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2003

SITE ENVIRONMENTAL REPORT

Brookhaven National Laboratory

A MESSAGE FROM THE LABORATORY DIRECTOR

As Director of Brookhaven National Laboratory (BNL), I expect nothing less than excellence from our employees and visiting researchers, in terms of the science carried out here, our support operations, and in our role as responsible stewards of the environment. One of BNL's highest priorities is ensuring that the Laboratory's environmental performance measures up to its world-class status in science. The Laboratory's motto, "Exploring Life's Mysteries…Protecting its Future," reflects BNL's management philosophy to fully integrate environmental stewardship into all facets of its missions and operations.

In 2001, BNL became the first DOE Office of Science, and the first Long Island-based organization, to achieve third-party registration to the internationally-recognized ISO 14001 Environmental Standard. In 2003, the Laboratory continued to demonstrate environmental leadership across the Department of Energy (DOE) complex by having our Environmental Management System (EMS) recertified to the ISO 14001 standard after undergoing a rigorous surveillance audit to confirm that BNL's EMS is being maintained and to document evidence of continued improvement.

BNL's strong Pollution Prevention (P2) Program continues to be a success. To date, pollution prevention projects instituted since 1999 have saved more than $1.5 million and have resulted in the reduction, recycling, or reuse of approximately 2.3 million pounds of industrial, sanitary, hazardous, and radioactive waste. In 2003, 19 pollution prevention proposals were submitted by scientific staff. Approximately $96,000 was invested in eight new projects, with an anticipated annual savings of $88,000 and an average payback period of 1.2 years. Energy improvements in buildings and ongoing conservation efforts continue to save money for the Laboratory.

Under the Laboratory's Environmental Management Program, cleaning up soil and groundwater contamination and preventing additional contamination from moving off site is a primary goal. Since the beginning of active groundwater cleanup activities in December 1996, BNL has removed 4,156 pounds of chemicals from the aquifer, treating nearly 6.8 billion gallons of groundwater. During 2003, seven groundwater remediation systems removed 510 pounds of chemicals and returned approximately 1.3 billion gallons of treated water to the Upper Glacial Aquifer.

The Upton Ecological and Research Reserve continues to produce new ecological data each year. Highlights for 2003 include the discovery of the redbellied snake, a species not seen on Long Island in more than 60 years, and research into the orange striped oakworm, a species capable of decimating the abundant oak forests that make up much of the Long Island ecosystem. Also in 2003, working with the Reserve's Technical Advisory Group, regulatory agencies, and other stakeholders, BNL developed a comprehensive, ecosystem-based Natural Resource Management Plan and approved funding for several research projects.

It is important that the Laboratory maintain stakeholder trust, and we will continue to deliver on our commitments and demonstrate real improvements in environmental performance. The annual publication of the Site Environmental Report is one of many ways the Laboratory keeps our neighbors, regulators, employees, and other interested parties informed about environmental issues and progress at BNL.

Praveen Chaudhari
Laboratory Director

Executive Summary

The 2003 Site Environmental Report (SER) was prepared to inform regulators, the public, Laboratory employees, and other stakeholders of Brookhaven National Laboratory's (BNL's) environmental performance for the calendar year. The report was prepared in accordance with Department of Energy (DOE) Order 231.1, Environment, Safety and Health Reporting, and summarizes BNL's performance in the areas of environmental management, environmental impacts, compliance with applicable regulations, surveillance monitoring, and restoration. A summary of the report is available as a separate document that provides a general overview of BNL's performance for 2003 and includes a CD version of the full report. The report and the summary are also available on the BNL web page at http://www.bnl.ser.htm.

BNL is operated and managed for DOE's Office of Science by Brookhaven Science Associates, a limited-liability company founded by Stony Brook University, and Battelle Memorial Institute, a nonprofit, applied science and technology organization. For more than 50 years, BNL 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. BNL's motto, "Exploring Life's Mysteries…Protecting its Future," reflects BNL's management philosophy to fully integrate environmental stewardship into all facets of its missions and operations.

Brief descriptions of Laboratory facilities, ecological resources, demographics, and history are provided in Chapter 1 of this report.

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 BNL ensuring that environmental issues are systematically identified, controlled, and monitored. It also provides mechanisms for responding to changing environmental conditions and requirements, reporting on environmental performance, and reinforcing continual environmental 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. BNL was the first U.S. DOE Office of Science Laboratory to become officially registered to this standard. Annual audits, which are required to maintain the registration, are conducted to validate that BNL's EMS is being maintained and to identify evidence of continual improvement. In 2003, an EMS Surveillance Audit determined that BNL remains in full conformance to the standard.

A strong Pollution Prevention (P2) Program is an essential element of the successful accomplishment of BNL's mission and EMS. The BNL 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. 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 at the Laboratory.

To date, pollution prevention projects have saved more than $1.5 million and have resulted in the reduction or reuse of approximately 2.3 million pounds of waste. In 2003, BNL invested approximately $96,000 in newly funded pollution prevention projects, with an annual anticipated savings of $88,000, for an average payback period of 1.2 years.

Chapter 2 of this report describes BNL's EMS and related programs in further detail.

BNL'S ENVIRONMENTAL MANAGEMENT PROGRAM

BNL's Environmental Management Program consists of several Laboratory-wide and facility-specific environmental programs. This program

identifies potential pathways for exposure of the public and the environment, and evaluates what impacts BNL activities may be having on the environment. The cornerstone of the Laboratory's Environmental Management Program is the BNL Environmental Stewardship Policy. This policy states the Laboratory's intentions and principles regarding overall environmental management and provides a framework for planning and action. The policy is posted throughout the Laboratory and on the BNL website and is included in all training programs for new employees, guests, and contractors. A brief overview of the Laboratory's environmental programs and a summary of performance for 2003 are presented below.

Compliance Monitoring Program

BNL has an extensive program in place to ensure compliance with all applicable environmental regulatory requirements and permits. 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 nine groundwater remediation systems, and several other binding agreements. In 2003, BNL operated in compliance with the majority of these requirements, and programs are in place to address areas for continued improvement. Routine inspections conducted during the year found no significant instances of noncompliance.

Compliance monitoring in 2003 showed that emissions of nitrogen oxides, carbon monoxide, and sulfur dioxide were all within permit limits; the potable water supply met all drinking water requirements; groundwater monitoring at the Major Petroleum Facility continued to demonstrate that current oil storage and transfer operations are not affecting groundwater quality; and liquid effluents met all applicable New York State Pollutant Discharge Elimination System (SPDES) permit requirements, with the exception of one excursion at the Sewage Treatment Plant (STP) and three at other outfalls. There were 22 reportable spills of petroleum products or antifreeze on site in 2003. All releases were cleaned up or addressed to the satisfaction of the New York State Department of Environmental Conservation (NYSDEC).

BNL underwent nine environmental audits by external regulatory agencies in 2003. These audits included inspections of petroleum storage, air emissions from the Central Steam Facility (CSF), STP operations, other regulated outfalls and recharge basins, and the potable water system. Immediate corrective actions were taken to address issues raised during these inspections.

Chapter 3 of this report describes BNL's Compliance Program and status in further detail.

Air Quality Program

BNL monitors radioactive emissions at several facilities on site to ensure compliance with the requirements of the Clean Air Act. Facilities that have the potential to deliver an annual radiation dose of greater than 0.1 mrem 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. The Brookhaven Linac Isotope Producer (BLIP) is the only BNL facility that requires continuous monitoring. There are three other facilities where periodic monitoring is conducted. During 2003, BNL facilities released a total of 3,725 curies of short-lived radioactive gases. Oxygen-15 (half-life: 122 seconds) and carbon-11 (half-life: 20.48 minutes) emitted from the BLIP constituted more that 99.7 percent of these air 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 CSF is the only BNL facility that requires monitoring for nonradiological emissions. Two of the four boilers at the CSF are equipped with continuous emission monitors to measure nitrogen oxides and opacity. In 2003, there were no measured exceedances above the regulatory limits of nitrogen oxides from boiler emissions.

The Laboratory also conducts ambient radiological air monitoring to verify local air quality and assess possible environmental impacts from BNL operations. Air monitoring stations are in place around the perimeter of the BNL site to measure tritium and gross alpha and beta airborne activity. Results measured at BNL in 2003 demonstrated that on-site radiological air quality was consistent with results observed at locations in New York State not located near radiological facilities.

Chapter 4 of this report describes BNL's Air Quality Program 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 helps ensure that wastewater discharges comply with all applicable requirements.

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 is monitored as a geographical control location for comparative purposes, as it is not affected by BNL operations. In 2003, 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 were slightly higher than in 2002 (but still less than 4 percent of the drinking water standard) due to activities at the High Flux Beam Reactor in preparation for its decommissioning. There were no detections of cesium-137 (Cs-137) or strontium-90 (Sr-90) in the STP effluent, a result of remediation activities in 2002 and 2003. Nonradiological monitoring of the effluent showed that, with the exception of isolated incidents of noncompliance, organic and inorganic parameters were within the SPDES effluent limitations or other applicable standards.

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 analysis of data in 2003 showed that low levels of alpha and beta activity were detected in most of the basin discharges and are not attributable to BNL operations, but to natural terrestrial/geological or cosmic sources. The presence of sediment in the stormwater may explain the low level of radionuclides which were detected. Tritium was not detected in the discharge to any basin above the Minimum Detection Level (MDL) during 2003. Nonradiological analyses in 2003 showed that all parameters, except for iron, complied with the respective groundwater discharge or water quality standards.

Chapter 5 of this report describes BNL's Water Quality Surveillance Program 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 staff, the public, and stakeholders 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 tiger salamander, eastern hognosed snake, and the 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. BNL also monitors and manages other animal populations, such as the white-tailed deer and the wild turkey, to ensure that they are sustained, and monitors invasive plant species to control their spread.

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 2003, deer sampling results were consistent with previous years. Deer sampled on the BNL site contain higher concentrations of Cs-137 than deer sampled from greater than 1 mile off site. This is most likely the result of deer consuming contaminated soil and grazing on vegetation growing in soil where elevated Cs-137 levels are know to exist. Removal of areas of contaminated soil at BNL began in 2000 and will continue. The New York State Department of Health (NYSDOH) has reviewed 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.

BNL and the local NYSDEC Fisheries Division maintain an on-going program for analyzing fish from the Peconic River and surrounding freshwater bodies. BNL stopped sampling shellfish in 2003, as historical records indicated there were no impacts attributable from BNL operations. Fish sampling results in 2003 were consistent with previous years. Low levels of Cs-137 were found in all samples taken from the Peconic River system. Concentrations of metals, pesticides, and polychlorinated biphenyls (PCBs) were not considered to have any health impact on fish or humans who may have consumed the fish. Aquatic sampling of sediment, vegetation, and freshwater in the Peconic River and a control location on the Carmans River showed low levels of Cs-137 in sediments at all locations, with levels on site slightly higher than off site. Metal analyses indicated levels both on and off site were above Suffolk County Department of Health Services (SCDHS) cleanup objectives, but below action levels. Pesticides and PCBs analyses of sediment, vegetation, and freshwater from nearly all locations found

the pesticide DDT or its breakdown products, DDD and DDE. These banned pesticides were historically used all across Long Island, including at BNL.

Vegetables grown in the BNL garden plot continue to support historical analyses that there are no Laboratory-generated radionuclides in the produce. Sampling of off-site farm vegetation was discontinued in 2003, since historic data indicated that there were no BNL-related radionuclides in off-site vegetation. Periodic confirmatory sampling will be conducted on a reduced frequency.

A new 5-year testing cycle for recharge basin sediment sampling was established in 2003. Sediment samples taken from a new recharge basin on site associated with one of the outfalls that received discharges permitted under the SPDES permit showed that there were no PCBs or pesticides detected. However, semivolatile organic compound analyses of basin sediments determined that most of the chemicals detected were attributable to a diesel fuel spill.

Precipitation samples were collected quarterly at air monitoring stations and analyzed for radiological content. Samples collected in 2003 showed sporadic detections of gross alpha activity above the MDL. In general, radioactivity in precipitation comes from naturally occurring radionuclides in dust and from activation products that result from solar radiation. Gamma analyses detected beryllium-7, another naturally occurring radionuclide resulting from solar flare activity, in one sample. Lead-212 and thallium-208 were also detected in one of the samples.

In November 2000, the Upton Ecological and Research Reserve (Reserve) was established on site by DOE. This 530-acre Reserve, managed by the U.S. Fish & Wildlife Service (FWS), is used to conduct resource management programs for the conservation, enhancement, and restoration of wildlife and habitat. In 2003, BNL worked with the Reserve's Technical Advisory Group (TAG), regulatory agencies, and other stakeholders to develop a comprehensive, ecosystem-based Natural Resource Management Plan and approved funding for several research projects. The Reserve continues to produce new ecological data each year. Highlights for 2003 include the discovery of the redbellied snake, a species not reported on Long Island in 60 years, and research into the orange striped oakworm, a species capable of decimating the abundant oak forests that make up much of the Long Island ecosystem.

The goal of BNL's Cultural Resource Management Program is to ensure that proper stewardship of BNL and DOE historic resources is established and maintained. Additional goals include maintaining compliance with various historic preservation and archeological laws and regulations, and ensuring the availability of resources to BNL personnel and the public for research and interpretation. In December 2003, BNL submitted a draft Cultural Resource Management Plan to DOE for approval. This plan will guide the management of all of the Laboratory's cultural resources. Also in 2003, compliance procedures and requirements for archaeological surveys were developed.

Chapter 6 of this report describes BNL's Natural and Cultural Resource Management Programs in further detail.

Groundwater Protection Management Program

The 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 cost-effective manner that is consistent with federal, state, and local regulations. BNL is committed to protecting groundwater resources from further impacts from current and past practices, and to remediating existing contaminated groundwater. BNL's extensive groundwater monitoring well network is used to verify that prevention and restoration activities are effective, and to track cleanup progress.

Program elements for groundwater monitoring include the installation of monitoring wells; planning and scheduling; developing and following quality assurance protocols; collecting and analyzing samples; verifying, validating, and interpreting data; and reporting results. Monitoring wells are used to evaluate BNL's progress in restoring groundwater quality, to comply with regulatory permit requirements, to monitor active research and support facilities, and to assess the quality of groundwater entering and leaving the BNL site.

In 2003, BNL collected groundwater samples from 754 monitoring wells during 2,810 individual sampling events. Since the beginning of active groundwater remediation activities in December 1996, BNL has removed 4,156 pounds of volatile organic compounds (VOCs) by treating nearly 6.8 billion gallons of groundwater. During 2003, seven groundwater remediation systems removed 510 pounds of VOCs and returned approximately 1.3 billion gallons of treated water to the Upper Glacial Aquifer. Under the Laboratory's Environmental Restoration Program, a primary goal is to remediate soil and groundwater contamination and prevent additional contamination from migrating off site. Although widespread improvements in groundwater quality at

BNL are expected to require approximately 10 years of aquifer treatment, noticeable improvements are already evident.

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. The quality of the BNL potable water supply is monitored as required by the Safe Drinking Water Act and the analytical results are reported to SCDHS. BNL also prepares an annual Consumer Confidence Report that is distributed to all employees and guests. Monitoring of BNL's potable water system in 2003 showed that the potable water supply met all drinking water requirements.

Chapter 7 of this report describes the BNL Groundwater Monitoring Program in further detail.

Radiological Dose Assessment Program

BNL routinely assesses its operations to ensure that any potential radiological dose to the public, BNL workers, and the environment is "As Low As Reasonably Achievable." The potential radiological dose is calculated as the maximum dose to a hypothetical Maximally Exposed Individual (MEI) at the BNL site boundary and calculated by considering all direct and indirect pathways. For dose assessment purposes, the pathways included direct radiation exposure, inhalation, ingestion, and skin absorption. Radiological dose assessments at BNL routinely show that the Effective Dose Equivalent (EDE) from BNL operations is well below the Environmental Protection Agency (EPA) and DOE regulatory dose limits for the public and the environment. The dose impact from all BNL activities in 2003 was found to be insignificantly above natural background radiation levels.

To assess the impact of direct radiation from BNL operations, thermoluminescent dosimeters (TLDs) are deployed at the BNL site and in the 16 wind sectors of the surrounding communities. In 2003, the average doses from 56 on-site and 18 off-site TLDs showed that there was no additional contribution from BNL operations to dose above natural background radiation on or off the site. The yearly average ambient external dose was calculated to be 64 ± 10 mrem (640 ± 100 μSv) on the BNL site and 61 ± 9 mrem (610 ± 90 μSv) at off-site locations. Both these measurements include contributions from cosmic and natural background sources.

The EDE from the air pathway was calculated as 5.96E-2 mrem (0.6 μSv) to the MEI. The ingestion pathway dose was estimated as 2.18 mrem (22 μSv) from venison consumption and 0.19 mrem (1.9 μSv) from consumption of fish caught at Swan Pond. BNL's total annual dose to the MEI from all pathways was estimated as 2.43 mrem (24 μSv). In comparison, EPA's annual regulatory dose limit is 10 mrem (100 μSv) for the air pathway, and DOE's annual dose limit is 100 mrem (1,000 μSv) from all pathways. In 2003, doses to aquatic animals, terrestrial plants, and terrestrial animals were found to be well below the DOE regulatory limits.

Remediation and waste management projects conducted in 2003 were evaluated for radiological emissions and dose impact. It was concluded that there was no significant dose and radiological risk to the public or the environmental from these activities.

Chapter 8 of this report describes the BNL Radiological Dose Assessment Program in further detail.

Quality Assurance Program

The multilayered components of the BNL Quality Assurance (QA) Program ensure that all analytical data reported in this report are reliable and of high quality, and that all environmental monitoring data meet quality assurance and quality control objectives. Samples are collected and analyzed in accordance with standard operating procedures that are designed to ensure that samples are representative and that the data are reliable and defensible. Quality control in the 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 they are used to support decision making.

In 2003, BNL used the on-site Analytical Services Laboratory (ASL) and four off-site contractor laboratories to analyze environmental samples. 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 testing, review of QA programs, and audits.

The laboratories performing radiological analyses (BNL's ASL and two contractor laboratories) each scored 95 percent or better in state and federal laboratory testing programs. BNL's "overall satisfactory" score in radiological testing was 95.9 percent. In nonradiological performance evaluation testing, BNL received an Acceptable rating of 96.1 percent and the off-site contractor laboratories scored Acceptable ratings of between 95 percent and 98 percent. For the 458 radiological and nonradiological performance evaluation tests carried out in 2003, BNL's combined "overall satisfactory" score was 95.9 percent.

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The SER Team realizes that many other employees contributed to this report and thanks everyone for their assistance.

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Introduction

Each year, Brookhaven National Laboratory (BNL), a multi-program national laboratory, prepares an annual Site Environmental Report (SER) in accordance with Order 231.1A, Environment, Safety and Health Reporting, of the U.S. Department of Energy (DOE). The SER is written to inform outside regulators, the public, and Laboratory employees of BNL's environmental performance during the calendar year in review, and to summarize BNL's on-site environmental data; environmental management performance; compliance with applicable DOE, Environmental Protection Agency (EPA), state, and local regulations; and environmental, restoration, and surveillance monitoring programs. BNL has prepared annual SERs since 1971 and has documented nearly all of its environmental history since the Laboratory's inception in 1947.

This report is intended to be a technical document. It is available in print and as a downloadable file on the BNL web page at http://www.bnl.ser.htm. A summary of the SER is also prepared each year to provide a general overview, and is distributed with a CD version of the full-length SER. The summary supports BNL's educational and community outreach program.

This chapter describes the Laboratory's facilities, ecological resources, demographics, and history. It also discusses local characteristics in terms of geology, hydrology, and climate, providing background material for the technical information in the chapters that follow. The appendices provide additional data and information and are intended to assist the reader to better understand the content of this report.

1.1 LABORATORY MISSION

Brookhaven National Laboratory's broad mission is to produce excellent science in a safe, environmentally sound manner with the cooperation, support, and appropriate involvement of the scientific and local communities. For more than 50 years, BNL has been one of the leading research institutions in the nation and the world. Much of the Laboratory's effort is directed at the study of the basic nature of matter, including subatomic particles and the structure of the atom. BNL research has also produced extraordinarily useful technology. To date, six Nobel Prizes have been awarded for research conducted at BNL, as well as numerous patents.

The Laboratory plays a lead role in the DOE Science and Technology mission and contributes to the DOE missions in Energy Resources, Environmental Quality, and National Security. The fundamental elements of BNL's role in support of these key DOE missions 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 new generations of scientists and engineers, to maintain technical capabilities in the nation's workforce, and to encourage scientific awareness in the general public.

BNL integrates environmental stewardship into all facets of its missions and operations. The Environmental Stewardship Policy, which is posted throughout the site, reflects BNL's commitment to conducting research and operational activities in a manner that protects the health of the public, employees, and the environment.

1.2 OPERATIONS AND RESEARCH

Established in 1947, BNL is a national laboratory operated for DOE by Brookhaven Science Associates (BSA), a not-for-profit partnership between Battelle Memorial Institute and the Research Foundation of the State University of New York on behalf of the State University of New York at Stony Brook. BSA began operating the Laboratory on March 1, 1998 under DOE Contract No. DE-AC02-98CH10886. From 1947 to 1998, BNL was operated by Associated Universities Incorporated. Prior to 1947, the site was 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. Many of the cultural resources from the Army era are preserved in the Camp Upton Museum and are discussed in Chapter 6.

Owned and primarily funded by DOE, BNL conducts applied research in the physical, biomedical, and environmental sciences, and in energy technologies. BNL also builds and operates major world-class research facilities that are available to university, industrial, and government personnel. Approximately 3,000 scientists, engineers, technicians, and support staff work at BNL, and more than 4,000 guest researchers from all over the world visit the site each year to participate in scientific collaborations. Some important scientific discoveries and research at BNL include major discoveries in particle physics; the use of L-dopa to treat Parkinson's disease; work on magnetically levitated (Maglev) trains; the radionuclide thallium-201, used in millions of heart stress tests each year; X-ray angiography for noninvasive heart imaging; and pioneering solar neutrino studies seeking the answer to the mystery of the "missing" neutrinos from our solar system's sun, and neutrino bursts from supernovae. Some topics of research now being conducted at the Laboratory include pollution-eating bacteria; structural studies of the Lyme disease protein for developing new vaccines; asbestos-digesting foam; large-scale studies of the effect of increased carbon dioxide on ecosystems; promising cocaine addiction treatments; and cleaner, more efficient oil burners.

1.3 HISTORY

BNL was founded in 1947 by the Atomic Energy Commission. The objective was to build a regional laboratory that could provide researchers with powerful tools too costly for their home institutions to build and maintain. Although BNL no longer operates any research reactors, the Laboratory's first major scientific facility was the Brookhaven Graphite Research Reactor (BGRR), which operated from 1950 to 1968 and is now being decommissioned. The BGRR was used for peaceful scientific exploration in the fields of medicine, biology, chemistry, physics, and nuclear engineering. 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 closed and decommissioned. All spent fuel from the HFBR was removed and transported to the Savannah River Laboratory.

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,

the Brookhaven Medical Research Reactor (BMRR) in 1959, and the Brookhaven Linac Isotope Producer (BLIP) in 1973. In the past three decades, BNL has helped pioneer development of a powerful medical imaging technique known as Positron Emission Tomography (PET). This technology has since provided a view of the body's inner workings for doctors treating millions of patients and performing medical research worldwide. Two more imaging techniques were added to the PET research efforts to form the Center for Imaging and Neuroscience in 1996. Except for the BMRR, all of these medical facilities are currently operating. 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 to the Savannah River Laboratory.

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–winning discovery in 1957. In 1960, the Alternating Gradient Synchrotron (AGS), a much larger accelerator that surpassed the Cosmotron's capabilities, became operational. The AGS, still in operation, has yielded many discoveries of new particles and phenomena, for which BNL researchers were awarded three Nobel Prizes in Physics in 1976, 1980, and 1988. The Tandem Van de Graaff accelerator, also still in use, began operating in 1970 and is the starting point of the chain of accelerators that provide ions of gold and other heavy metals for experiments at the Relativistic Heavy Ion Collider (RHIC). In 1982, researchers began using the National Synchrotron Light Source (NSLS), which guides charged particles in orbit inside a donut-shaped electron storage ring for use in a wide range of physical and biological experiments.

The RHIC, the Laboratory's newest two-ringed particle accelerator, began operation in 2002. The four RHIC detectors record full-energy collisions that recreate (on a microscopic scale) the hot, dense conditions that are thought to have existed when the universe first formed. This enables scientists to study the basic components of matter as they existed in their earliest forms. In August 1999, the RHIC became the first facility at BNL and also on Long Island to receive International Organization for Standardization (ISO) 14001 Environmental Management System certification, which is discussed in Chapter 2. The RHIC is an example of BNL's commitment to fully integrate today's world-class science with world-class protection of the environment.

Historical operations and past waste management practices at the Laboratory resulted in the release of chemicals and radioactive materials that led to soil and groundwater contamination. In 1989, BNL was added to the federal Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) National Priorities List of contaminated sites identified for priority cleanup, one of 27 such sites on Long Island. Since then, BNL has made significant progress toward improving environmental operations and remediating past contamination.

1.4 LOCATION, LOCAL POPULATION, AND LOCAL ECONOMY

BNL is located in Suffolk County on Long Island, New York, about 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. Approximately 150 people live in apartments and cottages on site, and many of the approximately 4,000 scientists and students who visit each year stay in the Laboratory's dormitories. More than 75 percent of BNL's approximately 3,000 employees live within a 15-mile radius of the site.

BNL is the largest employer on eastern Long Island, with an annual budget approaching $443 million. Employee salaries, wages, and fringe benefits account for almost 62 percent of that amount. Additionally, this budget directly supports the local economy through purchases of materials and services. 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).

1.5 FACILITIES AND OPERATIONS

Most of BNL'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. In November 2000, DOE set aside 530 acres of undeveloped land at BNL as the Upton Ecological and Research Reserve. Additional information regarding the "Upton Reserve" and BNL's natural resources can be found in Section 1.8 of this chapter and in Chapter 6.

The major scientific facilities at BNL are pictured and briefly described in Figure 1-1. The three former research reactors, no longer operational, are discussed in Section 1.2. Numerous other facilities, shown in Figure 1-2 and briefly described below, support BNL's science and technology mission by providing basic utility and environmental services.

- *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.
- *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 with once-through cooling, and reduces the need for local refrigeration plants.
- *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.
- *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 BNL's reliance on oil as a fuel source.
- *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 (NYSDEC).
- *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.
- *Fire Station*. The BNL Fire Rescue Group provides on-site fire suppression, emergency medical services, hazardous material response, salvage, and damage control. The Fire Station houses six response vehicles. The fire rescue group responds within five

minutes to any emergency in the core area of the Laboratory and within eight minutes to emergencies in the outer areas (RHIC and eastern portions of the site).

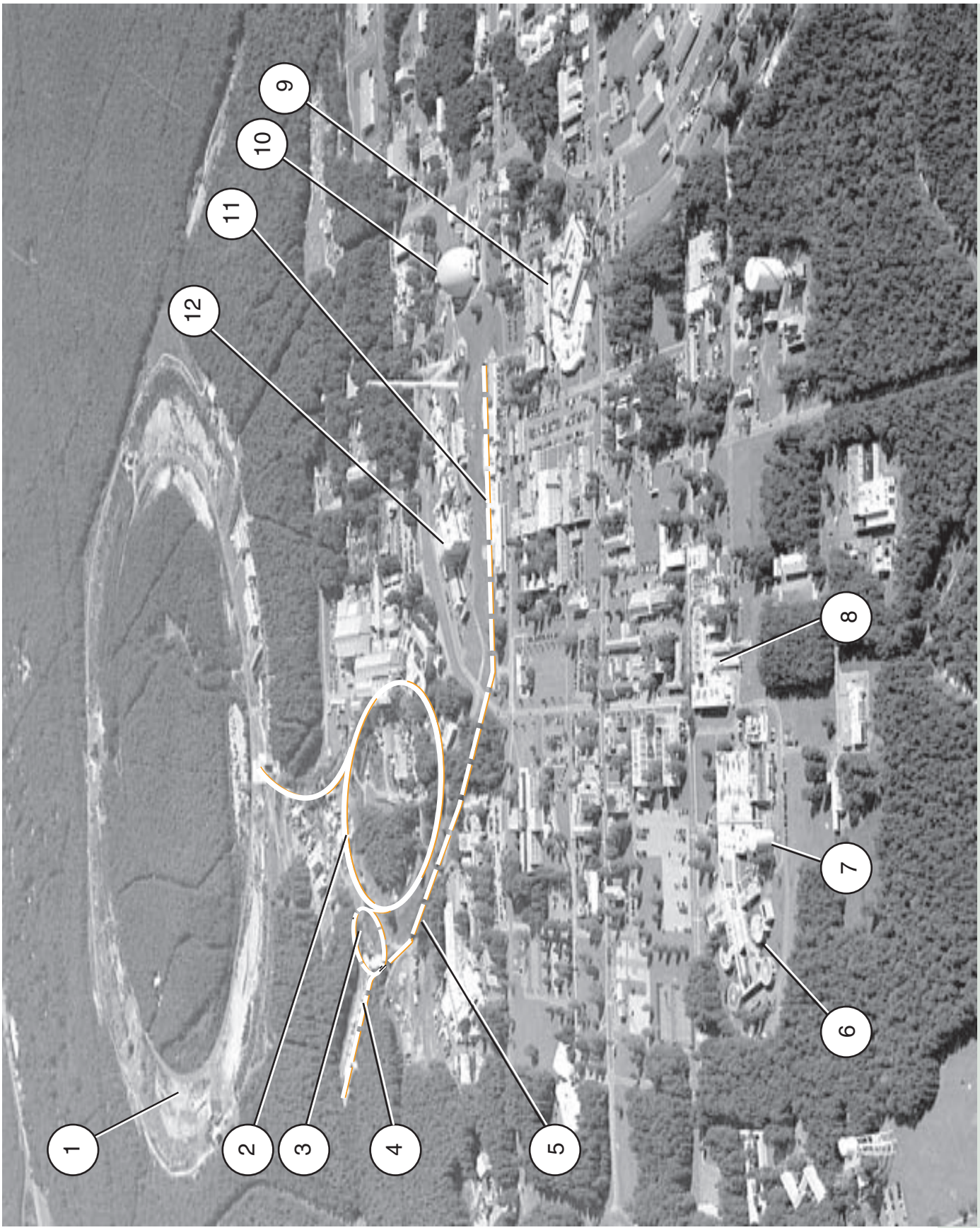
1.6 GEOLOGY AND HYDROLOGY

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 typically recharges to the groundwater; with normal to above-normal precipitation, the river receives water from the aquifer. Due to the high rate of precipitation in 2003, the Peconic River flowed off site the entire year.

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 surface of the land 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. The hydrology of the local area is well defined. 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 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 area has a high average recharge rate (22 inches per year) that varies seasonally.

The Long Island Regional Planning Board and Suffolk County have identified the BNL site as overlying a deep-flow recharge zone for Long Island groundwater (Koppelman 1978, Suffolk County Department of Health Services 1987). 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 and 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. BNL uses approximately 1.8 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 3.5 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 moving eastward along the Peconic River, southeast toward the Forge River, and south toward the Carmans River (Figure 1-3). Pumping from on-site supply wells affects the direction and speed of groundwater flow, especially in the central, developed areas of the site. The main groundwater divide on Long Island is aligned generally east–west, and lies approximately one-half mile north of BNL. 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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1. RELATIVISTIC HEAVY ION COLLIDER (RHIC)

RHIC is one of the world's largest and most powerful accelerators. RHIC drives two intersecting beams of gold ions head-on, to form a subatomic collision. 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.

2. ALTERNATING GRADIENT SYNCHROTRON (AGS)

The AGS is used for high-energy physics research. It accelerates protons to energies up to 30 GeV, and heavy-ion beams to 15 GeV. A 200 MeV Linear Accelerator (Linac), described below, serves as a proton injector for the AGS booster and also supplies a continuous beam of protons for radionuclide production by spallation reactions in the Brookhaven Linac Isotope Producer (BLIP) facility.

3. AGS BOOSTER

The AGS Booster is a circular accelerator, 200 meters in circumference, that receives either a proton beam from the Linac, or heavy ions from the Tandem Van de Graaff. The AGS Booster accelerates proton particles and heavy ions before injecting them into the AGS ring. This facility became operational in 1992.

4. LINEAR ACCELERATOR (LINAC) AND BROOKHAVEN LINAC ISOTOPE PRODUCER (BLIP)

The Linac provides beams of polarized protons for the AGS and for the Relativistic Heavy Ion Collider. BLIP utilizes the excess beam capacity of the Linac to produce radioisotopes used in research and medical imaging. It is one of the key production facilities in the nation for radioisotopes, which are crucial to clinical nuclear medicine. It 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 permits ions of intermediate mass to be injected into the AGS, where they can be accelerated to an energy of 15 GeV. These ions then are 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 for radiation therapy of 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 applications 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.

8. SCANNING TRANSMISSION ELECTRON MICROSCOPE (STEM)

This 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.

9. NATIONAL SYNCHROTRON LIGHT SOURCE (NSLS)

The NSLS utilizes a linear accelerator and booster synchrotron as an injection system for two electron storage rings which operate at energies of 750 MeV vacuum ultraviolet (VUV) and 2.5 GeV (x-ray). The synchrotron radiation produced by the stored electrons is used for VUV spectroscopy and x-ray diffraction studies.

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 as well as expanded the knowledge base of physics, chemistry, and biology. A leak in the fuel storage pool was discovered in 1997. Since that time, the HFBR has not been in operation and was permanently shut down in November 1999.

11. TANDEM VAN DE GRAAFF AND CYCLOTRON

These two facilities are used in medium-energy physics investigations and for producing special nuclides. The heavy ions from the Tandem Van de Graaff also can be injected into the AGS Booster for physics experiments.

12. BROOKHAVEN GRAPHITE RESEARCH REACTOR (BGRR)

No longer in operation, the BGRR was used for scientific exploration in the fields of medicine, biology, chemistry, physics, and nuclear engineering. The BGRR is currently being decommissioned.

Figure 1-1. Major Scientific Facilities at Brookhaven National Laboratory.

Figure 1-2. Major Laboratory Support and Services Facilities.

Bay, south shore streams, the Great South Bay, and the Atlantic Ocean. The regional groundwater flow system is discussed in greater detail in *Stratigraphy and Hydrologic Conditions* (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 BNL southern boundary.

1.7 CLIMATE

The Meteorological Group at BNL has been recording on-site weather data since 1949. 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 2003 annual wind rose for BNL, which depicts the annual frequency distribution of wind speed and direction, measured at an on-site meteoro-

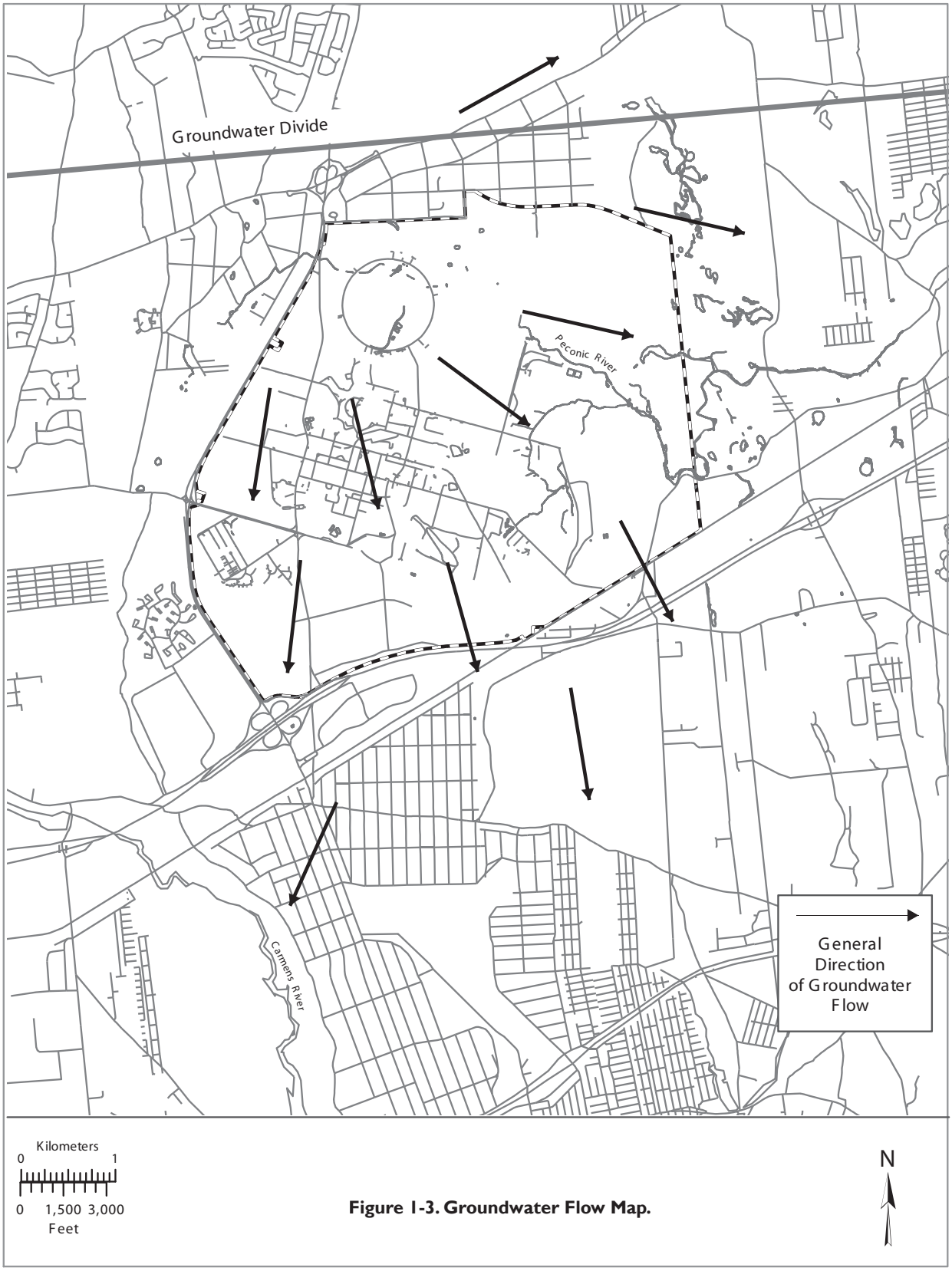
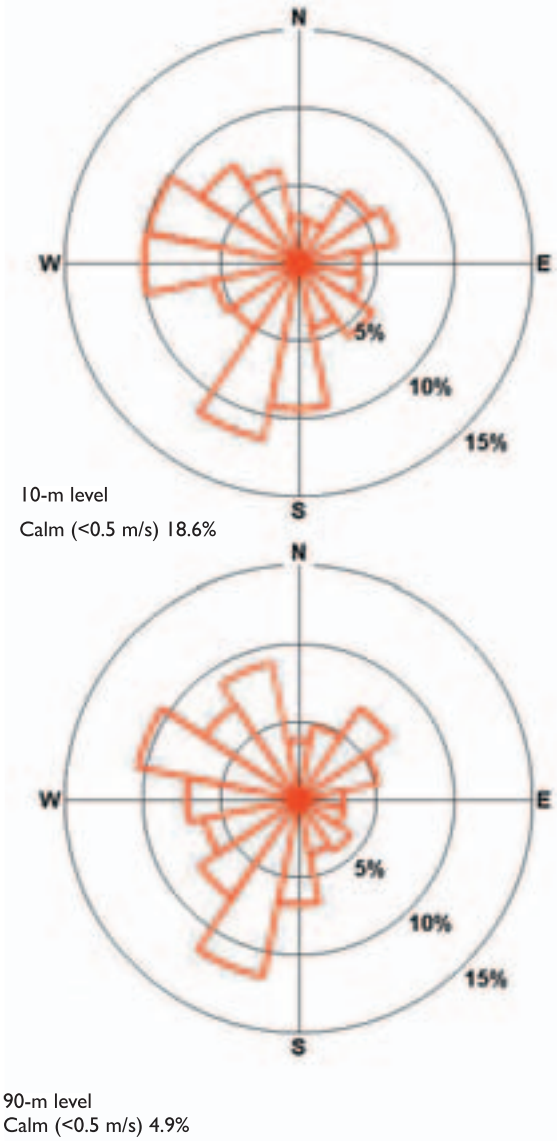


Figure 1-3. Groundwater Flow Map.



Brookhaven National Laboratory

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-southwest, at both levels.

Figure 1-4. Annual Wind Rose (2003).

logical tower at heights of 33 feet (10 meters) and 300 feet (90 meters).

The average annual snowfall for BNL is 29.6 inches. February and December 2003 snowfalls, 31.8 inches and 25.0 inches respectively, were the second and third largest snow periods recorded at the Laboratory, and the winter of 2002–2003 was the fifth snowiest winter in 56 years. The average yearly precipitation at BNL for 2003 was 63.11 inches, making it the third wettest year recorded. In June, 12.28 inches of rain fell, making it the second wettest month recorded. Figures 1-5 and 1-6 show the 2003 monthly and the 55-year annual precipitation data.

The average temperature for 2003 was 50.8°F, only 0.7 degrees above the overall average for the past 56 years. Five new record-high daily temperatures and one new record-low daily temperature occurred in 2003. The record low temperature of 4.5°F was set on March 7. On March 17, a new high was set, when the temperature rose to 72°F. August was the hottest month on record, with an average monthly temperature of 74.6°F. Figures 1-7 and 1-8 show the 2003 temperatures and the historical annual mean temperatures.

1.8 ECOLOGICAL RESOURCES

BNL 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 Scenic by the New York State Wild, Scenic, and Recreational River System Act of 1972. Due to the general topography and porous soil, the land is very well drained and there is relatively little surface runoff or open standing water. However, depressions form small, pocket wetlands with standing water on a seasonal basis (vernal pools), and there are six significant, 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.

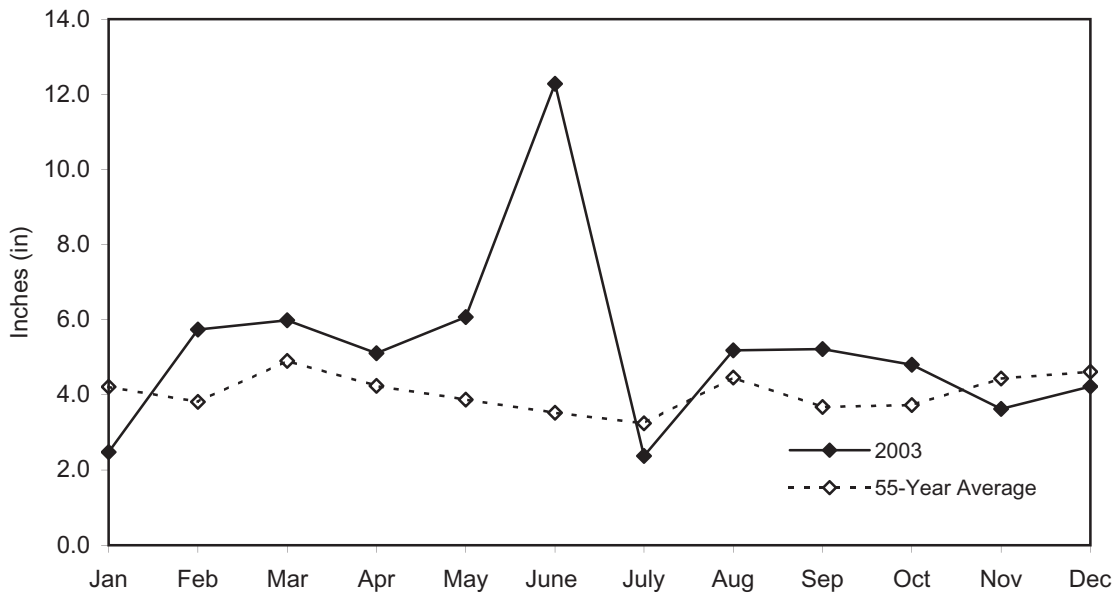


Figure 1-5. 2003 Monthly Precipitation Versus 55-Year Monthly Average.

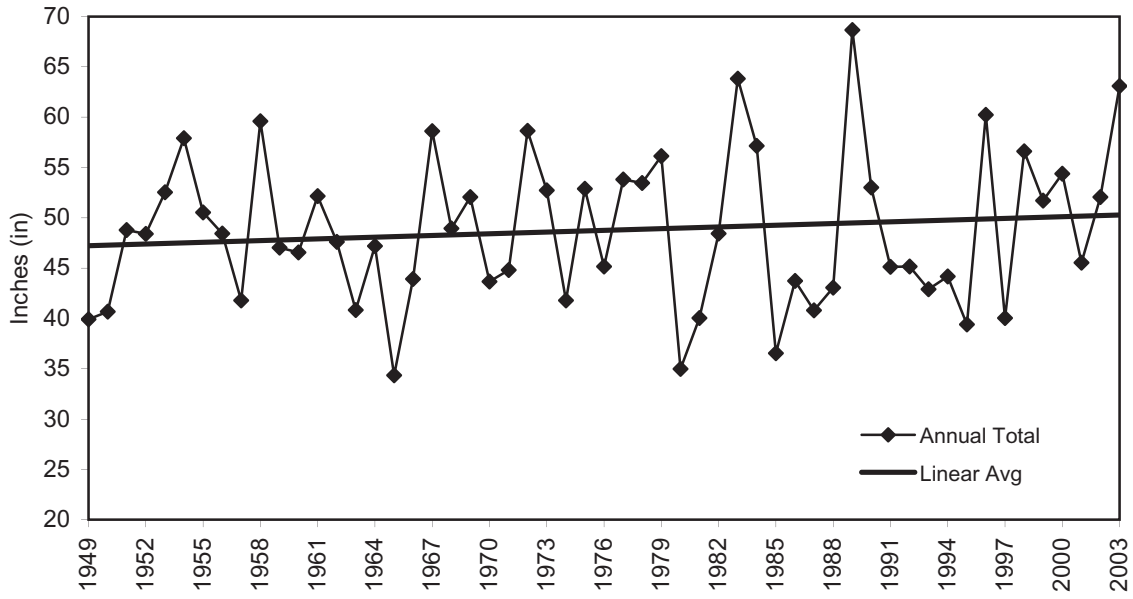


Figure 1-6. Annual Precipitation Trend (55 Years).

More than 230 plant species have been identified on site, including one New York State threatened species and two that are rare.

The animal species identified at BNL 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 are known to nest at BNL, and more than 216 species have been documented as visiting the site. These numbers can be attributed to BNL's location in the Atlantic Flyway and to the habitats that offer food and rest to migratory songbirds. Permanently flooded retention basins and other watercourses support amphibians and aquatic reptiles. Nine fish, 13 amphibian, and 13 reptile species have been identified at BNL. Two types of butterflies that are protected in New York are believed to

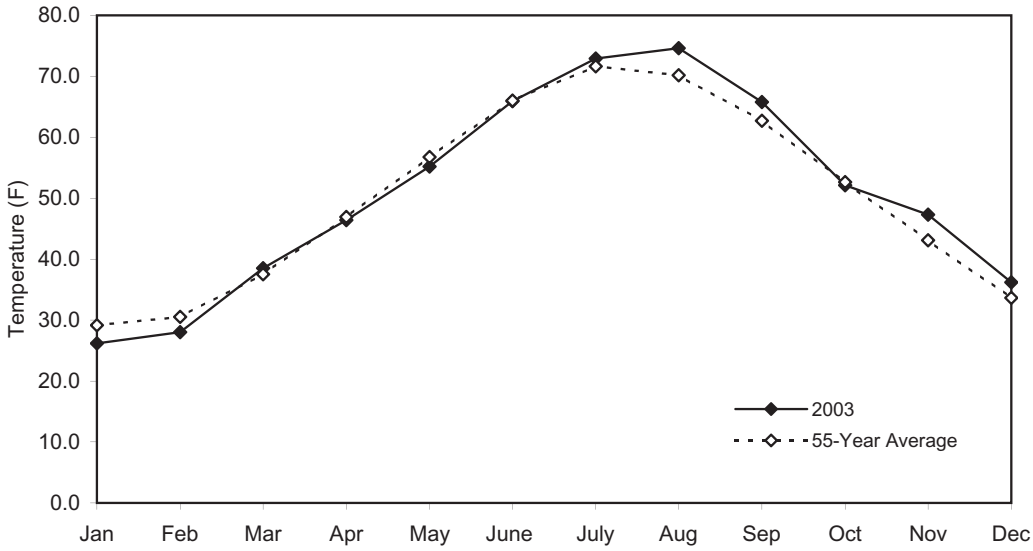


Figure 1-7. 2003 Monthly Mean Temperature Versus 55-Year Monthly Average.

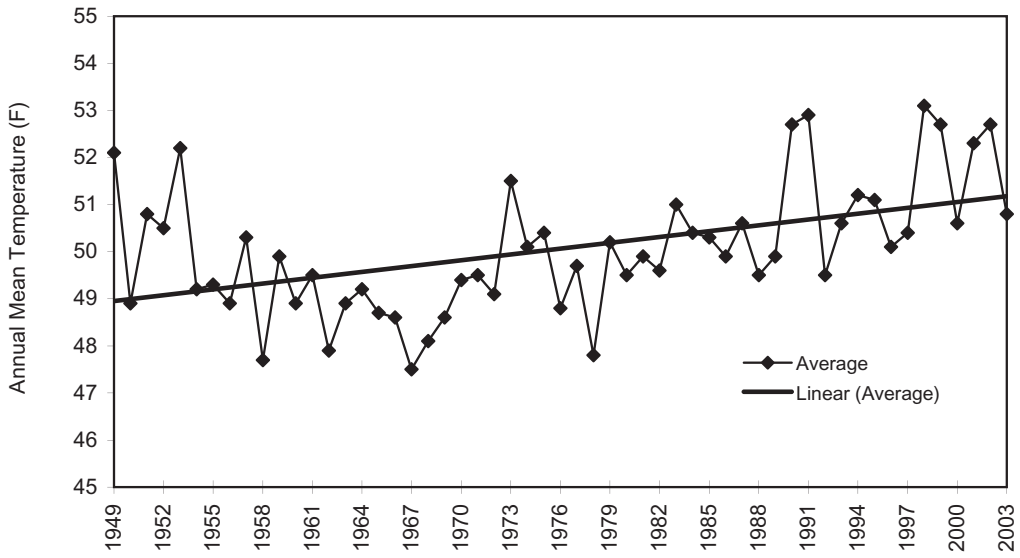


Figure 1-8. Annual Mean Temperature Trend (55 Years).

breed on site due to preferred habitat and host plants. 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 Pine Barrens. The Upton Reserve creates a unique ecosystem of forests and wetlands that provide habitats for plants, mammals, birds, reptiles, and amphibians, some of which are endangered, threatened, or of special concern. Under an Inter-Agency Agreement with DOE, the U.S. Fish & Wildlife Services (FWS) conducts resource management programs for the conservation, enhancement, and restoration of wildlife and habitat in the Reserve. The Upton Reserve Technical Advisory Group (TAG), made up of local land management agencies,

assists BNL and FWS with technical expertise and helps determine policy for the Reserve.

As part of DOE's commitment to protecting the environmental assets of its sites, the agency agreed to provide FWS with $200,000 per year for a five-year period to conduct land management activities and research at the Reserve. In 2003, this funding helped support activities in community outreach, conservation, and habitat protection. Three grants, selected by the TAG, were also awarded to support research relating to the Pine Barrens. In 2003, working with the TAG, regulatory agencies, and other stakeholders, BNL developed a comprehensive, ecosystem-based Natural Resource Management Plan for BNL and the Reserve. This plan provides management guidance, promotes stewardship of the natural resources found at BNL, and integrates environmental protection with pursuit of the Laboratory's mission. See Chapter 6 for details on BNL's natural resources.

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Environmental Management System

2

One of Brookhaven National Laboratory's highest priorities is ensuring that the Laboratory's environmental performance measures up to its world-class status in science. Brookhaven Science Associates, the contractor operating the Laboratory on behalf of the Department of Energy, takes environmental stewardship very seriously. As part of their commitment to environmentally responsible operations, they have established an Environmental Management System (EMS).

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.

BNL's EMS became officially registered to the ISO 14001 standard in July 2001. Annual audits are required to maintain the registration. The audits are conducted by NSF-International Strategic Registrations, LTD, an accredited ISO 14001 registrar. The purpose of the audits is to validate that the EMS is being maintained and to identify evidence of continual improvement (a requirement of the ISO 14001 standard). In 2003, an EMS Surveillance Audit determined that BNL remains in conformance with the ISO 14001 Standard. The audit identified two minor non-conformances, two opportunities for improvement, and 10 examples of continual improvement.

In 2003, BNL continued its strong support of the Pollution Prevention Program. This program seeks ways to eliminate waste and toxic materials and is the preferred approach to resolving environmental issues at BNL. Work planning processes incorporate the prevention approach, and benefits continue to accumulate. Pollution prevention projects have saved more than $1.5 million to date and have resulted in the reduction or reuse of approximately 2.3 million pounds of waste through 2003. In FY03, the BNL Pollution Prevention Council funded eight proposals, investing approximately $96,000. Anticipated savings from the projects are estimated at $88,000, for an average payback period of 1.2 years. The ISO 14001-registered EMS and the nationally recognized Pollution Prevention Program continue to contribute to BNL's success in promoting pollution prevention. BNL also continues to address legacy issues under the Environmental Restoration program and is openly communicating with neighbors, regulators, employees, and other interested parties on environmental issues and cleanup progress on site.

2.1 ENVIRONMENTAL STEWARDSHIP AT BNL

The International Organization for Standardization's ISO 14001 is a globally recognized standard that defines the structure of an organization's EMS for purposes of improving the organization's environmental performance. The process-based structure of ISO 14001 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 standard, an organization must comply with the set of 17 ISO 14001 requirements that are listed and described in Table 2-1.

BNL's EMS was first 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 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 2003, an EMS Surveillance Audit determined that BNL remains in conformance with the ISO 14001 Standard. The audit identified two minor nonconformances and two opportunities for improvement. In its recommendation for continued certification, NSF-International Strategic Registrations, Ltd. (NSF-ISR) highlighted 10 examples of BNL's continual improvement, some of which include BNL's ongoing improvement to and use of the process assessment tool, minimizing the use and storage of hazardous materials, and considerable improvements in pollution prevention and material reuse.

2.2 ENVIRONMENTAL STEWARDSHIP POLICY

The cornerstone of an EMS is a commitment to environmental protection at the highest levels of the organization. The Environmental Stewardship Policy, issued and signed by the Laboratory Director, is a statement of BNL'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 Environmental Stewardship Policy is posted throughout the Laboratory and on the BNL website at www.bnl.gov.

The Environmental Stewardship Policy contains the following goals and commitments, focusing on compliance, pollution prevention, cleanup, community outreach, and continual improvement:

- Achieve and maintain compliance with applicable environmental requirements. These requirements include more than 100 local, state, and federal laws and regulations; DOE Directives; Executive Orders; and numerous operating permits.
- Integrate pollution prevention/waste minimization, resource conservation, and compliance into BNL activities during planning and decision making. Adopt cost-effective practices that eliminate, minimize, or mitigate environmental impacts, including conserving natural resources and adhering to the policy known as "E-ALARA": ensuring that Environmental emissions, effluents, and waste generation are As Low As Reasonably Achievable.
- Define, prioritize, and aggressively correct and clean up existing environmental problems. This commitment encompasses removal or treatment of contamination caused by historical practices. It also includes strengthening the environmental monitoring program to ensure that controls designed to protect the environment are working, and to provide early detection of a potential threat to the environment (see Section 2.4.3).
- Maintain a positive, proactive, and constructive relationship with the local community, regulators, DOE, employees, and other stakeholders. Openly communicate with stakeholders about program planning, progress, and performance (see Section 2.4.2).
- Continually improve the environmental

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

Environmental Policy	The Environmental Stewardship Policy is a statement of BNL's intentions and principles regarding overall environmental performance. It provides a framework for planning and action. In the policy, BNL 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, BNL evaluates its operations, identifies the aspects of operations that can impact the environment, and determines which of those 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 and Targets	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 objectives and targets were established in FY 2003: ▪ 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 groundwater protection program ▪ Ensure responsible stewardship of natural and historical resources on site
Environmental Management Program	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. BNL has 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.
Structure and Responsibility	All employees at BNL 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.
Training, Awareness, and Compentence	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 select staff, and specific courses for managers, internal assessors, EMS implementation teams, and operations personnel whose work can impact the environment.
Communication and Community Involvement	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 Stewardship 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 *(concluded)*.

EMS Documentation	BNL has a comprehensive, up-to-date set of Laboratory-wide environmental documents describing the EMS. Using SBMS, staff can access detailed information on regulatory requirements, Laboratory-wide procedures, and manuals on how to control processes and perform work at BNL in a way that protects the environment. SBMS has improved the quality, usability, and communication of Laboratory-level requirements.
Document Control	SBMS contains 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 impacts 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 summarized annually in the Site Environmental Report. In addition, BNL tracks and trends its progress and performance in achieving environmental objectives and performance measures.
Nonconformance, and Corrective and Preventive Actions	BNL continues to improve processes that identify and correct problems. A Lessons Learned Program to prevent recurrences, a robust Self-Assessment Program, and an electronic web-based assessment and action tracking system have been implemented.
Records	EMS-related records, including audit and training records, are maintained to ensure integrity, facilitate retrieval, and protect them from loss.
EMS 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.

management system and performance. Establish appropriate environmental objectives and performance indicators to guide these efforts and measure progress. To maintain certification, BNL employs proactive measures to prevent problems. When problems do occur, the approach is to investigate the root cause and take corrective actions as appropriate.

2.3 PLANNING

The planning requirements of the ISO 14001 Standard require BNL to identify the environmental aspects and impacts of its activities, products, or 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, or services than can interact with the environment. As required by the ISO 14001 Standard, BNL evaluates its operations, identifies the aspects of operations that can impact the environment, and determines which of those impacts are significant. BNL's criteria for significance are based on both 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 procedure is an evaluation that is documented on a Process Assessment Form (PAF). The PAF consists of a written process description, a detailed process flow diagram, a regulatory determination of all process outputs, identification of pollution prevention opportunities, and identification of any Assessment, Prevention, and Control (APC) measures that should be considered. Environmental professionals worked closely with revision teams to ensure that environmental requirements were integrated into the 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 2003.

2.3.2 Legal and Other Requirements

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

2.3.3 Objectives and Targets

The establishment of environmental objectives and targets is accomplished through the 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 "critical outcomes." BNL works 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 Environmental Stewardship Policy, to regulatory agencies and to the public)
- Importance to DOE, the public, and other stakeholders

Laboratory-level objectives and targets are developed on a Fiscal Year (FY) schedule. In FY 2003 (October 1, 2002 through September 30, 2003), these objectives included:

- Maintain and improve the Environmental EMS
- Achieve full compliance with applicable environmental requirements
- Integrate pollution prevention into work planning and expand participation
- Improve communications, trust, and good relationships with stakeholders on environmental programs
- Fully implement the groundwater protection program
- Ensure responsible stewardship of natural and historical resources on site
- Implement environmental restoration projects efficiently

2.3.4 Environmental Management Programs

Each organization within BNL develops an action plan detailing how they will achieve their 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 that resources essential to the implementation and control of the EMS are provided.

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 program to help ensure full compliance with all applicable environmental regulatory requirements and permits. Some programs are routine, such as the National Emission Standards for Hazardous Air Pollutants (NESHAPs), National Pollutant

Discharge Elimination System (NPDES), and Resource Conservation and Recovery Act (RCRA) compliance programs. Other programs are 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 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 taking corrective actions quickly in response to unexpected monitoring results. Key elements of the groundwater program are the full and timely disclosure of any off-normal circumstances and regular communication on the performance of the program. Chapter 7 provides additional details about the Groundwater Protection Management Program and monitoring results for 2003.

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, BNL's unique scientific activities also generate waste streams that are subject to additional regulation and special handling, including radioactive, hazardous, and mixed waste.

In 2003, waste management operations were streamlined by combining the Environmental Services Division and the Waste Management Division. This successful merger resulted in significant cost savings to BNL. The combined group, known as the Environmental and Waste Management Services Division (EWMSD), is responsible for the collection, transportation, storage, and off-site disposal of site-generated waste. Waste is managed at a state-of-the-art facility designed especially for managing hazardous, industrial, radioactive, and mixed materials.

The EWMSD Waste Management Facility complex 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 2003, BNL generated the following types and quantities of waste from routine operations:

- Hazardous waste: 5.9 tons
- Mixed waste: 66 cubic feet
- Radioactive waste: 5,534 cubic feet

These quantities represent significant reductions from previous years, as shown in Figures 2-1a through c. Routine operations are defined as ongoing industrial and experimental operations. The picture is not complete, however, without consideration of waste generated from "nonroutine" or one-time events and waste generated from environmental restoration activities. 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 EWMSD. Nonroutine waste includes construction and demolition waste, environmental restoration waste, legacy waste, lead-painted debris, lead shielding, and 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 varies significantly from year to year. This is to be expected as environmental restoration activities move from remedial investigations and feasibility studies to remedial actions, which change annually based on the progress of BNL's cleanup schedule.

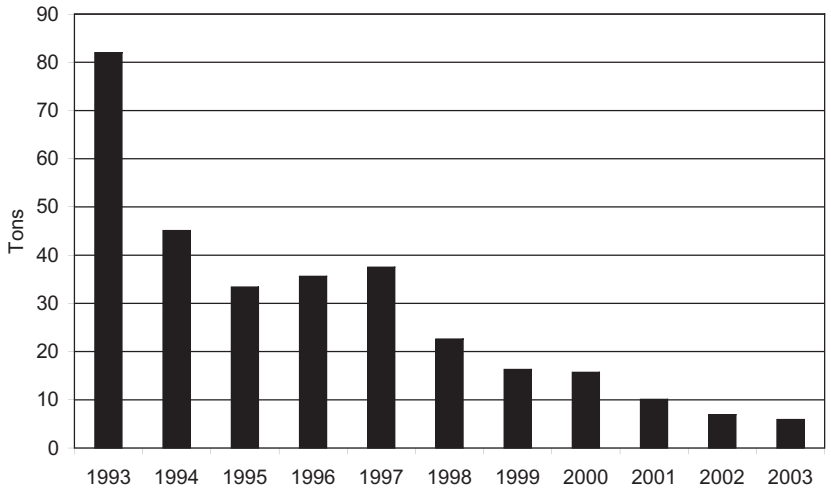

Figure 2-1a.
Hazardous Waste Generation from Routine Operations, 1993 – 2003.

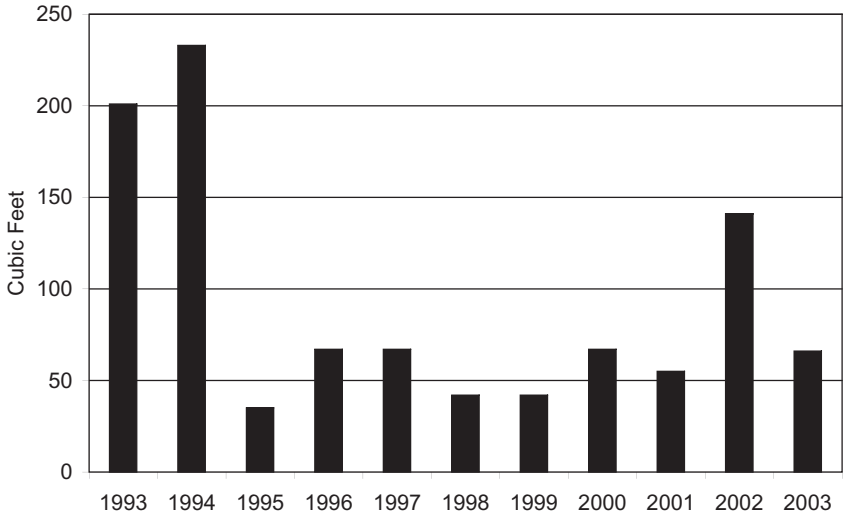

Figure 2-1b.
Mixed Waste Generation from Routine Operations, 1993 – 2003.

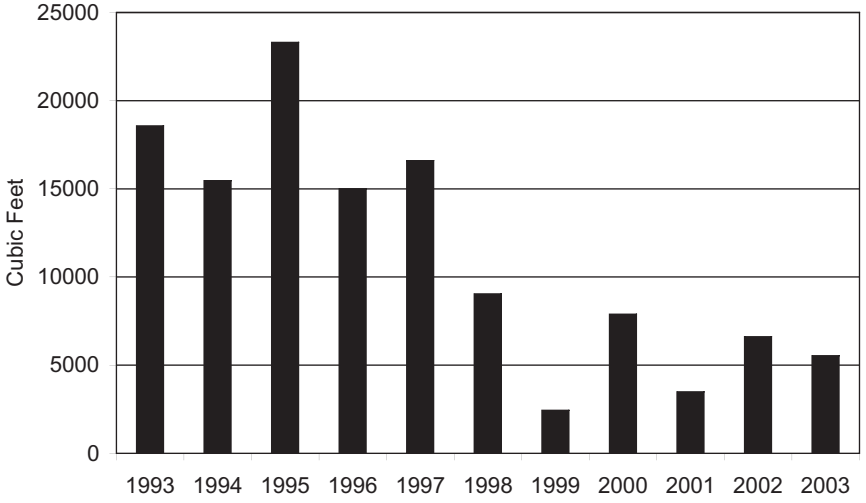

Figure 2-1c.
Radioactive Waste Generation from Routine Operations, 1993 – 2003.

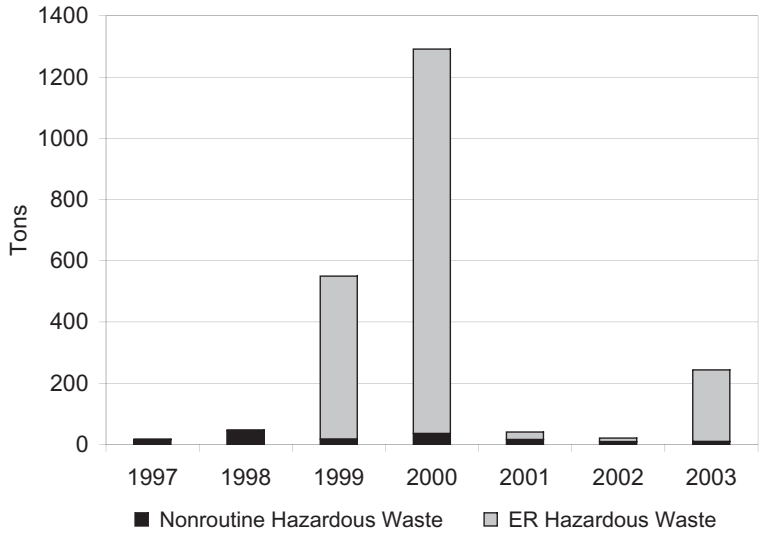

Figure 2-1d.
Hazardous Waste Generation from ER and Nonroutine Operations, 1997 – 2003.

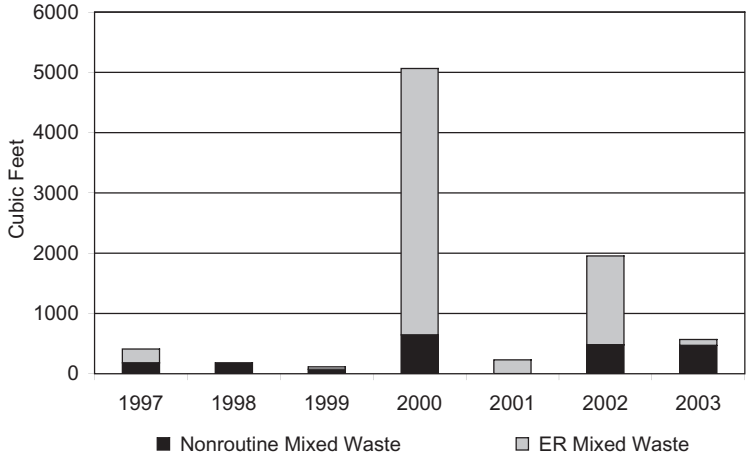

Figure 2-1e.
Mixed Waste Generation from ER and Nonroutine Operations, 1997 – 2003.

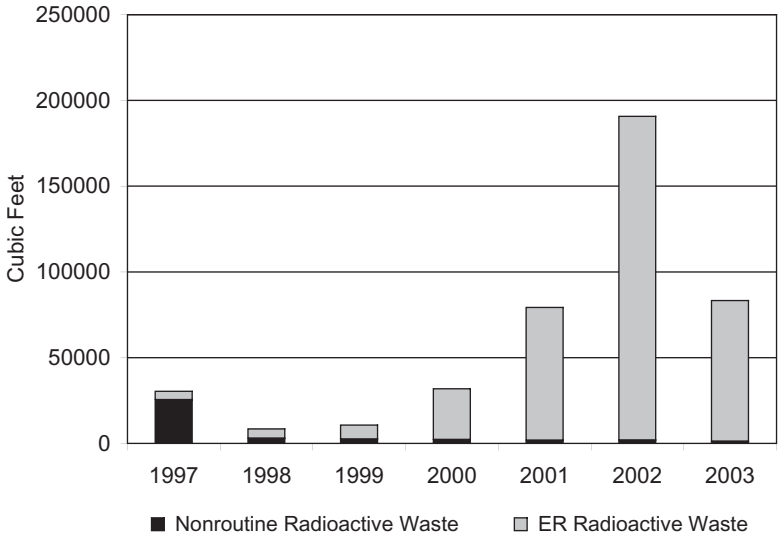

Figure 2-1f.
Radioactive Waste Generation from ER and Nonroutine Operations, 1997 – 2003.

2.3.4.4 Pollution Prevention and Minimization

The BNL Pollution Prevention (P2) Program is an essential element for 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.

DOE has incorporated pollution prevention and waste reduction goals into its contract with Brookhaven Science Associates (BSA). BSA recognizes its environmental stewardship responsibilities, the importance of stakeholder concerns, and the potential for savings, and has incorporated pollution prevention elements into its Environmental Stewardship Policy and the critical outcomes associated with the operating contract. 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 ("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 outreach and awareness of P2 goals, plans, and progress.

Proposals for funding pollution prevention opportunities are submitted to the BNL P2 Council. In January 2003, the P2 Council announced the winners of the "Return on Investment" funding competition. In FY03, the P2 Council funded eight proposals, investing approximately $96,000. The savings generated by these projects is estimated at $88,000, for an average payback period of 1.2 years.

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 work planning process. These positive trends are also driven by the ISO 14001 EMS's emphasis on preventing pollution and establishing objectives and targets to reduce environmental impacts.

Implementation of pollution prevention opportunities, recycling programs, and conservation initiatives has significantly reduced both waste volumes and management costs. By 2003, these efforts had resulted in more than $1.5 million in cost avoidance or savings and approximately 2.3 million pounds of materials being reduced, recycled, or reused. Table 2-2 describes the projects that were implemented through 2003 and includes the number of pounds of materials reduced, reused, or recycled and the estimated cost benefit of each project.

BNL also has an active and successful solid waste recycling program. The on-site recycling program involves all employees. In 2003, BNL collected more than 182 tons of paper for recycling. In addition to paper, the program recycles cardboard, bottles and cans, construction debris, motor oil, scrap metals, lead, automotive batteries, printer and toner cartridges, fluorescent light bulbs, machine coolant, and antifreeze. Table 2-3 shows the total number of tons (or units) of the materials recycled through 2003.

2.3.4.5 Water Conservation

BNL has a strong water conservation program and 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 systems, and reuse of once-through cooling water for other systems such as cooling towers. BNL's goal is to reduce the consumption of potable

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

Waste Description	Project Type	Pounds Saved* in 2003	Waste Type	Potential Cost for Status Quo	Cost of Recycle, Prevention	Estimated Cost Savings	Project Description Details **
Radioactive Waste	Source Reduction	1,500	Radioactive Waste	$6,000	$2,500	$6,000	Waste Yard sorting table surveying to sort clean waste from radioactive waste.
Radioactive Emissions	Emission Reduction	0	Radioactive Emissions	TBD in 2004 after data are analyzed	$13,400	$0	Installation of a shroud to fit over the 16-in. diameter shaft within the BLIP hot cell, thereby isolating the 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 to the exhaust stack because these radionuclides have very short half lives.
Waste generated through wet chemistry	Waste Minimization	30	Mixed waste/ Liquid Radioactive Waste	$17,600	$20,000	$22,500	Elimination of mixed waste with a Kinetic Phosphorescence Analyzer (KPA) system for uranium analysis. Eliminates mixed waste generation, reduces the volume of liquid waste by 90%, reduces the amount of radioactive material handled in the laboratory by 90%, minimizes exposure of Laboratory personnel to uranium, and decreases total labor time by 75%.
Waste from labeled chemicals	Waste Minimization/ Volume Reduction	0	Solid Radioactive Waste	$2,168	$3,795	$2,168	Vial crusher for glass vials, pipettes, and other glassware.
Waste from radio-labeled chemicals	Waste Minimization	112	Mixed Waste	$27,690	$35,000	$27,690	Microplate scintillation counter for a reduction in mixed waste generation.
Pump Oil	Substitution	51	Hazardous / Industrial Waste	$3,520	$6,000	$3,520	Replaced oil-displacement pumps with dry pumps.
Photographic Waste	Substitution	3,840	Hazardous / Industrial Waste	$7,600	$13,860	$16,489	New photographic processor reduces the amount of chemicals used and waste generated by up to 80%.
Electrophoretic Mini-Gels	Microscale Chemical Use	2,200	Hazardous Waste (Lab Pack)	$10,400	$0	$10,400	Minimization of 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	1,000	Industrial Waste	$17,000	$0	$17,000	Retrofit of garbage truck hydraulics with steel-braded hydraulic lines and a vegetable based hydraulic oil; this project will reduce the number of reportable spills and subsequent cleanup costs ($15,000).
Hydraulic Oil	Product Substitution	3,000	Industrial Waste	$26,000	$0	$26,000	Retrofit of hydraulic lift bays in Motor Pool Shop to vegetable-based hydraulic oil; this project minimized the potential for petroleum-based hydraulic oil leaks/ spills and subsequent cleanup costs ($20,000).

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

Waste Description	Project Type	Pounds Saved* in 2003	Waste Type	Potential Cost for Status Quo	Cost of Recycle, Prevention	Estimated Cost Savings	Project Description Details **
Sewage Sludge	Volume Reduction	234,000	Radioactive Waste	$910,000	$193,400	$716,600	60,000 gal of radioactive STP liquid waste could have been disposed of through a contractor at a cost of $910,000. Instead, the waste was dried using rolloffs, absorbent, and lime and sent for disposal via rail cars. In addition, a second drying bed was built to dry sludge (96% volume reduction) from the anaerobic sludge digester.
CO2 Snow Cleaning	Source Reduction	0	Hazardous Waste/ Industrial Waste	$5,000	$0	$0	Equipment purchased to evaluate CO2 Snow Cleaning for NSLS, Instrumentation, and Collider-Accelerator Department applications; this project has the potential to reduce solvent usage (hazardous waste), and aqueous cleaning wastes (industrial waste). Limited success due to moisture condensation.
Film and other radioisotopic imaging waste	Substitution	300	Hazardous Waste/ 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 pounds and industrial waste generation by 100 pounds. There are additional projected savings in annual supply costs ($3,000) and labor reduction ($15,000).
Digital Imaging System waste	Substitution	282	Hazardous, Radioactive, and Industrial Waste	$25,000	$0	$25,000	Reduction of hazardous (134 lbs), radioactive (80 lbs), and industrial waste (68 lbs) with a digital imaging system. There are additional projected savings in annual supply costs ($3,000) and labor reduction ($20,000).
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) to replace current 32P assay.
Photographic Waste	Segregation	2,320	Hazardous Waste	$5,500	$0	$5,500	Photography and Graphic Arts Division implemented a pollution prevention project that segregates hazardous fixer from non-hazardous developer; this reduced the hazardous waste stream by approximately 2,320 lbs.
Photographic waste from X-ray film processor	Source Reduction	765	Hazardous Waste	$3,115	$0	$3,115	The X-ray film processor at the clinic was replaced with a more efficient processor, reducing hazardous waste generation by 90 gal/yr; this avoids the cost of disposal (765 lbs) and saves $1,585 from reduced labor.
Photoresist waste	Source Reduction	500	Hazardous Waste	$1,000	$0	$1,000	A fully aqueous developer solution was installed in the printed circuit laboratory for processing dry film photoresist. The system replaced a solvent-based process that formerly generated approximately 500 lbs of hazardous waste annually.

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

Waste Description	Project Type	Pounds Saved* in 2003	Waste Type	Potential Cost for Status Quo	Cost of Recycle, Prevention	Estimated Cost Savings	Project Description Details **
Heavy metal solutions from crystallography experiments	Source Reduction	10,200	Hazardous Waste	$26,400	$0	$26,400	Installed a xenon pressure cell to allow preparation of samples for protein crystallography without the use of toxic heavy metal solutions. The project is estimated to eliminate 1,200 gal of heavy metal hazardous waste (10,200 lbs). Additionally, approximate $6,000 in savings is estimated from reduced labor and handling.
Lead Acid Batteries	Recycled	9,200	Hazardous Waste	$18,400	$0	$18,400	Estimate 40 lbs/battery and avoided disposal costs as hazardous waste.
Ion Exchange Wastewater	Source Reduction	1250	Hazardous and Sanitary Wastewater	$2,500	$100	$2,400	Prefilters were added to the deionization system to polish makeup water entering the ion exchange system; this extended the useful life of the ion exchange resins, requiring less frequent regeneration. The regeneration process generates hazardous and sanitary wastewaters.
Tritium Exit Signs	Source Reduction	724	Mixed Waste	$152,040	$6,000	$146,040	Removed 28 tritium Exit signs from service and returned them to the manufacturer. Replaced the Exit signs with energy-efficient light emitting diode (LED) signs; project reduced risk of tritium gas release and avoided disposal as mixed waste (70 ft^3).
Cooling Water	Reuse	153,000	Radioactive Waste	$153,000	$0	$153,000	Approximately 18,000 gal (153,000 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	625	Radioactive Waste	$380	$0	$380	Short half-life isotopes, particularly phosphorus-32 and phosphorus-33, are frequently used in life sciences experiments. Wastes generated from these operations (14.5 ft^3 solids and 6 gal liquids) were managed in accordance with BNL decay-in-storage requirements, rendering the wastes eligible for volumetric release.
Oily Waste Water	Source Reduction	6,240	Industrial Waste	$20,280	$0	$20,280	Installed automatic oil-water separators on compressor blowdown stations. These units capture the oily discharge and save significant labor hours compared to the previous system. Labor savings is estimated at $7,800/yr.
Lubricating Oil	Energy Recovery	8,000	Industrial Waste	$16,500	$500	$16,500	Approximately 1,000 gal of lubricating oils were collected, tested for suitable use as waste oil fuel, and used for energy production at the Central Steam Facility. Cost of analysis is estimated at $500. The fuel use savings are estimated at $50/gallon.

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

Waste Description	Project Type	Pounds Saved* in 2003	Waste Type	Potential Cost for Status Quo	Cost of Recycle, Prevention	Estimated Cost Savings	Project Description Details **
Cooling Tower Chemicals	Source Reduction	6,375	Industrial Waste	$15,000	$0	$15,000	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. Savings are estimated at $15,000/yr.
Hydraulic Oil	Source Reduction	6,000	Industrial Waste	$33,000	$0	$33,000	Replaced hydraulic lines on heavy equipment with steel-braided lines and replaced the petroleum-based hydraulic oils with bio-based vegetable oils. Hydraulic line breaks were responsible for a significant number of reportable spills and costly response and cleanup. This project reduced the frequency of spills and resulting response and cleanup costs. The biodegradable vegetable oil is subject to fewer reporting requirements. Avoided disposal costs are based on 6,000 lbs of industrial waste and savings from reduced response and cleanup costs are estimated at $33,000.
Blasocut Machining Coolant	Recycled/Reused	40,240	Industrial Waste	$80,480	$0	$92,780	The Central Shops Division operates a recycling system that reclaims Blasocut machining coolant and supplies it Laboratory-wide. 8,180 gal (65,440 lbs) of Blasocut lubricant were recycled in 2002. Recycling involves aeration, centrifuge, and filtration. Avoids cost of disposal as industrial waste plus an avoided cost of procurement of 6 drums of concentrate ($800/drum) and 150 drums for waste ($50/drum). The cost of recycle is estimated to be the same as cost of procurement and preparation of proper dilution for use.
Used Motor Oil	Energy Recovery	31,360	Industrial Waste	$67,470	$0	$67,470	Used motor oil from the motor pool and the on-site gas station is picked up free of charge by Strebel's Laundry Service and used to fire their waste oil dryers. In 2002, 4,655 gal of oil were picked up, avoiding cost for disposal and shipping of 95 drums ($50/drum).
Office Paper	Recycled	364,000	Sanitary Waste	$14,560	$0	$14,560	Estimate $80/ton for disposal as trash.
Cardboard	Recycled	352,000	Sanitary Waste	$14,080	$0	$14,080	Estimate $80/ton for disposal as trash.
Scrap Metal	Recycled	386,000	Sanitary Waste	$15,440	$0	$15,440	Estimate $80/ton for disposal as trash.
Bottles/Cans	Recycled	46,000	Sanitary Waste	$1,840	$0	$1,840	Estimate $80/ton for disposal as trash.
Construction Debris	Recycled	668,000	Sanitary Waste	$8,350	$0	$8,350	Estimate $25/ton for disposal as trash.
	TOTALS	2,339,314			$294,555		

Notes:
* Pounds saved = Disposal avoided by reduction, reuse, recycling, or conservation.
** Cost savings of projects funded by the BNL Pollution Prevention Council will be tracked for 3 years.
TBD = To be determined

Table 2-3. BNL Recycling Program Summary.

Recycled Material	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Mixed paper	155	136	197	220	106	196	204	370	336	246	209	182
Cardboard	21	81	164	85	101	103	97	124	132	127	157	176
Bottles/Cans	12	12	18	11	15	21	22	21	20	29	19	23
Tires	9	21	7	11	17	18.6	11.5	15.2	0	0	3.5	12.3
Construction debris	809	495	495	627	837	799	527	352	243	289	304	334
Used motor oil (gallons)	–	–	4,000	3,350	4,275	4,600	3,810	3,570	3,295	3,335	1,920	3920
Metals	201	210	33	153	158	266	64	47	534	38	48	193
Lead	–	–	–	–	–	4.4	3.7	0.7	2.5	–	–	–
Automotive batteries	–	5	0.81	0.72	6.8	4.3	2.1	1.1	2.2	4.8	6.3	4.6
Printer/Toner cartridges (units)	–	–	–	–	–	–	1480/175	1575/510	–	363	449	187
Fluorescent bulbs (units)	–	–	–	–	13,664	12,846	867	25,291	5,874	17,112	25,067	13611
Blasocut coolant (gallons)	–	–	–	–	–	–	–	3,575	7,500	10,660	8,180	5030
Antifreeze (gallons)	–	–	–	–	55	276	448	145	110	200	0	165
Tritium Exit signs (each)	–	–	–	–	–	–	–	–	185	190	28	181
Smoke detectors	–	–	–	–	–	–	–	–	–	171	40	0

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

water and reduce the possible impact of clean water discharges on Sewage Treatment Plant operations. Figure 2-2 shows the 9-year trend of water consumption. In 2003 (as in 2002), BNL used approximately half as much water as in 1995—nearly 700 million gallons less, in each of those years.

