*), golden shiner (*Notemigonus crysoleucas*), yellow perch (*Perca flavescens*), and black crappie (*Pomoxis nigromaculatus*). Gamma spectroscopy analysis was performed on all samples. Table 6-4 presents specific information on the sampling location, species collected, and analytical results. All sample results are presented as wet weight concentrations. Because Sr-90 is deposited only in bone, and fillets (not bone) were tested, no Sr-90 data is presented. Information on the natural radioisotope K-40 is included as a comparison.

Cs-137 was detected at low levels in all samples from the Peconic River system, ranging from 0.03 pCi/g wet weight in golden shiners from Swan Pond, to 0.22 pCi/g wet weight in chain pickerel from Donahue's Pond. In 2005, all fish taken from Lower Lake on the Carmans River (the non-Peconic control location) had estimated levels of Cs-137 below the minimum detection limit (MDL) and are shown in Table 6-4 as ND (nondetectable).

To account for the different feeding habits and weights of various species, it is important to compare species with similar feeding habits

Table 6-4. Radiological Analyses of Fish from the Peconic River System and Carmans River, Lower Lake.

Species	K-40	Cs-137
	pCi/g Wet Weight	
BNL, On Site (HQ area)		
Brown bullhead	3.09 ± 0.32	0.17 ± 0.02*
Donahue's Pond		
Largemouth bass	3.61 ± 0.47	0.15 ± 0.03*
Brown bullhead	3.04 ± 0.38	0.12 ± 0.02*
Golden shiner	2.85 ± 0.54	0.19 ± 0.03*
Bluegill	2.93 ± 0.50	0.13 ± 0.04*
Chain pickerel	2.86 ± 0.41	0.22 ± 0.03
Pumpkinseed	2.81 ± 0.16	0.08 ± 0.03*
Forge Pond		
Pumpkinseed	3.48 ± 0.39	0.04 ± 0.02*
Largemouth bass	3.30 ± 0.31	0.10 ± 0.02*
Yellow perch	3.20 ± 0.28	0.09 ± 0.01*
Black crappie	3.12 ± 0.49	0.10 ± 0.03
Bluegill	2.58 ± 0.70	0.04 ± 0.04*
Brown bullhead	2.97 ± 0.27	0.09 ± 0.01
Golden shiner	3.01 ± 0.30	0.05 ± 0.01
Chain pickerel	2.42 ± 0.25	0.09 ± 0.02
Swan Pond		
Pumpkinseed	2.34 ± 0.37	0.06 ± 0.02
Largemouth bass	3.83 ± 0.38	0.15 ± 0.02
Yellow perch	3.48 ± 0.44	0.15 ± 0.02
Black crappie	3.25 ± 0.41	0.12 ± 0.02
Bluegill	2.27 ± 0.32	0.07 ± 0.02
Brown bullhead	3.14 ± 0.39	0.06 ± 0.03
Golden shiner	3.10 ± 0.35	0.03 ± 0.02
Chain pickerel	3.46 ± 0.41	0.13 ± 0.03
Lower Lake, Carmans River (control location)		
Bluegill	2.19 ± 0.43	ND
Pumpkinseed	2.24 ± 0.48	ND
Brown bullhead	4.56 ± 0.75	ND
Largemouth bass	2.03 ± 0.41	ND

Notes:
All values are presented with a 95% confidence interval.
Potassium-40 (K-40) occurs naturally in the environment and is presented as a comparison to cesium-137 (Cs-137).
All samples analyzed as edible portions (fillets) except golden shiners, which were analyzed as whole body composite samples.
See Figure 5-8 for sampling locations.
ND = Not Detected
* = estimated value based on analytical laboratory qualifiers

(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 0.17 pCi/g wet weight; values for brown bullhead at the control location had nondetectable levels of Cs-137. On-site pumpkinseed showed Cs-137 levels of 0.08 pCi/g wet weight; it was nondetetable in pumpkinseed from the control location. Levels of Cs-137 in all fish species appear to be declining, compared with 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 Sewage Treatment Plant (STP) to the Peconic River in 2003, 2004, or 2005 (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 should 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. The cleanup of the Peconic River was completed in May 2005. Flows from the STP were directed back into the on-site portion of the river in early spring 2005. This resulted in on-site flows in the river being present for only a few months prior to the summer drought. The short time frame, drought, and the presence of the sediment trap at the east boundary of the Laboratory did not allow sufficient opportunity for fish to migrate into the on-site portions of river. Therefore, a population assessment was not performed. Heavy rains in October 2005 resulted in significant flows that would allow fish to migrate upstream. Population assessments will resume in 2006.

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. Since 2002, analysis has been 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. Since 2000, sampling has been performed from

Table 6-5. Metals Analyses of Fish from the Peconic River System and Carmans River, Lower Lake.

Location/Species	Barium	Chromium	Copper	Iron	Manganese	Mercury	Selenium	Zinc
	mg/kg							
BNL, On Site								
Brown bullhead	0.11	0.16	0.44	19.2	<MDL	0.26	<MDL	6.93
Donahue's Pond								
Largemouth bass	0.29	0.21	0.30	7.96	0.26	0.58	0.813	9.39
Brown bullhead	0.19	0.19	0.33	7.54	0.31	0.22	<MDL	5.47
Golden shiner	0.18	0.39	<MDL	13.5	2.6	0.19	<MDL	4.56
Bluegill	2.5	0.72	0.33	15	12.2	0.12	0.708	25.1
Chain pickerel	<MDL	0.35	<MDL	11.9	0.587	0.20	0.629	11
Pumpkinseed	<MDL	0.23	<MDL	9.12	<MDL	0.06	<MDL	9.38
Forge Pond								
Pumpkinseed	<MDL	0.21	<MDL	6.4	<MDL	0.06	<MDL	10.5
Largemouth bass	<MDL	5.01	<MDL	18.1	0.43	<MDL	<MDL	7.91
Yellow perch	0.14	0.17	<MDL	13.9	0.68	0.06	<MDL	7.16
Black crappie	1.75	0.29	<MDL	10.2	3.92	0.27	<MDL	9.31
Bluegill	0.56	0.23	<MDL	4.87	1.54	0.17	<MDL	9.21
Brown bullhead	0.13	0.15	0.53	13.9	0.24	0.09	<MDL	6.52
Golden shiner	2.18	0.27	<MDL	14.7	3.38	0.08	<MDL	16.6
Chain pickerel	0.13	0.23	0.417	7.68	0.87	0.30	<MDL	16.7
Swan Pond								
Pumpkinseed	<MDL	0.20	<MDL	2.81	0.38	0.03	<MDL	11.1
Largemouth bass	<MDL	0.36	<MDL	4.11	0.36	0.24	0.616	8.3
Yellow perch	<MDL	0.18	0.47	6.44	0.64	0.05	<MDL	8.1
Black crappie	0.38	0.20	<MDL	2.27	2.04	0.03	0.632	6.3
Bluegill	1.37	0.16	0.35	3.55	10.3	0.04	<MDL	9.15
Brown bullhead	0.13	0.22	0.30	6.24	0.39	0.03	<MDL	6.27
Golden shiner	0.35	0.12	<MDL	3.66	1.07	0.02	<MDL	8.68
Chain pickerel	<MDL	0.19	0.49	8.27	2.87	0.06	0.732	31.5
Lower Lake, Carmans River (control location)								
Bluegill	2.11	0.56	0.39	8.08	5.46	0.08	0.85	16.5
Pumpkinseed	0.84	0.33	<MDL	4.56	2.78	0.02	<MDL	17.5
Brown bullhead	0.11	0.18	<MDL	6.74	0.95	0.02	<MDL	5.34
Largemouth bass	<MDL	0.17	<MDL	1.95	<MDL	0.07	<MDL	5.18

Notes:
All fish were analyzed as edible portions (fillets) except golden shiners, which were analyzed as whole body composite samples.
See Figure 5-8 for sampling locations.
MDL = Minimum Detection Limit

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 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.

Table 6-5 shows the 2005 concentration of metals in fish. According to NYSDEC, none of the metal concentrations were considered capable of affecting the health of the consumers of such fish. Due to the fact that values for arsenic, beryllium, cadmium, cobalt, silver, thallium, and vanadium were less than the MDL for the analytical procedure, they were not included in Table 6-5. Other metals tested but not included in the table include aluminum, antimony, lead, nickel, and silver, as most values reported for these metals were less than the MDL. Values that were above the MDL are discussed below.

Mercury is the metal of highest concern, due to its known health effects. It was found (0.26 mg/kg) in the single brown bullhead taken just east of the BNL boundary. Mercury in off-site Peconic River samples ranged from less than MDL to 0.58 mg/kg in a largemouth bass from Donahue's Pond. The highest mercury value in the control location on the Carmans River was 0.08 mg/kg. All mercury values were less than the 1.0 mg/kg consumption standard set by the U.S. Food and Drug Administration.

Values for metals not shown in Table 6-5 because they were at or near MDL were as follows. Antimony was found in a largemouth bass (0.41 mg/kg) and black crappie (0.43 mg/kg) taken from Forge Pond. Lead was found in a largemouth bass (0.27 mg/kg) from the control location on the Carmans River. Nickel was recorded three times: in the brown bullhead (0.11 mg/kg) from east of BNL, in golden shiners (0.25 mg/kg) from Donahues' Pond, and in a largemouth bass (0.66 mg/kg) from Forge Pond. These reported values and those presented in Table 6-5 are not considered to pose any health

Table 6-6. Pesticide and PCB Analyses of Fish from the Peconic River System and Carmans River, Lower Lake.

Location/Species	4,4'-DDE	4,4'-DDD	Aroclor-1254	Aroclor-1260
	µg/kg			
BNL, On Site				
Brown bullhead	28.7	15.6	<MDL	<MDL
Donahue's Pond				
Largemouth bass	1.24*	<MDL	<MDL	<MDL
Brown bullhead	<MDL	<MDL	<MDL	<MDL
Golden shiner	3.80*	<MDL	<MDL	<MDL
Bluegill	2.43*	<MDL	<MDL	<MDL
Chain pickerel	<MDL	<MDL	<MDL	<MDL
Pumpkinseed	<MDL	<MDL	<MDL	<MDL
Forge Pond				
Pumpkinseed	2.08*	1.50*	<MDL	<MDL
Largemouth bass	1.69*	<MDL	<MDL	<MDL
Yellow perch	2.22*	<MDL	<MDL	<MDL
Black crappie	<MDL	<MDL	<MDL	<MDL
Bluegill	<MDL	<MDL	<MDL	<MDL
Brown bullhead	14	7.02	<MDL	<MDL
Golden shiner	2.96*	2.40*	<MDL	<MDL
Chain pickerel	5.38	1.67*	<MDL	<MDL
Swan Pond				
Pumpkinseed	2.04*	<MDL	<MDL	<MDL
Largemouth bass	2.12*	<MDL	<MDL	<MDL
Yellow perch	8.77	2.47*	45.9(<MDL)	34.8(31.8)
Black crappie	3.79	<MDL	<MDL	<MDL
Bluegill	2.08*	<MDL	<MDL	<MDL
Brown bullhead	2.03*	<MDL	<MDL	<MDL
Golden shiner	3.57*	1.56*	<MDL	<MDL
Chain pickerel	22.8	8.8	<MDL	5.9*(<MDL)
Lower Lake, Carmans River (control location)				
Bluegill	7.79	2.36*	<MDL	<MDL
Pumpkinseed	12	2.98*	<MDL	<MDL
Brown bullhead	39.4	11.5	<MDL	<MDL
Largemouth bass	18.9	4.88	<MDL	<MDL

Notes:
All fish analyzed as edible portions (fillets) except golden shiners, which were analyzed as whole-body composite samples.
* The reported concentration was estimated by the contract analytical laboratory.
See Figure 5-8 for sampling locations.
MDL = Minimum Detection Limit
PCB = Polychlorinated biphenyls

Table 6-7. Radiological Analyses of Aquatic Vegetation and Sediment from the Peconic River System and Carmans River, Lower Lake.

Sample type	K-40	Cs-137
	pCi/g Dry Sediment	
BNL		
Sediment	1.90 ± 0.61	0.07 ± 0.03**
Vegetation	35.9 ± 7.55*	ND
Sediment	2.91 ± 0.55	ND
Vegetation	9.01 ± 1.56	0.14 ± 0.01**
Sediment	4.19 ± 0.78	0.70 ± 0.09
Vegetation	21.4 ± 4.94	ND
Sediment	5.40 ± 0.87	1.86 ± 0.19
Vegetation	30.5 ± 6.08*	ND
Donahue's Pond		
Vegetation	12.2 ± 4.08	ND
Sediment	1.52 ± 0.27	.03 ± 0.01**
Forge Pond		
Lily pad	NR	0.20 ± 0.09**
Sediment	NR	0.17 ± 0.03**
Swan Pond		
Lily pad	17.6 ± 3.19*	ND
Sediment	2.82 ± 2.99	0.44 ± 0.20
Lower Lake, Carmans River (control location)		
Sediment	3.41 ± 1.77	ND
Lily pad	24.3 ± 5.52*	ND

Notes:
All values are presented with a 95% confidence interval.
See Figure 5-8 for sampling locations.
ND = Not detected
NR = Not reported
* The potassium-40 (K-40) concentration was reported as an estimated value by the contract analytical laboratory.
** The cesium-137 (Cs-137) concentration was reported as an estimated value by the contract analytical laboratory.

risks to humans or other animals that might consume fish.

Table 6-6 shows the concentrations of DDE and DDD, breakdown products of the pesticide DDT, that were found in low levels in both on- and off-site fish sampled in 2005. The brown bullhead taken east of BNL had Endrin (2.40 µg/kg, estimated) and Chlordane (36.9 µg/kg). Lindane (0.74 µg/kg) was found in a brown bullhead from Forge Pond. Heptachlor epoxide (2.88 µg/kg, estimated) was found in a brown bullhead from Lower Lake on the Carmans River. The levels of pesticides detected in fish do not exceed any standards that may constitute a health impact to the consumers of such fish and thus are not considered harmful. DDT was commonly used on Long Island before 1970. Chlordane was also commonly used across Long Island and is found occasionally in fish samples. Endrin, Lindane, and Heptachlor (which breaks down to Heptachlor epoxide) were used to treat soil insects in crops (termites in potatoes).

PCBs were found at levels above the MDL in two samples taken from Swan Pond. Aroclor-1254 was found in a yellow perch (45.9 µg/kg), but a re-analysis of this sample indicated the level to be below the MDL. The same yellow perch had an initial Aroclor-1260 concentration of 34.8 µg/kg, with the re-analysis indicating a concentration of 31.8 µg/kg. Additionally, a chain pickerel taken at Swan Pond had an Aroclor-1260 concentration estimated at 5.9 µg/kg; the re-analysis of the sample indicated a concentration less than the MDL. 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.

6.3.5 Aquatic Sampling

6.3.5.1 Radiological Analysis

Annual sampling of sediment, vegetation, and freshwater in the Peconic River and a control location on the Carmans River was conducted in 2005. See Chapter 5 for a discussion on water quality and monitoring, and Figure 5-8 for sampling stations. Table 6-7 summarizes the radiological data. Low levels of Cs-137 were documented in sediments at all locations, except Lower Lake on the Carmans River. A single on-site sample taken west of the east firebreak at BNL had a Cs-137 concentration of 1.86 pCi/g dry weight. This sample also had elevated metals and PCBs, indicating that it is an isolated area of contamination, as all other sediment samples on site were well below 1.0 pCi/g dry weight. The Laboratory has established a long-term sampling program for sediments in the Peconic River to document the effectiveness

Table 6-8. Metals Analyses of Aquatic Vegetation and Sediment from the Peconic River System and Carmans River, Lower Lake Control Location.

Location/ Sample Type	Aluminum	Barium	Cadmium	Chromium	Copper	Iron	Lead	Manganese	Mercury	Nickel	Silver	Vanadium	Zinc
	mg/kg												
BNL													
Sediment	1530	8.37	<MDL	1.83	6.34	1010	1.86	7.47	0.04	0.12	0.62	2.59	8.01
Vegetation	51.7	9.87	0.37	0.77	7.75	407	2.04	7.16	0.07	2.15	0.54	0.42	44.8
Sediment	1580	4.66	<MDL	2.09	2.35	612	1.6	9.44	0.05	0.99	0.52	1.83	4.3
Vegetation	60.6	3.2	0.14	0.34	5.94	71.4	0.391	4.71	0.21	1.74	0.32	0.17	33.2
Sediment	748	7.08	220	2.6	15.1	382	2.42	5.97	0.59	1.11	2.96	1.42	9.73
Vegetation	10.8	2.97	<MDL	0.23	3.4	16.3	<MDL	15	0.03	1.69	<MDL	0.15	20.5
Sediment	3130	35.3	0.74	10.8	31.3	1590	7.43	28.8	2.26	3.8	18.2	3.7	61.4
Vegetation	14.3	2.87	<MDL	0.25	2.16	24.8	<MDL	25.1	<MDL	1.39	<MDL	<MDL	9.34
Donahue's Pond													
Vegetation	11.4	14.8	<MDL	0.14	<MDL	108	<MDL	108	<MDL	0.43	0.16	<MDL	11.7
Sediment	341	2.2	<MDL	0.79	1.11	377	1.31	7.29	<MDL	0.47	0.16	0.97	3.64
Forge Pond													
Lily pad	7.6	44.9	<MDL	0.17	0.98	45.9	<MDL	28	<MDL	<MDL	<MDL	<MDL	5.6
Sediment	958	18.6	<MDL	1.7	3.1	1400	5.2	30.2	<MDL	1.2	<MDL	3.1	25.3
Swan Pond													
Lilly pad	10.3	18.6	<MDL	0.19	<MDL	27.8	0.25	106	<MDL	0.16	<MDL	<MDL	81
Sediment	5230	84.5	<MDL	20.5	9.9	2570	10.3	1580	<MDL	6.99	<MDL	26.5	52
Lower Lake, Carmans River													
Sediment	8740	111	0.97	42.5	17.1	13800	87.5	630	0.14	10.7	<MDL	29.3	156
Lily pad	<MDL	52.8	<MDL	0.12	<MDL	31.8	<MDL	27.1	<MDL	<MDL	<MDL	<MDL	4.29

Notes:
See Figure 5-8 for sampling locations.
MDL = Minimum Detection Limit

Table 6-9. Pesticide and PCB Analyses of Aquatic Vegetation, Water, and Sediment from the Peconic River System and Carmans River, Lower Lake.