2.3.4.6 Energy Management and Conservation

BNL's Energy Management Group has been in place since 1979. This group works to reduce energy use and costs by identifying cost-effective, energy-efficient projects, by monitoring energy use and utility bills, and by assisting in obtaining the least expensive energy sources possible. The group is responsible for developing, implementing, and coordinating BNL's Energy Management Plan (BNL 2003a).

BNL 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 2003, BNL used approximately 290 million kilowatt hours (kwH) of electricity, 4.7 million gallons of fuel oil, 39.4 thousand gallons of propane, and 568 thousand cubic feet of natural gas. Fuel oil and natural gas produce steam at the Central Steam Facility. Fuel oil use increased in 2003, due to a larger number of heating degree days, but favorable market conditions resulted in a cost savings of approximately $1 million. See additional information on fuel use in Chapter 4.

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 2003, participation in this program produced a rebate of $65,000. The Laboratory's participation is significant to LIPA: BNL's portion represents more than 12 percent of the 95-megawatt load-curtailment program total, making the Laboratory the single largest program contributor. In 2003, additional projects for energy reduction included lighting improvements in

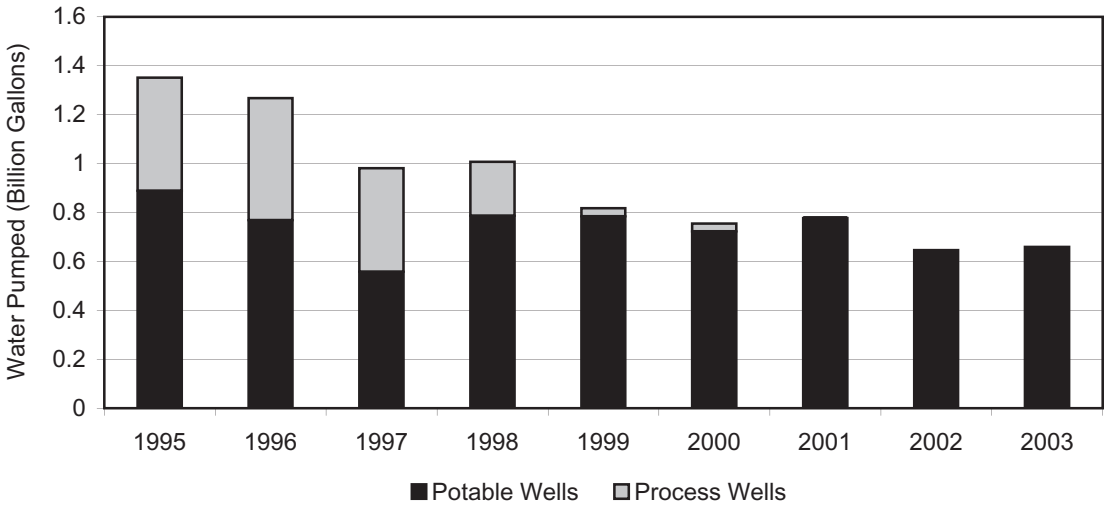

Figure 2-2. BNL Water Consumption Trend.

Buildings 510 and 515 that are expected to generate an estimated savings of $10,000.

The National Energy Conservation Policy Act, as amended by the Federal Energy Management Improvement Act of 1988 and the Energy Policy Act of 1992, 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 1985, by 20 percent in 2000, 30 percent by 2005, and 35 percent by 2010. BNL energy use per square foot in 2003 is 23 percent less than in 1985 (see Figure 2-3).

BNL also maintains a contract with New York Power Authority (NYPA), resulting in an overall cost avoidance of $15 million. Participation in NYPA's 2003 Load Curtailment Program produced a rebate worth $1 million. BNL will continue to seek out alternative energy sources to meet its future energy needs, support federally required "green" initiatives, and reduce energy costs.

2.3.4.7 Natural and Cultural Resource Management

The Laboratory continues to develop, enhance, and implement its Natural Resource Management Program, building on a foundation established by the Wildlife Management Plan (Naidu 1999). BNL has begun to develop a Cultural Resource Management Program 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 on December 11, 1980. As part of CERCLA, EPA established the National Priorities List (NPL), which identifies sites where cleanup of past contamination is required. BNL is listed on the NPL, with 27 other Long Island sites, 12 of which are in Suffolk County (see http://www.epa.gov/superfund/sites/npl/ny.htm).

Each step of the Superfund cleanup process is reviewed and approved by DOE, EPA, and NYSDEC, under a contract called the "Interagency Agreement." This agreement was formalized in 1992. Most of the contamination at BNL 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 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

The BNL site was initially divided into seven Operable Units (OUs), some of which were later combined (OU I/VI and OU II/VII). Significant progress was made in environmental restoration in 2003. Table 2-4 provides a description of each OU and a summary of environmental restoration actions taken during 2003. The goal of BNL's ER Program is to complete cleanup activities and install all groundwater treatment systems by 2006 (see Chapter 7 for further details).

2.3.4.9 The Facility Review Project

The Facility Review Project was a comprehensive examination of all site facilities, existing or demolished, to identify any past or current activities with the potential to degrade the environment. During this project, BNL reviewed the entire operating history of the site and more than 900 systems, facilities, and operations. This review included tanks, pipes, sumps, cesspools, storage areas, historical discharges, and current and past operating practices. Personnel from other DOE facilities provided high-level technical and management support during the review. A final report was issued on October 7, 1998 (BNL 1998).

The report identified 75 issues as having the highest priority, due to their potential to contaminate groundwater above drinking water standards. Additionally, more than 1,675 issues that had the potential to impact the environment were identified as needing further evaluation and then subdivided into operational and legacy issues. In March 2000, a plan (BNL 2000) for the Facility Review Disposition Project (FRDP) was approved. This three-year project provided the mechanisms needed to risk-rank, schedule, and resolve the issues identified during the Facility Review Project.

In 2003, a Final Report for the Facility Review Disposition Project was prepared (BNL 2003a). The report described the methods and processes used to deal with the 2,216 issues identified during the FRDP. In addition, a Memorandum of Understanding (MOU) was drafted on December 23, 2003, transferring the

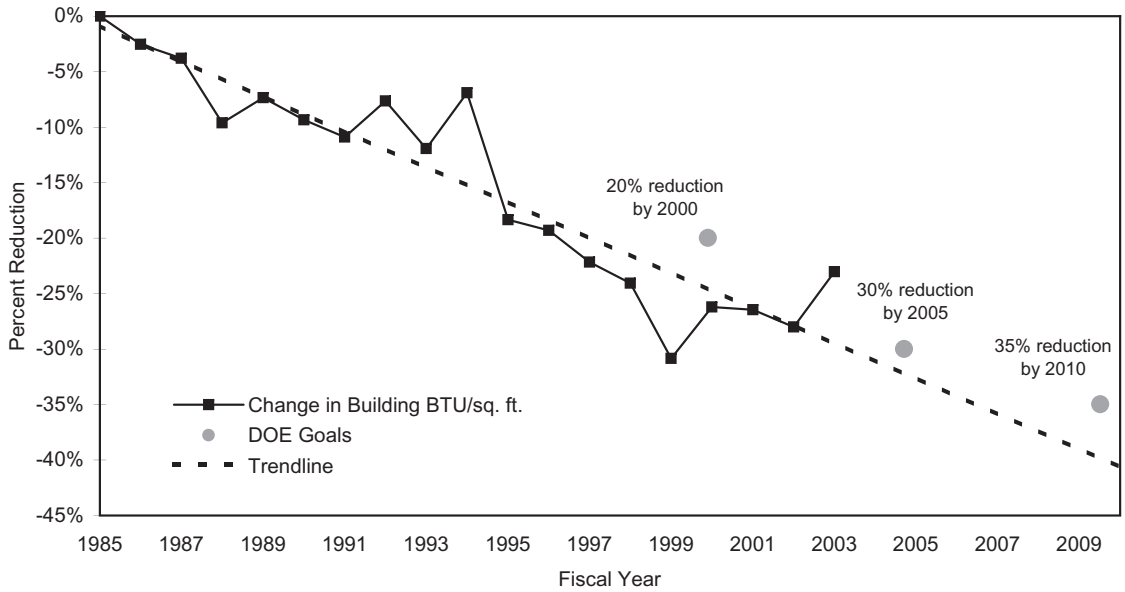

Figure 2-3. BNL Building Energy Performance, 1985 – 2010.

Table 2-4. Summary of BNL 2003 Environmental Restoration Activities.

Project	Description	Environmental Restoration Program Actions
Soil Projects	OU I OU II OUVII	▪ Completed the remediation of the Ash Pit with the installation of a soil cap. ▪ Completed the Meadow Marsh remediation that maintained a Tiger Salamander habitat. ▪ Completed the decontamination and decommissioning of nine buildings in the former hazardous waste management facility. ▪ Completed the decontamination and decommissioning of the Building 811 evaporator system.
Groundwater Projects	OU III	▪ Completed construction and began operations of an on-site groundwater treatment system Pilot Study for Sr-90 at the Chemical Holes area. ▪ Performed pre-design characterization, groundwater modeling, and initiated the design for the on-site Sr-90 treatment system for the BGRR/Waste Concentration Facility groundwater plumes. ▪ Completed construction of an off-site groundwater treatment system at the eastern portion of the Industrial Park for volatile organic compounds (VOCs). ▪ Issued the final designs and began construction of four additional off-site groundwater treatment systems for VOCs in East Yaphank and Manorville. ▪ Continued monitoring of the HFBR tritium plume. ▪ Continued characterization and monitoring of tritium in groundwater from g-2 activated soil. Further preparation and review of the Engineering Evaluation and Cost Analysis was postponed pending collection of additional data. (This is not included under any specific OU at this time but it is an AOC.) ▪ Successfully completed property access negotiations with seven off-site property owners for the installation and operation of the planned groundwater treatment systems. ▪ During 2003, 1.3 billion gallons of groundwater were treated and 510 pounds of VOCs were removed. Since the first groundwater treatment system started operating in December 1996, approximately 4,200 pounds of VOCs have been removed from more than 5 billion gallons of groundwater.
	OU IV	▪ Regulators approved a petition for system closure of the OU IV air sparge and soil vapor extraction soil and groundwater treatment system. The system was subsequently dismantled. ▪ The Five-Year Review Report for OU IV was approved by the regulators and submitted to the information repositories for public availability. ▪ Continued groundwater monitoring.
	OU VI	▪ Continued monitoring the ethylene dibromide plume. ▪ Issued the final design and began construction of the off-site groundwater treatment system in Manorville for ethylene dibromide. ▪ Successfully completed property access negotiations with two off-site property owners for the installation and operation of the planned groundwater treatment system.
	Groundwater Monitoring	▪ Completed the BNL 2002 Groundwater Status Report. ▪ Collected and analyzed 2,510 groundwater samples from 629 monitoring wells. ▪ Updated Environmental Monitoring Plan groundwater chapter.
Peconic River	OU V	▪ Completed the Sewage Treatment Plant Sand Filter Beds and Berms Project. Approximately 1,320 cubic yards of soil was shipped to Envirocare. ▪ Shipped approximately 1,500 cubic yards of contaminated sediment from the Peconic River Pilot Study project to Envirocare. ▪ Completed the Pre-Design Sampling and Analysis program for the Peconic River remediation project. An Action Memorandum for on-site cleanup was approved.
Reactors	BGRR	▪ Completed the draft Characterization of Building 701 Aboveground Surfaces, Systems, and Structures Report. ▪ Completed the Characterization Report on the Building 701 Belowground Structures, 702 Pile, and Remaining Soils. ▪ Began removal of the below grade duct filters and primary liner.
	HFBR	▪ Continued Long Term Surveillance and Maintenance Activities.
	BMRR	▪ Completed fuel removal.

responsibility for management of FRDP follow-up activities to the Environmental and Waste Management Services Division. These activities include closure of the remaining 36 open issues, tracking and ultimate disposition of all 332 transferred issues, and maintenance of the database and website for the project.

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. Every BNL employee is required to develop a Roles, Responsibilities, Accountabilities, and Authorities document signed by the employee, his or her supervisor, and the supervisor's manager. Specifics on environment, safety, and health performance expectations are included in this document.

BSA has clearly defined expectations for staff and management. Under the BSA performance-based management model, senior management has communicated their expectation that all line managers and staff take full responsibility and be held accountable for environmental, safety, and health 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 in place, thus ensuring that all personnel are aware of their environmental responsibilities.

2.4.2 Communication and Community Involvement

When BSA was awarded the contract to manage BNL in 1998, they made a commitment to establish an effective partnership among DOE, the Laboratory, and community members to address issues that affect the community's quality of life. At the core of the Laboratory's communication and community-involvement programs are two documents: the Environmental Stewardship Policy and the Community Involvement Plan (BNL 1999).

The Environmental Stewardship Policy is the Laboratory's commitment to maintain a positive, proactive, and constructive relationship with the community and regulators, and to promote open communication on environmental performance. Written with input from both internal and external stakeholders, the Community Involvement Plan documents BSA's commitment to ensure that: it will keep the public informed of issues; it will actively seek and consider input from regulators, stakeholders, and the general public; and it will continue to provide opportunities for an open exchange of information, knowledge, and concerns.

The Laboratory continues efforts to build positive relationships with regulatory agencies by sharing information and working to resolve issues on plans, priorities, and corrective actions. BNL meets regularly with regulators from the New York State Department of Environmental Conservation (NYSDEC), U.S. Environmental Protection Agency (EPA) Region II, and the Suffolk County Department of Health Services (SCDOHS). A SCDOHS inspector has a permanent office on site.

Another forum for communication is the Brookhaven Executive Roundtable, which was established by DOE in August 1997 and includes staff from the offices of local, state, and federal elected officials, regulatory agencies, and representatives from DOE and the Laboratory. Members are updated on the Laboratory's science initiatives, operations, and environmental issues at bimonthly meetings.

In addition, the Community Advisory Council (CAC) was established in September 1998, and consists of representatives from different stakeholder groups, including civic, business, union, health, education, employee, and environmental organizations. The CAC meets monthly and sets its own agenda in cooperation with the Laboratory to discuss issues regarding environmental remediation activities, including groundwater cleanup, the final disposition of the Brookhaven Graphite Research Reactor

(BGRR), and plans for cleaning up portions of the Peconic River. Feedback and recommendations from the CAC on issues that are of concern to the community are considered in the Laboratory's decision making.

In 2003, the CAC advised the Laboratory Director of the community's priorities regarding the cleanup of the Peconic River, as well as the cleanup of the Magothy Aquifer on and off the Laboratory site. Also in 2003, to gain a better understanding of the topics the CAC is considering, they hosted a panel discussion with EPA, NYSDEC, and SCDHS representatives, as well as a presentation on cleanup remedies by a consultant to Neighbors Expecting Accountability and Remediation (NEAR). Due to their interest in BNL's Pollution Prevention Program, the CAC plans to host a Pollution Prevention Workshop at BNL in April 2004.

Through working groups, roundtables, and one-on-one interactions with BNL managers and subject-matter experts, stakeholders are provided with many other opportunities to learn about and provide input on issues of importance to them. In 2003, BNL reached out to the public through briefings to local civic and community groups; meetings with and presentations to local, state and federal regulators, and elected officials; canvassing of community members; and regular interactions with nearby businesses and local educators.

Laboratory employees and retirees, who are well educated and up to date on current issues at BNL, regularly interact with their neighbors and community groups, thereby acting as the Laboratory's envoys. They provide information about Laboratory science, gather feedback, and respond to concerns.

During 2003, BNL hosted more than 29,000 visitors to the Laboratory site, including students, teachers, and other community members who participated in "Summer Sunday" open houses, science-museum visits, tours for students from high school through college, and other outreach programs. One Summer Sunday was devoted to increasing the community's awareness of the local environment through activities, demonstrations, information dissemination, and displays. During this event, visitors learned about the Laboratory's research initiatives in energy conservation and energy alternatives, such as fuel cells, improved residential oil burners, and alternative-fuel vehicles.

The Laboratory maintains an informative website at http://www.bnl.gov; issues press releases; and publishes *The Bulletin* (a weekly employee newsletter), *discover Brookhaven* (the Laboratory's science magazine), *cleanupdate* (a periodic newsletter on environmental cleanup), *Laboratory Link* (a monthly brief on research activities), and e-mail updates to keep the public and employees informed about the Laboratory's research, activities, and issues, including those concerning the environment.

In 2003, BNL celebrated Earth Day with a variety of activities involving BNL staff and the community, including environmental awards, a student art contest, a 4-mile running race, and an on-site office-supply swap event. The Laboratory also participated with other local organizations and businesses in the nearby Heckscher State Park Spring Festival, using interactive displays to promote environmental awareness. BSA contributed corporate funds in support of these events as part of their commitment to environmental stewardship.

2.4.3 Monitoring and Measurement

Effluent and emissions 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. This program identifies potential pathways for exposure of the public and the environment, as well as evaluating what impact BNL activities may be having on the environment. It also 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 the review of previous analytical results. As required under DOE Order 450.1, BNL's Environmental Monitoring Plan, Triennial Update (BNL 2003b) outlines annual sampling

goals by media and frequency. The 2003 plan also specifies the data quality objectives associated with the monitoring program.

There were 6,189 sampling events of groundwater, potable water, precipitation, air, plants and animals, soil, sediment, and discharges in 2003 under the Environmental Monitoring Program, as shown in Table 2-5. This does not include samples taken to characterize waste for disposal purposes or nonroutine samples collected in support of restoration characterization activities. 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 Central Steam Facility. Real-time, continuous emission monitoring equipment is installed and maintained at some of these facilities or samples are collected and analyzed periodically to ensure compliance with regulatory requirements. Analytical data are routinely reported to the permitting authority. See Chapter 3, Section 3.5 for details.
- *Wastewater discharge monitoring* is performed at the point of discharge to ensure that the effluent complies with release limits in BNL's State Pollutant Discharge Elimination System (SPDES) permits. Nineteen point-source discharges are monitored under the BNL program: seven 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, or radiological parameters. Monthly reports that provide analytical results and an assessment of compliance for that reporting period are filed with the permitting agency. See Chapter 3, Section 3.6 for details.
- *Groundwater monitoring* is also performed in accordance with permit requirements. Specifically, monitoring of groundwater is required under the Major Petroleum Facility License for the Central Steam Facility, and the RCRA permit for the Waste Management Facility. Extensive groundwater monitoring is also conducted under the ER program as required under the Records of Decision for many of the Operable Units or Areas of Concern (see Chapter 7 for details). Additionally, to ensure that the Laboratory maintains a viable potable water supply, groundwater is monitored as required by the New York State Department of Health.

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 that 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.

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

Table 2-5. Summary of BNL 2003 Sampling Programs Sorted by Media.

Environmental Media	No. of Sampling Events*	Purpose
Groundwater	2,817	To evaluate impacts of past and present operations on groundwater quality, under the Environmental Restoration, Environmental Surveillance, and Compliance programs.
On-site recharge basins	150	Recharge basins used for wastewater and stormwater disposal are monitored in accordance with discharge permit requirements and for environmental surveillance purposes.
Potable water	193	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 and for environmental surveillance purposes.
Sewage Treatment Plant	416	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 and direction, temperature, and atmospheric stability, to help model atmospheric transport and diffusion of radionuclides.
Air – Tritium	235	Silica gel cartridges are used to collect atmospheric moisture for subsequent tritium analysis. These data are used to assess environmental tritium levels. Due to several years of nondetectable measurements and the shutdown of the HFBR, monitoring was reduced from weekly to monthly in several areas of the site in 1999. See discussion in Chapters 4 and 8.
Air – Particulate	409	Gamma analysis is performed on samples of particulate matter collected from air samples. The purpose is to look for any impact from BNL operations.
Air – Charcoal	102	Charcoal samples are used to assess for radioiodines, which could be a byproduct of the production of radiopharmaceuticals.
Fauna	93	Fish, deer, and small mammals are monitored to assess impacts on wildlife associated with past (or current) BNL operations.
Flora	21	Since the primary pathway from soils to fauna is via ingestion, vegetation is sampled to assess possible uptake of contaminants by plants and hence to fauna.
Soils	1,634	Soil samples are collected from adjacent farms and other local areas to confirm that Laboratory emissions have no impact on surrounding areas. Soil samples are also collected as part of Environmental Restoration investigative work.
Miscellaneous	111	Samples are collected periodically from manholes and other locations to assess compliance with regulatory requirements.
Total number of sampling events	6,189	This number includes all the samples identified in the EMP (BNL 2003), plus samples collected by the field sampling team as special requests. The number does not include samples collected to monitor Environmental Restoration projects and air and water treatment system processes, waste generators, or Environmental Compliance Representatives for waste characterization purposes.

Note:
* In one sampling event, multiple samples may be collected from a single location. For example, during one sampling event, separate samples for tritium, gross alpha and beta, and VOCs may be collected from a groundwater monitoring well.

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 by thermoluminescent dosimeters (devices to measure radiation exposure) on and off site are routinely reviewed under this program.

Control samples (also called background or reference samples) also are collected on and off the site to compare BNL results to areas that could not have been impacted 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 EMS is operating as intended, audits are conducted. These audits are part of the Laboratory's Self-Assessment Program and are designed to ensure that any nonconformance to the ISO 14001 Standard is identified and addressed. An independent, accredited registrar also conducts annual ISO 14001 registration audits. 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 ISO 14001 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. Environmental experts routinely participate in these assessments. Management also conducts assessments to evaluate Laboratory 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. Laboratory management also routinely evaluates progress on key environmental improvement projects. BNL periodically coordinates with the local DOE office to 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 staff who do not have line responsibility for the work processes. 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. Staff from the offices of Battelle Memorial Institute and BSA subcontractors also perform periodic independent reviews. An independent third party conducts ISO 14001 registration audits of the Environmental Management System.

In July 2003, an ISO 14001 EMS Surveillance Audit was conducted by NSF-ISR, an independent and accredited ISO 14001 registrar. The independent registrar determined that BNL's EMS remains in conformance with the ISO 14001 standard. The auditors identified two minor nonconformances, two opportunities for improvement, and strong evidence of

continuous improvement. A corrective action plan that BNL prepared for the minor nonconformances was tracked to closure.

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 TODAY

BNL has unprecedented knowledge of its potential environmental vulnerabilities and current operations due to programs such as the Facility Review Project, process evaluations, the work planning and control system, and the management systems for groundwater protection, environmental restoration, and information management. Compliance assurance programs are improving BNL's compliance status. 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 issues and progress. To regain and maintain stakeholder trust, BNL will continue to deliver on commitments and demonstrate real improvements in environmental performance. This annual Site Environmental Report is an important communication mechanism, as it summarizes BNL's environmental programs and performance for 2003. Additional information about BNL's environmental programs is available on BNL's website at http://www.bnl.gov. The Laboratory continues to pursue other mechanisms to communicate data in a more user friendly, visual, and timely manner.

The existing BNL Environmental Management System is viewed as exemplary within DOE. BNL was the first DOE Office of Science national laboratory to obtain third-party registration to ISO 14001. Due to external recognition of BNL's knowledge and unique experience implementing the ISO 14001 EMS program, several DOE facilities and private universities have invited BNL to extend its outreach activities and share its experiences, lessons learned, and successes. As noted above, 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 evaluations, BNL has an improved 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 environmental goals and critical outcomes. 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, and visiting scientists.
- 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 penetration of the EMS throughout organizations, and cultural change has been sweeping.

For more than 50 years, the unique, leading-edge research facilities 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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Compliance Status

3

Brookhaven National Laboratory (BNL) is subject to more than 100 sets of federal, state, and local environmental regulations; numerous site-specific permits; equivalency permits for operation of nine groundwater remediation systems; and several other binding agreements. In 2003, BNL operated in compliance with the majority of these requirements, and programs are in place to address areas for continued improvement. Routine inspections conducted during the year found no significant instances of noncompliance.

Emissions of nitrogen oxides, carbon monoxide, and sulfur dioxide were all within permit limits. Approximately 3,900 pounds of ozone-depleting refrigerants were recovered for recycling. Monitoring of the BNL potable water system showed that the potable water supply met all drinking water requirements. Groundwater monitoring at the Major Petroleum Facility continued to demonstrate that current oil storage and transfer operations are not affecting groundwater quality. During 2003, liquid effluents discharged to surface water and groundwater met all applicable New York State Pollutant Discharge Elimination System permit requirements with the exception of one excursion at the Sewage Treatment Plant and three at other outfalls. The four permit excursions were reported to the New York State Department of Environmental Conservation (NYSDEC).

Twenty-two reportable spills of petroleum products or antifreeze occurred on site in 2003. Twelve were petroleum releases less than 10 gallons, five were small-volume antifreeze spills, four were discovered during tank or elevator upgrades, and the last was a release of chilled water. All releases were cleaned up or addressed to the satisfaction of NYSDEC.

BNL underwent nine environmental audits by external regulatory agencies in 2003. These audits included inspections of petroleum 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. NYSDEC did not conduct a Resource Conservation and Recovery Act audit in 2003. A Notice of Complaint for issues identified during the 2002 audit was received in January 2003. All corrective actions were completed before the end of the year.

3.1 COMPLIANCE WITH REQUIREMENTS

BNL is subject to more than 100 sets of federal, state, and local environmental regulations; several site-specific permits; 13 equivalency permits for the operation of nine groundwater remediation systems; and several other binding agreements. The federal, state, and local environmental statutes and regulations that BNL op-

erates under are summarized in Table 3-1, along with a discussion of BNL's compliance status with regard to each requirement. A complete listing of all environmental regulations is contained in Appendix E.

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 NYSDEC
- Major Petroleum Facility (MPF) license, issued by NYSDEC
- Resource Conservation and Recovery Act (RCRA) permit issued by NYSDEC for the Waste Management Facility (WMF)
- 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 14 emissions units
- Five 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
- Thirteen equivalency permits for the operation of nine groundwater remediation systems installed under the Inter-Agency Agreement (Federal Facility Agreement under the Comprehensive Environmental Response, Compensation and Liability Act [CERCLA] 120, Admin. Docket No. II-CERCLA-FFA-00201)

3.2.2 New or Modified Permits and Requests

3.2.2.1 State Pollutant Discharge Permits

The SPDES permit authorizes discharges from the BNL STP to the Peconic River, and discharges of cooling water and stormwater to recharge basins. In 2003, there were two requests for SPDES permit modifications. The first, submitted in June, sought to discontinue the monitoring of wastewater discharges from Building 498 (Central Shops Cleaning Facility) for the presence of volatile organic compounds (VOCs). The cleaning process used there removes mill scale and residual oils from machined parts using mild acid, alkaline, citrus-based cleanser, and ultrasonic agitation, followed by hot water rinses. The hot wastewater results in the formation of air bubbles in the sample collection vials used for subsequent VOC analyses. The presence of air in the vials nullifies the analytical results. Since organic compounds have never been detected in the discharge, the Laboratory requested that monitoring be terminated. The second permit modification requested filtration of stormwater samples prior to acid preservation, to remove suspended particulates (see Section 3.6.2).

3.2.2.2 Air Emissions Permits

Air emissions permits are granted by NYSDEC. Permits are issued either as "equivalency" permits for restoration projects conducted under CERCLA, or as changes to the BNL Title V operating permit, which was issued in January 2002 and subsequently amended in November 2002. During 2003, no CERCLA equivalency permits were issued and no changes were made to the BNL 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. BNL 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 UIC wells (e.g., drywells, cesspools, and leaching pools). BNL received a final permit in January 2001. This permit authorizes the operation of 90 UICs, including 86 stormwater drywells and four small sanitary systems. Construction was completed on 12 new UIC devices in 2003. Applications for the installation of these devices were submitted to EPA in 2002. UICs also are used for the disposal of treated groundwater at many restoration facilities. In 2003, a formal registration program was initiated for UICs used in the restoration program. These devices are authorized by rule, as opposed to a permit, and an inventory of the devices is maintained with EPA. See Section 3.7.3 for more details.

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

Regulator: Codified Regulation	Regulatory Program Description	Compliance Status	Report Reference 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 was added to the National Priorities List. In 1992, BNL entered into a tri-party agreement among EPA, 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 High Flux Beam Reactor complex, Brookhaven Graphite Research Reactor complex, and World War I trenches have been determined to be eligible for inclusion in the National Register of Historic Places. Any activities involving these facilities are identified through the NEPA process and an evaluation is initiated to determine if the proposed action would impact features that extend eligibility to these facilities. Some activities associated with the decontamination and decommissioning of the BGRR were determined to impact its eligibility, and mitigative actions are proceeding according to a Memorandum of Agreement between DOE and NYSHPO. In December 2003, BNL submitted to DOE, a draft Cultural Resource Management Plan to ensure compliance with applicable cultural resource regulations.	3.4 6.9
U.S. Department of Interior 43 CFR 7	The **Archeological Resources Protection Act** (ARPA) protects archeological resources (remains of past human activities or lifestyles that are at least 100 years old) on federal lands. ARPA contains both enforcement (criminal and civil penalties for damage or looting) and permitting provisions.	Archeological permits have been issued to non-BNL sponsored organizations to conduct surveys in advance of a potential natural gas pipeline project.	3.4
EPA: 40 CFR 50-80* 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 four excursions, these discharges met the SPDES permit limits in 2003.	3.6

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

Regulator: Codified Regulation	Regulatory Program Description	Compliance Status	Report Reference Sections
EPA: 40 CFR 141–149 NYSDOH: 10 NYCRR 5	The **Safe Drinking Water Act** (SDWA) and New York State Department of Health 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.	BNL maintains a sitewide public water supply. This water supply met all 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. The Suffolk County Department of Health and Safety (SCDHS) has safety codes (SCSC) 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 wastes and has a permitted waste management facility. While almost all wastes are handled and disposed in accordance with federal and state requirements, a 2002 audit identified several concerns, as documented in an NOV. These were immediately addressed by corrective actions.	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 New York State detailing the types and quantity of pesticides applied.	3.11
DOE: 10 CFR 1022 NYSDEC: 6 NYCRR 663 6 NYCRR 666	DOE regulations require its facilities to comply with floodplain/wetland review requirements. The **New York State Fresh Water Wetlands and Wild, Scenic, and Recreational Rivers** rules govern development in the state's natural waterways. Development or projects within a half-mile of regulated waters must have NYSDEC permits.	BNL is in the Peconic River watershed and has several jurisdictional wetlands; consequently, development of locations in the north and east of the site requires NYSDEC permits and review for compliance under DOE wetland/floodplain regulations. During 2003, five 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 NY list have been found at BNL, for a total of 37. In the "endangered" category are one insect, one amphibian, and one plant species. In the "threatened" category are one insect and two fish species. Of "special concern" are one insect, two amphibian, three plant, and four bird species. The remaining 16 species are vulnerable or rare plants. BNL's Natural Resource Management Plan outlines activities to protect species and protect their habitats (see Chapter 6).	3.13
DOE: Manual 231.1-1A and 231.1-2	The **Environment, Safety, and Health Reporting Program** objective is to ensure timely collection, reporting, analysis, and dissemination of information on environment, safety, and health issues as required by law or regulations or as needed to ensure that DOE is kept fully informed on a timely basis about events that could adversely affect the health and safety of the public, workers, the environment, the intended purpose of DOE facilities, or the credibility of the Department. Included in these manuals 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: Occurrence Reporting Program Description, Critiques Subject Area, Occurrence Categorizer's Procedure, and the ORPS Office Procedure.	All chapters

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

Regulator: Codified Regulation	Regulatory Program Description	Compliance Status	Report Reference Sections
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 public health and safety, workers, and the environment. Order 435.1 requires all DOE organizations that generate radioactive waste to implement a waste certification program. DOE Laboratories must develop a Radioactive Waste Management Basis (RWMB) Program Description, which includes exemption and timeframe requirements for staging and storing 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
DOE: Order 450.1	The **Environmental Protection Program** objective is to implement sound stewardship practices that protect the air, water, land, and other natural and cultural resources affected by DOE operations, in a cost-effective manner, meeting or exceeding applicable environmental; public health; and resource protection laws, regulations, and DOE requirements. DOE facilities meet this objective by implementing an Environmental Management System (EMS) that is part of an Integrated Safety Management System (ISMS). Other components include establishing sound environmental monitoring programs to comply with former DOE Order 5400.1.	BNL's EMS was officially registered to the ISO 14001:1996 standard in 2001. Annual audits to maintain certification were done in 2002 and 2003. Recertification is due in 2004. The BNL ISMS Program Description presents the Laboratory's approach to integrating environment, safety, and health (ES&H) requirements into the processes for planning and conducting work at BNL. It describes BNL's programs, including the SBMS, for accomplishing work safely and provides the road map of the systems and processes.	Chapter 2
DOE: Order 5400.5, Change 2	**The Radiation Protection of the Public and Environment Program** establishes standards and requirements for operations of DOE and DOE contractors to protect members of the public and the environment against undue risk from radiation.	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:
*Although there are gaps in the numbering, here the series are listed as continuous, to conserve space. For details, see Appendix E
ALARA = As Low As Reasonably Achievable
BGRR = Brookhaven Graphite Research Reactor
CAA = Clean Air Act
CERCLA = Comprehensive Environmental Response, Compensation, & Liability Act
CFR = Code of Federal Regulations
CWA = Clean Water Act
EMS = Emergency Management System
EPA = Environmental Protection Agency
EPCRA = Emergency Planning and Community Right-to-Know Act
ES&H = Environment, Safety, and Health
FIFRA = Federal Insecticide, Fungicide, and Rodenticide Act
HFBR = High Flux Beam Reactor
ISMS = Integrated Safety Management System
NEPA = National Environmental Policy Act
NESHAPs = National Emission Standards for Hazardous Air Pollutants
NYCRR = New York Codes, Rules, and Regulations
NYSDEC = New York State Department of Environmental Conservation
NYSDOH = New York State Department of Health
NYSHPO = New York State Historic Preservation Office
ORPS = Occurrence Reporting and Processing System
OSHA = Occupational Safety and Health Administration
RCRA = Resource Conservation and Recovery Act
RHIC = Relativistic Heavy Ion Collider
RWMB = Radioactive Waste Management Basis
SARA = Superfund Amendments and Reauthorization Act
SCDHS = Suffolk County Department of Health Services
SCSC = Suffolk County Sanitary Code
SDWA = Safe Drinking Water Act
SPDES = State Pollutant Discharge Elimination System
TSCS = Toxic Substances Control Act
WCPP = Waste Certification Program Plan

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	521	OU IV Air Sparge System	NA	31-Dec-03	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	NA	NA	NA	NA
NYSDEC- Hazardous Substance	BNL	Bulk Storage Registration Certificate	1-000263	27-Jul-05	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
NYSDEC - Air Quality	610	Combustion Unit	1-4722-00032/00115	06-Jan-07	U-61005	6101A
NYSDEC - Air Quality	630	Gasoline Storage & 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

(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	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	Liner Installation at Bldg. 1010	1-4722-00032/00131	20-Oct-03	NA	NA
NYSDEC - Natural Resources	RHIC	Construction of New Recharge Basin	1-4722-00032/00129	17-May-04	NA	NA
NYSDEC - Natural Resources	RHIC	Paving at Bldgs. 1002 & 1004	1-4722-00032/00135	09-Oct-08	NA	NA
NYSDEC - Natural Resources	RHIC	Construction of 9C Alcove Building	1-4722-00032/00137	08-Sep-08	NA	NA
NYSDEC - NESHAPs	REF	Radiation Effects/Neutron 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 & Recharge Basins	NY-0005835	01-Mar-05	NA	NA

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

3.3 NATIONAL ENVIRONMENTAL POLICY ACT

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 2003, environmental evaluations were completed for 138 proposed projects. Of these projects, 116 were considered minor actions requiring no additional documentation. The remaining 22 projects were addressed through the submission of Environmental Evaluation Notification Forms to DOE. Evaluation of these

projects resulted in the determination by DOE that they were covered by existing Categorical Exclusions, as defined in volume 10 of the Code of Federal Regulations, section 1021 (referred to as 10 CFR 1021). Therefore, environmental assessments were not required.

3.4 HISTORIC PRESERVATION AND ARCHEOLOGY

BNL is subject to several cultural resource laws, most notably the National Historic Preservation Act (NHPA) and the Archeological Resource Protection Act (ARPA). These acts require federal agencies to identify, evaluate, and consider the effects of federal actions on historical and archeological sites eligible for listing or inclusion on the National Register of Historic Places. The sites may include historic structures, objects, documents, and Native American Indian lands.

BNL has three structures or sites that have been determined to be eligible for listing on the National Register of Historic Places: the Brookhaven Graphite Research Reactor (BGRR) complex, the High Flux Beam Reactor (HFBR) complex, and the World War I Army training trenches associated with Camp Upton. In 2003, the New York State Historic Preservation Officer (SHPO) concurred with BNL's determination that the following WW II era buildings were not eligible for listing on the National Register of Historic Places:

- Building 118 – Physics Department Offices
- Building 184 – Library Annex/Museum
- Buildings 158, 206, 207, 208, and 209 – Warehouses
- Building 428 – Incinerator
- Building 457 – Spray Shop
- Building 458 – Boiler Plant
- Building 459 – Business Systems Division Offices.

A Stage 1 archeological survey of an area containing remnant foundations from WW I Camp Upton was performed in preparation for the construction of a new railroad spur. The annual Department of Interior questionnaire regarding historic and cultural resources was completed and submitted as required. Additional activities in 2003 associated with NHPA and ARPA compliance are identified in Chapter 6, Section 6.9, Cultural Resource Activities.

3.5 CLEAN AIR ACT

The objectives of the Clean Air Act (CAA) that 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

BNL 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 (RACT) requirements. Three of the boilers can burn either residual fuel oil or natural gas; Boiler 1A burns fuel oil only. In 2003, low nitrogen residual oil 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), RACT 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 and sulfur content below 0.3 percent. To ensure continued compliance, an outside contractor laboratory analyzed composite samples of fuel deliveries (collected quarterly) and confirmed that the fuel-bound nitrogen and sulfur 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. For the year 2003, NO_x emissions from Boilers 6 and 7 averaged 0.225 lbs/MMBtu and 0.200 lbs/MMBtu, respectively, and there were no known exceedances of the NO_x emission standard for either boiler.

3.5.1.2 Ozone-Depleting Substances

Refrigerants. BNL'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 used by trained technicians 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 January, 1,050 pounds of R-11 were recovered and reclaimed for future use from two 650-ton R-11 centrifugal chillers in Building 555 that were removed from service in August 2001 when the building was connected to the Central Chilled Water Facility. Another 880 pounds of R-11 were recovered and shipped out for reclamation from two 110-ton centrifugal chillers in Building 911A that were removed from service when that building was connected to the Central Chilled Water Facility. In April, 400 pounds of R-11 were recovered and sent out for reclamation from a 130-ton R-11 centrifugal chiller in Building 488 that was then replaced with a more energy-efficient 80-ton R-134A centrifugal chiller. Approximately 550 pounds of R-11, 1 pound of R-12, 327 pounds of R-22, 650 pounds of R-123, and 4 pounds of R-134A were recovered and recycled from refrigeration equipment that was serviced in 2003.

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, BNL 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 workers use halon recovery and recycling devices, to comply with the CAA provisions.

3.5.2 Hazardous Air Pollutants

In 1970, the Clean Air Act established standards to protect the general public from hazardous pollutants that may lead to death or an increase in irreversible or incapacitating illnesses. The NESHAPs were updated significantly in 1990. EPA developed a 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

During preparation of the Title V Phase II application, BNL reviewed existing state and federal regulations administered under the CAA to determine applicability to BNL activities and operations. Based on this review, it was concluded that no proposed or promulgated Maximum Available Control Technology (MACT) standards apply to BNL operations. Additional evaluation conducted in 2003 determined that no MACT standards apply to the anticipated emissions from proposed activities or operations.

3.5.2.2 Asbestos

As required, BNL provided notice to the EPA Region II office regarding the removal of materials that contained asbestos. During 2003, 2,500 linear ft of asbestos-containing pipe insulation, 9,446 ft^2 of asbestos-containing surface material (principally roofing and vinyl asbestos floor tile removed during demolition or renovation activities), and 280 yd^3 of bulk asbestos waste (again principally 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 affect the environment. A full description of the monitoring conducted by BNL in 2003 is provided in Chapter 4. BNL transmitted all data pertaining to radioactive air emissions and dose calculations to EPA on schedule, in fulfillment of the June 30 annual reporting requirement. In 2003, the maximum off-site dose due to airborne radioactive emissions from BNL 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 maximally exposed individual resulting from airborne emissions, calculated using EPA's modeling software, was 0.06 mrem (0.6 μSv).

3.6 CLEAN WATER ACT

The disposal of wastewater generated by BNL 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 BNL. This permit establishes release concentration limits and specifies monitoring requirements.

The BNL SPDES permit was renewed in September 1999 with an effective date of March 1, 2000 and an expiration date of March 1, 2005. This permit provides monitoring requirements and specifies effluent limits for nine of 12 outfalls, as described below.

- Outfall 001 is used for the discharge of treated effluent from the STP to the Peconic River.
- Outfalls 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. No monitoring requirements are imposed for Outfalls 003, 011, and 012.
- Outfall 007 receives backwash water from the potable Water Treatment Plant (WTP) filter building.
- Outfall 009 consists of numerous subsurface and surface wastewater disposal systems that receive predominantly sanitary waste, and steam- and air-compressor condensate discharges. There are no monitoring requirements imposed for this outfall.

See Figure 5-6 in Chapter 5 for the locations of BNL outfalls.

Each month, BNL prepares a Discharge Monitoring Report that details monitoring data, evaluates compliance with permit limitations, and identifies corrective measures taken to address permit excursions. This report is submitted directly to the NYSDEC central and regional offices and the Suffolk County Department of Health Services (SCDHS).

3.6.1 Sewage Treatment Plant

Sanitary and process wastewater generated by BNL operations is conveyed to the STP for processing before being discharged to the Peconic River. The STP provides tertiary treatment of this wastewater (i.e., 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. BNL monitors the STP discharge for more than 100 parameters monthly and well over 200 parameters quarterly. BNL's compliance with effluent limits was greater than 99 percent overall; there was only one excursion of SPDES permit limits in 2003. In March, a single concentration for iron exceeded the SPDES limit of 0.37 mg/L. Samples collected two days after the reported event were well within SPDES permit limits. Since this was only a one-time occurrence, no formal followup was performed. Figures 3-1 through 3-7 plot five-year trends for the maximum monthly concentrations of copper, iron, lead, silver, nickel, zinc, and mercury in the STP discharge.

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

Analyte	Min.	Max.	Min. Monitoring Frequency	SPDES Limit	No. of Exceedances	% Compliance*
Max. Temperature (°F)	45	79	Daily	90	0	100
pH (SU)	5.9	6.9	Continuous Recorder	Min. 5.8 Max. 9.0	0	100
Avg. 5-Day BOD (mg/L)	< 2	6	Twice Monthly	10	0	100
Max. 5-Day BOD (mg/L)	< 2	14	Twice Monthly	20	0	100
% BOD Removal	> 80(a)	> 99	Monthly	85	0	100
Avg. TSS (mg/L)	< 0.4	1.3	Twice Monthly	10	0	100
Max. TSS (mg/L)	< 0.4	1.8	Twice Monthly	20	0	100
% TSS Removal	> 91	> 99	Monthly	85	0	100
Settleable Solids (ml/L)	0.0	0.0	Daily	0.1	0	100
Ammonia Nitrogen (mg/L)	< 0.10	0.11	Twice Monthly	2	0	100
Total Nitrogen (mg/L)	2.8	10	Twice Monthly	10	0	100
Total Phosphorus (mg/L)	0.77	1.7	Twice Monthly	NA	0	100
Cyanide (μg/L)	< 1.7	2.0	Twice Monthly	100	0	100
Copper (mg/L)	0.028	0.069	Twice Monthly	0.15	0	100
Iron (mg/L)	0.07	0.39(b)	Twice Monthly	0.37	1	96
Lead (mg/L)	< 0.0021	0.0058	Twice Monthly	0.019	0	100
Nickel (mg/L)	0.0024	0.0053	Twice Monthly	0.11	0	100
Silver (mg/L)	< 0.0020	0.0034	Twice Monthly	0.015	0	100
Zinc (mg/L)	0.03	0.1	Twice Monthly	0.1	0	100
Mercury (mg/L)	< 0.0001	0.0003	Twice Monthly	0.0008	0	100
Toluene (μg/L)	< 5	< 5	Twice Monthly	5	0	100
Methylene Chloride (μg/L)	< 1	4.5	Twice Monthly	5	0	100
1,1,1-Trichloroethane (μg/L)	<5	< 5	Twice Monthly	5	0	100
2-Butanone (μg/L)	< 10	< 10	Twice Monthly	50	0	100
PCBs (μg/L)	< 0.065	< 0.4	Quarterly	NA	0	100
Max. Flow (MGD)	0.38	0.77	Continuous Recorder	2.3	0	100
Avg. Flow (MGD)	0.28	0.53	Continuous Recorder	NA	0	100
Avg. Fecal Coliform (MPN/100 mL)	< 2	2	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) The calculated % BOD-5 removal was > 80 percent in June of 2003. This was due to great uncertainty in many of the BOD-5 results due to dilution problems at the analytical laboratory, incorrect descriptions on a chain-of-custody form, low confidence in the proper mixing of samples before being placed in the sampling bottles for analysis, and dilute BOD-5 concentrations entering the Sewage Treatment Plant. The effluent to Outfall 001 met all permit requirements for BOD-5 concentration.
(b) A permit exceedance of the total iron concentration occurred on March 3, 2003. The total iron concentration of the samples collected on March 5 and 7, 2003 were within the permit limit. The concentration and duration of this excursion did not indicate a continual noncomplying discharge.

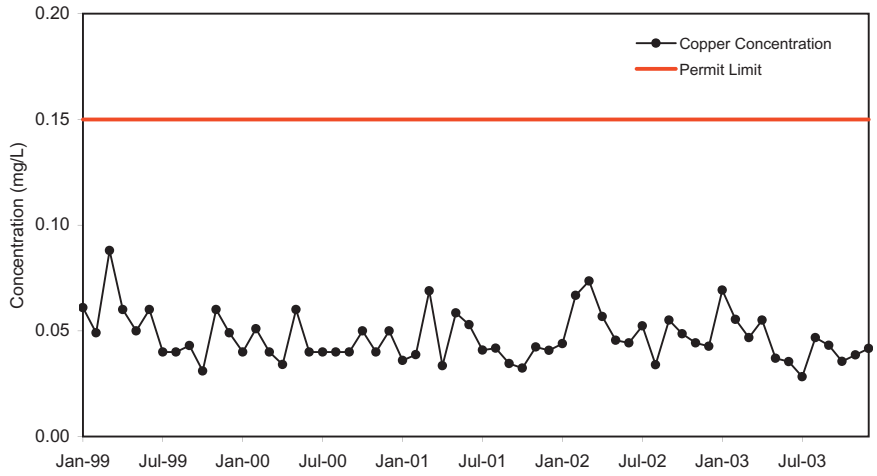

Figure 3-1. Maximum Concentration of Copper Discharged from the BNL Sewage Treatment Plant, 1999–2003.

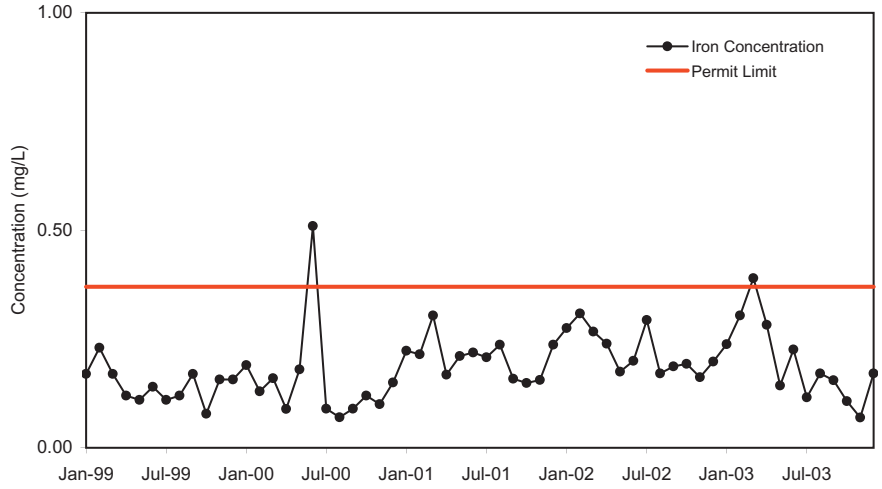

Figure 3-2. Maximum Concentration of Iron Discharged from the BNL Sewage Treatment Plant, 1999–2003.

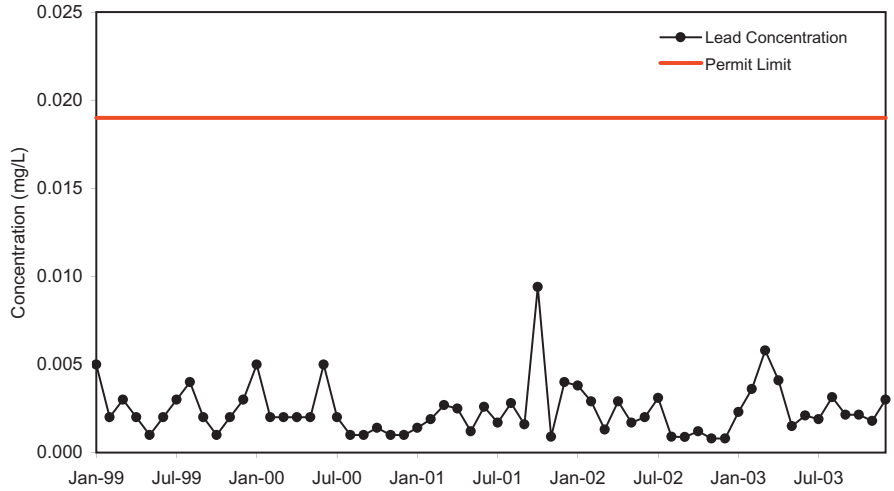

Figure 3-3. Maximum Concentration of Lead Discharged from the BNL Sewage Treatment Plant, 1999–2003.

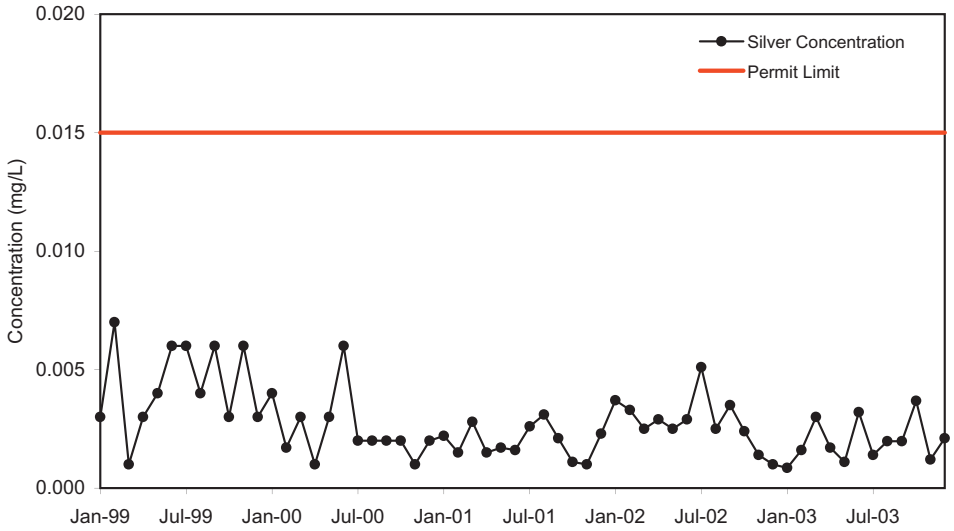

Figure 3-4. Maximum Concentration of Silver Discharged from the BNL Sewage Treatment Plant, 1999–2003.

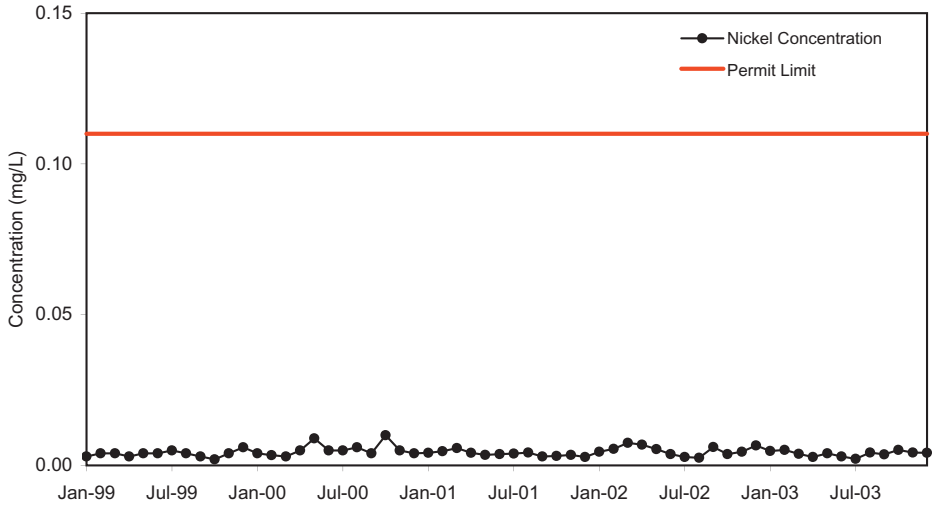

Figure 3-5. Maximum Concentration of Nickel Discharged from the BNL Sewage Treatment Plant, 1999–2003.

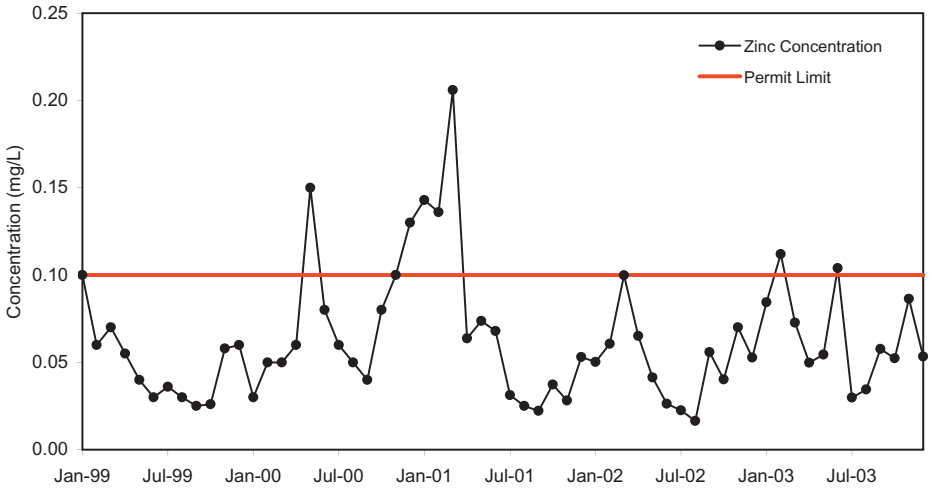

Figure 3-6. Maximum Concentration of Zinc Discharged from the BNL Sewage Treatment Plant, 1999–2003.

Note: Per NYSDEC guidance, the concentration of zinc exhibited in the effluent during February and June was not considered in violation of the SPDES effluent limit of 0.1 mg/L due to rounding off of significant figures.

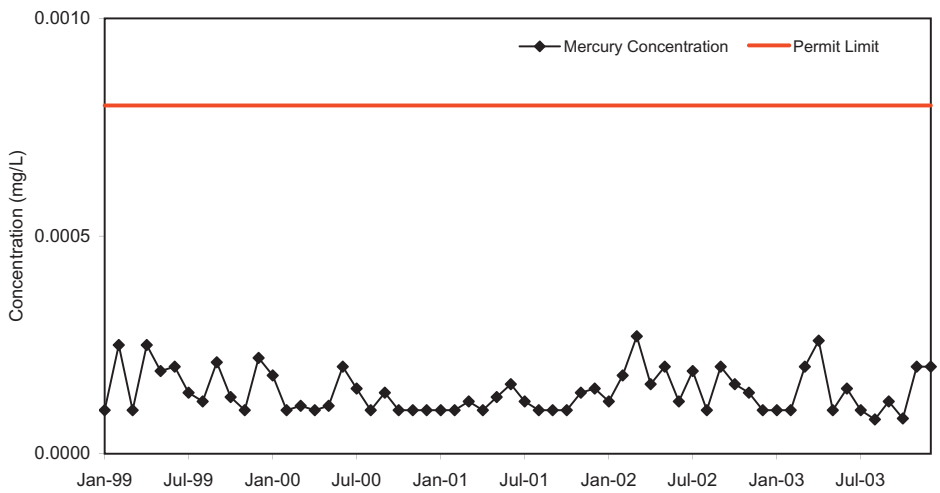

Figure 3-7. Maximum Concentration of Mercury Discharged from the BNL Sewage Treatment Plant, 1999–2003.

3.6.1.1 Chronic Toxicity Testing

BNL's SPDES permit requires that "whole effluent toxicity" 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. Samples are collected and tested quarterly. The program consists of performing seven-day chronic toxicity tests on two freshwater organisms, water fleas and fathead minnows. 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 seven days in each test. During testing, the size of fish and/or rate of reproduction for the water flea are measured and compared to untreated organisms (i.e., controls). The test results are submitted to NYSDEC for review.

In 2003, toxicity was not exhibited for either of the two test organisms in the four tests conducted; consequently, there was no need to proceed with the Toxicity Reduction Evaluation established with NYSDEC in 2002. Since there was no documented toxicity exhibited in the last five rounds of tests (December 2002 through December 2003), BNL petitioned NYSDEC for testing relief until the next permit cycle starting in 2005. This request is pending.

3.6.2 Recharge Basins and Stormwater

Outfalls 002 through 008 and Outfalls 010 through 012 discharge 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 2003.

There were three permit excursions at these outfalls in 2003. Two were for exceedances of effluent limits for aluminum at Outfalls 008 and 010. As part of the SPDES permit revision in 2002, metals analyses are performed for several stormwater discharges quarterly. Resuspension of sediment due to scouring of earthen channels and roadway runoff causes elevated metals levels (e.g., aluminum and iron) in water samples collected during rain events due to natural sources (i.e., soil). Since suspended soil does not adversely affect the recharge basins or groundwater, in 2003 BNL requested that water samples undergoing subsequent metals analyses be filtered before acid preservation. Discussions with NYSDEC indicate that this request is likely to be approved in early 2004. The third exceedance was for a release of excess cooling tower treatment reagent (tolytriazole) resulting from a broken valve. The valve was repaired upon discovery and the levels of this compound returned to below SPDES limits.

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

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	N	CR	CR	CR	CR	CR	CR	10	10			
(MGD)	Min.	0.09	0.0001	0.2	0.001	0.04	0.20	0.0005	0.005	NA		
	Max.	9.6	0.044	4.60	0.21	0.58	0.32	0.53	0.19	NA	NA	NA
pH	Min.	6.6	6.8	6.3	6.8	6.9	6.3	6.7	6.6	NA		
(SU)	Max.	8.4	8.6	8.5	8.3	8.2	8.9	7.9	8.5	8.5, 9.0 (a)	0	100
Oil and	N	12	11	12	12	10	NR	10	10			
Grease	Min.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	NR	< 5.0	< 5.0	NA		
(mg/L)	Max.	9.4	2	3.6	3.7	2.1	NR	3.6	3.4	15	0	100
Copper	N	NR	NR	4	NR	NR	NR	NR	4			
(mg/L)	Min.	NR	NR	0.003	NR	NR	NR	NR	0.006	NA		
	Max.	NR	NR	0.006	NR	NR	NR	NR	0.022	1.0	0	100
Aluminum	N	4	NR	NR	NR	NR	NR	4	4			
(mg/L)	Min.	0.02	NR	NR	NR	NR	NR	0.14	0.08	NA		
	Max	0.46	NR	NR	NR	NR	NR	2.3 (b)	3.2 (b)	2.0	2	83
Lead	N	NR	NR	NR	NR	NR	NR	NR	4			
(mg/L)	Min.	NR	NR	NR	NR	NR	NR	NR	0.002	NA		
	Max	NR	NR	NR	NR	NR	NR	NR	0.017	0.05	0	100
Vanadium	N	NR	NR	NR	NR	NR	NR	NR	4			
(mg/L)	Min.	NR	NR	NR	NR	NR	NR	NR	0.008	NA		
	Max	NR	NR	NR	NR	NR	NR	NR	0.018	NPL	NA	NA
Chloroform	N	4	NR	NR	NR	NR	NR	NR	NR			
(µg/L)	Min.	< 1	NR	NR	NR	NR	NR	NR	NR	NA	NA	
	Max.	1.5	NR	NR	NR	NR	NR	NR	NR	7	0	100
Bromo-	N	4	NR	NR	NR	NR	NR	NR	NR			
dichloromethane	Min.	< 1	NR	NR	NR	NR	NR	NR	NR	NA	NA	
(µg/L)	Max.	< 2	NR	NR	NR	NR	NR	NR	NR	5	0	100
1,1,1-trichloroethane	N	4	NR	NR	NR	NR	NR	4	NR			
(µg/L)	Min.	< 1	NR	NR	NR	NR	NR	< 1	NR	NA	NA	
	Max.	< 2	NR	NR	NR	NR	NR	< 5	NR	5	0	100
1,1-dicloroethylene	N	NR	NR	NR	NR	NR	NR	4	NR			
(µg/L)	Min.	NR	NR	NR	NR	NR	NR	< 1	NR	NA	NA	
	Max.	NR	NR	NR	NR	NR	NR	< 5	NR	5	0	100
Hydroxyethylidene-	N	4	4	4	4	4	NR	NR	NR			
diphosphonic acid	Min.	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	NR	NR	NR	NA	NA	
(mg/L)	Max.	< 0.05	< 0.05	< 0.05	< 0.05	0.09	NR	NR	NR	0.5	0	100
Tolyltriazole	N	4	4	4	4	4	NR	NR	NR			
(mg/L)	Min.	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	NR	NR	NR	NA	NA	
	Max.	0.99 (c)	< 0.005	< 0.005	< 0.005	< 0.005	NR	NR	NR	0.2	1	95

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, 006A, 006B,and 007.
(b) The total aluminum concentration exceeded the permit limit (Outfall 010 in April and Outfall 008 in July) due to resuspension of sediments at the outfall. Filtered samples were below the permit limit.
(c) The elevated concentrations were due to a broken valve on the feed equipment for the water treatment chemicals added to a cooling tower discharging to this outfall. The problem was repaired once it was discovered.

delegated to the New York State Department of Health (NYSDOH) and administered by the Suffolk County Department of Health Services. 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 2003) is prepared to comply with these requirements.

3.7.1 Potable Water

BNL maintains six groundwater wells for on-site distribution of potable water. To meet drinking water standards, 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. BNL also voluntarily monitors drinking water supplies for radiological contaminants. Tables 3-5 and 3-6 provide the potable water supply monitoring data for 2003. Color and iron exceeded drinking water standards in samples collected from three of the wells, before distribution. Treatment at the Water Treatment Plant effectively reduced these levels to below drinking water standards. At the point of consumption, drinking water complied with all drinking water standards during 2003. 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) at the interface between a facility and the domestic water main. Cross-connection control devices are required at all facilities where hazardous materials are used in a manner that could result in their introduction into the domestic water system, especially under low-pressure conditions. In addition, secondary cross-connection controls at the point of use are recommended, to protect users within a specific facility from hazards that might be posed by intra-facility operations.

BNL 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. Approximately 160 cross-connection control units were tested in 2003, including primary and secondary devices. If a problem is encountered during testing, the device is repaired and retested to ensure proper function.

3.7.3 Underground Injection Control

Underground injection control 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, since NYSDEC did not adopt UIC regulatory requirements. (New York State regulates discharges of pollutants to cesspools under the SPDES program.) Under the EPA's UIC program, all Class V injection wells must be included in an inventory maintained with the agency.

During 2003, BNL completed construction of 12 new UICs for managing stormwater: nine new UICs at Building 974 and single UICs at Buildings 634, 635, and 637, based on applications filed in late 2002. The UIC inventory on file with EPA has been updated to reflect these changes.

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

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

Compound	Well No. 4	Well No. 6	Well No. 7	Well No. 10	Well No. 11	Well No. 12	Potable Distribution Sample	NYS DWS
Water Quality Indicators								
Total Coliform	ND	ND	ND	ND	ND	ND	ND	Negative
Color (Units)	30*	30*	5	< 5	< 5	< 5	< 5	15
Odor (Units)	0	0	0	0	0	0	0	3
Cyanide (μg/L)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	NS
Conductivity (μmhos/cm)	156	160	178	208	282	285	275	SNS
Chlorides (mg/L)	29.2	21.9	21.9	4.4	17.1	15.1	28.7	250
Sulfates (mg/L)	9.3	10.5	9.2	5.9	9.3	9.4	9.1	250
Nitrates (mg/L)	0.23	0.31	0.21	0.11	0.56	0.54	0.26	10
Nitrites (mg/L)	< 0.10	< 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	< 0.10	SNS
pH (Standard Units)	6.1	6.0	5.9	6.5	6.0	5.9	6.8	SNS
MBAS (mg/L)	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	SNS
Metals								
Antimony (μg/L)	< 5.9	< 5.9	< 5.9	< 5.9	< 5.9	< 5.9	< 5.9	6.0
Arsenic (μg/L)	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	50
Barium (mg/L)	< 0.2	< 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	< 3.0	4.0
Cadmium (μg/L)	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	5.0
Chromium (mg/L)	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.1
Fluoride (mg/L)	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	2.2
Iron (mg/L)	1.12*	3.23*	1.84*	< 0.02	0.03	< 0.02	0.23	0.3
Lead (μg/L)	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	15
Manganese (mg/L)	0.13	0.13	0.06	< 0.01	< 0.01	< 0.01	0.04	0.3
Mercury (μg/L)	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	2.0
Nickel (mg/L)	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	SNS
Selenium (μg/L)	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	50.0
Sodium (mg/L)	15.1	12.4	12.7	6.2	12.3	10.9	16.5	SNS
Silver (μg/L)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	100
Thallium (μg/L)	< 1.9	< 1.9	< 1.9	< 1.9	< 1.9	< 1.9	< 1.9	2.0
Zinc (mg/L)	< 0.02	< 0.02	< 0.02	0.02	< 0.02	< 0.02	< 0.02	5.0
Radioactivity								
Gross Alpha Activity (pCi/L)	2.62	2.11	2.08	NA	1.31	2.16	NR	15.0
Beta (pCi/L)	3.92	2.70	< 1.98	NA	< 1.98	2.67	NR	50.0
Tritium (pCi/L)	< 363	< 363	< 363	NA	< 363	< 395	NR	20,000
Strontium-90 (pCi/L)	< 0.56	< 0.56	< 0.64	NA	< 0.58	< 0.48	NR	8.0
Other								
Asbestos (million fibers/L)	NR	NR	NR	NR	NR	NR	< 0.68	7
Calcium (mg/L)	4.8	4.6	4.9	6.5	6.4	7.0	10.1	SNS
Alkalinity (mg/L)	11.9	10.4	12.3	13.9	20.5	22.4	53.4	SNS

Notes:
See Figure 7-3 for well locations.
MBAS = Methylene Blue Active Substances
NA = Not Analyzed due to well shutdown
ND = Not Detected
NR = Analysis Not Required
NYSDWS = New York State Drinking Water Standard
SNS = Drinking Water Standard Not Specified
* Wells are treated at the Water Treatment Plant for color and iron reduction prior to site distribution.

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

Compound	WTP Effluent	Well No. 4	Well No. 6	Well No. 7	Well No. 10	Well No. 11	Well No. 12	NYS DWS
	µg/L							
Dichlorodifluoromethane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Chloromethane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Vinyl Chloride	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	2
Bromomethane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Chloroethane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Trichlorofluoromethane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,1-dichloroethene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Methylene Chloride	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
trans-1,2-dichloroethene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,1-dichloroethane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
cis-1,2-dichloroethene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
2,2-dichloropropane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Bromochloromethane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,1,1-trichloroethane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Carbon Tetrachloride	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,1-dichloropropene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,2-dichloroethane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Trichloroethene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,2-dichloropropane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Dibromomethane	< MDL	< MDL	< MDL	1.5	< MDL	< MDL	< MDL	5
trans-1,3-dichloropropene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
cis-1,3-dichloropropene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,1,2-trichloroethane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Trihalomethanes	3.6	3.4	5.6	1.0	21.7	< MDL	< MDL	100
1,3-dichloropropane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Chlorobenzene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,1,1,2-tetrachloroethane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Bromobenzene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,2,3-trichloropropane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
2-chlorotoluene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
4-chlorotoluene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,3-dichlorobenzene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,4-dichlorobenzene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,2-dichlorobenzene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,2,4-trichlorobenzene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Hexachlorobutadiene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Tetrachloroethene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,1,2,2-Tetrachloroethane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,2,3-trichlorobenzene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Benzene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Toluene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Ethylbenzene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
m,p-xylene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
o-xylene	< MDL	< 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 (Maximum Concentration) *(continued)*.

Compound	WTP Effluent	Well No. 4	Well No. 6	Well No. 7	Well No. 10	Well No. 11	Well No. 12	NYS DWS
	µg/L							
Styrene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Isopropylbenzene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
n-propylbenzene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,3,5-trimethylbenzene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
tert-butylbenzene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,2,4-trimethylbenzene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
sec-butylbenzene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
4-Isopropyltoluene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
n-butylbenzene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Methyl tert-butyl ether	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	50
Lindane	NR	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	0.2
Heptaclor	NR	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	0.4
Aldrin	NR	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Heptachlor Epoxide	NR	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	0.2
Dieldrin	NR	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Endrin	NR	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	0.2
Methoxychlor	NR	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	40
Toxaphene	NR	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	3
Chlordane	NR	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	2
Total PCB's	NR	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	0.5
2,4,5,-TP (Silvex)	NR	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	10
Dinoseb	NR	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	50
Dalapon	NR	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	50
Picloram	NR	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	50
Dicamba	NR	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	50
Pentachlorophenol	NR	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	1
Hexachlorocyclopentadiene	NR	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Bis(2-ethylhexyl)Phthalate	NR	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	50
Bis(2-ethylhexyl)Adipate	NR	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	50
Hexachlorobenzene	NR	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Benzo(A)Pyrene	NR	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	50
Aldicarb Sulfone	NR	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	SNS
Aldicarb Sulfoxide	NR	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	SNS
Aldicarb	NR	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	SNS
Oxamyl	NR	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	50
3-Hydroxycarbofuran	NR	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	50
Carbofuran	NR	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	40
Carbaryl	NR	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	50
Methomyl	NR	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	50
Glyphosate	NR	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	50
Diquat	NR	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	50
1,2-dibromomethane	NR	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	0.05
1,2-dibromoethane	NR	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	0.05

(continued on next page)

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

Compound	WTP Effluent	Well No. 4	Well No. 6	Well No. 7	Well No. 10	Well No. 11	Well No. 12	NYS DWS
	µg/L							
1,2-dibromo-3-chloropropane	NR	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	0.2
2,4,-D	NR	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	50
Alachor	NR	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	2
Simazine	NR	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	50
Atrazine	NR	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	3
Metolachor	NR	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	50
Metribuzin	NR	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	50
Butachlor	NR	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	50
Endothall	NR	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	100
Propachlor	NR	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	50
Tetrachloroethane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
1,1,2,2-Tetrachloroethane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL

Notes:
See Chapter 7, Figure 7-3 for well locations.
For compliance determination with New York State Department of Health standards, potable water samples were analyzed quarterly during the year by H2M Labs Inc., a New York State–certified contractor 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
NYSDWS = New York State Drinking Water Standard
WTP = Water Treatment Plant

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

3.8 SPILL PREVENTION, EMERGENCY PLANNING, AND REPORTING

Several federal, state, and local regulations address the management of storage facilities containing chemicals, petroleum, and other hazardous materials. These regulations include specifications for storage facilities, requirements for release planning documentation, and release reporting. The following subsections describe BNL's compliance with these regulations.

3.8.1 Preventing Oil Pollution and Spills

BNL must maintain a Spill Prevention Control and Countermeasures (SPCC) Plan as a condition of its Major Petroleum Facility License 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. The plan was last updated in December 2000 (Chaloupka 2000). In July 2002, EPA adopted significant changes to the SPCC regulations, which extended the requirements to previously unregulated facilities and provided some relief to existing covered facilities. These changes, among others, included extending the update requirements from three to five years and revising the *de minimus* quantity of oil to be counted toward reaching SPCC applicability (containers < 55 gallons need not be counted). Existing facilities have until August 2004 to revise existing SPCC plans. These revised plans must be implemented by February 2005. BNL is proceeding with changes to its

SPCC plan in accordance with these requirements. BNL remained in full compliance with the SPCC requirements in 2003.

BNL also maintains a Facility Response Plan that outlines emergency response procedures to be implemented in the event of a worst-case discharge of oil. EPA again reviewed this plan in 2002 and identified several technical deficiencies and formatting issues. The EPA comments were reviewed and a revised plan was transmitted to the EPA in September 2002. Due to the time needed to revise several maps, these were transmitted to the EPA in November 2002. There were no actions on the Facility Response Plan in 2003.

3.8.2 Local and State 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 and releases of certain chemicals that exceed specific thresholds 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. BNL complied with these requirements in 2003 through the submittal of the required reports under EPCRA Sections 302, 303, 311, and 312. During 2000 and 2001, the Part 313 Toxic Release Inventory (TRI) thresholds were significantly lowered for mercury, polychlorinated biphenyls (PCBs), and lead. Mercury and PCB thresholds were lowered from 10,000 pounds to 10 pounds, and lead from 10,000 to 100 pounds. In 2003, BNL was required to submit Tier III reports for these three classes of chemicals. In total, 140 pounds of mercury, 371,128 pounds of lead, and 25 pounds of PCBs were reported in the Form R TRI Report, which was submitted in June 2003. Due to an oversight, PCBs were not reported in the 2001 TRI report. A revised report was submitted in April 2003, documenting the off-site disposal of 14 pounds of PCBs in 2001. The significant increase in lead reported was due to decommissioning activities being conducted at the HFBR and BGRR, and alterations at the Alternating Gradient Synchrotron experimental facility. Large quantities of lead sheet, bricks, and other shielding components were disposed of in 2003. There were no releases of extremely hazardous substances reported under Part 304 during 2003.

3.8.3 Spills and Releases

When a spill of hazardous material occurs, BNL 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 the regulatory agencies. Any release of petroleum products to soil is reportable to both NYSDEC and SCDHS, and any release impacting a surface water is also reportable to the EPA National Response Center. In addition, releases of petroleum products in volumes greater than 5 gallons to impermeable surfaces or containment areas are also reported. Spills of chemicals in quantities greater than CERCLA-reportable quantities are reportable to the EPA National Response Center, NYSDEC, and SCDHS. Remediation of the spill is conducted as necessary to restore the site.

During 2003, there were 75 spills, of which 22 met external agency reporting criteria. These 22 reports are summarized in Table 3-7. The remaining 53 releases were either small-volume releases to containment areas or to other impermeable surfaces that did not exceed a reportable quantity. Twelve of the 22 reported releases involved very small volumes (< 10 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. Five of the 22 were small-volume releases of ethylene glycol from engine coolant leaks. Four of the 22 were large-volume (i.e., > 10 gallons) petroleum releases associated with equipment upgrade projects. One of these releases was the discovery of petroleum-contami-

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

Spill No. and Date	Material and Quantity	ORPS* Report	Source/Cause and Corrective Actions
03-03 1/8/03	Fuel oil > 100 gal	Yes (CH-BH-BNL-PE-2002-0006)	During planned removal of a 1,000-gal fuel oil UST at Bldg. 51, two dime-sized holes were seen on the bottom of the single-walled steel tank. NYSDEC staff observing the tank removal supervised soil removal, checking for signs of oil until further excavation became a safety concern. About 100 yd^3 of soil was removed for proper disposal. Geoprobe® samples were collected on 4/1/03 at NYSDEC request to check for groundwater contamination. All results were below laboratory detection limits and/or NY State soil cleanup guidance values, so no further action was needed.
03-10 2/27/03	Ethylene glycol 0.5 gal	No	A radiator hose on a government vehicle failed, releasing ethylene glycol to the asphalt road. BNL personnel applied absorbent material, then removed it for proper disposal. The release exceeded NYSDEC's 1-lb reportable quantity limit, although it was determined not to be ORPS reportable.
03-14 4/3/03	Hydraulic fluid 2 qt	No	As BNL workers loaded dead trees into a truck, the skid steer operator saw hydraulic oil spraying from one of the unit's hoses. He immediately moved the unit to the concrete road and shut it off. About 2 qt of oil sprayed the truck, skid steer, and ground next to the truck (~24 sq ft). Workers used oil-absorbent pads to clean the equipment. Most oil on the ground landed on a bed of leaves and dead grass, which was raked up and put in a 55-gal drum, with the absorbent pads, for proper disposal.
03-16 4/5/03	Fuel oil 7 gal	Yes (CH-BH-BNL-PE-2003-0002)	While removing debris from storm grates during a heavy rainfall, workers saw water with an oily sheen entering a storm drain. Tracing the runoff, they found oil-stained soil below a contractor's truck parked on an embankment. Fuel had leaked from the fill cap on one of the truck's 50-gal saddle tanks. The workers controlled the runoff with earthen berms and dikes of oil-absorbent material. To stop further water contact with the petroleum-soaked soil, they used plastic sheeting, anchored with blocks. Because oily water had entered the stormwater system, they put absorbent booms within the outfall weir and used absorbent pads to absorb oil already in the recharge basin. The next day, they removed the affected soil and absorbent materials for proper disposal.
03-18 5/1/03	Engine oil 4 qt	No	A deteriorating rubber hose on an employee vehicle broke, leaking oil onto asphalt, soil, and sand in the Bldg. 917 parking lot. Absorbent material was used, then removed along with the affected soil and sand for proper disposal.
03-22 5/20/03	Chilled water 28,000 gal	Yes (CH-BH-BNL-BNL-2003-0007)	A fitting on the chilled water system in Bldg. 463 failed, sending 28,000 gal of water to the floor within the building. The water was tested for pH and residual treatment chemical (chlorine from sodium hypochlorite). Discharge of the water to the STP was authorized since the chlorine level was 0.3 mg/L and pH was 7.6 SU. The cause was an inadequately restrained PVC pipe that did not withstand pressure anomalies in the chilled water system.
03-26 6/4/03	Hydraulic fluid 0.5 gal	No	BNL workers were clearing brush west of Bldg. 244 using a skid steer when a hydraulic fitting loosened, spraying fluid on the ground. Absorbent material was applied, then removed along with the affected soil for proper disposal.
03-27 6/4/03	Petroleum product 1 gal	No	An area of asphalt at the corner of Mitchell Lane and Upton Rd. was heavily stained with a petroleum product of unknown source. In a rainstorm, the oily substance migrated to soil via runoff. Absorbent material was applied to the asphalt and adjacent gutter, then removed, with soil, for proper disposal.
03-34 6/23/03	Ethylene glycol < 0.5 gal	Yes (CH-BH-BNL-BNL-2003-0009)	The radiator hose on a government vehicle failed, releasing ethylene glycol to the concrete pad and soil adjacent to trailer 575. BNL staff applied absorbent material, then removed it, with the impacted soil, for proper disposal. The release exceeded NYSDEC's 1-lb reportable quantity limit for ethylene glycol, and was ORPS reportable.
03-36 6/23/03	Form release agent < 1 pint	No	To ease the removal of concrete forms, they are treated with a release agent, often hydrocarbon based. During work near Bldg. 490, BNL staff sprayed release agent onto forms. Later that day, petroleum odor was noted near the site. Inspection revealed overspray of the release agent on the surrounding soil, which was subsequently removed for proper disposal. Different release agents or application methods are being considered for future work.

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

Spill No. and Date	Material and Quantity	ORPS* Report	Source/Cause and Corrective Actions
03-41 7/8/03	Fuel oil 5–8 gal	Yes (CH-BH-BNL-BNL-2002-0012)	(This relates to a 2002 spill report, #02-48, and ORPS Report CH-BH-BNL-BNL-2002-0012 from preliminary remediation work.) During the removal of a fuel oil UST at Bldg. 445, workers found small holes in the tank and saw darkened soil. They removed ~20 yd^3 of soil and took end point samples. The hole was backfilled to safeguard the building's foundation. Tests confirmed soil contamination, although final remediation was postponed until demolition of the building. When the site was re-excavated in Oct. 2003 under NYSDEC guidance, 60 yd^3 of soil was removed and additional samples were taken. All test results were below laboratory detection limits and/or NY State soil cleanup guidance values; therefore, no further action was needed.
03-42 7/8/03	Engine oil 0.4 gal	No	Motor oil leaked from a rented metal shearer/shredder when the unit was being picked up for transport back to the vendor for repair. BNL personnel applied absorbent material, which was removed along with the affected soil for proper disposal.
03-43 7/9/03	Hydraulic fluid < 16 gal	No	BNL is replacing single-walled hydraulic elevator units with double-walled units to prevent possible leaks of hydraulic oil around the casings. Working at Bldg. 911, a contractor saw ~16 gal of oil inside the casing; whether there had been a release to the environment could not be determined. When tested, the oil contained 148 mg/L of PCBs. The standing oil was removed and soil samples from below the shaft floor were taken. Results showed the PCBs had been contained within the casing to a depth of 5–10 ft. The remaining sand was removed from the entire casing to a depth of ~50 ft. Since the bottom of the casing seemed impermeable and the sand removed was essentially dry, it is believed that a release to the environment had not occurred.
03-50 7/28/03	Fuel oil 4 gal	No	During warehouse T-89 demolition, BNL staff noticed discolored soil and a petroleum odor. A record review on 7/29/03 suggested the likely source was a 7,000-gal UST implicated in two previous spill reports (NYSDEC 82-00515 and 82-0988) that were remediated to the satisfaction of the State. Workers removed all newly discovered discolored soil for proper disposal, ~10 yd^3, and took end point samples under the direction of a Suffolk Co. Dept. of Health engineer. All test results were below laboratory detection limits and/or NY State soil cleanup guidance values; therefore, no further action was needed.
03-51 7/30/03	Ethylene glycol and oil < 3.5 gal	No	An ethylene glycol spill was found on pavement near Bldg. 912; a significant amount collected in a 6- to 8-in. dip in the surface. Workers traced the stain trail east on E. Fifth Ave., north on Ring Rd., then west into the RHIC ring, where it ended across from Bldg. 1005E. The grass there looked wet and felt oily. The discharge was estimated at 3 gal of ethylene glycol and < 1 qt of oil. BNL staff applied absorbent material to all affected areas and collected it, along with affected soil, for proper disposal. The spill's source could not be traced to BNL equipment, so the spill was not reportable, although it exceeded the NYSDEC limit.
03-52 8/1/03	Hydraulic fluid < 1 gal	No	The hydraulic hose on the boom of a log loader failed, spilling < 1 gal of fluid to the tracks, ties, and soil below the rail spur at Power Line Rd. BNL staff spread plastic to catch leaks and applied absorbent material. After the hose was repaired, absorbent materials and the affected soil were removed for proper disposal.
03-54 8/13/03	Hydraulic fluid ~5 gal	No	A BNL vehicle developed a hole in a hydraulic line, leaking fluid to the road between Grove St. and Princeton Ave. The operator pulled off the road to report the problem, leaking fluid on ~ 50 ft of grass and soil. Absorbent materials were applied and removed, along with the affected soil and grass, for proper disposal.
03-58 9/10/03	Hydraulic fluid 80–85 gal	Yes (CH-BH-BNL-PE-2003-0003)	An elevator contractor renovating the elevator in Bldg. 463 performed preliminary safety tests for restart certification. During the "Stop Ring" test the elevator started to drop, signaling a problem. The contractor left the control room and saw hydraulic oil spraying through seams between the foundation wall and floor slab in the adjacent stairwell. The fluid loss was ~80 to 85 gal. Staff applied absorbents to clean up the oil in the stairwell and adjoining room. The remedial investigation is ongoing, with oversight from NYSDEC.