Location*/ Sample Type	4,4'-DDD	Aroclor-1254	Aroclor-260
		µg/kg	
BNL			
Sediment	< MDL	14.5	4.2**
Vegetation	< MDL	32.4	24.4
Sediment	< MDL	7.0	< MDL
Vegetation	< MDL	< MDL	< MDL
Sediment	8.19**	25.6	5.5
Vegetation	< MDL	< MDL	< MDL
Sediment	7.28**	122	16.7**
Vegetation	< MDL	< MDL	< MDL

Notes:
See Figure 5-8 for sampling locations.
*Samples also were taken at Donahue's Pond, Forge Pond, Swan Pond, and Carmans River (the control location), but were all less than the MDL (Minimum Detection Limit).
**The concentration was reported as an estimated value by the contract analytical laboratory.

of the cleanup operations. Aquatic vegetation taken from on-site locations had levels of Cs-137 ranging from nondetectable to an estimated value of 0.14 pCi/g dry weight. Lily pads from Forge Pond had an estimated Cs-137 concentration of 0.20 pCi/g dry weight.

6.3.5.2 Metals in Aquatic Samples

Metals analyses (Table 6-8) were conducted on aquatic vegetation and sediments from the Peconic River and Carmans River. Most of the data indicate metals at background levels. The standard used for comparison of sediments is the soil cleanup objectives for heavy metals supported by SCDHS. 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.

Off site, levels of arsenic and chromium were higher than the SCDHS cleanup objectives in sediment at Lower Lake. Chromium was higher than the cleanup objectives at Swan Pond and at one on-site sampling location on the Peconic River. The same BNL sampling location also had elevated mercury (2.26 mg/kg) and silver (18.2 mg/kg). These metals were co-located in the sample containing Cs-137, mentioned above, and appear to represent an isolated area of contamination.

6.3.5.3 Pesticides and PCBs in Aquatic Samples

Pesticides and PCBs are reported in Table 6-9 for only those samples with detectable limits. Samples were taken at Donahue's Pond, Forge Pond, and Swan Pond on the Peconic River, and at Lower Lake on the Carmans River. Sediments from the on-site portions of the Peconic River contained trace levels of DDD, a breakdown product of the pesticide DDT. Both sediments and vegetation from BNL had detectable levels of the PCBs Aroclor-1254 and -1260. Aroclor-1254 ranged in value from 7.0 to 122 µg/kg in sediment, and was present in a single sample of vegetation at 32.4 µg/kg. Aroclor-1260 ranged from an estimated value of 4.2 µg/kg in sediment, to 24.4 µg/kg in vegetation. DDT was one of the pesticides used widely in the 1950s and 1960s, and residual amounts of its breakdown products are still detected. Both PCBs reported were historically used on site.

6.3.6 Peconic River Post Clean-up Monitoring

The Peconic River cleanup began in April 2004 and was completed in May 2005. Prior to the cleanup, extensive sampling occurred to determine the extent of contamination in sediments. A study was also conducted in 2003 and 2004 to identify sections of the Peconic River that were preferentially converting inorganic mercury into methylmercury in the sediment and water column (QEA 2004a; QEA 2004b). Methylmercury monitoring is important because it is the form of mercury that is bio-available to biota and can accumulate in fish tissues. Long-term post remediation monitoring will include annual sediment sampling in June and annual water column sampling in June and August. In 2005, only water column sampling was conducted, as the cleanup had recently been completed and significant numbers of confirmatory sediment samples had been taken as part of the cleanup process. Therefore, only water column sampling results are presented for 2005 (Table 6-10, discussed below).

6.3.6.1 Water Column Sampling

Water column sampling in support of the post clean-up monitoring of the Peconic River occurred in June and August 2005. A water column sample was taken at the center of the river and at one-half the depth of the river at each of 20 locations (see Figure 6-5 for sampling locations and Table 6-10 for results), plus a comparison site in the Connetquot River. Each sample was analyzed for mercury, methylmercury, and total suspended solids (TSS). Additionally, water velocity, water depth, temperature, and water quality parameters were taken at each site. The results of these samples have been fully analyzed in a formal report (QEA 2006). During the August sampling period, several sampling locations were either dry or had water levels that were too shallow to allow of a suitable sample free of suspended sediment. The protocols for obtaining a representative sample require water depths sufficiently deep to totally immerse sample bottles in the water without disturbing sediments.

Mercury samples taken in June ranged from 6.61 ng/L (parts per trillion) at the furthest downstream, off-site sampling point (Figure 6-5), to 229 ng/L at the PR-WC-02 off-site location. Methylmercury values ranged from 1.22 ng/L at PR-WC-11 (downstream of the STP outfall), to 25.2 ng/L (east of the eastern boundary of the Laboratory). Associated TSS samples ranged from 0.58 mg/L downstream of the STP outfall, to 997 mg/L above the outfall. A number of the samples taken in June 2005 were higher in either mercury or methylmercury, or both, compared to values taken at the same location prior to cleanup. The QEA report suggests that this may be due to a number of factors: with recent completion of the cleanup project in May, disturbed sediments may not have had sufficient time to settle and consolidate, and vegetation had not had time to reestablish. In addition, sediment disturbance may have occurred during sampling.

Samples taken in August had mercury values ranging from 1.69 ng/L at locations far off site to 105 ng/L below the STP outfall. Methylmercury values ranged from an estimated low value of 0.028 ng/L below the STP outfall, to 4.79 ng/L at station PR-WC-03, off site. Associated TSS samples ranged from less than the MDL downstream of the STP outfall, to 52.2 mg/L at PR-WC-08 east of the eastern on-site firebreak. In general, values for both mercury

Table 6-10. Analysis Results of Peconic River Water Samples for Mercury, Methylmercury, and Total Suspended Solids (TSS)

	Jun-05			Aug-05		
	Mercury	Methyl-mercury	TSS	Mercury	Methyl-mercury	TSS
Location	ng/L	ng/L	mg/L	ng/L	ng/L	mg/L
Off-Site Control						
Connetquot River	0.68	0.107	2.2	3.88	0.431	< MDL
BNL						
PR-WC-14	58.9	22.2	997	NS	NS	NS
PR-WC-13	NS	NS	NS	dry	dry	dry
PR-WC-12	29.3	19	160	dry	dry	dry
PR-WC-11	79.4	1.22	0.58	105	.028*	1.900*
PR-WC-10	93.1	2.43	1.09	81	0.535	< MDL
PR-WC-09	769	3.44	9.1	81.3	0.69	1.900*
PR-WC-08	190	7.98	61.9	161	1.33	52.2
PR-WC-07	70.9	9.48	6.8	dry	dry	dry
PR-WC-06	200	9.93	58.1	dry	dry	dry
PR-WC-05	60.2	8.32	7	dry	dry	dry
PR-WC-04	160	25.2	34.7	dry	dry	dry
PR-WC-03	83.7	20.3	87	196	4.79	11.7
PR-WC-02	229	9.59	5.6	dry	dry	dry
PR-WC-01	46.4	6.05	7.7	11.4	1.58	6.3
Off Site						
PR-WCS-01	22.2	4.76	10.8	dry	dry	dry
PR-WCS-02	17.9	3.97	9.4	dry	dry	dry
PR-WCS-03	14	4.02	14	dry	dry	dry
PR-WCS-04	40	5.12	52.5	dry	dry	dry
PR-WCS-05	10.5	4.74	12.8	5.28	0.783	9
PR-WCS-06	8.15	4.03	4.1	1.69	0.743	6.5
PR-WCS-07	6.61	2.34	1.4	2.54	0.429	< MDL

Notes:
* Estimated value based on contract analytical laboratory qualifiers.
"Dry" refers to location being dry or water levels too low to sample.
NS = area not sampled
MDL = Minimum Detection Limit

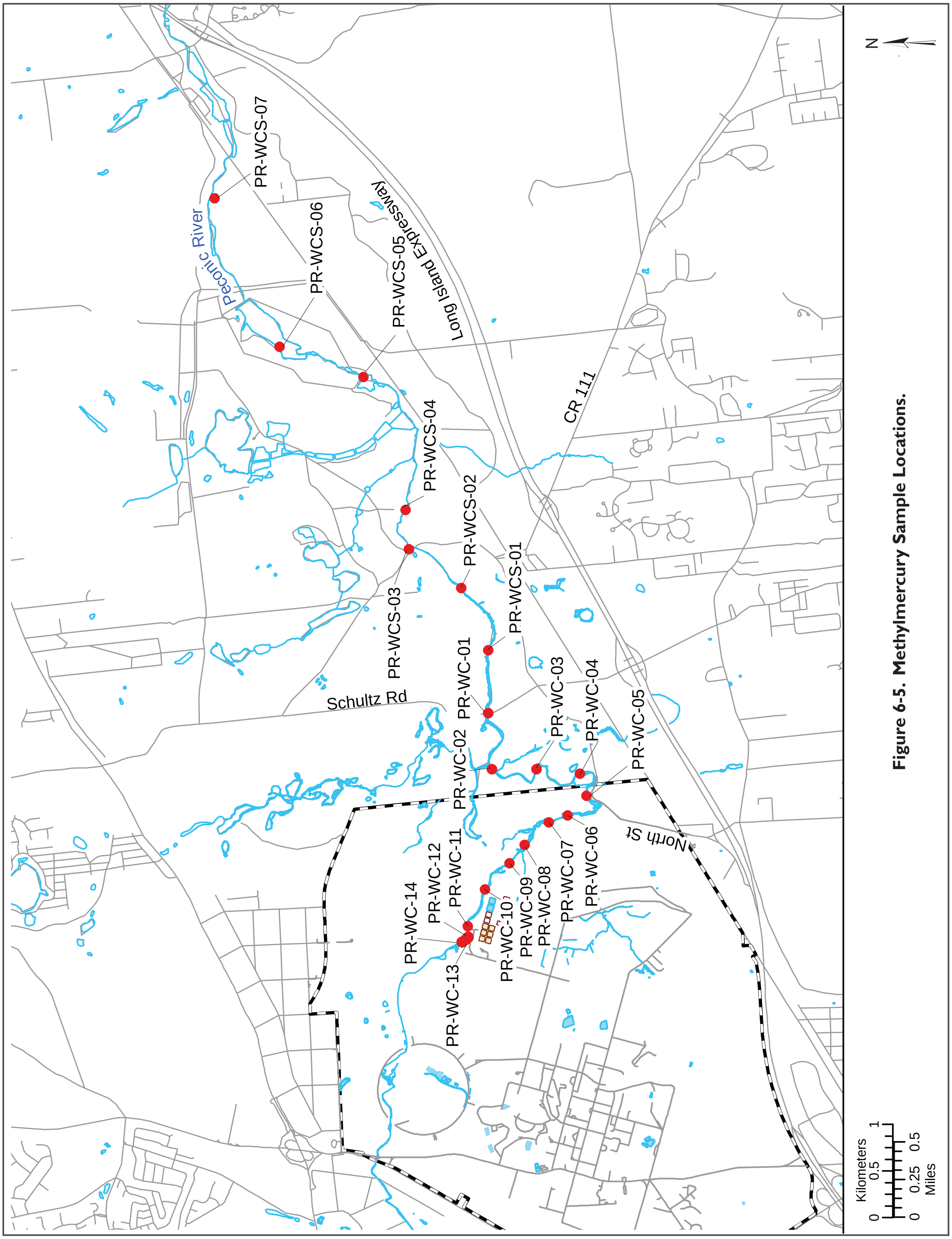


Figure 6-5. Methylmercury Sample Locations.

and methylmercury were lower than values seen before the Peconic River cleanup.

6.3.7 Vegetation Sampling

6.3.7.1 Garden Vegetables

On-site sampling of garden vegetables continued in 2005. Samples of zucchini, cucumber, tomato, pepper, and eggplant were analyzed for Cs-137 content. The radionuclide was not detected in any vegetable sample, nor in associated soil samples. Sampling of off-site farm vegetation was discontinued in 2003 because historical data have consistently indicated the absence of BNL-related radionuclides in off-site vegetation. Periodic confirmatory sampling (approximately every 5 years) will be conducted off site to obtain data on farm vegetables.

6.3.7.2 Grassy Plants

In 2003, grassy vegetation sampling was converted to a graded approach and was linked to other sampling programs. As an example of this approach, vegetation sampling would be conducted only if routine air sampling indicated that radionuclides had been released and deposited on soil and vegetation. Periodic confirmatory sampling of grassy vegetation will be conducted approximately every 5 years.

6.4 OTHER MONITORING

6.4.1 Soil Sampling

Soil sampling uses the same graded approach as that used for grassy vegetation sampling and was taken out of the basic monitoring protocols in 2003. Confirmatory soil sampling will be conducted every 5 years.

6.4.2 Basin Sediments

A new 5-year testing cycle for basin sediment samples was established in 2003. There are 14 basins associated with outfalls that receive discharges permitted under the State Pollutant Discharge Elimination System (SPDES) permit (see Figure 5-6 for outfall locations). The next round of basin sampling will occur in 2008.

6.4.3 Chronic Toxicity Tests

Under the SPDES discharge permit, BNL conducted chronic toxicity testing of the STP effluents. Results of this testing are discussed in Chapter 3, Section 3.6.1.1. Testing will continue in 2006.

6.4.4 Radiological 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. Four samples were taken from each of these two stations in 2005. There were no gross alpha activity measurements above the MDL at either sampling location.

Gross beta activity was measured in samples in the first three quarters from Station P4 and all quarters from Station S5. 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 4.5 pCi/L, with an average of 3.6 pCi/L. Location S5 had a maximum gross beta activity level of 3.6 pCi/L, with an average of 3.1 pCi/L. Gross beta activity values were within the range of values historically observed at these two locations. No radionuclide-specific analyses indicated values above MDL.

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 2005, the Environmental and Waste Management Services Division (EWMSD) and FERN hosted a total of 18 interns and one faculty member in the Natural Resource Program, as well as two high school interns, seven undergraduate interns, and three high school teachers during the summer. FERN also hosted six undergraduate interns for their Forest Health

Monitoring Program. Two of the undergraduate interns worked with a faculty member from North Carolina Agricultural and Technical University in the Faculty and Student Teams Program. Interns worked on a variety of projects: surveying dragonflies and damselflies, radio tracking turtles and snakes, analyzing the water chemistry of coastal plain ponds, investigating banded sunfish population dynamics, and studying various ecological aspects of forest health. A limited discussion concerning each project is presented below.

An intern in the Community College Internship (CCI) program continued work on the identification and distribution of dragonflies and damselflies (Order *Odonata*) that was started in 2003. These aquatic insects are common around the ponds and Peconic River on site. The distribution of aquatic invertebrates may be useful for monitoring the health of aquatic systems. In addition, results from the Odonate surveys will supplement the New York State Odonate Atlas. The intern increased the number of species identified from 46 to 55. One new species identified on site was the threatened Pine Barrens bluet (*Enallagma recurvatum*). A second species, the double-ringed pennant (*Celithemis verna*), was the first documented record of this dragonfly in New York. The state atlas project will continue for 2 more years, as will the Laboratory's surveys for Odonates.

Two interns in the CCI program from Rhode Island continued radio telemetry work on the Eastern hognose snake and spotted turtle. Both projects have resulted in interesting information concerning these two species, their habits, and habitat needs. The study on the hognose snake has resulted in the documentation of auto-expulsion of radio transmitters from the body and predation of the snake by small mammals and red-tailed hawks. The study on the spotted turtle resulted in better definition of the home range of this small, cryptic ("shy") species, and provided better understanding on the survival of "head-started" turtles (raised in captivity, then released).

An intern in the Science Undergraduate Laboratory Intern (SULI) program from Wesleyan College attempted to use the computer software DISTANCE with survey transects to estimate the hognose snake population at BNL. After criss-crossing the Laboratory with transects to document the snake, it was determined that the powerful DISTANCE software was not useful for this research, as small populations of cryptic species do not provide sufficient data for the program to analyze because the number of sightings is low. Therefore, the Laboratory's reliance on random sightings of this snake and reports by BNL personnel are more useful for determining population levels.

A population analysis of the NY State threatened banded sunfish, conducted by a SULI student from Lafayette College in Pennsylvania, is described in Section 6.1.2.3. A population study in 2006 will again estimate the population in the pond.

A Faculty and Student Team (FaST) conducted tests of four on-site ponds to look at chemical and water quality differences between ponds that are known to be used by tiger salamanders and those that are not used by tiger salamanders. Although no conclusive evidence was found for the differences in the two types of ponds, students gained experience, documented the presence of lead in one pond (a likely source is hunters' spent ammunition), and developed ideas for future work. This study will continue in 2006 and will include the testing of additional ponds, to gain a better understanding of factors that may affect tiger salamander distributions.