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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
03-62 10/3/03	Ethylene glycol 2 gal	No	Ethylene glycol was discovered on the asphalt pavement in the parking area at Bldg. 490 near the American Red Cross Kitchen loading dock. BNL personnel applied absorbent material to the release and removed it for proper disposal. The release was reported and cleaned up by BNL for the American Red Cross. It was not ORPS reportable, as it involved a non-BNL vehicle.
03-63 10/10/03	Diesel fuel 1–2 qt	No	A BNL employee walking in the woods near recharge basin HO found a plastic bag containing ~20 to 30 used absorbent pads. The bag was open at the top and rainwater had leached diesel fuel into the nearby pine needles, logs, and soil. Given the remote location, it is likely that this bag is from a 1996 sewer line replacement project. Staff removed the contaminated soil, debris, and bag of used pads for proper disposal.
03-65 10/28/03	Hydraulic fluid 15 gal	Yes (CH-BH-BNL-PE-2003-0005)	A passenger elevator in Bldg. 463 developed a mechanical failure in the flange area of the ram assembly, spilling hydraulic oil on the elevator pit floor. BNL staff put absorbent material around the ram assembly and sleeve to prevent further release, and used absorbent material to contain the oil on the floor. The oily soil inside the elevator ram casing was removed. Subsequent soil tests showed no significant impact. A team from the manufacturer helped BNL and the elevator contractor determine the cause of the leak: a misaligned point load when a 2,760-lb Geoprobe® unit was placed in the elevator car. The elevator load-carrying capacity, by code, is reduced to 25% of its rated capacity for Class A general freight if a single point load or single object is loaded. The maximum single-point load capacity of this car is 1,000 lb.
03-72 11/18/03	Ethylene glycol 2 pints	Yes (CH-BH-BNL-PE-2003-0008)	Workers reported a release of ethylene glycol from a BNL generator that is mounted on a trailer stored outdoors, north of Bldg. 629. Absorbent material was applied to the spill. When the generator was being transported for repair, more antifreeze spilled to the pavement and nearby soil. Workers applied additional absorbent material and collected it, along with affected soil, for proper disposal. The release exceeded NYSDEC's 1-pound reportable limit for ethylene glycol and was ORPS reportable.

Notes:
*ORPS: Occurrence Reporting and Processing System, established by DOE Manual 231.1-2, Occurrence Reporting and Processing of Operations Information
NYSDEC = New York State Department of Environmental Conservation
PCBs = Polychlorinated Biphenyls
PVC = Polyvinyl Chloride
STP = Sewage Treatment Plant
SU = Standard Units
UST = Underground Storage Tank

nated soil during a tank removal at Building 51 and three were associated with elevator upgrade projects. The remaining release was the discharge of 28,000 gallons of chilled water into Building 463. This spill was reported, due to the damage caused by the flood. Table 3-7 provides information on the reportable spills, including the date of the spill, material involved, and quantity released. It also includes a summary of the cause and corrective actions taken, and notes whether the spill was reportable to DOE through the Occurrence Reporting and Processing System (ORPS).

Five other incidents that were environmental in nature were reported to DOE through ORPS. These incidents 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 incidents.

3.8.4 Major Petroleum Facility License

The storage of 2.3 million gallons of petroleum products (principally No. 6 fuel oil) subjects BNL to Major Petroleum Facility licensing by NYSDEC. BNL maintains an MPF License for storing and transferring oil at the Central Steam Facility (CSF). During 2003, BNL remained in full compliance with license requirements. The license requires BNL to monitor groundwater in the vicinity of the seven active, aboveground storage tanks that range in size from 60,000 to 600,000 gallons. The license also requires that BNL inspect storage facilities monthly and test the systems for leak detection, high level monitoring, and secondary containment. Tank integrity is also checked periodically.

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

ORPS* ID: CH-BH-BNL-BNL-2003-0001 On 1/16/03, personnel and facility contamination occurred during Strontium-90 source transfer and repackaging at the Waste Management Facility Shielded Cell in Bldg. 865. As Sr-90 source tabs were being moved from a transfer cask to a shipping container, the scope of work was changed to include transferring the source tab trays and associated rusted metal container. During this unplanned action, activated particles from debris on the source trays migrated outside the shielded cell. The ventilation system played a role in their dispersal, and the lack of real-time airborne monitoring in the shielded cell led to delayed detection of the developing contamination, possibly contributing to its spread. The individual and facility were decontaminated, and changes have been made to the facility work control process and procedures to prevent similar occurrences in the future.	**Date:** 1/16/03 **Status:** Closed. All corrective actions have been completed.
ORPS ID: CH-BH-BNL-BNL-2003-0002 A Complaint dated 1/14/03 was received from NYSDEC for three deficiencies that were identified during a comprehensive, 5-day hazardous waste inspection ending on September 9, 2002. That inspection concluded with a brief closeout meeting; other NYSDEC staff had to be consulted before a compliance determination could be made on the few concerns raised during the inspection. On 10/8/02, BNL received a request from NYSDEC for information regarding four specific concerns; a response was submitted on 10/28/02. Of the three deficiencies identified in the 1/14/03 complaint letter, one was later repealed. A final Notice of Violation arrived 10/27/03. Corrective actions have been taken to rectify the issues.	**Date:** 1/17/03 **Status:** Closed. All corrective actions have been completed.
ORPS ID: CH-BH-BNL-BNL-2003-0003 BNL shipped two decontaminated spent-fuel shipping casks (LWT-2 and LWT-4) to the Savannah River Site (SRS). In outgoing radiological surveys of the casks on 1/24/03, all results were below 1,000 disintegrations per minute per 100 square centimeters (dpm/100 cm^2). During processing at SRS on 2/5/03, contamination surveys found up to 180,000 dpm/cm^2 on cask LWT-4. BNL staff reviewed the radiological survey data and determined that the spent-fuel shipping cask was in compliance with the requirements of the Transportation Code (49 CFR Contamination Control Limits, section 173.443), which requires decontamination before shipping. The increase in removable contamination was attributed to a recognized phenomenon known as weeping, which occurs when entrapped radioactive material migrates to the surface. It probably occurred due to the climate change between BNL and SRS and the lag time at SRS between cask receipt (Jan. 29) and cask survey (Feb. 4). No further shipments of this type are expected to originate from BNL in the future.	**Date:** 2/5/03 **Status:** Closed. All corrective actions have been completed.
ORPS ID: CH-BH-BNL-PE-2003-0006 At BNL on 10/14/03, two shipments of waste oil and soapy water were made from the Central Steam Facility (CSF) tank farm. The Hazardous Waste Manifest forms were signed by untrained employees who had not taken either the BNL Hazardous Material (Haz-Mat) training or the Haz-Mat Advanced Shippers training. Haz-Mat training is required by BNL procedures and federal regulations for personnel involved in off-site Haz-Mat shipments. Also, the waste transporter was not on the DOE Motor Carrier Evaluation Program list of approved waste haulers. The wastes, generated from tank cleaning at the CSF, were originally to be recycled as fuel, but the plan was changed to off-site disposal because burning of the waste clogged the fuel lines and affected CSF operations. The Waste Management Representative (WMR) for this group was not involved in the original planning process, because no waste was to be generated. If the WMR had been involved, the waste would have been properly characterized prior to shipment. Corrective actions taken include the modification of procedures and forms, and training of personnel who may contract work involving hazardous waste or shipments, to ensure Department of Transportation and Resource Conservation and Recovery Act compliance.	**Date:** 10/30/03 **Status:** Open. Although DOE has accepted the ORPS report, one corrective action remains open: revision of the Project Safety Review procedure with regard to transportation and shipping issues.
ORPS ID: CH-BH-BNL-BNL-2003-0023 On 12/19/03, BNL personnel found the basement of the Middle Road remediation system tower (Bldg. 517) flooded with approximately 5 ft of water. Investigations revealed that the day before, staff from the Air Conditioning shop had repaired a broken blower belt and restarted the South Boundary system (Bldg. 518) without also restarting Bldg. 517. Because these two systems normally operate in parallel, they must be run simultaneously unless specific valves and switches are aligned, per operating procedures. This, and the fact that the water override switch in Bldg. 517 had been left in the override (disabled) position, caused the flooding. Some water from Bldg. 517 leaked through electrical conduit to Bldg. 518, causing automatic system shutdown, as designed. Corrective actions taken include training and the installation of warning lights and postings in the treatment buildings.	**Date:** 12/9/03 **Status:** Closed. All corrective actions have been completed.

*Reportable under the Occurrence Reporting and Processing System, established by the requirements of DOE Manual 231.1-2.

Groundwater monitoring consists of monthly checks for floating products and twice-yearly analyses for volatile and semivolatile organic compounds. In 2003, no contaminants or floating products attributable to MPF activities were found in groundwater wells. See Chapter 7 for additional information on groundwater monitoring results.

The petroleum facility is inspected annually by NYSDEC. The 2003 annual inspection was conducted in July. The inspection noted four conditions that required corrective action, one related to the management of vegetative growth in the secondary containment berms at Building 610, two related to the routine inspection of the tanks at Building 610, and one related to cracks that developed within the concrete containment at Building 326. All conditions were corrected in accordance with the NYSDEC directives.

3.8.5 Chemical Bulk Storage

All underground tanks, and all aboveground tanks larger than 185 gallons that store specific chemical substances listed in Title 6 of the Official Compilation of the Codes, Rules and Regulations of the State of New York (NYCRR), Part 597, must be registered with NYSDEC. BNL holds a Hazardous Substance Bulk Storage Registration Certificate for eight tanks. Seven of the eight tanks are used to store potable water treatment chemicals (sodium hydroxide and sodium hypochlorite) and one tank is used to store 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 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 July 2003. Four issues were noted during this inspection that required corrective action. These issues included updating the Spill Prevention Report, adding containment for the delivery hose at Buildings 634, 635, and 637, labeling of remote fill stations, and broken alarms. All issues were corrected in accordance with the NYSDEC directives.

3.8.6 County Storage Requirements

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

Currently BNL has approximately 466 active storage facilities listed in the Suffolk County Tanks Database. Also included in the county database are another 32 storage facilities associated with environmental restoration activities conducted under the CERCLA program; these facilities are not regulated under Article 12. BNL 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 Laboratory research.

Since the 1987 MOA was signed, BNL has made significant progress in conforming to the environmental requirements of Article 12. Accomplishments include:

- Upgrading approximately 180 storage facilities. This included, but was not limited to, the construction of secondary containment systems and installation of high-level alarms and leak detection systems for many of the existing storage facilities.
- Removal of over 100 underground storage facilities.
- Submittal of over 80 design/specification packages to SCDHS for review/approval for upgrades to existing or new storage facilities.

In 2003, BNL prepared and submitted a report to SCDHS (BNL 2003a) describing the numerous projects that have been completed and management programs initiated since the 1987 MOA, including a summary of BNL's current status with conformance to Article 12 require-

ments. The report documented that approximately 98 percent of the registered storage facilities are in full or significant conformance with Article 12. Existing storage facilities that could not be upgraded to meet all of the Article 12 requirements have equivalent controls in place to ensure that impacts to human health and the environment are avoided. Seven remaining storage facilities that currently do not conform to Article 12 have plans in place for upgrades or are being prepared for permanent abandonment.

BNL 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 RESOURCE CONSERVATION AND RECOVERY ACT

RCRA regulates hazardous wastes that could present risks to human health or the environment if mismanaged. 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. BNL is considered a large-quantity generator 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 has a number of 90-day accumulation and storage areas.

NYSDEC did not conduct an inspection of BNL hazardous waste management operations in 2003. During 2003, the Laboratory continued its discussions with NYSDEC and EPA regarding the Notice of Violation (NOV) issued in January 2003 for inspection issues identified in the August 2002 RCRA inspection. On September 26, 2003 NYSDEC issued a letter to BNL withdrawing part of its Complaint and Notice of Hearing and Consent Order pertaining to its 2002 NOV alleging the improper management of CERCLA-derived wastes. As a result, a new NOV was issued outlining the two remaining issues. One item, a missing label, was corrected during the inspection. The other involved the preparation of a Land Disposal Restriction (LDR) Notification for intra-laboratory shipments of waste. BNL modified its procedures to ensure future completion of the LDR Notification and submitted a copy of the revised procedure to NYSDEC as evidence. BNL's response to the two remaining items in the Notice of Violation were deemed satisfactory by NYSDEC, and the case was closed in December 2003.

Mixed wastes are materials that are both hazardous (under RCRA guidelines) and radioactive. The Federal Facilities Compliance Act (FFCA), 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 (DOE or commercial) that are able to manage mixed waste produced at federal facilities, and to develop a schedule for treating and disposing of these waste streams.

BNL updates the BNL Site Treatment Plan annually and submits it to NYSDEC. The update 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 most of the mixed waste now in storage have been identified, and most of the current inventory was shipped off site for treatment and disposal in 2003. BNL will continue to update the treatment plan for wastes that have no identified disposal pathway.

In 2003, BNL managed 126,309 ft^3 of radioactive waste in compliance with the requirements of DOE Order 435.1, Radioactive Waste Management, and the BNL Radioactive Waste Management Basis Program Description. Of this quantity, almost 120,000 ft^3 (more than 90 percent) was generated as a result of environmental restoration activities on the BNL site, with most waste coming from the cleanup of BNL's Former Waste Management Facility. Radioactive wastes are generated by only a few departments at BNL during routine operations, and the management of those wastes is strictly regulated and controlled. Disposal of radioactive wastes occurs at two off-site fa-

cilities, DOE's Hanford Facility in the state of Washington, and a commercial facility, Envirocare of Utah. No wastes are disposed of at BNL.

3.10 POLYCHLORINATED BIPHENYLS

The storage, handling, and use of PCBs are regulated under the Toxic Substance and Control Act (TSCA). Capacitors manufactured before 1970 that are believed to be oil filled are handled as if they contain PCBs, even when the existence of PCBs cannot be verified through an investigation of 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. The PCB inventory is updated by July 1 of each year. All PCB-containing articles or PCB-contaminated equipment must be labeled. BNL responds to any PCB spill in accordance with standard emergency response procedures. BNL was in compliance with TSCA requirements in 2003.

3.11 PESTICIDES

The storage and application of pesticides (insecticides, rodenticides, herbicides, and algicides) are regulated under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). 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 also are 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, and herbicide use for the previous year. BNL was in full compliance with FIFRA requirements in 2003.

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. BNL 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 Natural Resource Protection Program 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, BNL must comply with the permit conditions.

In 2003, five projects were permitted under this program, three ongoing and two new. The three ongoing projects include construction of a new storage facility at the Alternating Gradient Synchrotron, construction of a new recharge basin, and installation of a liner at Building 1010. The new storage facility was substantially complete by the end of 2003. Final photos of the finished project and a completed project notification will be filed with NYSDEC in 2004 to close this permit. The construction of a new recharge basin within the RHIC area was also substantially complete in 2003. Planting of native vegetation and filing of photos and a completed project application will be completed in 2004. The final existing project, installation of a geomembrane at Building 1010, was completed in 2003 and a request to close this permit was submitted in October 2003. The two new projects involved construction of a modular building at RHIC to house electrical power supplies that are currently located within the RHIC ring, and paving parking areas at Buildings 1002 and 1004. By moving the electrical units outside the accelerator, maintenance can be conducted during operational periods with no radiation exposure to staff. These projects are expected to be completed in 2004.

3.13 ENDANGERED SPECIES ACT

In 2003, as part of ongoing work under the Natural Resource Management Plan (NRMP), BNL submitted a request to the New York Natural Heritage program for a list of all heritage elements located on the BNL site. The list was sent to BNL in late December. Review of the list resulted in the addition of several species to BNL's list of endangered, threatened, and species of special concern (see Table 6-1 in Chapter 6). Added to the list were two butterflies (the Persius duskywing, a state endangered species, and the mottled duskywing, a species of special concern); the eastern spadefoot toad, which was documented on site in May; two birds, the northern harrier (a state threatened species that was spotted in November), and Cooper's hawk, which was a documented nesting species in 2003; and several species of plants including stargrass, a state threatened species, crested fringed orchid, a state endangered species, and long-beaked bald-rush, a rare species. Two other species were identified in the correspondence from the Heritage Program but were not added to BNL's list since they were reported before World War II and were from areas that have since been disturbed. The two plants that were not added to the list are the dwarf huckleberry and the Virginia ground-cherry. If these plants are found to still exist in the area, they will be added to BNL's list and management activities for their conservation will be developed.

The tiger salamander is no longer the only state endangered species found at BNL. However, it is probably the most notable and best-studied species on site. Tiger salamanders are listed in New York State as endangered 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. In 2003, BNL prepared a Natural Resource Management Plan (BNL 2003b) replacing the former Wildlife Management Plan (Naidu 1999). The new plan formalizes the strategy and actions needed to protect 17 confirmed tiger salamander breeding locations identified at BNL. The strategy includes identifying and mapping habitats, monitoring breeding conditions, improving breeding sites, and controlling activities that could negatively affect breeding.

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 because eastern Long Island has the only known remaining populations of these fish in New York. Measures taken or being taken by BNL to protect the banded sunfish and swamp darter and their habitat include the following:

- Eliminating, reducing, or controlling pollutant discharges
- Upgrading the STP to reduce nitrogen loading in the Peconic River (completed in 1998)
- Monitoring populations and water quality
- Maintaining adequate flow to the river to enable the fish to survive drought
- Minimizing disturbances to the river and adjacent banks

Of the three butterfly species found at BNL that are endangered, threatened, or of special concern, both the frosted elfin and Persius duskywing depend on lupine, a wildflower in the pea family. In the past, a single area of lupine existed on BNL grounds. This habitat still exists and it is assumed that the butterflies are still present. The mottled duskywing prefers New Jersey Tea plant, which has not been found at BNL. Management of habitat and surveys for the three butterflies has been added to BNL's Natural and Cultural Resource Management Program.

BNL also has 11 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. The species of special concern found at BNL include the mottled duskywing butterfly, marbled salamander, eastern spadefoot toad, spotted turtle, eastern box turtle, eastern hognosed snake, horned lark, whip-poor-will, vesper sparrow, grasshopper

sparrow, and the Cooper's hawk. Management efforts taken 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 BNL. Observations of the eastern hognosed snake were reported on 17 different occasions in 2003, and a radio telemetry study was initiated to better understand its movements and habitat needs. BNL continues to evaluate bird populations as part of the management strategy outlined in the NRMP. Data concerning species of special concern are used appropriately in making management decisions regarding those species. 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.

BNL has 20 plant species 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. Locations of these rare plants must be determined, populations estimated, and management requirements established. Management of protected plants is included in the NRMP. See Chapter 6 for more information.

3.14 EXTERNAL AUDITS AND OVERSIGHT

A number of federal, state, and local agencies oversee BNL activities. BNL was inspected by federal, state, or local regulators on nine occasions in 2003. These inspections are summarized in Section 3.14.1. In 2003, SCDHS maintained a part-time, on-site staffer who provided day-to-day oversight of BNL activities. In addition to external audits and oversight, BNL has a comprehensive self-assessment program, as described in Chapter 2.

3.14.1 Inspections by Regulatory Agencies

- *Hazardous Waste*. NYSDEC did not conduct a RCRA/hazardous waste compliance inspection in 2003.
- *Air Compliance*. NYSDEC conducted an annual inspection of the Central Steam Facility in March. No issues were identified during this inspection.
- *Potable Water*. SCDHS conducts annual inspections of the BNL potable water system to collect samples and ensure that facilities are maintained. There were no issues identified in 2003. All sample results were within drinking water standards, except for iron, which occurs naturally in some of the wells. As noted in Section 3.7.1, BNL treats the drinking water supply to remove iron before distribution.
- *Sewage Treatment Plant.* SCDHS conducts quarterly inspections of the BNL STP. In 2003, no performance or operational issues were identified during these inspections. During these inspections, facility operations were evaluated and effluent samples were collected.
- *Recharge Basins.* As part of SCDHS oversight, inspections are conducted periodically of recharge basins and other SPDES outfalls. In 2003, SCDHS inspected the outfalls in March and collected samples during the assessment. Methyl-tertiarybutyl ether was detected in a sample collected by SCDHS from Outfall 001. Followup sampling by BNL did not confirm these results. No other issues were identified.
- *Major Petroleum Facility*. The MPF is inspected annually by NYSDEC. This inspection was conducted in July 2003. See Section 3.8.4 for a discussion of this inspection.
- *Chemical Bulk Storage Facilities*. The CBS facilities are inspected periodically by NYSDEC. This inspection was conducted in July 2003. See Section 3.8.5 for a discussion of this inspection.

3.14.2 Inspections by DOE

Neither DOE Headquarters (EH-10) nor the Chicago Operations Office conducted as-

sessments of the Laboratory's environmental programs in 2003. During 2003, the DOE Brookhaven Area Office (BAO) continued to oversee BNL programs and observed programmatic assessments of spill response procedures and procedures for storing and transferring nonhazardous and hazardous waste. BAO also reviewed BNL's program to comply with DOE Order 5400.5, and participated in a review of the specification and implementation of requirements under the Environmental Restoration Program. The results of these four assessments are summarized in the paragraphs below.

3.14.2.1 Spill Response Self-Assessment

BAO staff observed the Environmental and Waste Management Services Division (EWMS) Division programmatic assessment of the Standards-Based Management System (SBMS) subject area, Spill Response. The Spill Response assessment, which was conducted in the second quarter of 2003, reviewed Laboratory-wide compliance with spill response procedures and regulatory requirements. The assessment identified five observations and 13 areas for improvement of process-specific operations. Most of the items for improvement dealt with the availability of appropriate spill response kits in each department. Other issues identified included minor inconsistencies between regulatory and SBMS subject area requirements. A corrective action plan was prepared and all issues will be closed in early 2004.

3.14.2.2 Storage and Transfer Self-Assessment

In July and August of 2003, BAO observed the EWMS Division's self-assessment of BNL's implementation of the SBMS subject area Storage and Transfer of Hazardous and Non-Hazardous Materials. The purpose of the self-assessment was to evaluate the Laboratory-wide management of tanks and other storage facilities used to store materials, and to assess compliance with applicable regulations and guidance. The assessment identified five noteworthy practices and 21 instances where improvements were needed, which included the noncompliances identified by NYSDEC during the annual MPF and CBS inspections (see Sections 3.8.4 and 3.8.5). Most of the findings were administrative and included issues such as incorrect inspection documentation, failure to conduct an inspection, or lack of formal closure of out-of-service storage facilities. A corrective action plan was prepared and all issues are being tracked to closure.

3.14.2.3 Implementation of DOE Order 5400.5

BAO reviewed BNL's implementation of DOE Order 5400.5, Radiation Protection of the Public and the Environment. The BAO assessment primarily focused on the Laboratory's Environmental Monitoring Plan, environmental dose assessments, and justification of the environmental monitoring program. Four issues were identified: documentation of dose to biota, documentation of the technical justification for placement of thermoluminescent dosimeters (TLDs), isolated instances of inconsistent data reporting in the 2001 Site Environmental Report, and documentation of the technical justification for placement of air sampling devices during field activities. Corrective actions have been implemented to improve the Laboratory's compliance with the Order 5400.5 requirements.

3.14.2.4 Specification and Conformance to ARARs

The review for conformance to Applicable, Relevant, and Appropriate Requirements (ARARs) was conducted by Laboratory staff with observation by BAO and the Chicago Operations Office. The purpose of the review was to ensure that during restoration projects, ARARs were being identified and complied with. Three projects were reviewed for ARAR conformance: the Operable Unit (OU) III Middle Road groundwater remediation system, the OU I soil remediation project, and the OU III Industrial Park groundwater remediation system. In summary, the assessment concluded that ARARs are clearly defined and that evidence of conformance with the ARARs is readily available for the three projects reviewed.

3.14.3 Enforcement Actions and Memos

No new consent orders were issued to BNL in 2003. A Notice of Violation for administrative deficiencies was issued by NYSDEC as a

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	NYSDEC and DOE	1992 (Updated Annually)	The Federal Facilities Compliance Agreement (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" on 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 2003.
Enforcement Actions				
No Number	Notice of Violation–Resource Conservation and Recovery Act	NYSDEC	1/14/03	A Notice of Violation (NOV) was issued for three administrative deficiencies that were identified during the 2002 annual hazardous waste compliance inspection conducted by NYSDEC. Two of the three "deficiencies" related to CERCLA-derived wastes and were later retracted as deficiencies. The remaining item has been satisfactorily corrected.

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

result of the 2002 annual RCRA inspection (see discussion in Section 3.9). All existing enforcement actions and MOAs 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. The Laboratory continues to work with the regulators to close these actions as expeditiously as possible.

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4

Air Quality

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 2003, BNL facilities released a total of 3,725 curies of short-lived radioactive gases. Oxygen-15 and carbon-11 emitted from the Brookhaven Linac Isotope Producer constituted more than 99.7 percent of the site's radiological air emissions.

With natural gas prices higher than residual fuel prices throughout 2003, the Central Steam Facility relied more on residual fuel to meet the heating and cooling needs of BNL's major facilities than in past years. As a result, annual facility emissions of particulate matter, nitrogen oxides, and sulfur dioxide were considerably higher in 2003 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 (1990): 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 or 1µSv to a member of the public must be continuously monitored for emissions. Facilities capable of delivering radiation doses below that limit require periodic, confirmatory monitoring. BNL has one facility that requires continuous monitoring, the Brookhaven Linac Isotope Producer (BLIP), and three active facilities where periodic monitoring is conducted. Figure 4-1 indicates the locations of the monitored facilities for radiological emissions, and Table 4-1 presents the airborne release data from each of these facilities during 2003. Annual emissions from monitored facilities are discussed in the following sections of this chapter. A fourth inactive facility (the Evaporator Facility) that was periodically monitored in past years is also discussed. The associated radiation dose calculations are presented in Chapter 8.

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 with a half-life of 1.8 hours. After passage through the reflector, the air was routed through a roughing filter and a high-efficiency particu-

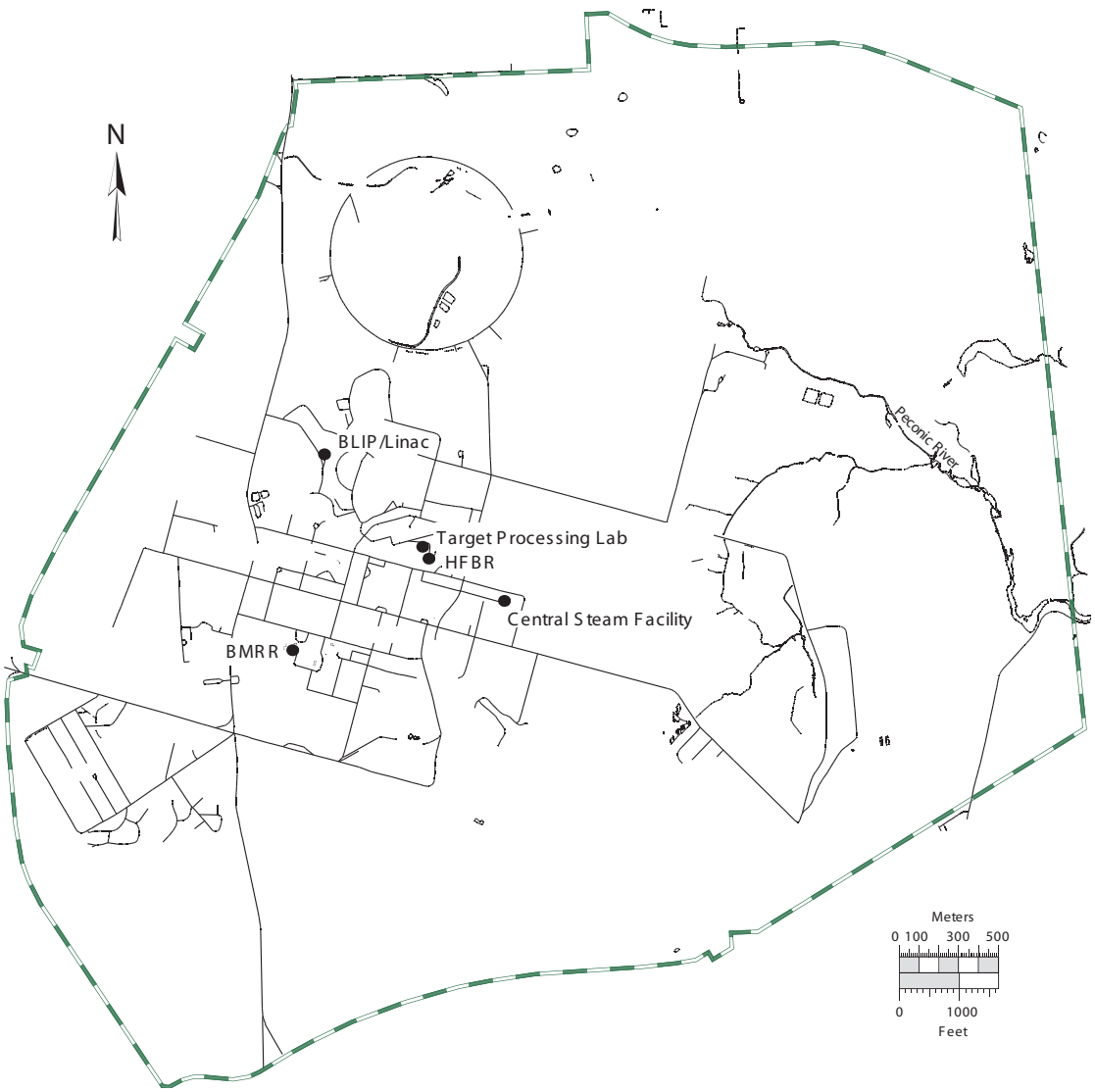

Figure 4-1. Air Emission Release Points Subject to Continuous Monitoring.

late air (HEPA) filter to remove any particulate matter. Charcoal filters also were 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 2003, sampling showed there were no detectable emissions of Ar-41 or other argon radionuclides at zero power level with building ventilation on.

In January 2003, the remaining fuel was removed from the BMRR reactor vessel, eliminating the last significant source for radionuclide emissions to the environment. The sole remaining emission source is evaporation of the cooling water, which was tritiated by neutron activation when the BMRR operated. In 2003, the release of tritium as tritiated water vapor (HTO) was estimated at 76.3 mCi, based on the concentration of tritium and measured decreases in the volume of water.

4.1.2 High Flux Beam Reactor

Following the discovery of an underground plume of tritiated groundwater emanating from a

leak in the spent fuel storage pool, the High Flux Beam Reactor (HFBR) was kept in a standby mode. This lasted from January 1997 until November 1999, when DOE announced that the HFBR would be permanently shut down. The storage pool had been drained in December 1997 to prevent additional leakage, as well as to facilitate repairs and double lining of the pool to conform to Suffolk County Article 12, which regulates storage tanks. When the HFBR operated, it used "heavy" water 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 the neutron fields generated inside the reactor vessel, the deuterium became activated, producing radioactive tritium (half-life: 12.3 years). Although the heavy water has been removed from the vessel, residual tritium still remains in the vessel and cooling loops. Tritiated water vapor is released from the vessel and associated piping systems to building air (via diffusion at valve seals and other system penetrations), where it is routed to the facility's 328-ft stack. Concentrations of HTO in air are assessed using a silica gel absorbent material. In 2003, 8.99 Ci of tritium as airborne HTO were released from the HFBR. This is an increase from the 1.93 Ci of tritium released in 2002. The increased emissions are believed to be the due to evaporative losses during the pump-out of the remaining water from the reactor core to a tanker trailer in July. Figure 4-2 illustrates the declining trend of tritium emissions from the HFBR since 1994. In 2003, sampling frequency continued at 1 week per month.

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

Facility	Nuclide	Half-life	Ci Released
BMRR	Argon-41	1.8 hours	None
	Tritium	12.3 years	7.63E-02*
HFBR	Tritium	12.3 years	8.99E+00
BLIP	Carbon-11	20.4 minutes	9.43E+02
	Oxygen-15	122 seconds	2.78E+03
	Tritium	12.3 years	1.76E-02
Target Processing Laboratory	Germanium-68	288 days	4.82E-09
	Germanium-69	1.6 days	4.52E-11
	Iodine-131	8.0 days	4.36E-08
	Selenium-75	119.8 days	2.64E-11
Total			**3.73E+03**

Notes:
Ci = 3.7E10 Bq.
BLIP = Brookhaven Linac Isotope Producer
BMRR = Brookhaven Medical Research Reactor (operations were terminated in December 2000)
HFBR = High Flux Beam Reactor (operations were terminated in November 1999)
* Estimated release (see Section 4.1.1 for details)

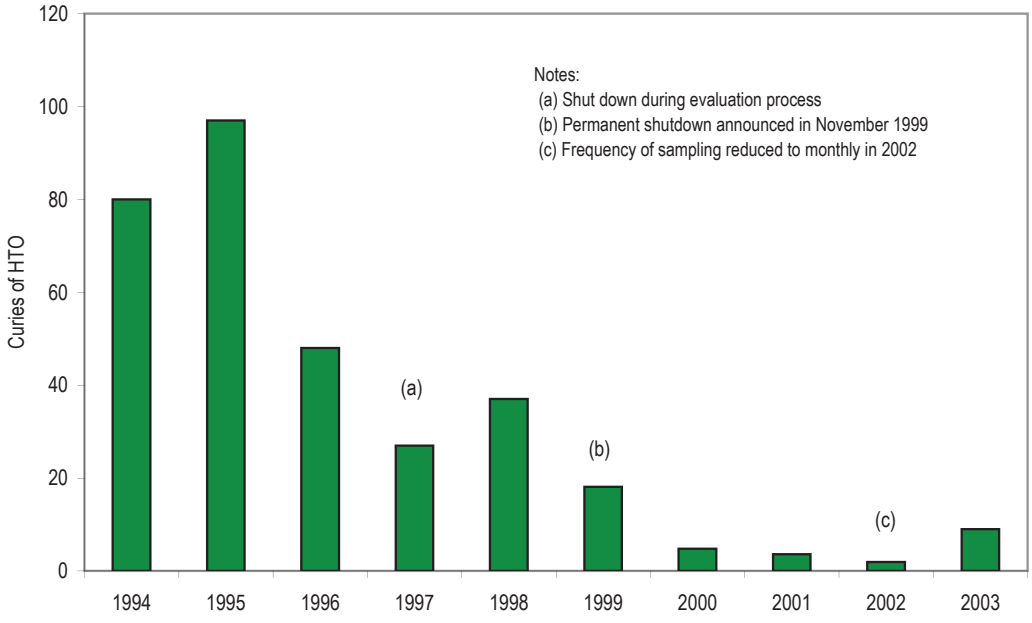

Figure 4-2. High Flux Beam Reactor Tritium Emissions, Ten-Year Trend (1994 – 2003).

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. The proton beam activates these metal targets to produce new radionuclides for diagnostic use. The activated metal targets are transferred to the Target Processing Laboratory (TPL) in Building 801 for separation and later 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 are oxygen-15 (O-15) and carbon-11 (C-11), radionuclides with half-lives of 122 seconds and 20.48 minutes, respectively. Both of these isotopes are released as gaseous, airborne emissions through the facility's 33-ft stack.

In 2003, the BLIP operated over a period of 16 weeks. During this period, 943 Ci of C-11 and 2,782 Ci of O-15 were released. Tritium produced from activation of the target cooling water was also released, but in a much smaller quantity, 1.76E-02 Ci. Emissions of C-11 and O-15 declined by more than 33 percent from 2002, primarily due to a reduced period of operation (16 weeks in 2003 compared to 21 weeks in 2002). The tritium release also was less than in 2002.

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. However, 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 directed to the same stack used by the HFBR to exhaust building air. This method was preferable to release via 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 there have been no emissions of tritiated water vapor from it. Because generation rates of aqueous wastes containing residual radioactivity are expected to remain low, it is no longer economical to process the waste in the same manner. As a result, plans are to decommission the WCF reverse osmosis process and the Evaporator Facility.

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 2003, the total release from the TPL was 0.049 μCi. See Table 4-1 for details on which radionuclides were released in 2003.

4.1.6 Additional Minor Sources

Several research departments at BNL use designated fume hoods for work that involves very small quantities of radioactive materials (in the μCi to mCi range). The work done using fume hoods typically involves transferring material between containers, using pipettes, and labeling chemical compounds. Due to the use of HEPA 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 Uncharacterized Radiological Emission Sources

Uncharacterized radiological emissions (diffuse or area sources) were evaluated in 2003 for compliance with NESHAPs, Subpart H. The EPA-approved CAP88-PC dose modeling program was used to calculate the dose to members of the public from planned research, environmental restoration, and waste management activities (see Chapter 8 for more details). These 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 2003.

One of the projects evaluated was the removal of filters and liners for belowground ducts (BGD) associated with the former Brookhaven Graphite Research Reactor (BGRR). This removal was accomplished using two Brokk Model Remote System machines fitted with a variety of remotely operated tools that enabled the operator to demolish the filter material into pieces small enough to be carried through a vacuum hose to a cyclone separator. All demolition was carried out in a temporary structure called the Duct Service Building (DSB), erected on a concrete slab. The structure was maintained at negative pressure with a separate 6,000-ft^3 (cfm) HEPA-filtered ventilation system. The results of airborne particulate and charcoal samples collected from the DSB's HEPA-filtered exhaust opening during demolition were evaluated using the CAP88-PC modeling program. The potential effective dose equivalent (EDE) estimated by the modeling program was 1.50E-05 mrem in a year to the maximally exposed individual (MEI). This value is well below the annual 0.1 mrem threshold that triggers the NESHAPs Subpart H requirements for continuous monitoring. Chapter 8 discusses this and other activities that were evaluated under NESHAPs Subpart H.

4.2 FACILITY MONITORING

In the past, potential sources of radioactive particulate emissions that have been monitored included the BMRR, the HFBR, the Evaporator Facility, the TPL (Building 801), and the BLIP. Since the BMRR and HFBR are permanently shut down and the Evaporator Facility did not process any aqueous wastes in 2003, 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 0.0007 and 0.0126 pCi/m^3, respectively. The annual average gross alpha and beta airborne activity levels for samples collected from the BLIP exhaust stack were -0.0001 and 0.1302 pCi/m^3, respectively. For a discussion of negative values associated with radioactivity monitoring, see Appendix B.

4.3 AMBIENT AIR MONITORING

As part of the Environmental Monitoring Program, an array of air monitoring stations is in place around the perimeter of BNL. Samplers are housed within six blockhouse stations (see Figure 4-3 for locations). The blockhouses are fenced to control access and protect costly sampling equipment. In the past, 16 pole-mounted, battery-powered silica-gel samplers,

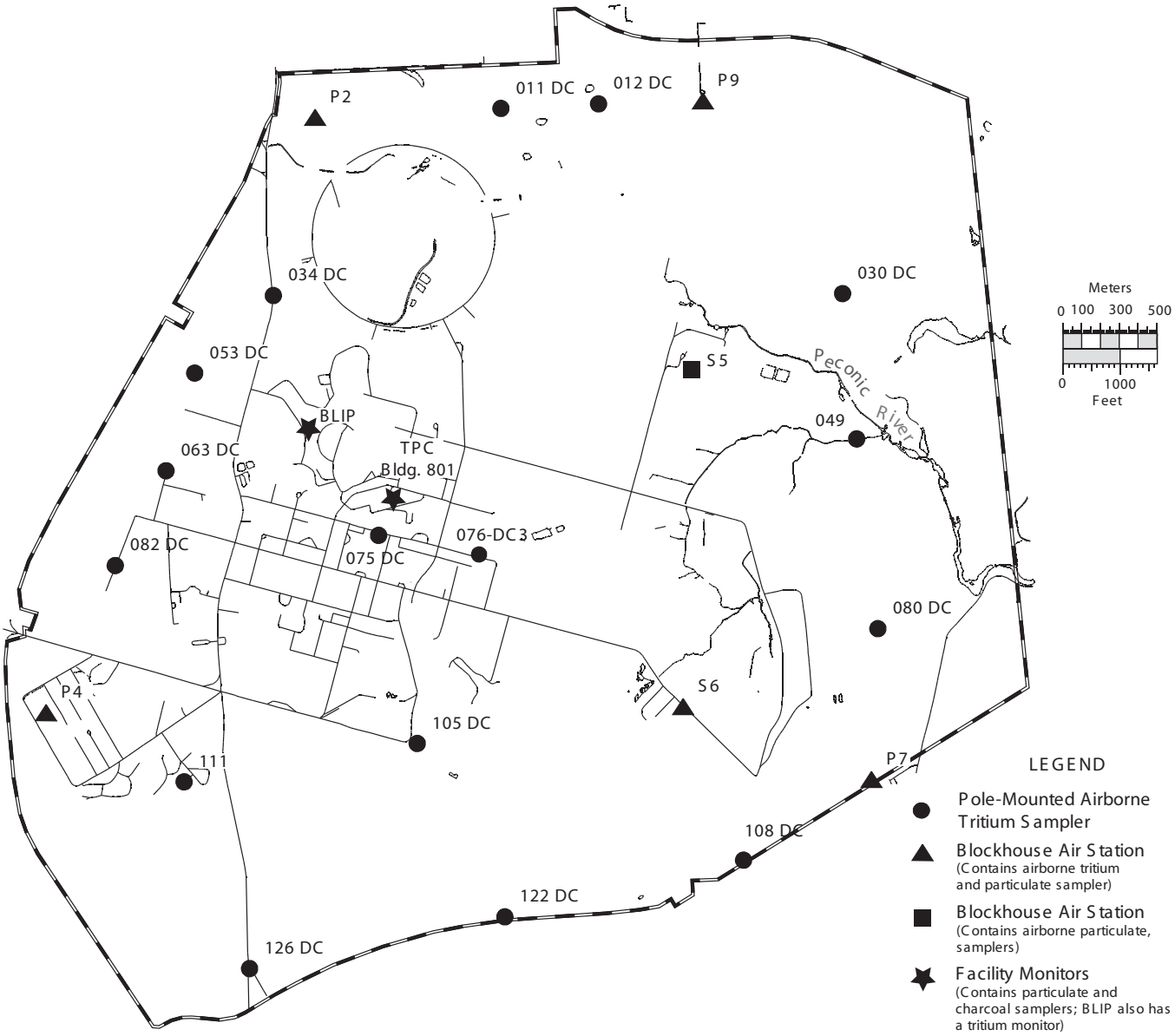

Figure 4-3. BNL On-Site Ambient Air Monitoring Stations.

located throughout the site, had been used for tritium monitoring. Examination of 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, which ranged from 1.0 to 6.0 pCi/m^3. As a result, it was determined that the number of battery-powered silica-gel tritium samplers could be reduced from 16 to 3, to eliminate redundant sampling. This reduction did not affect the purpose of the monitoring, which is to assess the potential health and environmental impacts of the remaining tritium emission sources on site.

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. Note that Station S5 does not contain a tritium sampler. Particulate filters are collected weekly and are analyzed for gross alpha and beta activity using a gas-flow propor-

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

Facility Monitor		Gross Alpha	Gross Beta
		(pCi/m^3)	
BLIP	N	46	46
	Max.	0.1610 ± 0.1200	0.9990 ± 0.3480
	Avg.	-0.0001 ± 0.0224	0.1302 ± 0.0397
	MDL	0.200	0.549
TPL - Bldg. 801	N	51	51
	Max.	0.0025 ± 0.0020	0.0480 ± 0.0070
	Avg.	0.0007 ± 0.0003	0.0126 ± 0.0006
	MDL	0.003	0.009

Notes:
See Figure 4-3 for sample monitoring stations.
All values shown with a 95% confidence interval.
Negative values occur when the measured value is less than background. (See Appendix B for description.)
N = Number of validated samples collected
MDL = Average Minimum Detection Limit
TPL = Target Processing Laboratory

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

Sample Station		Gross Alpha	Gross Beta
		(pCi/m^3)	
P2	N	52	52
	Max	0.0021 ± 0.0007	0.0233 ± 0.0021
	Avg.	0.0006 ± 0.0001	0.0126 ± 0.0002
	MDL	0.001	0.002
P4	N	50	50
	Max	0.0027 ± 0.0037	0.4230 ± 0.0236
	Avg.	0.0006 ± 0.0002	0.0199 ± 0.0010
	MDL	0.001	0.002
P7	N	52	52
	Max	0.0022 ± 0.0007	0.0212 ± 0.0025
	Avg.	0.0009 ± 0.0001	0.0123 ± 0.0002
	MDL	0.001	0.002
P9	N	52	52
	Max	0.0015 ± 0.0005	0.0216 ± 0.0023
	Avg.	0.0006 ± 0.0001	0.0109 ± 0.0004
	MDL	0.001	0.002
S5	N	52	52
	Max	0.0019 ± 0.0011	0.0259 ± 0.0025
	Avg.	0.0007 ± 0.0001	0.0122 ± 0.0004
	MDL	0.001	0.002
S6	N	52	52
	Max	0.0018 ± 0.0007	0.0246 ± 0.0024
	Avg.	0.0009 ± 0.0001	0.0144 ± 0.0002
	MDL	0.001	0.002
Grand Average		**0.0007 ± 0.0001**	**0.0137 ± 0.0027**

Notes:
See Figure 4-3 for sample monitoring stations.
All values shown with a 95% confidence interval.
N = Number of validated samples collected
MDL = Average Minimum Detection Limit

tional counter. In 2003, silica-gel samples were collected for processing by liquid scintillation analysis biweekly, which was an increase over the 2002 frequency of one week per month.

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 0.0007 and 0.0137 pCi/m^3, respectively. Annual gross beta activity trends recorded at Station P7 are plotted in Figure 4-4. The results at 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 gross alpha activity is not plotted because most results were below the MDL.

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 comparable to the Station P7 samples analyzed by the BNL Analytical Services Laboratory. Analytical results for gross beta activity reported by the NYSDOH laboratory were between 0.0066 and 0.0249 pCi/m^3, with an average concentration of 0.0161 pCi/m^3, whereas the BNL results ranged from -0.0012 to 0.0212 pCi/m^3, with an

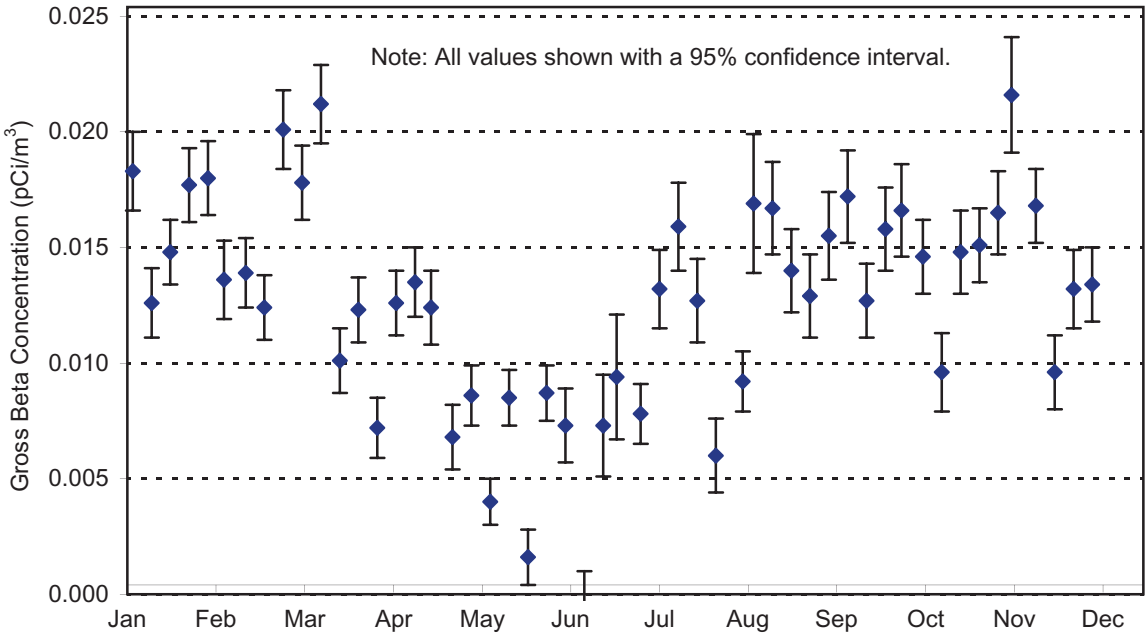

Figure 4-4. Airborne Gross Beta Concentration Trend Recorded at Station P7.

average concentration of 0.0123 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 2003, NYSDOH reported that airborne gross beta activity at that location varied between 0.0031 and 0.048 pCi/m^3. The average concentration at this control location was 0.0125 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 BNL site. In addition to the five blockhouses containing tritium samplers, three pole-mounted monitors used for tritium sampling are located at or near the property boundary (see Figure 4-3 for locations). Airborne tritium is collected by using a pump to draw air through a column of silica gel, a water-absorbent medium. The absorbed HTO is recovered by distillation and analyzed using liquid scintillation counting techniques, described in Appendix D.

Table 4-4 lists the number of validated samples collected at each location, the maximum value observed, and the annual average concentration. Validated samples are those not rejected due to equipment malfunction or other factors (e.g., a battery failure in the sampler, frozen or super-saturated silica gel, or the loss of sample during laboratory preparation). With the exception of Station 049, where biweekly sampling commenced on March 14, airborne tritium samples were collected biweekly from each sampling station during 2003. 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 2003 were comparable to concentrations observed in 2002, with the exception of Station S6, where the average concentration dropped from 45.6 to 0.8 pCi/m^3, consistent with background levels. Previous investigations into the elevated concentration of prior years had revealed no obvious source.

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. BNL 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 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, respectively. Each of these boilers 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 emissions are also continuously monitored for opacity. To measure combustion efficiency, both boilers are also monitored for carbon dioxide (CO_2). Continuous emission monitoring results from the two boilers are reported quarterly to EPA and the New York State Department of Environmental Conservation (NYSDEC).

From May 1 to September 15 (the peak ozone period), compliance with the 0.30 lbs/MMBtu (129 ng/J) NO_x emission standard for No. 6 oil and the 0.20 lbs./MMBtu (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 2003, there were no measured exceedances of the NO_x emission standards for either boiler. During the year, all but one of the Boiler 7 opacity measurements that exceeded the limit occurred during opacity monitoring system calibrations, boiler start-ups, or routine boiler tube soot blowing operations. While there are no regulatory requirements to continuously monitor opacity for Boilers 1A, 5, and 6, 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

Table 4-4. Ambient Airborne Tritium Measurements in 2003.

Sample Station	Wind Sector	Validated Samples	Maximum	Average
			(pCi/m^3)	
049	E	18	9.0 ± 4.7	1.2 ± 1.1
053	NW	23	6.9 ± 3.3	0.6 ± 0.7
122	SSE	20	6.6 ± 3.0	0.9 ± 0.7
P2	NNW	25	4.3 ± 2.9	0.6 ± 0.5
P4	WSW	25	<3.9	0.7 ± 0.4
P7	ESE	25	4.9 ± 3.0	0.2 ± 0.6
P9	NE	25	6.5 ± 2.9	0.8 ± 0.6
S6	SE	25	5.6 ± 3.2	0.8 ± 0.5
Grand Average				0.7 ± 0.2

Notes:
See Figure 4-3 for sample monitoring stations.
Wind sector is the downwind direction of the sample station from the HFBR stack.
All values reported with a 95% confidence interval.
Typical minimum detection limit for tritium is between 1.0 and 6.0 pCi/m^3.
DOE Order 5400.5 Air Derived Concentration Guide is 100,000 pCi/m^3.

Table 4-5. Central Steam Facility Fuel Use and Emissions (1996 – 2003).

	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	4,290.95	628,765	402.06	56,288	0.98	1,000	22.8	75.3	107.1	0.6

Notes:
NO_x = Nitrogen oxides
SO_2 = Sulphur dioxide
TSP = Total Suspended Particulates
VOCs = Volatile Organic Compounds

exceeding the regulatory limits established for these boilers.

In the spring of 1997, the Long Island Lighting Company completed work extending a natural gas main into the CSF. To accommodate the combustion of natural gas, new gas rings were added to the burners of Boiler 5, and natural gas trains were installed to connect the gas main to Boilers 5 and 7. In 1998, existing steam-atomized oil burners on Boiler No. 6 were replaced with two dual-fuel low-NO_x burners, and a natural gas train was added to connect the boiler to the gas main.

Throughout 2003, natural gas prices exceeded those for residual fuel oil. As a result, residual fuel supplied 99 percent of the heating and cooling needs of BNL's major facilities in 2003, while the combustion of natural gas accounted for less than one percent of these heating and cooling needs. By comparison, in 1999 natural gas satisfied more than 88 percent of the major facility heating and cooling needs, and in 2002, 36 percent. Consequently, 2003 emissions of particulates, NO_x, and SO_2 were 17.7, 21.8, and 90.4 tons higher than the respective totals for 1999 and were 7.4, 12.9, and 53.3 tons higher than the respective emission totals for 2002. Table 4-5 shows fuel use and emissions since 1996.

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5

Water Quality

Brookhaven National Laboratory discharges wastewater 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 careful operation of treatment facilities helps ensure that wastewater discharges comply with all applicable requirements and that the public, employees, and environment are protected.

Analytical data for 2003 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 were slightly higher than in 2002, due to activities at the High Flux Beam Reactor in preparation for its decommissioning. The maximum concentration of tritium released was less than 4 percent of the drinking water standard. Remedial activities at the STP have proved to be effective, as evidenced by no detections of cesium-137 and strontium-90 in the effluent. No other gamma-emitting nuclides attributable to BNL operations were detected. While very low concentrations of tritium were detected at the STP outfall, there were no detections above the minimum detection limit at any downstream monitoring station.

Nonradiological monitoring of the effluent showed that, with the exception of minor incidents of noncompliance, organic and inorganic parameters were within State Pollutant Discharge Elimination System effluent limitations or other applicable standards. Inorganic data from the upstream, downstream, and control locations demonstrated that elevated amounts of aluminum and iron detected in the Peconic River were a result of natural sources. In addition, the low pH of water samples collected at several sections of the river was also due to natural causes.

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 this discharge on the quality of the river, surface water monitoring is conducted at several locations upstream and downstream of the discharge point. Monitoring Station HY, located on site but upstream of all BNL operations, provides information on the "background" water quality of the Peconic River (see Figure 5-8). The Carmans River is monitored as a geographic control location for comparative purposes, as it is not affected by BNL operations.

On the BNL site, the Peconic River is an intermittent stream. Off-site flow only occurs during periods of sustained precipitation, typically in the spring. Due to a wet spring and summer in 2003, off-site flow was recorded from March through December. The following sections

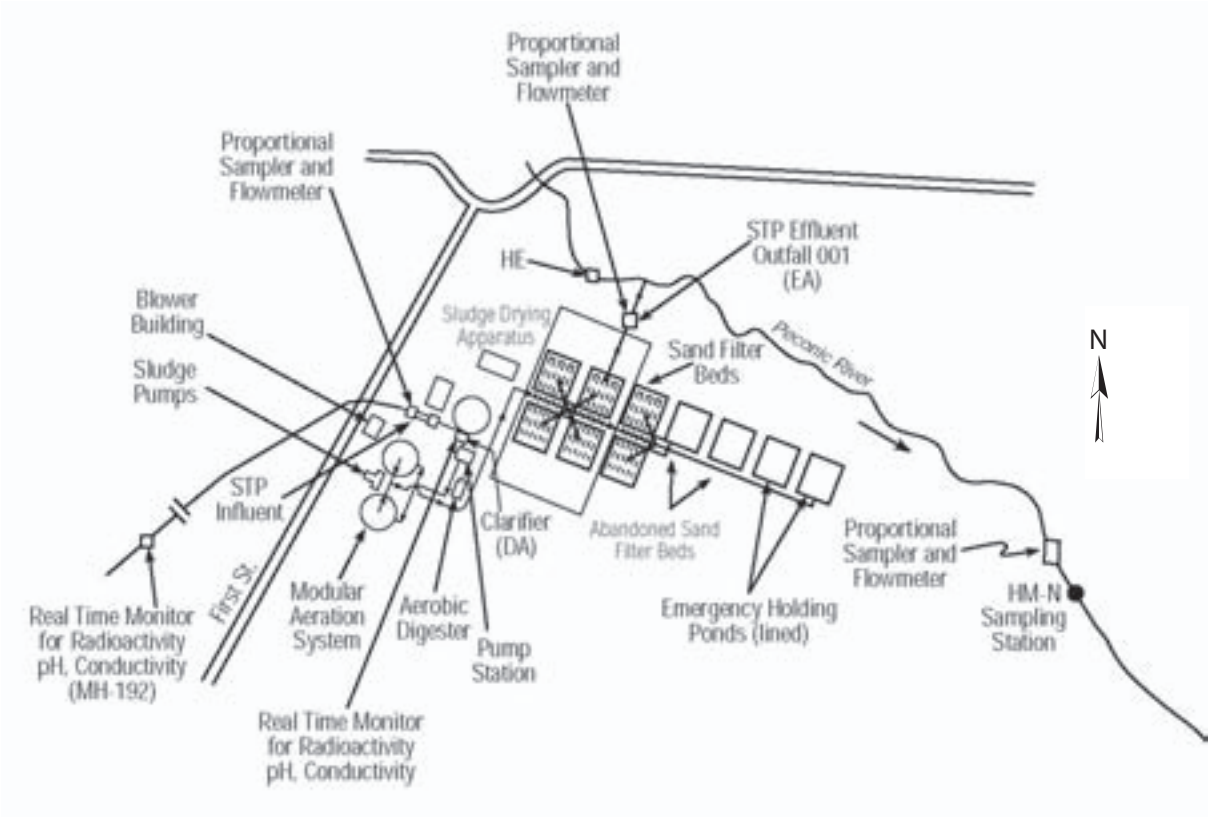

Figure 5-1. Schematic of BNL's Sewage Treatment Plant (STP).

describe BNL'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 BNL 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. During 2003, the STP discharge continuously met the nitrogen limit of 10 mg/L specified in the SPDES permit.

Real-time monitoring of the sanitary waste stream for radioactivity, pH, and conductivity takes place at two locations. The first site 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 clari-

fier. In addition to the monitoring that occurs at these two stations, as effluent leaves the primary clarifier it is also monitored for radioactivity.

Any influent to the clarifier that does not meet SPDES limits or BNL effluent release criteria is diverted to two double-lined holding ponds. The total combined capacity of the two holding ponds exceeds 7 million gallons, or approximately 14 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 or BNL effluent release criteria. No diversions were necessary in 2003.

Solids separated in the clarifiers are pumped to an aerobic digester for solids reduction. Sludge is emptied into a solar-powered drying bed, where it is dried to a semisolid cake. Because the dried sludge contains very low levels of radioactivity (e.g., cobalt-60 at less than 0.1 to 2.0 pCi/g), it 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) 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 beta activity and tritium concentrations. During 2003, 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).

Although the Peconic River is not used as a direct source of potable water, BNL applies the stringent Safe Drinking Water Act (SDWA) standards for comparison purposes when monitoring the effluent, in lieu of DOE wastewater criteria. The SDWA specifies that no individual may receive an annual dose greater than 4 mrem (40 μSv) from radionuclides present in drinking water. The SDWA annual average gross alpha activity limit is 15 pCi/L, including radium-226 but excluding radon and uranium. The SDWA also stipulates a 50 pCi/L gross beta activity screening level, above which radionuclide-specific analysis is required. In addition to this basic screening requirement, BNL performs radionuclide-specific gamma analysis, regardless of the gross beta activity. Other SDWA-specified drinking water limits are 20,000 pCi/L for tritium and 8 pCi/L for Sr-90. For all other radionuclides, Derived Concentration Guides (DCGs) found in DOE Order 5400.5 (1990) are used to determine the concentration of the nuclide that, if continuously ingested in a year, would produce an annual dose of 4 mrem (40 μSv).

Gross activity (alpha and beta) measurements were 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 2003. Annual average gross alpha and beta activity levels in the STP effluent were 2.9 ± 0.3 pCi/L and 8.1 ± 0.4 pCi/L, respectively. These concentrations were well below the New York State Drinking Water Standard (DWS) of 15 pCi/L and 50 pCi/L, respectively. Control location data (Carmans River Station HH—see Figure 5-8 for location) show average gross alpha and beta levels of 0.88 ± 1.38 pCi/L and 0.95 ± 1.36 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 that meet BNL discharge criteria from other facilities. Although the HFBR is no longer operating, tritium continues to be released from the facility at very low concentrations, due to evaporative losses of residual tritium remaining in the reactor coolant and from off-gassing of the facility. 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

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

	Flow	Tritium Maximum	Tritium Average	Gross Alpha Maximum	Gross Alpha Average	Gross Beta Maximum	Gross Beta Average
	(Liters)	(pCi/L)					
STP Influent							
January	3.83E+07	594 ± 294	29 ± 160	4.6 ± 2.1	2.0 ± 0.6	16.2 ± 4.7	8.0 ± 1.8
February	3.77E+07	< 287	-38 ± 133	3.9 ± 2.0	1.7 ± 0.6	10.5 ± 4.0	8.1 ± 1.2
March	3.94E+07	1800 ± 280	167 ± 276	3.2 ± 1.6	1.7 ± 0.5	10.3 ± 4.2	7.7 ± 1.0
April	4.58E+07	< 250	-101 ± 73	2.7 ± 1.5	1.5 ± 0.6	10.6 ± 4.2	8.0 ± 0.9
May	5.54E+07	< 287	38 ± 55	4.8 ± 2.2	2.3 ± 0.8	11.5 ± 4.8	8.0 ± 1.4
June	5.66E+07	< 336	91 ± 40	3.5 ± 2.2	2.1 ± 0.5	15.6 ± 5.0	9.7 ± 2.0
July	6.27E+07	737 ± 267	460 ± 87	3.0 ± 1.8	1.7 ± 0.5	10.4 ± 4.0	7.2 ± 1.1
August	6.41E+07	564 ± 255	313 ± 99	6.8 ± 2.7	2.5 ± 1.1	9.8 ± 4.0	6.4 ± 1.4
September	3.57E+07	557 ± 264	272 ± 77	4.2 ± 2.1	2.1 ± 0.6	10.2 ± 4.0	6.6 ± 1.5
October	3.63E+07	598 ± 209	257 ± 93	3.9 ± 2.1	1.9 ± 0.5	14.6 ± 4.3	8.2 ± 1.9
November	3.69E+07	< 346	46 ± 70	5.8 ± 2.6	2.1 ± 1.1	11.2 ± 4.6	6.6 ± 1.5
December	3.94E+07	469 ± 232	22 ± 80	6.3 ± 2.4	2.6 ± 0.9	9.9 ± 4.5	6.3 ± 1.2
Annual Average			131 ± 42		2.0 ± 0.2		7.6 ± 0.4
STP Effluent							
January	4.02E+07	< 339	41 ±125	4.0 ± 1.9	1.9 ± 0.7	13.0 ± 4.4	7.4 ± 1.3
February	3.81E+07	< 366	-27 ± 108	5.0 ± 2.1	2.9 ± 0.7	12.5 ± 4.2	7.2 ± 1.7
March	4.84E+07	< 362	92 ± 51	4.6 ± 2.2	1.9 ± 0.7	12.6 ± 4.3	8.7 ± 1.3
April	4.86E+07	< 250	-19 ± 62	4.6 ± 2.0	3.0 ± 0.4	11.6 ± 4.5	8.1 ± 1.2
May	5.60E+07	368 ± 208	123 ± 71	6.7 ± 2.7	3.7 ± 1.1	12.6 ± 4.3	8.0 ± 1.6
June	6.99E+07	< 305	143 ± 45	5.9 ± 2.4	2.3 ± 0.7	13.6 ± 5.0	9.7 ± 1.4
July	6.83E+07	704 ± 263	452 ± 83	5.8 ± 2.4	3.0 ± 0.9	12.8 ± 4.2	8.3 ± 1.2
August	6.45E+07	489 ± 249	351 ± 59	4.0 ± 2.1	2.2 ± 0.6	13.6 ± 4.6	7.5 ± 1.9
September	4.83E+07	466 ± 252	327 ± 62	6.3 ± 2.4	3.2 ± 0.7	14.1 ± 4.4	9.2 ± 1.4
October	3.86E+07	662 ± 225	326 ± 93	6.8 ± 2.7	3.5 ± 0.9	12.0 ± 4.0	8.5 ± 1.5
November	3.75E+07	384 ± 237	116 ± 89	5.6 ± 2.6	2.5 ± 1.0	12.6 ± 4.2	7.5 ± 2.0
December	4.61E+07	< 268	58 ± 50	6.1 ± 2.9	4.3 ± 0.8	11.3 ± 4.3	7.3 ± 1.3
Annual Average			166 ± 32		2.9 ± 0.3		8.1 ± 0.4
Total Release	6.04E+08		102.1 mCi		1.6 mCi		4.7 mCi
Average MDL (pCi/L)			312		2.1		5.8
SDWA Limit (pCi/L)			20,000		15		50

Notes:
All values shown 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
* Total Release is to the Peconic River

the equipment level of the HFBR. A plot of the 2003 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 2003, a total of 0.10 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 166 ± 32 pCi/L, which is higher than the average of 75 pCi/L recorded in 2002 but still well below the DWS of 20,000 pCi/L. The 2003 value is approximately one-half the average Minimum Detection Limit (MDL) for the BNL Analytical Services Laboratory of 312 pCi/L. The maximum concentration detected in the STP discharge (see Figure 5-2) was 704 pCi/L. Tritium was detected above the MDL in samples collected from July through October. The slight increase in tritium releases, compared to 2002, was attributed to increased releases from the HFBR due to preparations for its decommissioning. In July, the remaining liquid coolant was drained from the HFBR core, pumped to a tanker trailer, then chemically solidified in large containers and held until it was shipped off site for disposal in late August. When the coolant was drained from the core, some tritiated water vapor (HTO) was released into the building air. The condensation of this HTO over the next few months led to slightly higher concentrations of tritium in the condensate released to the STP. Although removing the coolant from the reactor led to minor tritium discharge increases in 2003, it will result in lower concentrations of tritium in future years.

Table 5-2 presents the gamma spectroscopy analytical data for anthropogenic radionuclides historically detected in the monthly STP wastewater composite samples. During 2003, the only gamma-emitting nuclides detected in the STP effluent were potassium-40 (K-40) and iodine-131 (I-131). K-40 occurs naturally. It is present in common foods like bananas, is a natural component of soil, and is found in human and animal tissue. I-131 is found periodically in both the STP influent and effluent and is attributed to excreta from employees or guests who have undergone thyroid diagnosis or treatment off site. In 2003, Cesium (Cs-137) and Sr-90 were not detected (or not detected above the MDL, in the case of Sr-90) in any samples, making

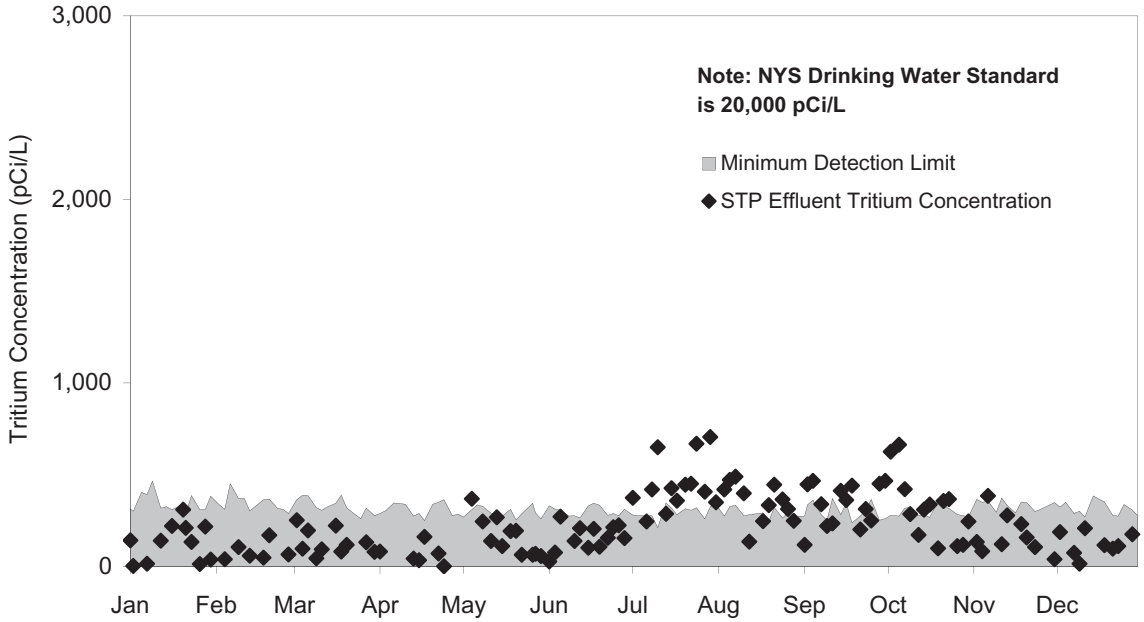

Figure 5-2. Tritium Concentrations in Effluent from the BNL Sewage Treatment Plant (2003).

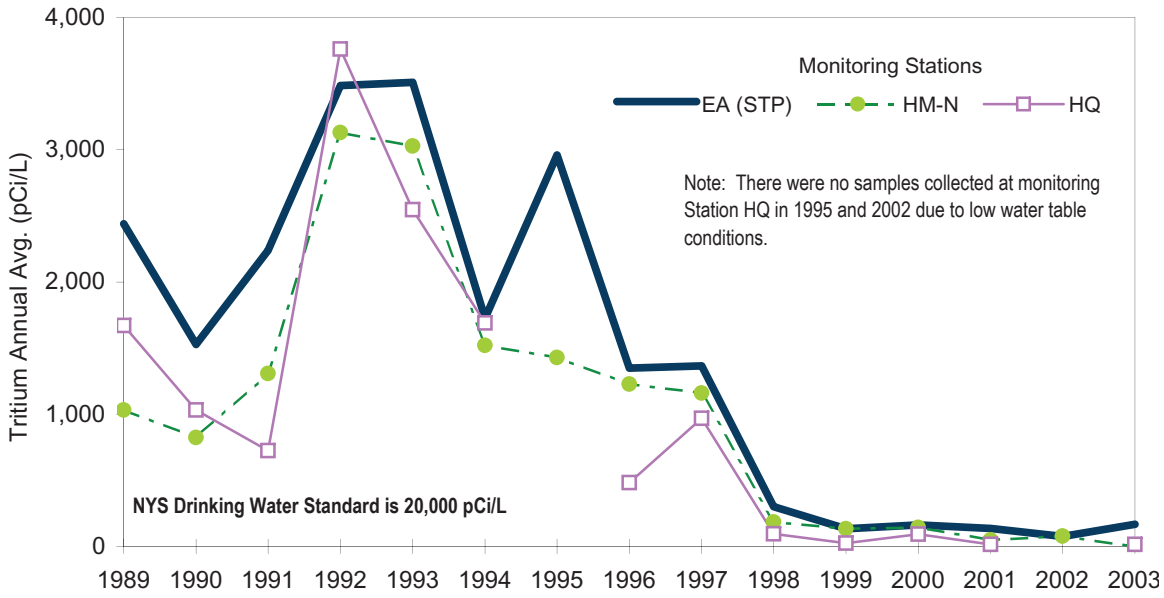

Figure 5-3. Sewage Treatment Plant/Peconic River Annual Average Tritium Concentrations (1989 – 2003).

this the first year that Cs-137 was not detected in the influent or effluent. This is probably the result of cleanup efforts undertaken in 2002 and 2003 to remove contaminated sand filter media from the STP. The Cs-137 concentrations in the STP influent and effluent have been steadily decreasing since 1990, as shown in Figure 5-5. Approximately 1,320 yd^3 of sand and debris containing low levels of radioactivity and heavy metals were removed from the STP in 2002 and staged for off-site disposal. This disposal was completed in 2003.

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

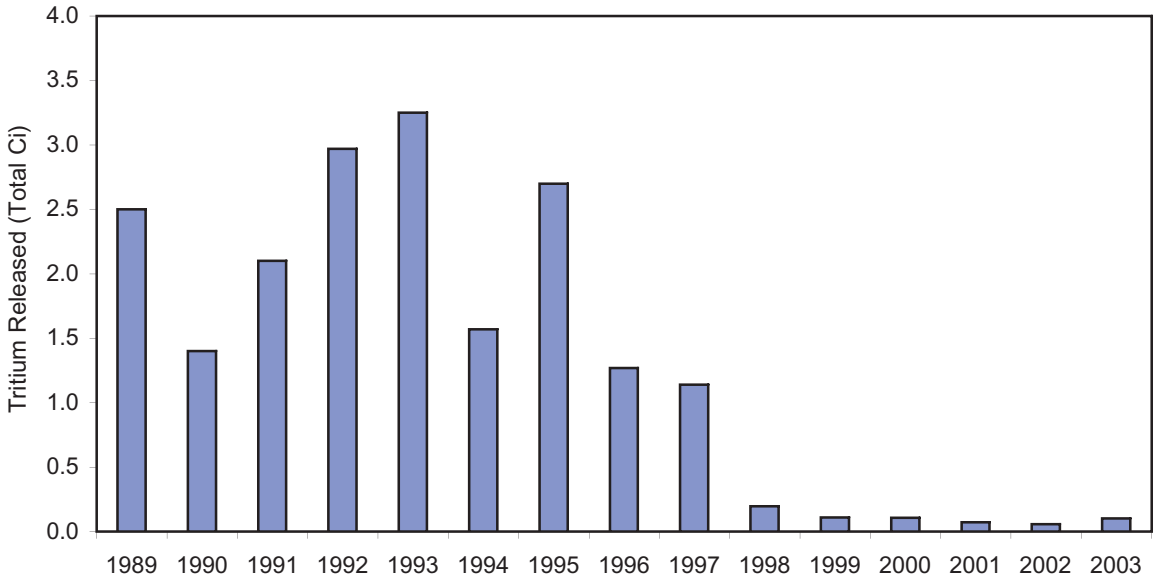

Figure 5-4. Tritium Released to the Peconic River, 15-Year Trend (1989 – 2003).

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

	Flow (Liters)	Co-60	Cs-137	Be-7	Na-22	Sr-90
		(pCi/L)				
STP Influent						
January	3.83E+07	ND	ND	ND	ND	< 0.21
February	3.77E+07	ND	ND	ND	ND	< 0.44
March	3.94E+07	ND	ND	ND	ND	< 0.42
April	4.58E+07	ND	ND	ND	ND	< 0.30
May	5.54E+07	ND	ND	ND	ND	< 0.38
June	5.66E+07	ND	ND	ND	ND	< 0.39
July	6.27E+07	ND	ND	ND	ND	< 0.52
August	6.41E+07	ND	ND	ND	ND	< 0.37
September	3.57E+07	ND	ND	ND	ND	< 1.3
October	3.63E+07	ND	ND	ND	ND	< 1.2
November	3.69E+07	ND	ND	ND	ND	< 1.2
December	3.94E+07	ND	ND	ND	ND	< 1.2
STP Effluent						
January	4.02E+07	ND	ND	ND	ND	< 0.27
February	3.81E+07	ND	ND	ND	ND	< 0.24
March	4.84E+07	ND	ND	ND	ND	< 0.44
April	4.86E+07	ND	ND	ND	ND	< 0.50
May	5.60E+07	ND	ND	ND	ND	< 0.32
June	6.99E+07	ND	ND	ND	ND	< 0.38
July	6.83E+07	ND	ND	ND	ND	< 0.34
August	6.45E+07	ND	ND	ND	ND	< 0.36
September	4.83E+07	ND	ND	ND	ND	< 1.0
October	3.86E+07	ND	ND	ND	ND	< 1.1
November	3.75E+07	ND	ND	ND	ND	< 1.2
December	4.61E+07	ND	ND	ND	ND	< 1.1
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 STP effluent to the Peconic River for 2003.
To convert values from pCi to Bq, divide by 27.03.
DCG = Derived Concentration Guide
EDE = Effective Dose Equivalent
ND = Not Detected

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). The BNL Analytical Services Laboratory or contracted laboratories analyze these composite samples for 21 inorganic compounds. 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

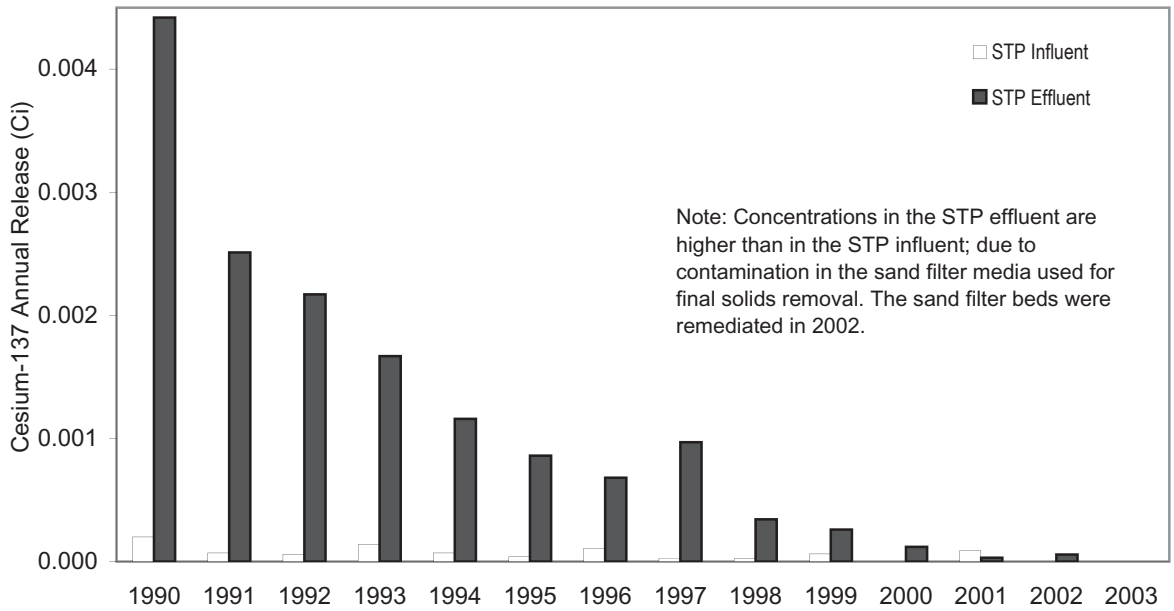

Figure 5-5. Cesium-137 in the BNL Sewage Treatment Plant Influent and Effluent (1990 – 2003).

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 other applicable standard) shows that most of the analytical parameters were within SPDES effluent permit limits (see also the compliance data in Chapter 3). There was one instance when aluminum exceeded the New York State Ambient Water Quality Standards (NYS AWQS), and three instances when iron was detected at concentrations exceeding the SPDES limits. Also, there was one detection of iron above the SPDES limit during routine compliance monitoring (see Chapter 3 for details). There are no defined sources that would explain these elevated readings. Both aluminum and iron are components of native soil and are most likely attributable to fine particles of sand carried over in the effluent. Zinc and selenium were also detected in single samples in the STP effluent, at concentrations of 179 and 10.3 µg/L, respectively. Sporadically, elevated levels of zinc are experienced in the STP effluent. A potential source for the zinc is wastewater generated during sludge removal operations, because wastewater in the aerobic digester has been analyzed on several occasions and was found to contain elevated levels of zinc. Zinc becomes concentrated in the waste sludge and commixed wastewater; when sludge is moved to the drying beds, short periods of elevated zinc levels in the STP effluent occur. The single detection of selenium is being attributed to analytical error, because high levels were also detected in the corresponding laboratory blank.