Associated with this study was a continuing effort by three teachers in the Lab Science Teacher Professional Development (LSTPD) Program. This project involves obtaining water quality data from all ponds on site. In 2005, the teachers in this program joined the FaST group to use GPS and GIS to enhance their data. They also evaluated and purchased field measurement equipment suitable for use in the classroom, and developed curricula for monitoring freshwaters. The curricula, equipment, and procedures that were developed will be utilized in the Laboratory's newly formed Open Space Stewardship Program called "Gaining Research Experience in the ENvironment [GREEN] Institute," operated out of BNL's Office of Education

Programs. The teachers will utilize their experience and training to run teacher workshops in 2006.

Two high school students completed separate projects in 2005. The first student, from the Stony Brook School, used GPS and GIS to survey invasive species in developed portions of the Laboratory. Such areas were deliberately excluded from the original invasive species surveys in 2003, but the need to better understand the potential source of invasives on site resulted in this project. The second student, from the Earl L. Vandermeulen High School, worked with a doctoral candidate to track tiger salamanders fitted with radio transmitters.

FERN hosted six summer students who conducted the first Forest Health Monitoring Program in the Long Island Central Pine Barrens. The students were able to establish 50 permanent monitoring plots throughout the pine barrens, gather data, analyze it, and produce six separate projects. Their scientific posters, forest health monitoring protocols, and the associated database are available on the FERN website at www.fern-li.org. The various projects dealt with different aspects of forest health or the ability to gather accurate information. Students evaluated differences in leaf litter among forest types, differences in understory composition and age class structure of the various forest types, differences between canopy estimates using human observers versus instruments, differences in snag (dead limb) density among forest types, and effects of overstory canopy on understory density. This project will continue in 2006, to finish establishing a sufficient number of plots to ensure an accurate assessment of forest health and to detect changes in forest health over time.

Members of EWMSD and other BNL departments volunteered as speakers for schools and civic groups and provided on-site ecology tours. EWMSD also hosted events in association with Earth Day. In October, BNL hosted the Tenth Annual Pine Barrens Research Forum, providing a venue for researchers who are conducting work on pine barrens ecosystems to share and discuss their results. BNL also hosted the annual Wildland Fire Academy, offered by NYSDEC and the Central Pine Barrens Commission. This academy trains fire fighters in the methods of wildland fire suppression, prescribed fire, and fire analysis, using the Incident Command System of wildfire management.

BNL has developed and is implementing a Wildland Fire Management Plan. In October 2004, the first prescribed fire at BNL was conducted. This fire treated approximately 7 acres to improve germination and recruitment of oak seedlings. It also reduced fine-textured forest fuels that tend to increase the severity of wildfires. Pre-fire monitoring was conducted before the fire was started, and post-fire monitoring indicated the fire was conducted properly for its intended purpose. Additional post-fire monitoring in 2005 indicated that the prescribed fire had improved conditions that support the germination of oak seedlings. BNL's second prescribed fire was planned for 2005, but heavy rainfall precluded conducting the activity in the timeframe allotted. The Laboratory intends to continue the use of prescribed fire for fuel and forest management in the future.

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), which will guide the management of all of BNL's historical resources, was approved by DOE in March 2005. 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 complex, the High Flux Beam Reactor 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 2005, the cultural resource program focused primarily on outreach activities. A drive-by tour of historic Laboratory structures was developed, along with an accompanying narrative CD and pamphlet. Talking points and visuals were also developed for tours of select WWI trench areas.

A portion of one BNL Summer Sunday Open House in August was devoted to BNL history. This event, which was open to the general public and promoted through radio and newspaper ads, featured displays related to the Laboratory and Camp Upton history, talks by scientific staff, as well as a bus tour and walking tour of the WWI trenches. More than 1,000 people visited the Laboratory on this day, with approximately 500 participating in the tours. Additional tours of the WW I trenches were provided to local organizations throughout the year.

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7

Groundwater Protection

Brookhaven National Laboratory's Groundwater Protection Management 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 2005, BNL collected groundwater samples from 864 monitoring wells during 2,567 individual sampling events. Twelve groundwater remediation systems removed 472 pounds of volatile organic compounds and returned approximately 1.7 billion gallons of treated water to the Upper Glacial aquifer. Since the beginning of active groundwater remediation in December 1996, the Laboratory has removed 5,280 pounds of volatile organic compounds by treating nearly 10 billion gallons of groundwater. During 2005, two additional groundwater treatment systems removed approximately 4.7 millicuries of strontium-90, while remediating approximately 5 million gallons of groundwater.

7.1 THE BNL GROUNDWATER PROTECTION MANAGEMENT PROGRAM

The primary goal of BNL's Groundwater Protection Management 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, and is described in the BNL Groundwater Protection Management Program Description (Paquette et al. 2002). 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 remediating 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 BNL 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, and 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). Samples from groundwater monitoring wells are 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 (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) Environmental Surveillance (ES) monitoring, designed to satisfy DOE and New York State monitoring requirements for active research and support facilities, and 2) Environmental Restoration (ER) monitoring related to BNL's obligations under the Comprehensive Environmental Response, Compensation and Liability Act. This monitoring is coordinated to ensure completeness and to prevent duplication of effort in the installation, monitoring, and abandonment of wells. The monitoring program elements have been integrated and include data quality objectives; plans and procedures; sampling and analysis; quality assurance; data management; and the installation, maintenance, and abandonment of wells. These elements were 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.

Table 7-1. Summary of BNL Groundwater Monitoring Program, 2005.

	Environmental Restoration Program	Environmental Surveillance Program
Number of wells monitored	739	125
Number of sampling events	2,282	285
Number of analyses performed	4,597	897
Number of results	86,652	8,015
Percent of nondetectable analyses	92	90
Number of new wells installed (a)	7	0
Number of wells abandoned	6	0

Note:
a) Permanent wells only. Single-use temporary wells used for characterization are not included.

7.1.3 Restoration

BNL was added to the National Priorities List in 1989 (see Chapter 2 for a discussion of BNL's ER Program). To help manage the restoration effort, 30 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 on installing and operating 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 an Interagency Agreement 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 Program ensures that BNL 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, the Laboratory has developed a Groundwater Protection Contingency Plan (BNL 2000) that provides a formal process to communicate off-normal or unusual monitoring results to BNL's management, DOE, regulatory agencies, and other stakeholders, including the public and employees, in a timely manner.

7.2 GROUNDWATER PROTECTION PERFORMANCE

Under the BNL Groundwater Protection Management Program, the Laboratory began tracking progress in 1998 toward preventing new contamination of the aquifer system. BNL has made significant investments in environmental and groundwater protection, and is making progress in achieving its goal of preventing new groundwater impacts. A new groundwater impact is defined as the detection and confirmation of unusual or off-normal groundwater monitoring results. The Groundwater Protection Contingency Plan (BNL 2000) 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 evaluating the source of the problem, notifying stakeholders, and implementing appropriate corrective actions.

Since 1998, BNL has installed several hundred permanent and temporary monitoring wells following a comprehensive evaluation of known or potential contaminant source areas. Using this enhanced monitoring system, BNL identified 10 new groundwater impacts during 1998 through 2001 (see Figure 7-1). No additional impacts have been identified since 2001. Five of the 10 identified impacts were determined to be from historical (or "legacy") contaminant releases, and five were related to active science operations and environmental protection activities. In all 10 cases, BNL thoroughly investigated the cause of the contamination and took corrective actions as necessary to eliminate or limit the scale of the impacts. The Laboratory will continue efforts to prevent new groundwater impacts, and is vigilant in measuring and communicating its performance.

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 (which are not used for the drinking water supply) 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 entering and leaving 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 supply. 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

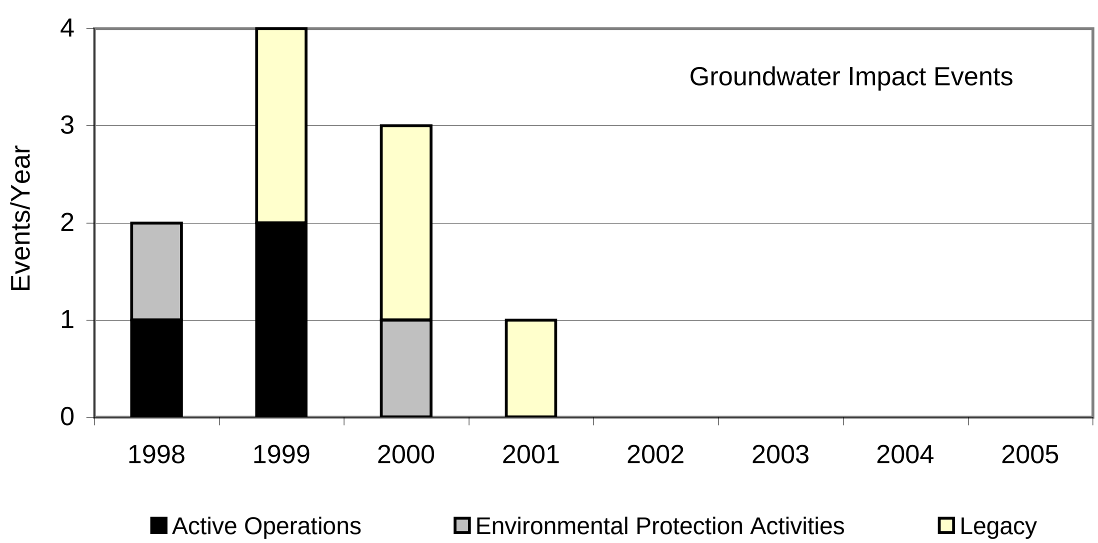

Figure 7-1. Groundwater Protection Performance, 1998 – 2005.

standards. Contaminant concentrations that are below the standards are also compared to background values to evaluate the potential effects from facility operations. The detection of low concentrations of facility-specific volatile organic compounds (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 860 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 flow. Groundwater flow directions in the vicinity of the Laboratory are shown in Figure 7-2.

The following active facilities have groundwater monitoring programs: the Sewage Treatment Plant and Peconic River area, Biology Agricultural Fields, Waste Management Facility, Central Steam Facility and adjacent Major Petroleum Facility, Alternating Gradient Synchrotron, Relativistic Heavy Ion Collider, Waste Concentration Facility, Supply and Material Area, and several other smaller facilities. Inactive facilities include the former Hazardous Waste Management Facility, two former landfill areas, the Brookhaven Graphite Research Reactor (BGRR), High Flux Beam Reactor (HFBR), and the Brookhaven Medical Research Reactor (BMRR). As a result of detailed groundwater investigations conducted over the past 15 years, six significant VOC plumes and eight radionuclide plumes have been identified (see Figures 7-3 and 7-4).

7.4 SUPPLEMENTAL MONITORING OF WATER SUPPLY WELLS

As discussed in Chapter 3, BNL is classified as a public water purveyor and maintains water supply wells and associated treatment facilities for the distribution of potable water on site. This water is also used for cooling water purposes at a number of facilities. Most of BNL's water supply is obtained from a network of six large-capacity wells (wells 4, 6, 7, 10, 11, and 12). A seventh well, number 9, is a small-capacity well that supplies process water to a facility where biological research is conducted. This well is not routinely monitored. The locations of the supply wells are shown in Figure 7-2.

The quality of the BNL potable water supply is monitored as required by the Safe Drinking Water Act (SDWA), and the analytical results are reported to the Suffolk County Department of Health Services. As required by SDWA, the Laboratory also prepares an annual Water Quality Consumer Confidence Report (BNL 2004b) that is distributed to all employees and guests. Results of the SDWA-required monitoring are described in Chapter 3.

All of BNL's supply wells are screened within the Upper Glacial aquifer. Because of the proximity of the potable supply wells to known or suspected groundwater contamination plumes and source areas, the Laboratory conducts a supplemental potable supply well monitoring program that includes testing for VOCs, anions, metals, and radiological parameters. During 2005, the BNL potable water system fully complied with all drinking water requirements. To better understand the geographical source of the Laboratory's drinking water and to identify potential sources of contamination within these geographical areas, BNL prepared the Source Water Assessment for Drinking Water Supply Wells (Bennett et al. 2000). In 2003, the New York State Department of Health (NYSDOH) prepared a source water assessment for all potable water supply wells on Long Island (NYSDOH 2003). The source water assessments are designed to serve as management tools in further protecting Long Island's sole source aquifer system.

7.4.1 Radiological Results

During 2005, samples collected quarterly from supply wells 6, 7, 11, and 12 were analyzed (see Table 7-2) for gross alpha and gross beta activity, tritium, and strontium-90 (Sr-90). Well 10, which was used infrequently during 2005, was only sampled one time. Well 4 was shut down in 2005 because of maintenance problems. Nuclide-specific gamma spectroscopy was also performed for potable well samples. All radioactivity levels in the potable water

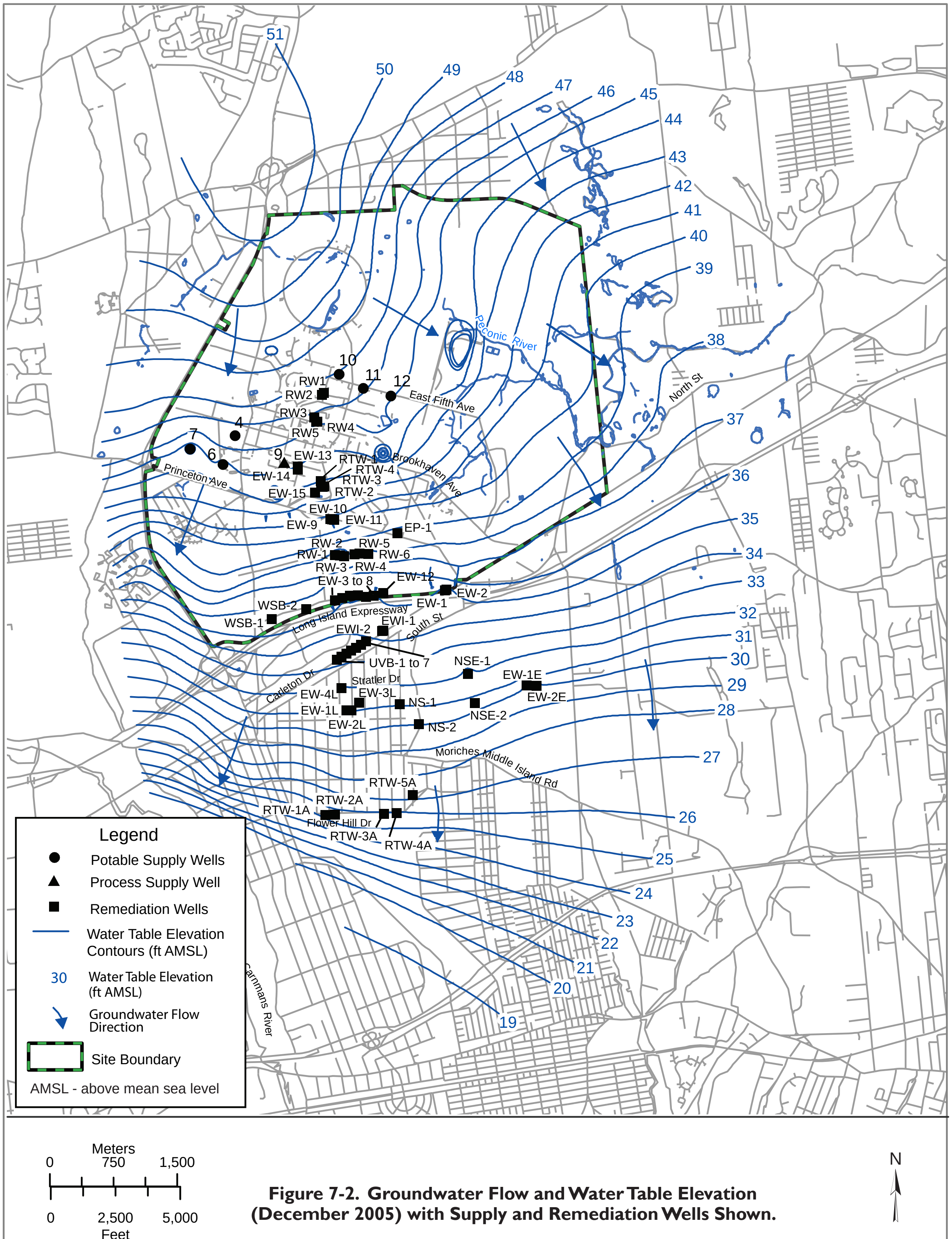

Figure 7-2. Groundwater Flow and Water Table Elevation (December 2005) with Supply and Remediation Wells Shown.

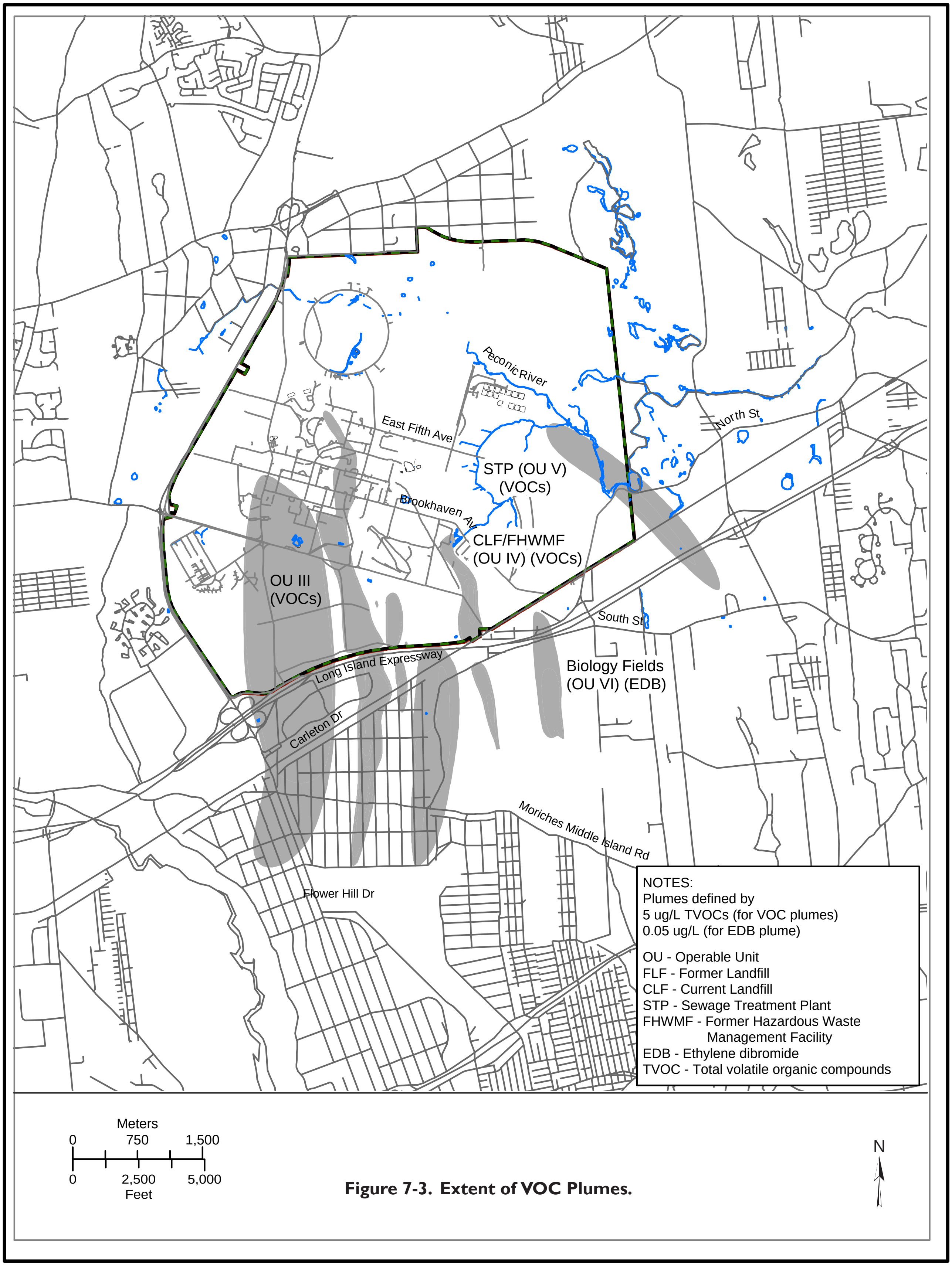

Figure 7-3. Extent of VOC Plumes.

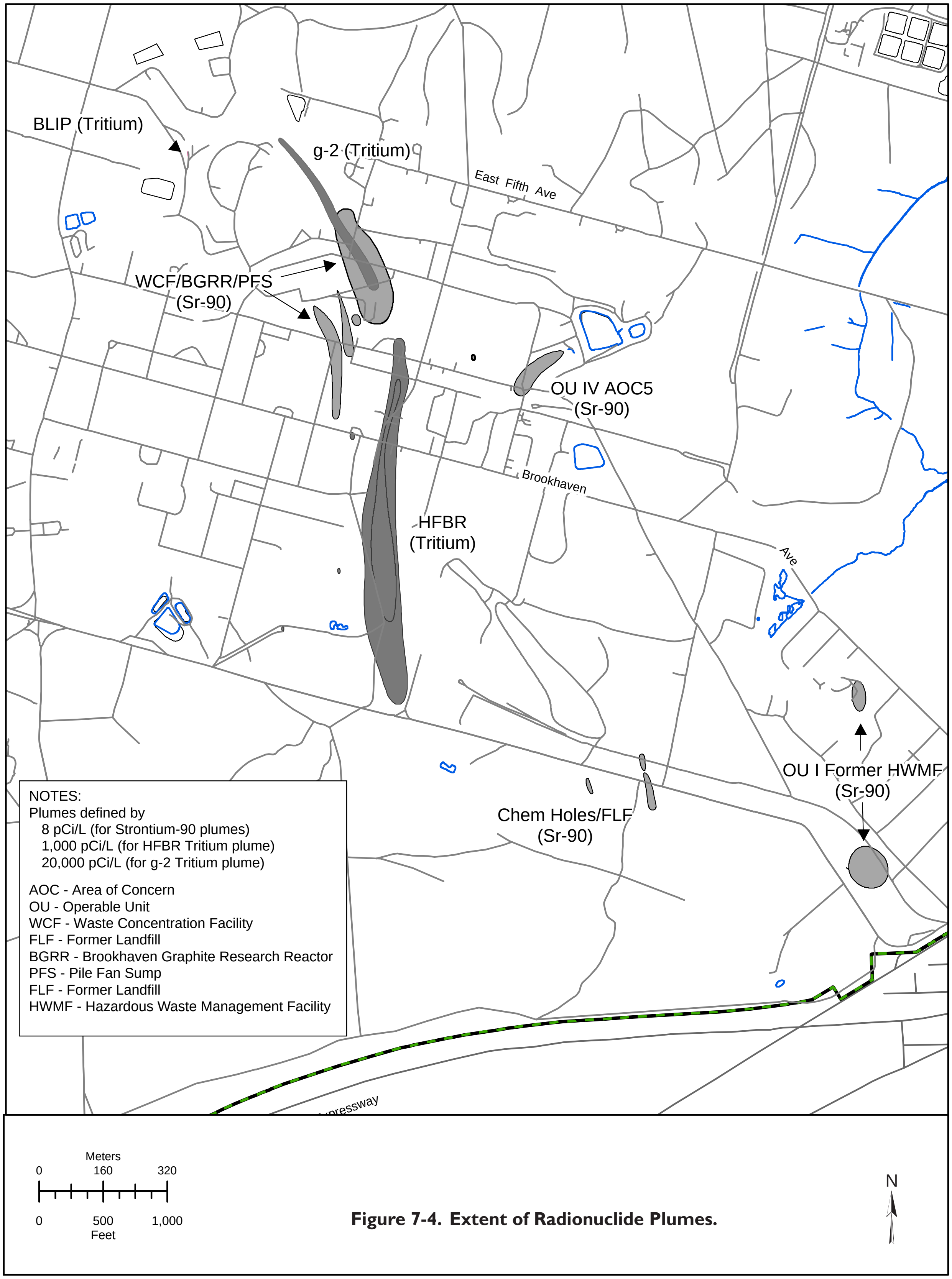

Figure 7-4. Extent of Radionuclide Plumes.

Table 7-2. Potable Well Radiological Analytical Results.

Potable Well ID		Gross Alpha	Gross Beta	Tritium	Sr-90
Well 4	Samples	WS	WS	WS	WS
	Max.				
	Avg.				
Well 6	Samples	3	3	3	3
	Max.	< 1.6	< 1.55	< 240	< 0.46
	Avg.	0.22 ± 0.44	0.87 ± 0.59	92.5 ± 91.99	-0.07 ± 0.24
Well 7	Samples	4	4	4	4
	Max.	< 1.1	< 1.72	< 240	< 0.67
	Avg.	0.61 ± 0.45	0.83 ± 0.14	6.75 ± 94.65	0.18 ± 0.04
Well 10	Samples	1	1	1	1
	Max.	0.18 ± 0.58	-0.3 ± 1.1	90 ± 190	-0.12 ± 0.32
	Avg.	NA	NA	NA	NA
Well 11	Samples	4	4	8	4
	Max.	< 1.2	< 1.7	< 300	< 0.52
	Avg.	0.07 ± 0.22	1.08 ± 0.41	91.18 ± 63.68	0.02 ± 0.06
Well 12	Samples	4	4	8	4
	Max.	< 1.4	< 1.8	< 310	< 0.49
	Avg.	-0.17± 0.23	1.24 ± 0.56	158.48 ± 60.42	0.22 ± 0.17
SDWA Limit (pCi/L)		15 (a)	4 mrem (b)	20,000	8

Notes:
See Figure 7-2 for well locations.
All values presented with a 95% confidence interval.
Potable Well #10 was shut down most of the year due to its possible effect on groundwater flow direction in the vicinity of the g-2 Tritium Plume.
WS = Well shut down due to operational problems
(a) Excluding radon and uranium
(b) The drinking water standards were changed from 50 pCi/L (concentration based) to (dose based) in late 2003. Because gross beta activity does not identify specific radionuclides, a dose equivalent cannot be calculated for the values in the table.

wells were consistent with those of typical background water samples.

7.4.2 Nonradiological Results

In addition to the quarterly SDWA compliance samples described in Section 3.7 of Chapter 3, BNL collected supplemental VOC samples from active supply wells during the year. The samples were analyzed for VOCs following either EPA Standard Method 524 or 624. Trace levels of chloroform continued to be routinely detected in samples from most wells, with a maximum concentration of 2.3 µg/L observed during 2005. The DWS for chloroform is 80 µg/L. Low levels of several other VOCs (e.g., 1,1,1-trichloroethane [TCA], bromodichloromethane, and dibromochloromethane) were occasionally detected, but at concentrations well below applicable DWS. Samples were also analyzed for metals and anions one time during the year from wells 6, 7, 11, and 12 (see Tables 7-3 and 7-4). As in previous years, iron was the only parameter detected at concentrations greater than the DWS, which is 0.3 mg/L for iron. The iron level in well 7 was 2.25 mg/L. Because high levels of iron are naturally present in some portions of the Upper Glacial aquifer on the western side of the Laboratory site, water obtained from wells 4, 6, and 7 is treated at the BNL Water Treatment Plant to reduce iron levels before distribution.

7.5 ENVIRONMENTAL SURVEILLANCE PROGRAM

BNL's ES Program includes groundwater monitoring at 10 active research facilities (e.g., accelerator beam stop and target areas) and support facilities (e.g., fuel storage facilities). During 2005, 125 groundwater wells were monitored during 285 individual sampling events. Detailed descriptions and maps related to the ES groundwater monitoring program can be found in SER Volume II, Groundwater Status Report.

Although no new impacts to groundwater quality were discovered during 2005, groundwater quality continues to be impacted at four facilities: continued high levels of tritium at the g-2/VQ-12 area of the Alternating Gradient Synchrotron (AGS) facility; tritium at the Brookhaven Linac Isotope Producer (BLIP) facility; low-level VOCs at the Motor Pool/Facility Maintenance area; and low levels of VOCs at the Service Station. Monitoring results for these areas are described below.

- Although tritium continues to be detected at concentrations above the 20,000 pCi/L

DWS in wells immediately downgradient of the g-2/VQ-12 source area in the AGS facility, the levels are much lower than those observed in 2002 and 2003. Tritium concentrations reached a maximum of 3,440,000 pCi/L in 2002 and have shown a steady decline, dropping to 86,200 pCi/L by October 2005.

- In July 2005, tritium concentrations exceeded the 20,000 pCi/L DWS in one well immediately downgradient of BLIP, with a concentration of 46,500 pCi/L. Tritium concentrations declined to less than the DWS limit for the remainder of the year.
- At the Motor Pool/Site Maintenance area, the solvents TCA and 1,1-dichloroethane (DCA) continued to be detected at concentrations greater than the NYS AWQS of 5 µg/L. TCA was detected at concentrations up to 32.7 µg/L, and DCA was detected at concentrations up to 11.9 µg/L. Methyl tertiary butyl ether (MTBE), a gasoline additive, was also detected, with a maximum observed concentration of 3.9 µg/L. The NYS AWQS for MTBE is 10 µg/L.
- At the Service Station, VOCs associated with petroleum products and solvents continued to be detected at concentrations greater than the NYS AWQS of 5 µg/L. Petroleum-related compounds detected in groundwater included m/p xylene at 30 µg/L, o-xylene at 15 µg/L, 1,2,4-trimethylbenzene at 20 µg/L, and 1,3,5-trimethylbenzene at 5.5 µg/L. The solvent tetrachloroethylene (TCE) was detected in several wells with a maximum concentration of 12 µg/L. Trace levels of MTBE were also detected, at a maximum concentration of 0.6 µg/L.

Although the engineered stormwater controls appeared to be effectively protecting the g-2/VQ-12 and BLIP source areas, monitoring data suggested that the continued release of tritium in both areas appeared to be caused by the flushing of residual tritium from the vadose (or unsaturated) zone following significant natural periodic rises in the local water table. It is expected that the amount of tritium remaining in the vadose zone close to the water table will decline over time due to this flushing mechanism and by natural radioactive decay (the half-life of tritium is 12.3 years).

Table 7-3. Potable Water Supply Wells Water Quality Data.

Potable Well ID		Chlorides	Sulfates (mg/L)	Nitrate and Nitrite
Well 4	N	WS	WS	WS
	Value	–	–	–
Well 6	N	NS	NS	NS
	Value	–	–	–
Well 7	N	1	1	1
	Value	22.5	10.1	0.36
Well 11	N	1	1	1
	Value	18.8	11.1	0.62
Well 12	N	1	1	1
	Value	19.6	10.9	0.97
NYS DWS		250	250	10
Typical MDL		4	4	1

Notes:
See Figure 7-2 for location of wells.
Potable Well #10 was shut down most of the year due to its possible effect on groundwater flow direction in the vicinity of the g-2 Tritium Plume.
N = Number of samples
NS = Not Sampled
NYS DWS = New York State Drinking Water Standard
MDL = Minimum Detection Limit
WS = Well shut down due to operational problems

Monitoring of the leak detection systems at both vehicle maintenance facilities indicated that the gasoline storage tanks and associated distribution lines were not leaking. Furthermore, BNL's ongoing evaluation of vehicle maintenance operations indicates that all waste oils and used solvents are being properly stored and recycled. Therefore, it is believed that the contaminants detected in groundwater at these facilities originated from historical vehicle maintenance activities, and were not related to current operations.

7.6 ENVIRONMENTAL RESTORATION GROUNDWATER MONITORING PROGRAM

The mission of the Laboratory's Environmental Restoration Groundwater Monitoring

Table 7-4. Total Metals Concentration Data for Potable Water Supply Well Samples.

Well ID		Ag	Al	As	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg	Mn	Na	Ni	Pb	Sb	Se	Tl	V	Zn
		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	µg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Well 4 *	N	WS	WS	WS	WS	WS	WS	WS	WS	WS	WS	WS	WS	WS	WS	WS	WS	WS	WS	WS	WS
	Value	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–			
Well 6 *	N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Value	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Well 7 *	N	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Value	< 2.0	8.6	2	22.4	< 2.0	< 2.0	0.58	< 5.0	4.2	2.25	< 0.2	76.1	16.7	1.3	< 3.0	< 5.0	< 5.0	< 5.0	< 5.0	7.3
Well 11	N	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Value	< 2.0	< 50.0	1.8	27.8	< 2.0	< 2.0	< 5.0	< 5.0	9.2	0.01	< 0.2	< 5.0	15.8	< 10	20.5	1.7	< 5.0	< 5.0	< 5.0	5.1
Well 12	N	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Value	< 2.0	< 50.0	< 5.0	28.7	< 2.0	< 2.0	< 5.0	< 5.0	20.9	0.02	< 0.2	0.6	15.2	< 10	2	< 5.0	< 5.0	< 5.0	< 5.0	8.3
NYS DWS		100	SNS	50	2000	4	5	SNS	100	1300	0.3	2	300	SNS	SNS	15	6	50	2	SNS	5000
Typical MDL		1.0	2.2	3.0	1.8	0.7	1.1	0.1	1.0	2.0	0.08	0.1	5.0	1.0	1.1	1.3	0.9	5.0	0.7	5.5	4.0

Notes:
See Figure 7-2 for well locations.
Potable Well #10 was shut down most of the year due to its possible effect on groundwater flow direction in the vicinity of the g-2 Tritium Plume.
* Water from these wells is treated at the Water Treatment Plant for color and iron reduction prior to site distribution.
MDL = Minimum Detection Limit
NS = Not Sampled
NYS DWS = New York State Drinking Water Standard
SNS = Drinking Water Standard not specified
WS = Well shut down due to operational problems

Program is to monitor the contaminant plumes on and off site. The monitoring results are used to track the progress that the groundwater treatment systems are making toward plume remediation. In 2005, a total of 739 groundwater wells were monitored, during 2,282 individual sampling events.

Maps showing the main VOC and radionuclide plumes are provided as Figures 7-3 and 7-4, respectively. Detailed descriptions and maps related to the ER Groundwater Monitoring Program can be found in SER Volume II, Groundwater Status Report. Highlights of the program are described below.

- Groundwater monitoring during 2005 showed that tritium concentrations directly downgradient from the HFBR have remained relatively low since the first quarter of 2004, when a concentration of 378,000 pCi/L was detected in well 075-43. The highest concentration detected in the area during 2005 was 243,000 pCi/L.