Except for a single detection (4.6 µg/L) of acetone, a common laboratory contaminant, no organic compounds were detected above the MDL throughout 2003. 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 acetone reading in the STP effluent was less than 10 percent of NYSDEC's 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 characterized to determine the appropriate means of disposal. The analytical results are compared with the appropriate discharge limit, and the wastewater is

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

	STP Influent				STP Effluent				SPDES Limit or Ambient Water Quality Standard[1]
	No. of Samples	Min.	Max.	Avg.	No. of Samples	Min.	Max.	Avg.	
pH (SU)[2]	157	6.1	7.4	NA	174	5.8	7.5	NA	5.8 - 9.0
Conductivity (µS/cm)[2]	NA	NA	NA	NA	174	151	425	274.6	SNS
Temperature (°C)[2]	NA	NA	NA	NA	174	2.4	25.2	13.9	SNS
Dissolved Oxygen (mg/L)	NA	NA	NA	NA	174	5.7	13.9	9.2	SNS
Chlorides (mg/L)	12	34.8	57.5	45.67	12	36.7	59.3	44.62	SNS
Nitrate (as N) (mg/L)[3]	12	< 1	9.48	2.27	12	2.5	10.6	5.47	10 (Total N)
Sulfates (mg/L)	12	14.2	20.8	17.11	12	13.3	19.6	15.89	250 (GA)
Aluminum (µg/L)	12	16.7	1380	317.12	12	4.8	163	38.68	100 (Ionic)
Antimony (µg/L)	12	< 0.88	< 5	< 5	12	< 0.88	< 5	< 5	3 (GA)
Arsenic (µg/L)	12	2.1	< 12	< 12	12	< 2.2	< 5	< 5	150 (Dissolved)
Barium (µg/L)	12	22.5	61.4	35.13	12	14.7	37.9	22.83	1,000 (GA)
Beryllium (µg/L)	12	< 0.1	< 2.64	< 2.64	12	< 0.1	< 2	< 2	11 (Acid Soluble)
Cadmium (µg/L)	12	< 0.3	< 4.4	< 4.4	12	< 0.3	< 2	< 2	1.1 (Dissolved)
Chromium (µg/L)	12	0.87	11.9	4.04	12	1.2	2.3	1.68	34.4 (Dissolved)
Cobalt (µg/L)	12	0.3	< 5	< 5	12	0.2	< 5	< 5	5 (Acid Soluble)
Copper (µg/L)	12	28.1	376	119.22	12	22.7	65.3	38.64	150 (SPDES)
Iron (mg/L)	12	0.26	2.04	0.96	12	0.08	0.57	0.24	0.37 (SPDES)
Mercury (µg/L)	12	< 0.1	< 0.2	< 0.2	12	< 0.1	< 0.2	< 0.2	0.8 (SPDES)
Manganese (µg/L)	12	12.7	35.2	24.56	12	2.12	8.8	4.72	300 (GA)
Molybdenum (µg/L)	8	58.1	193	138.6	8	54.5	193	101.52	SNS
Nickel (µg/L)	12	2	8.1	4.62	12	2.2	4.2	3.27	110 (SPDES)
Lead (µg/L)	12	1.3	22.3	9.54	12	< 1.1	3.6	< 3	19 (SPDES)
Selenium (µg/L)	12	< 2	< 20	< 20	12	1.4	10.3	< 5	4.6 (Dissolved)
Silver (µg/L)	12	< 0.4	< 4	< 4	12	0.49	2.1	1.28	15 (SPDES)
Sodium (mg/L)	12	27.1	80.4	40.63	12	26.6	42.5	34.32	SNS
Thallium (µg/L)	12	< 0.66	< 5	< 5	12	< 0.66	< 5	< 5	8 (Acid Soluble)
Vanadium (µg/L)	12	< 1.3	< 22	< 22	12	2.7	< 5.5	< 5.5	14 (Acid Soluble
Zinc (µg/L)	12	37.7	185	78.83	12	41	179	70.53	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.
AWQS = Ambient Water Qualty Standards
GA = Class GA (groundwater) Ambient Water Quality Standard
NA = Not Applicable
SNS = Standard Not Specified
SPDES = State Pollutant Discharge Elimination System
[1] Unless otherwise provided, the reference standard is NYSDEC Class C Surface Water Ambient Water Quality Standards.
[2] The pH, conductivity, and temperature values reported are based on analyses of daily grab samples.
[3] Two sets of values for both locations (including the 10.6 maximum) are reported as nitrate and nitrite due to a change in analytical laboratory and method.

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 BNL SPDES permit includes requirements for quarterly sampling and analysis of process-specific wastewater discharged from photographic developing operations in Building 197B, 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 at Buildings 244 and 423. These operations were monitored for contaminants such as metals, cyanide, VOCs (EPA Method 624), and SVOCs (EPA Method 625). Analyses of these waste streams 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, and other industrial wastewaters. To determine the appropriate disposal method, samples were analyzed for contaminants specific to the process. The analyses were then reviewed and the concentrations were compared to the SPDES effluent limits and BNL effluent release criteria. If the concentrations were within limits, authorization for sewer 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 BNL effluent release criteria was sent to the BNL Waste Management Facility for proper disposal.

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 BNL's discharges to recharge basins, also called outfalls. Figure 5-7 presents an overall schematic of potable water use at BNL. 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.
- Basin HX receives Water Treatment Plant filter backwash water.
- Basin HO receives cooling water discharges from the AGS and stormwater runoff from the area surrounding the HFBR.
- Several other recharge areas are used exclusively for discharging stormwater runoff, including Basin HW in the warehouse area, Basin CSF at the Central Steam Facility, Basin HW-M at the Former Waste Management Facility, and Basin HZ near Building 902.

Each of the recharge basins is a permitted point-source discharge under BNL'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 2003, EMP water samples were collected from all the basins listed above except basins HX (at the Water Treatment Plant) and HW-M (which

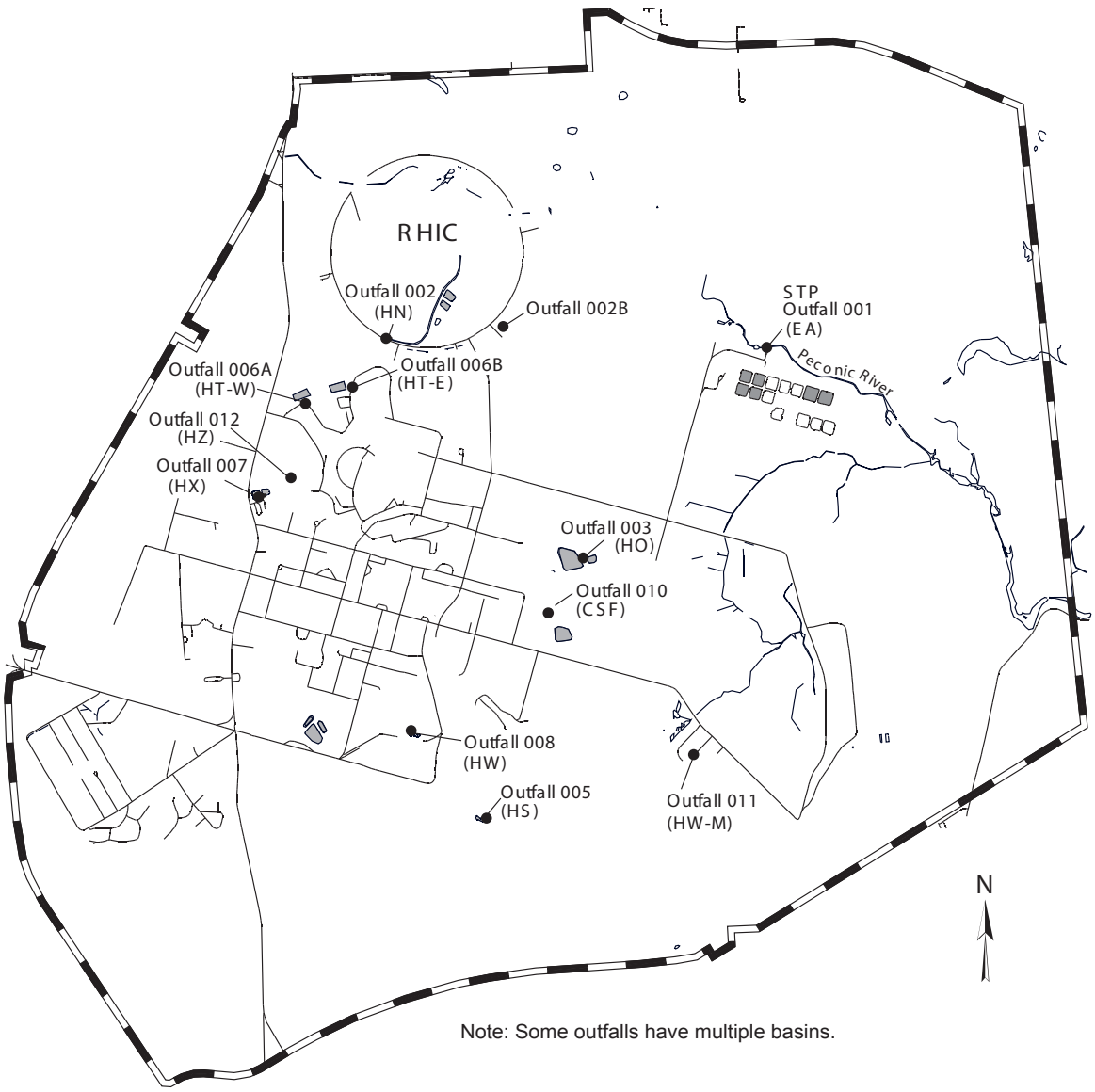

Figure 5-6. BNL Outfall Locations.

is being monitored as part of the remediation of the Former Waste Management Facility).

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, with Basin HN exhibiting higher concentrations than the others. The maximum concentrations of alpha and beta activity detected in Basin HN were 15.8 ± 1.4 pCi/L (0.6 ± 0.1 Bq/L) and 13.4 ± 1.4 pCi/L (0.5 ± 0.1 Bq/L), respectively. The accompanying gamma analysis of water samples collected from all basins showed that only naturally occurring K-40, thallium-208, and beryllium-7 were detectable in the water samples. These gamma-emitting nuclides are attributed to natural terrestrial/geological or cosmic sources. Carryover of sediment in the stormwater could explain the presence of these radionuclides, all at very low levels. Tritium was not detected in any basin above the MDL during 2003.

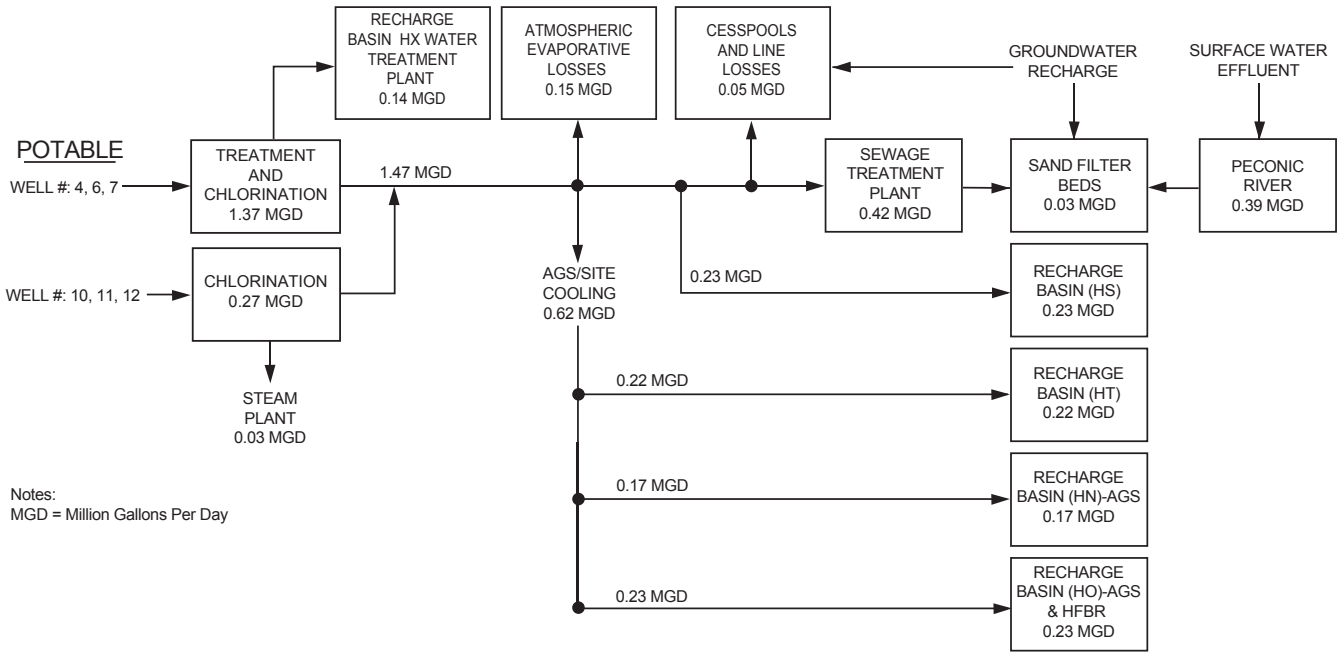

Figure 5-7. Schematic of Potable Water Use and Flow at BNL.

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, Part 703.6. Samples were collected quarterly for water quality parameters, metals, and VOCs, and analyzed by the BNL Analytical Services 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 were routinely detected in several discharges. These VOCs included bromoform, chloroform, dibromochloromethane, and dichlorobromomethane. Concentrations ranged from nondetectable to a maximum of 10 µg/L. Sodium hypochlorite and bromine, used to control algae in cooling towers, were responsible for the formation of these compounds. Acetone and methylene chloride were detected in several samples collected from numerous recharge basins at concentrations up to 10 µg/L. In most instances, acetone and methylene chloride were also found as contaminants in the analytical laboratory, as evidenced by detections in blank samples. There are no known sources of either contaminant in the BNL operations that contribute to these discharges.

The analytical data in Tables 5-5 and 5-6 show that all parameters, except for iron, complied with the respective groundwater discharge or water quality standards. Chlorides were found to be relatively higher in discharge samples collected during the winter months, from salt used to control snow and ice buildup. Iron is a natural component of soil and readily dissolves 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 effluent limit. Filtration of most samples resulted in iron concentrations that were less than the ambient water quality or groundwater discharge standard. Since the iron is in particulate form, it poses no threat to groundwater quality, because the recharge basin acts as a natural filter, trapping the iron particles before they reach groundwater.

Investigation into the extent of lead contamination in soil at the Central Steam Facility (CSF) outfall continued in 2003. These efforts included preparation of a draft remedial action plan and revision of that plan based on comments received from the Suffolk County Department of Health Services (SCDHS). The most significant comments pertained to additional characterization of soil in some areas and reduction in the proposed remedial goal for lead. To address the issue of soil characterization, additional soil samples were collected in July and September of 2003. Results from these samples showed that the extent of contamination had been well defined in the original draft plan, requiring only nominal expansion of the area to be remediated. When proposing a remedial goal for lead, BNL had initially selected 1,200 ppm lead based on residential soil concentration guidelines in the Toxic Substance Control Act. BNL reduced the goal to 400 ppm lead, in response to SCDHS concerns. The remedial plan was revised and will be submitted to the regulatory agencies in 2004.

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

Basin		Gross Alpha	Gross Beta	Tritium	Sr-90
		(pCi/L)			
HN	N	4	4	4	NS
	Max.	15.80 ± 1.40	13.40 ± 1.41	323 ± 240	
	Avg.	4.70 ± 7.29	7.41 ± 5.48	7 ± 209	
HO	N	4	4	4	NS
	Max.	< 0.577	< 1.03	< 204	
	Avg.	0.13 ± 0.12	0.48 ± 0.62	12 ± 54	
HS	N	4	4	4	NS
	Max.	1.10 ± 0.44	1.47 ± 0.89	< 267	
	Avg.	0.80 ± 0.43	0.98 ± 0.73	-36 ± 233	
HT-E	N	4	4	4	NS
	Max.	1.88 ± 0.53	6.39 ± 1.26	< 270	
	Avg.	1.11 ± 0.79	2.61 ± 2.99	-57 ± 140	
HT-W	N	4	4	4	NS
	Max.	0.77 ± 0.36	< 1.4	< 290	
	Avg.	0.49 ± 0.33	0.46 ± 1.12	-66 ± 170	
HW	N	4	4	4	NS
	Max.	2.74 ± 0.54	4.92 ± 1.08	< 355	
	Avg.	1.46 ± 0.95	2.69 ± 1.78	20 ± 171	
HZ	N	4	4	4	NS
	Max.	1.55 ± 0.45	4.36 ± 1.02	< 288	
	Avg.	1.06 ± 0.51	2.70 ± 1.90	-32 ± 77	
SDWA Limit		15	50	20,000	8

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.
N = Number of samples collected for analysis
NS = Samples not collected for this analysis
SWDA = Safe Drinking Water Act

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 BNL site. Basins HN, HZ, HT-W, and HT-E receive runoff from the collider–accelerator complex; Basin HO receives runoff from the areas around the Brookhaven Graphite Research Reactor (BGRR) and HFBR; Basin CSF receives runoff from the area around the Central Steam Facility and areas 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 Waste Management Facility.

Stormwater runoff from the BNL site 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, an aggressive maintenance and inspection program, and formal restoration of these areas when operations cease.

5.5 PECONIC RIVER SURVEILLANCE

Several locations were monitored along the Peconic River to assess the overall water qual-

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

Recharge Basin	pH (SU)	Conductivity (µS/cm)	Temperature (°C)	Dissolved Oxygen	Chlorides	Sulfates	Nitrate as N
				(mg/L)			
HN (RHIC)	4	4	4	4	4	4	4
	6.4	108	5.1	8.4	13.6	7.7	1.0
	8.4	924	10.0	11.5	130	50.6	1.7
	NA	491	7.2	10.4	66.3	28.5	1.32
HO (AGS)	4	4	4	4	4	4	4
	7.1	153	12.3	8.6	23.9	9	< 1
	7.9	190	19.4	11.3	30.7	11.3	< 1
	NA	174	16.9	10.1	26.8	10.1	< 1
HS (stormwater)	4	4	4	4	4	4	4
	6.9	172	7.0	10.5	25.6	8.5	1.0
	8.3	259	13.6	12.3	42.8	17.5	1.2
	NA	210	10.3	11.5	33.0	13.0	1.1
HT-E (AGS)	4	4	4	4	4	4	4
	7.1	51	7.1	8.6	3.6	1.7	< 1
	8.4	208	16.8	11.6	23.2	11.6	< 1
	NA	106	9.7	10.2	12.3	7.2	< 1
HT-W (Linac)	4	4	4	4	4	4	4
	7.2	123	5.8	9.8	15.5	6.5	< 1
	8.8	205	12.5	12.9	33	14.8	< 1
	NA	174	10.1	10.8	23.0	11.1	< 1
HW (stormwater)	4	4	4	4	4	4	4
	7.5	71	2.0	8.0	3.1	<4	0.2
	8.3	171	21.2	13.1	80.2	10.3	1.2
	NA	123	10.3	10.0	27.9	5.9	0.05
CSF (stormwater)	4	4	4	4	4	4	4
	6.3	52	3.9	7.9	3.5	6.8	< 1
	8.5	2164	20.3	11.1	1760	13.2	< 1
	NA	896	11.8	9.6	542	8.8	< 1
HZ (stormwater)	4	4	4	4	4	4	4
	7.5	174	4.6	8.9	27.9	< 4	< 1
	8.1	290	16.1	13.0	46.9	21.3	< 1
	NA	230	11.1	10.7	38.1	12.5	< 1
NYSDEC Effluent Standard	6.5 - 8.5	SNS	SNS	SNS	500	500	10
Typical MDL	NA	NA	NA	NA	4	4	1

Notes:
See Figure 5-6 for the locations of recharge basins.
AGS = Alternating Gradient Synchrotron
CSF = Central Steam Facility
Linac = Linear Accelerator
MDL = Minimum Detection Limit
N = Number of samples
NA = Not Applicable
NYSDEC = New York State Department of Environmental Conservation
RHIC = Relativistic Heavy Ion Collider
SNS = Effluent Standard Not Specified

Table 5-6. Metals Analyses of BNL On-Site Recharge Basin Samples.

Recharge Basin	No. of Samples		Ag µg/L	Al µg/L	As µg/L	Ba µg/L	Be µg/L	Cd µg/L	Co µg/L	Cr µg/L	Cu µg/L	Fe mg/L	Hg µg/L	Mn µg/L	Mo µg/L	Na mg/L	Ni µg/L	Pb µg/L	Sb µg/L	Se µg/L	Tl µg/L	V µg/L	Zn µg/L
HN (RHIC)	4	Min.	< 0.4	14.2	< 2.2	17.8	< 0.1	0.32	0.3	1.1	32.5	0.38	< 0.1	21.6	24.9	9.01	2.5	1.6	< 0.88	< 2.0	< 0.66	2	53.4
		Max.	< 1.0	457	21.8	43.2	< 0.66	< 1.1	< 1.6	18.8	85.2	1.1	< 0.1	62	1850	134	13.2	5.8	< 2.8	113	< 2.3	< 5.5	142
		Avg.	< 1.0	213.0	6.3	30.4	< 0.66	< 1.1	< 1.6	9.5	58.3	0.7	< 0.1	35.8	1055.0	53.2	7.1	4.2	< 2.8	31.0	< 2.3	< 5.5	91.9
HN (filtered) (RHIC)	2	Min.	< 1.0	< 2.2	< 3.0	21.6	< 0.66	< 1.1	0.2	< 1	16.7	< 0.08	< 0.1	6.9	24.1	16.7	1.9	< 1.32	< 0.88	< 5	< 0.66	< 5.5	34.5
		Max	4.6	< 2.2	< 3.0	28.3	< 0.66	< 1.1	0.4	13.9	56.6	0.15	< 0.1	13.5	1860	130	9.9	< 1.32	1.1	10	< 0.66	< 5.5	56.6
		Avg.	2.3	< 2.2	< 3.0	25.0	< 0.66	< 1.1	0.3	7.0	36.7	0.1	< 0.1	10.2	942.1	73.4	5.9	< 1.32	< 0.88	5.0	< 0.66	< 5.5	45.6
HO (total) (AGS)	4	Min.	< 0.4	< 2.2	< 2.2	12.3	< 0.1	< 0.3	< 0.12	0.87	3.3	0.14	< 0.1	6.2	< 5.0	16.9	1.1	1.3	< 0.88	< 2.0	< 0.66	< 1.3	8.3
		Max.	< 1.0	119	< 3.0	29.1	< 0.66	< 1.1	< 1.6	1.0	7.5	0.34	< 0.1	20.6	< 5.0	22.1	2.1	< 1.32	< 2.8	< 5.0	< 2.3	< 5.5	51.4
		Avg.	< 1.0	37.8	< 3.0	20.3	< 0.66	< 1.1	< 1.6	< 1.0	5.5	0.2	< 0.1	12.3	< 5.0	19.5	< 1.3	< 1.32	< 2.8	< 5.0	< 2.3	< 5.5	22.8
HO (filtered) (AGS)	2	Min.	< 1.0	< 2.2	< 3.0	18.8	< 0.66	< 1.1	< 0.12	< 1.0	2.3	< 0.08	< 0.1	< 2.0	< 5.0	17.1	< 1.1	< 1.32	< 0.88	< 5.0	< 0.66	< 5.5	7.5
		Max.	< 1.0	< 2.2	< 3.0	28.3	< 0.66	< 1.1	< 0.12	< 1.0	4.9	< 0.08	< 0.1	9.2	< 5.0	17.6	2.0	< 1.32	< 0.88	< 5.0	< 0.66	< 5.5	21.9
		Avg.	< 1.0	< 2.2	< 3.0	23.6	< 0.66	< 1.1	< 0.12	< 1.0	3.6	< 0.08	< 0.1	4.6	< 5.0	17.4	< 1.1	< 1.32	< 0.88	< 5.0	< 0.66	< 5.5	14.7
HS (total) (stormwater)	4	Min.	< 0.4	2.4	< 2.2	16.7	< 0.1	< 0.3	0.1	< 1.0	3.6	< 0.08	< 0.1	2.3	< 5.0	16.4	< 1.1	< 1.32	< 0.88	< 2.0	< 0.66	1.8	8.7
		Max.	3.9	470	< 3.0	32.6	< 0.66	< 1.1	< 1.6	1.7	9.7	0.54	< 0.1	18.9	9.4	27.3	2.0	4.3	< 2.8	< 5.0	< 2.3	< 5.5	81.2
		Avg.	< 1.0	125.2	< 3.0	25.1	< 0.66	< 1.1	< 1.6	< 1.0	6.1	0.2	< 0.1	8.3	< 5.0	22.3	< 1.1	< 1.32	< 2.8	< 5.0	< 2.3	< 5.5	39.1
HS (filtered) (stormwater)	2	Min.	< 1.0	< 2.2	< 3.0	16	< 0.66	< 1.1	0.2	1.0	3.0	< 0.08	< 0.1	3.8	< 5.0	21.6	< 1.1	< 1.32	< 0.88	< 5.0	< 0.66	< 5.5	4.5
		Max.	1.2	< 2.2	< 3.0	30.2	< 0.66	< 1.1	0.2	1.0	4.5	< 0.08	< 0.1	4.2	< 5.0	26.4	< 1.1	< 1.32	< 0.88	< 5.0	< 0.66	< 5.5	7.4
		Avg.	< 1.0	< 2.2	< 3.0	23.1	< 0.66	< 1.1	0.2	< 1.0	3.8	< 0.08	< 0.1	4.0	< 5.0	24.0	< 1.1	< 1.32	< 0.88	< 5.0	< 0.66	< 5.5	6.0
HT-E (fotal) (AGS)	4	Min.	< 1.0	< 2.2	< 2.36	5.8	< 0.23	< 0.61	0.12	< 1.0	5.8	< 0.08	< 0.03	2.8	23.3	2.0	< 1.1	< 1.32	< 0.88	< 5.0	< 0.66	2.1	< 4.0
		Max.	< 2.0	586	< 5.0	27.4	< 2.0	< 2.0	< 5.0	< 5.0	11.9	0.47	< 0.2	11.9	72.4	33.5	< 10.0	2.2	< 3.28	< 5.0	< 5.0	< 5.5	57.0
		Avg.	< 2.0	239.5	< 5.0	14.5	< 2.0	< 2.0	< 5.0	< 5.0	9.0	0.2	< 0.2	7.8	47.9	14.0	< 10.0	< 2.14	< 3.28	< 5.0	< 5.0	< 5.5	27.1
HT-E (filtered) (AGS)	2	Min.	< 1.0	< 2.2	< 3.0	6.85	< 0.23	< 0.61	0.3	< 1.0	6.5	< 0.08	< 0.03	2.90	27.0	2.8	< 1.1	< 1.32	< 0.88	< 4.56	< 0.66	< 2.47	< 4.0
		Max.	< 1.98	< 70.8	< 3.0	11.5	< 0.66	< 1.1	< 1.1	< 2.08	7.88	0.03	< 0.1	2.92	27.0	32.6	< 2.98	< 2.14	< 3.28	< 5.0	< 4.08	< 5.5	36.8
		Avg.	< 1.98	< 70.8	< 3.0	9.2	< 0.66	< 1.1	< 1.1	< 2.08	7.2	< 0.08	< 0.1	2.9	27.0	17.7	< 2.98	< 2.14	< 3.28	< 5.0	< 4.08	< 5.5	18.4
HT-W (fotal) (Linac)	4	Min.	< 0.4	< 2.2	< 2.2	12.2	< 0.1	< 0.3	0.1	1.0	14.0	0.08	< 0.1	6.4	< 5.0	12.5	< 1.1	< 1.32	< 0.88	< 2.0	< 0.66	< 1.3	5.9
		Max.	12.4	214	< 3.0	35.2	< 0.66	< 1.1	< 1.6	4.8	99.1	0.43	< 0.1	39.5	< 5.0	33.2	3.7	3.5	< 2.8	< 5.0	< 2.3	< 5.5	97.9
		Avg.	4.7	63.1	< 3.0	21.9	< 0.66	< 1.1	< 1.6	1.5	38.6	0.2	< 0.1	21.9	< 5.0	22.0	1.5	< 1.32	< 2.8	< 5.0	< 2.3	< 5.5	34.9

(continued on next page)

Table 5-6. Metals Analyses of BNL On-Site Recharge Basin Samples *(concluded)*.

Recharge Basin	No. of Samples		Ag µg/L	Al µg/L	As µg/L	Ba µg/L	Be µg/L	Cd µg/L	Co µg/L	Cr µg/L	Cu µg/L	Fe mg/L	Hg µg/L	Mn µg/L	Mo µg/L	Na mg/L	Ni µg/L	Pb µg/L	Sb µg/L	Se µg/L	Tl µg/L	V µg/L	Zn µg/L
HT-W (filtered)	2	Min.	< 1.0	< 2.2	< 3.0	11.2	< 0.66	< 1.1	< 0.12	< 1.0	7.3	< 0.08	< 0.1	< 2	< 5.0	21.9	< 1.1	< 1.32	< 0.88	< 5.0	< 0.66	< 5.5	< 4.0
(Linac)		Max.	< 1.0	< 2.2	< 3.0	33.0	< 0.66	< 1.1	0.30	< 1.0	16.8	< 0.08	< 0.1	19.9	< 5.0	33.3	3.8	< 1.32	< 0.88	< 5.0	< 0.66	< 5.5	13.3
		Avg.	< 1.0	< 2.2	< 3.0	22.1	< 0.66	< 1.1	0.2	< 1.0	12.1	< 0.08	< 0.1	10.0	< 5.0	27.6	1.9	< 1.32	< 0.88	< 5.0	< 0.66	< 5.5	6.7
HW (total)	3	Min.	< 1.0	253	< 3.0	7.9	< 0.66	0.51	0.4	1.2	5.2	0.61	< 0.1	10.0	< 5.0	2.69	1.4	3.1	< 0.88	< 5.0	< 0.66	2.7	27.8
(stormwater)		Max.	< 2.0	809	< 5.0	11.0	< 2.0	< 1.1	< 5.0	3.1	12.0	1.12	< 0.2	27.9	< 5.0	51.9	2.2	18.9	2.8	7.4	< 5.0	< 5.5	50.0
		Avg.	< 2.0	485.0	< 5.0	8.9	< 2.0	< 1.1	< 5.0	2.3	7.9	0.8	< 0.2	17.7	< 5.0	24.5	1.7	10.5	0.9	< 5.0	< 5.0	< 5.5	36.6
HW (filtered)	1	Value	< 1.0	59.8	< 3.0	3.3	< 0.66	< 1.1	0.5	1.3	7.3	< 0.08	< 0.1	5.1	< 5.0	52.7	1.3	< 1.32	< 0.88	7.9	< 0.66	< 5.5	22.0
(stormwater)																							
CSF (total)	2	Min.	< 1.0	723	< 3.0	20.4	< 0.66	< 1.1	1.2	4.5	38.0	1.34	< 0.1	40.7	< 5.0	222	5.4	9.9	< 0.88	< 5.0	< 0.66	8.8	15.0
(stormwater)		Max.	< 1.0	2210	3.1	22.2	< 0.66	< 1.1	2.8	5.4	39.3	2.25	< 0.1	48.3	7.4	389	31.8	19.3	< 0.88	7.9	< 0.66	17.6	110
		Avg.	< 1.0	1466.5	< 3.0	21.3	< 0.66	< 1.1	2.0	5.0	38.7	1.8	< 0.1	44.5	< 5.0	305.5	18.6	14.6	< 0.88	< 5.0	< 0.66	13.2	65.5
CSF (filtered)	1	Value	< 1.0	138	< 3.0	12.9	< 0.66	< 1.1	1.1	1.7	25.1	0.12	< 0.1	17.3	7.6	222	17.9	< 1.32	< 0.88	8.2	< 0.66	6.3	16.6
(stormwater)																							
HZ	4	Min.	< 0.4	< 2.2	< 2.2	7.4	< 0.1	< 0.3	< 0.12	0.69	11.0	0.10	< 0.1	3.9	< 5.0	19.4	< 1.3	1.9	< 0.88	< 2.0	< 0.66	< 1.3	35.2
(stormwater)		Max.	< 1.0	276	< 3.0	23.2	1.0	1.1	< 1.6	2.0	31.2	0.52	0.16	37.6	328	31.3	2.7	26.1	< 2.8	8.7	< 2.3	< 5.5	94
		Avg.	< 1.0	81.5	< 3.0	18.7	< 0.66	< 1.1	< 1.6	< 1.0	21.0	0.2	< 0.1	18.6	138.7	24.8	1.5	9.8	< 2.8	< 5.0	< 2.3	< 5.5	68.2
HZ (filtered)	2	Min.	< 1.0	< 2.2	< 3.0	4.5	< 0.66	< 1.1	0.4	< 1.0	7.2	< 0.08	< 0.1	6.7	< 5.0	20.6	< 1.1	1.4	< 0.88	< 5.0	< 0.66	< 5.5	31.5
(stormwater)		Max.	< 1.0	35.5	< 3.0	19.9	< 0.66	< 1.1	0.4	< 1.0	25.1	0.08	< 0.1	21.1	309	20.8	2.4	17.8	< 0.88	8.2	< 0.66	< 5.5	75.9
		Avg.	< 1.0	17.8	< 3.0	12.2	< 0.66	< 1.1	0.4	< 1.0	16.2	< 0.08	< 0.1	13.9	154.5	20.7	1.2	9.6	< 0.88	< 5.0	< 0.66	< 5.5	53.7
NYSDEC Effluent Limitation or AWQS			50.0	2,000.0	50.0	2,000.0	SNS	10.0	5.0	100.0	1,000.0	0.6	1.4	600.0	SNS	SNS	200.0	50.0	6.0	20.0	SNS	SNS	5,000.0
Typical MDL			1.0	2.2	3.0	1.8	0.7	1.1	0.1	1.0	2.0	0.015	0.2	2.0	5.0	1.0	1.1	1.3	0.9	5.0	0.7	5.5	4.0

Notes:
See Figure 5-6 for locations of recharge basins.
Recharge basin HX was not sampled for metals during 2003.
AGS = Alternating Gradient Synchrotron
AWQS = Ambient Water Quality Standards
CSF = Central Steam Facility
Linac = Linear Accelerator
MDL = Minimum Detection Limit
NYSDEC = New State Department of Environmental Conservation
RHIC = Relativistic Heavy Ion Collider
SNS = Effluent Standard Not Specified

ity 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 scheduled for monitoring in 2003, although additional locations were sampled by field personnel. A sampling station along the Carmans River (HH) was also monitored as a geographic control location, not affected by BNL operations. All locations were routinely monitored for radiological and non-radiological parameters. In 2003, to streamline the monitoring program, sample locations along the Peconic were changed to closely coincide with areas where fish, sediment, and vegetation samples are collected (sample results are discussed in Chapter 6). These changes included the removal of stations HB, HC, and HR and the inclusion of Swan Pond, Forge Pond, and Donahue's Pond. The sampling stations are located as follows:

Upstream sampling stations

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

Downstream sampling stations

- HM-N, on site, 0.5 mile downstream of the STP outfall
- HM-S, on site on a typically dry tributary to 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 2003, some samples were collected at HC due to access problems at Donahue's Pond and the close proximity of the two locations.)
- Forge Pond, off site
- Swan Pond, off site

Control location

- HH, Carmans River (Note: A sample was also collected at Lower Lake Yaphank on the Carmans River when fauna samples were collected.)

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 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 2003 are summarized in Table 5-7. Radiological analysis of upstream water samples showed that gross alpha and beta activity was detected at all upstream locations. The highest concentrations of gross alpha and beta were detected upstream at the BNL site boundary and at Station HM-S. Since these stations receive runoff and are not associated with STP releases, these levels of alpha and beta activity are 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 drinking water standard. No gamma-emitting radionuclides attributable to BNL operations were detected either upstream or downstream of the STP.

Tritium results of water samples collected upstream and downstream of the STP discharge were below detectable levels at all stations with the exception of a single detection at the BNL downstream site boundary (HQ), of 276 pCi/L (10.2 Bq/L). Note that this was only 1 pCi/L above the MDL for that day, which was 275 pCi/L. The New York State DWS for tritium is 20,000 pCi/L (740 Bq/L).

Monitoring for Sr-90 was performed at nine of the 10 stations sampled in 2003. Trace levels were found at all locations, with the highest at Station HH (off-site control location). Sr-90 was detected there at a maximum concentration of 0.87 ± 0.20 pCi/L (0.03 ± 0.01 Bq/L), which is approximately 11 percent of the drinking water standard. Detections of Sr-90 in the river are attributed to soil contamination resulting from

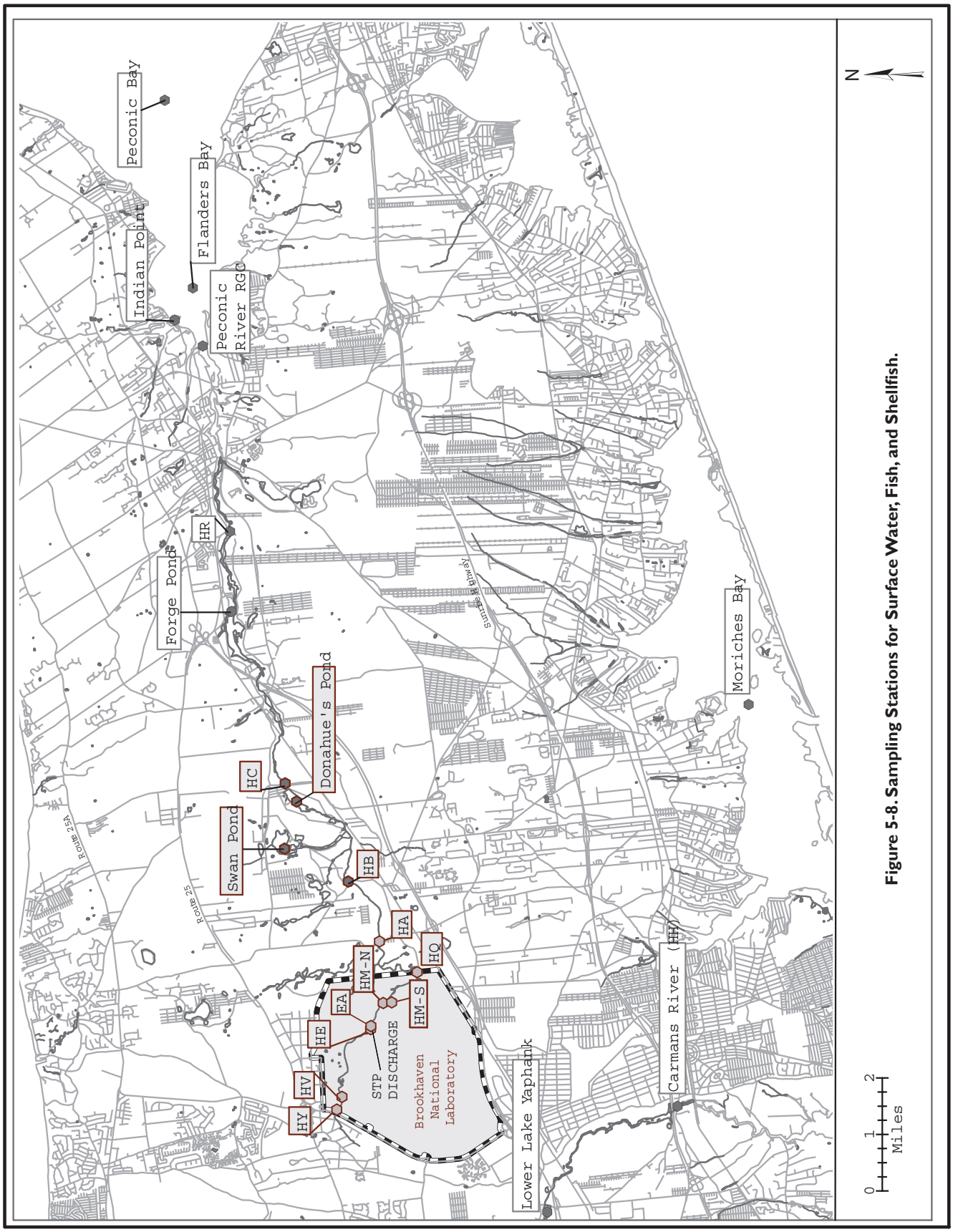

Figure 5-8. Sampling Stations for Surface Water, Fish, and Shellfish.

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

Sample Station	Geographic Location		Gross Alpha	Gross Beta	Tritium	Sr-90
			(pCi/L)			
HY	Peconic River (headwaters) onsite, west of the RHIC ring	N	5	4	5	4
		Max.	20.06 ± 1.54	4.69 ± 1.06	< 313	< 0.44
		Avg.	7.20 ± 6.91	2.60 ± 1.70	-73 ± 121	0.07 ± 0.08
HV	Peconic River (headwaters) onsite, inside the RHIC ring	N	4	4	4	NS
		Max.	11.40 ± 1.21	3.37 ± 1.00	< 342	
		Avg.	3.60 ± 5.10	2.53 ± 0.61	-67 ± 73	
HE	Peconic River, upstream of STP Outfall	N	4	4	4	4
		Max.	2.99 ± 0.71	11.50 ± 1.35	< 294	0.47 ± 0.25
		Avg.	1.26 ± 1.18	4.04 ± 5.38	-21 ± 121	0.32 ± 0.12
HM-N	Peconic River, downstream of STP, on site	N	12	12	12	2
		Max.	13.00 ± 1.22	10.70 ± 1.28	< 337	< 0.42
		Avg.	3.60 ± 1.92	6.87 ± 1.12	-2 ± 59	0.17 ± 0.22
HM-S	Peconic River tributary, on site	N	4	4	4	4
		Max.	21.90 ± 1.66	18.20 ± 1.65	< 271	< 0.78
		Avg.	6.07 ± 10.35	5.61 ± 8.34	-22 ± 67	0.31 ± 0.15
HQ	Peconic River, downstream of STP, at BNL site boundary	N	10	10	10	3
		Max.	3.28 ± 2.04	7.48 ± 4.28	276 ± 176	0.36 ± 0.19
		Avg.	1.83 ± 0.59	5.65 ± 1.15	15 ± 97	0.27 ± 0.11
HA	Peconic River, off site	N	4	4	4	4
		Max.	3.33 ± 0.76	4.80 ± 1.20	< 271	< 0.79
		Avg.	1.84 ± 1.53	2.48 ± 2.33	-31 ± 173	0.17 ± 0.20
HC	Peconic River, off site	N	3	3	3	3
		Max.	2.20 ± 0.65	3.16 ± 1.13	< 272	< 0.39
		Avg.	1.09 ± 1.12	1.53 ± 1.93	-39 ± 192	0.26 ± 0.07
Donahue's Pond	Peconic River, off site	N	1	1	1	1
		Value	< 0.54	< 1.34	-46 ± 173	0.14 ± 0.19
Forge Pond	Peconic River, off site	N	4	4	4	4
		Max.	1.98 ± 0.57	3.26 ± 0.95	< 358	< 0.43
		Avg.	1.02 ± 0.77	1.60 ± 1.57	-31 ± 76	0.17 ± 0.07
Swan Pond	Control location, off site	N	4	4	4	4
		Max.	1.21 ± 0.54	2.92 ± 1.12	< 360	< 0.62
		Avg.	0.58 ± 0.42	2.21 ± 0.92	-56 ± 103	0.27 ± 0.17
HH	Carmans River Control location, off site	N	4	4	4	4
		Max.	2.98 ± 0.65	2.42 ± 0.90	< 320	0.87 ± 0.20
		Avg.	0.88 ± 1.38	0.95 ± 1.36	-76 ± 70	0.41 ± 0.32
Lower Lake, Yaphank	Carmans River Control location, off site	N	1	1	1	1
		Value	2.22 ± 0.50	4.06 ± 1.15	< 339	< 0.42
SDWA Limit (pCi/L)			15	50	20,000	8

Notes:
See Figure 5-8 for sample station locations.
All values shown with 95% confidence interval.
Negative numbers occur when the measured value is lower than background levels. (See Appendix B for description.)

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

world-wide fallout as a result of historical nuclear weapons testing.

5.5.2 Peconic River - Nonradiological Analyses

Peconic River samples collected in 2003 were analyzed for water quality parameters (pH, temperature, conductivity, and dissolved oxygen), anions (chlorides, sulfates, and nitrates), metals, and VOCs. The inorganic analytical data for the Peconic River and Carmans River samples are summarized in Tables 5-8 (water quality) and 5-9 (metals).

No VOCs were routinely detected in river water samples above the MDL. Methyl tertiary butyl ether (MTBE) was detected at the off-site control location, Station HH, on several occasions. MTBE was used as a gasoline oxygenating agent until 2002, when it was removed from formulated gasoline due to its detection in groundwater nationwide and its very high aqueous mobility. The highest 2003 concentration at Station HH (a Carmans River control location), was 17.4 µg/L, detected in January. MTBE was not detected at the other Carmans River control location. Toluene was detected (8.9 µg/L) in a single sample collected at station HY, on site but upstream of BNL operations. Roadway runoff is the most likely source of both these contaminants.

Comparison of 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 that from the Carmans River control location (HH). Chlorides, sulfates, and nitrates tend to be slightly higher in samples collected immediately downstream of the STP discharge (Stations HM-N and HQ) and were consistent with the concentrations in the STP discharge. However, chlorides were highest at upstream Station HY. The sample collected from Station HY in April measured 15,800 mg/L, most probably due to road salting and surface runoff and that station's proximity to William Floyd Parkway. There are no ambient water quality standards imposed for chloride discharges to surface water; however, NYSDEC imposes a discharge 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 3.7 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 2003, 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, mercury, silver, and zinc were present in concentrations that in some locations exceeded ambient water quality standards in one or more samples collected at numerous locations both upstream and downstream of the STP discharge, and/or at the control location HH. Aluminum and iron are detected throughout the Peconic and Carmans Rivers at concentrations that exceed the 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 dissolving of these elements. Copper and lead were detected at the highest levels in samples collected at the upstream station (HY) as well as immediately downstream of the STP discharge. While the NYS AWQS for both copper and lead is extremely restrictive, the SPDES permit provides higher limits. All concentrations found at the downstream location were within the SPDES limits. Upstream levels of copper and lead are likely the result of stormwater runoff from nearby William Floyd Parkway. Similarly, concentrations of silver and zinc are found at concentrations exceeding the AWQS at stations immediately downstream of the STP (HM-N

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

Sample Station	Geographic Location		pH (SU)	Conductivity (µS/cm)	Temp. (°C)	Dissolved Oxygen	Chlorides	Sulfates	Nitrates as N
						(mg/L)			
HY	Peconic River (headwaters) on site, east of Wm. Floyd Pkwy.	N	4	4	4	4	4	4	4
		Min.	4.0	48	0.5	0.7	4.2	2.4	< 1
		Max.	7.1	17327	18.8	10.9	15800	104	< 1
		Avg.	NA	4418	10.1	7.4	3967	26.6	< 1
HV	Peconic River (headwaters) on site, inside RHIC ring	N	4	4	4	4	NS	NS	NS
		Min.	4.3	59	0.1	5.1			
		Max.	6.3	249	14.2	11.7			
		Avg.	NA	141	7.6	8.0			
HE	Peconic River, upstream of STP Outfall	N	4	4	4	4	4	4	4
		Min.	5.0	54	4.8	3.5	6.4	4.3	< 1
		Max.	7.7	81	24.3	13.1	14.0	10.6	< 1
		Avg.	NA	67	11.0	10.2	9.0	6.9	< 1
HM-N	Peconic River, downstream of STP, on site	N	12	12	12	12	12	12	12[a]
		Min.	5.5	50	1.1	4.9	15.8	7.4	1.1
		Max.	6.9	291	22.2	13.3	45.9	15.7	6.6
		Avg.	NA	185	11.0	8.4	32.5	12.5	3.1
HM-S	Peconic River tributary, on site	N	4	4	4	4	4	4	4
		Min.	3.9	40	2.9	0.5	< 4	< 4	< 1
		Max.	4.2	92	17.7	10.0	5.6	6.6	< 1
		Avg.	NA	75.3	9.9	6.4	2.7	1.7	< 1
HQ	Peconic River, downstream of STP, at BNL site boundary	N	10	10	10	10	10	10	10[a]
		Min.	5.5	55	3.4	0.5	< 4	< 4	< 1
		Max.	7.2	225	24.0	12.5	45.3	11.9	5.8
		Avg.	NA	157	12.7	5.8	25.0	8.4	1.1
HA	Peconic River, off site	N	4	4	4	4	4	4	4
		Min.	4.9	51	0.5	1.2	7.3	< 4	< 1
		Max.	5.8	90	21.1	8.7	14.2	16.0	< 1
		Avg.	NA	70.5	11.8	5.4	9.3	7.4	< 1
HC	Peconic River, off site	N	3	3	3	3	3	3	3
		Min.	5.2	68	3.7	8.7	8.8	7.8	< 1
		Max.	6.1	101	13.8	8.9	12.5	14.8	< 1
		Avg.	NA	80	10.4	8.8	10.2	10.2	< 1
Donahue's Pond	Peconic River, off site	N	1	1	1	1	1	1	1
		Value	5.6	89	31.8	1.6	22.6	6.2	< 1

(continued on next page)

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

Sample Station	Geographic Location		pH (SU)	Conductivity (µS/cm)	Temp. (°C)	Dissolved Oxygen	Chlorides	Sulfates	Nitrates as N
						(mg/L)			
Forge Pond	Peconic River, off site	N	4	4	4	4	4	4	4
		Min.	6.1	92	4.4	7.3	12.6	7.5	< 1
		Max.	7.1	139	25.1	12.6	18.0	15.6	< 1
		Avg.	NA	113	14.5	10.2	15.6	11.5	< 1
Swan Pond	Control location, off site	N	4	4	4	4	4	4	4
		Min.	5.0	83	0.5	4.8	9.0	8.4	< 1
		Max.	6.6	136	23.4	10.4	19.9	17.0	< 1
		Avg.	NA	99	12.9	7.7	12.3	12.4	< 1
HH	Carmans River control location, off site	N	4	4	4	4	4	4	4
		Min.	6.2	160	2.9	9.2	25.6	10.1	< 1
		Max.	7.8	165	19.6	12.8	27.9	13.2	1.6
		Avg.	NA	162	11.6	10.8	26.3	11.8	1.1
Lower Lake, Yaphank	Carmans River control location, off site	N	1	1	1	1	1	1	1
		Value	8.3	133	26.2	10.2	15.9	13.2	< 1
NYSDEC AWQS			6.5 - 8.5	SNS	SNS	> 4.0	250[b]	250[b]	10[b]
Typical MDL			NA	NA	NA	NA	4.0	4.0	1.0

Notes:
See Figure 5-8 for sample station locations.
AWQS = Ambient Water Quality Standards
MDL = Minimum Detection Limit
N = Number of samples
NA = Not Applicable
NS = Not Sampled
NYSDEC = New York State Department of Environmental Conservation
SNS = Standard Not Specified
[a] One value for HM-N and two values for HQ (including maximum of 5.8) are reported as Nitrate and Nitrite due to a change in analytical laboratory and method.
[b] Since there are no NYSDEC Class C Surface Water Ambient Water Quality Standards (AWQS) for these compounds, the AWQS for groundwater is provided, if specified.

and HQ). Silver and zinc were detected in upstream and downstream locations not associated with the STP, indicating a natural source for these metals. Downstream concentrations were within the SPDES permit limits. Silver was detected at the highest levels at Station HM-S in unfiltered samples, but none was detectable in filtered samples. Mercury was detected at highest concentrations immediately downstream of the STP (HM-N), due to historical operations.

With the exception of aluminum and iron, filtering the samples reduced concentrations of most parameters to below the AWQS, indicating that most detections were due to sediment carryover. As documented in the Operable Unit (OU) V Remedial Investigation, high concentrations of metals such as copper, mercury, and silver in Peconic River sediments are defining the plans for remediation of the Peconic River (BNL 1998). Remedial activities are scheduled for 2004. This project will excavate contaminated sediments downstream of the STP to the site boundary and beyond, depending on public and regulatory input to the remediation plan. The OU V activities conducted in 2003 are presented in Table 2-4.

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

Sample Station	N		Ag µg/L	Al µg/L	As µg/L	Ba µg/L	Be µg/L	Cd µg/L	Co µg/L	Cr µg/L	Cu µg/L	Fe mg/L	Hg µg/L	Mn µg/L	Mo µg/L	Na mg/L	Ni µg/L	Pb µg/L	Sb µg/L	Se µg/L	Tl µg/L	V µg/L	Zn µg/L
Peconic River																							
HY (total)	4	Min.	< 2.0	353	< 5.0	5.6	< 1.32	< 2.0	0.45	1.1	4.2	0.26	< 0.1	9.8	< 10.0	4.83	< 2.2	4.1	< 1.76	< 5.0	< 1.32	1.7	13.1
		Max.	< 2.0	1520	< 6.0	186	< 2.0	< 2.2	< 5.0	15.6	453	5.76	0.14	137	< 10.0	3250	< 10.0	20.0	< 5.0	< 10.0	< 5.0	< 11.0	58.2
		Avg.	< 2.0	980.5	< 6.0	56.62	< 2.0	< 2.2	< 5.0	5.52	125.2	1.98	< 0.1	73.5	< 10.0	824.91	< 10.0	9.83	< 5.0	< 10.0	< 5.0	< 11.0	32.58
HY (dissolved)	2	Min.	< 2.0	436	< 6.0	10.8	< 1.32	< 2.2	0.44	< 2.0	4.3	0.23	< 0.1	45.7	< 10.0	9.38	< 2.2	< 2.64	< 1.76	< 10.0	< 1.32	< 11.0	29.4
		Max.	< 2.0	1300	< 6.0	17.1	< 1.32	< 2.2	1.7	5.4	4.8	5.59	0.13	107	< 10.0	31.1	3.3	6.2	< 1.76	< 10.0	< 1.32	< 11.0	31.9
		Avg.	< 2.0	868	< 6.0	13.95	< 1.32	< 2.2	1.07	2.7	4.55	2.91	< 0.1	76.35	< 10.0	20.24	< 2.2	3.1	< 1.76	< 10.0	< 1.32	< 11.0	30.65
HV (total)	1	Value	< 2.0	532	< 5.0	8.8	0.15	< 2.0	< 5..0	0.95	2.9	3.22	< 0.2	26.0	NAP	6.8	< 10.0	5.1	2.0	< 5.0	< 5.0	4.0	8.9
HE (total)	4	Min.	< 0.4	236	< 2.2	11.0	< 0.1	< 0.3	0.8	0.62	< 2.0	0.4	< 0.1	67.5	< 5.0	5.2	1.7	< 1.32	< 0.88	< 2.0	< 0.66	3.0	13.8
		Max.	< 1.0	625	< 3.0	21.8	< 0.66	< 1.1	< 1.6	< 1.0	3.1	6.32	< 0.1	126	5.8	9.71	1.8	1.9	< 2.8	< 5.0	< 2.3	< 5.5	82.5
		Avg.	< 1.0	355.5	< 3.0	17.08	< 0.66	< 1.1	< 1.6	< 1.0	2.05	2.37	< 0.1	90.68	< 5.0	6.53	1.78	< 1.32	< 2.8	< 5.0	< 2.3	< 5.5	42
HE (dissolved)	2	Min.	< 1.0	185	< 3.0	9.3	< 0.66	< 1.1	1.2	< 1.0	< 2.0	0.59	0.25	81.6	< 5.0	6.1	1.6	< 1.32	< 0.88	< 5.0	< 0.66	< 5.5	12.6
		Max.	< 1.0	225	< 3.0	20.9	< 0.66	< 1.1	1.5	< 1.0	< 2.0	1.55	0.25	117	< 5.0	9.62	1.7	< 1.32	< 0.88	< 5.0	< 0.66	< 5.5	46.6
		Avg.	< 1.0	205	< 3.0	15.1	< 0.66	< 1.1	1.35	< 1.0	< 2.0	1.07	0.25	99.3	< 5.0	7.86	1.65	< 1.32	< 0.88	< 5.0	< 0.66	< 5.5	29.6
HM-N (total)	12	Min.	0.73	< 2.2	1.9	8.7	< 0.1	< 0.3	0.2	< 1.0	14	0.34	< 0.1	< 2.0	< 5.0	11.4	1.5	< 1.32	< 0.88	< 2.0	< 0.66	2.4	28.2
		Max.	15.2	1780	< 12.0	50.1	< 2.64	< 4.4	< 5.0	8.1	153	4.41	1.2	219	126	44.2	4.7	10.5	< 5.0	< 20.0	< 5.0	< 22.0	112
		Avg.	2.15	336.46	< 12.0	22.21	< 2.64	< 4.4	< 5.0	2.37	42.12	1.0	< 0.2	49.34	55.54	25.85	3.01	< 3.0	< 5.0	< 20.0	< 5.0	< 22.0	56.09
HM-N (dissolved)	7	Min.	< 0.4	44.9	< 2.2	12.3	< 0.1	< 0.3	0.21	< 1.0	12.9	0.19	0.1	5.19	39.0	20.5	1.2	< 1.1	< 0.88	< 2.0	< 0.66	1.7	23.5
		Max.	< 2.0	224	< 5.0	19.2	< 2.0	< 2.0	3.9	< 5.0	43.1	0.62	< 0.2	62.1	74.6	30.4	3.3	< 3.0	< 5.0	< 5.0	< 5.0	< 5.5	84.4
		Avg.	< 2.0	101.67	< 5.0	15.36	< 2.0	< 2.0	< 1.6	< 5.0	22.56	0.33	< 0.2	30.08	56.78	24.93	2.62	< 3.0	< 5.0	< 5.0	< 5.0	< 5.5	49.81
HM-S (total)	4	Min.	< 1.0	599	< 3.0	5.3	< 0.66	< 1.1	0.24	1.4	< 2.0	0.24	< 0.1	12	< 5.0	2.84	1.3	1.1	< 0.88	< 5.0	< 0.66	2.3	10.1
		Max.	< 2.0	953	< 6.0	15.6	< 2.0	< 2.2	< 5.0	< 5.0	< 10.0	8.16	< 0.2	47.7	< 10.0	3.35	< 2.2	< 2.64	< 5.0	< 10.0	< 5.0	< 11.0	28.2
		Avg.	< 2.0	722.5	< 6.0	10	< 2.0	< 2.2	< 5.0	< 5.0	< 10.0	2.36	< 0.2	24.42	< 10.0	3.06	< 2.2	< 2.64	< 5.0	< 10.0	< 5.0	< 11.0	18.15
HM-S (dissolved)	2	Min.	< 1.0	718	< 3.0	6.8	< 0.66	< 1.1	0.34	2.0	2.1	0.32	< 0.1	24.4	< 5.0	2.9	1.6	< 1.32	< 0.88	< 5.0	< 0.66	< 5.5	18.7
		Max.	38.9	782	< 6.0	9.98	< 1.32	< 2.2	0.8	2.0	< 4.0	2.98	0.27	28.1	< 10.0	3.08	< 2.2	< 2.64	< 1.76	< 10.0	< 1.32	< 11.0	32.3
		Avg.	19.45	750	< 6.0	8.39	< 1.32	< 2.2	0.57	2.0	< 4.0	1.65	0.14	26.25	< 10.0	2.99	< 2.2	< 2.64	< 1.76	< 10.0	< 1.32	< 11.0	25.5

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

Sample Station	N		Ag µg/L	Al µg/L	As µg/L	Ba µg/L	Be µg/L	Cd µg/L	Co µg/L	Cr µg/L	Cu µg/L	Fe mg/L	Hg µg/L	Mn µg/L	Mo µg/L	Na mg/L	Ni µg/L	Pb µg/L	Sb µg/L	Se µg/L	Tl µg/L	V µg/L	Zn µg/L
HQ (total)	10	Min.	< 0.4	35.9	< 2.2	6.5	0.1	< 0.3	0.2	0.92	7.6	0.12	< 0.1	< 4.0	7.2	9.7	1.4	1.2	< 0.88	1.4	< 0.66	< 1.3	9.9
		Max.	< 2.0	384	< 6.0	18.1	< 2.0	< 2.2	< 5.0	< 2.0	24.1	0.9	< 0.2	110	66.5	30.4	3.9	< 3.0	< 5.0	< 10.0	< 5.0	< 11.0	69.7
		Avg.	< 2.0	146.58	< 6.0	12.1	< 2.0	< 2.2	< 5.0	< 2.0	12.53	0.43	< 0.2	28.8	31.45	21.77	2.98	< 3.0	< 5.0	< 10.0	< 5.0	< 11.0	34.72
HQ (dissolved)	6	Min.	< 2.0	29.4	< 2.2	5.9	< 0.1	< 0.3	0.5	0.6	7.8	0.1	< 0.1	5.7	24.9	13.4	2.4	< 1.1	< 0.88	< 2.0	< 0.66	< 1.3	17.7
		Max.	2.7	257	< 5.0	15.1	< 2.0	< 2.0	3.7	1.3	23.6	0.44	< 0.2	48.6	36.8	28.8	< 10.0	< 3.0	< 5.0	< 5.0	< 5.0	< 5.5	99.9
		Avg.	< 2.0	114.37	< 5.0	10.47	< 2.0	< 2.0	0.2	1	12.1	0.25	< 0.2	23.05	31.6	22.08	< 10.0	< 3.0	< 5.0	< 5.0	< 5.0	< 5.5	42.37
HA (total)	4	Min.	< 1.0	64.1	< 3.0	7.7	0.19	< 1.1	0.2	0.86	2.0	0.4	< 0.1	32.6	< 5.0	4.89	< 1.1	< 1.32	< 0.88	1.3	< 0.66	2.1	5.2
		Max.	3.7	163	< 5.0	17.2	< 0.66	< 2.0	< 5.0	< 1.0	5.8	2.25	0.24	95.8	5.1	9.29	< 10.0	1.9	< 5.0	< 5.0	< 5.0	< 5.5	16.7
		Avg.	< 2.0	118.28	< 5.0	11.62	< 0.66	< 2.0	< 5.0	< 1.0	2.7	1.04	< 0.2	61.05	1.3	6.8	< 10.0	0.5	< 5.0	< 5.0	< 5.0	< 5.5	11.98
HA (dissolved)	2	Min	< 1.0	61.6	< 3.0	9.9	< 0.66	< 1.1	0.4	< 1.0	< 2.0	0.78	< 0.1	76.6	< 5.0	6.6	< 1.1	< 1.32	< 0.88	< 5.0	< 0.66	< 5.5	7.8
		Max.	< 1.0	92.3	< 3.0	16.8	< 0.66	< 1.1	1.1	< 1.0	2.5	1.33	< 0.1	104	< 5.0	9.18	1.4	< 1.32	< 0.88	< 5.0	< 0.66	< 5.5	23.2
		Avg.	< 1.0	76.95	< 3.0	13.85	< 0.66	< 1.1	0.75	< 1.0	1.3	1.05	< 0.1	90.3	< 5.0	7.89	0.7	< 1.32	< 0.88	< 5.0	< 0.66	< 5.5	15.5
HC (total)	3	Min.	< 1.0	53	< 3.0	8.9	< 0.66	< 1.1	0.2	< 1.0	< 2.0	0.6	< 0.1	23.6	< 5.0	6.07	< 1.1	< 1.32	< 0.88	< 5.0	< 0.66	< 5.0	8.1
		Max.	14.4	69.1	< 5.0	17.5	< 2.0	< 2.0	< 5.0	< 5.0	< 10.0	0.68	< 0.2	141	< 5.0	8.9	< 10.0	1.4	< 5.0	< 5.0	< 5.0	< 5.5	13.9
		Avg.	4.8	59.07	< 5.0	12.17	< 2.0	< 2.0	< 5.0	< 5.0	< 10.0	0.64	< 0.2	70.1	< 5.0	7.19	< 10.0	0.5	< 5.0	< 5.0	< 5.0	< 5.5	4.63
HC (dissolved)	1	Value	< 1.0	48.5	< 3.0	16.1	< 0.66	< 1.1	0.3	< 1.0	< 2.0	0.42	< 0.1	126	< 5.0	8.9	1.5	< 1.32	< 0.88	< 5.0	< 0.66	< 5.5	36.5
Donohue's Pond (total)	1	Value	< 2.0	1510	12.1	31.9	< 1.32	< 2.2	0.9	20.3	62.2	4.06	< 0.1	493	< 10.0	11.2	4.2	10.3	< 1.76	< 10.0	< 1.32	< 11.0	53.7
Donohue's Pond (dissolved)	1	Value	< 1.0	64.4	< 3.0	10.5	< 0.66	< 1.1	0.8	< 1.0	2.3	0.77	< 0.1	205	< 5.0	11.0	< 1.1	< 1.32	< 0.88	< 5.0	< 0.66	< 5.5	8.7
Swan Pond (total)	4	Min.	< 1.0	46.1	< 3.0	5.4	< 0.66	< 1.1	0.12	< 1.0	< 2.0	0.05	< 0.1	28.3	< 5.0	6.4	< 1.1	0.96	0.88	< 5.0	< 0.66	0.88	6.9
		Max.	13.9	111	< 5.0	16.7	< 2.0	< 2.0	< 5.0	< 5.0	< 10.0	0.45	< 0.2	278	< 5.0	12.5	< 10.0	2.6	2.0	< 5.0	< 5.0	< 5.5	< 10.0
		Avg.	3.48	78.12	< 5.0	10.28	< 2.0	< 2.0	< 5.0	< 5.0	< 10.0	0.23	< 0.2	119.15	< 5.0	8.2	< 10.0	1.36	0.5	< 5.0	< 5.0	< 5.5	< 10.0

(continued on next page)

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

Sample Station	N		Ag µg/L	Al µg/L	As µg/L	Ba µg/L	Be µg/L	Cd µg/L	Co µg/L	Cr µg/L	Cu µg/L	Fe mg/L	Hg µg/L	Mn µg/L	Mo µg/L	Na mg/L	Ni µg/L	Pb µg/L	Sb µg/L	Se µg/L	Tl µg/L	V µg/L	Zn µg/L
Swan Pond	2	Min.	< 1.0	< 2.2	< 3.0	6.5	< 0.66	< 1.1	0.3	< 1.0	< 2.0	0.1	< 0.1	51.4	< 5.0	6.92	< 1.1	< 1.32	< 0.88	< 5.0	< 0.66	< 5.5	4.8
(dissolved)		Max.	< 1.0	82.3	< 3.0	16.0	< 0.66	< 1.1	0.7	< 1.0	< 2.0	0.39	< 0.1	245	< 5.0	12.8	1.2	< 1.32	< 0.88	< 5.0	< 0.66	< 5.5	14.1
		Avg.	< 1.0	41.15	< 3.0	11.25	< 0.66	< 1.1	0.5	< 1.0	< 2.0	0.24	< 0.1	148.2	< 5.0	9.86	0.6	< 1.32	< 0.88	< 5.0	< 0.66	< 5.5	9.45
Forge Pond	4	Min.	< 1.0	24.2	< 3.0	11.6	< 0.66	< 1.1	< 0.12	< 1.0	< 2.0	0.35	< 0.1	33.6	< 5.0	9	< 1.1	< 1.32	0.88	< 5.0	< 0.66	< 5.5	< 10.0
(total)		Max.	< 2.0	108	< 5.0	21.3	< 2.0	< 2.0	< 5.0	< 5.0	< 10.0	2.7	< 0.2	103	< 5.0	12.4	< 10.0	< 3.0	2.2	< 5.0	< 5.0	< 5.5	6.5
		Avg.	< 2.0	58.62	< 5.0	17.2	< 2.0	< 2.0	< 5.0	< 5.0	< 10.0	1.01	< 0.2	71.85	< 5.0	10.68	< 10.0	< 3.0	0.55	< 5.0	< 5.0	< 5.5	1.63
Forge Pond	2	Min.	< 1.0	16.5	< 3.0	18.3	< 0.66	< 1.1	0.2	< 1.0	< 2.0	0.21	< 0.1	89.4	< 5.0	10.8	< 1.1	< 1.32	< 0.88	< 5.0	< 0.66	< 5.5	5.4
(dissolved)		Max.	< 1.0	22.4	< 3.0	19.4	< 0.66	< 1.1	0.8	< 1.0	< 2.0	1.92	< 0.1	94.0	< 5.0	12.7	< 1.1	< 1.32	< 0.88	< 5.0	< 0.66	< 5.5	26.4
		Avg.	< 1.0	19.45	< 3.0	18.85	< 0.66	< 1.1	0.5	< 1.0	< 2.0	1.07	< 0.1	91.7	< 5.0	11.75	< 1.1	< 1.32	< 0.88	< 5.0	< 0.66	< 5.5	15.9
Carmans River																							
HH (total)	4	Min.	< 1.0	< 2.2	< 3.0	24.8	< 0.66	< 1.1	0.1	< 1.0	< 2.0	0.29	< 0.1	41	< 5.0	16.0	< 1.1	1.3	< 0.88	< 5.0	< 0.66	< 5.0	4.2
		Max.	< 2.0	91.0	< 5.0	31.8	< 2.0	< 2.0	< 5.0	< 5.0	< 10.0	0.8	< 0.2	152	< 5.0	18.4	< 10.0	2.1	< 5.0	< 5.0	< 5.0	< 5.5	19.6
		Avg.	< 2.0	56.88	< 5.0	28.4	< 2.0	< 2.0	< 5.0	< 5.0	< 10.0	0.52	< 0.2	88.58	< 5.0	17.27	< 10.0	0.525	< 5.0	< 5.0	< 5.0	< 5.5	8.6
HH (dissolved)	2	Min.	< 1.0	< 2.2	< 3.0	24.3	< 0.66	< 1.1	0.2	< 1.0	< 2.0	0.31	< 0.1	78.4	< 5.0	17.8	< 1.1	< 1.32	< 0.88	< 5.0	< 0.66	< 5.5	5.8
		Max.	< 1.0	4.5	< 3.0	30.1	< 0.66	< 1.1	0.8	< 1.0	< 2.0	0.36	< 0.1	116	< 5.0	18.4	< 1.1	< 1.32	< 0.88	< 5.0	< 0.66	< 5.5	24.4
		Avg.	< 1.0	2.25	< 3.0	27.2	< 0.66	< 1.1	0.5	< 1.0	< 2.0	0.33	< 0.1	97.2	< 5.0	18.1	< 1.1	< 1.32	< 0.88	< 5.0	< 0.66	< 5.5	15.1
Lower Lake (total)	1	Value	< 1.0	231	< 3.0	32.1	< 0.66	< 1.1	0.4	1.7	2.9	0.62	< 0.1	27.7	< 5.0	10.8	1.3	< 1.32	< 0.88	< 5.0	< 0.66	< 5.5	147
NYSDEC AWQS			0.1	100	150	SNS	11	1.1	5	34	4	0.3	0.2	SNS	SNS	SNS	23	0.1	SNS	4.6	8	14	37
Solubility State			I	I	D		AS	D	AS	D	D	AS	D				D	D		D	AS	AS	D
Typical MDL			1	2.2	3	1.8	0.66	1.1	0.12	1	2	0.075	0.2	2	5	1	1.1	1.3	0.88	5	0.66	5.5	4

Notes:
See Figure 5-8 for sample station locations.
AWQS = Ambient Water Quality Standards
AS = Acid Soluble
D = Dissolved
I = Ionic
MDL = Minimum Detection Limit
N = No. of Samples
NAP = No analysis performed
NYSDEC = New York State Department of Environmental Conservation
SNS = Standard Not Specified for these elements for Class C Surface Waters

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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 management strategy is based on an understanding of the site's resources and on compliance with applicable regulations. The goals of the program include protecting and monitoring the ecosystem, conducting research, and communicating with staff and the public. BNL focuses on protecting New York State Threatened and Endangered species on site, as well as the Laboratory's 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 2003, 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.

Completing the third year of managing the Upton Ecological and Research Reserve (Upton Reserve), its technical advisory group approved funding for research on the 530-acre area. Multiple research grants to investigate important local ecological issues were awarded and are discussed 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 is currently being developed to identify, assess, and document BNL's historic and cultural resources. In 2003, compliance procedures and requirements for archaeological surveys were developed.

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 completed and issued the Natural Resource Management Plan (NRMP) (BNL 2003a), which built on the successes of the Wildlife Management Plan (Naidu 1999). The NRMP describes the program strategy, elements, and planned activities for managing the various resources found on site. The plan and related information about natural resources at the Laboratory can be found at http://www.bnl.gov/esd/wildlife/.

6.1.1 Identification and Mapping

An understanding of the environmental baseline is the foundation of natural resource management planning. In 2001, through funding managed by the U.S. Fish & Wildlife Service (FWS), the entire BNL property was surveyed using the National Vegetation Standard. Using a Geographical Information System (GIS), a map overlay was produced that clearly identified the major vegetation complexes on site (Figure 6 -1). This software allows the user to predict distributions of key animal species based on the presence of suitable habitats. In addition to the vegetation map, overlays for soil types and the locations of wetlands and natural resource monitoring stations were added to BNL's GIS system. These tools enable resource managers to track changes over time, detect interactions between components of the ecosystem, and identify the locations of management activities on the 5,265-acre property.

A wide variety of vegetation, birds, reptiles, amphibians, and mammals inhabit the BNL site. Through implementation of the NRMP, additional endangered, threatened, and species of special concern have been identified as having been resident at BNL within the past 30 years. The only New York State endangered species confirmed as now inhabiting BNL property is the tiger salamander (*Ambystoma t. tigrinum*). Additionally, the New York State endangered Persius duskywing butterfly (*Erynnis p. persius*)

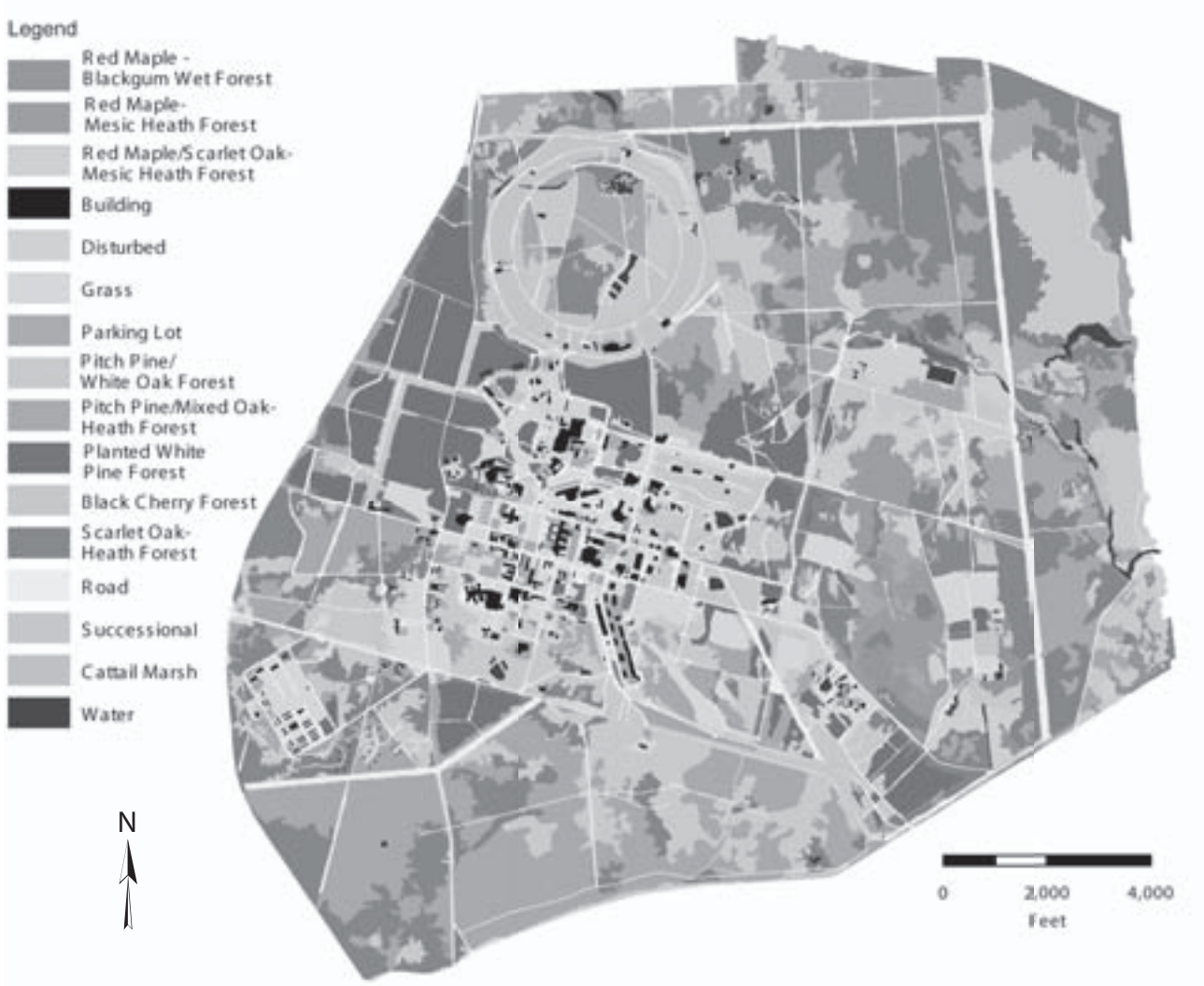

Figure 6-1. Vegetation Map of BNL.

and the crested fringed orchid (*Plantathera cristata*) have been identified on the BNL site in the past. Four 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. 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*) has historically been found and is likely to persist. Several other species that either inhabit the BNL site, visit during migration, or have historically been identified at BNL, are listed as rare, species of special concern, or exploitably vulnerable by New York State (Table 6-1).

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

Common Name	Scientific Name	State Status
Insects		
Frosted elfin	Callophrys iris	T
Mottled duskywing	Erynnis martialis	SC
Persius duskywing	Erynnis persius persius	E
Fish		
Banded sunfish	Enniacanthus obesus	T
Swamp darter	Etheostoma fusiforme	T
Amphibians		
Eastern tiger salamander	Ambystoma tigrinum tigrinum	E
Marbled salamander	Ambystoma opacum	SC
Eastern spadefoot toad	Scaphiopus holbrookii	SC
Reptiles		
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
Long-beaked bald-rush	Rhynchospora scirpoides	R
Swamp azalea	Rhododendron viscosum	V
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

6.1.2 Habitat Protection and Enhancement

BNL has precautions in place to protect onsite habitats and natural resources. Activities to eliminate or minimize negative effects on sensitive or critical species are either incorporated into 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. Routine activities that are not expected to affect habitat (such as road maintenance) are not undertaken until they have been duly evaluated.

6.1.2.1 Tiger Salamander Efforts

To safeguard 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 tiger salamander from exploitation by collectors and the pet trade. The map is updated annually as new information concerning tiger salamanders is generated through research and monitoring. Other efforts to protect this state endangered species include determining when adult salamanders are migrat-

ing toward breeding locations, when metamorphosis has been completed, and when juveniles are migrating after metamorphosis. During these times, construction and maintenance activities near tiger salamander habitats are postponed. BNL environmental protection staff must review any project planned near tiger salamander habitats, and every effort is made to minimize impacts.

Water quality testing is conducted as part of the routine monitoring of water basins. 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 confirmed that 17 on-site ponds are used by tiger salamanders. Normally, all ponds that had egg masses during the spring surveys are 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 BNL were conducted in 2003. An intern working through the Summer Undergraduate Laboratory Intern program offered by DOE and BNL's Office of Education Programs, conducted surveys of two known tiger salamander ponds. The results of this study showed large numbers of tiger salamanders emerging from one pond and marbled salamanders from the second pond. The success of this survey resulted in further interest by NYSDEC and researchers at SUNY Binghamton. Additional work on tiger salamanders is planned for spring and summer of 2004, and a doctoral student will use BNL as a study site. Information acquired from this 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 Hognosed Snake

In 2003, a radio telemetry study of the eastern hognosed snake (*Heterodon platirhinos*) was initiated. This species of special concern was considered to be very rare on Long Island. Reports of the snake were spotty through 1995, with no reports from Long Island between 1995 and 2001. In 2002, five sightings of this snake occurred at BNL, with photo documentation for two of the sightings. The presence of the snake at BNL raised interest as to the health of the population, and a FWS biologist with the Upton Reserve began looking for the snake in order to conduct radio telemetry work and determine habitat use. Six snakes were captured by the end of May 2003. Veterinarians from the Wildlife Conservation Society (Bronx Zoo) surgically implanted radio transmitters into five of the snakes. The snakes were held for several days to recover from surgery before being released. The snakes were routinely followed throughout the summer of 2003, and location and habitat data were recorded each time the snakes were found. Early in the project, two snakes could not be located. Information gained from the remaining three snakes provided biologists with a better understanding of this snake's movement and habitat use. It was originally thought that the eastern hognosed snake preferred open sandy habitats. Results of the study now suggest that the snake utilizes multiple habitats that include sandy open areas, grassy areas, and forest habitats. During the summer months, additional sightings of eastern hognosed snakes occurred. A total of 17 individual snakes were documented. Biologists hope to expand the radio telemetry study in 2004.

6.1.2.3 Other Species

As part of the tiger salamander and herpetological surveys, information on other species is being gathered. Including the tiger salamander (see Section 6.1.2.1), a total of 26 species of reptiles and amphibians were recorded. These species include the northern red-back salamander (*Plethodon c. cinereus*), marbled salamander (*Ambystoma opacum*), four-toed salamander (*Hemidactylium scutatum*), red-spotted newt (*Notophthalmus viridescens*), spring peeper (*Pseudacris crucifer*), wood frog (*Rana sylvatica*), gray tree frog (*Hyla versicolor*), bullfrog (*Rana catesbiana*), green frog (*Rana clamitans*), pickerel frog (*Rana palustris*), Fowler's toad (*Bufo woodhousei fowleri*), eastern spadefoot toad (*Scaphiopus holbrooki*), snapping turtle (*Chelydra serpentine*), painted turtle (Chrysemys p. picta), musk turtle (*Sternotherus*

odoratus), spotted turtle (*Clemmys guttata*), eastern box turtle (*Terrapene c. Carolina*), hog-nosed snake (*Heterodon platirhinos*), 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*), and the northern red-bellied snake (*Storeria occiptiomaculata*). This listing indicates that BNL has one of the most diverse herpetofaunal assemblages on Long Island. One species, the northern red-bellied snake, had not been reported on Long Island for nearly 60 years prior to its discovery in October 2003.

Banded sunfish protection efforts include observing whether adequate flow of the Peconic River is maintained within areas currently identified as sunfish habitat, ensuring that existing vegetation in the sunfish habitat is not disturbed, and evaluating all river remediation efforts for potential impacts on these habitats. In an attempt to rescue banded sunfish and swamp darters from severe drought conditions in 2002, a large coastal plain pond was seined to remove the remaining fish. Of the fish rescued, only six banded sunfish survived. The rescued fish were kept by fisheries experts at the Cold Spring Harbor Museum and Fish Hatchery in Cold Spring Harbor, New York and were released when the pond filled with water in May 2003. Peconic river surveys in 2003 identified a single banded sunfish east of sampling station HM-N (see Figure 5-8 for sampling stations).

BNL's Natural Resource Management Plan also calls for habitat enhancement. A total of 216 species of birds have been identified at BNL since 1948, of which at least 85 are known to nest on site. Some of these nesting birds have shown declines in their populations nationwide over the past 30 years. The Laboratory conducts routine monitoring of songbirds along six permanent bird survey routes in various habitats on site. The sixth route was established within the Upton Reserve, in order to gain data. In 2003, monthly surveys were conducted, starting at the end of March and extending through the end of September. These surveys resulted in the identification of 79 species during the year. Of these species, six species were seen that had not been counted in previous surveys, resulting in a total of 106 species having been identified during surveys in the past four years; 45 of these species were present each year. Variations in the number and species identified may be the result of the time of sampling, variations in weather patterns between years, or actual changes in the environment. The two most diverse transects pass near wetlands by the Biology Fields and the Peconic River. The four transects passing through the various forest types (white pine, moist pine barrens, and dry pine barrens) showed a less diverse bird community. Data are stored in an electronic database that is linked to BNL's GIS.