  Data obtained during 2005 indicated that the plume had shifted to the east of much of the downgradient portion of the monitoring well network and that the high concentration area of the plume was approaching the Chilled Water Plant Road vicinity. Additional characterization work was scheduled for early 2006 to address these data gaps. The results of this characterization work are contained in SER Volume II of this report.
- Monitoring in the Building 96 area indicated that concentrations of VOCs (primarily perchloroethylene [PCE] and TCA) continued to persist in the "silt zone" source area north of treatment well RTW-1. Downgradient treatment wells RTW-2, -3, and -4 were placed in standby mode in July 2004 and continued to remain in standby mode during 2005. RTW-1 was also placed in standby mode in July 2005, but a rebound of VOC concentrations resulted in this well being put back in operation during October 2005. Potassium permanganate was injected into the silt zone source area in late 2004 and early 2005 in an effort to treat the contamination. Additional potassium permanganate injections were implemented in April 2005 and January 2006 due to persistently elevated VOC concentrations. The area will be monitored in 2006 with no plans for additional injections. If VOC concentrations do not decline, alternative methods for remediating the silt zone source area contamination will be evaluated.
- Declining carbon tetrachloride concentrations continued in 2005 in samples from wells that monitor the carbon tetrachloride plume and the associated remediation system, which is now in standby mode.
- Ethylene dibromide (EDB) data from off-site monitoring wells in 2005 indicated that the EDB plume had reached the remediation system extraction wells.
- VOC concentrations remained stable or declined slightly for the OU V VOC plume.
- Sr-90 concentrations remained stable or declined in monitoring wells located at and downgradient from the former Building 650 sump outfall.

7.7 GROUNDWATER TREATMENT SYSTEMS

The primary mission of the Laboratory's Environmental Restoration Program is to operate and maintain treatment systems that remediate groundwater contamination and prevent additional contamination from migrating off site. The cleanup goals are to prevent or minimize plume growth and reduce contaminant concentrations in the Upper Glacial aquifer to below NYS Maximum Contaminant Level (MCL) standards. Based on additional information obtained during the Strontium-90 Pilot Study and Magothy aquifer characterization, BNL prepared the OU III Explanation of Significant Differences (BNL 2004a), which was submitted for public review in December 2004. The report identified changes to the OU III cleanup goal time frames. For the BGRR/Waste Concentration Facility and Chemical Holes Sr-90 plumes, MCLs must be reached within 70 years and 40 years, respectively. Cleanup of the Magothy aquifer VOC contamination must meet MCLs within 65 years. With NYSDEC concurrence, EPA approved the Explanation of Significant Differences in early 2005.

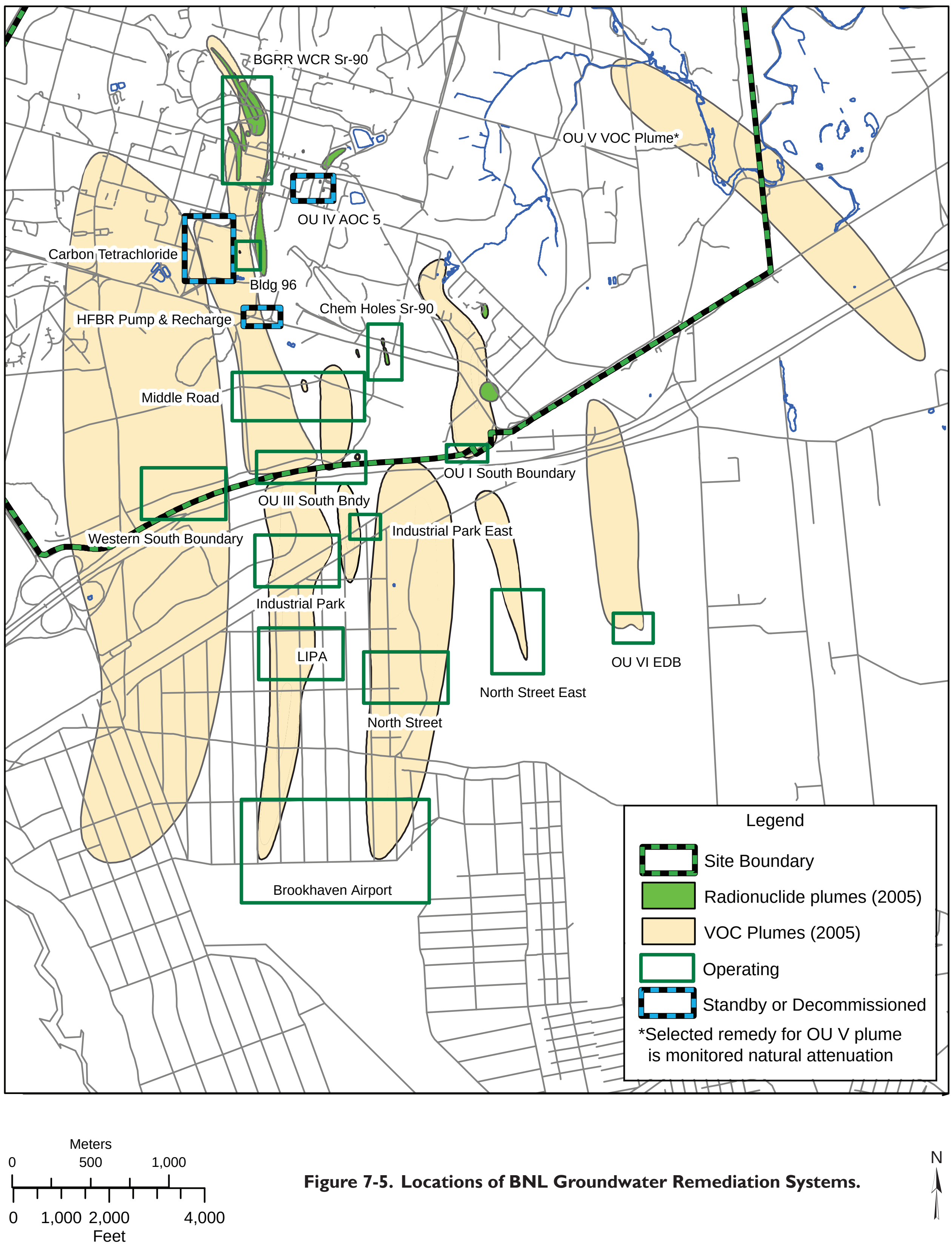

Figure 7-5. Locations of BNL Groundwater Remediation Systems.

Table 7-5. BNL Groundwater Remediation Systems Treatment Summary for 1997 through 2005.

		1997-2004		2005	
Remediation System	Start Date	Water Treated Gallons	VOCs Removed Pounds (e)	Water Treated Gallons	VOCs Removed Pounds (e)
OU I South Boundary	12/1996	2,696,275,000	313	196,974,000	10
OU III HFBR Tritium Plume (a)	05/1997	241,528,000	180	Not in Service	0
OU III Carbon Tetrachloride (d)	10/1999	150,164,075	348	3,374,000	1
OU III Building 96	02/2001	122,865,416	67	9,692,000	2
OU III Middle Road	10/2001	808,353,550	520	157,297,000	88
OU III South Boundary	06/1997	2,564,859,850	2,276	248,240,000	133
OU III Western South Boundary	09/2002	357,048,000	32	120,115,000	7
OU III Industrial Park	09/1999	966,928,330	838	116,370,000	63
OU III Industrial Park East	05/2004	57,113,000	17	86,485,000	7
OU III North Street	06/2004	144,702,000	115	201,139,000	72
OU III North Street East	06/2004	84,000,000	5	162,900,000	6
OU III LIPA/Airport	06/2004	134,444,000	62	302,238,000	83
OU IV AS/SVE (b)	11/1997	(c)	35	Decommissioned	0
OU VI EDB	08/2004	20,000,000	<1	157,652,000	<1
Total		8,348,281,221	4,808	1,763,476,000	472

		2003-2004		2005	
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	5,060,826	1.17	1,552,000	0.57
OU III BGRR/WCF Sr-90	06/2005	Not in Service	0	3,576,000	4.15
Total		5,060,826	1.17	5,128,000	4.72

Notes:
(a) System was shut down and placed in standby mode on September 29, 2000.
(b) System was shut down on January 10, 2001 and decommissioned in 2003.
(c) Air Sparging/Soil Vapor Extraction (AS/SVE) system performance is measured by pounds of VOCs removed per cubic feet of air treated.
(d) System was shut down and placed in standby mode in August 2004.
(e) Values are rounded to the nearest whole number.

All of the 16 planned groundwater remediation systems have been constructed (see Figure 7-5). The HFBR Pump and Recharge System has remained in standby mode since September 2000, the OU IV Air Sparging/Soil Vapor Extraction System was decommissioned in 2003, and the Carbon Tetrachloride Plume Treatment System was placed in standby mode in August 2004 following regulatory agency approval. Furthermore, because VOC concentrations in three of the four Building 96 re-circulation wells remained significantly low, those wells were shut down and placed in standby mode in July 2004. The fourth recirculation well (RTW-1) was placed in standby in June 2005 and remained in standby until it was restarted in October 2005 due to a rebound in VOC concentrations.

Pulse-pumping operations were initiated during 2005 for the OU I South Boundary, OU III Airport, and OU III Western South Boundary treatment systems. The BGRR Strontium-90 Treatment System was started in January 2005. The OU III South Boundary, OU III Industrial

Park, and OU III LIPA Magothy treatment systems continue to demonstrate significant mass removal of VOCs.

In 2005, BNL continued to make significant progress in restoring groundwater quality on site, with 14 groundwater remediation systems in active operation. Figure 7-5 shows the locations of the groundwater treatment systems. Table 7-5 provides a summary of pounds of VOCs and curies (Ci) of radioactivity removed, and gallons of water treated during 1997–2005. During 2005, 472 pounds of VOCs and 4.72 mCi of Sr-90 were removed from the groundwater, and more than 1.7 billion gallons of treated groundwater were returned to the aquifer. To date, approximately 5,280 of the estimated 25,000 to 30,000 pounds of VOCs in the aquifer have been removed. It is expected to take up to 10 years of aquifer treatment before widespread improvements in groundwater quality at BNL are achieved. Some noticeable improvements in groundwater quality are already evident in the OU I South Boundary, OU III South Boundary, OU IV, Building 96, and Carbon Tetrachloride areas. The Chemical Holes Strontium-90 System has removed 1.75 mCi of Sr-90 out of a projected 19.6 mCi total. The BGRR/Waste Concentration Facility Strontium-90 System, which started operation in June 2005, removed 4.15 mCi of Sr-90 out of a projected total of 63.8 mCi. Detailed information on the groundwater treatment systems can be found in SER Volume II, Groundwater Status Report.

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Radiological Dose Assessment

8

Brookhaven National Laboratory routinely evaluates site operations to ensure that the radiological dose impact to members of the public, BNL workers, and the environment is "As Low As Reasonably Achievable" (ALARA). All scientific and operational processes and activities that can in any way impact the health and safety or potentially contribute to radiological dose are reviewed for their environmental impacts. The potential radiological dose to the public is calculated as the maximum dose to a hypothetical Maximally Exposed Individual (MEI) at the BNL site boundary. Doses are calculated by considering all direct and indirect sources and pathways, such as inhalation of air emissions, ingestion of deer meat and fish, and any immersion dose. The dose assessment has routinely shown that the total Effective Dose Equivalent from Laboratory activities is well below the EPA regulatory dose limits for the public, workers, and the environment.

The average annual external dose from all potential ambient sources was 67 ± 12 mrem (670 ± 120 µSv) on site and 64 ± 9 mrem (640 ± 90 µSv) at off-site locations. Both measurements include contributions from natural background and cosmic radiation sources. A statistical comparison of the average doses measured at 47 on-site and 16 off-site locations using thermoluminescent dosimeters (TLDs) showed that there was no additional external dose contribution from BNL operations above the dose from natural background radiation. In addition to measuring background, nine TLDs were used to monitor known radiation source areas. The results of these measurements are described in Section 8.1.2.

The effective dose from air emissions was calculated as 5.30E-02 mrem (0.53 µSv) to the MEI. The ingestion pathway dose was estimated as 0.32 mrem (3.2 µSv) from consumption of deer meat and 0.08 mrem (0.8 µSv) from consumption of fish caught on the BNL site. The total annual dose to the MEI from all pathways was estimated as 0.45 mrem (4.5 µSv). The BNL dose from the air inhalation pathway was less than 10 percent of EPA's annual regulatory dose limit of 10 mrem (100 µSv), and the total dose less than 1 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 DOE regulatory limits. Other short-term projects conducted in 2005, such as remediation work and waste management disposal activities, were evaluated for their radiological emissions and potential dose impact; there was no radiological risk to the public, BNL workers, or the environment from these activities. In conclusion, the overall dose impact from all Laboratory activities in 2005 was indistinguishable from natural background radiation levels.

8.1 DIRECT RADIATION MONITORING

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

Direct penetrating beta-gamma radiation is measured using TLDs. The principle of TLD operation 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), the 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 BNL are composed of calcium fluoride and lithium fluoride crystals. The TLDs' accuracy is verified by comparing the absorbed dose of a TLD exposed to a known and characterized radiation source. BNL participates in the inter-comparison proficiency testing programs sponsored by DOE as a check of its ability to measure radiation doses accurately.

8.1.1 Ambient Monitoring

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

In 2005, 55 TLDs were deployed on site; nine were placed in known radiation areas (i.e., facility area monitoring TLDs) and 16 were deployed off site (see Figures 8-1 and 8-2 for locations). An additional 30 control TLDs were stored in a lead-shielded container in Building 490; the average of the control TLDs is

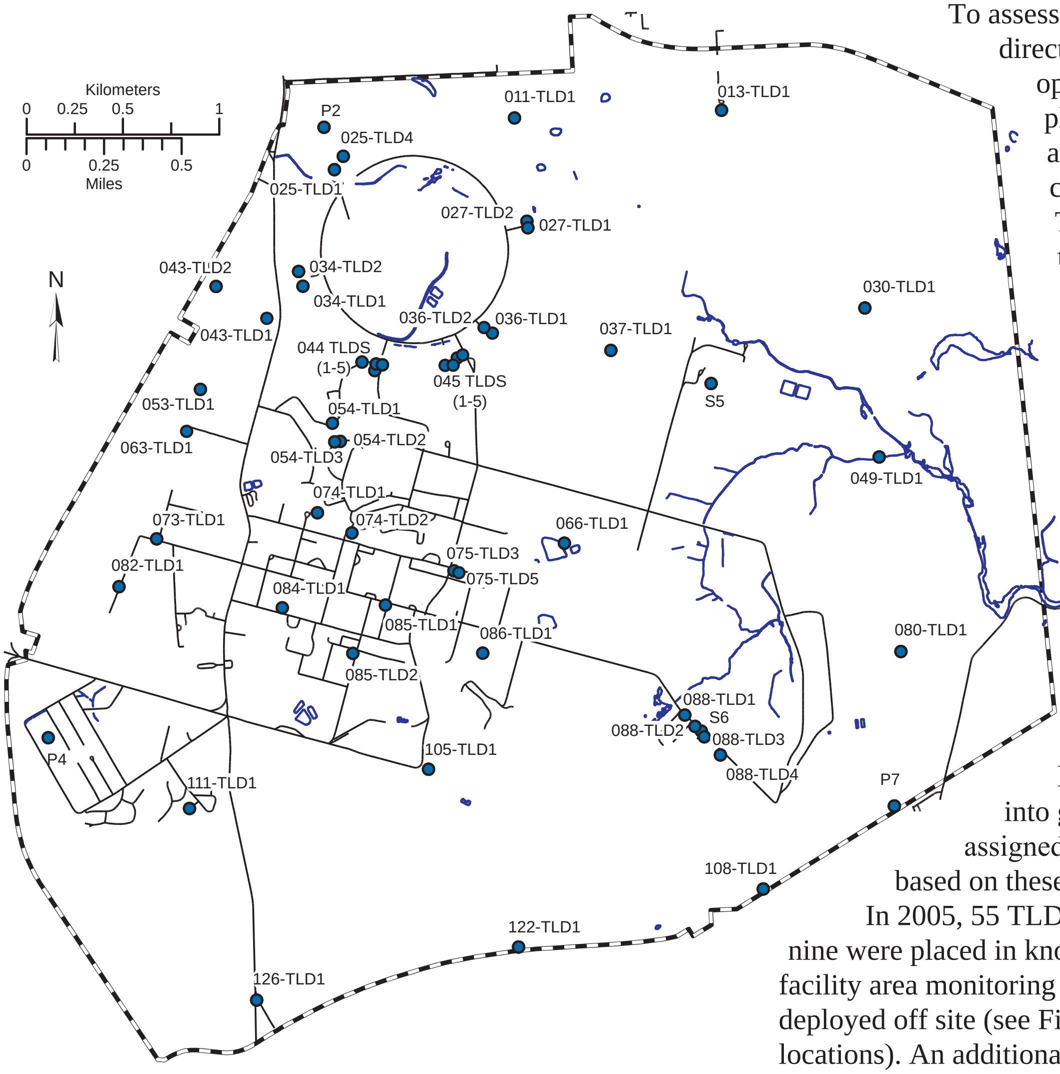

Figure 8-1. On-Site TLD Locations.

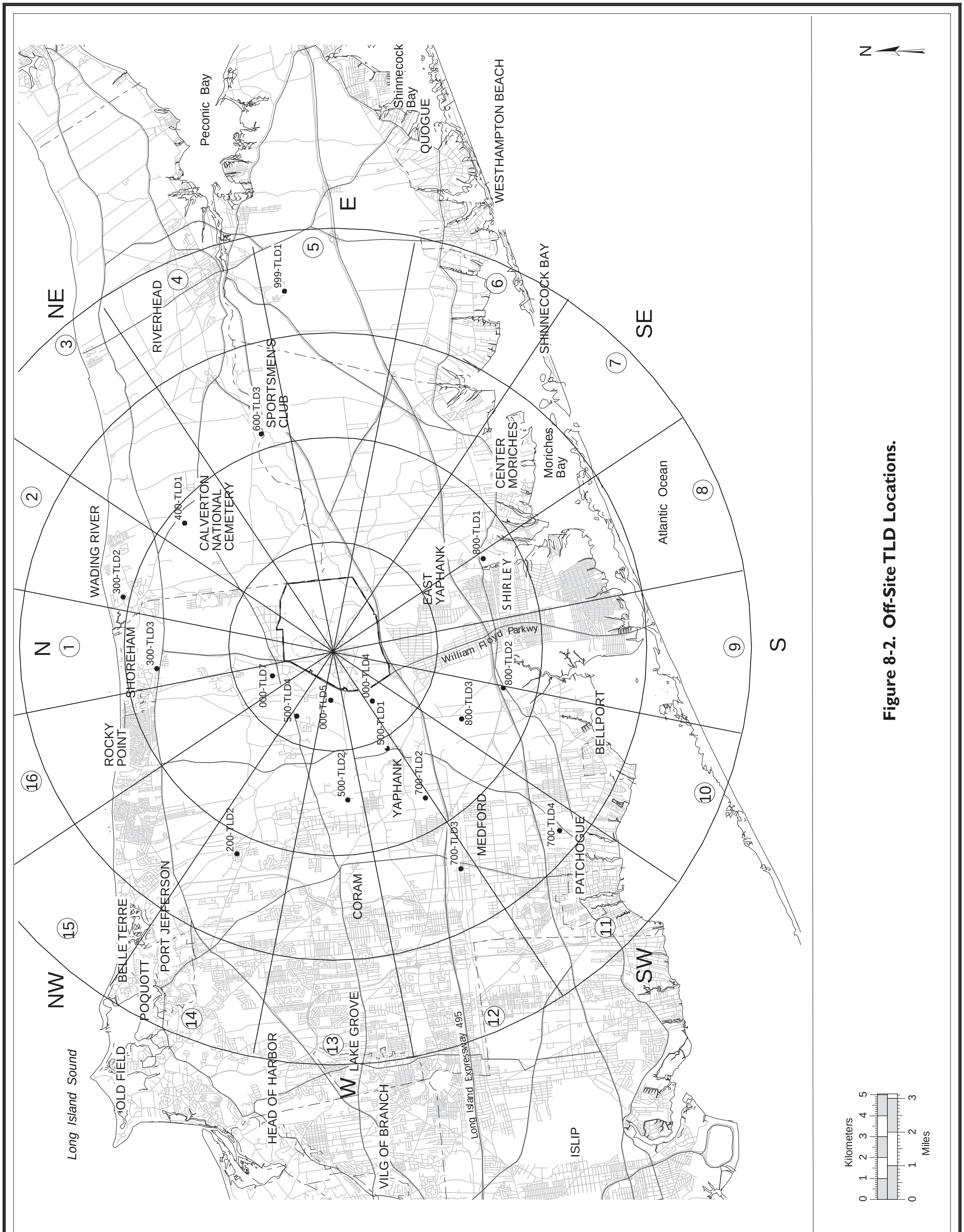

Figure 8-2. Off-Site TLD Locations.

reported as “075-TLD4” in Tables 8-1 and 8-2, for comparison. Note that some residual dose remains on the control TLDs when they are annealed and it is impossible to completely shield the control devices from all natural background and cosmic radiation sources. Therefore, small doses are measured by the control TLDs. The on- and off-site TLDs are collected and read quarterly to determine the external radiation dose measured.

Table 8-1 shows the quarterly and yearly on-site radiation dose measurements. The on-site average external dose for the first, second, third, and fourth quarters was 17.7 ± 3.2, 15.7 ± 3.0, 15.3 ± 3.1, and 18.2 ± 3.5 mrem, respectively. The on-site average annual external dose from all potential environmental sources, including cosmic and terrestrial radiation sources, was 67 ± 12 mrem (670 ± 120 µSv).

Table 8-2 shows the quarterly and yearly off-site radiation dose measurements. The off-site average external dose for the first, second, third, and fourth quarters was 17.1 ± 4.5, 14.8 ± 2.5, 14.8 ± 1.8, and 17.0 ± 2.2 mrem, respectively. The off-site average annual ambient dose from all potential environmental sources, including cosmic and terrestrial radiation sources, was 64 ± 9 mrem (640 ± 90 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 (64 ± 9 mrem) and on-site dose (67 ± 12 mrem) at the 95 percent confidence level. From these measured doses, it can be safely concluded that there was no external dose contribution to on- and off-site locations from BNL operations in 2005.

8.1.2 Facility Area Monitoring

Nine of the 56 on-site TLDs were designated as Facility Area Monitors (FAM). These TLDs are deployed at locations known in the past to have radiation contamination, possible radiation scatter, or that are near radiological posted areas, as these areas have a higher probability to contribute to external radiation doses. Table 8-3 shows the external doses measured with the FAM TLDs. Environmental TLDs 088-TLD1 through 088-TLD4 are posted at the S-6 blockhouse location and on the fence of the

Table 8-1. On-Site Direct 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	15.3	13.8	14.9	15.7	15 ± 2	60 ± 6
013-TLD1	North firebreak	17.3	15.5	14.0	16.9	16 ± 3	64 ± 12
025-TLD1	Bldg. 1010 beam stop 1	16.2	14.0	15.0	18.5	16 ± 4	64 ± 15
025-TLD4	Bldg. 1010 beam stop 4	16.9	13.9	13.7	18.9	16 ± 5	63 ± 20
027-TLD1	Bldg. 1002A South	17.0	14.0	13.0	15.8	15 ± 3	60 ± 14
027-TLD2	Bldg. 1002D East	15.3	15.5	13.9	14.7	15 ± 1	59 ± 6
030-TLD1	NE Firebreak	20.0	15.6	14.5	17.6	17 ± 5	68 ± 19
034-TLD1	Bldg. 1008 collimator 2	17.7	15.3	14.5	18.2	16 ± 4	66 ± 14
034-TLD2	Bldg. 1008 collimator 4	16.6	15.5	14.4	18.2	16 ± 3	65 ± 13
036-TLD1	Bldg. 1004B East	15.5	14.0	13.4	18.1	15 ± 4	61 ± 16
036-TLD2	Bldg. 1004 East	20.4	18.7	15.7	18.9	18 ± 4	74 ± 16
037-TLD1	S-13	15.8	13.6	14.0	17.0	15 ± 3	60 ± 13
043-TLD1	North access road	18.3	18.0	16.7	18.8	18 ± 2	72 ± 7
043-TLD2	North of Meteorology Tower	17.5	16.5	16.9	18.9	17 ± 2	70 ± 8

(continued on next page)

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

TLD#	Location	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Avg./Qtr. **± 2σ (95%)**	Annual Dose **± 2σ (95%)**
		(mrem)					
044-TLD1	Bldg. 1006	16.7	14.5	14.5	18.2	16 ± 4	64 ± 14
044-TLD2	South of Bldg. 1000E	18.0	15.8	14.8	18.1	17 ± 3	67±13
044-TLD3	South of Bldg. 1000P	16.0	13.9	13.1	17.7	15 ± 4	61±16
044-TLD4	NE of Bldg. 1000P	18.0	16.5	15.6	19.6	17 ± 3	70±14
044-TLD5	N of Bldg. 1000P	20.6	17.4	15.5	21.1	19 ± 5	75±21
045-TLD1	Bldg. 1005S	17.2	14.9	15.0	16.7	16 ± 2	64±9
045-TLD2	East of Bldg. 1005S	18.3	17.0	16.5	19.6	18 ± 3	71±11
045-TLD3	SE of Bldg. 1005 S	17.8	16.5	15.1	18.6	17 ± 3	68±12
045-TLD4	SW of Bldg. 1005 S	17.2	15.2	15.0	16.8	16 ± 2	64±9
045-TLD5	WSW of Bldg. 1005 S	16.0	14.2	13.7	14.7	15 ± 2	59±8
049-TLD1	East firebreak	16.7	14.4	14.6	16.4	16 ± 2	62±9
053-TLD1	West firebreak	17.9	17.7	16.5	19.6	18 ± 2	72±10
054- TLD1	Bldg. 914	21.5	16.6	L	17.7	19 ± 5	74±20
063-TLD1	West firebreak	18.4	17.3	17.3	21.9	19 ± 4	75±17
066-TLD1	Waste Management Facility	16.1	13.4	12.5	17.3	15 ± 4	59±17
073-TLD1	W Meteorology Tr. /Bldg. 51	17.9	16.8	18.0	17.8	18 ± 1	71±5
074-TLD1	Bldg. 560	17.9	17.4	16.1	19.2	18 ± 3	71±10
074-TLD2	Bldg. 907	17.7	16.1	14.9	16.1	16 ± 2	65±9
080-TDL1	East firebreak	19.4	17.3	16.7	20.0	18 ± 3	73±12
082-TLD1	West firebreak	21.2	17.5	17.9	21.0	19 ± 4	78±15
084-TLD1	Tennis courts	19.7	16.5	17.4	17.5	18 ± 3	71±11
085-TDL2	Upton gas station	18.3	17.1	15.3	18.9	17 ± 3	70±13
085-TLD1	TFCU (Credit Union)	19.3	NP	16.5	17.7	18 ± 3	71±11
086-TLD1	Baseball fields	21.1	18.7	18.2	22.3	20 ± 4	80±15
105-TLD1	South firebreak	19.7	17.1	18.3	20.3	19 ± 3	75±11
108-TLD1	Water tower	17.0	15.9	15.8	19.0	17 ± 3	68±12
111-TLD1	Trailer park	17.2	15.6	15.6	20.3	17 ± 4	69±17
122-TLD1	South firebreak	16.8	15.0	15.7	18.0	16 ± 3	65±10
126-TLD1	South gate	18.4	17.3	18.9	21.4	19 ± 3	76±14
P2		15.0	12.4	12.6	14.4	14 ± 3	54±10
P4		16.6	14.4	14.5	17.6	16 ± 3	63±12
P7		17.2	15.0	13.9	16.9	16 ± 3	63±12
S5		16.0	14.4	14.1	16.9	15 ± 3	61±11
On-site average		17.7	**15.7**	**15.3**	18.2	17 ± 3	67±12
Std. dev. (2 σ)		3.2	3.0	3.1	**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. +/- 2σ (95%)	Annual Dose +/- 2σ (95%)
		(mrem)					
000-TLD4	Private property	23.4	14.7	13.8	16.0	17 ± 9	68 ± 35
000-TLD5	Longwood Estate	16.0	14.5	13.9	16.5	15 ± 2	61 ± 10
000-TLD7	Mid-Island Game Farm	17.0	14.2	14.9	16.1	16 ± 2	62 ± 10
200-TLD2	Private property	18.6	16.7	NP	NP	18 ± 3	71 ± 10
300-TLD2	Private property	NP	NP	NP	NP		
300-TLD3	Private property	16.0	14.6	15.4	P	15 ± 1	61 ± 6
400-TLD1	Calverton Nat. Cemetery	17.7	15.7	16.6	17.9	17 ± 2	68 ± 8
500-TLD1	Private property	14.1	11.9	NP	NP	13 ± 3	52 ± 13
500-TLD2	Private property	15.5	13.4	14.1	16.4	15 ± 3	59 ± 11
500-TLD4	Private property	NP	15.2	16.0	18.3	16 ± 3	66 ± 12
600-TLD3	Sportsmen's Club	17.0	14.6	14.8	16.1	16 ± 2	63 ± 9
700-TLD2	Private property	NP	16.9	NP	NP	17 ± 0	
700-TLD3	Private property	18.5	15.3	15.3	18.4	17 ± 4	67 ± 14
700-TLD4	Private property	16.0	15.3	15.2	17.7	16 ± 2	64 ± 9
800-TLD1	Private property	NP	NP	14.6	16.8	16 ± 3	63 ± 12
800-TLD2	Private property	NP	NP	NP	NP		
800-TLD3	Suffolk County CD	17.2	15.3	15.3	18.8	17 ± 3	67 ± 13
999-TLD1	Private property	15.1	13.6	13.3	15.5	14 ± 2	57 ± 8
Off-site average		17.1	14.8	14.8	17.0	16 ± 2	64 ± **9**
Std. dev. (2 σ)		**4.5**	**2.5**	1.8	2.2		
075-TLD4	Control TLD average	**9.2**	**8.9**	**9.3**	**8.9**	**9.1** ± 0	36 ± 2

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

former Hazardous Waste Management Facility (HWMF). These TLDs measured slightly higher external dose than the typical natural background dose measured in other BNL areas. The slightly elevated external dose measured at the former HWMF can be attributed to the presence of small amounts of contamination in the soils after remediation began in 2004. As part of the CERCLA Program, all former HWMF buildings were demolished in 2003 and excavation of the contaminated soil was completed in 2005. Comparison of the 2005 dose rates with those from previous years clearly shows that dose rates have declined since the removal of the radioactive soil and are now slightly above natural background levels. The former HWMF is fenced, access is controlled, and only qualified staff members are allowed inside the facility. These values should decline further in 2006.

Two TLDs (075-TLD3 and 075-TLD5) posted near Building 356 showed higher quarterly averages, 22 ± 3 mrem (220 ± 30 μSv) and 23 ± 4 mrem (230 ± 40 μSv), respectively. The yearly doses were measured at 88 ± 10 mrem (880 ± 100 μSv) for 075-TLD3, and 92 ± 17 mrem (920 ± 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 measurements from Building 356 can be attributed to the "sky-shine" phenomenon and shielding of Building 356. Although individuals who use the parking lot outside this building could re-

Table 8-3. Facility Area Monitoring

TLD#	Location	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Avg./Qtr. +/- 2σ (95%)	Annual Dose +/- 2σ (95%)
		(mrem)					
054-TLD2	N/E of Bldg. 913-B	71.7	28.1	15.2	18.3	33 ± 51	133 ± 205
054-TLD3	N/W of Bldg. 913-B	35.9	15.1	14.1	16.7	20 ± 20	82 ± 81
S6		19.4	18.4	16.4	18.2	18 ± 2	72 ± 10
088-TLD1	HWMF-50' east of S-6	22.3	19.2	18.8	18.9	20 ± 3	79 ± 13
088-TLD2	HWMF-50' west of S-6	20.8	22.5	20.6	19.6	21 ± 2	84 ± 10
088-TLD3	HWMF-100' west of S-6	25.2	20.2	20.3	21.4	22 ± 5	87 ± 19
088-TLD4	HWMF-150' west of S-6	20.0	17.7	17.8	19.7	19 ± 2	75 ± 10
075-TLD3	Bldg. 356	22.0	21.9	20.6	23.7	22 ± 3	88 ± 10
075-TLD5	North Corner of Bldg. 356	23.7	21.0	21.7	25.7	23 ± 4	92 ± 17

Notes:
See Figure 8-1 for TLD locations.
HWMF = Hazardous Waste Management Facility

ceive a dose from this source, the dose would be minimal, due to the fact that an individual would most likely spend limited time in the parking lot.

Two TLDs placed on the fence northeast and northwest of Building 913-B (the AGS Tunnel Access) also showed higher than normal ambient external dose. The 054-TLD2 located on the northeast side of Building 913-B showed higher dose in the first quarter (71.7 mrem, or 717µSv) and the second quarter (28.1 mrem, or 281 µSv). The northwest TLD (054-TLD3) showed higher dose only in the first quarter (35.9 mrem, or 359 µSv). The potential cause of the higher doses during the first and second quarter is associated with skyshine phenomenon from heavy ions and polarized protons during the initial startup of the Alternating Gradient Synchrotron (AGS).

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 monitoring and requirements for reporting the 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 are also discussed in detail in Chapter 4.

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 monitored and assessed for any potential to release radioactive materials, and to determine their dose contribution, if any, to the environment. In 2005, new processes or activities were 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 all radioactive emission sources as continuous over the course of a year,

Table 8-4. MEI 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	1.60E-15	(b)
490	Medical Research	BNL-489-01	8.37E-9	(b)
490A	Energy and Environment National Security	None	1.21E-15	(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	6.84E-16	(b)
750	High Flux Beam Reactor	None	1.16E-4	(c)
801	Target Processing Lab	None	1.19E-6	(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	5.27E-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			**5.28E-2**	
EPA Limit			10.0 mrem	

Notes:
Diffuse, Fugitive, and Other sources are not included in this table since they are short-term emissions.
MEI = Maximally Exposed Individual
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 2005.
(e) NO = Not operational in 2005.
(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.

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 software, the Clean Air Act Assessment Package-1988 (CAP88-PC), Version 2.10. 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 effective dose equivalent (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 purposes of modeling the dose to the MEI, all 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 the environmental releases and are based 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 BNL's meteorological tower, which includes 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 of time, these residents are also 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. 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 contaminated fish and deer containing radioactivity attributable to BNL 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.

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, Version 2.10 dose model program. 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/year) 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 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 approximately 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 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/year) = ***intake*** (kg/year) × ***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 pounds of deer meat ingested during the course of a year was 64 pounds (29 kg) per year (NYSDOH 1999).

8.3 DIFFUSE, FUGITIVE, AND OTHER DOSES

Diffuse sources are described as emissions of radioactive contaminants to the atmosphere that do not have a well-defined emission point, such as a stack. Such sources are also known as non-point or area sources. Fugitive sources include releases to the air that are not released through an actively ventilated air stream (i.e., leaks from vents). The following potential radiological remediation/diffuse sources were evaluated in 2005 for potential contribution to the overall site dose.

8.3.1 Laser Electron Stripping Experiment

A NESHAPs compliance review was performed of the 200 MeV laser electron stripping experiment conducted in the Radiation Effects Facility (REF), Building 937. The source term was based on the production rate of 0.2 thermal and fast neutrons per proton. The proton energy was at 200 MeV with a beam intensity of 1.85E10 protons per second. The REF tunnel is equipped with a 255-cfm fan that vents to the outside via a 2-meter-high stack with a 6-inch inner diameter. A HEPA filtration system was used to prevent the release of any particulate radioactivity to the environment.