The eastern bluebird (*Sialia sialis*) has been identified as one of the declining species of migratory birds in North America. This decline is due to loss of habitat and to nest site competition from European starlings (*Sturnus vulgaris*) and house sparrows (*Passer domesticus*). Since 2000, BNL has installed 46 nest boxes around open grassland areas on site to enhance the bluebird population. In 2003, the boxes were monitored approximately every three weeks during the breeding season to determine use and nesting success. Nineteen bluebird nests were observed. Other birds using the houses included house wrens (*Troglodytes aedon*), black-capped chickadees (*Poecile atricapilla*), and tree swallows (*Tachycineta bicolor*). Bluebirds have consistently produced 19 broods each year for the past 4 years.

6.1.3 Population Management

BNL 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 Turkeys

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 around 250 birds by the end of 2001. Due to drought conditions, the population

dropped to around 175 birds by the end of 2002. Conditions greatly improved in 2003, and the population was estimated to be over 300 birds. The last brood of turkeys was seen in mid-September 2003.

NYSDEC requested authorization from BNL to trap and release wild turkey from BNL to other locations on Long Island. In March 2003, four male turkeys were trapped at BNL and released in the Easthampton area. Additional attempts at trapping failed, and trapping was suspended in early April due to the approaching breeding season. Plans have been made to make additional relocation attempts in 2004. At year's end, the four turkeys that were released in March were still being sighted, indicating success of the trap and release program. BNL will continue to monitor the turkey population and cooperate with NYSDEC to ensure the turkeys' success at BNL and at other sites on Long Island.

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 BNL, there are no significant pressures on the population to migrate beyond their typical home range of approximately 1 square mile. A 1992 study indicated that the population of deer on site exceeded 700, or approximately 85 per square mile (Thomlinson 1993). Normally, a population density of 10 to 30 per square mile is considered an optimum sustainable level for a given area. This would equate to approximately 80 to 250 deer inhabiting the BNL property, under normal circumstances. This was the approximate density in 1966, when the Laboratory reported an estimate of 267 deer on site (Dwyer 1966). The current estimate, based on surveys conducted late in 2003, is 1,784 deer, or approximately 217 deer per square mile. Significant damage to the ecosystems can occur when there are only 8 deer per square mile.

The deer surveys are conducted at least two times per year: mid-spring before fawns are born and late summer after all fawns have been born. Depending on winter weather conditions, late winter surveys are conducted to determine mortality resulting from weather. These surveys track reproductive success and mortality. In 2003, spring surveys indicated a population of 1,202 deer. Late summer surveys estimated 1,784 deer, for an 11 percent increase in the population over the previous year, and a 48 percent increase over the spring population. The significant increase resulted in higher rates of car–deer accidents in 2003. The spring count of 1,202 deer indicated a winter mortality of approximately 25 percent. The survey methods used require good weather for accurate counts. An infrared aerial survey would be more accurate and less dependent on weather conditions. In 2003, the Upton Reserve committee began discussing plans for conducting an infrared aerial survey of several Long Island properties, including 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 2003, there were 24 deer-related collisions on site, compared to the 20 accidents documented in 2002. This increase in the number of on-site collisions is attributed to increasing populations. Deer health appeared to be affected due to drought conditions that reduced the summer and fall food sources. Deer damage to vegetation around buildings was not significant during the winter of 2002–2003, due to mild temperatures, but some damage from deer browse was evident on ornamental vegetation. Although damage to shrubbery is not a threat to human health, it is undesirable because it may result in the need to replace shrubs, at substantial cost.

Because the high deer population is a regional problem, BNL is working on the issue with other entities. BNL is represented on a deer advisory panel for the hamlet of Lloyd Harbor. In addition, BNL environmental biologists 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 one of the keys to ensuring that environmental impacts of a proposed action or activity are adequately evaluated and addressed. BNL 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, The Nature Conservancy, the Town of Brookhaven, the Community Advisory Council, and local environmental advocacy groups are involved in reviewing major projects that have the potential for significant environmental impacts.

6.2 UPTON ECOLOGICAL AND RESEARCH RESERVE

On November 9, 2000, then-Secretary of Energy Bill Richardson, and Susan MacMahon, Acting Regional Director of Region 5 FWS, dedicated 530 acres of Laboratory property as an ecological research reserve. The property was designated by DOE as the Upton Ecological and Research Reserve (Upton Reserve) and is managed by FWS under an Interagency Agreement (DOE–FWS 2000). Additional information on the establishment of the Upton Reserve and accomplishments during 2003 can be found at http://www.bnl.gov/esd/reserve/default.htm. The Upton Reserve, near the eastern boundary of BNL (Figure 6-2), 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 BNL, 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 over a five-year period, to manage the reserve. In 2001, the first full year of the reserve's existence, FWS hired two biologists, formally established the boundary, and posted the area. During 2002, the staff conducted baseline biological survey work, initiated basic research, and funded educational programs in conjunction with BNL, Suffolk County Community College, and Longwood High School. In 2003, grants were awarded and research was initiated involving the Upton Reserve and Stony Brook University, Dowling College, and Rutgers University.

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 is to help develop the comprehensive Natural Resource Management Plan for both BNL and the Upton Reserve. This plan replaces the Wildlife Management Plan developed in 1999. The TAG also has developed criteria for soliciting and reviewing proposals and awarding funds for research to be conducted within the Upton Reserve. The TAG has approved research proposals that include an assessment of the effects of prescribed fire on the survival of orange-striped oakmoth (*Anisota senatoria*) pupae, and a project to investigate why some vines are more invasive than others. Preliminary results of the oak moth study were presented at the annual Pine Barrens Research Forum held at BNL in October 2003. Several other projects were nearing completion at the end of 2003 and reports and/or publications are expected sometime in 2004.

Additionally, education programs funded by the Upton Reserve began investigating the

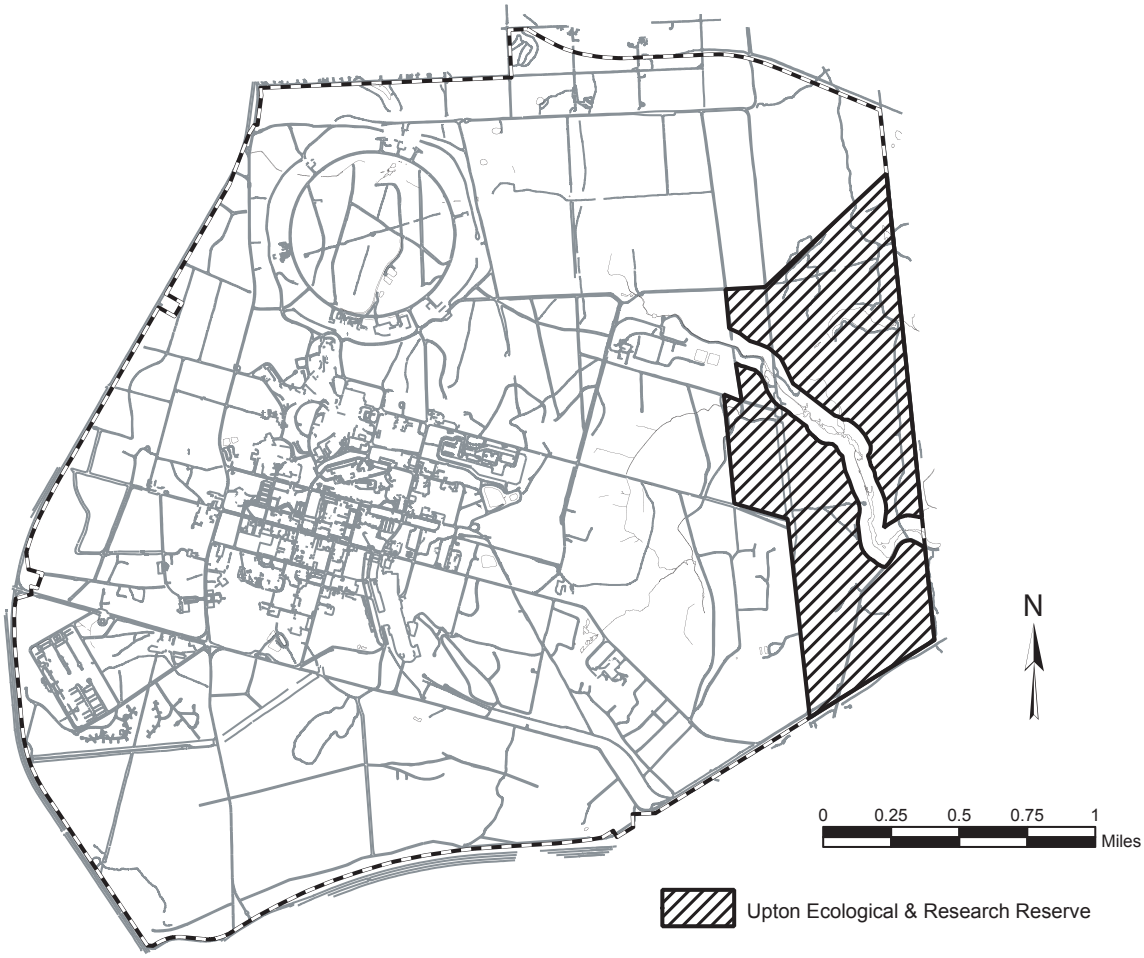

Figure 6-2. BNL Site Map Indicating the Boundary of the Upton Ecological and Research Reserve.

gypsy moth (*Lymantria dispar*) population. Students from Longwood High School began monitoring gypsy moth egg mass distributions within the Upton Reserve in the early spring of 2003. The gypsy moth has historically caused moderate to severe damage to oak trees, due to spring defoliation. The information gained from this study will assist the U.S. Forest Service in determining potential management activities. The information is important to the Upton Reserve and BNL, due to the coupled effects of spring defoliation by the gypsy moth and late season defoliation by the orange-striped oak moth caterpillar. This double defoliation, if it occurs year after year, can result in tree death and large sections of oak forest at BNL could be lost. In 2003, areas of BNL were experiencing oak death due to this repeated defoliation. Through coordination provided by the Upton Reserve, the U.S. Forest Service surveyed large sections of the Central Pine Barrens and created a map of the defoliation. At the time the map was produced, approximately 4,000 acres of oak forest had been defoliated; approximately 1,600 acres are on the BNL site. An additional 1,000-acre area was estimated to have been defoliated by the time of leaf drop in early October. The surveys, along with monitoring, will document the long-term effects of defoliation on forest health.

FWS management activities for the Upton Reserve in 2003 included mapping trails, assisting with bird and deer surveys, conducting educational and outreach activities, coordinating researcher access and training requirements, and managing fire prevention and suppression measures (including the development of BNL's Wildland Fire Management Plan [BNL 2003b]).

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 soils contaminated with cesium-137 (Cs-137), a radioactive isotope of cesium, were 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 isotope of potassium, and Cs-137. K-40 occurs naturally in the environment and 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

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, 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 potential radiation dose to consumers of deer meat containing Cs-137.

In 2003, 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 BNL, NYSDEC provides a few samples that result in data on deer that move beyond BNL boundaries, where they can be legally hunted, and also provides control data on deer living 1 mile or more from BNL. Also, FWS informs BNL staff of deer that have died in or near the Wertheim National Wildlife Refuge and other FWS properties on Long Island. Compared to a few years ago, a larger number of deer samples were collected in 2003. This is due to the larger number of deer–vehicle accidents that occurred on and off site, which corresponds to an increasing deer population. In all, 24 deer were obtained on site and 31 were from off-site locations, ranging from adjacent to BNL along the William Floyd Parkway, to as far away as East Islip, New York.

BNL sampling technicians collect the samples and process them for analysis. A sample of meat, liver, and bone is 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). In addition to the 55 deer samples taken under the routine monitoring program, four deer that entered the Former Waste Management Facility (FWMF) area were sampled to determine uptake of Cs-137 and Sr-90.

6.3.1.1 Cs-137 in Deer

It has been previously established (BNL 2000) that deer sampled on the BNL site contain higher concentrations of Cs-137 (half-life = 30 years) than deer from greater than 1 mile off site. This is most likely the result of deer consuming contaminated soil and grazing 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 lawn soils were remediated in 2000. Some soil contamination is still present in areas that are part of Operable Units (OU) I/VI and V (operable units are explained in Chapter 2). The cleanup of areas covered by the Record of Decision for Operable Units I and Radiologically Contaminated Soils (BNL 1999) is scheduled and will be completed as funds are available. Cleanup of one of the two remaining contaminated soil areas under the OU I/VI actions was completed in 2002. A Record of Decision for the Sewage Treatment Plant, a part of OU V, was signed in 2001; cleanup there began in 2002 and was completed in 2003. All buildings at the FWMF were re-

moved in 2003, and the remainder of the facility is scheduled for cleanup in 2004.

The number of deer taken for sampling has steadily increased since 1996. 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 that depends on vehicle/deer accidents and people reporting dead deer. The number of deer hit by cars varies widely from year to year, depending on the population of deer present near major roadways. Figure 6-3 shows the location of all deer samples taken within a 5-mile radius of BNL since 1999. Most of the off-site samples are concentrated along the William Floyd Parkway on the west boundary of BNL, while 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 2003, Cs-137 concentrations in deer meat samples taken at BNL ranged from 0.07 to 5.57 picocuries per gram (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 2003 on-site concentration (5.57 pCi/g wet weight) is slightly higher than the highest level reported in 2002 (4.95 pCi/g wet weight), but much lower than the highest level ever reported (11.74 pCi/g wet weight, in 1996). The arithmetic average concentration in on-site meat samples was 1.06 pCi/g. The average concentration of all off-site meat samples was 1.07 pCi/g wet weight.

Cesium-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 nearby range from 0.07 to 4.23 pCi/g wet weight, with an average of 1.51 pCi/g wet weight; concentrations in meat taken from farther away ranged from nondetectable to 0.32 pCi/g wet weight, with an average of 0.11 pCi/g wet weight.

Figure 6-4 compares the average values of Cs-137 concentrations in meat samples collected in 2003 from four different location groupings. Although the figure does not show this, 70 percent of all samples taken both on and off site are below 1 pCi/g wet weight (see Table 6-2).

Figure 6-5 presents the five-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 5 years, there is a statistical difference between values in 2000 (when landscape soils were cleaned up) and values in 2002. The slightly higher value in 2003 compared to 2002 is statistically the same.

Cesium-137 values appear to fluctuate seasonally (see Table 6-2), with lower values from January through July and higher values in the fall and early winter months (the same pattern exists in previous years' data). This is likely due to diet and biological processing of cesium. From January through May, deer eat mostly dry vegetation from the previous year's growth (fixed concentration of Cs-137 and a limited food supply), while in the summer and fall deer eat vegetation that is constantly growing. If the deer feed on vegetation growing in soil containing Cs-137, then they are likely to obtain a continuous supply, which is incorporated in their tissues. By January or February, the Cs-137 in their tissues is eliminated through biological processes. The levels of Cs-137 in deer tissue during June through early August are not well known, as there are few vehicle/deer accidents at this time of year.

When possible, liver samples are taken concurrently with meat samples. Liver generally accumulates Cs-137 at a lower rate than muscle tissue (meat). The lower values in liver allow the results to be used somewhat 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 2003, the range of Cs-137 concentrations was 0.05 to 1.43 pCi/g wet weight, with an average of 0.33

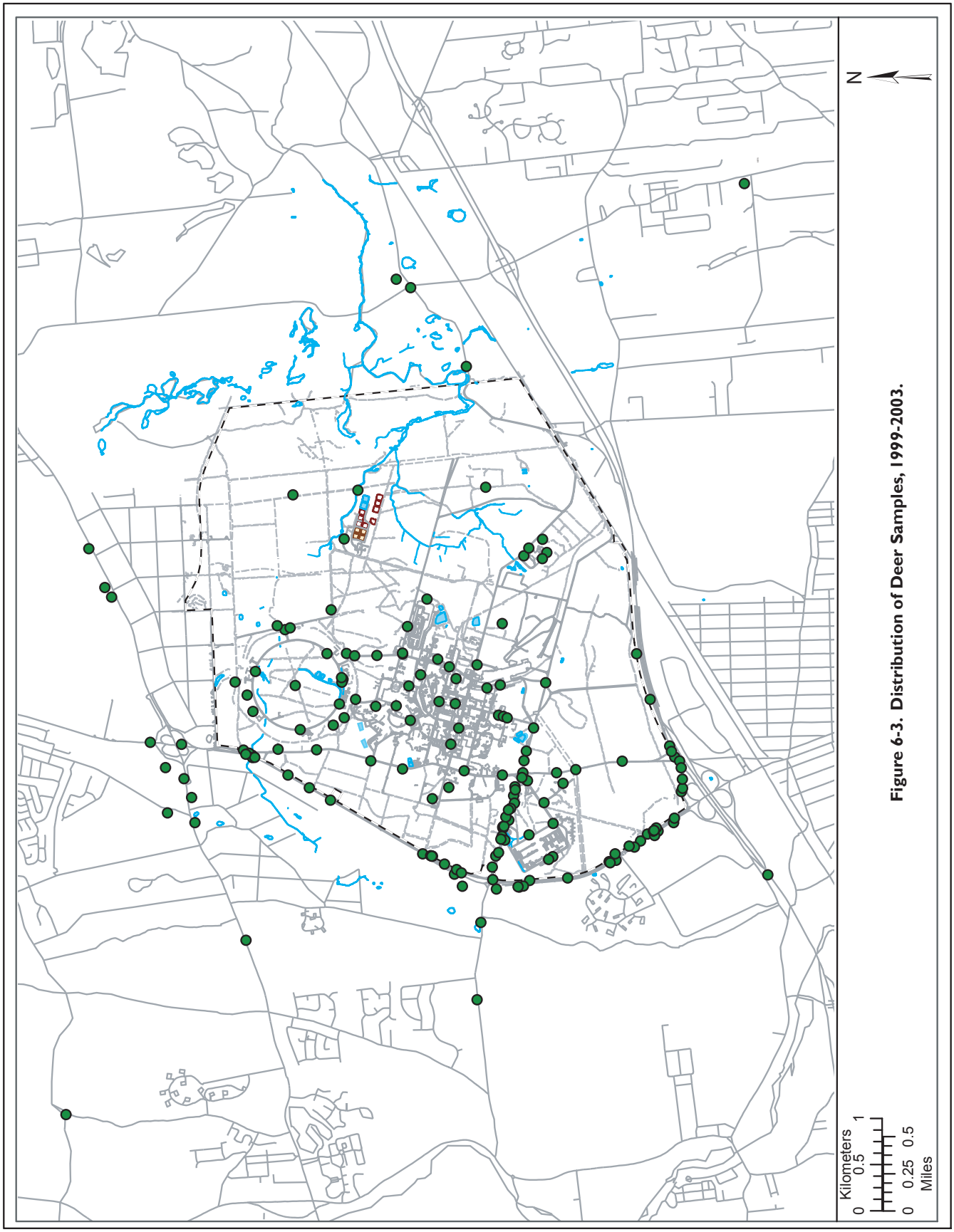

Figure 6-3. Distribution of Deer Samples, 1999-2003.

Table 6-2. Radiological Analyses of Deer Tissue, Organ, and Bone.

Sample Location	Collection Date	Tissue/ Organ/ Bone	K-40 pCi/g Wet Weight	Cs-137 pCi/g Wet Weight	Sr-90 pCi/g Dry Weight
BNL					
South of Bldg. 600	01/16/03	Flesh	2.89 ± 0.33	0.67 ± 0.05	
		Liver	2.56 ± 0.33	0.20 ± 0.02	
		Bone			2.39 ± 0.34
Upton St., south of Princeton Ave.	02/24/03	Flesh	2.92 ± 0.33	0.70 ± 0.07	
		Liver	1.82 ± 0.26	0.17 ± 0.02	
		Bone			2.59 ± 0.30
Main Gate, outbound lane	03/17/03	Flesh	2.78 ± 0.48	0.59 ± 0.08	
		Liver	2.67 ± 0.34	0.13 ± 0.02	
		Bone			2.36 ± 0.26
RHIC inner circle, Bldg. 1008	04/03/03	Flesh	3.18 ± 0.34	0.57 ± 0.05	
		Liver	5.16 ± 0.69	0.34 ± 0.04	
		Bone			2.83 ± 0.48
Mendel and Yale Ave.	04/10/03	Flesh	3.30 ± 0.33	0.28 ± 0.04	
		Liver	2.56 ± 0.37	0.09 ± 0.02	
		Bone			1.37 ± 0.33
Corner of Princeton Ave. and Grove	04/21/03	Flesh	3.36 ± 0.37	0.52 ± 0.04	
		Liver	3.39 ± 0.41	0.13 ± 0.02	
		Bone			2.93 ± 0.50
RHIC inner circle, HN Bldg.	04/23/03	Flesh	2.93 ± 0.48	0.42 ± 0.06	
		Liver	1.82 ± 0.26	0.10 ± 0.02	
		Bone			3.26 ± 0.49
BNL Fire House on Upton Rd.	04/29/03	Flesh	2.60 ± 0.31	0.31 ± 0.03	
Upton Rd., Bldg. 860	04/29/03	Flesh	3.36 ± 0.34	0.10 ± 0.02	
East Margin Dr. and Upton Rd.	05/02/03	Flesh	3.06 ± 0.35	0.42 ± 0.04	
		Liver	2.41 ± 0.33	0.13 ± 0.02	
		Bone			7.65 ± 0.78
RHIC inner circle, Bldg. 1005	05/06/03	Flesh	2.84 ± 0.39	0.38 ± 0.04	
		Liver	2.63 ± 0.32	0.12 ± 0.02	
		Bone			3.43 ± 0.57
East Fifth Ave. between HO east basin & MH192	07/21/03	Flesh	3.31 ± 0.35	0.35 ± 0.03	
		Bone*			1.54 ± 0.60
RHIC Ring, Bldg. 1010	08/05/03	Flesh	3.56 ± 0.39	0.58 ± 0.05	
		Liver	2.97 ± 0.38	0.21 ± 0.02	
		Bone			2.94 ± 0.61
Main Gate, outbound near Jersey barriers	09/22/03	Flesh	3.50 ± 0.36	0.21 ± 0.02	
		Bone*			1.91 ± 0.73
South Gate Rd., north of transfer station gate	09/26/03	Flesh	2.87 ± 0.39	0.26 ± 0.03	
		Bone*			1.60 ± 0.69
Yale Rd. and West Princeton Ave.	10/21/03	Flesh	3.52 ± 0.36	1.27 ± 0.10	
		Liver	2.42 ± 0.29	0.33 ± 0.04	
		Bone*			1.85 ± 0.49
Upton Rd., 150 feet south of North Gate	11/09/03	Flesh	3.13 ± 0.33	3.39 ± 0.26	
		Bone			3.28 ± 0.82
Princeton Ave., outbound lane	11/12/03	Flesh	3.50 ± 0.35	1.07 ± 0.13	

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

Sample Location	Collection Date	Tissue/ Organ/ Bone	K-40 pCi/g Wet Weight	Cs-137 pCi/g Wet Weight	Sr-90 pCi/g Dry Weight
RHIC Ring, Bldg. 1008	11/13/03	Flesh	3.34 ± 0.36	5.57 ± 0.40	
		Liver	2.81 ± 0.36	1.43 ± 0.11	
		Bone			3.80 ± 0.68
Bldg. 912 near well 054-07	11/19/03	Flesh	3.29 ± 0.34	4.64 ± 0.35	
		Liver	2.25 ± 0.28	1.10 ± 0.10	
		Bone			2.57 ± 0.53
Yale Rd. by 3-way stop sign	11/19/03	Flesh	3.10 ± 0.32	1.76 ± 0.22	
		Bone*			0.81 ± 0.40
Railroad Ave. between East Fifth and RHIC Ring	11/20/03	Flesh	2.97 ± 0.41	0.84 ± 0.09	
		Bone*			0.90 ± 0.39
Bldg. 820	12/03/03	Flesh	3.50 ± 0.36	0.07 ± 0.01	
		Liver	3.61 ± 0.48	0.05 ± 0.01	
		Bone			ND
RHIC Ring, Bldg. 1012	12/04/03	Flesh	2.80 ± 0.28	0.54 ± 0.07	
		Liver	2.85 ± 0.42	0.46 ± 0.06	
		Bone			4.26 ± 0.76
< 1 Mile from BNL					
LIE service road at south Gate	02/10/03	Flesh	2.43 ± 0.36	0.83 ± 0.10	
		Liver	2.36 ± 0.25	0.15 ± 0.02	
		Bone			3.41 ± 0.38
LIE north service road at south Gate	03/11/03	Flesh	2.39 ± 0.26	0.96 ± 0.12	
		Bone*			0.68 ± 0.19
William Floyd Pkwy. between LIE and Whispering Pines	03/18/03	Flesh	3.02 ± 0.48	0.85 ± 0.10	
		Bone			1.73 ± 0.50
LIE ramp outside South Gate	04/07/03	Flesh	3.83 ± 0.51	0.76 ± 0.08	
		Bone			1.79 ± 0.41
William Floyd Pkwy.	05/02/03	Flesh	3.45 ± 0.45	0.39 ± 0.04	
William Floyd Pkwy. at North Gate	05/06/03	Flesh	3.44 ± 0.94	0.40 ± 0.11	
		Liver	2.15 ± 0.28	0.11 ± 0.02	
		Bone			3.43 ± 0.57
LIE service road at South Gate	05/08/03	Flesh	2.97 ± 0.32	0.53 ± 0.04	
		Bone			4.96 ± 0.71
William Floyd Pkwy., south of Colonial Pines entrance	05/15/03	Flesh	2.80 ± 0.38	0.39 ± 0.04	
		Liver	2.70 ± 0.32	0.15 ± 0.02	
		Bone			5.75 ± 0.72
1/2 mile south of Main Gate	06/26/03	Flesh	3.37 ± 0.35	0.27 ± 0.03	
		Bone			2.07 ± 0.48
William Floyd Pkwy., 200 ft. south of Main Gate	08/01/03	Flesh	3.32 ± 0.37	0.18 ± 0.02	
		Liver	2.75 ± 0.30	0.07 ± 0.01	
		Bone			3.64 ± 0.71
LIE service road at South Gate	10/03/03	Flesh	3.46 ± 0.38	2.00 ± 0.15	
		Liver	*3.14 ± 0.39*	*2.22 ± 0.17*	
		Bone			3.07 ± 0.77
William Floyd Pkwy., south of North Gate entrance	10/15/03	Flesh	3.26 ± 0.44	0.50 ± 0.06	
		Bone*			1.13 ± 0.57

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

Sample Location	Collection Date	Tissue/ Organ/ Bone	K-40 pCi/g Wet Weight	Cs-137 pCi/g Wet Weight	Sr-90 pCi/g Dry Weight
William Floyd Pkwy., median at North Gate entrance	10/15/03	Flesh	3.87 ± 0.50	1.82 ± 0.19	
		Liver	2.60 ± 0.30	0.71 ± 0.06	
		Bone			2.61 ± 0.61
William Floyd Pkwy., 100 yds. south of North Gate	10/17/03	Flesh	3.46 ± 0.35	3.76 ± 0.47	
		Bone*			1.42 ± 0.44
William Floyd Pkwy., 100 yds. north of North Gate	10/17/03	Flesh	3.69 ± 0.45	2.51 ± 0.28	
		Bone			2.83 ± 0.59
William Floyd Pkwy. - buck	11/03/03	Flesh	3.41 ± 0.38	2.31 ± 0.17	
William Floyd Pkwy.	11/04/03	Flesh	3.69 ± 0.44	1.86 ± 0.21	
		Bone*			1.92 ± 0.66
William Floyd Pkwy., 1/4 mile north of Main Gate	11/05/03	Flesh	3.33 ± 0.38	2.45 ± 0.21	
		Bone*			1.97 ± 0.75
East of Exit 68 on LIE	11/19/03	Flesh	3.02 ± 0.41	1.57 ± 0.16	
		Bone			ND
William Floyd Pkwy., north of Colonial Pines	11/19/03	Flesh	2.68 ± 0.38	4.23 ± 0.43	
		Liver	2.50 ± 0.32	1.18 ± 0.11	
		Bone*			0.89 ± 0.38
William Floyd Pkwy., north of SCWA	12/09/03	Flesh	3.27 ± 0.43	2.33 ± 0.24	
		Liver	2.35 ± 0.27	0.58 ± 0.05	
		Bone			ND
> 1 Mile from BNL					
Seatuck Wildlife Refuge Deer 1	01/10/03	Flesh	2.42 ± 0.28	0.04 ± 0.01	
		Liver	2.73 ± 0.30	ND	
		Bone			1.65 ± 0.31
Seatuck Wildlife Refuge Deer 2	01/10/03	Flesh	3.11 ± 0.43	0.09 ± 0.02	
		Liver	2.18 ± 0.24	0.02 ± 0.01	
		Bone			1.25 ± 0.29
Seatuck Wildlife Refuge Deer 3	01/10/03	Flesh	3.39 ± 0.37	0.07 ± 0.01	
		Liver	3.04 ± 0.36	0.03 ± 0.01	
		Bone			1.12 ± 0.28
Seatuck Wildlife Refuge Deer 4	02/12/03	Flesh	3.18 ± 0.44	0.01 ± 0.01	
		Liver	2.76 ± 0.32	ND	
Seatuck Wildlife Refuge Deer 5	02/12/03	Flesh	3.28 ± 0.33	0.02 ± 0.01	
		Liver	2.18 ± 0.28	ND	
Seatuck Wildlife Refuge Deer 6	02/20/03	Flesh	3.18 ± 0.36	0.02 ± 0.01	
		Liver	2.62 ± 0.35	ND	
		Bone			1.47 ± 0.29
Church Lane, Middle Island	05/06/03	Flesh	2.73 ± 0.44	0.32 ± 0.05	
		Liver	2.11 ± 0.32	0.13 ± 0.02	
		Bone			2.61 ± 0.52
Rte. 27, west of William Floyd Pkwy.	09/13/03	Flesh	3.29 ± 0.37	0.01 ± 0.01	
		Liver	2.68 ± 0.29	0.02 ± 0.01	
		Bone			2.27 ± 0.59
Wertheim Gate	12/29/03	Flesh	3.26 ± 0.36	0.24 ± 0.02	
		Bone			2.33 ± 0.63

(continued on next page)

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

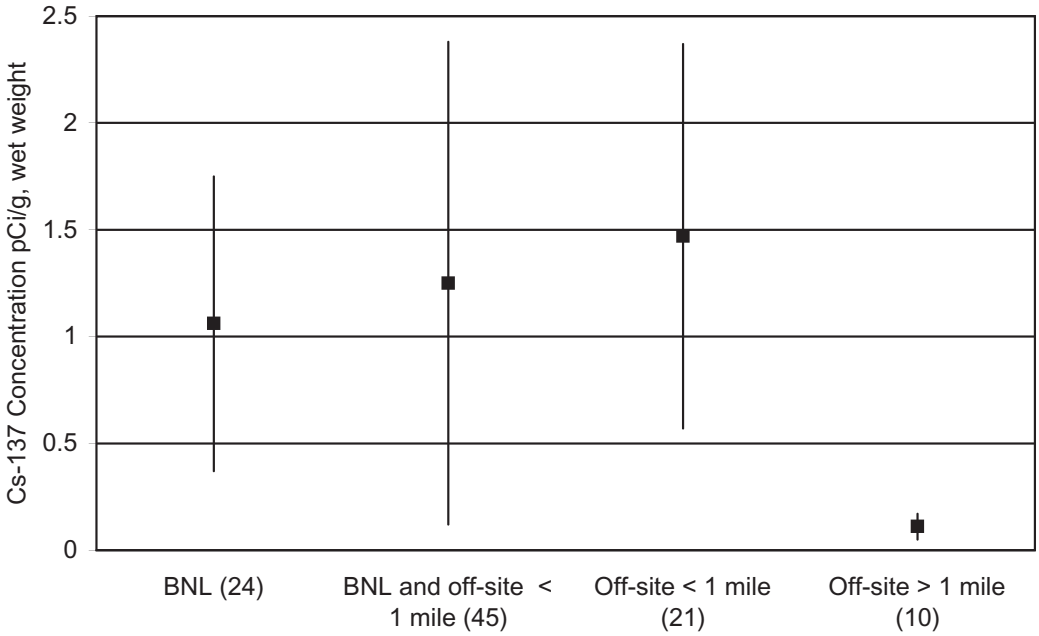
Sample Location	Collection Date	Tissue/ Organ/ Bone	K-40 pCi/g Wet Weight	Cs-137 pCi/g Wet Weight	Sr-90 pCi/g Dry Weight
Smith Rd. south of Wertheim	12/29/03	Flesh	2.84 ± 0.32	0.29 ± 0.03	
		Liver	2.33 ± 0.31	0.01 ± 0.00	
		Bone*			1.09 ± 0.40
Averages by Tissue	**No. of Samples**				
Flesh					
Avg. for all samples	55		3.2 ± 3.0	1.1 ± 1.1	
BNL on-site avg.	24		3.2 ± 1.8	1.1 ± 0.7	
BNL on- and off-site < 1 mile avg.	45		3.2 ± 2.7	1.3 ± 1.1	
Off site avg.	31		3.2 ± 2.4	1.0 ± 0.9	
Off-site < 1 mile avg.	21		3.2 ± 2.0	1.5 ± 0.9	
Off-site > 1 mile avg.	10		3.1 ± 1.2	0.11 ± 0.06	
Liver					
Avg. for all samples	32		2.66 ± 0.34	0.33 ± 0.05	
BNL on-site avg.	15		2.79 ± 0.38	0.33 ± 0.05	
BNL on- and off-site < 1 mile avg.	23		2.72 ± 0.36	0.44 ± 0.06	
Off-site avg.	17		2.54 ± 0.31	0.34 ± 0.06	
Off-site < 1 mile avg.	8		2.57 ± 0.31	0.65 ± 0.08	
Off-site > 1 mile avg.	9		2.51 ± 0.31	0.03 ± 0.01	
Bone					
Avg. for all samples	48				2.38 ± 0.58
BNL on-site avg.	21				2.63 ± 0.59
BNL on- and off-site < 1 mile avg.	40				2.51 ± 0.61
Off-site avg.	27				2.18 ± 0.57
Off-site < 1 mile avg.	19				2.37 ± 0.62
Off-site > 1 mile avg.	8				1.72 ± 0.43

Notes:
All values are shown with a 95% confidence interval.
K-40 occurs naturally in the environment and is presented as a comparison to Cs-137.
All averages are the arithmetic average and include nondetections as 0 for Cs-137. Confidence limits are 2s (95%) propogated error.
Sr-90 averages in bone were calculated using estimated values for ND. Confidence limits are 2s (95%) propogated error.
ND = Not Detected
* This bone value is estimated.

pCi/g wet weight. The off-site Cs-137 concentration in liver ranged from nondetectable to 2.22 pCi/g wet weight, with an average for all off-site liver samples being 0.34 pCi/g wet weight.

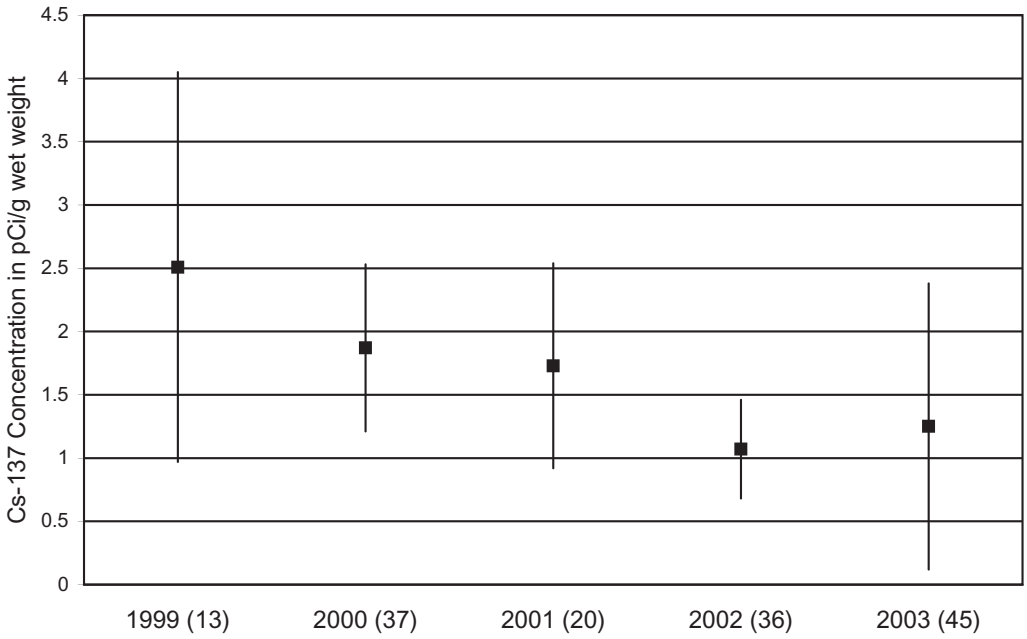
The potential radiological dose resulting from deer meat consumption is discussed in Chapter 8. The New York State Department of Health (NYSDOH) has formally considered the potential public health risk associated with elevated Cs-137 levels in on-site deer and determined that neither hunting restrictions nor formal health advisories are warranted (NYSDOH 1999). Their report can be accessed at http:// http://www.bnl.gov/esd/wildlife/deer_issues.htm.

With respect to the health of the 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



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

Figure 6-4. Comparison of Cs-137 Average Concentrations in Deer, 2003.



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

Figure 6-5. Five-Year Cs-137 Concentration Trends in Deer Meat at BNL and Within 1 Mile of BNL, 1999 to 2003.

wet weight, reported in 1996) would carry a total body burden (total amount in body) of about 0.2 µCi. Under these conditions, an 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, although the general health of the herd is not optimal because of overpopulation.

6.3.1.2 Strontium-90 in Deer Bone

BNL began testing deer bones (when available) for Sr-90 content in 2000, and continued this analysis in 2003. Sr-90 content ranged from nondetectable to 7.65 pCi/g dry weight in on-site samples, with higher values seen in bone taken during special sampling at the FWMF. Sr-90 in off-site samples ranged from nondetectable to 5.75 pCi/g dry weight in samples taken within 1 mile of BNL, and 1.09 to 2.61 pCi/g dry weight in samples taken from locations greater than a mile from BNL. This overlap in values between all samples suggests that Sr-90 is present in the environment at background levels; this is likely 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 deer.

6.3.1.3 Special Sampling of Deer in FWMF

The FWMF is the last major area containing Cs-137 contamination at BNL and was identified in 2002 as being a potential source of Cs-137 in two deer that were sampled along the William Floyd Parkway. Repairs were made to the fence that surrounds the FWMF, and periodic checks were made to determine whether deer were inside the fence. No indications were present to suspect deer being in the facility until November 13, 2003.

In 2003, cleanup operations at the FWMF began. The initial phases of cleanup involved the removal of contaminated material from the area, then proceeded to the removal of all of the buildings. One of the last buildings to be removed was building 455. This structure was located at one corner of the FWMF, and the facility's perimeter chain link fencing terminated at the southeast and northwest corners of the building. When the building was removed, a temporary, 8-ft high fence was installed across the gap the removal created. The temporary fence was checked daily to ensure it stayed in place. However, a windstorm during the night of November 13 knocked the temporary fence down. A permanent fence was installed the next day. Toward the end of the day, four deer, two does and two fawns, were discovered within the facility. There was no way to determine whether the deer were present in the compound for just a day or whether they had entered the compound earlier. Therefore, a decision was made to sample the deer, ensuring that they would not move to an area where they could be hunted. The first deer, a fawn, was taken after being in the facility for a minimum of 9 days. The second two deer were taken after being in the facility for a minimum of 13 days. The fourth deer, the remaining fawn, was wounded and escaped after being in the facility for a minimum of 16 days. The wound was considered fatal, and immediate attempts to track the fawn were made but failed. The fawn was found dead 17 days later and samples were taken. Table 6-3 presents the data from this special sampling group.

While the relationship of the fawns to the does was not determined, it is likely that the fawns were twins. Cs-137 in muscle tissue (meat) taken from these four deer ranged from 4.56 to 8.02 pCi/g wet weight. The lowest value was from one of the does that had been in the facility for at least 13 days, and the highest value was from the fawn that escaped and was later found dead. The 8.02 pCi/g wet weight value may be slightly high, as the fawn had likely been dead for several days and had begun to desiccate. Cesium-137 in liver ranged from 1.37 to 5.07 pCi/g wet weight. Although it is not known whether these deer had a significant Cs-137 content prior to their entering the facility, the values in both meat and liver suggest that Cs-137 can be incorporated into tissues

Table 6-3. Special Sampling of Deer from the Former Waste Management Facility (FWMF) Area.

Sample	Collection Date	Sample	Days in FWMF	K-40 pCi/g, Wet Weight	Cs-137 pCi/g, Wet Weight	Sr-90 pCi/g, Dry Weight
Fawn 1	11/22/03	Meat	9	3.52 ± 0.39	6.67 ± 0.48	NA
		Liver		3.26 ± 0.38	3.64 ± 0.28	NA
		Bone		NA	NA	38.6 ± 2.41
Doe 1	11/26/03	Meat	13	3.36 ± 0.39	4.56 ± 0.35	NA
		Liver		3.12 ± 0.43	1.37 ± 0.16	NA
		Bone		NA	NA	5.1 ± 0.96
Doe 2	11/26/03	Meat	13	2.99 ± 0.34	7.52 ± 0.63	NA
		Liver		3.05 ± 0.36	3.35 ± 0.28	NA
		Bone		NA	NA	48.5 ± 2.64
Fawn 2*	12/17/03	Meat	16	3.33 ± 0.35	8.02 ± 0.67	NA
		Liver		3.04 ± 0.39	5.07 ± 0.39	NA
		Bone		NA	NA	68.9 ± 2.56

Notes:
All values are shown with a 95% confidence interval.
K-40 occurs naturally in the environment and is presented as a comparison to Cs-137.
NA = Not Analyzed
* Fawn 2 had escaped from the FWMF on 11/29/03 and was found dead on 12/17/03. It was probably dead for 1 or 2 days before sampling.

rapidly. All Cs-137 values were lower than the historic high value recorded in 1996 from deer on or near BNL.

A sample of bone was taken from each animal and analyzed for Sr-90. Three of the deer, the two fawns and one doe, contained high levels of this bone-seeking radionuclide, values from 38.6 to 68.9 pCi/g dry weight. The other doe had a Sr-90 value of 5.1 pCi/g, which is in the typical range for deer on Long Island. The higher values in three of the deer may be a result of the doe having consumed dirt containing high levels of Sr-90. An area of the FWMF with high levels of Sr-90 was exposed when asphalt was removed, and deer are known to consume dirt in order to acquire micronutrients. A lactating doe would have higher calcium requirements, resulting in preferential uptake of Sr-90, which she would then pass on to her fawns. The fact that one doe and both fawns had higher levels of both Cs-137 and Sr-90 supports this hypothesis.

6.3.2 Small Mammal Sampling

BNL continued small mammal sampling in 2003. The original idea for this sampling was to determine the suitability of using 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 laboratory for dissection and analysis. The 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 6-4. Cs-137 in off-site samples ranged from 0.06 to 0.30 pCi/g dry weight. On-site samples contained Cs-137 ranging from 0.31 to 3.27 pCi/g dry weight. Sr-90 was not detected in any of the bone samples of eight squirrels, four on site and four off site.

Small mammals will continue to be sampled to obtain additional information about their usefulness in environmental surveillance.

6.3.3 Other Animals Sampled

Occasionally, other animals of interest are found dead along the roads of BNL and the immediate vicinity. The wild turkey is prevalent at BNL and has a mixed diet, eating mostly insects in the spring and summer and acorns during the fall and winter. In 2003, NYSDEC submitted a turkey to BNL that was hit by a car along

Table 6-4. Radiological Analyses of Small Mammals (Squirrels).

Location	Collection Date	K-40 pCi/g, Dry Weight	Cs-137 pCi/g, Dry Weight	Sr-90 pCi/g, Dry Weight
BNL				
RA-5 Area	1/30/03	13.30 ± 1.85	0.37 ± 0.08	ND
T-533	1/30/03	11.70 ± 1.77	0.31 ± 0.08	ND
RA-5 Area*	4/24/03	ND	1.36 ± 0.22	ND
Bldg. 811	10/16/03	ND	3.27 ± 0.28	ND
Off Site				
Moriches	1/26/03	8.21 ± 0.90	0.30 ± 0.05	ND
Holbrook	4/18/03	ND	ND	ND
Holbrook	5/30/03	ND	ND	ND
Holbrook*	9/9/03	ND	0.21 ± 0.15	ND

Notes:
All values are shown with a 95% confidence interval.
K-40 occurs naturally in the environment and is presented as a comparison to Cs-137.
ND = Not Detected
* Cs-137 value for this sample is estimated based on laboratory analytical qualifiers.

the William Floyd Parkway. The turkey had a Cs-137 concentration of 0.02 pCi/g wet weight. This is comparable to the 0.04 pCi/g wet weight value seen in a turkey sampled on site in 2002.

Two Canada geese were sampled after cars on site hit them during 2003. Geese typically graze on the lawns around the Laboratory, but are less selective in feeding compared to deer. Cs-137 was found in concentrations between 0.01 and 0.02 pCi/g wet weight. This is comparable to the far off-site values found in deer meat.

Sr-90 was not detected in bone taken from the turkey and was estimated to be between 0.49 and 0.65 pCi/g dry weight in bone samples taken from the two geese. These values are comparable to values seen in squirrels on site.

6.3.4 Fish Sampling

In collaboration with the NYSDEC Fisheries Division, BNL maintains an ongoing program for collecting and analyzing fish from the Peconic River and surrounding freshwater bodies. The annual sampling at BNL over the past several years has depleted the number of larger fish. As a result, it would be necessary to take more of the smaller fish to obtain a sufficiently large sample to complete all analyses desired. For this reason, BNL suspended most on-site sampling beginning in 2001 and will continue with the suspension for up to three years to allow the on-site fish populations to recover and mature. To determine population recovery, a population assessment was conducted and the results are discussed in Section 6.3.4.2. BNL stopped sampling shellfish (clams and oysters) in 2003, as historical records indicated no detection of radionuclides were from on-site operations.

Off-site fish sampling continued as in the past. All samples were analyzed for whole-body content of each of the analytes reported; in most instances, the samples were a composite of several fish to ensure adequate sample size for analysis. In 2003, 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 not connected to the BNL tributary) 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. Fifteen samples were taken, representing seven species of fish.

Table 6-5. Radiological Analyses (Whole Body) of Fish from the Peconic River System and Carmans River Control Location.

Location/ Species	K-40 pCi/g, Dry Weight			Cs-137 pCi/g, Dry Weight			Sr-90 pCi/g, Dry Weight		
Swan Pond									
Pumpkinseed	9.2	±	1.1	0.23	±	0.04	1.15	±	0.38
Brown Bullhead*	11.9	±	1.3	0.36	±	0.06	0.75	±	0.27
Largemouth Bass*	8.1	±	1.2	0.55	±	0.1	0.69	±	0.27
Donahue's Pond									
Bluegill	9.12	±	1.47	0.38	±	0.07	1.14	±	0.34
Largemouth Bass	9.71	±	1.55	0.53	±	0.11	1.37	±	0.34
Forge Pond									
Largemouth Bass*	9.82	±	1.21	0.23	±	0.05	0.58	±	0.23
Pumpkinseed**	7.9	±	1.25	0.13	±	0.1	0.74	±	0.3
Brown Bullhead***	13.5	±	1.24	0.18	±	0.04		< MDL	
Lower Lake, Carmans River (a)									
Golden Shiner	9.56	±	1.08		< MDL			< MDL	
Largemouth Bass***	10.4	±	1.17	0.05	±	0.03		< MDL	
Brown Bullhead***	11.8	±	1.4	0.05	±	0.02		< MDL	
Bluegill***	9.12	±	1.37	0.09	±	0.05		< MDL	
Brown Trout***	10.3	±	2.34	0.15	±	0.11		< MDL	

Notes:
All values are presented with a 95% confidence interval.
K-40 occurs naturally in the environment and is presented as a comparison to Cs-137.
See Figure 5-8 for sampling stations.
MDL = Minimum Detection Limit
* Estimated value for Sr-90
** Estimated value for both Cs-137 and Sr-90
*** Estimated value for Cs-137
(a) Carmans River Control Location

6.3.4.1 Radiological Analysis of Fish

The species collected for radiological analysis in 2003 by BNL, NYSDEC, 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*), and brown trout (*Salmo trutta*). Gamma spectroscopy analysis was performed on all samples. Table 6-5 presents specific information on the sampling location, species collected, and analytical results. All sample results are presented as dry weight concentrations.

Cs-137 was identified at low levels in all samples from the Peconic River system, ranging from 0.13 pCi/g dry weight in pumpkinseed from Forge Pond, to 0.55 pCi/g dry weight in largemouth bass from Swan Pond. In 2003, fish taken from Lower Lake on the Carmans River (the non-Peconic control location) showed estimated levels of Cs-137 ranging from below minimum detection limit (MDL) in golden shiners to 0.15 pCi/g dry weight in brown trout.

Sr-90 is readily deposited in bone. In 2003, BNL continued the testing for Sr-90 that was initiated in 2000. Values ranged from nondetectable to 1.37 pCi/g dry weight. Because fish were analyzed for whole-body content, values for Sr-90 may vary somewhat, as seen in the data presented in Table 6-5. These variations result from random pieces of bone included in the aliquot of the sample used for analysis. BNL will continue to test for Sr-90 in off-site samples in order to build baseline values for future comparisons.

Some Cs-137 is detectable in the environment worldwide as a result of global fallout from past aboveground nuclear weapons testing. This is evident when examining the analytical results of fish from the control locations. To account for the different feeding habits and weights of various species, it is important to compare

Table 6-6. Fish Population Survey Results in the Peconic River System (STP to HM-N), 2001–2003.

	2001		2002		2003	
Species	No. Caught	Avg. Length (in.)	No. Caught	Avg. Length (in.)	No. Caught	Avg. Length (in.)
Banded Sunfish	18	2.8	1	2.1	1	1.5
Brown Bullhead	43	5.1	13	6.2	6	2.9
Chain Pickerel	20	7.1	1	11.3	22	7.1
Creek Chubsucker	53	3.6	4	2.6	11	2.7
Golden Shiner	9	4.4	23	1.8	505*	1.9
Largemouth Bass	1	5.5	NC	NC	NC	NC
Pumpkinseed	15	3.9	77	1.6	38	3.7
Total No. Caught	159		119		84 **	

Notes:
HM-N = Outfall just beyond the East Firebreak
STP = Sewage Treatment Plant
NC = No fish caught
See Figure 5-8 for sampling stations.
*This number includes 499 fingerlings that were too small to measure accurately. The average length is for the six measurable fish.
** The 2003 total does not inlcude the 499 fingerlings which could not be measured.

species with similar feeding habits (i.e., bottom feeders such as brown bullhead should be compared to other bottom feeders—in this case, other brown bullhead). Cs-137 concentrations in bullhead collected at all locations along the Peconic River had values less than 0.36 pCi/g dry weight, whereas values for bullhead at Lower Lake on the Carmans River had 0.05 pCi/g dry weight. 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—with the exception of tritium—were released between the late 1950s and early 1970s, and 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 STP to the Peconic River in 2003. See Figure 5-5 for a trend of Cs-137 discharges.

6.3.4.2 Fish Population Assessment

As mentioned in Section 6.3.4, BNL suspended fish sampling on site in 2001 because prior fish sampling had depleted the population and limited the remaining fish to smaller sizes. To document the number and size of fish in the on-site portions of the Peconic River, BNL conducted an electroshock survey (which does not harm the fish) from the Sewage Treatment Plant outfall (EA) to just beyond the east firebreak sampling station (HM-N) (see Figure 5-8 for sampling stations). The results of the 2003 survey, compared with the 2001 and 2002 surveys, are summarized in Table 6-6. In 2003, a total of 86 fish comprising six species were found in this section of river. The average length of fish ranged from 1.5 inches to 7.1 inches, depending on species The largest fish was an 8.75-inch chain pickerel. The total number of fish is indicative of poor population numbers. The variation from year to year in the number of fish caught relates to sampling conditions: 2002 was a drought year with low water levels and poor reproductive conditions, and 2003 had above-normal precipitation, resulting in high river flows that made electroshock efforts difficult. The single banded sunfish captured in 2003 indicates that sunfish are still present in the river, but the exact numbers cannot be provided. BNL will continue to monitor the fish population to determine when routine sampling may resume. Based on the present numbers,

Table 6-7. Metals Analyses of Fish from the Peconic River System and Carmans River Control Location.

Location	Sample Type	Barium	Chromium	Copper	Iron	Lead	Manganese	Mercury	Selenium	Sodium	Zinc
		(mg/kg)									
Swan Pond	Brown Bullhead	0.6	0.33	0.52	10.3	0.31	1.75	0.2	0.44	776	7.76
	Largemouth Bass	< MDL	0.2	< MDL	3.42	< MDL	0.18	0.8	< MDL	819	5.03
	Pumpkinseed	1.12	0.49	0.18	10.7	< MDL	7.17	0.03	0.49	1380	13.1
Forge Pond	Brown Bullhead	1.48	0.36	0.7	88.1	< MDL	4.88	0.02	< MDL	1220	12.8
	Largemouth Bass	0.52	0.36	0.28	16.7	< MDL	1.57	0.08	< MDL	1110	9.51
	Pumpkinseed	0.07	0.2	0.22	7.67	< MDL	0.43	0.18	< MDL	815	8.21
Donahue's Pond	Bluegill	1.6	0.43	0.26	10.7	< MDL	7.85	0.1	< MDL	1260	15.9
	Largemouth Bass	2.06	0.42	0.42	158	< MDL	16.4	0.22	< MDL	1460	12.6
Lower Lake, Carmans River (a)	Black Crappie	4.55	0.73	0.21	6.34	< MDL	7.5	0.05	0.78	1180	19.3
	Bluegill	3.49	0.79	0.62	34.5	0.42	12.1	0.07	0.66	1200	23
	Brown Bullhead	0.67	0.8	0.51	54.7	< MDL	12.7	0.03	< MDL	901	9.04
	Brown Trout	0.28	< MDL	0.28	8.21	< MDL	1.46	0.07	0.71	1010	10.1
	Golden Shiner	1.21	< MDL	0.45	10.6	< MDL	3.63	0.04	0.72	743	20.5
	Largemouth Bass	0.69	0.29	0.23	6.56	< MDL	2.76	0.07	0.52	897	9.13
	Pumpkinseed	3.46	0.73	0.48	29.7	0.36	12.4	0.08	0.42	1460	27.4

Notes:
See Figure 5-8 for sampling stations.
MDL = Minimum Detection Limit
(a) Carmans River Control Location

BNL will not likely attempt taking on-site samples in 2004.

6.3.4.3 Nonradiological Analysis of Fish

In 1997, under the OU V remediation project, the BNL ER Program sampled and analyzed fish from the Peconic River for metals, pesticides, and polychlorinated biphenyls (PCBs). The contaminant levels found were not considered to have a health impact on fish or humans, but DOE directed that sampling and analysis should be done annually. This analysis was conducted on site in 1999 and 2000; analysis in 2002, as in 2001, was limited to off-site fish. The timing of sampling has varied from year to year, as well as the sample preparation (whole-body, tissue separation, composite sampling). In 1997, sampling was performed during April through May; in 1999, sampling was performed during September through December. Since 2000, sampling has occurred from July through August. Additionally, there has been a wide variation in fish size; 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 in tissues.

Table 6-7 shows the concentration levels of metals in fish for 2003. 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 cadmium, beryllium, nickel, silver, thallium, and vanadium were all less than the MDL for the analytical procedure, they were not included in Table 6-7. Other metals tested but not included in the table include antimony, arsenic, and cobalt. Pumpkinseed and bullhead taken from Swan Pond had a content of 0.36 mg/kg of antimony, while pumpkinseed from Forge Pond had a content of 0.44 mg/kg. Arsenic was present in golden shiners and bluegill taken from Lower Lake on the Carmans River at levels of 0.24 and 0.43 mg/kg,

Table 6-8. Average Pesticide Analyses of Fish from the Peconic River System and Carmans River Control Location.

Location/Species	4,4'-DDD	4,4'-DDE	4,4'-DDT	Dieldrin	Endrin aldehyde
	µg/kg				
Swan Pond					
Brown Bullhead	13.7	33.6	6.2*	1.6*	2.0*
Largemouth Bass	7.3	42.2	10.0	< MDL	3.2*
Pumpkinseed	11.9	31.1	< MDL	< MDL	< MDL
Donahue's Pond					
Bluegill	4.6*	13.8	2.4*	< MDL	< MDL
Largemouth Bass	8.3	15.7	4.7	< MDL	< MDL
Forge Pond					
Brown Bullhead	2.4*	6.9	< MDL	< MDL	< MDL
Largemouth Bass	6.2	23.1	5.4	< MDL	1.1*
Pumpkinseed	19.4	51.2	11.1	< MDL	< MDL
Lower Lake, Carmans River (a)					
Black Crappie	4.4	28.0	< MDL	2.6*	< MDL
Bluegill	30.7	184	26.6	7.8*	< MDL
Brown Bullhead	12.0	49.9	5.0*	2.4*	< MDL
Brown Trout	27.5	302	31.0	5.0*	< MDL
Golden Shiner	9.0	30.6	< MDL	< MDL	< MDL
Largemouth Bass	5.2*	32.9	6.2*	< MDL	< MDL
Pumpkinseed	4.6	25.8	3.1*	< MDL	< MDL

Notes:
Fish were analyzed for whole body composites of several fish per sample.
See Figure 5-8 for sampling stations.
MDL = Minimum Detection Limit
* Estimated value based on laboratory qualifiers.
(a) Carmans River Control Location

respectively. Cobalt was measured in brown bullhead from Swan Pond at a level of 0.14 mg/kg.

Mercury was found in all fish at levels less than 0.22 mg/kg, which is much less than the 1.0 mg/kg consumption standard set by the U.S. Food and Drug Administration. The highest levels of mercury detected were in largemouth bass, taken from Donahue's Pond.

Table 6-8 shows the concentrations of pesticides in fish for 2003. The table reflects only samples with detectable levels of pesticide in the tissues. 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. In addition to those pesticides shown in Table 6-8, the brown bullhead sample from Swan Pond also had indications that it contained the pesticides endosulfan II and methoxychlor at levels estimated to be 0.841 µg/kg and 6.37 µg/kg, respectively. Methoxychlor was reported in 2002 in largemouth bass and pumpkinseed taken in Swan Pond. Endosulfan II has not been previously reported. The pesticide DDT and its breakdown products, DDD and DDE, were detected at low levels at several off-site locations. DDT was commonly used before 1970. Chlordane was also commonly used across Long Island and is found occasionally in fish samples, but it was not confirmed in any fish samples taken in 2003. Dieldrin is a breakdown product of aldrin, which was commonly used to treat soil insects in crops (termites in potatoes). Endrin aldehyde is an impurity or breakdown product of endrin, which was a common pesticide for insects, rodents, and birds. Of the pesticides detected, only the DDT and its breakdown products remain at significantly measurable levels in the environment.

Table 6-9. Radiological Analyses of Aquatic Vegetation and Sediment from the Peconic River System and Carmans River Control Location.

Location/Sample Type	K-40			Cs-137		
	(pCi/g, Dry Weight)					
BNL (EA to HM-N)						
Burr Reed		NV			< MDL	
Burr Reed		NV			< MDL	
Burr Reed*		NV		0.17	±	0.09
Duckweed*		NV		1.17	±	0.15
Sediment*		NV		0.14	±	0.02
Sediment*		NV		0.45	±	0.04
Sediment*		NV		1.47	±	0.17
Sediment*		NV		0.50	±	0.06
Forge Pond						
Lily Pad	21.2	±	2.6	0.30	±	0.10
Sediment*	2.09	±	0.32	0.17	±	0.03
Swan Pond						
Lily Pad	20.0	±	2.7		< MDL	
Sediment	1.2	±	2.6	0.55	±	0.20
Donahue's Pond						
Lily Pad*	7.2	±	1.8	0.12	±	0.07
Sediment*	1.14	±	0.24	0.06	±	0.02
Lower Lake, Carmans R. (a)						
Lily Pad*	14.4	±	1.8	0.12	±	0.05
Sediment*	0.90	±	0.70	0.12	±	0.07

Notes:
All values are shown with 95% confidence interval.
See Figure 5-8 for sampling stations.
MDL = Minimum Detection Limit
NV = No Value Given
*Estimated values based on laboratory qualifiers.
(a) Carmans River Control Location

No detectable levels of PCBs (aroclor-1242 and aroclor-1260) were found in fish taken from the Peconic River or control site locations. Historically, aroclor-1260 was used in electrical equipment and this PCB has been found in fish taken at BNL in previous years.

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 2003. (See Chapter 5 for a discussion on water quality and monitoring, and Figure 5-8 for sampling stations.) Table 6-9 summarizes the radiological data. Low levels of Cs-137 were documented in sediments at all locations, with levels on site slightly higher than off site. Aquatic vegetation, both on and off site, showed very low levels of Cs-137, with levels being higher on site compared to off site. The highest values for Cs-137 in vegetation correspond with the highest levels found in sediments at the same sample location.

6.3.5.2 Metals in Aquatic Samples

Metals analyses (Table 6-10) 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 the Suffolk County Department of Health Services (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.

On-site levels of copper, mercury, and silver were above SCDHS cleanup objectives but below action levels. Vegetation contained significantly lower levels of these metals than was seen in the sediments. Off site, levels of arsenic, chromium, and mercury were higher than the SCDHS cleanup objectives but much lower than action levels.

6.3.5.3 Pesticides and PCBs in Aquatic Samples

Pesticides and PCBs are reported in Table 6-11 for only those samples with detectable limits. Various samples of sediment, vegetation, and water at nearly all locations contained DDT or its breakdown products, DDD and DDE. Single detections (not included in Table 6-11) of dieldrin (0.36 mg/kg) and endrin (0.74 mg/kg) were detected in sediments taken from Forge Pond, and delta-BHC (1.50 mg/kg) was detected in lily pads taken from Swan Pond. These pesticides were used historically across Long Island, including at BNL. The PCBs aroclor 1254 and 1260 were detected in low levels in sediments at BNL. These PCBs were historically found in electrical equipment on site and have been documented in Peconic River sediments. Much of the PCB-contaminated sedi-

Table 6-10. Metals Analyses of Aquatic Vegetation and Sediments from the Peconic River System and Carmans River Control Location.

Location/ Sample Type	Arsenic	Barium	Cadmium	Chromium	Copper	Iron	Lead	Manganese	Mercury	Nickel	Silver	Sodium	Vanadium	Zinc
	(mg/kg)													
BNL (EA to HM-N)														
Burr Reed	< MDL	2.72	< MDL	< MDL	3.05	119	< MDL	10.7	0.02	< MDL	< MDL	491	< MDL	6.49
Burr Reed	< MDL	4.54	< MDL	< MDL	1.81	121	0.42	55.1	0.02	< MDL	< MDL	576	< MDL	6.85
Burr Reed	< MDL	16.5	< MDL	< MDL	1.4	51.8	0.267	163	0.01	0.39	< MDL	232	< MDL	6.28
Duckweed	< MDL	2.64	0.10	< MDL	4.92	85	0.364	58.9	0.02	0.504	< MDL	501	< MDL	26.9
Sediment	0.45	4.53	< MDL	2.76	7.14	1160	2.64	9.81	0.12	1.25	1.9	19.7	4.33	7.34
Sediment	0.79	16.2	0.25	4.41	37.1	1510	6.02	14.9	0.84	3.64	10.9	44.1	6.74	23.3
Sediment	0.39	38.1	0.98	7.14	25	955	4.89	26.4	0.68	3.32	4.32	59.1	4.59	61.5
Forge Pond														
Lily Pad	< MDL	14	< MDL	< MDL	0.23	37.4	< MDL	91.6	0	< MDL	< MDL	205	< MDL	2.54
Sediment	0.69	7.51	< MDL	1.16	1.65	1690	3.85	12.1	0.01	0.84	< MDL	24.4	1.96	12.1
Swan Pond														
Lily Pad	< MDL	21.8	< MDL	0.17	< MDL	27.7	0.29	611	< MDL	< MDL	< MDL	336	< MDL	3.94
Sediment	6.67	77.5	1.75	12.8	19.1	5510	80.5	2320	0.22	8.99	< MDL	326	24.2	90.5
Donahue's Pond														
Lily Pad	0.42	32.5	< MDL	0.28	0.48	539	0.34	459	< MDL	0.17	< MDL	743	0.32	9.57
Sediment	1.27	6.36	< MDL	1.34	3.13	601	3.57	39.8	0.01	0.49	< MDL	18.7	1.28	6.2
Lower Lake, Carmans River (a)														
Lily Pad	< MDL	30.6	< MDL	< MDL	0.2	36.8	< MDL	24.4	< MDL	< MDL	< MDL	618	< MDL	3.97
Sediment	8.57	109	1.04	40	16.2	10500	84.6	635	0.28	9.37	< MDL	173	28.2	131

Notes:
See Figure 5-8 for sampling stations.
MDL = Minimum Detection Limit
(a) Carmans River Control Location

Table 6-11. Pesticide and PCB Analyses of Aquatic Vegetation, Sediment, and Water from the Peconic River System and Carmans River Control Location.

Location/Sample Type	4,4'-DDD	4,4'-DDE	4,4'-DDT	Aroclor 1254	Aroclor 1260
	(mg/kg)				
BNL (EA to HM-N)					
Burr Reed	< MDL	< MDL	< MDL	< MDL	< MDL
Burr Reed	< MDL	< MDL	< MDL	< MDL	< MDL
Burr Reed	< MDL	< MDL	< MDL	< MDL	< MDL
Duckweed	< MDL	< MDL	< MDL	< MDL	< MDL
Sediment	< MDL	< MDL	< MDL	0.01	< MDL
Sediment	0.07	0.05*	< MDL	0.50	0.06
Sediment	< MDL	< MDL	< MDL	0.03	< MDL
Sediment	< MDL	< MDL	< MDL	0.07	0.02
Forge Pond					
Lily Pad	< MDL	3.55	4.71	< MDL	< MDL
Sediment	< MDL	0.002*	< MDL	< MDL	< MDL
Water (mg/L)	< MDL	< MDL	< MDL	< MDL	< MDL
Swan Pond					
Lily Pad	< MDL	< MDL	3.15	< MDL	< MDL
Sediment	0.15	0.17	< MDL	< MDL	< MDL
Water (mg/L)	< MDL	0.01	< MDL	< MDL	< MDL
Donahue's Pond					
Lily Pad	< MDL	< MDL	< MDL	< MDL	< MDL
Sediment	0.002	0.003	0.002	< MDL	< MDL
Water (mg/L)	< MDL	0.02	0.09	< MDL	< MDL
Lower Lake, Carmans River (a)					
Lily Pad	< MDL	< MDL	< MDL	< MDL	< MDL
Sediment	< MDL	< MDL	< MDL	< MDL	< MDL
Water (mg/L)	< MDL	< MDL	0.05	< MDL	< MDL

Notes:
Water values are reported in mg/L.
See Figure 5-8 for sampling stations.
MDL = Minimum Detection Limit
* Estimated value based on laboratory qualifiers.
(a) Carmans River Control Location

ment in the on-site portion of the Peconic River is co-located with mercury-containing sediments and is scheduled for cleanup actions in 2004.

6.3.6 Vegetation Sampling

6.3.6.1 Garden Vegetables

On-site sampling of garden vegetables continued in 2003. Samples of zucchini, cucumber, tomato, pepper, eggplant, and sweet corn were analyzed for Cs-137 content. None of the samples analyzed contained Cs-137. Sampling of off-site farm vegetation was discontinued in 2003 because historic data 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.

6.3.6.2 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 contaminants had been released and deposited on soil and vegetation. Periodic confirmatory sampling of grassy vegetation will be conducted approximately every 5 years.

Table 6-12. Semivolatile Organic Compound Analyses of New Basin Sediments from Sampling Station HN-NS.

Basin	HN-NS	HN-NS	HN-NS	HN-NS-1	HN-NS-1	HN-NS-1
Depth	0"– 2"	2"– 4"	4"– 6"	0"– 2"	2"– 4"	4"– 6"
	(mg/kg)			(mg/kg)		
2-Methylnaphthalene	<MDL	<MDL	<MDL	1.4	<MDL	<MDL
Acenaphthylene	<MDL	0.087*	<MDL	0.83	<MDL	<MDL
Anthracene	<MDL	0.042*	<MDL	0.1*	<MDL	<MDL
Benzo(a)anthracene	<MDL	<MDL	<MDL	0.3*	<MDL	<MDL
Benzo(a)pyrene	<MDL	<MDL	<MDL	0.3*	<MDL	<MDL
Benzo(ghi)perylene	<MDL	<MDL	<MDL	0.1*	<MDL	<MDL
Bis(2-ethylhexyl)phthalate	0.05*	<MDL	<MDL	<MDL	<MDL	<MDL
Chrysene	<MDL	<MDL	<MDL	0.2*	<MDL	<MDL
Fluoranthene	<MDL	<MDL	<MDL	0.41	<MDL	<MDL
Fluorene	<MDL	<MDL	<MDL	0.2*	<MDL	<MDL
Indeno(1,2,3-cd)pyrene	<MDL	0.11*	<MDL	<MDL	<MDL	<MDL
Naphthalene	<MDL	<MDL	<MDL	5.4	<MDL	<MDL
Phenanthrene	<MDL	<MDL	<MDL	0.55	<MDL	<MDL
Pyrene	<MDL	<MDL	<MDL	0.67	<MDL	<MDL

Notes:
MDL = Minimum Detection Limit
* Values that are below the contracted detection limit, but above the instrument detection limit.
Only basins and depths with detections above the minimum detection limit are provided in table format.
See Figure 5-8 for sampling stations.

6.4 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 periodically.

6.5 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 basin locations). A new basin, HN-NS, was added to the group of recharge basins in the southern end of the area near the Relativistic Heavy Ion Collider (RHIC), to manage stormwater runoff from the Alternating Gradient Synchrotron (AGS) complex. Soil samples are taken to a depth of 6 inches and split into 2-inch increments. Samples under HN-NS headings in the associated tables were taken in February 2003 in different areas of the basin; samples under HN-NS-1 were taken during May 2003. No PCBs or pesticides were detected in any of the samples taken at basin HN-NS.

6.5.1 Chemical Analysis

Table 6-12 presents the results of analyses for semivolatile organic compounds (SVOCs) in basin sediments. Only chemicals that were detected are presented in the table. Most values in the table are estimated, meaning that the chemical was detected but the value was below the contracted MDL but above the instrument's MDL. Most of the chemicals detected were found within the top 2 inches of sediments taken during the May sampling period. The chemicals are typical components of diesel fuel. There was a diesel fuel spill from construction equipment in April 2003, near the outfall associated with the HN-NS basin. Rainy weather contributed to the spill reaching the recharge basin.

Table 6-13. Metals Analyses of New Basin Sediments from Sampling Station HN-NS.

Basin	HN-NS	HN-NS	HN-NS	HN-NS-1	HN-NS-1	HN-NS-1
Depth	0" – 2"	2" – 4"	4" – 6"	0" – 2"	2" – 4"	4" – 6"
	(mg/kg)			(mg/kg)		
Aluminum	1900	1550	1980	4770	6950	10300
Antimony	0.69	0.53	0.67	< MDL	< MDL	< MDL
Arsenic	< MDL	0.88	< MDL	0.99	1.6	1.2
Barium	5.9	4.2	6	12.5	16.5	28.7
Beryllium	0.05	< MDL	0.052	0.2	0.29	0.48
Calcium	164	118	183	130	117	119
Chromium	2.9	3.7	3.5	7.7	10.8	17.3
Cobalt	1	0.72	1.1	2.7	4	5.7
Copper	6.6	4.4	4.6	5.6	7.2	10.8
Iron	2550	2780	2780	5550	8740	12900
Lead	2.4	1.6	2	3.3	4.8	6.4
Magnesium	383	266	396	1090	1470	2990
Manganese	26.2	20.6	27.7	63.9	85.7	128
Nickel	2.1	1.7	2.2	5	6.6	11
Potassium	131	104	162	431	542	854
Sodium	31.2	24.1	41.9	21.1	18	19.8
Vanadium	5	4.9	5.5	10.6	17.6	25.8
Zinc	16.2	12.3	11.9	26	27.1	36.8

Notes:
MDL = Minimum Detection Limit

The single detection of Bis(2-ethylhexyl) phthalate is likely a result of the chemical leaching from the sample container during transport to the laboratory. Phthalates are commonly used as plasticizers and the sample container was made of plastic.

6.5.2 Metals

Table 6-13 presents the baseline results of metals analysis on basin HN-NS sediments. Only metals that were detected are presented. Cadmium, mercury, selenium, silver, and thallium were not detected. Most of the metals are within the range of typical soils found on the Laboratory site. Aluminum and magnesium are higher in the HN-NS basin, because they are components of local clay and there is high clay content in this basin's sediments.

6.5.3 Radiological Analysis

Basin HN-NS sediments were sampled and analyzed for gamma-emitting radionuclides. The results of this sampling and analysis are presented in Table 6-14. All of the radionuclides presented are naturally occurring and are seen at similar levels in soil samples and from other basins on site.

6.6 CHRONIC TOXICITY TESTS, SEWAGE TREATMENT PLANT

Under the SPDES discharge permit, BNL conducted chronic toxicity testing for the Sewage Treatment Plant effluent. Two species were evaluated—the fathead minnow (*Pimephales promelas*) and the water flea (*Ceriodaphnia dubia*). Results from this testing program are presented in Chapter 3, Section 3.6.1.1.

Table 6-14. Radiological Analysis of Basin HN-NS Sediments .

Basin	Sample Depth	Potassium-40	Thallium-208	Lead-212	Lead-214	Actinium-228	Thorium-232
		pCi/g					
HN-NS	0”-2”	3.88 ± 0.73	0.15 ± 0.04	0.51 ± 0.08	0.35 ± 1.16	0.48 ± 0.09	0.62 ± 0.23
HN-NS	2”-4”	3.76 ± 0.72	0.16 ± 0.04	0.39 ± 0.07	0.18 ± 0.09	0.42 ± 0.08	0.42 ± 0.18
HN-NS	4”-6”	1.93 ± 0.94	0.11 ± 0.08	0.20 ± 1.42	ND	0.29 ± 0.25	ND
HN-NS-1	0”-2”	8.14 ± 0.14	0.21 ± 0.04	0.68 ± 0.10	0.53 ± 0.07	0.65 ± 0.09	0.55 ± 0.22
HN-NS-1	2”-4”	9.83 ± 1.64	0.23 ± 0.05	0.69 ± 1.03	0.49 ± 1.11	0.62 ± 0.09	0.67 ± 0.26
HN-NS-1	4”-6”	13.10 ± 2.13	0.27 ± 0.05	0.86 ± 1.30	0.64 ± 1.32	0.85 ± 0.11	0.93 ± 0.31

Notes:
ND = not detected
All values are shown with a 95% confidence interval.

6.7 PRECIPITATION MONITORING

As part of the BNL Environmental Monitoring Program, precipitation samples were collected approximately quarterly at air monitoring Stations P4 and S5 (see Figure 4-4 for station locations), and were analyzed for radiological content. Four samples were taken from each of these two stations in 2003. Gross alpha activity measurements above the MDL were found in each quarterly sample taken at Station S5 and in the January sample taken at Station P4. The samples from the P4 location showed a maximum of 0.9 pCi/L activity, whereas the samples from the S5 location had a maximum activity level of 5.95 pCi/L. Both of these values are within the range of historic values reported for gross alpha activity and are considered to be background.

Gross beta activity was measured in all samples at each of the sampling locations, except for the April samples. 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 3.87 pCi/L, with an average of 2.84 pCi/L. Location S5 had a maximum of 8.47 pCi/L, with the average activity of 4.16 pCi/L. Gross beta activity values were within the range of values historically observed at these two locations. Tritium was detected in the October sample taken at S5: 446 pCi/L, which is well below the drinking water limit of 20,000 pCi/L. Gamma analysis of samples showed the presence of beryllium-7 at a maximum of 50.3 pCi/L at Station S5 in October and 54 pCi/L in July at Station P4. Beryllium-7 is a naturally occurring radionuclide resulting from solar flare activity. Lead-212 and Thallium-208 were detected in the July sample from Station P4, at 5.69 pCi/L and 1.85 pCi/L, respectively. These two naturally occurring radionuclides are found in soil and are likely due to dust in the samples.

6.8 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 2003, the Environmental and Waste Management Services Division (EWMSD) hosted four student interns and a high school volunteer during the summer. Two interns from the Community College of Rhode Island and University of Rhode Island worked on identification and distribution of dragonflies and damselflies (Order Odonata). 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 are expected to supplement

a planned statewide survey of these insects in the near future. As discussed in Section 6.1.2.1, a third intern, from the University of Massachusetts, continued working on tiger salamander research that has been an ongoing project at BNL.

The fourth intern, from the State University of New York Environmental Sciences and Forestry College, began mapping invasive plant species found at BNL. This important effort is one of the first steps toward understanding the management requirements for controlling invasive plants. The mapping effort relied on the use of a Global Positioning System (GPS) and GIS to accurately build a mapping layer. Comparison of the invasive plant layer to other vegetation and physical layers will assist BNL in making management decisions for the control of invasives. The mapping project is being continued through a new volunteer group called the BNL Weed Watchers.

A high school volunteer from the Longwood school district near BNL assisted with collection and identification of turtles and other reptile and amphibian species on site. This effort substantially increased the knowledge of where various species of reptiles and amphibians are located.

Additional research involving the interns and Upton Reserve biologists added to the list of known species present at BNL. Much of the work was featured in a year-long news series published by *Newsday*, titled "Long Island, Our Natural World." Feature articles discussed the finding and tracking of the eastern hognosed snake, damselflies and dragonflies, invasive species, the use of fire for controlling the orange-striped oakmoth, issues with white-tailed deer, explosive breeding of eastern spade-foot toads, and the identification of other species that have not been reported on Long Island for several years.

In addition to hosting interns, 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 and provided activities to educate Laboratory employees and the general public on the environment and conservation during a Summer Sunday event in July. In October, BNL hosted the Eighth 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.

6.9 CULTURAL RESOURCE ACTIVITIES

The BNL Cultural Resource Management (CRM) Program is being developed to ensure that the Laboratory fully complies with numerous federal and state cultural resource requirements. BNL submitted a draft Cultural Resources Management Plan to DOE in December 2003 (BNL 2003c). Development of a formal Cultural Resources Management Plan will guide the management of all of BNL's cultural resources. Along with achieving compliance with applicable regulations, one of the major goals of the CRM Program is to fully assess both known and potential cultural resources. The potential range of BNL cultural resources includes buildings and structures, WWI earthwork features, the Camp Upton Historical Collection, scientific equipment, photo archives, and institutional records. As various cultural resources are identified, plans for their long-term stewardship will be developed and implemented. Achieving these goals will ensure that the contributions BNL and the BNL site have made to our history and culture are documented and available for interpretation.

BNL has three structures or sites that have been determined to be eligible for listing on the National Register of Historic Places: the Brookhaven Graphite Research Reactor (BGRR) complex, the High Flux Beam Reactor (HFBR) complex, and the World War I training trenches associated with Camp Upton.

Figure 6-6 is a photograph from WWI Camp Upton showing a trench warfare training area as it appeared circa 1918. Figure 6-7 is a recent photograph depicting how the trenches appear approximately 85 years later. The BNL trenches

may be the only surviving examples of World War I earthworks in the United States.

In 2003, BNL produced geo-referenced digital overlay maps depicting the World War I and World War II Camp Upton maps (including camp buildings, roads, etc.) overlying the present day BNL site map. These maps are useful tools that clearly demonstrate the extent of the two Army camps compared to BNL's current developed facilities. Figure 6-8 shows the World War I Camp Upton map (circa 1918) superimposed over the RHIC Ring Road and a few of BNL's existing structures, including Berkner Hall; the Medical, Biology, and Chemistry buildings; the National Synchrotron Light Source (NSLS); the HFBR; the BGRR; and Buildings 902, 912, 913, and 475.

A BGRR History Video was completed and submitted to the New York State Historic Preservation Officer in October 2003. Completing this project satisfies another major milestone in the "Memorandum of Agreement

Figure 6-6. WWI Training Trench at Camp Upton, Circa 1918.

Figure 6-7. WWI Training Trench As It Appears on the BNL Site Today.

Figure 6-8. WWI Camp Upton Map Superimposed Over Current Laboratory Site.

Figure 6-9. Brookhaven Graphite Research Reactor (BGRR).

(MOA) for the Mitigation of the BGRR Decommissioning" (Desmarais 2000). The video presents a history of the BGRR through the recollections of key individuals who contributed to its success as a premier research tool throughout its 18-year operating history, (1950–1968) (see Figure 6-9). Physicists, engineers, and scientists describe the challenges and rewards of their accomplishments, along with the experiences of everyday life associated with the BGRR. The film's narrator guides viewers through the design, construction, operation, scientific research, and shutdown of America's first nuclear reactor designed for peacetime civilian applications.

Additional projects in 2003, performed by outside contractors, included identifying and developing draft regulatory compliance processes, and formally evaluating archeological survey requirements for the BNL site.

Chapter 3, Section 3.4, Historic Preservation and Archeology, identifies additional cultural resource compliance accomplishments performed in 2003. The overall goal of the Cultural Resource Management program is to establish processes that ensure proper stewardship over the historic resources of the BNL site.

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7

Groundwater Protection

The Brookhaven National Laboratory Groundwater Protection Management Program is made up of four elements: prevention, monitoring, restoration, and communication. BNL has implemented aggressive pollution prevention measures to protect groundwater resources. BNL's extensive groundwater monitoring well network is used to verify that prevention and restoration activities on site are effective. In 2003, BNL collected groundwater samples from 754 monitoring wells during 2,810 individual sampling events. Seven groundwater remediation systems removed 510 pounds of volatile organic compounds and returned approximately 1.3 billion gallons of treated water to the Upper Glacial Aquifer. Since the beginning of active groundwater remediation in December 1996, BNL has removed 4,156 pounds of volatile organic compounds by treating nearly 6.8 billion 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 cost-effective manner that is consistent with federal, state, and local regulations. BNL's program helps to fulfill the environmental monitoring requirements outlined in U.S. Department of Energy Order 450.1, Environmental Protection Program. This program is described in the BNL Groundwater Protection Management Program Description document (Paquette et al. 2002). The BNL Groundwater Protection 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 interested parties on groundwater protection issues. BNL is committed to protecting groundwater resources from further chemical and radionuclide releases, and to remediating existing contaminated groundwater.