The laser electron stripping experiment was scheduled for 3 weeks and operated for 20 hours per week. The principal radionuclides, from an environmental risk and dose compliance perspective, were carbon-11 (C-11, $T_{1/2}$ = 20 min, β^+), nitrogen-13 (N-13, $T_{1/2}$ = 10 min, β^+), oxygen-15 (O-15, $T_{1/2}$ = 2 min, β^+), fluorine-18 (F-18, $T_{1/2}$ = 110 min, β^+), and argon-41 (Ar-41, $T_{1/2}$ = 1.8 hr, β/γ). It was determined that the REF facility was in compliance with the NESHAPs regulations for emissions during the laser stripping experiment. The effective dose equivalent to the MEI was calculated to be 3.24E-07 mrem (3.24 pSv) in a year at the southeast location.

8.3.2 Alternating Gradient Synchrotron Tritium Production

The AGS Snake Magnet is pre-cooled with liquid nitrogen for up to approximately 10 days and then switched over to the helium cooling system. The potential for tritium production in the liquid helium was evaluated in 2004 and the AGS facility was found to be compliant with NESHAPs regulations for fugitive losses of the tritium. However, the scatter and absorption interactions of protons lost from the high-energy polarized beam can produce secondary and tertiary hadrons, which potentially could interact with the liquid nitrogen used to pre-cool the AGS Snake Magnet. Therefore, a NESHAPs compliance review was completed to estimate the production of nitrogen isotopes and their emissions during pre-cooling of the magnet.

Trace amounts of H-3 and Be-7 are produced in the liquid nitrogen during the beam operations and were considered in this risk/dose assessment. Although trace amounts of C-11 and N-13 are also produced in the liquid nitrogen, due to their very low concentrations and short half-lives the fugitive losses to the environment were considered insignificant. The dose assessment showed that the EDE to the MEI from the H-3 and Be-7 emissions in the northwest direction was 9.88E-7 mrem (9.88 pSv) in a year. While there was no dose risk to members of the public, there was potential for radiological hazard to workers from immersion dose in the immediate vicinity of the AGS Ring. Only trained personnel have access to the area.

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 DOE 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 water recirculating in a 16-inch-diameter shaft. The principal gaseous radionuclides produced as a result of activation of the cooling water are O-15 and C-11. Because the BLIP facility has the potential to exceed one percent of the DOE 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 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 weekly sample collection and analyses.

In 2005, the BLIP facility operated over a period of 17 weeks. During the year, 816 Ci of C-11 and 2,432 Ci of O-15 were released from the BLIP facility. Tritiated water vapor (5.16E-02 Ci) was also released, due to activation of the targets' cooling water. The annual EDE to the MEI from BLIP operations was calculated to be 5.30E-02 mrem (0.53 µSv).

An analysis of the past 3 years' of BLIP operating data and the real-time emissions data collected to date shows that BLIP emissions have been effectively reduced by approximately 30 percent since the installation of a sealed Lucite cover to enclose the cooling water surface, the source of most BLIP emissions. Tests completed in March 2005 with the sealed enclosure opened and then closed showed a decrease of 34 percent in emission activity at 72 micro-amps and 117 MeV energy. Additionally, while the total micro-amp-hours of operation increased by 155 percent in 2005 from the 2004 level, the EDE to the MEI increased only 20 percent, due to the effectiveness of the enclosure.

8.4.2 Brookhaven Medical Research Reactor

In 2005, the Brookhaven Medical Research Reactor (BMRR) facility was in a cold-shutdown mode and was downgraded from a nuclear facility to a radiological facility. During the year, the primary cooling water (1,850 gallons), Janus plates, control rod blades, activated hydraulic fluid from the shutters, and condensate from air handlers were shipped off site. Regular inspections of the decommissioned facility are conducted to ensure that safety and security aspects are intact and in compliance.

8.4.3 Unplanned Releases

There were no unplanned releases in 2005.

8.5 DOSE FROM INGESTION

Deer and fish bioaccumulate radionuclides in their tissues and organs, and therefore samples are 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 were used to assess the potential dose impact to the MEI. Eleven samples of deer meat (flesh) were used to calculate the "off site and less than 1 mile" average for the purpose of dose calculations. Potassium-K (K-40) and Cs-137 were the two radionuclides detected in the tissue samples. K-40 is a naturally occurring radionuclide and is not related to BNL operations. The average K-40 concentrations were 3.9 ± 1.1 pCi/g (wet weight) in the flesh and 2.8 ± 0.9 pCi/g (wet weight) in the liver. The average Cs-137 concentrations were 0.8 ± 0.3 pCi/g (wet weight) in the flesh and 0.3 ±0.1 pCi/g (wet weight) in the liver ("off site and less than 1 mile average," from Table 6-2). The potential dose from consuming deer meat with the average Cs-137 concentration was estimated as 0.32 mrem (3.2 µSv) in a year. This is 3 percent of the health advisory limit of 10 mrem (100 µSv) established by NYSDOH.

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 2005, the chain pickerel samples collected in the Peconic River on the BNL site had the highest concentration (0.22 pCi/g) of Cs-137, so this value was used to estimate the EDE to the MEI (assuming consumption of 15 pounds of fish). The potential dose from consuming fish was estimated at 0.08 mrem (0.8 µSv) in a year. It is highly unlikely that an individual would consume fish with the highest concentration and from this location, but

Table 8-5. BNL Site Dose Summary for 2005.

Pathway	Dose to Maximally Exposed Individual	Percent of DOE 100 mrem/year Limit	Estimated Population Dose per year
Inhalation			
Air	0.053 mrem (0.53 µSv)	<1%	0.19 person-rem
Ingestion			
Drinking water	None	None	None
Fish	0.08 mrem (0.8 µSv)	<1%	Not tracked
Deer Meat	0.32 mrem (3.2 µSv)	<1%	Not tracked
All Pathways	0.45 mrem (4.5 µSv)	<1%	0.19 person-rem

these data were used to estimate potential maximum dose as a worst-case scenario for the MEI.

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 environmental surveillance data. The RESRAD-BIOTA 1.0 biota dose screening 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 proposed Rule 10 CFR 834, Subpart F (66 FR 25380). The terrestrial animal and plant doses were evaluated based on 0.82 pCi/L of strontium-90 (Sr-90) in surface waters at the HM-N sampling location on the Peconic River (see Figure 5-8 for sampling stations). Soil samples were not collected this year due to a graded approach used for soil sampling (see Chapter 6 for more information). The dose to terrestrial animals was based on the surface water concentrations and calculated to be 1.62E-08 Gy/day and 3.95E-10 Gy/day to terrestrial plants. The doses to terrestrial animals and plants were well below the biota dose limit of 1 mGy/day.

For calculating dose to aquatic animals, radionuclide concentration values from the HM-N location on the Peconic River were used and both the surface water and sediment samples came from the same location. The Cs-137 sediment concentration was 103 Bq/L, and the Sr-90 concentration in surface water was 0. 03 Bq/L. The aquatic animal dose was estimated to be 7.16E-07 Gy/day; and to riparian animals, the estimated dose was 3.79E-06 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. The total dose to the MEI from air and ingestion pathways was estimated to be 0.45 mrem (4.5 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 effective dose was well below the DOE and EPA regulatory limits, and the ambient TLD dose was within normal background levels seen at the BNL 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 and not 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 5 to 20 mrem (50–200 µSv) per exposure. Using natural gas in homes yields about 9 mrem (90 µSv) 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 conservative estimates of dose from the air pathway and ingestion of local deer meat and fish, the cumulative dose from BNL operations was well below the dose that could be received from a single chest x-ray.

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Quality Assurance

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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. 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 2005 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 Volume 10 of the Code of Federal Regulations, Section 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 BNL 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, legal requirements, and stakeholder concerns. An environmental monitoring plan or project-specific sampling plan is then prepared, specifying

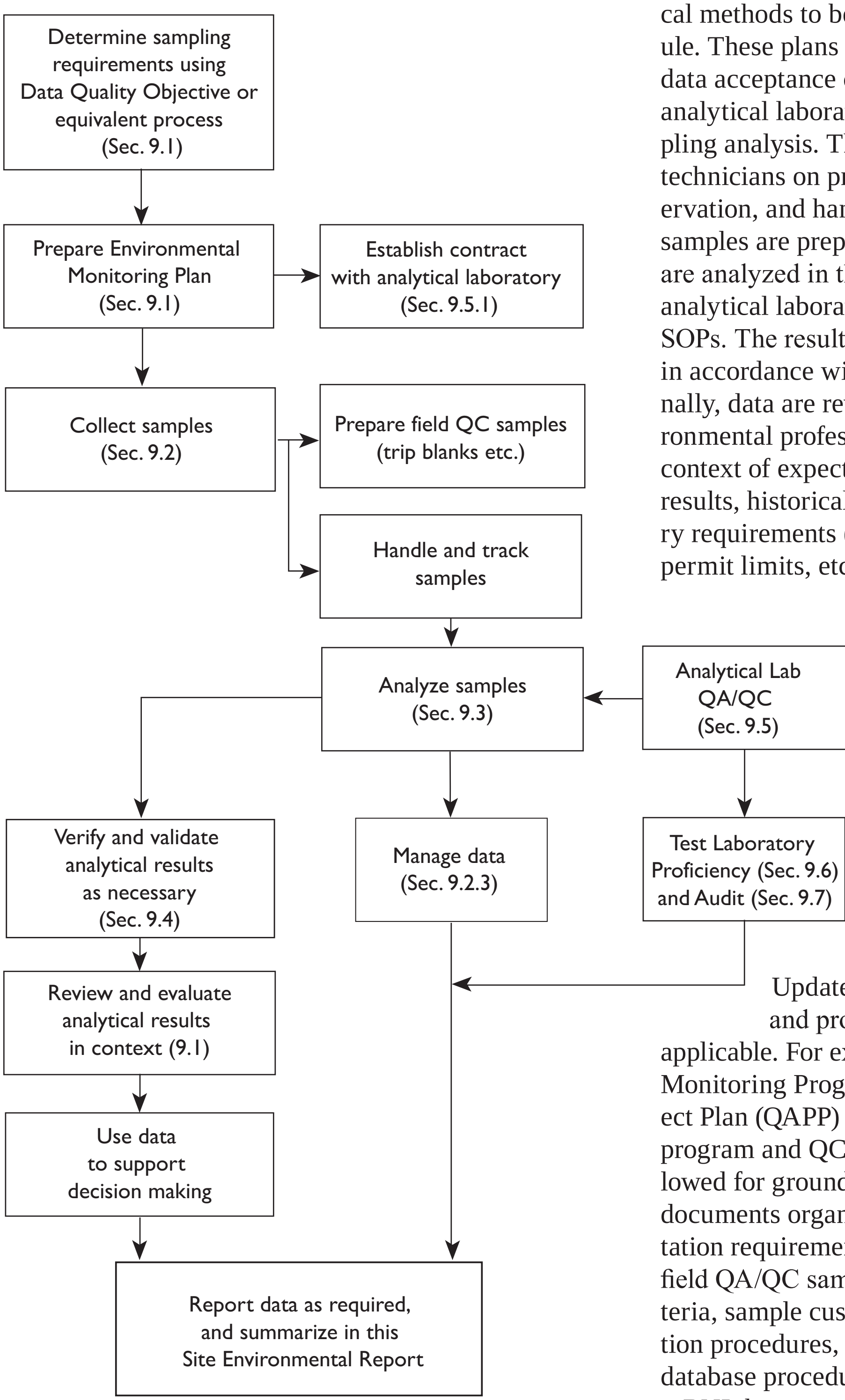


Figure 9-1. Flow of Environmental Monitoring QA/QC Program Elements.

the location, frequency, type of sample, analytical methods to be used, and a sampling schedule. These plans and the EM-SOPs also specify data acceptance criteria. Contracts with off-site analytical laboratories are established for sampling analysis. The EM-SOPs direct sampling technicians on proper sample collection, preservation, and handling requirements. Field QC samples are prepared as necessary. 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 2005, environmental monitoring samples were collected as specified by EM-SOPs, the BNL Environmental Monitoring Plan Update January 2005 (BNL 2005), and project-specific work plans, as applicable. For example, the BNL Groundwater Monitoring Program Quality Assurance Project Plan (QAPP) (BNL 1999) describes the QA program and QC requirements that must be followed for groundwater monitoring. This plan documents organizational structure, documentation requirements, sampling requirements, field QA/QC sample collection, acceptance criteria, sample custody requirements, data validation procedures, and general data handling and database procedures.

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 BNL 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 2005. 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 2003). All environmental monitoring samples in 2005 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.

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 methylmercury 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.

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 2005.

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 nondedicated or reusable sampling equipment.

A ***trip blank*** is provided with each shipping container of samples to be analyzed for volatile organic compounds (VOCs). Analysis of trip blanks shows whether a sample bottle was contaminated 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 2005.

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 the groundwater samples. For other programs, the frequency of field blank collection is based on their specific DQOs.

In 2005 (as in other years), the most common contaminants detected in the trip, field, and equipment blanks included methylene 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 2005 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 2001). 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 2005, 111 duplicate samples were collected for nonradiological analyses, and 123 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 7,630 nonradiological parameters analyzed in 2005, 99.7 percent of the analyses met QA criteria. Of the 982 radiological parameters monitored, 97.9 percent met QA criteria. These results indicate consistency between the contract analytical laboratory and field sampling technicians.

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 2005 for routine matrices such as water and soil. Nonroutine 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. The 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 BNL's 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 provided 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 2005, environmental samples were analyzed by one of five 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 2005:

- General Engineering Lab (GEL) in Charleston, South Carolina, for radiological and nonradiological analytes
- H2M Lab in Melville, New York, for nonradiological analytes
- Severn-Trent Lab (STL), 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

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 2005 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, as per the BNL Groundwater Monitoring Program Quality Assurance Project Plan (BNL 1999), a significant portion of the groundwater samples analyzed for environmental restoration projects underwent data validation in addition to verification.

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 initial investigations 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 2005 were verified and/or validated, when project DQOs required, using BNL EM-SOPs in the 200 Series and EPA contract laboratory program guidelines (EPA 1992, 2001). Radiological packages were verified and validated using BNL and DOE guidance documents (BNL 2002, DOE 1994). During 2005, the verifications were conducted using a combination of manually checking the hard copy data packages and the use of a computer program developed at BNL to verify the information reported electronically and stored in the EIMS.

9.5 CONTRACT ANALYTICAL LABORATORY QA/QC

In 2005, 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

Four of the contract analytical laboratories (GEL, STL, H2M, and Brooks Rand) participated in several national and state PE testing programs in 2005. The fifth contractor, Chemtex Laboratory, 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 National Voluntary Laboratory Accreditation Program, the voluntary Mixed Analyte Performance Evaluation Program (MAPEP), 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 methyl mercury, their PE results are not summarized. Brooks Rand maintained the required certification when performing analyses for BNL in 2005.

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, rather than BNL.

Figure 9-2 summarizes radiological performance scores in the ERA and MAPEP programs. During 2005, the New York State ELAP did not provide radiological samples for PE testing, so there were no ELAP scores as there have been in past years. GEL and STL had average overall satisfactory scores of 98 and 88 percent, respectively. More details about the radiological assessments are in Section 9.6.2.1.

Figure 9-3 summarizes the nonradiological performance results of the three participating laboratories (GEL, H2M, and STL) in the ERA, MAPEP, and ELAP tests. For nonradiological tests, the average overall satisfactory results ranged from 93.1 to 99.4 percent. Additional details on nonradiological evaluations are in Section 9.6.2.2.

9.6.2.1 Radiological Assessments

In 2005, STL participated in the ERA radiological program and the MAPEP evaluations of mixed analytes. GEL participated in the ERA and MAPEP programs. The NYSDOH Environmental Laboratory Accreditation Program (ELAP) provided no samples for radiological testing in 2005.

Both GEL and STL participated in the ERA radiological PE studies. 100 percent of GEL's tests on radiological samples were in the acceptable range; 84.6 percent of STL's tests were acceptable. Both GEL and STL participated in the MAPEP evaluations. 97.0 percent of GEL's tests on radiological samples were in the acceptable range, as were 92.3 percent of STL's tests.

9.6.2.2 Nonradiological Assessments

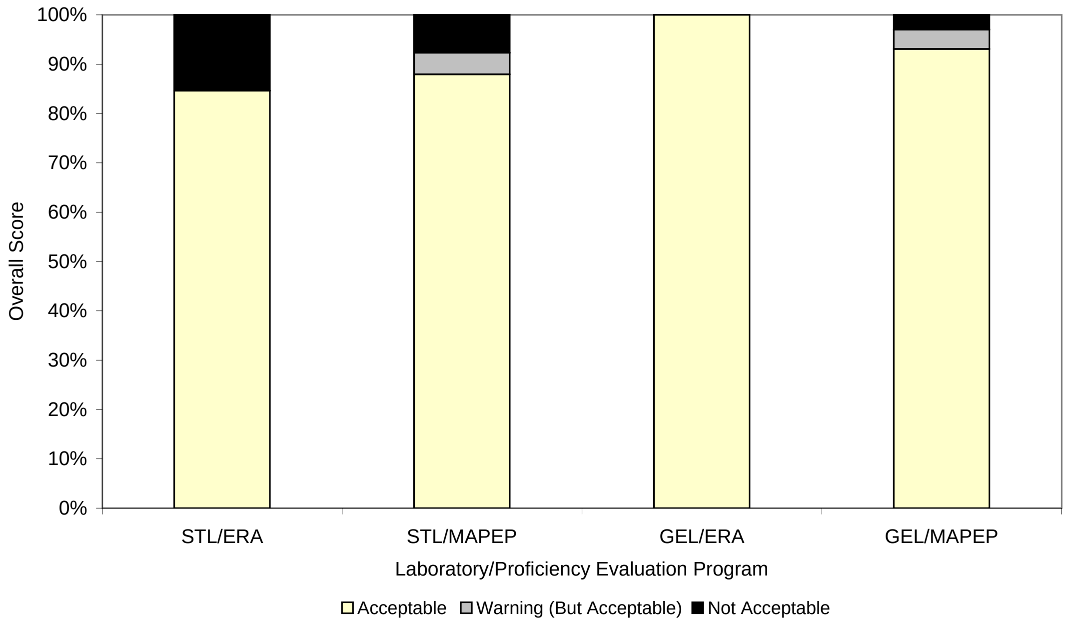
During 2005, H2M and GEL participated in the NYSDOH ELAP evaluations of performance on tests of nonpotable water, potable water, and solid wastes. NYSDOH found 99.8 percent of H2M's nonradiological tests to be in the acceptable range and 93.1 percent of GEL's nonradiological tests to be in the acceptable range. STL, which is certified through the National Environmental Laboratory Accreditation Conference (NELAC), was not required to participate in ELAP evaluations.