7.1.1 Prevention

BNL has conducted a three-phased project to prevent further groundwater contamination from ongoing operations. The first phase, completed in 1998-2000, was to identify past or current activities with the potential to affect groundwater quality. This effort resulted in the implementation of operational and engineered controls at potential source areas and the installation of 85 new monitoring wells to confirm that these controls are working. The second phase, completed in May 2000, resulted in a Laboratory-wide review of all experiments and industrial-type operations to determine the potential impacts of those activities on the environment and to integrate pollution prevention and waste minimization, resource conservation, and compliance into planning, decision making, and implementation. Finally, phase three was to develop and implement an Environmental Management System (EMS), which was finalized when BNL received ISO 14001 certification in 2001. The continuous improvement aspects of the EMS and ongoing reviews are designed to prevent further pollution of the sole source aquifer underlying the BNL site and are described in Chapter 2. In addition, as described in Chapter 3, efforts are

being made to achieve or maintain compliance with regulatory requirements and to implement best management practices designed to protect groundwater. Examples include upgrading underground storage tanks (USTs), closing cesspools, adding engineered controls (e.g., barriers to prevent rainwater infiltration that could move contaminants out of the soil and into groundwater), and administrative controls (e.g., reducing the toxicity and volume of chemicals in use or storage).

7.1.2 Monitoring

BNL's groundwater monitoring network is designed to evaluate the impacts of groundwater contamination from former and current operations and to track cleanup progress (Table 7-1). Groundwater monitoring is a means of verifying that protection and restoration efforts are working. Groundwater monitoring is focused in 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 (CERCLA). 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.

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 (AOC) were grouped into six Operable Units (OU). Remedial Investigation/Feasibility Studies have been conducted for each OU, and the focus is now on designing and implementing cleanup systems. Contaminant sources (e.g., contaminated soil, USTs) are being removed or remediated to prevent further contamination of groundwater. All remediation work is carried out under the 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 the community 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 the Community Advisory Council (CAC) and the Brookhaven Executive Roundtable. Technical reports that summarize data, evaluations, and program indices are prepared annually. In addition, BNL 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 in a timely manner.

7.2 GROUNDWATER PROTECTION PERFORMANCE

Since 1998, the BNL Groundwater Protection Management Program has been tracking progress toward preventing new contamination of the aquifer system. The Laboratory has made significant investments in environmental and groundwater protection, and is making real progress in achieving its goal of preventing any new groundwater impacts. A "new" groundwater impact is defined as the detection 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 as a result of 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 (Figure 7-1). No impacts were identified during 2002 or 2003. It is important to note that five of the 10 identified impacts were determined to be from historical (or "legacy") contaminant releases. These legacy issues include low-level petroleum hydrocarbon contamination in groundwater near the Upton Service Station, tritium near the Former U-Line target and beam stop area at the Alternating Gradient Synchrotron (AGS), 1,1,1-trichloroethane (TCA) near Building 830 and the BNL Motor Pool, and higher than expected strontium-90 (Sr-90) groundwater contamination at the Brookhaven Graphite Research Reactor (BGRR).

The five remaining cases were related to active science operations and environmental protection activities. Three small tritium plumes that originated from active experimental areas at the AGS (the g-2 and E-20 Catcher areas) and the Brookhaven Linac Isotope Producer (BLIP) facility were discovered in 1998 and 1999. Activities associated with the Laboratory's environmental protection programs resulted in two new groundwater impacts. One impact was the inadvertent release of carbon tetrachloride during the removal of a UST, and the second was caused by an unexpected displacement of tritium during an innovative grout injection process designed to protect groundwater quality by stabilizing activated soil at the BLIP facility. In all ten cases, BNL thoroughly investigated the cause of the contamination and took corrective actions as necessary to eliminate or limit the scale of these impacts. BNL will continue efforts to prevent new groundwater impacts, and is vigilant in measuring and communicating its performance.

Table 7-1. Summary of BNL Groundwater Monitoring Program, 2003.

	Restoration	Environmental Surveillance
Number of wells monitored	629	125
Number of sampling events	2,510	300
Number of analyses performed	5,504	552
Number of results	106,000	6,400
Percent of non-detectable analyses	68	95
Number of new wells installed[(a)]	40	0
Number of wells abandoned	9	0

[(a)]Permanent wells only. Single-use temporary wells used for characterization, not included.

7.3 GROUNDWATER MONITORING

Groundwater monitoring program elements include installing monitoring wells; planning and scheduling; developing and following quality assurance measures; 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 BNL site.

BNL monitors research and support facilities where there is a potential for environmental impact and areas where past waste handling practices or accidental spills have already degraded groundwater quality. The groundwater beneath the BNL 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 New York State and DOE reference levels and background water quality levels. Nonradiological analytical results from groundwater samples collected from surveillance wells are usually compared to NYS AWQS. Radiological data are compared to NYS DWS (for tritium, gross beta, and Sr-90), NYS AWQS (for gross alpha and radium-226/228),

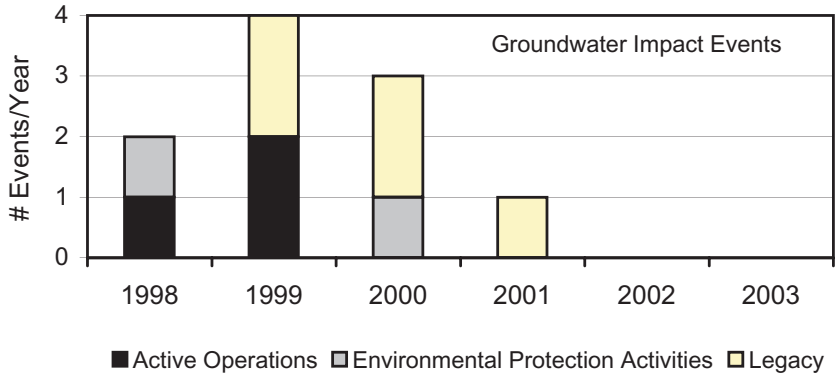

Figure 7-1. Groundwater Protection Performance, 1998 – 2003.

and Safe Drinking Water Act (SDWA)/DOE Derived Concentration Guides (for determining the 4-mrem dose for other beta/gamma-emitting radionuclides). Contaminant concentrations that are below these 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 780 on and off-site surveillance wells (see Figure 7-2). In addition to water quality assessments, water levels are routinely measured in more than 875 on- and off-site wells to assess variations in directions and velocities of groundwater flow. Groundwater flow directions in the vicinity of BNL are shown in Figure 7-3.

Among the active and inactive facilities that have groundwater monitoring programs are the Sewage Treatment Plant (STP) and Peconic River area, Biology Agricultural Fields, Former Waste Management Facility (FWMF), new Waste Management Facility (WMF), two former landfill areas, Central Steam Facility (CSF) and Major Petroleum Facility (MPF), AGS, Waste Concentration Facility (WCF), Supply and Material, and several other smaller facilities. As the result of detailed groundwater investigations conducted over the past 15 years, six significant VOC plumes and eight radionuclide plumes have been identified (Figures 7-4 and 7-5).

7.4 SUPPLEMENTAL MONITORING OF POTABLE AND PROCESS 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 the site. The BNL network of potable and cooling water supply wells consists of six 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 on fish is conducted. This well is not routinely monitored. The locations of the supply wells are shown in Figure 7-3.

The quality of the BNL potable water supply is monitored as required by the SDWA, and the analytical results are reported to the Suffolk County Department of Health Services (SCDHS). As required by the SDWA, BNL 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, BNL conducts a supplemental potable supply well monitoring program. Supplemental monitoring of the potable and process supply wells in 2003 included testing for VOCs, anions, metals, and radiological parameters. During 2003, the BNL potable water system fully complied with all

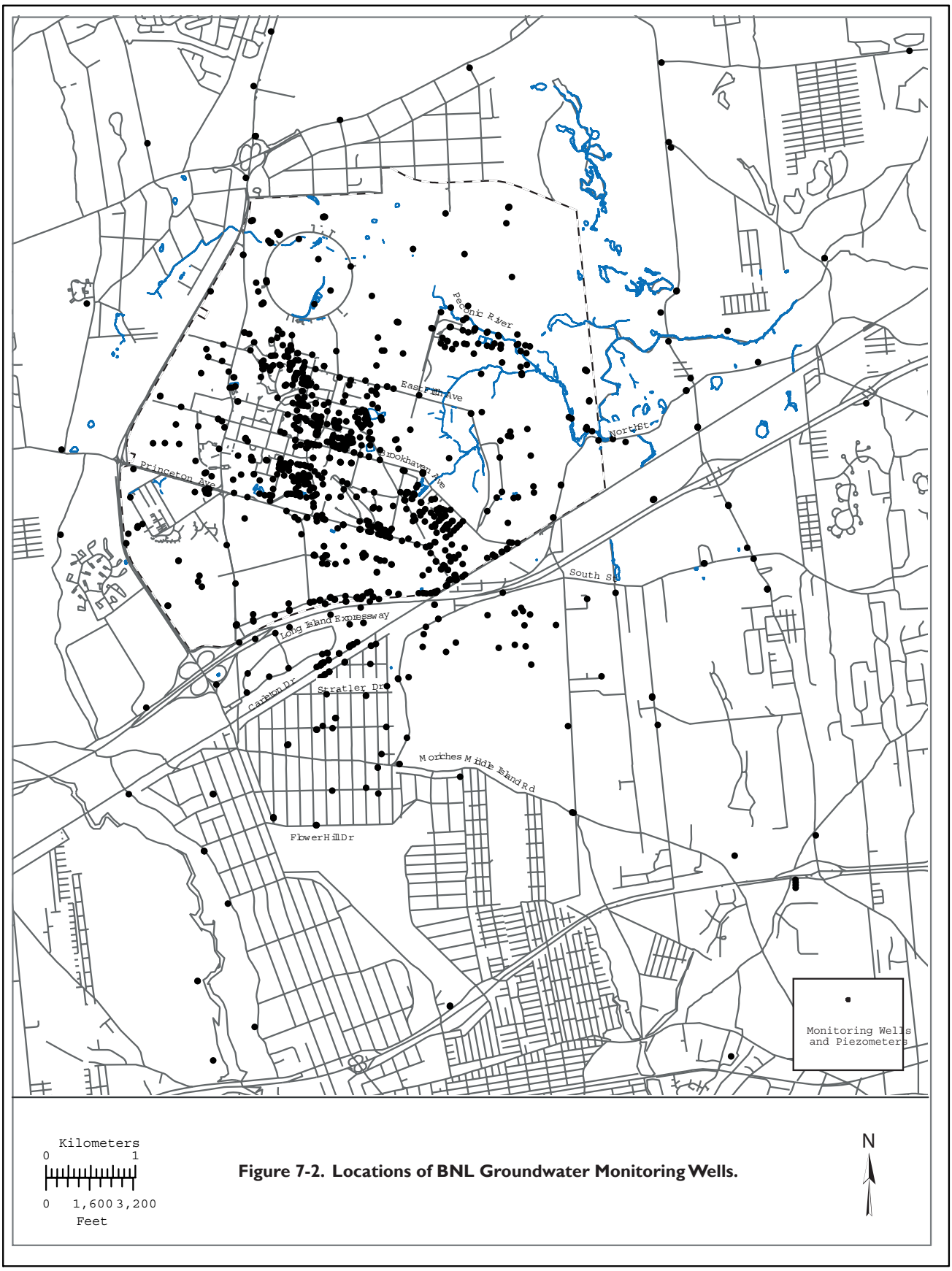

Figure 7-2. Locations of BNL Groundwater Monitoring Wells.

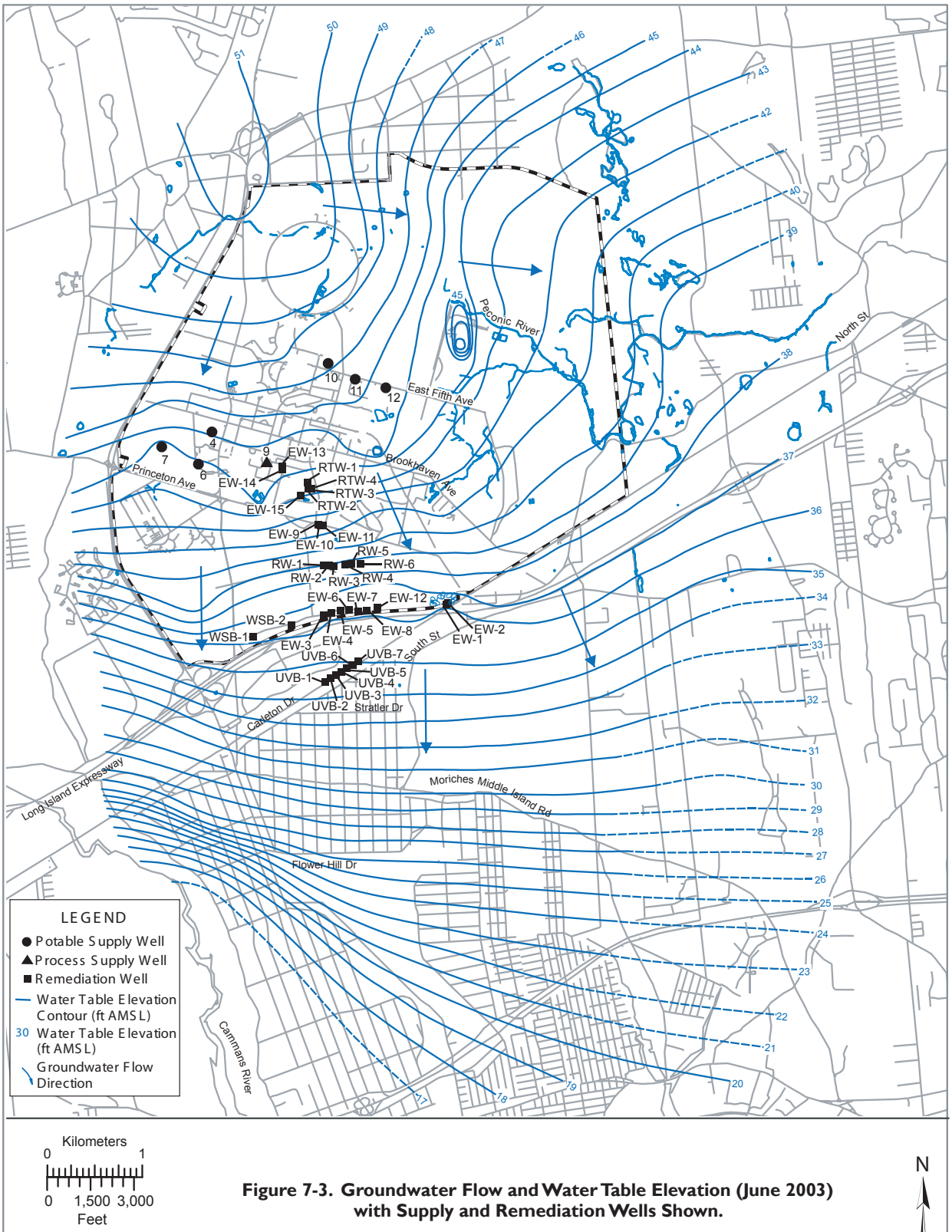

Figure 7-3. Groundwater Flow and Water Table Elevation (June 2003) with Supply and Remediation Wells Shown.

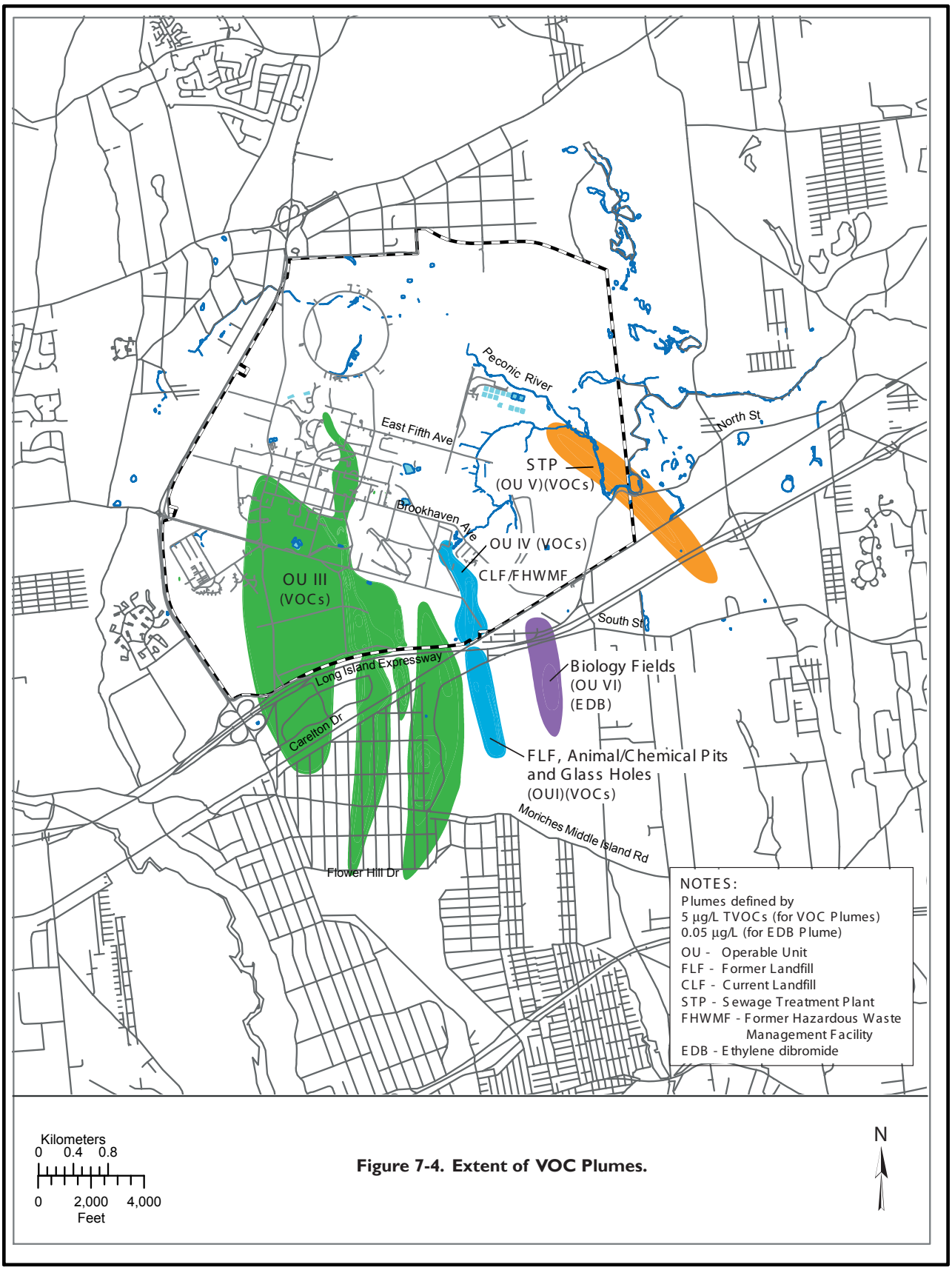

Figure 7-4. Extent of VOC Plumes.

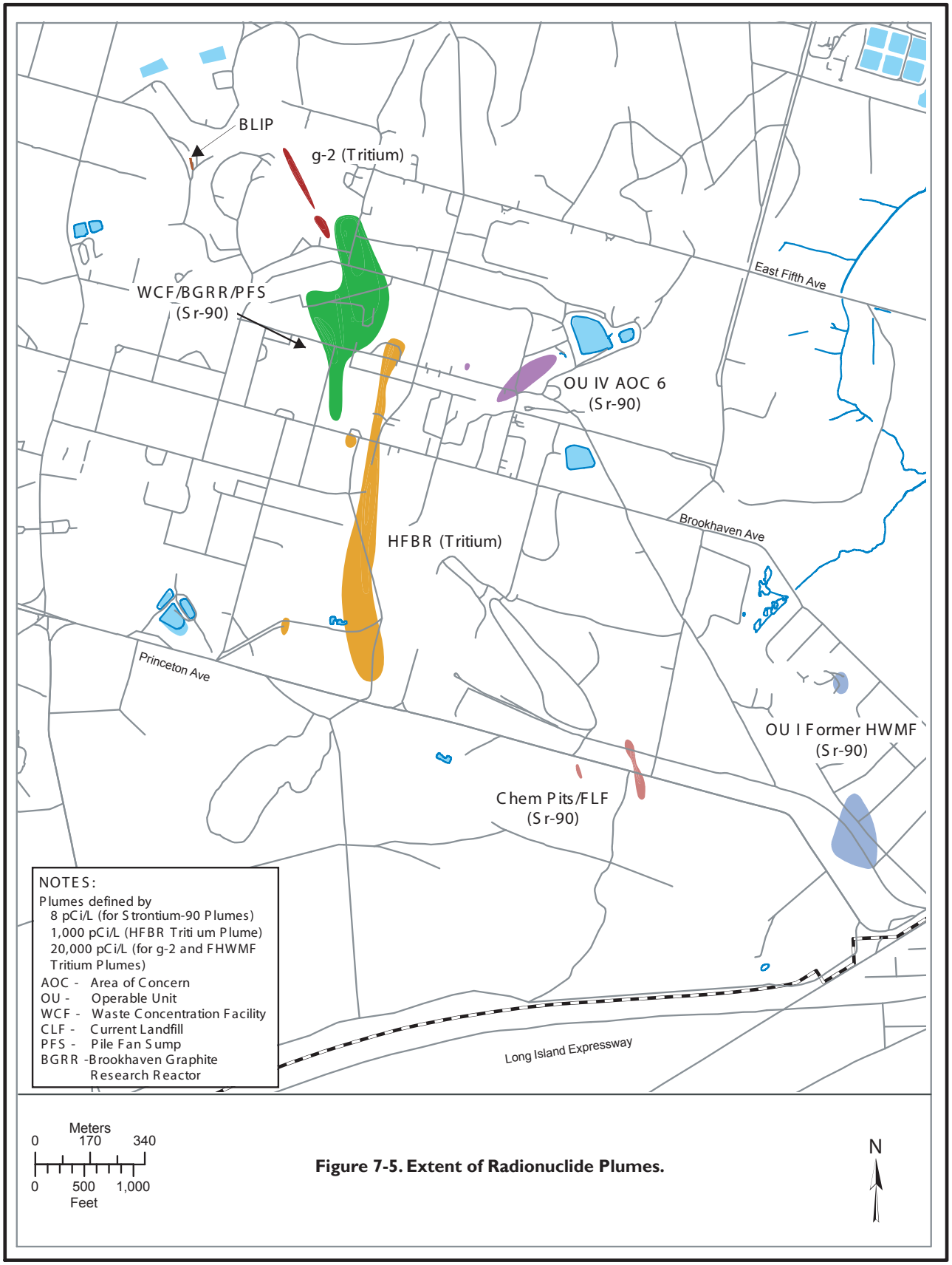

Figure 7-5. Extent of Radionuclide Plumes.

Table 7-2. Potable Well Radiological Analytical Results.

Potable Well ID		Gross Alpha	Gross Beta	Tritium	Sr-90
		(pCi/L)			
Well 4	Samples	4	4	4	4
	Max.	2.62 ± 0.64	3.92 ± 1.02	< 280	< 0.44
	Avg.	0.96 ± 1.14	0.76 ± 2.32	2 ± 172	0.04 ± 0.19
Well 6	Samples	4	4	4	4
	Max.	2.11 ± 0.61	2.70 ± 1.11	< 337	< 0.49
	Avg.	0.97 ± 0.76	0.77 ± 1.56	9 ± 146	0.12 ± 0.18
Well 7	Samples	4	4	4	4
	Max.	2.08 ± 0.61	< 1.69	< 280	< 0.61
	Avg.	1.03 ± 1.01	0.73 ± 0.32	14 ± 134	0.05 ± 0.23
Well 11	Samples	4	4	13	4
	Max.	1.31 ± 0.45	< 1.62	< 273	< 0.48
	Avg.	0.61 ± 0.56	0.13 ± 0.89	63 ± 47	0.23 ± 0.11
Well 12	Samples	5	5	14	4
	Max.	2.16 ± 0.58	2.67 ± 0.96	< 282	< 0.57
	Avg.	0.80 ± 0.80	1.14 ± 1.39	74 ± 62	0.21 ± 0.10
Tap Water(a)	Samples	246	246	246	NS
Control Samples	Max.	8.14 ± 2.96	14.61 ± 4.28	366 ± 209	
Building 490 (FN)	Avg.	3.33 ± 0.19	4.79 ± 0.33	25 ± 16	
SDWA Limit (pCi/L)		15 (b)	50 (c)	20,000	8

Notes:
See Figure 7-3 for well locations.
All values shown with 95% confidence interval.
No anthropogenic gamma-emitting radionuclides were detected in samples collected from these wells in 2003.
Potable Well #10 was shut down most of the year due to its possible effect on groundwater flow directions in the vicinity of the g-2 Tritium Plume.
NS = Not Sampled for this analyte
(a) The gross activity values for Building 490 tap water (FN sample point) are elevated compared with the potable well samples, due to differences in the analytical procedure (i.e., smaller sample volumes and shorter counting times) used to obtain the activity values.
(b) Excluding radon and uranium.
(c) Screening level above which analysis for individual radionuclides is required.

primary drinking water requirements. To better understand the geographical source of BNL's drinking water and to identify potential sources of contamination within these geographical areas, BNL prepared the report titled Source Water Assessment for Drinking Water Supply Wells (Bennett et al. 2000). In 2003, the NYS Department of Health 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 2003, samples were typically collected quarterly from supply wells 4, 6, 7, 11, and 12, and were analyzed for gross alpha and gross beta activity, tritium, and Sr-90. Because of the detection of low levels of tritium in a WMF monitoring well, nearby supply wells 11 and 12 were tested for tritium on a more frequent basis (see Section 7.5.2.5). The analytical results are listed in Table 7-2. (Note: Well 10 was used infrequently during 2003, and was only sampled under the compliance monitoring program described in Chapter 3.) In addition, tap water

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

Potable Well ID		Chlorides	Sulfates	Nitrate as N
		mg/L		
	N	1	1	1
Well 4	Value	25	11.4	< 1.0
Well 6	N	1	1	1
	Value	20.2	11.1	< 1.0
Well 7	N	1	1	1
	Value	21.9	12.6	< 1.0
Well 10 (a)	N	NS	NS	NS
	Value			
Well 11	N	1	1	1
	Value	17.2	13.3	< 1.0
Well 12	N	1	1	1
	Value	16.3	13.6	< 1.0
NYSDWS		250	250	10
Typical MDL		4	4	1

Notes:
See Figure 7-3 for location of wells.
N = Number of samples
NYSDWS=New York State Drinking Water Standard
MDL = Minimum Detection Limit
NS = Not Sampled for this analyte
(a) Well was shut down at time of annual sampling for anions.

samples were collected daily from Building 490 and the BNL Analytical Services Laboratory (ASL), and analyzed for gross alpha and beta activity and tritium. Nuclide-specific gamma spectroscopy was also performed for potable well samples, supplementing the requirements of SDWA, which does not require this analysis unless gross beta activity exceeds 50 pCi/L. Average gross activity and tritium levels in the potable water wells were consistent with those of typical background water samples. Neither Sr-90 nor any other man-made gamma-emitting radionuclides were observed above the minimum detection limit (MDL) in any of the potable 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 additional VOC samples from active supply wells during the year. These samples were analyzed for VOCs following either EPA Standard Method 524 or 624. Trace levels (typically <2 µg/L) of chloroform were routinely detected in samples from most wells, with a maximum concentration of 8.4 µg/L. The DWS for chloroform is 80 µg/L. Low levels of several other VOCs (e.g., TCA, bromodichloromethane, and dibromochloromethane) were occasionally detected, but at concentrations well below applicable DWS. Samples were also collected and analyzed for metals and anions one time during the year from wells 4, 6, 7, 11, and 12 (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. Iron levels in wells 6 and 7 were 3.56 and 2.01 mg/L, respectively. Because naturally high levels of iron are present in some portions of the Upper Glacial Aquifer on the western side of the BNL site, water obtained from wells 4, 6, and 7 is treated at the BNL Water Treatment Plant to reduce the iron levels before distribution.

7.5 ENVIRONMENTAL SURVEILLANCE PROGRAM

BNL's ES Program includes groundwater monitoring at active research facilities (e.g., accelerator beam stop and target areas) and support facilities (e.g., fuel storage facilities). During 2003, 125 groundwater surveillance wells were monitored during approximately 300 individual sampling events. Results for these programs are summarized in this section. Detailed descriptions and maps related to groundwater monitoring in the ES Monitoring Program can be found in the 2003 BNL Groundwater Status Report (BNL 2004c).

7.5.1 Research Facilities

7.5.1.1 Alternating Gradient Synchrotron Complex

Activated soils have been created near a number of AGS experimental areas as the result of secondary particles (primarily neutrons) produced at beam targets and beam stops. Radionuclides, such as tritium and sodium-22 (Na-22), have been produced by the interaction of these secondary particles with the soils that surround the experimental areas. Furthermore,

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

Well ID		Ag µg/L	Al µg/L	As µg/L	Ba µg/L	Be µg/L	Cd µg/L	Co µg/L	Cr µg/L	Cu µg/L	Fe mg/L	Hg µg/L	Mn µg/L	Mo µg/L	Na mg/L	Ni µg/L	Pb µg/L	Sb µg/L	Se µg/L	Tl µg/L	V µg/L	Zn µg/L
Well 4	N	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Value	< 1.0	< 2.2	< 3.0	25.9	< 0.66	< 1.1	0.5	< 1.0	26.4	1.43	< 0.1	129	< 5.0	16.8	< 1.1	2.0	< 0.88	< 5.0	< 0.66	< 5.5	10.4
Well 6	N	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Value	< 1.0	< 2.2	< 3.0	25.4	< 0.66	< 1.1	1.0	1.5	15.3	3.56	< 0.1	124	< 5.0	14.9	7.0	< 1.32	< 0.88	< 5.0	< 0.66	< 5.5	12.0
Well 7	N	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Value	< 1.0	< 2.2	< 3.0	19.7	< 0.66	< 1.1	0.7	1.0	3.1	2.01	< 0.1	61.8	< 5.0	14.9	1.6	< 1.3	< 0.88	< 5.0	< 0.66	< 5.5	< 4.0
Well 10(a)	N	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Value																					
Well 11	N	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Value	< 1.0	< 2.2	< 3.0	27.0	< 0.66	< 1.1	< 0.12	1.1	5.7	< 0.08	< 0.1	< 2.0	< 5.0	14.9	< 1.1	< 1.32	< 0.88	< 5.0	< 0.66	< 5.5	< 4.0
Well 12	N	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Value	< 1.0	< 2.2	< 3.0	22.9	< 0.66	< 1.1	< 0.12	< 1.0	6.1	< 0.08	< 0.1	< 2.0	< 5.0	13.1	< 1.1	< 1.32	< 0.88	< 5.0	< 0.66	< 5.5	< 4.0
NYSDWS		100	SNS	50	2000	4	5	SNS	100	1300	0.3	2	300	SNS	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	2.0	1.0	1.1	1.3	0.9	5.0	0.7	5.5	4.0

Notes:
See Figure 7-3 for well locations.
MDL = Minimum Detection Limit
NS = Not Sampled for this analyte
NYSDWS = New York State Drinking Water Standard
SNS = Drinking Water Standard not specified
(a)Well was shut down at time of annual sampling for metals.

historical surface spills and discharges of solvents to cesspools and recharge basins near the AGS have contaminated soil and groundwater with VOCs. VOC contamination is monitored under the ER Program's OU III Central Areas Project (see Section 7.6.3).

During 2003, 56 wells were monitored to evaluate groundwater quality near potential soil activation areas within the AGS Complex (e.g., Building 912, AGS Booster beam stop, 914 Transfer Tunnel, g-2 experimental area, E-20 Catcher, Former U-Line target area, and the new J-10 beam stop). Following the installation of 39 new wells in the AGS area during 1999–2000, BNL detected three tritium plumes (i.e., groundwater with tritium concentrations greater than the DWS of 20,000 pCi/L). These plumes originated from activated soil shielding at the g-2 experimental area, the Former U-Line area, and the E-20 Catcher region of the AGS Complex. Following these discoveries, BNL installed impermeable caps over the soil activation areas to prevent rainwater from infiltrating the soil and leaching tritium into the groundwater. Monitoring conducted since 2001 has shown that these caps have effectively reduced tritium concentrations to less than the 20,000 pCi/L DWS at the Former U-Line and Former E-20 Catcher areas. However, tritium continues to be detected at concentrations above the DWS downgradient of the g-2 facility (Figure 7-6).

g-2 Experimental Area. A groundwater investigation conducted during November and December 1999 revealed a narrow tritium plume approximately 250 to 300 feet long, with a maximum tritium concentration of 1,800,000 pCi/L and Na-22 concentration of 60 pCi/L. (Note: The DWS for Na-22 is 400 pCi/L.) The source of the contamination was determined to be activated soil shielding adjacent to the g-2 experiment's VQ-12 Magnet. In December 1999, a coated concrete cap was installed over the soil activation area to prevent rainwater infiltration and the continued leaching of radionuclides out of the soil and into the groundwater. In September 2000, the activated soil shielding and the associated tritium plume were designated as "Sub-Area of Concern 16T." During 2001 through 2003, BNL monitored the source area to evaluate the effectiveness of the cap and conducted additional characterization work to obtain the necessary plume concentration and position data required to determine whether additional corrective actions are required. Characterization efforts will continue until 2005, and a Focused Feasibility Study will be prepared in 2006.

Samples collected during 2003 from wells approximately 150 feet downgradient of the VQ-12 area indicate that tritium continues to be released to the groundwater, but at lower concentrations compared to those observed in July 2002, when a tritium concentration of 3,440,000 pCi/L was observed in well 054-07. During 2003, tritium concentrations showed a steady decline from a maximum of 1,040,000 pCi/L (well 054-07) in January to 113,000 pCi/L (well 054-185) in October. During 2003, 12 temporary Geoprobe™ wells were installed in the AGS parking lot area to characterize the leading edge of the g-2 tritium plume. The maximum observed tritium concentration was 415,000 pCi/L, which was detected in Geoprobe™ well GP-20. This well is approximately 1,000 feet from the VQ-12 source area. Figure 7-6 shows the locations of the Geoprobe™ wells and the position of the g-2 tritium plume during 2003. The two segments of the plume depicted on Figure 7-6 are representative of three distinct periods of tritium release (also referred to as slug releases). The leading segment of tritium contamination was released in 1999 before the installation of the cap over the VQ-12 area, whereas the second and third slug are related to tritium released in 2000 and 2001.

Inspections of the cap and review of its design indicate that the cap over the VQ-12 area has not failed and is properly positioned. The cap appears to be effective in preventing the infiltration of rainwater into the activated soil-shielding zone. The leading hypothesis at this time is that a natural rise in the water table may have released residual tritium from the unsaturated soil into the groundwater. It is believed that this tritium had migrated close to the water table (in the "vadose zone") before the cap was put in place in December 1999. There appears to be good correlation between high tritium

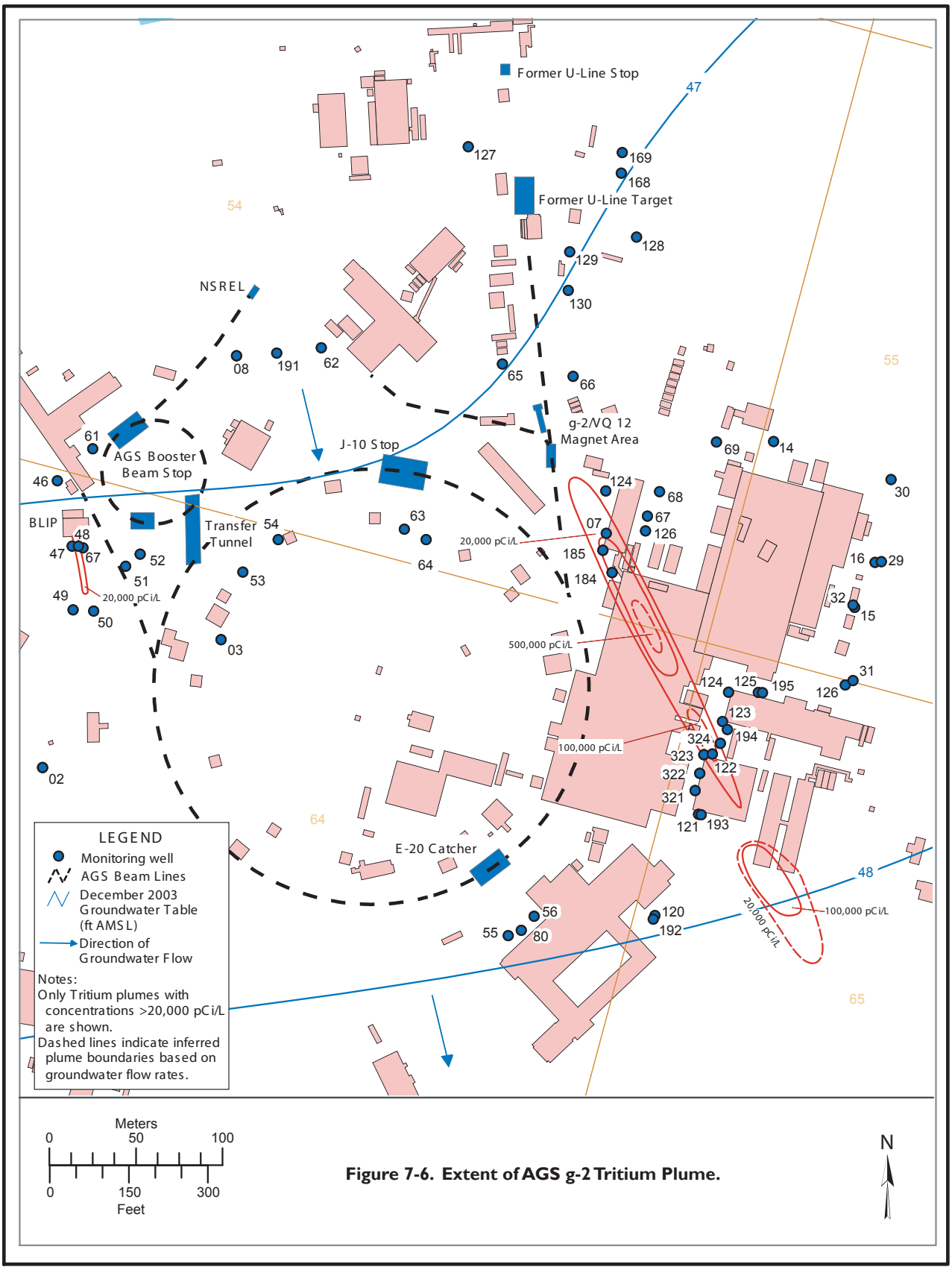

Figure 7-6. Extent of AGS g-2 Tritium Plume.

concentrations detected in monitoring wells immediately downgradient of VQ-12, and the groundwater table elevation about one year prior to the sampling. The groundwater travel time from beneath the source to the monitoring wells is about one year.

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.

Former E-20 Catcher. During 1999–2000, tritium and Na-22 were detected at concentrations above their applicable DWS in wells approximately 100 feet downgradient of the Former E-20 Catcher. The location of the Former E-20 Catcher is shown in Figure 7-6. The highest levels of tritium (40,400 pCi/L) and Na-22 (704 pCi/L) were found in temporary well 064-65. In April 2000, a temporary impermeable cap was installed over the Former E-20 Catcher soil activation area to prevent rainwater infiltration and the continued leaching of radionuclides out of the soil and into groundwater. A permanent cap was constructed by October 2000.

Following the installation of the cap in 2000, tritium and Na-22 concentrations decreased to levels well below applicable DWS. During 2003, the maximum tritium concentration was 3,430 pCi/L, detected in well 064-55. The reduction in tritium and Na-22 concentrations since the impermeable cap was constructed indicates that the cap has been effective in preventing rainwater infiltration into the activated soil.

Former U-Line Target and Beam Stop Areas. The U-Line experiment area operated from 1974 through 1986. In 1999 and 2000, BNL installed permanent and temporary monitoring wells downgradient of the Former U-Line target and beam stop areas (Figure 7-6) to evaluate whether rainwater infiltration through residual activated soil shielding was affecting groundwater quality. Although only low levels of tritium were observed downgradient of the former target area, tritium was found in concentrations up to 71,600 pCi/L downgradient of the beam stop area. Na-22 was not detected in any of the samples. In May 2000, a temporary impermeable cap was installed over the Former U-Line beam stop area, and a permanent cap was constructed by October 2000.

From 2001 through 2003, low levels of tritium continued to be detected in wells downgradient of the former target and stop areas, but at concentrations below the 20,000 pCi/L DWS. The highest tritium concentration downgradient of the Former U-Line target area was 321 pCi/L, detected in well 054-130. The highest concentration downgradient of the Former U-Line beam stop area was 577 pCi/L, detected in well 054-128.

The significant decrease in tritium concentrations since 2000 indicates that the impermeable cap has been effective in stopping rainwater infiltration into the residual activated soil surrounding the Former U-Line beam stop.

7.5.1.2 Brookhaven Linac Isotope Producer

The BLIP facility is at the southern end of the Linear Accelerator (Linac) (Figure 7-6). When the BLIP is operating, the Linac delivers a beam of protons onto a series of targets within the BLIP target vessel. During irradiation, activation of the soil immediately outside of the vessel occurs, due to the creation of secondary particles produced at the target.

In February 1998, elevated levels of tritium (52,000 pCi/L) and Na-22 (151 pCi/L) were detected in wells downgradient of the BLIP. To prevent rainwater from infiltrating the activated soil beneath the building, the BLIP building's roof drains were redirected away from the building, paved areas were resealed, and an extensive coated concrete cap was installed on three sides of the building. Groundwater monitoring data collected from January 1999 to July 2000 indicated that these corrective actions were highly effective in preventing additional release of tritium and Na-22 from the activated soil.

In June 2000, BNL took an additional protective measure by using an innovative silica grouting technique to reduce the permeability of the activated soil. Soon after the activated soil was treated with the silica grout injection process, significant increases in tritium and Na-22 concentrations were observed in groundwater samples. In early July 2000, tritium

concentrations in wells approximately 40 feet downgradient of the BLIP increased to 5,700 pCi/L. By October 2000, tritium concentrations increased to 56,500 pCi/L. In accordance with the BNL Groundwater Protection Contingency Plan (BNL 2000), BNL and DOE notified the regulatory agencies of this situation and increased the sampling frequency for the wells. An evaluation of the grouting process suggested that it displaced residual activated pore water that was in the soil near the target vessel. The maximum Na-22 concentration was 299 pCi/L in well 064-67, which is below the 400 pCi/L DWS. By December 21, 2000, tritium concentrations dropped to below the 20,000 pCi/L DWS in the wells immediately downgradient of the BLIP. During 2001–2002, tritium concentrations in wells immediately downgradient of the BLIP did not exceed the 20,000 pCi/L DWS. During 2002, the maximum tritium concentration was 15,100 pCi/L, detected in well 064-67. In January 2003, tritium concentrations once again exceeded the 20,000 pCi/L standard in wells immediately downgradient of the BLIP, with a concentration of 27,700 pCi/L detected in well 064-67. Tritium concentrations increased throughout most of the year, reaching a maximum of 42,900 pCi/L in October. Tritium concentrations declined to less than 20,000 pCi/L by November. Na-22 concentrations reached a maximum concentration of 185 pCi/L, well below the 400 pCi/L standard. Tritium concentrations in wells 150 feet downgradient of the BLIP were less than 5,000 pCi/L during the year.

A comparison of tritium concentrations to changes in water table position suggests that the 2003 increase in tritium concentrations may be correlated to a 6.5-ft increase in water table elevation that occurred between November 2002 and July 2003. As the water table rose, older tritium that was leached from the activated soil prior to capping in 1987 and released during the grout injection project may have been flushed from the soil close to the 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.

7.5.1.3 Relativistic Heavy Ion Collider

Within the Relativistic Heavy Ion Collider (RHIC) facility, there are three areas where low levels of radionuclides could be produced in the soil outside of the collider tunnel. The first area contains two beam stops at the 10 o'clock position of the ring, the second contains two collimators at the 8 o'clock region, and the third is a beam stop at the 6 o'clock position. Secondary particles created at the internal beam stop and collimator areas have the potential to activate the soil immediately surrounding those areas. Even though the predicted level of soil activation is expected to be very small, BNL installed impermeable caps over these areas as a precautionary measure. Thirteen monitoring wells are used to provide a means of verifying that the impermeable caps and the operational controls designed into the RHIC beam stops and collimators are effective in protecting groundwater quality.

Groundwater samples were collected from the 13 RHIC monitoring wells on a semi-annual schedule during 2003. Surface water samples were also collected from the Peconic River, both upstream and downstream of the beam stop area to verify that potential tritium in groundwater is not discharged to the river during high water table conditions. As in previous years, no tritium was detected in any of the groundwater or surface water samples.

7.5.1.4 Brookhaven Medical Research Reactor

During a 1997 evaluation of groundwater quality near the Brookhaven Medical Research Reactor (BMRR), low levels of tritium (up to 11,800 pCi/L) were detected in the groundwater downgradient of the reactor building. No other reactor-related radionuclides were detected in the groundwater. After inspecting the facility and reviewing historical records, BNL concluded that the tritium might have originated from past discharges of small amounts of BMRR primary cooling water to a basement floor drain and sump system that leaked. Although the last discharge of primary cooling water to the floor drain system occurred in 1987, the floor drains continued to be used for secondary (nonradioactive) cooling water until 1997. The infiltration

of this water may have promoted the movement of residual tritium from the soil surrounding the floor drain piping system to the groundwater. The floor drains were permanently sealed in 1998 to prevent any future accidental releases to underlying soil.

During 2003, tritium concentrations continued to be well below the DWS of 20,000 pCi/L. Detectable levels of tritium were observed in two downgradient wells, with a maximum value of 892 pCi/L observed in well 084-27.

7.5.1.5 Building 801

In December 2001, approximately 8,000 gallons of stormwater seeped into the basement of Building 801. Analysis of the water indicated that it contained Cs-137, Sr-90, and tritium at levels that exceeded DWS. It is believed that the water became contaminated when it came into contact with the basement floor, which contains residual contamination from historical spills. On March 8, 2002, all the remaining contaminated water (approximately 4,950 gallons) was pumped from the basement. Taking into account possible losses due to evaporation, an estimated 1,350 to 2,750 gallons of contaminated water may have leaked into the soil beneath Building 801. To evaluate the potential impact this release may have on future groundwater quality, BNL increased the monitoring frequency for three existing nearby monitoring wells, and installed a new well (065-325) closer to the building to provide improved monitoring of the release area.

Sr-90 concentrations in samples collected during 2002 were consistent with values observed before the Building 801 floodwater release. During 2002, the highest Sr-90 concentrations were detected in shallow well 065-235, at concentrations up to 47.9 pCi/L. During 2003, samples from well 065-325 had Sr-90 concentrations ranging between 33.4 to 54.2 pCi/L, and Sr-90 was detected at 83.1 pCi/L in nearby temporary well PFS-1. No Cs-137 or tritium was detected in any of the samples.

It is estimated that it could take three to eight years for Sr-90, and approximately 100 years for Cs-137, from the Building 801 floodwater release to migrate to the closest downgradient well (065-325). Furthermore, any new groundwater impacts from the 2001 release will be difficult to identify, because the local groundwater was already contaminated with radioactivity from legacy releases.

7.5.2 Surveillance Monitoring of Support Facilities

7.5.2.1 Sewage Treatment Plant Area

As described in Chapters 1 and 3, the STP processes sanitary sewage from BNL facilities. Approximately 15 percent of the treated effluent released to the STP's sand filter beds either evaporates or directly recharges to groundwater; the remaining water is collected by drainage piping and is discharged to the Peconic River.

Discharges from the STP are monitored as part of the State Pollutant Discharge Elimination System (SPDES) program. The STP groundwater surveillance program provides an additional means of verifying that current treatment plant operations are not affecting groundwater quality. During 2003, six wells were used to monitor groundwater quality in the filter bed area and three wells were monitored in the holding pond area. Groundwater quality impacts resulting from historical STP discharges are monitored as part of the OU V program, using wells that are located at the site boundary and off-site areas (see Section 7.6.5).

Groundwater monitoring results for 2003 indicate that STP operations are not significantly affecting groundwater quality, and that BNL's administrative and engineered controls designed to prevent the discharge of chemicals and radionuclides to the sanitary system have been highly effective.

Radionuclides. Radioactivity levels in samples collected from the STP wells were consistent with ambient (background) levels from naturally occurring radionuclides, with the exception of a low level of tritium (1,690 pCi/L) detected in one sample from well 039-88. Low levels of tritium have been periodically detected in well 039-88 and nearby well 039-89 since their installation in 2000. These wells are downgradient of the holding ponds. Because the ponds have not been used recently to hold tritiated wastewater and the wells are also downgradient of the filter bed area, it is likely that the tritium origi-

nated from past water releases to the filter beds. See Section 5.2.1 for information related to historical tritium concentrations in STP effluent.

Volatile Organic Compounds, Metals, and Anions. During 2003, all water quality readings and most metal concentrations were below the applicable AWQS. Sodium was detected at concentrations slightly above the AWQS of 20 mg/L in filter bed area well 039-86, at a maximum concentration of 33.3 mg/L. Nitrates were detected in most filter bed area wells, with a maximum concentration of 7.4 mg/L detected in monitoring well 039-08. The AWQS for nitrate is 10 mg/L. No VOCs were detected in any of the monitoring wells.

7.5.2.2 Motor Pool Facility

Building 423 serves as the site Motor Pool, where BNL's fleet vehicles are repaired and refueled. Gasoline is stored in two 8,000-gallon capacity USTs, waste oil is stored in one 260-gallon capacity aboveground storage tank, and heating oil is stored in one 3,000-gallon capacity UST. Although the USTs and associated distribution lines conform with Suffolk County Article 12 requirements for secondary containment, leak detection, and high-level alarms, BNL initiated a groundwater monitoring program in 1996 as a means of verifying that groundwater quality is not being affected by current Motor Pool operations.

Groundwater surveillance results for 2003 indicate that releases from historical operations continue to have an impact on groundwater quality in the area. Several activities were conducted to verify that the groundwater contamination came from historical, not current, operations. Monitoring of the leak detection systems, groundwater wells downgradient of the gasoline USTs, and product reconciliation records indicate that the tanks and their associated distribution lines are not leaking. Furthermore, 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 solvents detected in groundwater originate from historical vehicle maintenance activities at the Motor Pool and are not related to current operations.

Underground Storage Tank Area. During 2003, the gasoline additive methyl tertiary butyl ether (MTBE) was the only chemical related to gasoline detected in groundwater downgradient of the UST area. Compared to previous years when MTBE concentrations were less than the NYS AWQS for MTBE (10 µg/L), MTBE concentrations in well 102-06 increased to 33.8 µg/L in March 2003, then decreased to 13 µg/L by September. In past years, low levels of the solvent TCA were also detected in both downgradient wells, but at concentrations below the NYS AWQS of 5 µg/L. The presence of MTBE and TCA could be related to historical parts degreasing operations at the Motor Pool facility, because these contaminants are also detected in wells downgradient of the Motor Pool Building. Wells 102-05 and 102-06 were also tested for the presence of floating petroleum hydrocarbons. As in previous years, no floating product (oil floating on top of the groundwater) was observed.

Motor Pool Building. As in previous years, VOCs continue to be detected in all four downgradient wells at concentrations exceeding NYS AWQS. During 2003, TCA was detected in all four wells at concentrations ranging from 6 µg/L to 53.4 µg/L, and 1,1-dichloroethane (DCA) was detected in wells 102-11 and 102-12 at concentrations up to 14.8 µg/L. The NYS AWQS for TCA and DCA is 5 µg/L. The gasoline additive MTBE was detected in all four wells, with a maximum observed concentration of 27.3 µg/L. It is believed that these chemicals originate from historical vehicle maintenance/part degreasing operations.

7.5.2.3 Upton Service Station

Building 630 is a commercial automobile repair and gasoline station for the BNL site. Gasoline is stored in two 8,000-gallon capacity USTs and one 6,000-gallon capacity UST, and waste oil is stored in one 500-gallon capacity UST. Although the storage tanks and associated distribution lines conform with Suffolk County Article 12 requirements for secondary containment, leak detection, and high-level alarms, BNL initiated a groundwater monitoring program in 1996 as a means of verifying that

groundwater quality is not being affected by current operations.

Groundwater quality in the Upton Service Station area has been impacted by historical station operations and by carbon tetrachloride contamination released from a former nearby UST that was used as part of a scientific experiment conducted in the 1950s. During 2003, carbon tetrachloride continued to be observed in the service station monitoring wells. The maximum carbon tetrachloride concentration was 278 µg/L, observed in well 085-17 in May 2003. The NYS AWQS for carbon tetrachloride is 5 µg/L. Carbon tetrachloride concentrations decreased during the year, with concentrations dropping to less than 120 µg/L by September. These concentrations were considerably less than those observed in 2000, when carbon tetrachloride concentrations in wells near the service station approached 4,500 µg/L. The decrease reflects the effectiveness of the groundwater remediation system designed to treat this plume.

In addition to the carbon tetrachloride contamination, groundwater quality has been affected by a variety of petroleum- and solvent-related VOCs that appear to be related to historical Service Station operations. During 2003, high levels (>100 µg/L) of petroleum-related compounds such as xylene and ethylbenzene were detected in wells 085-17, 085-236, and 085-237. Samples collected from well 085-17 in July 2003 indicated petroleum-related compounds such as m/p xylene at 129 µg/L, o-xylene at 108 µg/L, 1,2,4-trimethylbenzene at 60 µg/L, and 1,3,5-trimethylbenzene at 22 µg/L. A similar increase in these compounds was detected in samples collected from well 085-236 in March 2003. The solvent PCE was detected also, with a maximum concentration of 22 µg/L observed in the July sample from well 085-17.

The gasoline additive MTBE continued to be detected in wells 085-236 and 085-237 at concentrations exceeding the NYS AWQS of 10 µg/L. In 2003, MTBE levels increased from a maximum concentration of 32 µg/L in 2002, to a maximum concentration of 144 µg/L in the July sample from well 085-237. MTBE levels dropped to <50 µg/L by October.

Monitoring of the leak detection systems, groundwater wells downgradient of the gasoline USTs, and product reconciliation records indicated that the tanks and their associated distribution lines were not leaking. Furthermore, evaluation of vehicle maintenance operations indicated that all waste oils and used solvents were being properly stored and recycled. Therefore, it is believed that the solvents detected in groundwater originated from historical vehicle maintenance activities at the Motor Pool and were not related to current operations.

7.5.2.4 Major Petroleum Facility

The Central Steam Facility (CSF, Building 610) supplies steam for heating to all major facilities of the Laboratory through an underground distribution system. The Major Petroleum Facility (MPF) is the storage area for most fuels used at the CSF. Eight shallow Upper Glacial Aquifer wells monitor the MPF as part of the licensing requirements for this facility. Additional surveillance wells are in the nearby CSF area, and are used to monitor groundwater contamination resulting from a 1977 leak of approximately 25,000 gallons of Alternative Liquid Fuel (a mixture of fuel oil and spent solvent). Contaminated soil and groundwater near the 1977 spill underwent active remediation from 1997–2001 (see Section 7.6.4.1).

In accordance with the license conditions for the MPF, groundwater samples are analyzed twice a year for semivolatile organic compounds (SVOCs) and VOCs, and the wells are tested monthly for the presence of floating petroleum hydrocarbons. During 2003, none of the target compounds associated with fuel oil were detected, and no floating petroleum product was observed. However, as in past years, VOCs continued to be detected in several wells at concentrations exceeding the NYS AWQS of 5 µg/L. TCA was detected in upgradient well 076-25 at a concentration of 15 µg/L. Low levels of TCA have been detected in this well for many years, and it probably originates from a solvent spill area near Building 650. (Note: Solvent spill areas along the north side of Building 650 were evaluated during the OU IV Remedial Investigation.) Degreasing solvents continued

to be detected in downgradient well 076-380, but at lower concentrations compared to 2002. 1,2-dichloroethene (DCE) (total) was detected at a concentration of 22 μg/L, PCE at 38 μg/L, and trichloroethene (TCE) at 7.3 μg/L. (Note that 1,2-DCE is a breakdown product of PCE.)

In an effort to identify the source of the VOC contamination detected in well 076-380, in early 2003 BNL installed four temporary Geoprobe™ wells, with three wells downgradient of the suspected source areas near Building 610. Only downgradient Geoprobe™ well MPF-GP-03 had detectable levels of VOCs, with PCE at a concentration of 6.6 μg/L and cis-1,2-DCE at a concentration of 14.5 μg/L. Although well MPF-GP-03 was downgradient of the former oil tank valve house, a source closer to Building 610 cannot be ruled out.

7.5.2.5 Waste Management Facility

In 1997, BNL began operating its new Waste Management Facility. The WMF is designed and operated in a manner that meets all applicable federal, state, and local environmental protection requirements. Nevertheless, BNL established a voluntary groundwater monitoring program as a secondary means of verifying the effectiveness of the facility's administrative and engineered controls. The WMF is monitored by eight shallow Upper Glacial Aquifer wells. Groundwater monitoring results for 2003 were consistent with previous monitoring, and continued to show that WMF operations were not impacting groundwater quality.

Volatile Organic Compounds, Metals, and Anions. All anions (chlorides, sulfates, and nitrates) and most metals concentrations were below applicable NYS AWQS. As in past years, sodium was detected at concentrations slightly above the NYS AWQS of 20 mg/L in several wells. Sodium was detected in upgradient wells 055-03 and 066-07 at concentrations of 27.9 and 22.9 mg/L, respectively, and in well 056-21 near the RCRA Building at a concentration of 21.3 mg/L. No VOCs were detected at concentrations above NYS AWQS. Trace levels (<1 μg/L) of chloroform were occasionally detected in upgradient wells 055-03, 055-10, 066-03, downgradient well 066-84, and nearby water supply wells 11 and 12. Trace levels (up to 1.3 μg/L) of TCA were also detected in upgradient well 066-06.

Radionuclides. Gross alpha and beta concentrations in samples from both upgradient and downgradient monitoring wells are consistent with background concentrations, and no BNL-related gamma-emitting radionuclides were identified. During the year, tritium levels in monitoring well 056-23 near the Reclamation Building increased from 407 pCi/L in February to 1,120 pCi/L in August. Although these tritium concentrations were well below the 20,000 pCi/L DWS, BNL implemented its Groundwater Protection Contingency Plan in an attempt to identify the source of the tritium and verify that the tritium was not affecting the quality of water obtained from nearby supply wells 11 and 12. As part of this response, the monitoring frequency was increased for well 056-23, nearby monitoring wells 056-22 and 066-84, and supply wells 11 and 12. BNL also formed a technical team to help identify a possible source of the tritium. Tritium concentrations in well 056-23 increased to 2,430 pCi/L in November 2003. Tritium was not detected in any of the samples collected from supply wells 11 and 12. Although a definitive source for the tritium has not been identified to date, a thorough review of waste management operations suggests that the tritium was not released from the WMF. Rather, the periodic detection of tritium in upgradient well 066-07 suggests that the tritium was released from an upgradient source.

7.6 ENVIRONMENTAL RESTORATION GROUNDWATER MONITORING PROGRAM

The mission of the Environmental Restoration Groundwater Monitoring Program is to monitor the various contaminant plumes on and off site, as well as to monitor the progress that the groundwater treatment systems are making toward plume remediation. The information in this section provides an overview of ER groundwater monitoring and remediation activities for 2003. In this period, a total of 629 groundwater surveillance wells were monitored during 2,510 individual sampling events.

Maps showing the main VOC and radionuclide plumes are provided as Figures 7-4 and

7-5. For each significant contaminant source area and plume described here, specific groundwater contaminant distribution maps are provided. These maps depict the areal extent of contamination and were created by selecting the highest contaminant concentration observed for a given set of wells during a selected sampling period. The 2003 BNL Groundwater Status Report (BNL 2004) presents detailed descriptions of the monitoring program, maps, and cross sections that show the extent of contamination, concentration trend data, and the hydrogeology for BNL and the surrounding area.

7.6.1 Background Monitoring

Background groundwater quality for the BNL site was monitored with a network of 10 wells in the northern portion of the site and in off-site areas to the north. The background wells provide information on the composition of groundwater that has not been affected by activities at BNL. These background data are a valuable reference for comparison with groundwater quality data from areas that have been affected. This well network can also provide warning of any contaminants originating from potential sources upgradient of the BNL site. Historically, low concentrations of VOCs have been detected in some background wells and this was true for 2003, also. The highest concentration detected was chloroform at 0.7 µg/L. Although background samples are no longer tested for radionuclides, historical monitoring has demonstrated that radionuclide concentrations are consistent with natural levels.

7.6.2 Operable Unit I

7.6.2.1 Former Landfill, Animal/Chemical Pits, and Glass Holes

The Former Landfill area was initially used by the U.S. Army as a landfill area during World Wars I and II. BNL used the southeast corner of the landfill from 1947 through 1966 for the disposal of construction and demolition debris, sewage sludge, chemical and low-level radioactive waste, used equipment, and animal carcasses. From 1960 through 1966, BNL waste, glassware containing chemical and radioactive waste, and animal carcasses containing radioactive tracers were buried in shallow holes in an area directly east of the Former Landfill. From 1966 through 1981, BNL disposed of used glassware in shallow pits directly north of the Animal/Chemical Pits. The Former Landfill was capped in 1996 and the Animal/Chemical Pits and Glass Holes were excavated in 1997 and the waste was disposed of according to regulations.

A network of eight wells monitors the Former Landfill area. This monitoring program is designed in accordance with post-closure operation and maintenance requirements specified in 6 NYCRR Part 360: Solid Waste Management Facilities. The objective of this program is to verify that the cap effectively prevents the continued leaching of contaminants from the landfill, and to document anticipated long-term improvements to groundwater quality. In addition to these wells, BNL established a separate network of 24 wells to monitor the Animal/Chemical Pits and Glass Holes areas and the downgradient portions of the Former Landfill plume. The downgradient portions of these plumes are currently being monitored as part of the OU III North Street Monitoring Program.

Former Landfill Monitoring Results. The areal extent of VOC contamination from the Former Landfill and Animal/Chemical Pits and Glass Holes area is shown in Figure 7-7. The contaminants of concern for the Former Landfill wells were VOCs and Sr-90. Recent monitoring has shown declining VOC and Sr-90 concentration trends in downgradient wells, indicating that the landfill cap is performing as planned. A detailed evaluation of VOCs, radionuclides, leachate parameters, metals, and pesticides and PCBs is provided in the Environmental Monitoring Report, Current and Former Landfill Areas (BNL 2004a).

During 2003, VOC concentrations did not exceed NYS AWQS in any of the wells monitoring the Former Landfill. VOC concentrations have been low in all of the wells over the past five years, with infrequent detections that exceeded the NYS AWQS.

Historically, Sr-90 has been detected in shallow well 097-64, less than 100 feet downgradient of the landfill footprint. Sr-90 concentrations in this well have been steadily

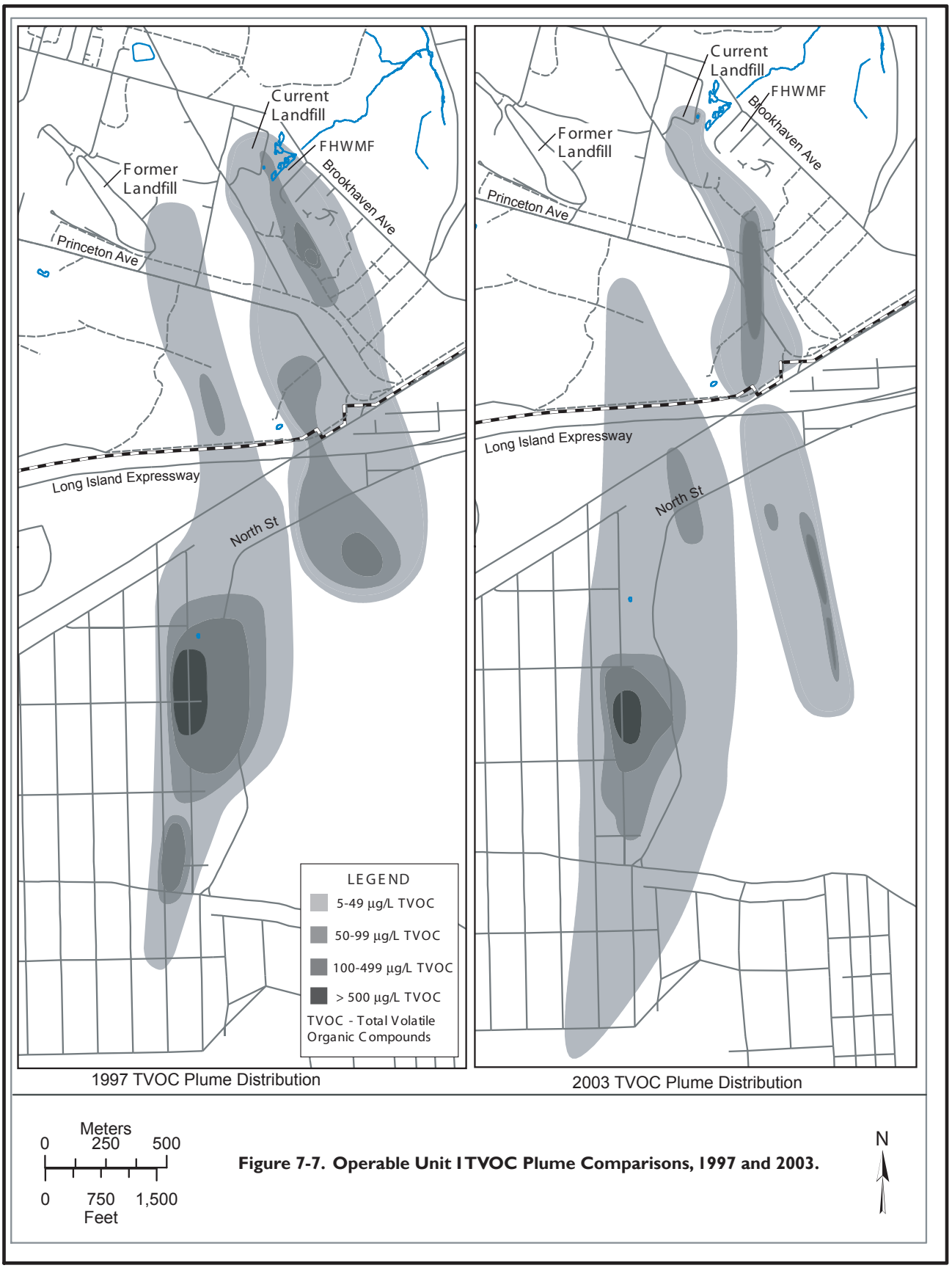

Figure 7-7. Operable Unit I TVOC Plume Comparisons, 1997 and 2003.

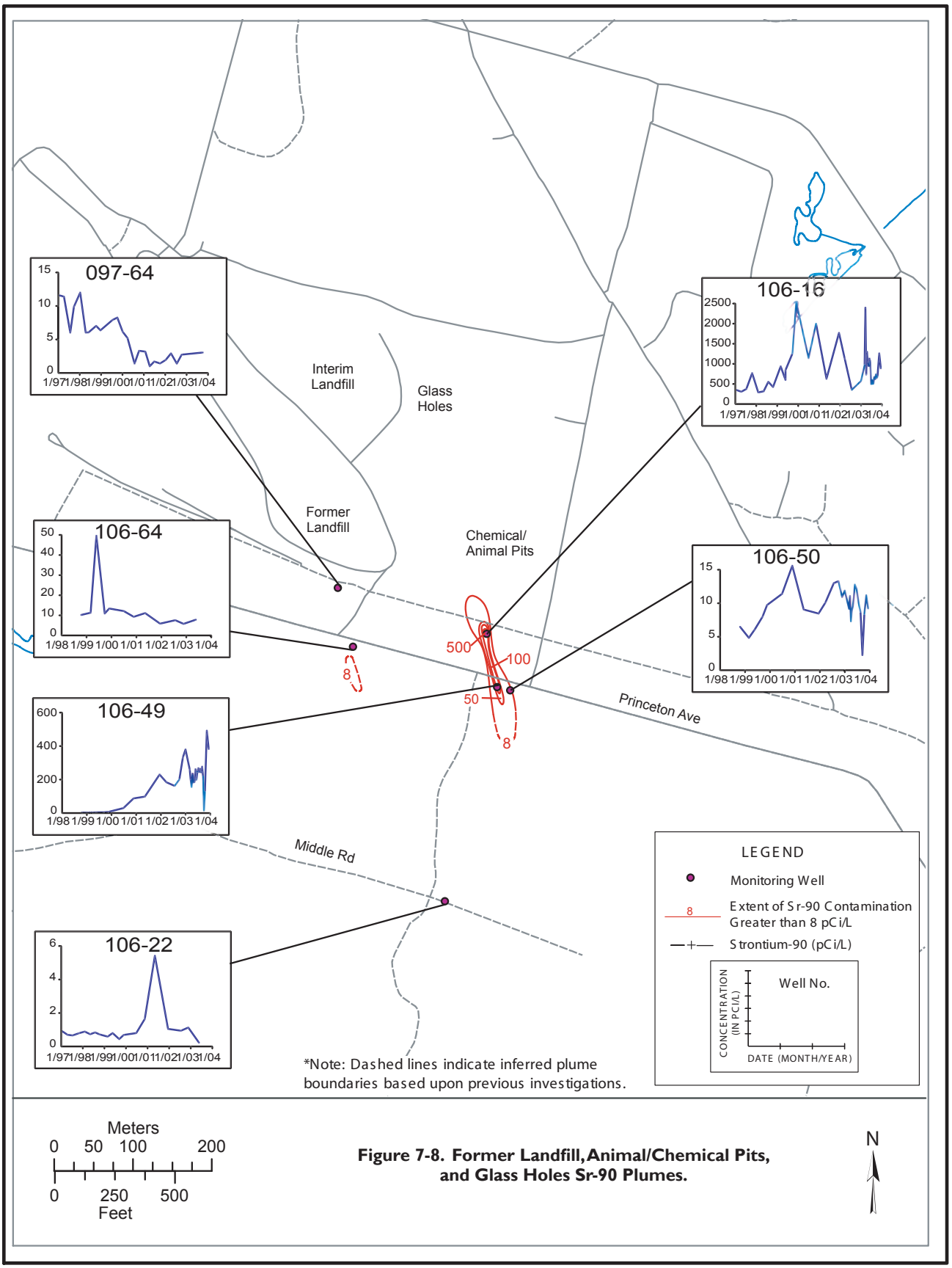

Figure 7-8. Former Landfill, Animal/Chemical Pits, and Glass Holes Sr-90 Plumes.

declining since 1998, when it was last detected above the 8 pCi/L DWS. The highest Sr-90 concentration in this well during 2003 was 3 pCi/L, in January. The Sr-90 plume had shifted south of wells 097-64 and 106-64, as shown in Figure 7-8.

During 2003, all conventional landfill leachate parameters (e.g., alkalinity, sulfates, chlorides, total nitrogen, nitrates, nitrites, TKN, total dissolved solids, and total suspended solids) were below applicable NYS AWQS. Iron and aluminum were occasionally detected at concentrations above NYS AWQS in two downgradient wells. Iron was detected at 1.3 mg/L in well 086-72, and aluminum was detected up to 0.418 mg/L in well 106-30. The NYS AWQS for iron and aluminum are 0.3 and 0.2 mg/L, respectively.

Animal/Chemical Pits and Glass Holes Monitoring Results. Groundwater samples were obtained from 36 monitoring wells during 2003. Twelve of these wells were installed in 2002 as part of the Chemical/Animal Holes Strontium-90 Pilot System that is designed to determine the feasibility of treating the contaminated groundwater.

Figure 7-8 shows the Sr-90 plume distribution. The highest Sr-90 concentration observed during 2003 was 2,400 pCi/L in well 106-16, which is immediately south of the Animal Pits. This well has historically shown the highest Sr-90 concentrations in this area (see trend plot on Figure 7-8). The sharp increase in Sr-90 in this well appears to be correlated with the excavation of the Animal Pits area in 1997, which may have released additional Sr-90 to the groundwater.

The high concentration segment of the Sr-90 plume, with concentrations greater than 100 pCi/L, extends from approximately 35 feet northwest of well 106-16 to approximately 65 feet south of the Princeton Avenue firebreak road (Figure 7-8). The leading edge of the plume, as defined by the 8 pCi/L DWS, is approximately 275 feet south of this firebreak road. A second, smaller plume occurs south of the Former Landfill. The trailing edge of the plume is estimated to be approximately 75 feet south of the Princeton Avenue firebreak road.

7.6.2.2 Current Landfill

The Current Landfill operated from 1967 through 1990. (Note: this landfill is called the Current Landfill to distinguish it from the older [Former] landfill that closed in 1966.) It was used for disposal of putrescible waste, sludge containing precipitated iron from the Water Treatment Plant, and anaerobic digester sludge from the Sewage Treatment Plant. The STP sludge contained low concentrations of radionuclides, and possibly metals and organic compounds. BNL also disposed of limited quantities of laboratory wastes containing radioactive and chemical material at the landfill. As a result, the Current Landfill is a source of groundwater contamination. Permanent closure (capping) of this landfill was completed in November 1995 as part of the ER Program.

The Current Landfill post-closure groundwater monitoring program consists of a network of 11 monitoring wells adjacent to the landfill in both upgradient and downgradient locations. These wells are monitored quarterly to determine the cap's effectiveness in preventing the continued leaching of contaminants from the landfill, and to document the anticipated long-term improvements to groundwater quality. The monitoring well network was designed in accordance with New York State-specified landfill post-closure operation and maintenance requirements. Data collected to date show that, in general, contaminant concentrations have been decreasing following the capping of the landfill in 1995. A detailed evaluation of VOCs, radionuclides, leachate parameters, metals, and pesticides/PCBs is provided in the 2003 Environmental Monitoring Report, Current and Former Landfill Areas (BNL 2004a).

Volatile Organic Compounds. During 2003, benzene, DCA, and chloroethane concentrations exceeded groundwater standards in four of 10 downgradient monitoring wells. Benzene was detected above the 0.7 µg/L standard in well 087-11 at a concentration of 2.6 µg/L, and DCA was detected above the 5 µg/L standard in well 088-109 at a concentration of 26 µg/L. Chloroethane was detected at concentrations above the 5 µg/L standard in wells 087-11, 087-23, 088-109, and 088-110, with a maximum

concentration of 77 µg/L detected in well 088-109. The extent of the Current Landfill VOC plume is shown in Figure 7-7.

Radionuclides. As in previous years, low levels of tritium and Sr-90 were detected in Current Landfill monitoring wells during 2003, but at concentrations well below their applicable DWS of 20,000 pCi/L and 8 pCi/L, respectively. The maximum Sr-90 concentration was detected in well 088-23 at 2.13 pCi/L, and the maximum tritium concentration was 1,450 pCi/L, detected in well 087-27.

Leachate Parameters and Metals. Most conventional landfill leachate parameters (e.g., alkalinity, sulfates, chlorides, total nitrogen, nitrates, nitrites, TKN, total dissolved solids, and total suspended solids) were below applicable NYS AWQS, except for ammonia. Total dissolved solids and total suspended solids readings were similar to previous years, and indicate some continued movement of leachate from the landfill. Although there was a general decrease in ammonia concentrations from previous years, ammonia concentrations exceeded the NYS AWQS of 2 mg/L in three downgradient wells. The highest ammonia concentration was detected in well 088-110 at 3.6 mg/L. Ammonia is a common landfill contaminant and is generated by the degradation of organic material. During 2003, iron, manganese, and sodium continued to be detected above their respective groundwater standards. Iron in the downgradient wells peaked at a maximum of 68.1 mg/L in well 087-11. In contrast to background concentrations, in well 87-09 iron ranged from 0.234 to 31.7 mg/L. Manganese ranged from 0.030 to 7.2 mg/L in background well 087-09, and up to 7.4 mg/L in the downgradient wells. Background sodium levels ranged from 7.6 to 30.6 mg/L, whereas downgradient levels ranged up to 37.7 mg/L. Thallium was reported above the groundwater standard of 0.0005 mg/L in several wells, with concentrations up to 0.012 mg/L. Thallium detections have historically been observed at similar levels in Current Landfill wells.

7.6.2.3 Current Landfill and FWMF Plumes

Groundwater contamination originating from the downgradient section of the Current Landfill plume and the Former Waste Management Facility is being monitored under the OU I South Boundary program. This monitoring program uses a network of 57 wells downgradient of the Current Landfill and FWMF. Until 1997, the FWMF was BNL's central facility for processing, neutralizing, and storing hazardous and radioactive wastes before off-site disposal. As the result of past waste handling and storage practices, groundwater at the FWMF is contaminated with both chemicals and radionuclides at concentrations that exceed NYS AWQS or DWS.

The Current Landfill and FWMF plumes become commingled south of the FWMF (Figure 7-7). The Current Landfill/FWMF plume is being remediated using a groundwater extraction and treatment system consisting of two wells screened in the deep portion of the Upper Glacial Aquifer at the site boundary. This system provides hydraulic containment of those on-site portions of the plume that have total volatile organic compound (TVOC) concentrations greater than 50 µg/L. (Note: TVOC is a summation of all individual VOC concentrations for a particular well sample.) In 2003, BNL began construction of a second treatment system, the North Street East System, to treat the off-site portion of the plume. This system will begin operations in 2004.

Volatile Organic Compounds. Total VOC concentration distributions for the Current Landfill/FWMF plume are shown in Figure 7-7. The primary VOCs found on site include chloroethane and DCA (the signature contaminants for the Current Landfill), whereas TCA, 1,1-DCE, TCE, and chloroethane are prevalent in the off-site (North Street East) segment of the plume. DCA and chloroethane are primarily detected in the Shallow Glacial Aquifer near the source areas, and in the deep Upper Glacial Aquifer at the site's boundary and off site. TCA, DCE, TCE, chloroethane, and chloroform are found in the mid to deep Upper Glacial Aquifer off site south of North Street.

The Current Landfill/FWMF plume (defined by TVOC concentrations greater than 5 µg/L) extends south from the Current Landfill to an area approximately 2,080 feet south of North

Street (approximately 7,500 feet long as measured from the Current Landfill). Its maximum width is about 1,230 feet at the southern site boundary. The areas of the plume displaying the highest VOC concentrations (greater than 100 µg/L) are approximately 980 feet downgradient of the FWMF (at well 098-59), and off site, south of well 000-124. (Note: The depiction of the extent of the plume south of well 000-124 is based on data obtained from temporary wells installed in 2001 and from estimated plume migration rates.)

The distribution of the plume has changed since the south boundary pump-and-treat system began operations in 1997 (Figure 7-7). The system appears to have created a break in the plume, characterized by a region of low-level TVOC concentrations from south of the extraction wells to just south of the Long Island Expressway (LIE). The North Street East treatment system is designed to remediate the high concentration portion of the VOC plume located off site (see Figure 7-16).

Radionuclides. Tritium levels in wells inside the FWMF have been declining since 1997, when concentrations approached 44,000 pCi/L in well 088-26. During 2003, the maximum tritium concentration in this well was only 1,540 pCi/L. Tritium concentrations in downgradient well 098-30 declined from 24,600 pCi/L in 2002 to 19,400 pCi/L in 2003. Low levels of tritium continued to be detected off site during 2003, with a maximum concentration of 1,230 pCi/L, in well 000-138.

Sr-90 has historically been detected on site at concentrations above the DWS of 8 pCi/L in three wells within and downgradient of the FWMF (088-26, 098-21, and 098-30). The extent of Sr-90 concentrations that are greater than the 8 pCi/L DWS is shown in Figure 7-9. The peak Sr-90 concentration during 2003 was 21 pCi/L, in well 088-26.

7.6.3 Operable Unit III

The monitoring well network established to monitor the OU III VOC and radionuclide source areas and associated contaminant plumes is comprised of approximately 180 monitoring wells positioned from the north-central portion of the site to the southern site boundary and off site. The OU III groundwater monitoring program is specifically designed to address the following groundwater contamination and plume remediation issues:

- Monitor VOC plumes with identified or suspected sources in the AGS Complex, Paint Shop, former carbon tetrachloride UST area, former Building 96 area, and the Supply and Material area.
- Monitor the tritium plume associated with the High Flux Beam Reactor (HFBR) and Sr-90 plumes associated with the WCF and the formerly operated BGRR.
- Evaluate the effectiveness of the OU III South Boundary, Western South Boundary, Middle Road, Carbon Tetrachloride, Industrial Park, and Building 96 groundwater treatment systems. These monitoring programs characterize the effects of the pumping on the contaminant plumes and provide the data necessary for making decisions on the future operations of the remediation systems.
- Monitor the off-site segment of the OU III plume and sentinel wells south (downgradient) of the defined extent of the off-site VOC plume, to provide data on future downgradient migration of the plume. Sentinel wells are also situated in the southwestern portion of BNL, directly upgradient of the Suffolk County Water Authority (SCWA) Parr Village Well Field near the William Floyd Parkway. These sentinel wells would provide an early warning if contaminants from BNL were to migrate toward the SCWA wells.

7.6.3.1 OU III Volatile Organic Compound Plumes

Figure 7-10 shows the areal extent of the OU III VOC plume, which extends from the AGS Complex in the central part of the site south to the vicinity of Flower Hill Drive in North Shirley, a distance of approximately 17,700 feet.

The OU III VOC plume consists of multiple commingled plumes originating from a number of source areas in the central areas of the BNL site. The primary VOCs detected

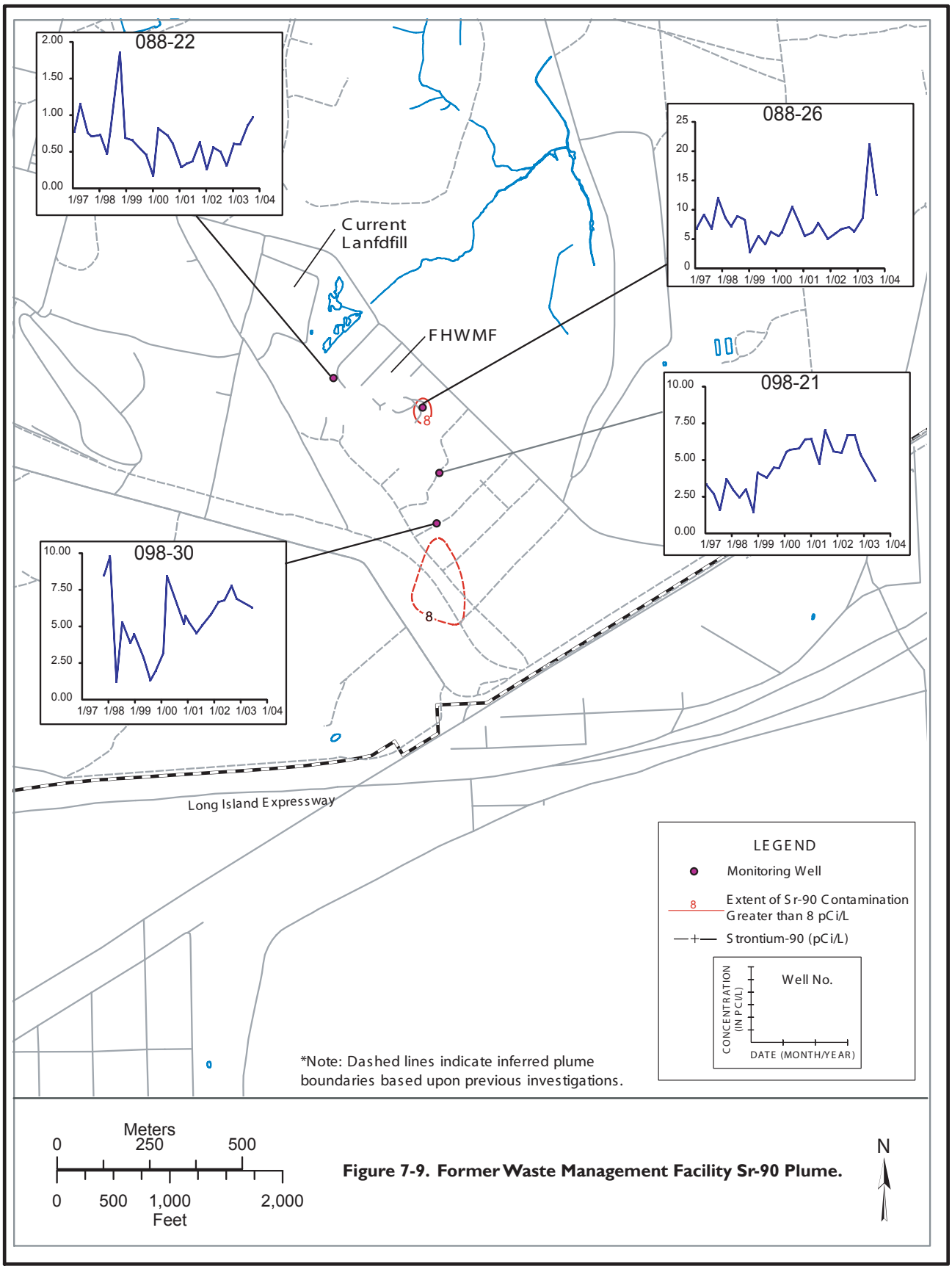

Figure 7-9. Former Waste Management Facility Sr-90 Plume.

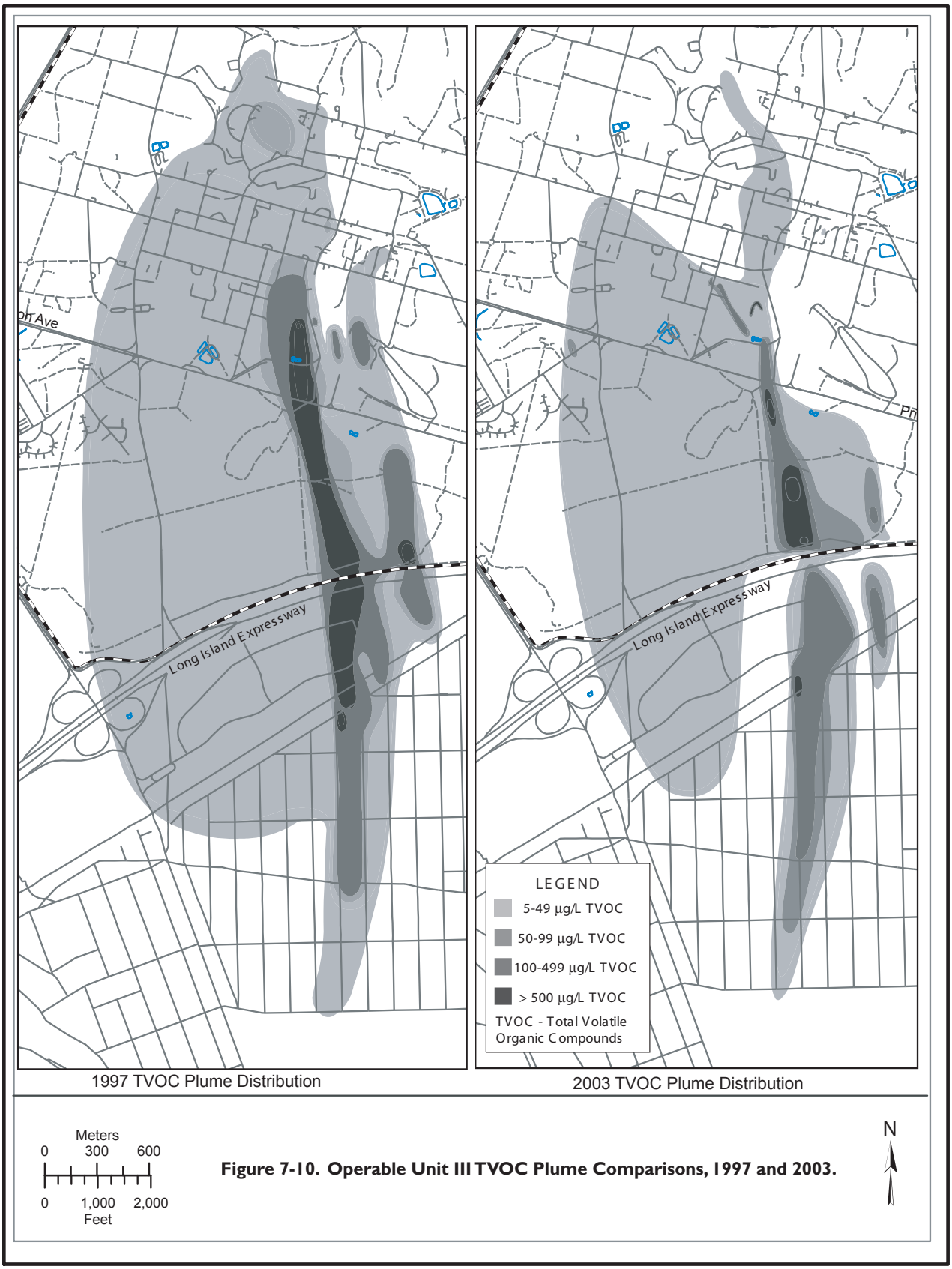

Figure 7-10. Operable Unit III TVOC Plume Comparisons, 1997 and 2003.

in on-site monitoring wells include TCA, PCE, and carbon tetrachloride. Carbon tetrachloride and PCE are the primary VOCs detected in off-site groundwater monitoring wells. On-site portions of the plume displaying the highest VOC concentrations during 2003 were south of Building 96, with TVOC concentrations up to 1,312 µg/L, continuing south to the Middle Road with TVOC concentrations of 1,997 µg/L, and the south boundary with TVOC concentrations up to 857 µg/L. TVOC levels range up to 772 µg/L (primarily carbon tetrachloride and PCE) in the off-site industrial park area.

Monitoring results also indicate that there is significant carbon tetrachloride contamination off site in the Upper Magothy Aquifer in the vicinity of the Industrial Park and Carleton Drive in North Shirley. Characterization of the Magothy Aquifer in this area began in 2000 and was completed in 2002 (see Arcadis-Geraghty and Miller 2003). The characterization study included the installation of 22 temporary vertical profile wells and 13 permanent monitoring wells. During 2003, carbon tetrachloride levels exceeded NYS AWQS in five Magothy wells, with the highest levels observed in wells 000-130 and 000-249, at concentrations of 110 and 739 µg/L, respectively. Lower levels of other VOCs were also detected, such as chloroform (up to 38 µg/L in well 000-249), tetrachloroethylene (up to 13 µg/L in well 000-130), TCA (up to 16.9 µg/L in well 000-249) and TCE (up to 11.1 µg/L in well 000-425). In 2004, BNL will install two additional off-site groundwater extraction wells (one on Stratler Drive and one at the Industrial Park East area). The purpose of these extraction wells is to treat existing high TVOC concentrations in the Upper Magothy Aquifer and to prevent the continued migration of contaminants into the Magothy Aquifer.

A comparison of the OU III plumes between 1997 and 2003 is provided in Figure 7-10. A summary of significant source areas and groundwater treatment areas is provided here.

OU III Central Area. A number of low-level (less than 100 µg/L) source areas and nonpoint source contamination sites have been identified within the developed central areas of the BNL site. These areas are monitored under the OU III Central project.

The monitoring well network established for the central area of the site consists of 21 wells. This network also is supplemented with Environmental Surveillance Program wells that are used to monitor active research and support facilities. During 2003, VOC concentrations in most of the OU III Central wells were near or below the NYS AWQS.

Wells 109-03 and 109-04 serve as sentinel wells for the SCWA William Floyd Well Field and are located near the eastern BNL site property boundary. Toluene was detected in well 109-03 (screened in deep Upper Glacial Aquifer) at 5.3 µg/L in a sample obtained on September 12, 2002. There were no VOC detections in this well exceeding NYS AWQS or guidance values prior to this sampling event. The well was re-sampled on October 29, 2002 and sent to two different analytical laboratories. MTBE was detected by both laboratories at concentrations ranging from 4.8 µg/L to 7 µg/L, as well as trace amounts of toluene (0.2 µg/L). The well was sampled again in December 2002. No VOCs were detected in these samples. The SCDHS sampled the well in early January 2003 and also did not detect any VOCs. Routine BNL monitoring detected MTBE at 67 µg/L in a sample collected on February 21, 2003. Benzene, m/p xylene, and toluene were also detected at concentrations of 1.4, 6.2, and 8.7 µg/L, respectively. BNL sampled the well again on April 3, 2003 and detected MTBE at 5 µg/L and toluene at 1 µg/L. The well was sampled by both BNL and SCDHS on April 23, 2003 and no VOCs were detected in these samples. There were no detections of VOCs exceeding NYS AWQS during the remainder of the year for either well. There were no detections of tritium in either well during 2003.

Building 96 Area. The OU III Remedial Investigation/Feasibility Study identified the Building 96 area as a significant source of the PCE detected in the OU III plume. This area encompasses four distinct areas: Building 96 and associated leaching structures, Building 96 Scrap yard, Former Building T-239 and associated leaching structures, and the former truck wash area.

An in-well air sparging system to remediate the Building 96 VOC source area began operations in February 2001. The Building 96 groundwater treatment system consists of four recirculation treatment wells. The VOC plume consists primarily of PCE and lower concentrations of TCA. The NYS AWQS for PCE and TCA is 5 µg/L. During 2003, the Building 96 area VOC plume was monitored using 21 permanent wells. Although VOC concentrations throughout most of the plume have declined significantly since the treatment system was installed, high concentrations of VOCs continue to be detected in the northern section of the source area (north of treatment well RTW-1), with a maximum TVOC concentration of 1,305 µg/L in well 085-335. These persistently high levels of VOCs appear to be coming from a silty layer that is slowly releasing contaminants. BNL is planning to install additional monitoring wells and will conduct an engineering study on the source term and alternative treatment technologies in 2004.

Carbon Tetrachloride UST Area. In April 1998, an inactive UST used to store carbon tetrachloride was excavated and removed. This tank was approximately 200 feet northeast of the Upton Service Station (at the corner of Rowland Street and Rochester Street). Although groundwater samples collected from a nearby well had shown low-level concentrations of carbon tetrachloride since 1995, samples collected in June 1998 revealed levels approaching 100,000 µg/L. The NYS AWQS for carbon tetrachloride is 5 µg/L. The increase in contaminant concentration was probably due to the spillage of residual carbon tetrachloride during removal of the UST. A groundwater remediation system consisting of two extraction wells (EW-13 and EW-14) screened in the shallow Upper Glacial Aquifer began operating in October 1999. A third extraction well (EW-15) installed in the downgradient segment of the plume began operating in December 2001. The effects of the pump-and-treat system on the source area are apparent in the sharp decline in carbon tetrachloride concentrations in wells near the former UST area.

The carbon tetrachloride contamination extends from the former UST southeast to the vicinity of the Weaver Drive recharge basin, a distance of approximately 1,300 feet. The width of the plume, as defined by concentrations greater than 50 µg/L, is approximately 120 feet. In 1999, carbon tetrachloride concentrations in groundwater immediately downgradient of the former UST were greater than 150,000 µg/L (in well 085-98). Carbon tetrachloride concentrations in this area steadily decreased following the start of groundwater treatment system pumping. The maximum carbon tetrachloride concentration during 2003 was only 184 µg/L. Carbon tetrachloride concentrations were also observed to decrease in wells near the Upton Service Station. For example, carbon tetrachloride concentrations in well 085-17 dropped from 3,760 µg/L in February 2001 to 120 µg/L by the fourth quarter of 2003. Carbon tetrachloride concentrations continue to decline in the downgradient segment of the plume as a result of the treatment system. Carbon tetrachloride levels in well 095-279, which is near the southernmost extraction well EW-15, declined from 388 µg/L in the first quarter of 2003, to 60 µg/L in the fourth quarter of 2003. Carbon tetrachloride was not detected in any of the sentinel wells near Weaver Drive.

The cleanup goals for this remediation system have been satisfied, and in early 2004 BNL will submit a petition to the regulatory agencies to shut down the system. Groundwater monitoring of this plume will continue.

Middle Road Treatment Area. Six groundwater extraction wells are used to hydraulically control the OU III VOC plume, near the Middle Road. This system began operating in October 2001. Groundwater near the Middle Road system is monitored using a network of 23 wells.

TVOC concentrations in plume core wells 105-23 and 105-44 have decreased since 2001. TVOC concentrations in well 105-23 decreased from 1,794 µg/L in 2001, to as low as 258 µg/L in 2003, and in well 105-44 TVOC concentrations decreased from 423 to 20 µg/L. High VOC concentrations continue to be found in the vicinity of extraction wells RW-2 and RW-3, based on influent concentrations for these wells and monitoring well data. For example, well 113-11 had a TVOC concentration of 1,488 µg/L in May 2003. The highest TVOC concen-

tration detected was in bypass detection well 113-17, located south of the extraction wells, at 1,997 µg/L. High VOC concentrations had been observed in the vicinity of this bypass well before the operation of the pump-and-treat system, and it is expected that this contamination will ultimately be captured by the OU III South Boundary System.

Southern Boundary Treatment Area. Hydraulic control of the OU III plume at the site boundary has been attained using seven extraction wells that pump water from the deep portions of the Upper Glacial Aquifer to an air stripper for treatment. This system began operating in June 1997. The seven recovery wells are screened at the depths showing the highest VOC concentrations. The effectiveness of the Southern Boundary treatment system is monitored using a network of 38 wells. Monitoring data have demonstrated that the extraction well system has created a break in the plume, characterized by a region of low-level VOC concentrations from south of the extraction wells to just south of the Long Island Expressway. High levels of VOCs continue to be detected in some South Boundary monitoring wells and are likely due to slugs of high-level contaminants migrating from upgradient areas. During 2003, the highest TVOC concentration detected near the extraction well system was 856 µg/L in well 121-23, near well EW-5.

Western South Boundary Treatment Area. The Western South Boundary pump-and-treat system began operating in 2002. The system has two extraction wells and is designed to capture the western portion of the OU III VOC plume, which contains VOC concentrations generally less than 50 µg/L. This area is monitored using a network of 17 wells. The primary contaminants associated with this portion of the OU III plume are TCA, TCE, chloroform, and dichlorodifluoromethane (a freon). The maximum TVOC concentration during 2003 was 49 µg/L, in well 126-11.

Industrial Park Area. The OU III Industrial Park Treatment system was designed to contain and remediate the portion of the OU III plume existing between BNL's southern boundary and the Parr Industrial Park. This segment of the OU III plume consists primarily of carbon tetrachloride that is in the deep portions of the Upper Glacial Aquifer and upper portion of the Magothy Aquifer. A groundwater treatment system, consisting of seven in-well air stripping treatment wells, was initiated in the Industrial Park in 1999 to treat VOC contamination in the deep Upper Glacial Aquifer.

The monitoring well network for this area consists of 40 wells that extend from the Industrial Park to Carleton Drive. These wells are used to monitor the effectiveness of the in-well air stripping groundwater treatment system. The highest TVOC concentration in the Industrial Park area during 2003 was 772 µg/L, which was observed in monitoring well 000-249. Wells that monitor the Upper Glacial Aquifer downgradient of the treatment system, along Carleton Drive, showed stable or decreasing VOC concentrations during 2003, with a maximum TVOC concentration of approximately 21 µg/L.

Two new groundwater remediation systems are being planned to clean up the southern extent of the OU III plume not remediated by the Industrial Park treatment system. The treatment systems will be located along the northern edge of the Town of Brookhaven Airport and along the Long Island Power Authority (LIPA) right-of-way south of Carleton Drive. These systems will be constructed by 2004.

North Street Monitoring. The North Street Monitoring Program (formerly known as OU I/IV Monitoring Program) addresses both a VOC plume that is primarily south of the site boundary and potential radiological contaminants that may have been introduced to groundwater in the OU IV portion of the site (particularly the Building 650 and 650 Sump Outfall areas).

The VOC plume extends from just south of the Animal/Chemical Pits area southward to the vicinity of Brookhaven Airport (Figure 7-7). The primary VOCs associated with this plume are carbon tetrachloride, PCE, and TCA. Historically the highest VOC concentrations (primarily carbon tetrachloride) have been detected in well 000-154 in the North Street area. TVOC concentrations greater than 1,000 µg/L were observed in 1997 and 1998 but have steadily declined since that time as the high concentration segment has migrated southward. The

leading edge of this high concentration segment appears to be approaching well 800-63.

The North Street VOC plume will be remediated using two groundwater treatment systems. The first system will consist of two extraction wells and four recharge wells between Sleepy Hollow Road and North Street. This system will capture the higher concentration portion of the VOC plume within the Upper Glacial Aquifer that contains TVOC concentrations greater than 50 µg/L. This system will help to minimize the potential for VOC migration to the Magothy Aquifer. Details on the pre-design groundwater characterization and the planned groundwater treatment system can be found in the North Street Groundwater Remediation System 90 Percent Design Report (Arcadis-Geraghty and Miller 2002). This treatment system is scheduled to start operations in Spring 2004. The second groundwater remediation system is to be located at the Brookhaven Airport. This system will remediate the leading edge of the plume, as well as the leading edge of the OU III VOC plume to the west. Details on the proposed remediation system and pre-design characterization activities can be found in the OU III Airport Groundwater Treatment System 90 Percent Design Documents (J.R. Holzmacher 2002a). This system is scheduled to begin operations in the summer of 2004.

Low levels of tritium have been detected off site in localized areas of the deep Upper Glacial Aquifer since the monitoring program started in 1998, but at concentrations well below the 20,000 pCi/L DWS. The maximum tritium concentration observed in 2003 was 1,570 pCi/L, in well 000-153. The highest tritium concentration detected to date was 9,130 pCi/L, detected in temporary well 000-337 installed in 2001 approximately 300 feet north of well 000-153. Potential sources for this tritium are located in the Former Landfill, Animal/Chemical Pits, and OU IV Building 650 areas of the site.

7.6.3.2 OU III Radionuclide Plumes

HFBR Tritium Plume. In late 1996, tritium was detected in wells near the High Flux Beam Reactor. The source of the release was traced to the HFBR spent fuel pool. In response, the fuel rods were removed from the pool for off-site disposal, the spent fuel pool was drained, and the HFBR was removed from service in 1997. Also, numerous monitoring wells were constructed to characterize the tritium plume downgradient of the HFBR. In May 1997, operation of a three-well groundwater extraction system began. This system was constructed on Princeton Avenue approximately 3,500 feet downgradient of the HFBR to capture the leading edge of the tritium plume. Extracted water was recharged at the Remedial Action (RA) V recharge basin. Groundwater models predict that the tritium plume will naturally attenuate to below DWS before reaching the site boundary. Three years of monitoring data showed that the plume had reached a relative steady state due to natural attenuation and it was not growing significantly. As a result, the extraction system was turned off and placed on standby status in September 2000. The extraction system will be reactivated if tritium concentrations exceed 20,000 pCi/L in monitoring wells at Weaver Drive, or 25,000 pCi/L at the Chilled Water Plant Road.

The selected remedy for the HFBR tritium plume includes monitoring and low-flow extraction programs to prevent or minimize the plume's growth. During 2000 and 2001, low-flow extraction was applied to the highest concentration area of the plume. A total of 95,000 gallons of tritiated water was sent off site for disposal. Since April 2001, tritium concentrations have remained below 750,000 pCi/L; a concentration above this would trigger low-flow pumping.

A monitoring well network of 159 wells is used to monitor the extent of the plume. During 2003, four temporary wells were installed to help define certain segments the plume. The extent of the tritium plume, determined from data collected during the fourth quarter of 2003, is shown in Figure 7-11. Tritium concentrations in groundwater immediately south of the HFBR building in monitoring well 075-43 increased from 22,600 pCi/L in 2002, to 130,000 pCi/L in 2003. In 1999, tritium concentrations in this well reached 2,500,000 pCi/L. The concentration increase observed in 2003 is likely due to

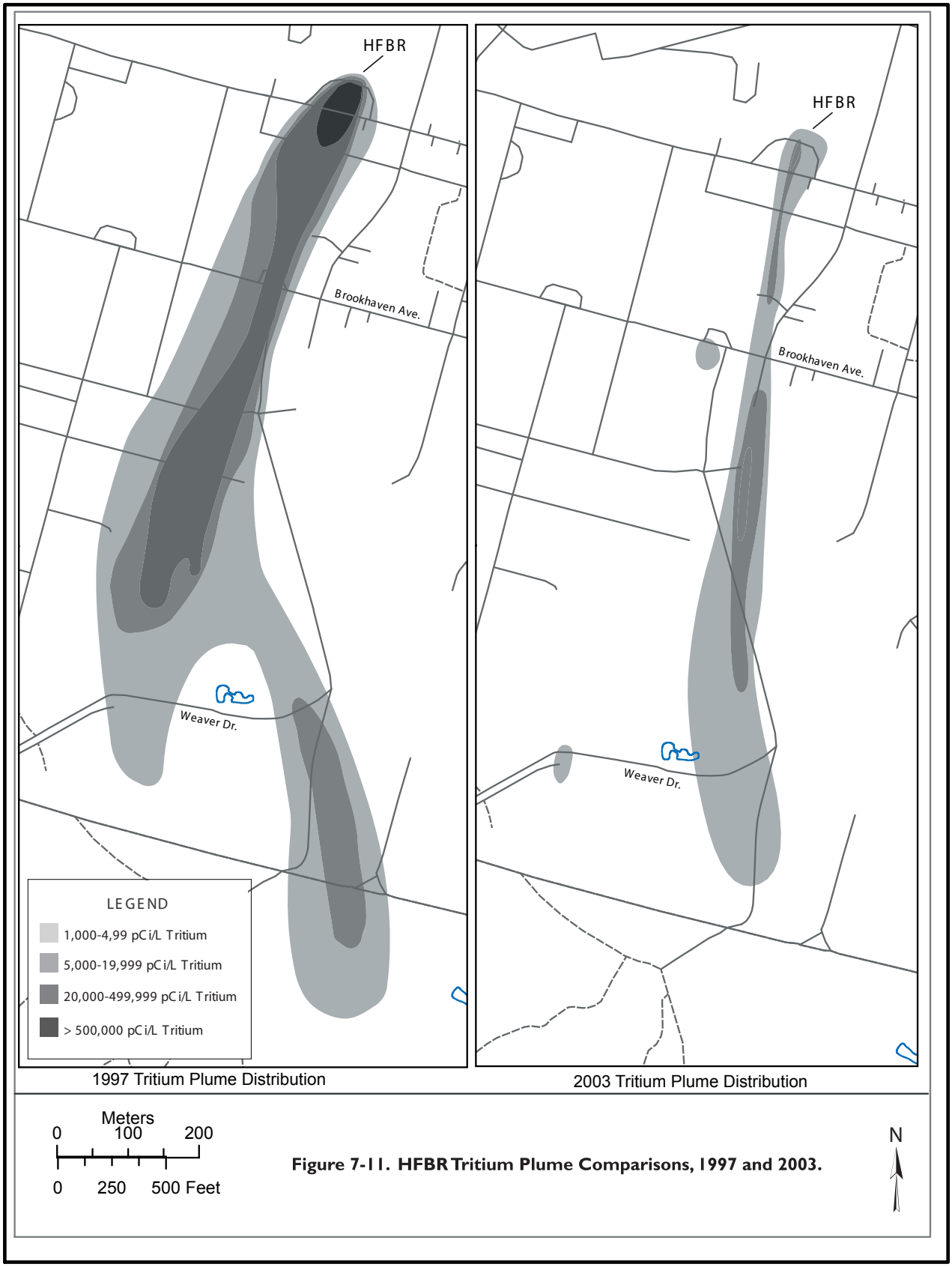

Figure 7-11. HFBR Tritium Plume Comparisons, 1997 and 2003.

a rise in the water table elevation and resulting flushing of residual tritium from the soil beneath the HFBR. During 2003, the highest concentration segment of the HFBR tritium plume was located in the vicinity of Bell Avenue, with a maximum concentration of 217,000 pCi/L detected in temporary well 085-341. The leading edge of the >20,000 pCi/L portion of the tritium plume is estimated to be in the vicinity of the Chilled Water Plant Road.

WCF and BGRR-Area Sr-90 Plumes. Historical waste handling operations at the Waste Concentration Facility and Building 801, and operations at the BGRR and associated Pile Fan Sump and Stack, resulted in the release of Sr-90 to the groundwater beneath these facilities. The Sr-90 plumes from these facilities are monitored using 61 wells. During September 2003 through January 2004, additional groundwater characterization work was conducted in the BGRR area using 60 temporary wells (BNL 2004c).

There are three source areas where Sr-90 concentrations are greater than 50 pCi/L (Figure 7-12). The first area is near the BGRR's Below Ground Ducts (BGD), where in 2003 a groundwater sample from temporary well BGRR-8 contained Sr-90 concentrations of 3,150 pCi/L. Strontium-90 concentrations greater than 50 pCi/L are estimated to extend south of the BGD area to just south of Cornell Avenue. The segment of the plume with concentrations that exceed 8 pCi/L extends from the BGRR, south approximately 600 feet toward Brookhaven Avenue.

The second area of notable Sr-90 concentrations is the WCF. During 2003, the highest Sr-90 concentration was observed in temporary well WCF-13, at 1,000 pCi/L. This well is immediately downgradient of the WCF's former "D" tanks area. The segment of the plume with concentrations that exceed 8 pCi/L extends from the WCF, south approximately 1,500 feet to just south of Cornell Avenue.

The third area of notable Sr-90 concentrations is downgradient of Building 801, where Sr-90 concentrations up to 54.2 pCi/L were detected in shallow well 065-325, and up to 83.1 pCi/L in temporary well PFS-1 (see Section 7.5.1.5).

7.6.4 Operable Unit IV

The Operable Unit IV area contains two significant source areas: the 1977 fuel oil/solvent spill site (AOC 5), and the Building 650 Sump and Sump Outfall area (AOC 6).

7.6.4.1 1977 Oil/Solvent Spill Site

In 1977, between 23,000 and 25,000 gallons of a mixture of No. 6 fuel oil and mineral spirits were released when a pipe ruptured as the contents of a UST were being transferred to aboveground storage tanks at the Central Steam Facility. The primary chemical contaminants that were found in the OU IV plume near this 1977 spill site were TCA, PCE, DCE, TCE, toluene, ethylbenzene, and xylenes. In addition, several small spills of No. 6 fuel oil from the CSF fuel unloading area were documented between 1988 and 1993; it also is suspected that small volumes of solvents such as PCE were released to the ground near the CSF.

From 1997 through 2001, BNL operated an air sparging/soil vapor extraction (AS/SVE) system to remediate soil and groundwater contamination associated with the 1977 spill. The performance goals for soil cleanup were achieved in 1998 and the goals for groundwater cleanup were met in August 2000. Groundwater monitoring was continued until the regulatory agencies approved BNL's Petition for Closure and Termination of Formal Post-Closure Monitoring of OU IV Air Sparge/Soil Vapor Extraction Remediation System (BNL 2002), and the system was decommissioned in 2003. Post-closure groundwater monitoring of six wells was initiated in the fourth quarter of 2003. Although there were no detections of VOCs exceeding NYS AWQS in wells monitoring the 1977 spill site, VOC concentrations did exceed standards in well 076-380, west of the spill site. This contamination is associated with a source in the CSF (see Section 7.5.2.4).

7.6.4.2 Building 650 and 650 Sump Outfall Areas (AOC 6)

Building 650 was used as a decontamination facility for radioactively contaminated clothing and equipment. Drainage from an exterior heavy equipment decontamination pad was

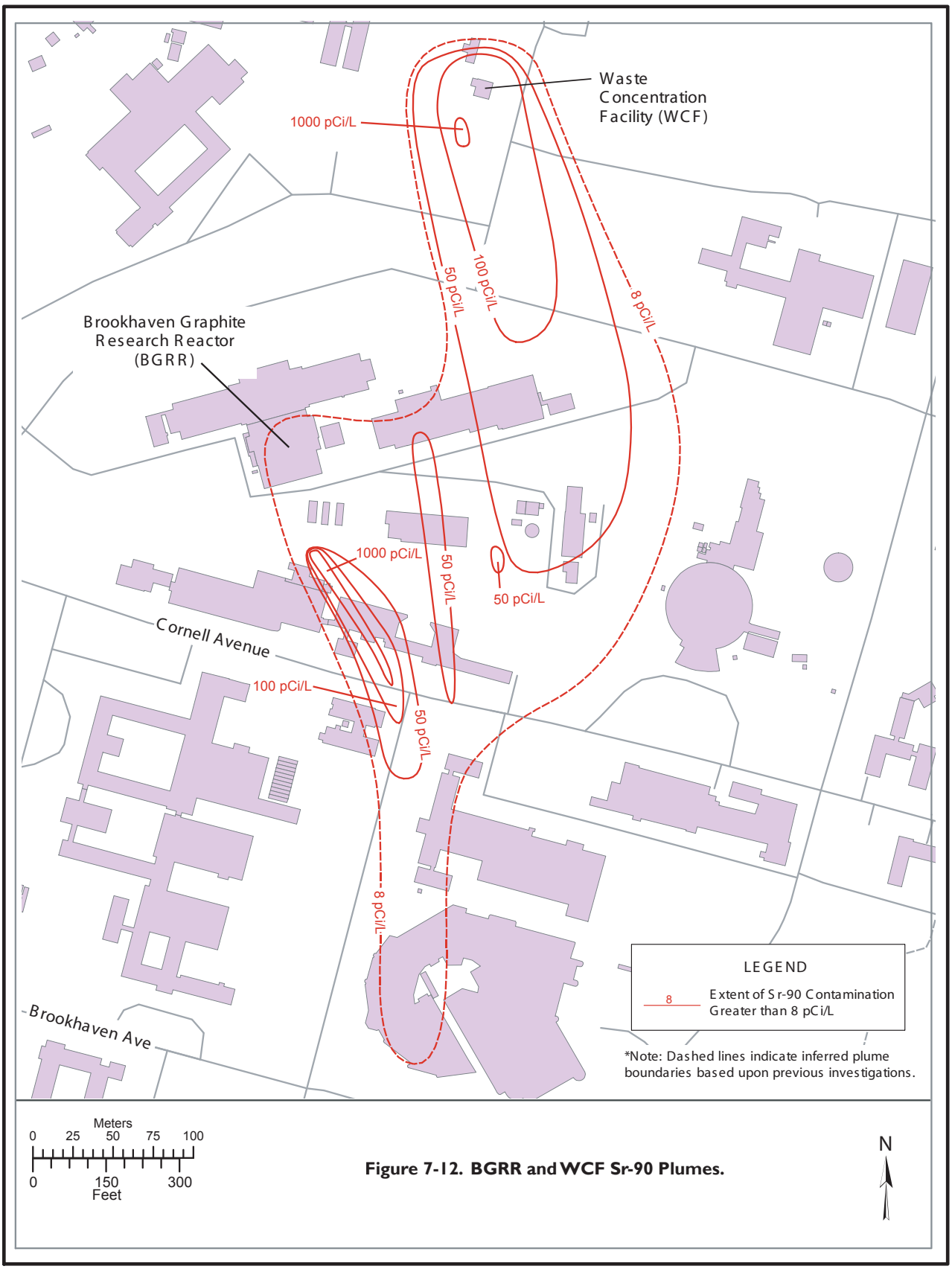

Figure 7-12. BGRR and WCF Sr-90 Plumes.

piped to a natural depression approximately 800 feet to the northeast, near recharge basin HO. As a result of these operations, soil and groundwater were contaminated at the decontamination pad and the sump outfall. The soils associated with the Building 650 sump outfall and the pipe leading to the outfall were excavated and disposed of off site during the spring and summer of 2002.

The overall extent of the Building 650 Sump Outfall Sr-90 plume (with concentrations greater than the 8 pCi/L DWS did not change significantly from 2000 to 2003 (Figure 7-13). The leading edge of the plume is projected to be just east of the CSF. The highest Sr-90 concentrations were detected in well 076-13, at 42 pCi/L, in February 2003. Sr-90 concentrations in Building 650 monitoring well 076-28 remained below the 8 pCi/L DWS during 2003.

7.6.5 Operable Unit V

Historically, BNL's Sewage Treatment Plant received discharges of contaminants from routine operations. Releases of VOCs, metals, and radionuclides to groundwater occurred via the STP sand filter beds and discharges to the Peconic River. In addition, trace levels of pesticides have been detected in some off-site wells. The OU V monitoring program uses 34 monitoring wells downgradient of the STP. These wells monitor VOC and tritium contamination resulting from historical releases at the STP. Surveillance of groundwater quality near the STP filter beds and emergency holding pond areas is performed as part of the BNL Environmental Surveillance Program for the STP (see Section 7.5.2.1).

Volatile Organic Compounds, Metals, and Pesticides. The extent of the OU V VOC plume is shown in Figure 7-14. The highest TVOC concentration observed during 2003 was 17 µg/L in well 061-05, near the eastern site property boundary. VOCs detected at levels exceeding NYS AWQS were TCE, TCA, 1,2-dichloropropane, and 1,2,3-trichloropropane. The maximum TCE concentration was detected in well 000-122, at 7.1 µg/L (the standard is 5 µg/L), and TCA was detected in well 061-05 at a concentration of 5.3 µg/L (the standard is 5 µg/L). Low levels of 1,2-dichloropropane and 1,2,3-trichloropropane were detected in shallow off-site well 600-25, at concentrations of 2 and 0.98 µg/L, respectively. The NYS AWQS for these compounds are 1.0 and 0.04 µg/L, respectively. Because well 600-25 is shallow, it is likely that the 1,2-dichloropropane and 1,2,3-trichlropropane originated from an offsite source.

There were no pesticide detections above reporting limits in groundwater during 2003. In past years, low levels of pesticides were detected in shallow offsite wells; their origin was likely associated with agricultural spraying at nearby farms.

Aluminum, antimony, arsenic, chromium, iron, manganese, sodium, and thallium were detected in monitoring wells for the OU V program at concentrations above the applicable NYS AWQS or federal DWS. Arsenic was detected in three wells above the federal DWS of 0.010 mg/L, with the highest concentration of 0.0178 mg/L detected in well 050-02. Aluminum was detected in 14 wells above the NYS standard of 0.2 mg/L, with the highest concentration of 24.4 mg/L detected in well 600-21. Antimony was detected in five wells above the 0.003 mg/L standard, with the highest concentration of 0.611 mg/L detected in well 600-22. Chromium was detected in well 600-21 above the 0.05 mg/L standard. Iron was detected in 19 wells at concentrations above the 0.3 mg/L standard, with the highest concentration of iron of 29.7 mg/L in well 50-02. Manganese was detected in eight wells above the 0.3 mg/L standard, with the highest concentration of 1.23 mg/L detected in well 50-02. Sodium was detected in six wells above the 20 mg/L standard, with the highest concentration of 135 mg/L detected in well 600-19. Thallium was detected in six wells above the 0.0005 mg/L standard, with the highest concentration of 0.0048 mg/L detected in well 061-05.

Radionuclides. Detectable levels of tritium were found in three wells near BNL's southeastern site boundary (wells 049-06, 050-02, and 061-05), but the concentrations were well below the DWS of 20,000 pCi/L. The highest level of tritium during 2003 was detected in well 050-02 at a concentration of 1,980 pCi/L. Tritium was

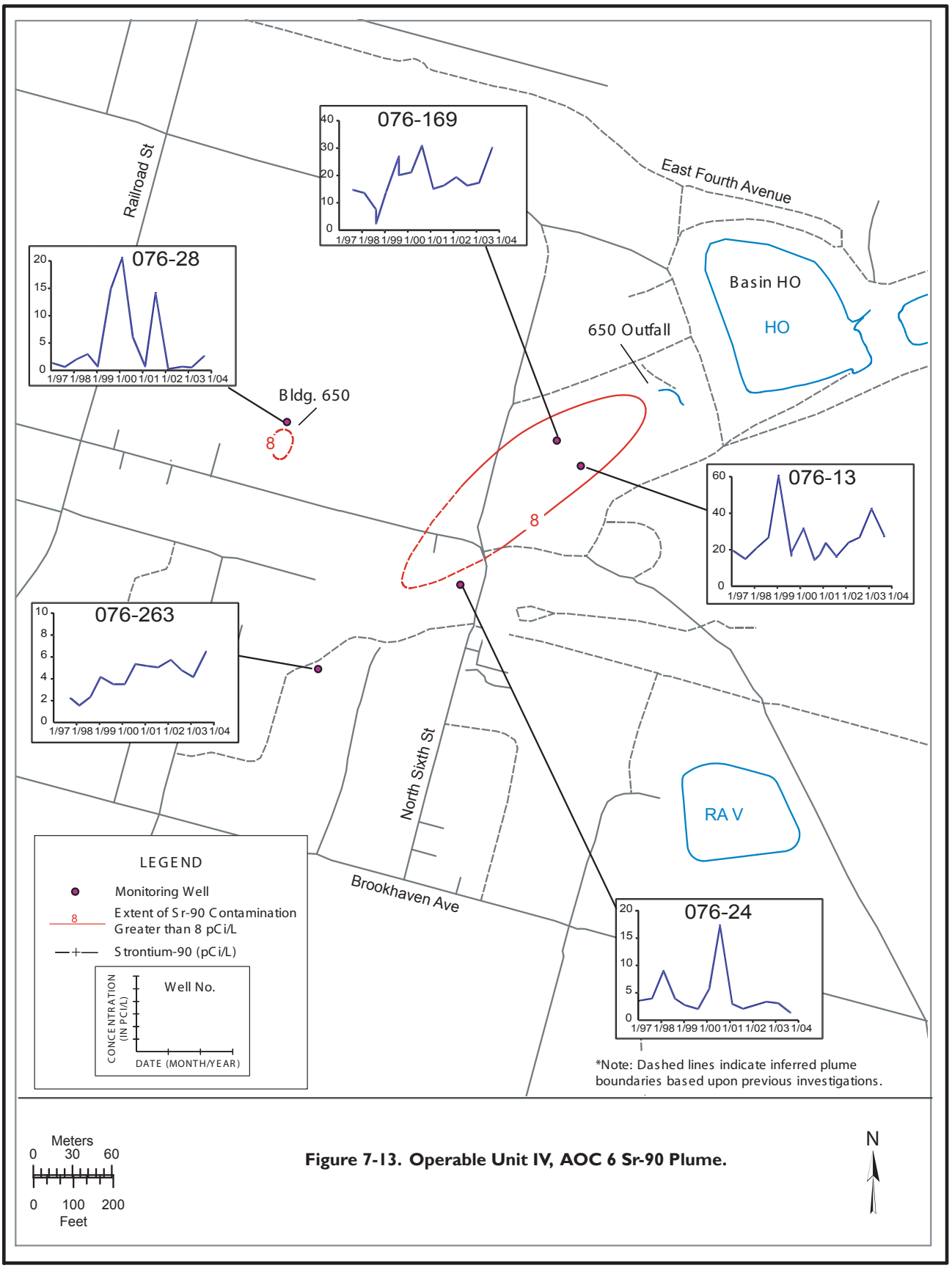

Figure 7-13. Operable Unit IV, AOC 6 Sr-90 Plume.

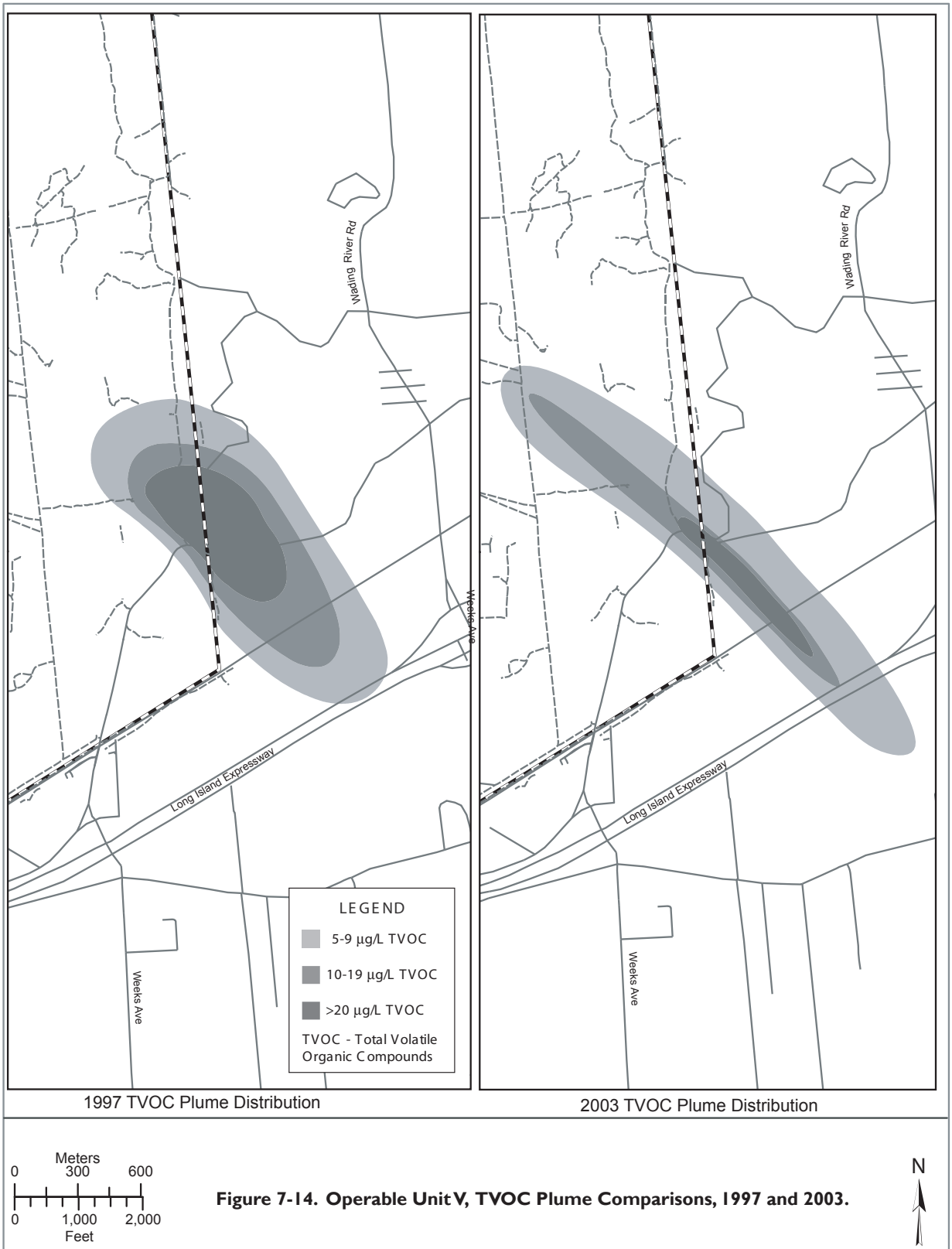

Figure 7-14. Operable Unit V, TVOC Plume Comparisons, 1997 and 2003.

Figure 7-15. Operable Unit VI, EDB Plume Comparisons, 1997 and 2003.

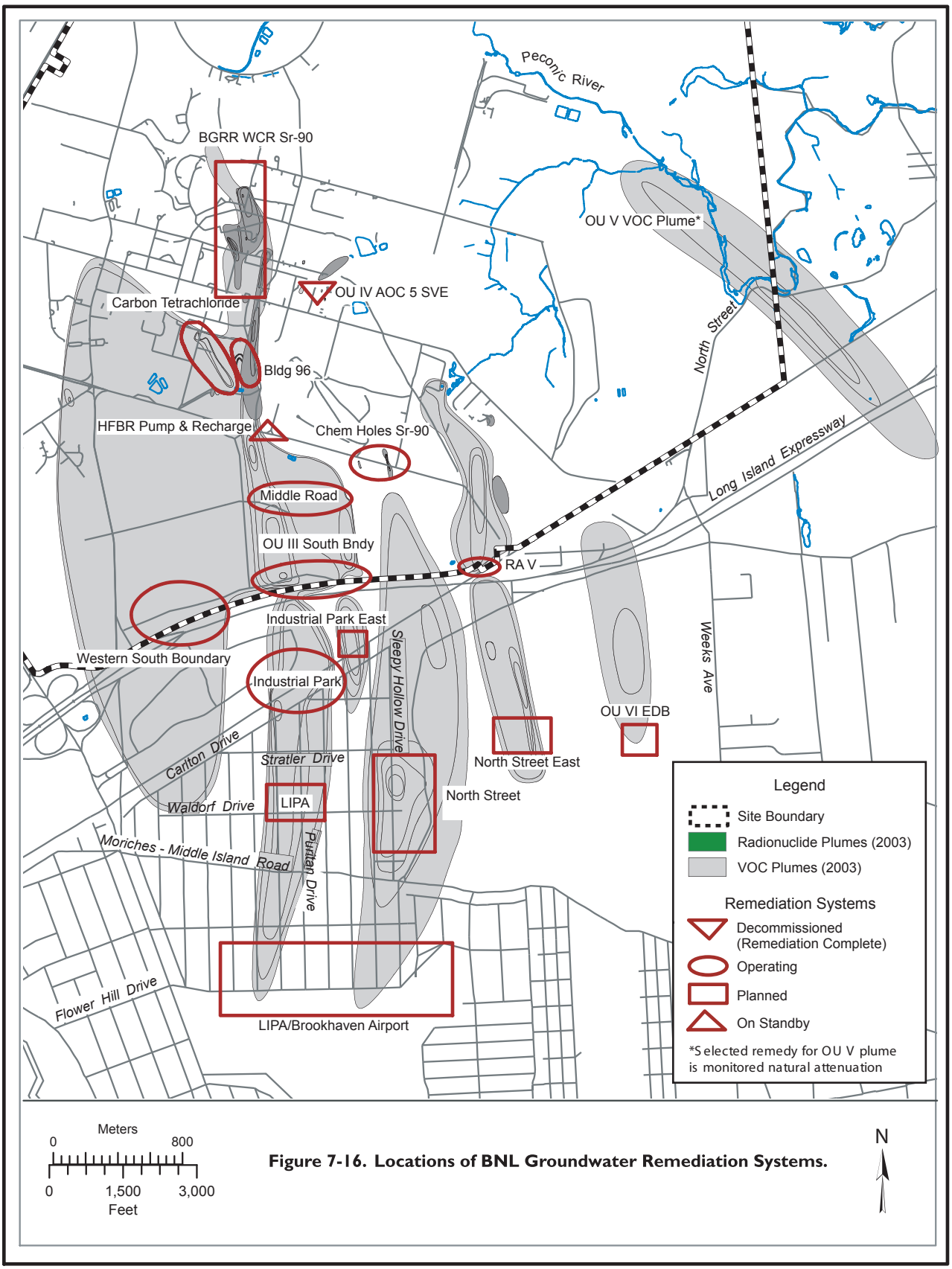

Figure 7-16. Locations of BNL Groundwater Remediation Systems.

Table 7-5. BNL Groundwter Remediation Systems Treatment Summary for 1997 through 2003.

Remediation System	Start Date	1997 – 2002 Water Treated (Gallons)	1997 – 2002 VOCs Removed (Pounds) (d)	2003 Water Treated (Gallons)	2003 VOCs Removed (Pounds) (d)
OU III South Boundary	June 1997	1,901,436,850	1,920	353,423,000	184
OU III Industrial Park	Sept. 1999	602,915,330	631	187,013,000	127
OU III Western South Boundary	Sept. 2002	74,287,000	12	138,761,000	10
Carbon Tetrachloride	Oct. 1999	122,798,300	327	27,348,000	14
OU I South Boundary	Dec. 1996	2,118,390,000	278	306,390,000	19
HFBR Tritium Plume (a)	May 1997	241,528,000	180	Not in Service	0
OU IV AS/SVE (b)	Nov. 1997	(c)	35	Decommissioned	0
Building 96	Feb. 2001	69,238,416	46	29,027,000	9
Middle Road	Oct. 2001	336,353,550	217	278,000,000	147
Total		5,466,947,446	3,646	1,341,199,330	510

Remediation System	Start Date	1997 – 2002 Water Treated (Gallons)	1997 – 2002 Sr-90 Removed (mCi)	2003 Water Treated (Gallons)	2003 Sr-90 Removed (mCi)
OU III Chemical Holes Sr-90	Feb. 2003	Not in Service	0	3,834,826	0.88

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 system performance is measured by pounds of VOC removed per cubic feet of air treated.
(d) Values are rounded to the nearest whole number.

not detected in any of the off-site monitoring wells. A detailed discussion on the distribution of tritium within the OU V area is provided in the 2003 BNL Groundwater Status Report (BNL 2004c). Gross alpha and gross beta levels were consistent with established background levels for the site.

7.6.6 Operable Unit VI, Biology Fields

Ethylene dibromide (EDB) was used as a fumigant in the BNL Biology Department's agricultural fields in the southeast portion of the site. Available records indicate that the application of EDB in this area took place in the 1970s. As the result of these historical releases of EDB, a contaminant plume (as defined by concentrations greater than the 0.05 µg/L DWS for EDB) extends approximately 4,600 feet, from near BNL's southeastern site boundary to an area south of the Long Island Expressway (Figure 7-15). The leading edge of the plume is downgradient of wells 000-283 and 000-284. Additional sentinel wells to monitor the leading edge of the plume will be installed in 2004. The plume is located entirely in the deep Upper Glacial Aquifer. The highest EDB concentration observed during 2003 was 6.8 µg/L, in well 000-284. As in past years, no tritium was detected in samples from these wells.

A groundwater remediation system to address the off-site EDB plume is scheduled to begin operations in 2004. Detailed information on this remediation system is presented in the OU VI EDB Plume Groundwater Remediation System 90 Percent Design Documents (J.R. Holzmacher, Inc. 2002b).

7.7 GROUNDWATER TREATMENT SYSTEMS

The primary mission of the Laboratory's Environmental Restoration Program is to remediate soil and groundwater contamination and prevent additional contamination from migrating off the BNL site. The cleanup goals are to 1) prevent or minimize plume growth, and 2) reduce contaminant concentrations in the Upper Glacial Aquifer to below regulatory standards within 30 years. In 2003, BNL continued to make significant progress in restoring groundwater quality on site. Eight groundwater remediation systems were operating by the end of 2003. Sixteen of the 17 planned groundwater remediation systems have been constructed. The HFBR Pump and Recharge System remained in standby mode following regulatory agency approval, and the OU IV Air Sparging/Soil Vapor Extraction system was decommissioned. Compared to 2002, the total groundwater cleanup treatment capacity was increased from 2,875 gallons per minute (gpm) to 2,925 gpm. Ultimately, the total groundwater cleanup capacity will be approximately 4,800 gpm. Figure 7-16 shows the locations of the current and planned groundwater treatment systems. Table 7-5 provides a summary of pounds of VOCs and curies of radioactivity removed and gallons of water treated during 1997–2003. During 2003, 510 pounds of VOCs and 0.88 mCi of Sr-90 were removed from the groundwater and more than 1 billion gallons of treated groundwater were returned to the aquifer. Detailed information on these treatment systems can be found in the 2003 BNL Groundwater Status Report (BNL 2004c).

It is expected to take up to 10 years of aquifer treatment before widespread improvements in groundwater quality at BNL are achieved. Even so, some noticeable improvements in groundwater quality are evident in OU I South Boundary, OU III South Boundary, OU IV, Building 96, and the Carbon Tetrachloride Area. Groundwater remediation activities are expected to continue until approximately 2030 to meet the ultimate cleanup objective.

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8 Radiological Dose Assessment

Brookhaven National Laboratory routinely assesses its operations to ensure that any potential radiological dose to the public, BNL workers, and the environment is "As Low As Reasonably Achievable." All scientific and research activities at BNL that can adversely affect health and safety or contribute to dose are evaluated for mitigation. 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 pathways, such as radiation sources, inhalation, ingestion, and skin absorption. Radiological dose assessment has routinely shown that the Effective Dose Equivalent from BNL operations is well below the EPA and DOE regulatory dose limits to the public and the environment.

The yearly ambient external dose was 64 ± 10 mrem (640 ± 100 μSv) on site and 61 ± 9 mrem (610 ± 90 μSv) at off-site locations. Both of these measurements include contributions from cosmic and natural background radiation sources. A statistical comparison of the average doses from 56 on-site and 18 off-site thermoluminescent dosimeters showed that there was no additional contribution to dose from BNL operations above natural background radiation. The Effective Dose Equivalent from the air pathway was calculated as 5.96E-2 mrem (0.6 μSv) to the MEI. The ingestion pathway dose was estimated as 2.18 mrem (22 μSv) from venison consumption and 0.19 mrem (1.9 μSv) from consumption of fish caught at Swan Pond. BNL's total annual dose to the MEI from all pathways was estimated as 2.43 mrem (24 μSv). In comparison, EPA's annual regulatory dose limit is 10 mrem (100 μSv) for the air pathway, and DOE's annual dose limit is 100 mrem (1,000 μSv) from all pathways.

Dose to aquatic and terrestrial biota also were evaluated and found to be well below the DOE regulatory limits. Remediation and waste management projects conducted in 2003 were evaluated for radiological emissions and dose impact. It was concluded that there was no significant dose and radiological risk to the public or the environment from these activities. The dose impact from all BNL activities in 2003 was found to be insignificant above natural background radiation levels.

8.1 DIRECT RADIATION MONITORING

External direct radiation monitoring is implemented at BNL to measure the direct dose impact to members of the public and workers from radiation sources. 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 are then compared to each other's averages (using the statistical t-test) to evaluate varia-

tion and the contribution from BNL operations above natural background radiation.

Direct penetrating beta-gamma radiation is measured using thermoluminescent dosimeters (TLDs). The principle of TLD operation is that when certain crystals are exposed to radiation, impurities in the crystals' low-temperature trapping sites for the electrons are excited to higher energy states. These electrons remain in a high-energy state at normal ambient temperature. When the TLDs are heated, electrons return to the lower energy state. The electrons emit photon energy (i.e., light), which is measured with a photomultiplier tube; the light intensity given out is directly proportional to the absorbed dose of radiation. The environmental TLDs used at BNL are composed of calcium fluoride and lithium fluoride. The TLDs' accuracy is verified by using TLDs exposed to known sources of radiation as controls, and by participating in the inter-comparison testing programs. The instrument that reads the dosimeter is calibrated to read absorbed dose—that is, quantity of energy deposited by radiation in the tissue or mass of the material.

8.1.1 Ambient Monitoring

To assess the impact of direct radiation from BNL operations, TLDs are deployed at the BNL site and in the 16 wind sectors of the surrounding communities. On-site TLD location selection criteria are based on the potential for exposure to gaseous plumes, atmospheric particulates, and radiation-generating facilities. Also, BNL perimeter areas are posted with TLDs to assess potential impact beyond the Laboratory boundary. On- and off-site areas are divided into grids and each TLD is assigned an identification code based on these grids.

Fifty-six TLDs were deployed on site and 18 were deployed off site in 2003, as shown in Figures 8-1 and 8-2, respectively. An additional 30 control TLDs were stored in a lead-shielded container in Building 490; the average of the control TLDs is reported as "075-TLD4" in Tables 8-1 and 8-2, for comparison. Note that it is not possible to completely shield the control devices from all natural background and cosmic radiation or completely eliminate residual dose on the control TLDs;

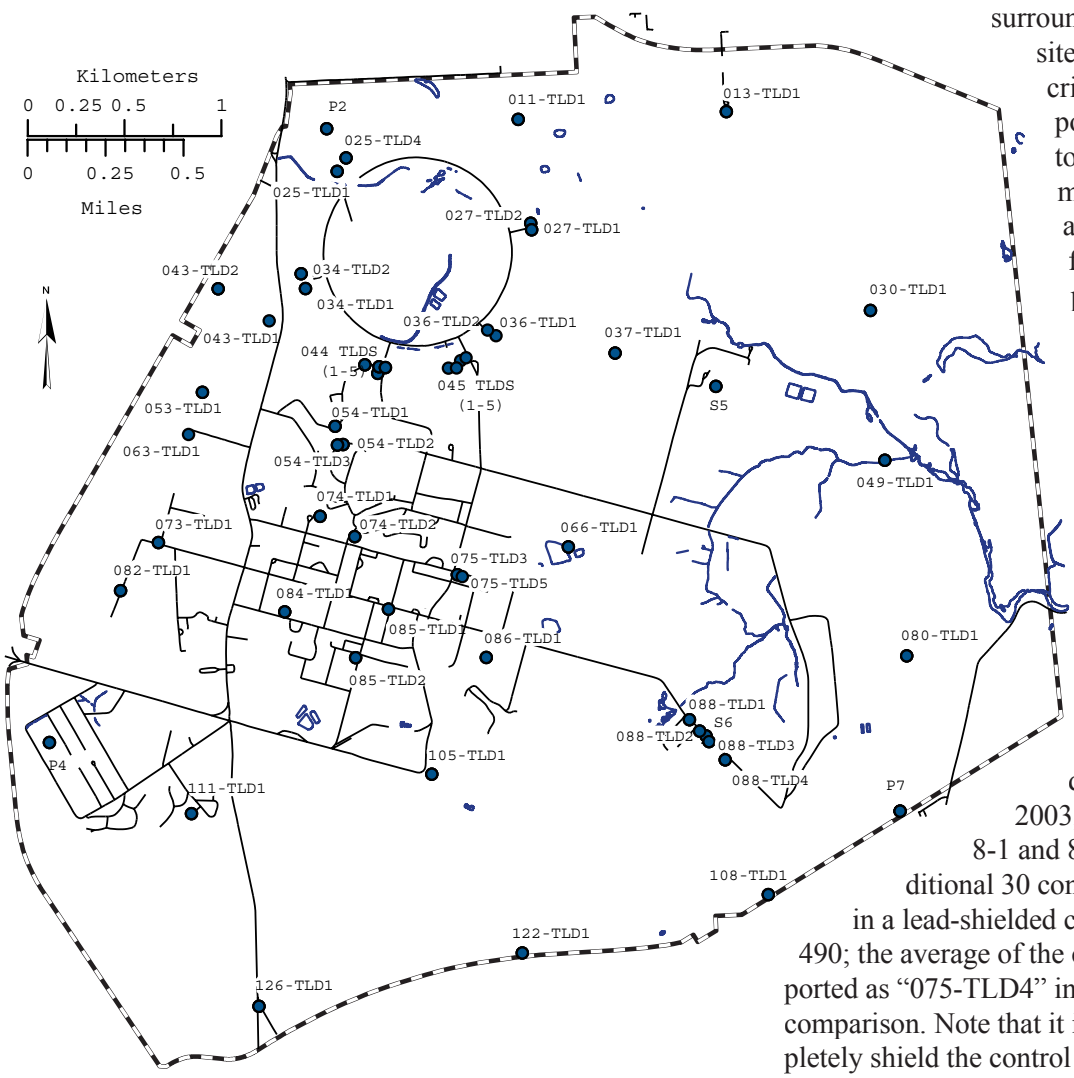

Figure 8-1. On-Site TLD Locations.

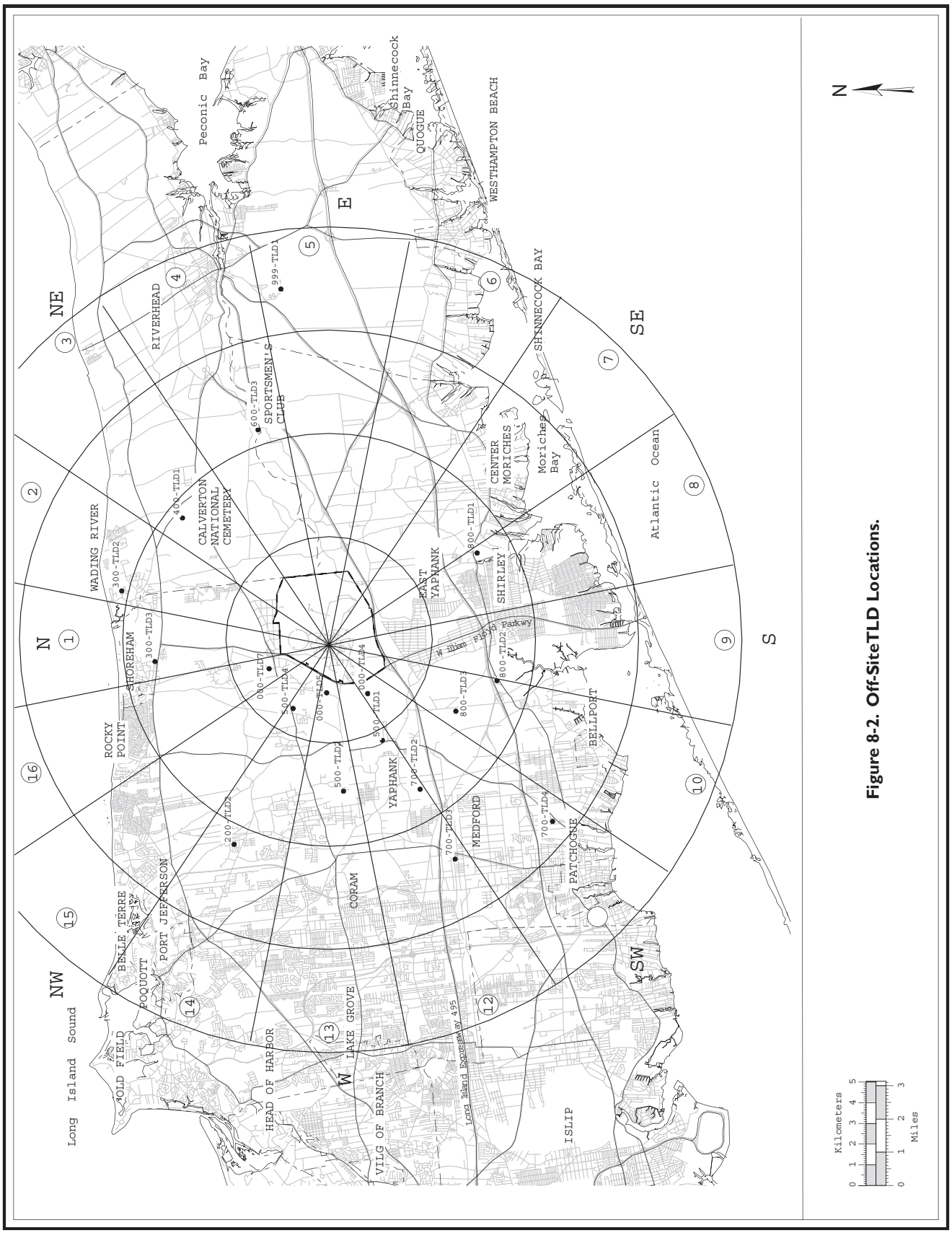

Figure 8-2. Off-SiteTLD Locations.

therefore, small doses are measured by the control TLDs. The on- and off-site TLDs were collected and read quarterly to determine the direct external radiation dose.

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 16.4 ± 3.6, 15.0 ± 3.0, 14.8 ± 3.2, and 17.7 ± 3.8 mrem, respectively. The annual on-site external dose from all potential sources, including the contribution from cosmic and terrestrial radiation sources was 64 ± 10 mrem. Table 8-2 shows the quarterly and yearly off-site radiation dose measurements to determine the BNL contribution to the ambient external radiation dose. The off-site average external dose for the first, second, third, and fourth quarters was 16.0 ± 2.7, 14.4 ± 2.6, 14.1 ± 2.4, and 16.0 ± 2.8 mrem, respectively. The annual off-site average ambient dose was 61 ± 9 mrem. A statistical t-test between the external dose averages shows no significant difference from off site (61 ± 9 mrem) and on site (64 ± 10 mrem) locations. In conclusion, there was no external dose contribution to on- and off-site locations from BNL operations.

8.1.2 Facility Area Monitoring

Seven of the 56 on-site TLDs were designated as the Facility Area Monitors (FAM). These TLDs were deployed at locations known to have radiation sources or radiological contamination with significantly higher probability to contribute to the external radiation doses. Table 8-3 shows the external doses measured with the FAM TLDs. TLDs are posted at the S-6 blockhouse location and on the fence of the Former Waste Management Facility (FWMF) (088-TLD1 through 088-TLD4). These TLDs measured much higher external dose than typical natural background dose measured in the vicinity and the doses were above the on-site average. The high external dose measured can be attributed to the presence of radioactive materials, contaminated soil, and radioactive sources that were being repackaged for shipment to a radiological waste disposal site. Dose rate comparison from the previous years has shown that the dose rates are declining contiuously as the radioactive materials are being removed and other remediation actions are implemented. The FWMF is currently posted as a radiological area and only radiation-trained personnel wearing personal dosimeters are allowed inside the facility until all the contaminated soil is removed or remediated.

Two TLDs (075-TLD3 and 075-TLD5) posted near Building 356 also showed higher quarterly averages, 29 ± 8 mrem and 33 ± 9 mrem, respectively. The yearly doses were recorded to be as high as 118 ± 34 mrem for 075-TLD3, and 131 ± 36 mrem for 075-TLD5. The doses are significantly higher than on-site annual average. These elevated measurements can be attributed to the sky-shine phenomenon and shielding buildup in Building 356 that has a cobalt source, which is used to irradiate materials, parts, and electronic circuit boards. The potential radiological exposure from Building 356 is in the parking lot area, but because the occupancy factor for the parking lot is low, the dose impact to the worker was minimal.

8.2 AIR EMISSIONS

EPA regulates emission 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 emissions greater than 10 mrem (100 μSv) per year from DOE operations. The emission monitoring requirements are set forth in Subpart H, Section 61.93(b) which include the use of a reference method for continuous monitoring at major release points (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 discussed in more detail in Chapter 4, Section 4.1.

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	14.3	NP	14.8	15.2	15 ± 1	59 ± 4
013-TLD1	North firebreak	15.1	13.5	12.9	16.3	14 ± 3	58 ± 12
025-TLD1	Bldg. 1010 beam stop 1	16.9	14.3	12.6	15.8	15 ± 4	60 ± 15
025-TLD4	Bldg. 1010 beam stop 4	20.0	14.2	15.4	16.3	16 ± 5	66 ± 20
027-TLD1	Bldg. 1002A South	13.5	13.8	13.0	14.7	14 ± 1	55 ± 6
027-TLD2	Bldg. 1002D East	13.5	15.9	14.0	15.9	15 ± 2	59 ± 10
030-TLD1	NE Firebreak	15.2	12.9	14.5	16.6	15 ± 3	59 ± 12
034-TLD1	Bldg. 1008 collimator 2	16.1	15.7	13.7	17.2	16 ± 3	63 ± 11
034-TLD2	Bldg. 1008 collimator 4	16.3	16.1	15.0	16.3	16 ± 1	64 ± 5
036-TLD1	Bldg. 1004B East	15.1	13.8	12.2	15.9	14 ± 3	57 ± 13
036-TLD2	Bldg. 1004 East	17.3	18.9	15.6	19.7	18 ± 4	72 ± 14
037-TLD1	S-13	16.4	14.4	13.3	17.2	15 ± 4	61 ± 14
043-TLD1	North access road	16.8	15.5	14.9	18.1	16 ± 3	65 ± 11
043-TLD2	North of Met. Tower	18.4	15.5	16.7	17.7	17 ± 2	68 ± 10
044-TLD1	Bldg. 1006	20.0	15.0	14.3	16.6	16 ± 5	66 ± 20
044-TLD2	South of Bldg. 1000E	14.5	15.4	13.8	17.2	15 ± 3	61 ± 12
044-TLD3	South of Bldg. 1000P	14.7	15.7	13.5	16.0	15 ± 2	60 ± 9
044-TLD4	NE of Bldg. 1000P	16.0	17.4	15.0	17.9	17 ± 3	66 ± 10
044-TLD5	N of Bldg. 1000P	14.8	16.5	14.3	17.2	16 ± 3	63 ± 11
045-TLD1	Bldg. 1005S	16.4	15.3	14.6	17.8	16 ± 3	64 ± 11
045-TLD2	East of Bldg. 1005S	15.8	17.4	14.8	21.5	17 ± 6	70 ± 23
045-TLD3	S/E of Bldg. 1005 S	15.2	17.3	15.1	17.9	16 ± 3	66 ± 11
045-TLD4	S/W of Bldg. 1005 S	14.3	14.7	15.6	16.5	15 ± 2	61 ± 8
045-TLD5	WS/W of Bldg. 1005 S	13.1	13.8	11.8	14.9	13 ± 3	54 ± 10
049-TLD1	East firebreak	15.5	12.6	14.9	16.2	15 ± 3	59 ± 12
053-TLD1	West firebreak	18.3	15.9	18.0	18.8	18 ± 3	71 ± 10
054- TLD1	Bldg. 914	17.2	13.7	12.5	15.7	15 ± 4	59 ± 16
054-TLD2	N/E of Bldg. 913-B	16.5	16.0	15.6	20.7	17 ± 5	69 ± 19
054-TLD3	N/W of Bldg. 913-B	15.1	15.4	13.2	21.3	16 ± 7	65 ± 27
063-TLD1	West firebreak	17.4	14.0	16.6	18.8	17 ± 4	67 ± 16
066-TLD1	New HWM Facility	14.7	11.0	13.3	17.3	14 ± 5	56 ± 21
073-TLD1	West Met. Twr. /Bldg. 51	17.9	16.2	16.1	18.7	17 ± 3	69 ± 10
074-TLD1	Bldg. 197	19.1	17.4	15.1	17.9	17 ± 3	70 ± 13
074-TLD2	Bldg. 907	16.6	15.6	15.6	16.5	16 ± 1	64 ± 4
080-TDL1	East firebreak	17.0	14.7	18.3	23.0	18 ± 7	73 ± 27
082-TLD1	West firebreak	17.8	16.6	15.9	18.2	17 ± 2	69 ± 8
084-TLD1	Tennis courts	18.4	14.4	16.1	18.5	17 ± 4	67 ± 15
085-TDL2	Upton gas station	16.3	14.2	15.8	20.7	17 ± 5	67 ± 22
085-TLD1	TFCU (Credit Union)	17.6	15.4	16.3	20.2	17 ± 4	70 ± 16
086-TLD1	Baseball fields	19.6	16.3	18.9	22.3	19 ± 5	77 ± 19
105-TLD1	South firebreak	22.0	14.1	15.7	17.8	17 ± 7	70 ± 27
108-TLD1	Water tower	16.0	16.2	14.9	16.4	16 ± 1	64 ± 5
111-TLD1	Trailer park	16.0	13.2	15.6	16.5	15 ± 3	61 ± 11
122-TLD1	South firebreak	16.0	13.2	14.7	17.5	15 ± 4	61 ± 14
126-TLD1	South gate	17.7	14.0	17.4	19.5	17 ± 4	69 ± 18
P2		14.3	12.6	11.7	15.4	13 ± 3	54 ± 13
P4		15.9	15.7	13.8	16.2	15 ± 2	62 ± 9
P7		16.0	14.3	13.7	16.4	15 ± 3	60 ± 10
S5		15.7	13.6	13.4	19.1	15 ± 5	62 ± 21
On-site average		**16.4**	**15.0**	**14.8**	**17.7**	**16 ± 3**	**64 ± 10**
Std. dev. (2 σ)		**3.6**	**3.0**	**3.2**	**3.8**		
075-TLD4	**Control TLD average**	11.5	12.2	10.4	9.4	11 ± 2	44 ± 10

Notes:
NP = TLD not posed for the quarter.
See Figure 8-1 for TLD locations.

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	14.4	13.3	13.7	14.6	14 ± 1	56 ± 5
000-TLD5	Smith Estate	16.1	14.6	13.4	15.5	15 ± 2	60 ± 9
000-TLD7	Mid-Island Game Farm	15.6	13.6	14.2	17.1	15 ± 3	61 ± 12
200-TLD2	Private property	18.1	16.9	16.4	17.8	17 ± 2	69 ± 6
300-TLD2	Private property	16.0	16.5	15.2	NP	16 ± 1	64 ± 5
300-TLD3	Private property	17.9	13.3	14.4	15.1	15 ± 4	61 ± 15
400-TLD1	Calverton Nat. Cem.	L	15.2	NP	18.1	17 ± 4	67 ± 16
500-TLD1	Private property	13.5	11.7	11.7	12.8	12 ± 2	50 ± 7
500-TLD2	Private property	14.5	12.6	13.1	14.7	14 ± 2	55 ± 8
500-TLD4	Private property	15.2	14.0	14.3	16.7	15 ± 2	60 ± 10
600-TLD3	Sportsmen's Club	15.1	15.0	13.7	15.6	15 ± 2	59 ± 6
700-TLD2	Private property	15.0	NP	13.6	15.0	15 ± 2	58 ± 6
700-TLD3	Private property	15.9	14.4	13.1	16.9	15 ± 3	60 ± 13
700-TLD4	Private property	18.8	15.0	16.0	17.4	17 ± 3	67 ± 13
800-TLD1	Private property	16.0	13.9	14.6	15.6	15 ± 2	60 ± 7
800-TLD2	Private property	17.1	14.9	NP	NP	16 ± 3	64 ± 12
800-TLD3	Suffolk County CD	16.3	15.2	14.9	17.1	16 ± 2	64 ± 8
999-TLD1	Private property	15.7	13.9	12.7	15.2	14 ± 3	58 ± 11
Off-site average		**16.0**	**14.4**	**14.1**	**16.0**	**15 ± 2**	**61 ± 9**
Std. dev. (2 σ)		**2.7**	**2.6**	**2.4**	**2.8**		
075-TLD4	Control TLD average	11.5	12.2	10.4	9.4	11 ± 2	44 ± 10

Notes:
L = TLD lost in the field.
NP = TLD not posted for the quarter.
See Figure 8-2 for TLD locations.

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)					
S6		29.0	24.8	27.9	34.8	29 ± 8	116 ± 33
088-TLD1	FWMF-50' East of S-6	38.6	35.8	34.4	41.6	38 ± 6	150 ± 25
088-TLD2	FWMF-50' West of S-6	39.8	37.2	37.7	52.7	42 ± 14	167 ± 57
088-TLD3	FWMF-100' West of S-6	36.6	33.7	36.3	43.6	38 ± 8	150 ± 33
088-TLD4	FWMF-150' West of S-6	22.4	20.7	20.4	25.4	22 ± 4	89 ± 18
075-TLD3	Bldg. 356	34.1	24.4	27.5	31.6	29 ± 8	118 ± 34
075-TLD5	North Corner of Bldg. 356	39.6	30.6	29.4	31.3	33 ± 9	131 ± 36

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

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
463	Biology Facility	None	2.84E-11	(b)
490	Medical Research	BNL-489-01	7.91E-12	(b)
490	Radiation Protection (ASL)	None	1.61E-6	(b)
491	BMRR	None	ND	(c), (e)
510	Calorimeter Enclosure	BNL-689-01	ND	(f)
510A	Physics	None	2.91E-9	(b)
535	Instrumentation	None	5.81E-13	(b)
555	Chemistry Facility	None	1.29E-10	(b)
703	Analytical Laboratory	None	ND	
725	National Synchrotron Light Source	None	1.44E-10	(b)
750	HFBR	None	2.63E-6	(c)
801	Target Processing Lab	None	1.09E-10	(b), (c)
802B	Evaporator Facility	BNL-288-01	N.O.	(e)
820	Accelerator Test Facility	BNL-589-01	ND	(d)
830	Environmental Science Department	None	4.48E-10	(d)
865	Reclamation Building	None	6.19E-7	(c)
906	Medical-Chemistry	None	2.22E-9	
931	BLIP	None	5.96E-2	(c)
938	REF/NBTF	BNL-789-01	ND	(g)
942	AGS Booster	BNL-188-01	ND	(h)
---	RHIC	BNL-389-01	ND	(d)
Total Potential Dose from BNL Operations			**5.96E-2**	
EPA Limit			**10.0 mrem**	

Notes:
Diffuse, Fugitive, and Other sources are not included in this table since they are short term emissions
AGS = Alternating Gradient Synchrotron
BLIP = Brookhaven Linac Isotope Producer
BMRR = Brookhaven Graphite Research Reactor
HFBR = High Flux Beam Reactor
MEI = Maximally Exposed Individual
NBTF = Neutron Beam Test Facility
REF = Radiation Effects Facility
RHIC = Relativistic Heavy Ion Collider

(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 2003.
(e) N.O. = Not operational in 2003.
(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.

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 dose contribution, if any, to the environment. A number of ER and Waste Management (WM) activities were evaluated in 2003 for NESHAPs compliance. EPA's approved dose modeling software was used in dose calculations (see Section 8.2.1 for details). Because this software was designed to treat all radioactive emission sources as continuous chronic emissions that

occur over the course of a year, it is not well suited for estimating short-term or acute releases. Consequently, it overestimates potential contributions to dose from such sources and 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). Beta version 3.0 of the software was used for calculations in 2003, except for calculations involving the Brookhaven Linac Isotope Producer (BLIP), for which version 2.0 was used. 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 for 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. The CAP88-PC model provides very conservative (overestimated) dose, in most cases. 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-level environmental releases and chronic intakes for a year. The input parameters used in the model include radionuclide type, emission rate in curies 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 temperature (see Chapter 1 for details). Population data used in the model are based on the Long Island Power Authority population survey (LIPA 1999). 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 Maximally Exposed Individual

The MEI is defined as a hypothetical person who resides at the site boundary and has a lifestyle such that no other member of the public could receive a higher dose than the MEI. This person is assumed to reside 24 hours a day, 365 days a year at the BNL boundary in the downwind direction, and consumes significant amounts of contaminated fish and deer based on projections from the New York State Department of Health (NYSDOH, 1999). In reality, it is a highly unlikely, worst-case scenario that such a combination of "maximized dose" to any single individual would occur, but it is used to evaluate the maximum potential risk and dose.

8.2.3 Doses from Diffuse, Fugitive, and Other Sources

Diffuse sources are radioactive contaminants (emissions) released into the atmosphere that do not have a well-defined source point. Such sources are also known as nonpoint or area sources. The following potential radiological diffuse sources were evaluated in 2003 for their contribution to the overall BNL site dose.

8.2.3.1 BGRR Remediation Project

The Brookhaven Graphite Research Reactor (BGRR) has been identified as Area of Concern (AOC) 9B (Removal Action #3) in the Interagency Agreement between EPA, DOE, and the New York State Department of Environmental Conservation (NYSDEC). The Below Ground Duct (BGD) is located in Building 701 of BGRR. As part of the BGRR decommissioning project, the removal of the BGD filters was initiated in 2003. The removal of the duct liner will follow after the removal of the filters is completed. The Duct Service Building (DSB) is a temporary structure (30 ft wide, 76 ft long, and 30 ft high at the center, on a 10-in. concrete slab) that was erected to facilitate the removal of the contaminated filters and duct liners.

Two Brokk Model 360 diesel-powered, radio-remote controlled manipulators were used

to remove the contaminated filters. The remote manipulators were used because the area is highly contaminated and the exposure rates are extremely high. All controls for the Brokk machines were located at a video console in the instrument room. Each Brokk machine has two forward video cameras and one rear-facing camera. The Brokk machines could be fitted with various tools (such as, a steel plate sawing system, clamshell bucket, impact hammer, shearing tools, and tool holders) to remotely perform any required task. These tools were used to size reduce the filters into pieces small enough to be carried through the vacuum hose to a cyclone separator in the DSB. Any loose surface contamination and debris were removed via vacuuming. The separated solids and pieces that could not be reduced in size were then packaged into shipping containers for off-site disposal.

The DSB and BGD were maintained at negative pressure with high-efficiency particulate air (HEPA) filters to prevent release of contamination and particulate emission. Two self-contained skid-mounted 6,000 cfm HEPA-filtered ventilation units were used to minimize contaminant release. Airborne particulate and charcoal monitoring was implemented in accordance with the ANSI/HPS N13.1-1999 standard at the exhausts of the single 26-in.-diameter duct for decommission and decontamination (D&D) work. The source term was based on the Table of Isotopic Radionuclides Concentrations in the Safety Analysis Document (BGRR-SE-03-01). The potential EDE was calculated to be 1.50E-05 mrem in a year to the MEI. The air particulate samples and charcoal samples collected at the BGRR exhaust duct showed that emission to the environment was well below the minimum detection levels. Therefore, it was concluded that there was no dose risk or any significant impact to the environment from D&D work at the BGRR.

8.2.3.2 Medical-Chemistry Building 906

The Chemistry Department uses radiotracers for animal neuroimaging research in Building 906. The potential emission source is the exhalation of butane labeled with carbon-11 (C-11, half-life: 20.38 minutes). A mushroom type fan is located on the west side of Building 906, about 3 meters above ground level, which exhausts the room air to the outside.

The source term was based on the potential estimate of the C-11–labeled butane used during the year, nearly 5.0E-02 Ci. The source term calculations were based on 10 mCi of C-11–labeled butane gas that was injected into the animal, with a total of five experiments planned over the course of year, so the total source available for dispersion would be 50 mCi. Even though only a miniscule fraction of this activity would be released in the work area via exhalation, it was assumed that the complete inventory of 50 mCi of C-11 was released into the environment. Also, the decay correction was not performed, to assume a worst-case scenario. A conservative (overestimated) EDE to the MEI from the neuroimaging experiment was 2.9E-06 mrem in a year. Furthermore, this dose calculation was based on five experiments, but only two experiments were completed during the year; therefore, the actual dose consequences would be even less than the estimated dose.