H2M, STL 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 98.9 percent of H2M's tests were in the acceptable range and 96.6 percent of STL's tests were in the acceptable range, as were 90.1 percent of GEL's tests.

GEL and STL also voluntarily participated in MAPEP evaluations. These evaluations showed that 97.0 percent of GEL's nonradiological tests were in the acceptable range, as were 95.9 percent of STL's tests.

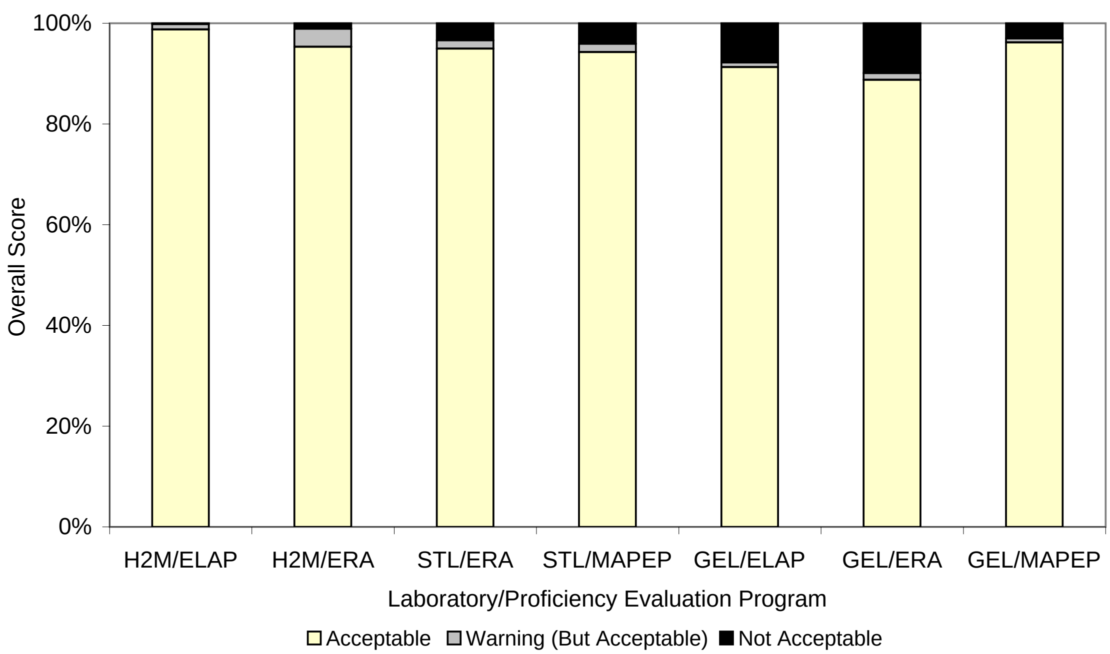
9.7 AUDITS

As part of DOE's Integrated Contract Procurement Team Program, STL and GEL were audited during 2005 (DOE 2005a, b). 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



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.

indicate that the contract analytical laboratory cannot adequately perform services for DOE (DOE 2002). There were no Priority I findings for STL and GEL.

The results of the STL audit included 15 Priority II findings: two radiological findings, five QA management system findings, seven waste management findings, and one organic finding.

The results of the GEL audit included two Priority II findings: one organic finding and one inorganic finding. Corrective action plans were submitted to DOE by both contract analytical laboratories to document that procedures were put in place to correct these findings. 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 2005 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.

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
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
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
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
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
EPA*	U.S. Environmental Protection Agency
EPCRA*	Emergency Planning and Community Right-to-Know Act
ER	environmental restoration
ERA	Environmental Resource Associates
ERD	Environmental Restoration Division
ES*	environmental surveillance

ES&H	environment, safety, and health
ESA*	Endangered Species Act
ESH&Q	Environment, Safety, Health, and Quality Directorate
ESSH	Environmental Safety, Security and Health
EWMSD	Environmental and Waste Management Services Division
FFCA*	Federal Facilities Compliance Act
FIFRA*	Federal Insecticide, Fungicide, and Rodenticide Act
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
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
Linac	Linear Accelerator
LIPA	Long Island Power Authority
LSTPD	Laboratory Science Teacher Professional Development
MACT	Maximum Available Control Technology
MAPEP	Mixed Analyte Performance Evaluation Program
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

NT not tested
NYCRR* New York Codes, Rules, and Regulations
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
ODS ozone-depleting substances
OMC Occupational Medical Clinic
ORC oxygen-releasing compound
ORPS* Occurrence Reporting and Processing System
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
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
RCRA* Resource Conservation and Recovery Act
RF resuspension factor
RHIC Relativistic Heavy Ion Collider
ROD* Record of Decision
RPD relative percent difference
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
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
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
TCE* trichloroethylene
TCLP toxicity characteristic leaching procedure
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
WCPP Waste Certification Program Plan
WCF Waste Concentration Facility
WET Whole Effluent Toxicity
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. (*source:* http://www.cr.nps.gov/linklaws.htm, accessed 3-7-05)

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 @ http://www.epa.gov/oar/oaqps/peg_caa, 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. (*source*: EPA web site http://www.epa.gov/superfund/action/law/cercla.htm, 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." The CFR is available online at http://www.gpoaccess.gov/cfr/index.html (acessed 3-7-05).

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. (*source*: http://www.epa.gov/region5/water/cwa.htm, 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. It can be found at http://www.directives.doe.gov (accessed 3/7/05).

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. It can be found at http://www.directives.doe.gov (accessed 3/7/05).

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. It can be found at http://www.directives.doe.gov (accessed 3/7/05).

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. (*source*: http://www.epa.gov/region5/defs/html/epcra.htm, accessed 3-7-05)

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. (*source*: http://www.epa.gov/region5/defs/html/esa.htm, accessed 3-7-05)

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. (*source:* http://tis.eh.doe.gov/oepa/laws/ffca.html, accessed 3-7-05)

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. (*source*: http://www.epa.gov/region5/defs/html/fifra.htm, accessed 3-7-05)

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. (*source:* http://northeast.fws.gov/ameel/petition.html, accessed 3/7/05)

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). (*source*: http://www.epa.gov/region5/defs/html/nepa.htm, accessed 3-7-05)

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. (*source*: www.epa.gov/radiation/neshaps, accessed 3-7-05)

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." (*source*: http://www.achp.gov/overview.html, accessed 3-7-05)

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. (*source*: http://www.epa.gov/owow/nps, accessed 3-7-05)

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. (*source:* http://tis.eh.doe.gov, accessed 3-24-04)

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. (*source*: http://www.epa.gov/region5/defs/html/rcra.htm, accessed 3-7-05)

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. (*source:* http://www.epa.gov/region5/defs/html/sara.htm, accessed 3-7-05)

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. (*source*: http://www.epa.gov/region5/defs/html/sdwa.htm, accessed 3-7-05)

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**. (*source*: www.dec.state.ny.us/website/dcs/spdes/spdes02.html, accessed 3-7-05)

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. (*source*: http://www.epa.gov/region5/defs/html/tsca.htm, accessed 3-7-05)

TVOC (total volatile organic compounds) – A sum of all individual **VOC** concentrations detected in a given sample.

U

UIC (underground injection control) – A hole with vertical dimensions greater than its largest horizontal dimensions; used for disposal of wastewater.

UST (underground storage tank) – A stationary device, constructed primarily of nonearthen material, designed to contain petroleum products or hazardous materials. In a UST, 10 percent or more of the volume of the tank system is below the surface of the ground.

upgradient/upslope – A location of higher **groundwater** elevation; analogous to "upstream."

V

vadose – Relating to water in the ground that is above the permanent groundwater level.

vernal pool – A small, isolated, and contained basin that holds water on a temporary basis, most commonly during winter and spring. It has no aboveground outlet for water and is extremely important to the life cycle of many amphibians (such as the tiger salamander), as it is too shallow to support fish, a major predator of amphibian larvae.

VOC (volatile organic compound) –A general term for organic compounds capable of a high degree of vaporization at standard temperature and pressure. Because VOCs readily evaporate into the air, the potential for human exposure is greatly increased. Due to widespread industrial use, VOCs are commonly found in soil and groundwater.

VUV – Stands for "very ultraviolet" and refers to a beamline at the NSLS with wavelengths at the far ultraviolet end of the spectrum.

W

waste minimization – Action that avoids or reduces the generation of waste, consistent with the general goal of minimizing current and future threats to human health, safety, and the environment. Waste minimization activities include recycling, improving energy usage, reducing waste at the source, and reducing the toxicity of hazardous waste. This action is associated with pollution prevention, but is more likely to occur after waste has been generated.

water table – The water-level surface below the ground where the unsaturated zone ends and the saturated zone begins. It is the level to which a well that is screened in the unconfined aquifer will fill with water.

watershed – The region draining into a river, a river system, or a body of water.

weighting factor – A factor which, when multiplied by the dose equivalent delivered to a body organ or tissue, yields the equivalent risk due to a uniform radiation exposure of the whole body. *See also* **EDE**.

wet weight – The wet weight concentration of a substance is before a sample is dried for analysis (in other words, in its "natural" state), and is the form most likely to be consumed. Wet weight concentrations are typically lower than dry weight values.

wind rose – A diagram that shows the frequency of wind from different directions at a specific location.

X

x-rays – A form of electromagnetic **radiation** with short wavelength, generated when high-energy electrons strike matter or when lower-energy **beta** radiation is absorbed in matter. **Gamma** radiation and x-rays are identical, except for the source.

Z

zeolite – A naturally occurring group of more than 100 minerals, formed of silicates and aluminum, with unique and diverse crystal properties. Zeolites can perform ion exchange, filtering, odor removal, and chemical sieve and gas absorption tasks. Synthetic zeolites are now used for most applications.

Understanding Radiation

This section introduces the general reader to some basic concepts of radioactivity and an understanding of the radiation emitted as radioactive materials decay to a stable state. To better comprehend the radiological information in the Site Environmental Report (SER) it, is important to remember that not all radiations are the same and that different kinds of radiation affect living beings differently.

This appendix includes discussions on the common sources of radioactivity in the environment, types of radiation, the analyses used to quantify radioactive material, and how radiation sources contribute to radiation dose. Some general statistical concepts are also presented, along with a discussion of radionuclides that are of environmental interest at 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 in 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

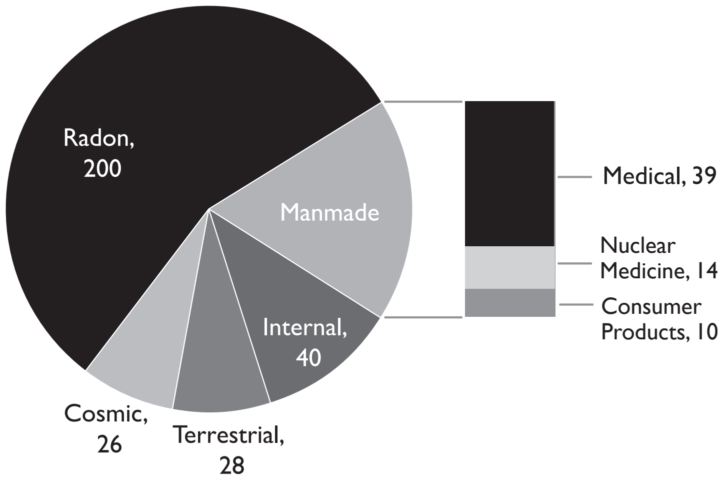

Figure B-1. Typical Annual Radiation Doses from Natural and Man-Made Sources (mrem). *Source: NCRP Report No. 93 (NCRP 1987)*

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 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, because 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 by-product of reactor operations. The following areas with Sr-90 contamination have been or are being addressed as part of the Environmental Remediation Program: former Hazardous Waste Management Facility, Waste Concentration Facility, Building 650 Reclamation Facility and Sump Outfall Area, the BGRR, Former and Interim Landfills, Chemical and Glass Holes Area, and the STP.

The information in SER tables is arranged by method of analysis. Because Sr-90 requires a unique method of analysis, it is reported as a separate entry. Methods for detecting Sr-90 using state-of-the-art equipment are quite sensitive (detecting concentrations less than 1 pCi/L), which makes it possible to detect background levels of Sr-90.

Tritium – Among the radioactive materials that are used or produced at BNL, tritium has received the most public attention. Approximately 4 million Ci (1.5E+5 TBq) per year are produced in the atmosphere naturally (NCRP 1979). As a result aboveground weapons testing in the 1950s and early 1960s in the United

States, the global atmospheric tritium inventory was increased by a factor of about 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 the 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 (BLIP), where tritium is formed from secondary radiation interaction with cooling water. Tritium has been found in the environment at BNL as a groundwater contaminant from operations in the following areas: Current Landfill, BLIP, Alternating Gradient Synchrotron, and the High Flux Beam Reactor. Although small quantities of tritium are still being released to the environment through BNL emissions and effluents, the concentrations and total quantity have been drastically reduced, compared with historical operational releases as discussed in Chapters 4 and 5.

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Units of Measure and Half-Life Periods

UNITS OF RADIATION MEASUREMENT AND CONVERSIONS

U.S. System	International System	Conversion
curie (Ci)	becquerel (Bq)	1 Ci = 3.7 x 10^{10} Bq
rad	gray (Gy)	1 rad = 0.01 Gy
rem	sievert (Sv)	1 rem = 0.01 Sv

APPROXIMATE METRIC CONVERSIONS

When you know	multiply by	to obtain	When you know	multiply by	to obtain
centimeters (cm)	0.39	inches (in.)	in.	2.54	cm
meters (m)	3.28	feet (ft)	ft	0.305	m
kilometers (km)	0.62	miles (mi)	mi	1.61	km
kilograms (kg)	2.20	pounds (lb)	lb	0.45	kg
liters (L)	0.264	gallons (gal)	gal	3.785	L
cubic meters (m^3)	35.32	cubic feet (ft^3)	ft^3	0.03	m^3
hectares (ha)	2.47	acres	acres	0.40	ha
square kilometers (km^2)	0.39	square miles (mi^2)	mi^2	2.59	km^2
degrees Celcius (°C)	1.8 (°C) + 32	degrees Fahrenheit (°F)	°F	(°F - 32) / 1.8	°C

SCIENTIFIC NOTATION USED FOR MEASUREMENTS

Multiple	Decimal Equivalent	Notation	Prefix	Symbol
1 x 10^{12}	1,000,000,000,000	E+12	Tera-	T
1 x 10^{9}	1,000,000,000	E+9	giga-	G
1 x 10^{3}	1,000	E+03	kilo-	k
1 x 10^{-2}	0.01	E-02	centi-	c
1 x 10^{-3}	0.001	E-03	milli-	m
1 x 10^{-6}	0.000001	E-06	micro-	µ
1 x 10^{-9}	0.000000001	E-09	nano-	n
1 x 10^{-12}	0.000000000001	E-12	pico-	p

CONCENTRATION CONVERSIONS

1 ppm	=	1,000 ppb		
1 ppb	=	0.001 ppm	=	1 µg/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

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 435.1	Order, Change 1: Radioactive Waste Management 08/28/2001
DOE O 450.1	Order: Environmental Protection Program 01/15/2003
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

Executive Order 13148 Greening of the Government Through Leadership in Environmental Management

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 …NPDES
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… Facilities
40 CFR 265	Interim … Standards for … Owners and Operators of Hazardous Waste … Facilities
40 CFR 266	Standards for the Management of Special 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 … Required for …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 & 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 … 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: Reg. Solid Waste Management Facility
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 Systems and … Standards for Generators… 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 & Procedures in Petroleum Cleanup & 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	Regulations for … the Wild, Scenic, and Recreational Rivers System in NYS…
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

2005 Site Environmental Report Reader Response Form

The 2005 Site Environmental Report (SER) was written to inform outside regulators, the public, and BNL employees of the Laboratory's environmental performance for the calendar year. The report summarizes BNL's on-site environmental data; environmental management performance; compliance with applicable regulations; and environmental, restoration, and surveillance monitoring programs.

BNL welcomes your comments, suggestions for improvements, or any questions you may have. Please fill in the information below, and mail your response form to:

Brookhaven National Laboratory
Environmental and Waste Management Services Division
Attention: SER Project Coordinator
Building 120
P.O. Box 5000
Upton, NY 11973-5000

Name ______________________________

Address ______________________________

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Phone ______________________________

Email ______________________________

Comments, Suggestions, or Questions

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☐ I would like to be added to your Environmental Issues mailing list.

BROOKHAVEN NATIONAL LABORATORY

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