8.2.3.3 Former Waste Management Facility Remediation

The FWMF was a Resource Conservation and Recovery Act (RCRA) permitted facility for processing and storage of radioactive and mixed wastes generated at BNL. The FWMF is located south of Brookhaven Avenue in the southeast wind sector of the Laboratory. Eight buildings and structures were scheduled for D&D, as follows:

1. Building 444 was used for handling chemical waste and incinerating waste materials. This metal building had an area of approximately 1,500 ft^2 and was built on a concrete slab. There was a 1,000-gallon No.2 fuel oil underground storage tank (UST) on the east side of the building in an unpaved area. The initial phases of the D&D project included removal, stabilization, and repackaging of the UST, oil-contaminated soil, and the associated pipes. On the west side of Building 444, there was a drywell (buried open-top 55-gallon drum with a gravel base). The remediation work included demolition of

Building 444 and removal and disposal of the UST, dry well, and associated concrete slab, along with the debris.

2. Building 445 was an office building constructed with concrete block walls, a concrete slab floor, and a metal roof. The floor area was approximately 3,700 ft^2. The remediation project encompassed the demolition of Building 445 and removal of its concrete slab, an associated UST and septic tank, and other debris. A 1,000-gallon No. 2 fuel oil UST was located on the west side of Building 445 (outside of the radiological boundaries). A septic tank on the south side of Building 445 was included in the D&D work.
3. Building 446 was a radioactive waste-sorting barn constructed with insulated metal walls and a metal roof, built on a concrete slab. The building's area was approximately 1,600 ft^2. On the north side of Building 446 was a 275-gallon No. 2 fuel oil aboveground storage tank on a concrete slab. This tank met the free-release criteria. The D&D work included the demolition and removal of Building 446 and its concrete slab.
4. Building 447, approximately 580 ft^2 in size, was a rigging shed made of insulated metal and built on a concrete slab. The D&D work included demolition and removal of the building and its concrete slab.
5. Building 448, a 1,500-ft^2 metal building, was used as the chemical receiving barn. The D&D work included the demolition and removal of Building 448 and its concrete slab.
6. Building 483 was a 2,000-ft^2, three-sided fiberglass-panel shed with a metal roof, used for waste storage. Framing consisted of steel columns and girders. The D&D work included the demolition and removal of the building.
7. The detonation-viewing bunker (Structure 625) was a concrete bunker used to confine the detonation of unstable chemicals. It was approximately 11 ft long, 11 ft wide, and 9 ft high. The D&D work included demolition of the concrete bunker and removal of the debris.
8. The Sprung/Tent structure was a temporary, octagonal tent used as an enclosure to mitigate the spread of contaminants during the removal of waste items. The remediation project included dismantling the tent structure, reducing it to small pieces, and subsequent packaging for off-site disposal.

The buildings in the FWMF were mostly built of metal or concrete, and had only small amounts of radioactive removable surface contamination. Because of the impracticality of conducting demolition in confined space and the prohibitive expense to install dedicated ventilation, HEPA filters, or a containment tent, the D&D work of the structures was performed in open area. The demolition was completed using heavy equipment, mechanical shearing, saw cutters or torch cutters, a ramhoe, or other viable means and methods to reduce the size of large components. Mobilization equipment (crane, clamshell, forklift, and flatbeds) was used to load the packaged radiological waste on to rail cars.

Workers used dust suppression control techniques such as spraying water mist on soil and applying adhesive to loose surface contamination to minimize and reduce the resuspension of aerodynamic particulates during all D&D work. An air particulate filter sample collection station was set up in the downwind direction to monitor releases, if any, during the D&D work. The radiological contamination characterization work at the FWMF was reviewed in order to develop the source term for dose calculations. Previous characterization work included radiological swipes of the walls and floors, area surveys, and soil sample analyses. The surface area and estimated volume of debris that was to be removed from the D&D work for the buildings listed above was considered in development of the source term. Dose modeling was based on the radionuclides characterized in the soil analyses. An EDE to the MEI was calculated to be 4.64E-02 mrem in a year at the southeast location. The downwind particulate filter sampling analyses showed that the actual airborne concentrations were well below the minimum detection levels, and therefore there was no dose contribution from the remediation activities.

8.2.3.4 Waste Management Facility

A NESHAPs review was completed for the proposed release of krypton-85 (Kr-85), an inert gas, through a fume hood that exhausts via a 30-ft stack in Building 865. The emission source was a small copper tube with 60 mCi of Kr-85 gas, dated 2/8/1988. It was decay-corrected to 22 mCi for the purpose of the dose calculation. For the release of the Kr-85 gas, the CAP88-PC synopsis report provided a conservative estimate of an EDE of 1.03E-08 mrem in a year to the MEI at the southeast location.

8.2.3.5 Neutron Am-Be Source

A 50-Ci americium-beryllium neutron source [^{241}Am-Be(α, n)] was acquired from Nuclear Materials and Equipment Corporation in 1965. The sealed neutron source was cylindrical and doubly encapsulated in a tantalum inner container and an outer stainless steel container. The ^{241}Am-Be(α, n) reaction had a flux intensity of 10^8 n/cm^2/sec, and average energy of 4.5 MeV. The activity after decay correction in 2003 was calculated to be 47 Ci. A radiological risk assessment was completed in case the integrity of the seal was breached, which would contaminate the building and could have dose consequences for the worker, other occupants of the building, and members of the public. Based on the loose surface contamination, resuspension factor, breathing rate under normal work conditions, and an occupancy factor, an intake of 2.08 E-05 µCi of americium was calculated. The americium derived air concentration was 3.0E-12 µCi. It was concluded that, if the source were breached, the intake of the worker would be below the annual limit on intake. The EDE to the MEI residing 2,500 meters in the southeast direction would be 0.1 mrem in a year if all the activity were to be released, which was an unlikely scenario. Again, it was concluded that the dose consequences would be minimal, in comparison to the regulatory limit of 100 mrem in a year.

8.2.4 Dose from Point Sources

8.2.4.1 Brookhaven Linac Isotope Producer

Source term descriptions for point sources are given in Chapter 4; however, an update on emissions from the BLIP is appropriate here because the BLIP is the only emission source with the potential to contribute dose to members of the public greater than 1 percent of the DOE limit. The BLIP facility uses the excess beam capacity of the Linac to produce short-lived radioisotopes for medical diagnostic procedures, medical imaging, and scientific research. During the irradiation process, the targets are cooled continuously by recirculating water in a 16-in.-diameter shaft. The principal gaseous radionuclides produced as a result of activation of the cooling water are oxygen-15 (O-15, with a 2-min. half-life), and C-11 (20.38-min. half-life).

Because the BLIP facility is considered a major emission source, 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 captured by conventional methods. Particulates and radioiodines are monitored with filter cartridges (conventional, and activated charcoal), which are exchanged weekly for analysis. The tritium sampler also operates continuously with weekly sample collection and analyses.

In 2003, the BLIP facility operated over a period of 16 weeks. The average proton beam current was measured to be 75 microamperes. During the year, 934 Ci of C-11 and 2,782 Ci of O-15 (both short-lived gases) were released from the facility. Tritium from activation of the targets' cooling water was also released, but in miniscule quantities. The EDE to the MEI was calculated to be 5.96E-02 mrem in a year from BLIP operations.

The total emissions from the facility decreased in 2003 in comparison to 2002, and an objective to further reduce emission is being pursued for the BLIP facility. Since moisture is the primary source of emissions (humidity from the Hot Cell's cooling water), a shroud seal was installed to enclose the cooling water surface (16-in.-diameter shaft), target holder transfer cases, chain drive assembly (including motor supports), and other associated appurtenances. The shroud seal engineering control is expected to significantly reduce (about 28 percent) the gaseous emissions from the BLIP facility. The

shroud seal was installed in January 2003. An inspection team from the EPA Office of Radiation and Indoor Air, Radiation Protection Division visited BNL in January 2003 and conducted an inspection of the BLIP facility with the new shroud seal construction. There were no compliance issues identified during the inspection, but a few documents in relation to the NESHAPs modeling program were requested and were provided to EPA.

The efficiency test of the shroud seal was not satisfactorily completed in 2003 because the BLIP runtime was short (16 weeks), beam power was not stable, and the detector calibration was questionable. Therefore, the shroud test will be completed in 2004 when BLIP receives the proton beam and becomes operational.

8.2.4.2 Brookhaven Medical Research Reactor

In January of 2003, the fuel elements from the Brookhaven Medical Research Reactor (BMRR) were shipped to an off-site location, greatly reducing any potential for radioactive emissions from the facility. The semi-annual particulate and charcoal air sampling data showed no quantifiable radioactive emissions from the BMRR. In September 2003, BNL requested approval from EPA to stop monitoring emissions at the BMRR. However, EPA requested clarification of the sampling data submitted and also required an additional round of sampling before making a final determination to eliminate BMRR emissions sampling. The BMRR reactor vessel's evaporation rate of tritium was estimated to be 76.3 mCi in a year, and the dose consequences to the MEI from the tritium emission were insignificant.

8.2.4.3 Sr-90 Unplanned Release

Personnel at the Waste Management Facility (WMF) at BNL are responsible for collecting, characterizing, consolidating, and repackaging hazardous radioactive waste materials for shipment to the off-site licensed disposal facilities. Building 865 (Reclamation Building) is the primary facility for handling radioactive waste. The waste handling activities are performed in accordance with Radiological Work Permits, Technical Work Documents, and Health and Safety procedures for the facility. In 2003, WMF personnel performed a transfer and repackaging of $SrSiO_3$ sources for off-site disposal. The transfer and repackaging of these sources was performed inside the WMF Shielded Cell in Bldg. 865 with remote viewing and handling. After the transfer of the $SrSiO_3$ stainless steel clad strips from a shielded storage cask into five Type B containers, the Sr-90/Y-90 micro spheres became airborne and triggered the alarm, most likely due to ruptured cladding. Differential pressure in the Shielded Cell was maintained to minimize dispersion of any loose surface contamination. The event lasted for approximately 8 hours before containment.

A NESHAPs evaluation was conducted to evaluate the potential dose to a member of the public from the Sr-90 unplanned release. The source term estimation was based on the assumption that all the activity present inside the Building 865 Hi-Bay area became airborne and was therefore dispersed into the environment. Based on the monitoring data and information provided on the NESHAPs Assessment Form, the source term for the NESHAPs evaluation was taken to be the maximum airborne concentration during the event (3.1E-10 μCi/mL), and a total release volume of 43,000 m^3 (exhaust flow rate, 3,200 ft^3 /min, x 480 minutes, x feet-to-meters conversion factor 0.028). The estimated radioactivity released to the environment from the event was 13.33 μCi. The potential EDE to the MEI situated in the northeast sector was estimated at 6.19E-07 mrem in a year. Therefore, the dose consequence from this event to the members of the public was insignificant.

8.3 INGESTION PATHWAY

Deer and fish bioaccumulate radionuclides in their tissues and organs, and therefore samples of these species 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 of the BNL site boundary used to assess the potential dose impact to the MEI. In order to estimate the dose impact, it was assumed that the MEI consumed 15 pounds of fish from the Peconic River and approximately 64 pounds of venison per year (NYSDOH 1999).

Twenty-one samples of deer meat (flesh) were used for the purpose of dose calculations. Potassium-40 (K-40) and cesium-137 (Cs-137) were the two radionuclides detected in these samples. K-40 is a naturally occurring radionuclide and is not related to BNL operations. The average K-40 concentrations were 3.2 ± 2.0 pCi/g in the flesh and 2.6 ± 0.3 pCi/g (wet weight) in the liver. The average Cs-137 concentrations were 1.5 ± 0.9 pCi/g in the flesh and 0.7 ± 0.1 pCi/g (wet weight) in the liver (average for the "off site and less than 1 mile radius" group). The potential dose from consuming deer meat with the average Cs-137 concentration was estimated as 2.18 mrem (22 μSv) per year. This is about 22 percent of the health advisory limit of 10 mrem (100 μSv) established by the New York State Department of Health.

In 2001, fish sampling was suspended on the BNL site because previous fish sampling had depleted the population of larger fish. As a result, it would require many smaller fish to be obtained for a sample size sufficiently large enough to complete all desired analyses and detection sensitivity. BNL will continue with the suspension to allow the on-site fish populations to recover and mature. In collaboration with the NYSDEC Fisheries Division, BNL maintains an ongoing program of collecting and analyzing fish from the Peconic River and surrounding freshwater bodies. In 2003, the largemouth bass samples collected by NYSDEC at Swan Pond had the highest concentration (0.55 pCi/g) of Cs-137, so this value was used to estimate EDE to the MEI (assuming consumption of 15 pounds of fish). The potential dose from consuming fish was estimated at 0.19 mrem (1.9 μSv) per year. It is highly unlikely that an individual would consume fish with the highest concentration from this location, but these data were used to estimate dose as a worst-case scenario to the MEI.

8.4 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 2.43 mrem (24 μSv), as shown in Table 8-5. 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 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.

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 about 300 mrem (3 mSv). A diagnostic chest x-ray would result in 5 to 20 mrem per exposure to a person. Using natural gas in homes yields about 9 mrem per year, cosmic radiation gives 26 mrem, and natural potassium in the body gives about 39 mrem of internal dose. Even with conservative estimates of dose from 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.

Table 8-5. BNL Site Dose Summary.

Pathway	Dose to Maximally Exposed Individual	Percent of DOE 100 mrem/year Limit	Estimated Population Dose per year
Inhalation			
Air	0.059 mrem (0.6 micro Sv)	<1%	0.24 person-rem
Ingestion			
Drinking water	None	None	None
Fish	0.19 mrem (2 micro Sv)	<1%	Not tracked
Deer Meat	2.18 mrem (22 micro Sv)	<3%	Not tracked
All Pathways	2.43 mrem (24 micro Sv)	<3%	0.24 person-rem

8.5 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 0.36 pCi/L of Sr-90 in surface waters at the HQ sampling location on the Peconic River (see Figure 5-8 for sampling stations). Soil samples were not collected, and therefore the terrestrial biota dose from soil was not evaluated. The dose to terrestrial animals was calculated to be 1.78E-07 Gy/day and to terrestrial plants at 2.76E-09 Gy/day. The doses to terrestrial animals and plants were well below the biota dose limit of 1 mGy. For calculating dose to aquatic animals, the Cs-137 sediment concentration of 1,470 pCi/kg at HM north; Am-241 at 252 pCi/kg at HM north, and Sr-90 concentration in surface water at HQ locations were used (see Figure 5-8 for sampling stations). The sum of aquatic animal dose was estimated to be 9.96E-06 Gy/day, and to riparian animals, the dose was 4.88E-05 Gy/day. Therefore, the dose to aquatic animals was well below the 10 mGy limit.

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9

Quality Assurance

Quality assurance (QA) is an integral part of every activity at BNL. A comprehensive program is in place to ensure that all environmental monitoring data meet QA and quality control requirements. Samples are collected and analyzed in accordance with standard operating procedures that are designed to ensure that samples are representative and data are reliable and defensible. Quality control in the 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 they are used to support decision making. The multilayered components of QA monitored at BNL ensure that all analytical data reported for the 2003 Site Environmental Report are reliable and of high quality.

In 2003, BNL used the on-site Analytical Services Laboratory (ASL) and four off-site contractor laboratories to analyze environmental samples. 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 testing, review of QA programs, and audits. The ASL ceased performing nonradiological analyses on October 31, 2003. After that time, nonradiological samples were sent to off-site analytical laboratories for the remainder of the year.

The laboratories performing radiological analyses (BNL's ASL and two contract laboratories) each scored 95 percent or better in state and federal laboratory testing programs. BNL's "overall satisfactory" score in radiological testing was 95.9 percent. In nonradiological performance evaluation testing, BNL received an Acceptable rating of 96.1 percent and the off-site contractor laboratories scored between 95 percent and 98 percent Acceptable. For the 458 radiological and nonradiological performance evaluation tests carried out in 2003, BNL's combined "overall satisfactory" score was 95.9 percent.

9.1 QUALITY PROGRAM ELEMENTS

As required by DOE Order 450.1, Environmental Protection Program, BNL has established a Quality Assurance/Quality Control (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, and DOE Order 414.1A, Quality Assurance. The responsibility for quality at BNL starts with the Laboratory Director and extends throughout the entire organization. The purpose of the BNL Quality Management (QM) System is to implement QM methodology throughout the various BNL management systems and associated processes to:

- Plan and perform BNL operations in a reliable and effective manner to minimize any

impact on the health and safety of the public, Laboratory employees, and the environment
- Standardize processes and support continual improvement in all aspects of BNL operations
- Enable the delivery of products and services that meet or exceed our 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 improvements. QC activities measure each process or service against the QA standards. QA/QC practices and procedures are documented in detail in manuals, plans, and a comprehensive set of standard operating procedures (SOPs) for environmental monitoring (EM-SOPs). Staff 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, Laboratory 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.

BNL environmental personnel determine sampling requirements using the EPA Data Quality Objective (DQO) process 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 the location, frequency, type of sample, analytical methods to be used, and a sampling schedule. These plans or the SOPs also specify data acceptance criteria. Contracts with off-site analytical laboratories are established as necessary. Detailed 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 laboratories in accordance with 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 2003, environmental monitoring samples were collected as specified by SOPs, the BNL Environmental Monitoring Plan (2003a), and project-specific work plans, as applicable. For example, the BNL Groundwater Monitoring Program Quality Assurance Project Plan (BNL 1999a) describes the QA program and QC requirements 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/database procedures. Because almost half of all environmental monitoring samples collected for BNL are of groundwater, this chapter uses groundwater procedures for many of the examples.

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 samples collected by outside contractors in 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 equip-

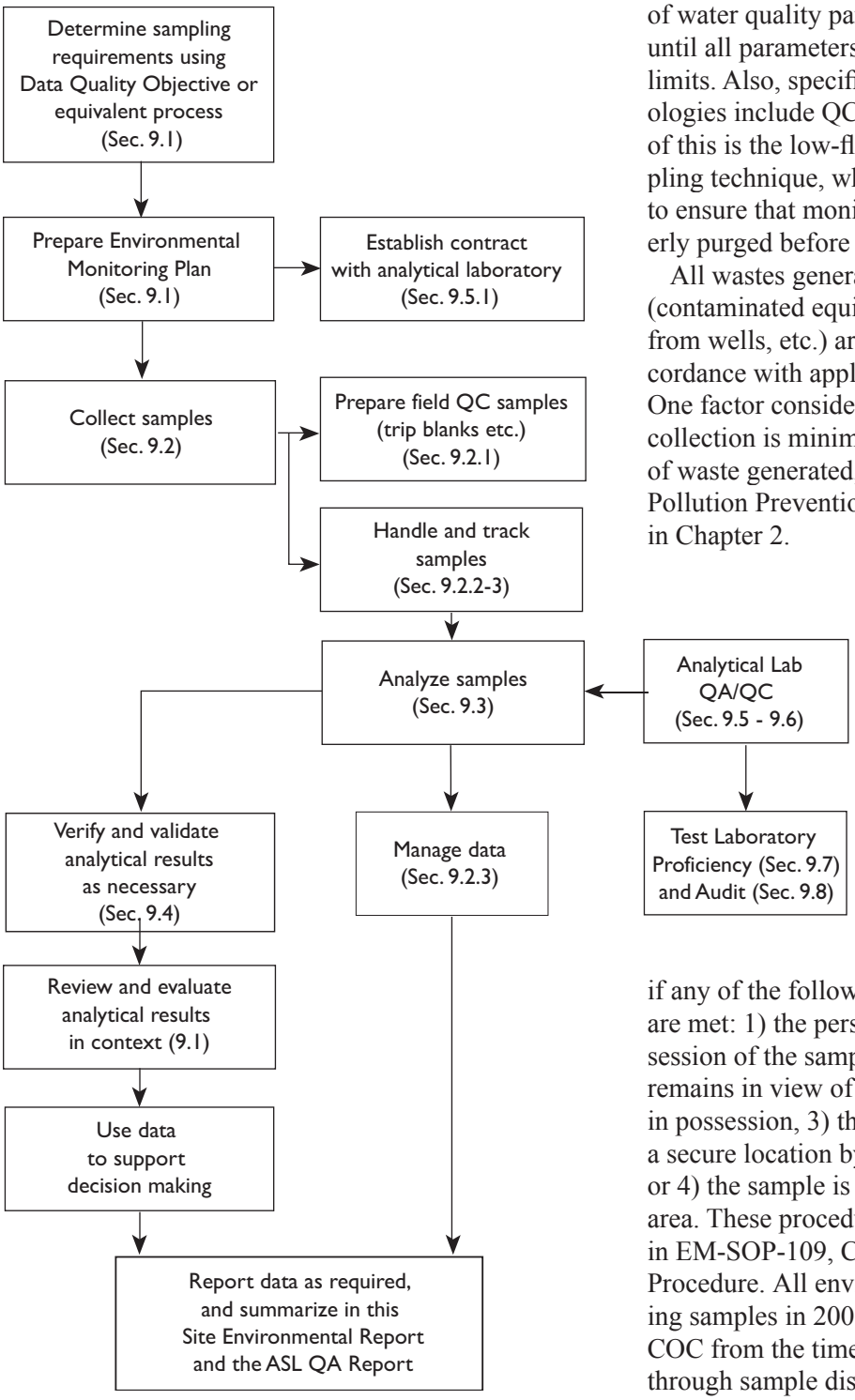

Figure 9-1. Flow of Environmental Monitoring QA/QC Program Elements.

ment 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. One 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. 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 Procedure. All environmental monitoring samples in 2003 maintained a valid COC from the time of sample collection through sample disposal by the 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 analytical laboratory. Samples requiring refrigeration are placed immediately into a refrigerator or a cooler with cooling media, and kept under custody rules. The technician who maintains custody of the samples signs the COC form when relinquishing custody of them. The laboratory or group receiving the samples signs the COC form when accepting custody.

The field sampling technician is also required to maintain a bound, weatherproof field logbook, which is filled out when samples are collected. The field technician records sample ID number, collection time, description, collection method, and COC number, as well as notes on daily weather conditions, field measurements, and other appropriate site-specific observations.

9.2.1.2 Preservation and Shipment

Samples shipped to off-site laboratories are managed as follows. Before sample collection, the field sampling technicians prepare all bottle labels and put them on 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.

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 EM-SOP-200, Collection and Frequency of Field Quality Control Samples. Equipment blanks and trip blanks (see below) were collected for all appropriate media in 2003.

An ***equipment blank*** is a volume of solution (in this case, laboratory-grade water) that is used to rinse a sampling tool before sample collection. The rinse water is collected and tested to verify that the sampling tool is not contaminated. Equipment blank samples are collected, as needed, to verify the effectiveness of the decontamination procedures on non-dedicated or reusable sampling equipment. For the groundwater monitoring program, equipment blanks are collected from the final rinse water that is generated during decontamination.

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 the laboratory, or during analysis at a lab. Trip blanks consist of an aliquot of distilled water sealed in a sample bottle, prepared either by the analytical laboratory prior to shipping the sample bottles to BNL, or by field sampling technicians before they collect the samples. Trip blanks were included with all shipments of aqueous samples for VOC analysis in 2003.

Field blanks are collected to check for cross-contamination that might occur during sample collection. For the groundwater monitoring program, one field blank is collected for every twenty samples, or one per sampling round, whichever was more frequent. On any given day, the field blanks are analyzed for the same parameters as the groundwater samples.

Contaminants in trip, field, and equipment blanks included methylene chloride, acetone, and toluene. These compounds are commonly detected in blanks and do not pose significant problems with the reliability of the analytical results. When these contaminants are detected, validation and/or verification procedures are used, where applicable, to qualify the associated data as nondetects, as described in procedures EM-SOPs 203 through 212 (see Section 9.4). The results from blank samples collected during 2003 did not indicate any significant impact to the quality of groundwater results.

Field duplicate samples are analyzed to check the reproducibility of sampling and analytical results, based on EPA Region II guidelines (EPA 1996). For example, in the groundwater moni-

toring program, duplicates are collected for 5 percent of the total number of samples collected for a project per sampling round. During 2003, 83 duplicate samples were collected for nonradiological analyses and 85 duplicate samples were collected for radiological analyses. All duplicate samples were acceptable for input into the Environmental Information Management System (EIMS) database. Duplicates were analyzed only for the parameters relevant to the program they monitored. In 2003, of the 5,310 nonradiological parameters analyzed, 98.8 percent of the analyses met QA criteria. Of the 353 radiological parameters monitored, 98 percent met QA criteria. These results indicate consistency between the laboratory and field sampling technicians.

Matrix spike* and *matrix spike duplicates are performed to determine whether the sample matrix (water, soil, air, etc.) 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. In the case of the groundwater monitoring program, that rate is approximately one per 20 samples collected per project. For groundwater samples, no significant matrix effects were observed in 2003. For media other than groundwater, several results were considered suspect after field QC sample results were evaluated. These specific instances are discussed in detail in Chapters 3 through 8.

9.2.3 Tracking and Data Management

9.2.3.1 Sample Tracking

Most environmental monitoring samples and analytical results were tracked in the EIMS. Tracking was initiated when a sample was recorded on a chain-of-custody 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 analytical laboratory also maintains its own internal sample tracking system.

9.2.3.2 Data Management

Data management procedures are in place to govern tracking, validation, verification, and distribution of the analytical data. When samples were shipped to an analytical laboratory, COC information is entered into the EIMS. Following sample analysis, the contract laboratory provides the results to the project manager or designee and, when applicable, to the validation subcontractor in accordance with their contract.

9.2.3.3 Distribution of Analytical Data

Once data are entered into the EIMS, reports can be generated by project personnel and DOE-Brookhaven Area Office staff using a web-based data query tool that provides access to all analytical sample results and standard report formats. Also, the EIMS data management group is available to generate reports that may require special formatting.

9.3 SAMPLE ANALYSIS

In 2003, environmental samples were analyzed either by the on-site ASL or by one of four contractor laboratories, whose selection is discussed in Section 9.3.2. All samples were analyzed according to EPA-approved methods, where such methods exist. Where no EPA-approved methods exist, standard industry methods were used. In addition, field sampling technicians performed field monitoring of wastewater for parameters such as conductivity, dissolved oxygen, pH, temperature, and turbidity.

When demand exceeded ASL capacity, some samples were sent off site, including those to be tested for metals and polychlorinated biphenyls (PCBs). Most samples used to verify compliance with permitting requirements were sent off site, as were samples requiring semivolatile organic compound (SVOC) analysis or the toxicity characteristic leachate procedure (TCLP). Samples also were sent off site for radiological analyses that ASL did not perform, such as actinide analyses in soil, vegetation, animal tissue, and water.

9.3.1 ASL Qualifications

Typically, BNL's ASL performs approximately 5,000 radiological and nonradiological (chemical) analyses per year on environmental samples to support both environmental monitoring and facility operations. BNL's ASL is certified in the Environmental Laboratory Accreditation

Program (ELAP) conducted by the New York State Department of Health (NYSDOH), and in the EPA's National Environmental Laboratory Accreditation Program (NELAP). Analyses covered by these certifications include tritium, gross alpha/beta (GAB), and gamma in potable and nonpotable water analysis in several matrices.

ASL's nonradiological chemical group is certified by the NYSDOH ELAP to perform analyses using EPA Methods 524 and 624 for VOCs, in potable and wastewaters, respectively. In 2003, 37 groundwater and wastewater samples were provided for analysis with Method 624. This represented an additional 26 new analytes since 1998. EPA Method 524 (for potable water) included 63 organic analytes and was a new addition to ASL's capabilities in 2003. Metals were analyzed using both atomic absorption spectroscopy and inductively coupled plasma/mass spectroscopy (ICP/MS), using EPA methods. ASL is certified for analyses of 17 metals (the entire ELAP list) in potable water, as well as 21 metals in wastewater. Certification for three anions was established for potable and wastewaters using EPA Method 300.

9.3.2 Contractor Lab Qualifications

BNL procured and maintained contracts with the following off-site laboratories for analysis of environmental samples in 2003:

- 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/or nonradiological analytes
- Chemtex Lab in Port Arthur, Texas, for select nonradiological analytes

The process of selecting contractor laboratories involves a number of factors: 1) their record on performance evaluation (PE) tests, 2) the laboratory's contract with the DOE Integrated Contract Procurement Team, 3) pre-selection bidding, and 4) their adherence to their own QA/QC programs. 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 analytical laboratories that BNL used in 2003 were certified by NYSDOH for the relevant analytes, where such certification existed. The laboratories also were subject to PE testing (see Section 9.7) and DOE-sponsored audits.

9.4 VERIFICATION AND VALIDATION OF ANALYTICAL RESULTS

Environmental monitoring data are subject either to data verification or data validation performed in accordance with established procedures, when the data quality objectives of the project require this step.

The data verification process involves checking for common errors associated with analytical data. The following criteria 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 analytical laboratory is insufficient to allow validation of results.
- *Incorrect minimum detection limit (MDL)* The 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 and personnel.

- *Matrix interference* – Analysis is affected by dissolved inorganic/organic materials in the matrix.
- *Incomplete data package or report* – Some information is missing.

Data validation is a more extensive process that includes all the verification checks as well as checks for less common errors, including calibration that was not conducted as required, internal standard errors, transcription errors, and calculation errors. The amount of data checked varies, depending on the environmental media and on the data quality objectives for each project. Data for some projects, such as long-term groundwater monitoring, may require only verification. Data from initial groundwater 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 Verifying and Validating ASL Results

For samples analyzed by BNL's Analytical Services Laboratory in 2003, the QA officer or group leader verified that all analytical batches fulfilled internal QA/QC acceptance criteria. These criteria, which include precision, accuracy, recovery, instrument background checks, and stable instrument efficiency performance, are fully described in ASL's QA Program Plan (BNL 1999b). All QA/QC data were reviewed before ASL results were reported. As per the BNL Groundwater Monitoring Program Quality Assurance Project Plan (BNL 1999a), a significant portion of the groundwater samples analyzed by ASL for environmental restoration projects also underwent data verification, as described in Section 9.4.

9.4.2 Checking Off-Site Results

Nonradiological data analyzed off site in 2003 were verified and validated using EPA Contract Laboratory Program guidelines (EPA 1992, 1996). Radiological packages were verified and validated using BNL and DOE guidance documents (BNL 1997, DOE 1994).

9.5 ANALYTICAL LAB QA/QC

In 2003, sample results for environmental restoration, compliance, and surveillance were analyzed by ASL or by one of the off-site contract laboratories. For ASL analyses, procedures for calibrating instruments, analyzing samples, and assessing QC were consistent with EPA methodology (see Appendix D). QC checks that were 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. The ASL supervisor, QA officer, or group leaders reviewed all ASL analytical and QA results before data were reported. More details of the ASL QA program are in Section 9.6.

Off-site contractor laboratories that perform radiological and chemical analyses for BNL also are required to maintain stringent QA programs. Their contracts specify analytes, methods, required detection limits, and deliverables—which include standard batch QA/QC performance checks. As part of the contract laboratory selection process, contract laboratories are required to provide BNL with copies of their QA/QC manuals, as well as their QA program plans.

A nonconformance report was generated when discrepancies were found in field sampling designs, documented procedures, COC forms, data analyses, data processing systems, QA software, or when failures in PE testing occurred. Following an investigation into the root cause, corrective actions were taken and tracked to closure.

9.6 ASL INTERNAL QA PROGRAM

The QA procedures followed at ASL included daily instrument calibrations, efficiency and background checks, and routine tests for precision and accuracy. A detailed description of these activities can be found in the ASL QA Program Plan (BNL 1999b). A brief summary of 2003 ASL PE testing results follows. Additional details can be found in Appendix D.

9.6.1 Radiological Instrument Calibrations

ASL operated eight high-purity germanium gamma detectors in 2003. Each detector was calibrated daily for energy and instrument efficiency using a NIST-traceable cesium-137 standard. Annual geometry efficiency calibrations were performed. Efficiency is measured by noting which radiological decaying events are converted into observable counts (counts per minute). During 2003, all eight gamma detectors performed well within the EPA acceptance limit. One gamma detector was out of service for repair during the month of January, and two gamma detectors were taken out of service as a result of a regional blackout in August. After August, five of the eight gamma detectors were operational.

ASL operated two gross alpha/beta detectors and two liquid scintillation spectrometers for tritium. Instrument background and count-time were used to determine the minimum detection limit of a radiological analyte. In 2003, there was no unusual drift or variability in instrument background for alpha, beta, or tritium, based on the mean background count-rates (and one standard deviation value). Instrument efficiencies were determined daily, using a calibration standard, and averaged for the calendar year.

9.6.2 Accuracy and Precision

Accuracy is the percent difference between a measured value and its known (expected) value. Precision is the percent difference between two measured values. The measure of batch precision is the Relative Percent Difference (RPD) statistic. This is defined as the absolute difference between the two results, divided by the average of both results, multiplied by 100. In radiological analyses, a spike of radioactive tracer solution is added to either a routine sample or tap water sample as a means of determining both precision and accuracy. In nonradiological analyses, the spike is a known amount of a given analyte added to a sample. The accuracy is stated as "percent recovery," which is the ratio of the measured amount, divided by the known (spiked) amount, multiplied by 100.

9.6.2.1 Gross Alpha/Beta

For gross alpha/beta analyses, the RPD was determined for each batch of analyses performed. Tap water was spiked with known amounts of americium-241 (for alpha) and strontium/yttrium-90 (for beta) in order to determine batch precision. The acceptance criterion for batch precision is an RPD less than 20 percent, for activity concentrations that are five times greater than the method MDL. During 2003, GAB batch precision for all 540 batches tested was within the acceptable range; there were four rejected batches, for a 0.7 percent rejection rate.

9.6.2.2 Tritium

Tritium precision was determined for 294 batches processed in 2003. ASL utilizes three sampling protocols for differing sample volumes (i.e., 7 mL distilled, 7 mL undistilled, and 1 mL undistilled). There were two rejected batches for tritium in 2003, corresponding to a rejection rate of 0.7 percent.

9.6.2.3 Strontium-90

Since 2002, strontium-90 samples have been sent to off-site contractor laboratories for analysis.

9.6.3 Nonradiological Analyses

Method precision was determined for 14 VOCs, three anions, and 21 metals processed by ASL in 2003. All metal and anion analyses had RPDs within ASL's internal acceptance limit of ± 20 percent. The standard deviation uncertainties were also within the EPA acceptance criteria.

ASL has an internal QC program for the ion chromatography, ICP/MS, and atomic absorption methods used for inorganic analyses. Several QC checks were performed for each batch of metals and anions in 2003. For the 21 certified metals analyzed by ASL, no analytes exceeded the EPA acceptance criteria for recovery.

The ASL has an internal QC program for the gas chromatography/mass spectroscopy method used for 14 primary VOCs. Recoveries and 99-percent confidence intervals were determined for approximately 100 independent VOC batch-

es in 2003. Average recoveries for all of the 14 analytes were within their EPA target ranges of ± 25 percent for EPA methods 524.0 and 624.0 (these methods are discussed in Appendix D).

The 99-percent confidence intervals for surrogate recoveries also were determined for four analytes in 2003. All surrogate recoveries were within EPA acceptance limits.

9.7 PERFORMANCE OR PROFICIENCY EVALUATIONS

As in prior years, ASL and three contractor laboratories (GEL, STL, and H2M) participated in several national and state PE testing programs in 2003. The fourth 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 DOE Environmental Measurements Laboratory (EML) Quality Assessment Program, the voluntary Mixed Analyte Performance Evaluation Program (MAPEP), NYSDOH Environmental Laboratory Accreditation Program (ELAP), and the Analytical Products Group (APG). The results from these tests are summarized in Section 9.7.1 and discussed in more detail in Sections 9.7.2 (radiological) and 9.7.3 (nonradiological).

9.7.1 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 of the target value. Note that the ASL scores are labeled on both graphs as "BNL."

Figure 9-2 summarizes radiological performance scores in the mandatory DOE EML program as well as the voluntary ERA and MAPEP programs. During 2003 (as in 2002), the NYS ELAP did not provide radiological samples for PE testing, so there were no ELAP scores as there have been in some past years. ASL's average overall satisfactory score on radiological PE tests was 95.9 percent. GEL and STL had average overall satisfactory scores of 96.3 and 92 percent, respectively.

Figure 9-3 summarizes the four participating laboratorys' nonradiological performance results in the NYS ELAP, ERA, MAPEP, and APG tests. On the chart, bars that represent combined scores from more than one type of test are labeled "IND." For nonradiological tests, the average overall satisfactory results ranged from 94 to 95 percent.

BNL's combined average overall satisfactory score of 95.9 percent on the 458 radiological and nonradiological PE tests performed in 2003 is considered excellent.

9.7.2 Radiological Assessments

ASL, GEL, and STL participated in the DOE EML Quality Assessment Program and the ERA radiological program in 2003. Results are summarized in Figure 9.2.

9.7.2.1 EML Radiological Results

Overall, ASL's performance in the EML program was satisfactory in 94.9 percent of the analyses performed on air, vegetation, water, and soil. Twenty-five of 39 analyses (64.1percent) were Acceptable, 12 results (30.8 percent) were Warning (But Acceptable), and 2 analyses (5.1 percent) were Not Acceptable.

GEL's performance was satisfactory in 95.3 percent of the DOE EML analyses performed on air, vegetation, water, and soil. Sixty-three of 86 analyses (73.3 percent) were Acceptable, 19 of 86 analyses (22.1 percent) were Warning (But Acceptable), and 4 analyses were Not Acceptable.

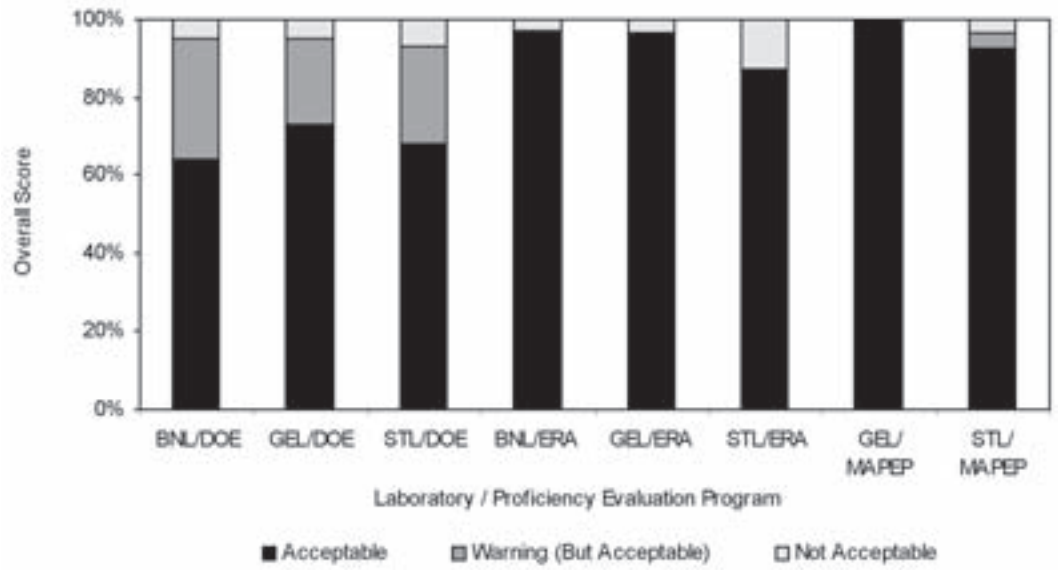

Figure 9-2. Summary of Scores in the Radiological Proficiency Evaluation Programs. Note that the Acceptable scores and the Warning (But Acceptable) scores combined constitute the "overall satisfactory" category referred to in the text of this chapter.

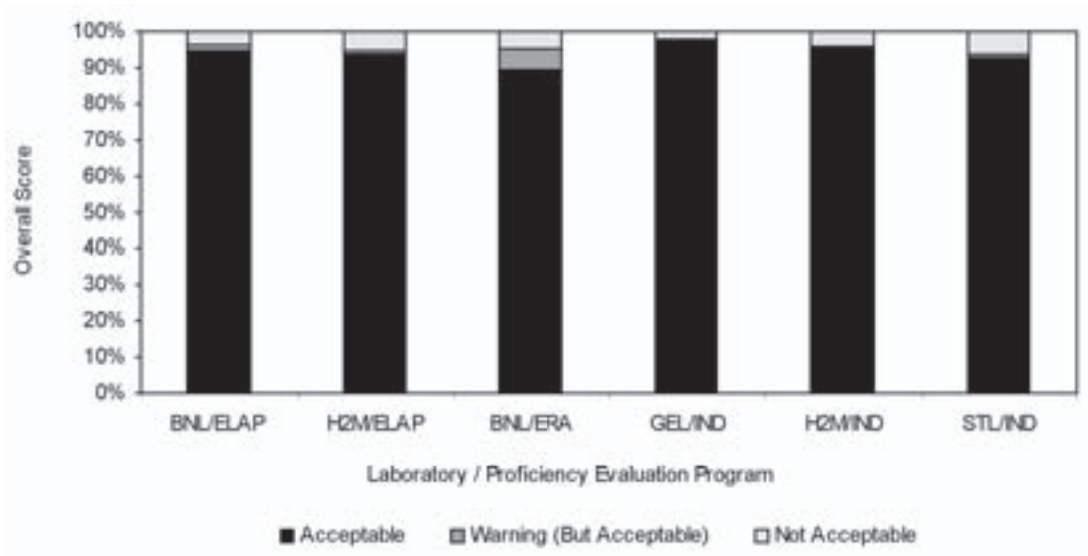

Figure 9-3. Summary of Scores in the Nonradiological Proficiency Evaluation Programs.

STL also participated in the DOE EML program. Of 88 analyses, 60 (68 percent) were Acceptable, 22 (25 percent) were Warning (But Acceptable), and 6 were Not Acceptable, corresponding to an average overall satisfactory score of 93.2 percent.

9.7.2.2 ELAP Radiological Results

The New York State Department of Health Environmental Laboratory Accreditation Program provided no samples for radiological testing in 2003.

9.7.2.3 ERA Radiological Results

ASL, GEL, and STL participated in the ERA radiological PE studies. ASL's average overall score for the 34 results in 2003 was 97.1 percent, with one Not Acceptable result. GEL's

average overall satisfactory score in these studies was 96.65 percent; STL's average overall satisfactory score was 87 percent.

9.7.2.4 Voluntary PE Studies

Both GEL and STL participated in the MAPEP. GEL's average overall score for 15 analytes was 100 percent. STL's average overall score for 27 analytes was 96.4 percent.

9.7.3 Nonradiological Assessments

During 2003, ASL and H2M participated in the NYSDOH ELAP tests for nonpotable water, potable water, and solid wastes. GEL and STL did not participate in the ELAP tests because those laboratories are certified through the National Environmental Laboratory Accreditation Conference (NELAC). ASL and GEL also participated in the ERA water supply and water pollution studies, although participation in these tests is not required for New York State certification. Note that in Figure 9.3, GEL's score is labeled "IND" rather than "ERA" because that bar represents a composite of GEL's APG and ERA scores. Finally, H2M and STL voluntarily participated in APG and ERA testing, also reported as composite scores labeled "IND." The results of all these tests are shown in Figure 9-3.

9.7.3.1 ELAP Nonpotable Water Results

Of the 120 results reported for ASL, there were seven Not Acceptable, earning ASL an average overall satisfactory score of 94.2 percent. H2M reported 788 results, with 43 Not Acceptable, scoring 94.5 percent.

9.7.3.2 ELAP Solid and Hazardous Waste Chemistry

In the Solid and Hazardous Waste Chemistry portion of the NYSDOH ELAP, ASL scored 100 percent for their 14 results.

9.7.3.3 ELAP Potable Water Results

In the potable water category of the NYSDOH ELAP, ASL reported 72 results, with one Not Acceptable, earning an average overall satisfactory score of 98.6 percent. H2M reported 343 results, with 18 Not Acceptable, for an average overall satisfactory score of 94.8 percent.

9.7.3.4 Voluntary PE Studies

ASL and GEL participated in the voluntary ERA water pollution and water supply PE studies. For these studies combined, ASL reported 179 results: 160 Acceptable, 11 Warning (But Acceptable), and 8 Not Acceptable. The average overall satisfactory score for ASL in these studies was 95.5 percent. GEL reported 1,693 results, with 1,645 Acceptable, 9 Warning (But Acceptable), and 39 Not Acceptable. GEL's average overall satisfactory score in these studies was 97.7 percent.

STL and H2M participated in the Analytical Products Group (APG) and ERA PE testing programs. Results in these two independent programs are labeled as IND on the bar graph in Figure 9-3. STL's average overall satisfactory score was 94.8 percent; H2M's average overall satisfactory score was 95.6 percent.

9.8 AUDITS

NYSDOH ELAP/NELAC audited the ASL radiological group in October 2003. There were four minor findings, which were corrected within one month of the audit. The minor findings included the updating of certification forms, a list of SOPs in the quality manual, a SOP regarding oven temperature related to radiological analyses, and the calibration of pipettes.

As part of the DOE's Integrated Contract Procurement Team Program, STL and GEL were audited during 2003 (DOE 2003a,b). The results of the STL audit included eight Priority II findings: two radiological findings, one inorganic finding, three organic findings, and two general findings. The results of the GEL audit included ten Priority II findings: two radiological findings, three inorganic findings, two organic findings, and three general findings. Corrective action plans were submitted to DOE by both laboratories to document that procedures were put in place to correct these findings. Results of the audits indicated that the analytical data from these laboratories is of acceptable quality.

9.9 CONCLUSIONS

Detailed data on laboratory performance evaluation testing for ASL and the BNL contractor laboratories are maintained in ASL QA records. For radiological performance tests, the three laboratories reporting analytical data in the 2003 Site Environmental Report (ASL, GEL, and STL) each had combined satisfactory results of 95 percent or better in both state and federal performance evaluation programs. For nonradiological performance evaluation testing, ASL and the three participating contractor laboratories (H2M, GEL, and STL) all had an overall satisfactory score of approximately 95 percent. BNL's combined average overall satisfactory score was 95.9 percent on the 458 radiological and nonradiological laboratory evaluation tests performed in 2003. Based on implementation and evaluation of the QA/QC program, it can be concluded that the analytical data reported in this report are reliable and of high 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
ASL	Analytical Services Laboratory (BNL)
AST	aboveground storage tank
BAF	Booster Applications Facility
BAO	Brookhaven Area Office
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
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
CERCLA*	Comprehensive Environmental Response, Compensation and Liability Act
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
CWA*	Clean Water Act
CY	calendar year
D_2O*	heavy water
DCA	1,1-dichloroethane
DCE	1,1-dichloroethylene
DCG*	derived concentration guide
D&D	decontamination and decommissioning
DDD	dichlorodiphenyldichloroethane
DDE	dichloroethylene
DDT	dichlorodiphenyltrichloroethane
DMR	Discharge Monitoring Report
DOE*	U.S. Department of Energy
DOE BAO	DOE Brookhaven Area Office
DOE CH	DOE Chicago Operations Office
DQO	Data Quality Objective
DSB	Duct Service Building
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
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
EWMSD	Environmental and Waste Management Services Division
FFCA*	Federal Facilities Compliance Act
FIFRA*	Federal Insecticide, Fungicide, and Rodenticide Act

FS*	feasibility study
FWMF	Former Waste Management Facility
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
GEL	General Engineering Laboratory (contracted)
GeV	giga (billion) electron volts
GIS	Geographical Information System
GWh	gigawatt hour
H2M	name of a contracted analytical lab
HEPA	high efficiency particulate air
HFBR	High Flux Beam Reactor
HTO	tritiated water (liquid or vapor)
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
ISOCS	In-Situ Object Counting System
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
LIE	Long Island Expressway
Linac	Linear Accelerator
MACT	Maximum Available Control Technology
MAPEP	Mixed Analyte Performance Evaluation Program
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
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
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
NSLS	National Synchrotron Light Source
NT	not tested
NYCRR*	New York Codes, Rules, and Regulations
NYS	New York State
NYS AWQS	NYS ambient water quality standard
NYS DWS	NYS drinking water standard
NYSDEC	NYS Department of Environmental Conservation
NYSDOH	NYS Department of Health
NYSHPO	NYS Historic Preservation Office
O_3*	ozone
ORC	oxygen-releasing compound
ORPS*	Occurrence Reporting and Processing System
OU*	operable unit
P2*	pollution prevention
PAAA*	Price-Anderson Act Amendment
Pb	lead
PCBs*	polychlorinated biphenyl
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	Reasonable Available Control Technology
RCRA*	Resource Conservation and Recovery Act
RHIC	Relativistic Heavy Ion Collider
ROD*	Record of Decision
RPD	relative percent difference
RWMB	Radioactive Waste Management Basis
RWP	Radioactivity 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
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
STL	Severn Trent Laboratories (contracted)
STP	Sewage Treatment Plant
SU	standard unit
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	Toxicity 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
USI	unreviewed safety issues
UST*	underground storage tank
VOC*	volatile organic compound
WAC	waste acceptance criteria
WCPP	Waste Certification Program Plan
WCF	Waste Concentration Facility
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.

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.

AMSL – *See* **MSL, mean sea level**.

analyte – A constituent that is being analyzed.

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:* www.cr.nps.gov/linklaws.htm, accessed 3-23-04)

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, each charged particle having a mass of approximately one-two thousandth the mass of a protron (actually, 1/1837). A negatively charged beta particle is identical to an electron. A positively charged beta particle is called a positron. Beta radiation is slightly 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) in the same type of container 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.

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 @ www.epa.gov/oar/oaqps/peg_caa, accessed 3-23-04)

cap – A layer of material, such as clay or a synthetic material (like Gunite™), used to prevent rainwater from penetrating and spreading contaminated materials. 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. Over five years, $1.6 billion was collected and the tax went to a trust fund for cleaning up abandoned or uncontrolled hazardous waste sites. 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 www.epa.gov/superfund/action/law/cercla.htm, accessed 03-23-04)

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 www.pgoaccess.gov/ecfr.

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.

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.

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.

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*: www.epa.gov/region5/water/cwa.htm, accessed 03-23-04)

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 www.directives.doe.gov/cgi-bin/explhcgi?qry2014382843;doe-87 (accessed 4/15/04).

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 www.directives.doe.gov/cgi-bin/explhcgi?qry1436408403;doe-221 (accessed 4/15/04).

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 www.directives.doe.gov/cgi-bin/explhcgi?qry1697547635;doe-320 (accessed 4/15/04).

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.

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, soluble in ethanol, ether, and most organic solvents. It was used as an additive in leaded gasoline, as a soil and grain fumigant, and in waterproofing preparations. 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. The U.S. Department of Health and Human Services has determined that ethylene dibromide may reasonably be anticipated to be a carcinogen.

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, surveillance [ES) 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. The BNL Environmental Monitoring Plan (EMP) was developed by the Environmental and Waste Management Services Division and describes the EMS in detail.

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*: www.epa.gov/region5/defs/html/epcra.htm, accessed 3-23-04)

ES – *See* **EM**.

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*: www.epa.gov/region5/defs/html/esa.htm, accessed 3-24-04)

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 3-23-04)

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*: www.epa.gov/region5/defs/html/fifra.htm, accessed 3-23-04)

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) – FWS is the principal federal agency assigned to the protection, conservation, and enhancement of fish, wildlife, and their habitats. FWS provides expert advice to other federal agencies, industry, and foreign governments, and manages more than 700 offices and field stations. (*source*: http://info.fws.gov/functions.html, accessed 3-24-04)

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."

grab sample – A single sample collected at one time and place.

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.

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.

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 Organization de Standards International (ISO), formed in Amsterdam in 1947, 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.

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*: www.epa.gov/region5/defs/html/nepa.htm, accessed 3-23-04)

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 hazards. 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 3-24-04)

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*: www.achp.gov/overview.html, accessed 3-24-04)

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*: www.epa.gov/owow/nps/Section319III/intro.htm, accessed 3-24-04)

NO_X – All oxides of nitrogen except for nitrous oxide, which is expressed as nitrogen dioxide (NO_2). NO_x is a conventional (nonradioactive) pollutant, a byproduct of auto exhaust and of burning fuel such as at the boilers.

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 O 231.1A (sic).

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 form 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)

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.

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*: www.epa.gov/region5/defs/html/rcra.htm, accessed 3-23-04)

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).

ROD (Record of Decision) – A document that records a regulator 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:* www.epa.gov/region5/defs/html/sara.htm, accessed 3-23-04)

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*: www.epa.gov/region5/defs/html/sdwa.htm, accessed 3-23-04)

sediment – The layer of soil and minerals at the bottom of surface waters, such as streams, lakes, and rivers.

semi-control – In this document, semi-control refers to the location of a sampling point on a tributary of the Peconic River; this tributary is not connected to the BNL tributary.

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 by the air, 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 3-24-04)

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 – *See* **VOC**.

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*: www.epa.gov/region5/defs/html/tsca.htm, accessed 3-23-04)

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) – Secondary petrochemicals, including light alcohols, acetone, trichlorethylene, perchloroethylene, dichloroethylene, benzene, vinyl chloride, toluene, and methylene chloride. These potentially toxic chemicals are used as solvents, degreasers, paints, thinners, and fuels. Because of their volatile nature they readily evaporate into the air, increasing the potential for human exposure. Due to widespread industrial use, VOCs are commonly found in soil and **groundwater**. SVOCs (semivolatile organic compounds) are similar in source and effect to VOCs, only somewhat less easily converted into a vapor.

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**.

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.

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Concepts of Radioactivity

This section introduces some of the basic concepts of radioactivity to provide the general reader with a basic understanding of the radiological information in the Site Environmental Report. The definitions of commonly used radiological terms are found in the Technical Topics section of the glossary, Appendix A, and are indicated in bold-face type the first time they are used only when the definition in the glossary provides additional detail.

Included here, in Appendix B, are discussions of the analyses used to quantify radioactive material, the common sources of radioactivity in the environment, and how radiation sources contribute to radiation dose. Some general statistical concepts are also presented, along with a discussion of radionuclides of environmental interest at BNL. The discussion begins with some definitions and background information on scientific notation, numerical prefixes, and units used when measuring dose and radioactivity.

RADIOACTIVITY AND OTHER TERMS

The atom is the basic constituent of all matter and is one of the smallest units into which matter can be divided. Each atom is composed of a tiny central core of particles (protons and neutrons) that comprise the nucleus, surrounded by a cloud of negatively charged particles called electrons. Some atoms possess excess energy, causing them to be physically unstable. Unstable atoms become stable when the excess energy is released in the form of charged particles or electromagnetic waves, known as *radiation*. The term *radioactivity* refers to the release of a charged particle or electromagnetic wave from an atom.

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 non-ionizing radiation. Examples of non-ionizing 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 a name followed by a number, such as cesium-137. The number indicates the mass of that element and the total number of particles 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 standard Periodic Table of the Elements. This type of abbreviation is used in many of the SER data tables and text.

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 as multiples of 10. For example, the number two million five hundred thousand (two and a half million, or 2,500,000) could be 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 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.

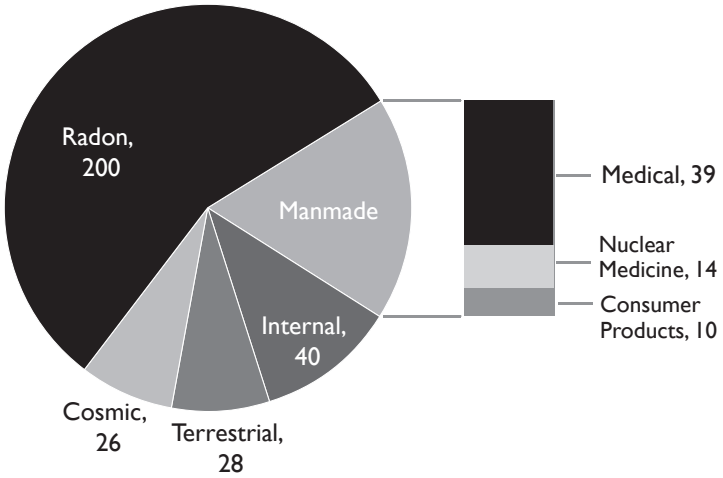

Figure B-1. Typical Annual Radiation Doses from Natural and Man-Made Sources (mrem). *Source: NCRP Report No. 93 (NCRP 1987)*

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. See the table on the inside back cover of the SER for additional common prefixes, including *pica* (p), which means trillionth, *giga* (G), which means billion or E+09, and *tera* (T), which means trillion, E+12.

UNITS FOR DOSE AND RADIOACTIVITY

Rem – The amount of radiation absorbed by body tissues or organs is referred to as the *dose equivalent* or, more generally, as the *dose*. Radiation doses are measured in units of *rem*. Since the rem is a fairly large unit, most doses are expressed in terms of thousandths of a rem, *millirem* or *mrem* (1,000 mrem = 1 rem). To give a sense of the size and importance of a 1-mrem dose, Figure B-1 indicates the number of mrem typically received each year by a person (living in the United States) from natural and non-occupational sources of radiation. Dose varies with location, as the section Sources of Radiation explains.

Sievert – Instead of rem, the International System of Units (SI) measures dose using the *sievert*, abbreviated *Sv*. One sievert is equivalent to 100 rem. Likewise, 1 one-thousandth of a sievert (1 millisievert, or 1 mSv) is equivalent to 100 one-thousandths of a rem (100 mrem).

Curie – The unit used to express the quantity of radioactive material in a sample is the *curie* (Ci). This is a measure of the rate at which radioactive atoms are transformed to stable atoms. Since 1 curie represents a relatively large number of decays per second (3.7E+10, or 37 billion), the *picocurie* (pCi) is often used. This unit is equal to one trillionth of a Ci, or 0.037 (3.7E-02) decays per second.

Becquerel – Another unit for quantifying radioactivity is the SI unit *becquerel*, abbreviated Bq. One becquerel is equal to one decay per second. In the SER, radioactivity is expressed in curies.

SOURCES OF IONIZING RADIATION

Radioactivity and radiation are part of the earth's natural environment. Humans are exposed to ionizing radiation from a variety of common sources, the most significant of which are discussed below.

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 about 26 mrem per year.

Terrestrial – Terrestrial radiation is released by radioactive elements that have been present in the soil since the formation of the Earth about five billion years ago. 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 about 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 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.

Medical – Every year, 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 in the United States 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 of the 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).

Background – 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.

COMMON TYPES OF IONIZING RADIATION

The three most common types of ionizing radiation are described below.

Alpha – 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. Naturally occurring radioactive elements such as uranium emit alpha radiation.

Beta – 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 Lucite™ (plexiglass) panels. Beta radiation has a range in air of several feet. Naturally occurring radioactive elements such as potassium- 40 emit beta radiation.

Gamma – Gamma radiation is a form of electromagnetic radiation, like radio waves or visible light, but with a much shorter wavelength. The Radiochemistry Society Online defines gamma radiation as "electromagnetic radiation emitted in the process of nuclear transformation or particle annihilation" 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 for the source.

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.

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 emissions. The energy of these emissions is unique for each nuclide, acting as a "fingerprint" to identify a specific nuclide.

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 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.

RADIONUCLIDES OF ENVIRONMENTAL INTEREST

Several types of radionuclides are found in the environment at BNL due to historical operations.
Cesium-137 – Cesium-137 (Cs-137) is a man-made, 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 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). Cesium-137 is a beta-emitting radionuclide, but it can be detected by gamma spectroscopy because its decay product, barium-137m, emits gamma radiation.

Cesium-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. For many years 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. 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 Waste Management Facility, Waste Concentration Facility, Bldg. 650 Reclamation Facility and Sump Outfall Area, and the Brookhaven Graphite Research Reactor.
Strontium-90 – 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 conducted more recent tests that have contributed to the global Sr-90 inventory. This radionuclide was also released as a result of the 1986 Chernobyl accident in the former Soviet Union.

Sr-90 is present at BNL in the soil and groundwater. As in the case of Cs-137, some Sr-90 at BNL results from worldwide nuclear testing; the remaining contamination is a byproduct of reactor operations. The following areas with Sr-90 contamination have been or are being addressed as part of the Environmental Remediation Program: Former Waste Management Facility, Waste Concentration Facility, Bldg. 650 Reclamation Facility and Sump Outfall Area, the Brookhaven Graphite Research Reactor, the Former and Interim Landfills, the Chemical and Glass Holes Area, and the Sewage Treatment Plant.

The information in the SER tables is arranged by method of analysis. Because strontium-90 requires a unique method of analysis, it is reported as a separate entry. Methods for detecting strontium-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 strontium-90.

Tritium – Among the radioactive materials that are used or produced at BNL, tritium has received the most public attention. Tritium exists in nature and is formed when cosmic radiation from space interacts with the gaseous nitrogen in the Earth's upper atmosphere. Approximately 4 million Ci (1.5E+5 TBq) per year are produced in the atmosphere in this way, with the total global quantity being about 70 million Ci (2.6E+6 TBq) at any given time (NCRP 1979). As a result of the U.S. aboveground weapons testing in the 1950s and early 1960s, 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 wrist watches 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 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 tritium beta radiation; therefore, only when tritium is taken into the body can it cause an exposure. Tritum 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). All tritium released from BNL sources is in the form of HTO. Sources of tritium at BNL include the reactor facilities, where water (either heavy or light) is converted to tritium via neutron bombardment; 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.

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Radiological Data Methodologies

DOSE CALCULATION - ATMOSPHERIC RELEASE PATHWAY

The effective dose equivalent (**EDE**) for low levels of airborne radioactive materials dispersed into the environment was calculated for each of the 16 compass sectors using the CAP88-PC, Version 2.0 and Beta Version 3.0 dose model program (EPA 1992). Site meteorology data were used to calculate annual dispersions for the midpoint of a given sector and distance. Facility-specific radionuclide release rates (in curies per year [Ci/yr]) were also used. All annual site boundary and collective dose values were generated using the CAP88-PC V. 2 computer code, which calculates the total dose due to contributions from the immersion, inhalation, and ingestion pathways. The dose and risk estimates were based on low levels of chronic intake of radionuclides.

DOSE CALCULATION - FISH INGESTION PATHWAY

To estimate the EDE from the fish consumption pathway, the following procedure was used.

Intake. The average fish consumption for a person engaged in recreational fishing in the Peconic River was based on a study done by the New York State Department of Health (NYSDOH), which estimates the consumption rate at approximately 15 pounds (7 kg) per year (NYSDOH 1996).

Activity in Flesh. Radionuclide data for fish samples were all converted to picocuries per gram (pCi/g) wet weight, since "wet weight" is the form in which fish are caught and consumed.

Dose Factor. The committed dose equivalent factor for Cs-137 is 5.0E-02 rem per microcurie (rem/µCi), as set forth in DOE Order 5400.5. The formula is shown below.

$$\textbf{\textit{Dose}}\ (\text{rem/yr}) = \textbf{\textit{Intake}}\ (\text{kg/year}) \times \textbf{\textit{Activity in flesh}}\ (\mu\text{Ci/kg}) \times \textbf{\textit{Dose factor}}\ (\text{rem}/\mu\text{Ci})$$

DOSE CALCULATION – DEER MEAT CONSUMPTION

This calculation is similar to that for fish consumption. The same DOE dose conversion factors are used. The only change is the estimate of total pounds ingested during the course of a year. For deer meat, the consumption rate of 64 pounds (29 kg) per year is used, based on the U.S. Environmental Protection Agency Exposure Factors Handbook (EPA 1996).

RADIOLOGICAL DATA PROCESSING

Radiation events occur randomly; if a radioactive sample is counted multiple times, a 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 truly 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. As with most laboratories, the BNL Analytical Services Laboratory sets its 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 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

Table C-1. Typical Minimum Detection Limits for Gross Activity and Tritium in Water Analysis by BNL Analytical Services Laboratory.

Analysis	Aliquot (mL)	MDL (pCi/L)
Gross alpha	100 200	4 1
Gross beta	100 200	9 2
Tritium	1 7	3,900 350

Table C-2. Typical Minimum Detection Limits for Gamma Spectroscopy Analysis by BNL Analytical Services Laboratory.

Nuclide	300 g Soil (µCi/g)	300 mL Water (µCi/mL)	3L Marinelli (µCi/mL)
Be-7	7E-08	1E-07	1E-08
Na-22	9E-09	1E-08	1E-09
K-40	2E-07	2E-07	2E-08
Sc-48	1E-08	1E-08	3E-08
Cr-51	8E-08	1E-07	1E-08
Mn-54	8E-09	1E-08	1E-09
Mn-56	2E-07	3E-07	2E-08
Co-57	7E-09	9E-09	1E-09
Co-60	1E-08	1E-08	1E-09
Zn-65	2E-08	2E-08	2E-09
Cs-134	1E-08	1E-08	1E-09
Cs-137	9E-09	1E-08	1E-09
Ra-226	3E-08	3E-08	4E-08
Th-228	2E-08	3E-08	1E-07
Br-82	1E-08	2E-08	8E-08
I-131	9E-09	1E-08	3E-09
I-133	1E-08	2E-08	3E-09

Note:
All MDLs shown above are approximate. For gamma spectroscopy, the MDL of the analysis depends on several variables, such as the efficiency of the particular detector and the activity of the sample. These factors will vary between analyses and instrumentation.

Table C-3. Typical Minimum Detection Limits for Chemical Analyses by BNL Analytical Services Lab and Off-Site Analytical Laboratories.

Constituent	BNL Laboratory mg/L	Off-Site Laboratories mg/L
Ag	0.025	0.010
Cd	0.0005	0.005
Cr	0.005	0.010
Cu	0.050	0.025
Fe	0.075	0.100
Hg	0.0002	0.0002
Mn	0.050	0.015
Na	1.0	5.0
Pb	0.005	0.003
Zn	0.02	0.020
Ammonia-N	NA	0.02
Nitrite-N	NA	0.01
Nitrate-N	1.0	NA
Specific Conductance	10 µhos/cm	NA
Chlorides	4.0	NA
Sulfates	4.0	NA
1,1,1-trichloroethane	0.002	0.005
trichloroethylene	0.002	0.005
tetrachloroethylene	0.002	0.005
chloroform	0.002	0.005
chlorodibromomethane	0.002	0.005
bromodichloromethane	0.002	0.005
bromoform	0.002	0.005
benzene	0.002	0.005
toluene	0.002	0.005
xylene	0.002	0.005

Notes:
All concentrations in mg/L except where noted.
NA = Not Applicable (Laboratory does not perform analysis for constituent)

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 Procedure (NCRP 1985) and the Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance (DOE 1991). Typical MDLs for the various analyses performed on environmental and effluent samples are shown in Tables C-1, C-2, and C-3.

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.

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Instrumentation and Analytical Methods

The Analytical Services Laboratory (ASL) is divided into radiological and nonradiological sections to facilitate the analysis of specific parameters in each category. The methods and instrumentation for each category are briefly described below. Only validated and regulatory-referenced methods were used during analysis. All samples were collected and preserved by trained technicians according to appropriate referenced methods. Qualified and trained analysts performed all analyses.

RADIOLOGICAL ANALYTICAL METHODS

The ASL is certified by the New York State Department of Health (NYSDOH) for gross alpha, gross beta, gamma, tritium, and strontium-90 (non-potable water). The following is a description of the radiological analytical methods.

Gross Alpha and Gross Beta Analysis - Water Matrix - EPA 900.0

Water samples are collected in 4-L polyethylene containers by BNL sampling teams and preserved at the time of collection by acidification to pH 2 using nitric acid. Effluent or surface stream samples of 100 mL are extracted for analysis. Groundwater samples are typically analyzed using a 200-mL aliquot. The aliquot is evaporated to near-dryness in a glass beaker. Two drops of concentrated nitric acid are added, after which the solids are "policed" down the side of the beaker. The sample is transferred to a stainless steel planchet. Four drops of 10% Triton-X are added to the sample, then it is completely evaporated on a hot plate. The planchets are placed in a drying oven at 105°C for a minimum of 2 hours, removed to a desiccator and allowed to cool, weighed, and finally counted in a gas-flow proportional counter for 50 minutes. Groundwater samples are counted for 200 minutes. Samples are normally processed in batch mode. The first sample of each batch is a background, for which the count rate is subtracted from the raw data before the net activity concentration is computed. System performance is checked daily with National Institute for Standards and Technology (NIST) traceable standards: americium-241 for alpha, and strontium-90 for beta. Spiked duplicates are performed within each batch of samples to determine precision and accuracy.

Gross Alpha and Gross Beta Analysis - Air Particulate Matrix

Air particulate samples are collected on 50-mm glass fiber filters at a nominal flow rate of 1.5 cubic feet per minute. At the end of the collection, the filters are returned to the ASL for assay. After a 1-week holding time, filters are counted once in a gas flow proportional counter for 50 minutes. This delay permits the short-lived radon/thoron daughters to decay. The first sample of each batch is a blank filter whose count rate is subtracted from the raw data before the net activity concentration is calculated. The system's performance is checked daily with NIST-traceable standards: americium-241 for alpha and strontium-90 for beta.

Tritium Analysis - Water Matrix - EPA 906.0

Water samples are collected in glass containers. No preservatives are added before the samples are collected. Effluent and surface stream samples, as well as groundwater samples, are analyzed using a 7-mL aliquot. Potable-water samples (as well as other samples requiring a low minimum detection limit) are distilled following the method outlined in EPA Method 906.0 (EPA 1980), and a 7-mL aliquot is analyzed. Liquid scintillation cocktail is added to the aliquot so that the final volume in the liquid scintillation counting vial is 7 mL of sample plus 10 mL of cocktail. Samples then are counted in a low-background liquid scintillation counter for 50 minutes. Samples are normally processed in batch mode. The first sample of each batch is a steam-distilled water

background sample that is subtracted from the raw data before the net activity concentration is calculated. The second sample in each batch is a NIST-traceable tritium standard, which is used to verify the system's performance and efficiency. Each sample is also monitored for quenching. Corrections for background, quenching, and efficiency of the sample matrix are factored into the final net concentrations for each sample. Spiked duplicates are performed within each batch of samples to determine precision and accuracy.

Tritium Analysis - Air Matrix

The concentration of tritium in ambient and facility air is measured by drawing the air through a desiccant at a rate of approximately 200 cc/min. At the end of each collection period, typically one week, the desiccant is brought to the ASL for processing. It is heated in a glass manifold system, using dedicated glassware. The desiccant, containing moisture from the sampled air, is heated using an electric mantle, and the evaporated moisture is condensed by a water-cooled glass condenser. The total volume of water collected is determined gravimetrically. A 7-mL aliquot of this water is then assayed for tritium content. If the desiccant contains less than 7 mL of condensed liquid, a 1-mL aliquot is used. Liquid scintillation cocktail is added to the aliquot so the final volume in the counting vial is 17 mL, and these samples are counted in a low-background liquid scintillation counter for 50 minutes. If a 1-mL aliquot was used, liquid scintillation cocktail is added to the vial so the final volume is 11 mL, and these samples are counted for 100 minutes. Samples are normally processed in batch mode. The first sample of each batch is a steam-distilled water background whose count rate is subtracted from the raw data before the net activity concentration is computed. The second sample in each batch is a NIST-traceable tritium standard, which is used to verify the system's performance and efficiency. Each sample is also monitored for quenching. Corrections for background, water recovery, air sample volume, quenching, and efficiency for the sample matrix are factored into the final net concentrations for each sample. Spiked duplicates are performed within each batch of samples to determine precision and accuracy.

Strontium-90 Analysis

Strontium-90 analyses are performed on water. Groundwater samples are processed by the ASL, using either DOE (1995) Method RP500, which utilizes a crown ether to selectively separate strontium from the acidified sample matrix, or an ion exchange resin method. The strontium is eluted from the resin or filtration disk using dilute nitric acid. The resulting eluent is evaporated on a 5-cm stainless steel planchet and the sample is counted in a gas-flow proportional counter. Samples are prepared in batches, including a standard and a method blank in each batch. Chemical recovery is determined for each sample by the recovery of strontium carbonate. NIST-traceable strontium-90 standards are used to calibrate and verify the performance of the counting instrument. Samples are counted once after a 2-week radiological in-growth time.

Potable water samples, as well as samples of solids, are shipped to a contractor laboratory, which is certified to perform the EPA (1980) 905.0 method for strontium-90 in drinking water. This method employs wet-chemistry techniques to isolate strontium from the sample. Samples are counted twice to verify strontium-90 and yttrium-90 in-growth. Samples are typically processed in a batch. Backgrounds and system performance are verified with each batch. Chemical recoveries are determined by either gravimetric or gamma-emitting strontium-85 standard addition techniques.

Gamma Spectroscopy Analysis – EPA 901.1

Surface, potable, and groundwater surveillance samples (typically 4 liters) are placed in polyethylene bottles acidified to pH 2 with nitric acid. Each sample is then measured into a 4-L Marinelli™ beaker and counted on a calibrated gamma spectroscopy detector for 50,000 seconds (13.8 hours). Air-particulate filters and air-charcoal canisters are counted directly on the calibrated gamma spectroscopy detector for 10,000 seconds (2.8 hours). Soil, vegetation,

and aquatic biota are all processed following collection. Typically, a 100-, 200-, or 300-gram sample is taken, placed in a Teflon-lined aluminum can, and directly counted. For gamma spectroscopy analyses, overnight backgrounds are counted once per week, with calibration and background checked daily. Analytical results reflect net activity that has been corrected for background and efficiency for each counting geometry used.

NUCLIDE-SPECIFIC ACTINIDE ANALYSIS; FRISCH GRID METHOD

This method is followed for the determination of ^{241}Am, ^{238,239,240}Pu, ^{234,235,238}U, and ^{228,232}Th in either solid or liquid matrices. Radium-226 and radon-222 and its progeny can be determined, if necessary. No separation chemistry is required and the pulverized (< 50 mg) or evaporated sample is directly counted in an Aptec Frisch Grid Detector that is capable of resolving alpha peak energies separated by 0.050 Mev (50 keV) in a massless sample. Precision is typically $\pm$ 2 % for a single sample containing 0.6 cps of activity, counted twice for 20 minutes. Alpha-emitting tracers ^{243}Am, ^{236}Pu, ^{232}U, ^{230}Th may be added to the sample prior to counting to determine detection efficiency and/or recovery of added tracer. Typical backgrounds with the detector are <36 cph over a 3- to 9-MeV energy range. Full-Width Half-Maximum (FWHM) resolution ranges from 75 to 100 keV. Alpha efficiencies are matrix-dependent and are typically 0.15 cpm dpm^{-1} for mg amounts of soil, 0.18 cpm dpm^{-1} for cellulose-nitrate air filters, and 0.45 cpm dpm^{-1} for mL amounts of evaporated, untreated water samples. Optimum alpha-peak resolution and detection efficiencies were obtained when absorber thicknesses were maintained below 400 µg cm^{-2} on either 5-cm diameter stainless steel or aluminum planchets or 4.5-cm diameter membrane filters. Minimum detectable levels (MDLs) of 15 pCi/g^{-1} , 0.2 pCi/mL^{-1} , and 0.4 pCi/filter are achievable for 40 mg soil, 1 mL tap water, and 4.5-cm diameter filter samples, respectively, each counted for 60 minutes. The matrices and reported units are soils and sludge (pCi/kg), liquids (pCi/L), air filters (pCi/cc of air sampled), and other solids (dpm/100 cm^2).

NONRADIOLOGICAL ANALYTICAL METHODS

The ASL is certified by the NYSDOH Environmental Laboratory Approval Program (ELAP) for purgeable aromatics, purgeable halocarbons, PCBs, anions, and metal compounds, in both potable and wastewater matrices, using EPA 524, EPA 608, EPA 8082, EPA 624, EPA 200.8, EPA 245.2, EPA 236.1, EPA 273.1, and EPA 300.0 methods. Tables D-1 and D-2 list the nonradiological organic and inorganic NYSDOH ELAP–certified analytes, respectively. Not reflected in those tables are the PCB analyses that ASL is certified to conduct, for Aroclors 1016, 1221, 1232, 1242, 1248, 1254, and 1260.

Purgeable Aromatics and Purgeable Halocarbons

Water samples are collected in 40-mL glass vials with removable teflon-lined caps without any headspace, and acidified with 1:1 HCl to a pH <2.0. Samples are stored at 4°C and analyzed within 14 days. Thirty-eight purgeable compounds (including: benzene, toluene, ethyl benzene, total xylenes, chloroform, 1,1-dichloroethane, 1,1-dichloroethylene, tetrachloroethylene, 1,1,1-trichloroethane, trichloroethylene, chlorobenzene, carbon tetrachloride, methyl chloride and acetone) are analyzed under this category following EPA Method 624 protocols using gas chromatography/mass spectrometry (GC/MS). In 2003, two Hewlett-Packard™ GC/MS instruments were used to analyze purgeable organic compounds. Because groundwater at BNL is classified as a sole source aquifer under the Safe Drinking Water Act and as Class GA groundwater by the New York State Department of Environmental Conservation (NYSDEC), the detection limits reported for the compounds are close to NYS drinking water standards and the ambient water quality standard. EPA Methods 524.2 and 624 are used to analyze water, based on the project manager's data quality requirements.

The methods involve purging a 25-mL aliquot of the sample with ultra pure helium in a

specially designed sparger using the Purge and Trap technique. Each sample is spiked with a known concentration of internal standards and surrogates before purging to facilitate identifying, quantifying, and determining the extraction efficiency of analytes from the matrix. The purged analytes are trapped onto a specially designed trap and thermally desorbed onto the capillary chromatographic column by back flushing the trap with helium. Individual compounds are separated with a temperature program of the GC and enter the mass spectrometer, where they undergo fragmentation to give characteristic mass spectra. The unknown compounds are identified by comparing their mass spectra and retention times with reference compounds, then quantified by the internal standard method. The quantitation data are supported by extensive Quality Assurance/Quality Control, such as tuning the mass spectrometer to meet bromofluorobenzene criteria, performing initial and continuing calibrations that verify daily response factors, using method blanks, surrogate recoveries, duplicate analysis, matrix spike and matrix spike duplicate analysis, and reference standard analysis to verify the daily working standard.

PCB Analysis

The ASL is NYSDOH Certified for PCB Aroclors 1016, 1221, 1232, 1242, 1248, 1254 and 1260. Samples are collected in 50- or100-mL glass containers with Teflon™-lined lids, stored at 4°C, and analyzed within 30 days. Transformer oil, mineral oil, hydraulic fluid, waste oil, and spill-wipe samples are analyzed for PCBs using the gas chromatography-dual electron capture detector (GC-ECD) method. This method is similar to EPA SW-846 Method 8082 and is targeted to identify and quantify seven different mixtures of PCB congeners in samples.

The method consists of diluting a known weight of the sample with isooctane and removing the interfering compounds with one or more aliquots of concentrated sulfuric acid until the acid layer is almost colorless. The entire oil matrix and other interfering polar compounds are selectively removed from the sample, leaving the PCBs in isooctane solvent.

There is currently a single GC-ECD instrument for analyzing PCB. The PCBs found in the samples are identified and quantified by comparing the retention times and chromatographic patterns with the standards. Method blanks, duplicates, spikes, calibration, and reference check standards are run as part of Quality Assurance/ Quality Control.

Anions

Chloride, nitrate-N, and sulfate anions are analyzed using Dionex™ Ion-chromatography (IC) with the ion suppression and conductivity detection technique. Samples from monitoring wells are collected in 100-mL polyethylene bottles, cooled to 4°C, and analyzed within 28 days. For nitrate in drinking water, samples are analyzed within 48 hrs. In 2003 (as in past years), holding times were exceeded for nitrate analysis of some nonpotable monitoring well samples, but the depletion of nitrate is understood to be negligible.

The anions are passed through an anion-exchange polymer column and eluted with carbonate/bicarbonate solution. Then the eluent passes through a membrane suppressor, where the background contribution from the eluent is suppressed, improving signal to noise ratio (and detection limits). The target anions are then detected by a conductivity meter.

Initially, the system is calibrated with standards to define its working range. The target anions in the samples are identified and quantified by comparing the retention times and areas with the standards. Method blanks, duplicates, replicates, spikes, and reference standards are routinely analyzed as part of Quality Assurance/ Quality Control.

Metals

Samples are collected in 500-mL glass bottles and stabilized with ultra pure nitric acid to a pH of <2. The samples are analyzed within 6 months, except for mercury, which is analyzed within 26 days.

Iron and sodium are analyzed with a Perkin-Elmer atomic absorption spectrometer. Using the flame technique, the sample containing the target element is nebulized and atomized in an

oxy-acetylene flame. At the same time, a beam of light from an element-specific hollow cathode lamp corresponding to the absorption frequency of the target element is passed through the flame. The atomized element absorbs the energy specific to that element from the cathode lamp; the intensity of absorption is proportional to the concentration of the element in the sample. Calibration curves establish the linearity of the system and samples are quantified by comparison with standards.

Fourteen of the 17 elements offered for certification in potable water by NYSDOH ELAP are analyzed by Inductively Coupled Plasma/ Mass Spectrometry (ICP/MS). Iron and sodium are detailed in the preceding paragraph, and mercury in the following. Including aluminum, cobalt, molybdenum, and vanadium (for which only wastewater certification is available), 18 elements are analyzed by the ICP/MS technique. Aqueous samples are nebulized and introduced into a radio frequency argon plasma, at temperatures reaching 8000°K. The de-solvated, atomized analytes are ionized to predominantly singly-charged cations, which are identified and quantified by the use of a quadrupole mass spectrometer. Isobaric and polyatomic ion interferences are corrected using elemental interference equations based on natural isotopic abundances. Internal standardization eliminates or minimizes instrument drift and matrix-induced signal suppressions and enhancements. Using this technique, sub-part per billion sample detection limits are achievable.

Using a cold-vapor technique for mercury, a 100-mL aliquot of the sample is digested with potassium permanganate/persulfate oxidizing solution at 95°C for two hours to oxidize any organically bound and/or monovalent mercury to the mercury (II) oxidation state. Excess oxidizing agent is reduced with hydroxylamine hydrochloride. The mercuric ion later is reduced to elemental mercury with excess stannous chloride, which is purged with argon into the absorption cell. The absorption is directly proportional to the concentration of mercury in the sample. A Leeman PS 200 II automated mercury analyzer (detection limit = <0.1 µg/L) is used. All the atomic absorption techniques involve initial calibrations to define the calibration range, continuing calibrations, method blanks, duplicates, replicates, matrix spikes, and reference standard analysis as a part of Quality Assurance/Quality Control.

REFERENCES AND BIBLIOGRAPHY

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NYSDEC. 1995. Analytical Services Protocols. Bureau of Technical Services and Research, New York State Department of Environmental Conservation. Albany, NY.

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Helpful Information on Units of Measure and Conversions

UNITS OF RADIATION MEASUREMENT AND CONVERSIONS

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

APPROXIMATE METRIC CONVERSIONS

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

SCIENTIFIC NOTATION USED FOR MEASUREMENTS

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

CONCENTRATION CONVERSIONS

1 ppm	=	1,000 ppb		
1 ppb	=	0.001 ppm	=	1µg/L*
1 ppm	=	1 mg/L	=	1000 µg/L*

* For aqueous fractions only.

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