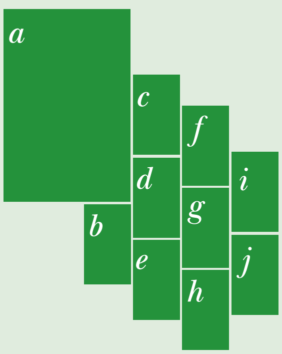
1999

BROOKHAVEN NATIONAL LABORATORY

Site Environmental Report

About the Cover and Interior Artwork

In celebration of the thirtieth anniversary of Earth Day, Brookhaven National Laboratory invited students in grades three through five from local schools to participate in a “Your Environment” art contest. The goal of the contest was to raise students’ awareness about environmental stewardship and pollution prevention. Over 250 entries were received from a dozen schools across eastern Long Island and were judged by a panel of Brookhaven staff. The winning artwork is on the cover of this 1999 Site Environmental Report, and the artist received a gift certificate presented during the Earth Week celebrations held at the Laboratory. Ten other artists were also recognized and received awards. Their work is featured on the back cover and at the beginning of each chapter. Brookhaven would like to thank all of the students who participated for their artistry and their interest in the environment. Below is a listing indicating the students, their school, grade, teacher, and the location in this document where their artwork is featured.



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EXPLORING EARTH'S MYSTERIES
...PROTECTING ITS FUTURE

BROOKHAVEN NATIONAL LABORATORY

1999 Site Environmental Report

September 2000

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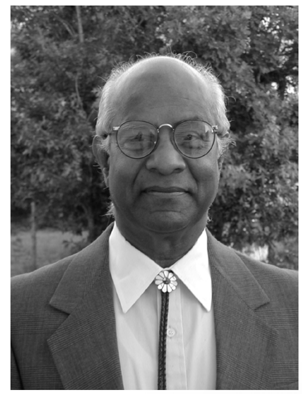
Dedication

Jan Naidu, Ph.D.



This Site Environmental Report is dedicated to Dr. Janakiram (Jan) Naidu, an ecologist at Brookhaven National Laboratory from 1975 until his retirement in 2000. Born in Bangalore, India, Jan has dedicated his life to the protection of the environment and to higher education.

Dr. Naidu's early work at BNL focused on evaluating the impacts of Laboratory operations on the environment (groundwater, surface water, and biota). Jan was responsible for the environmental protection program from 1981 through 1991 and was instrumental in improving the Laboratory's groundwater monitoring program throughout the 1980s. He was the principal editor and a contributing author of the annual Site Environmental Report from 1976 through 1998. In his later years at BNL, Jan focused his attention on wildlife ecology and was an active voice on Long Island Pine Barrens issues.

In addition to these significant accomplishments, Dr. Naidu has advanced the field of environmental science by mentoring many high school and college students, as well as high school teachers. As a mentor to students and colleagues alike, Jan has been a valuable source of information on the environment.

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Executive Summary

Throughout the scientific community, Brookhaven National Laboratory (BNL) is renowned for its leading-edge research in physics, medicine, chemistry, biology, materials, and the environment. BNL is committed to supporting its world-class scientific research with an internationally recognized environmental protection program. The *1999 Site Environmental Report* (SER) summarizes the status of the Laboratory's environmental programs and performance, including the steady progress towards cleaning up the site and fully integrating environmental stewardship into all facets of the Laboratory's mission.

BNL is located on 5,265 acres of pine barrens in Suffolk County in the center of Long Island, New York. The Laboratory is situated above a sole source aquifer at the headwaters of the Peconic River; therefore, protecting ground and surface water quality is a special concern. Approximately 3,600 acres of the site are undeveloped and serve as habitat for a wide variety of animals and plants, including one New York State endangered species, the tiger salamander, and two New York State threatened species, the banded sunfish and the stiff goldenrod. Monitoring, preserving, and restoring these ecological resources is a high priority for the Laboratory.

ENVIRONMENTAL PROGRAMS

The calendar year 1999 represented the first full year of operation under the management of Brookhaven Science Associates. In 1999, BNL achieved significant improvements in its environmental performance. As a result of the Process Evaluation Project, the Laboratory now has an unprecedented level of knowledge of current operations and potential environmental vulnerabilities. Additionally, the Laboratory is openly and routinely communicating with neighbors, regulators, employees, and other interested parties on issues and progress.

BNL continues to develop, implement, and enhance an Environmental Management System that is consistent with the International Standards Organization (ISO) 14001 Standard, with increased emphasis in the areas of compliance assurance, pollution prevention, and community outreach. Most notably in 1999, one of the major scientific facilities at BNL, the Relativistic Heavy Ion Collider, was officially certified to the ISO 14001 Standard by an independent accredited registrar. The Relativistic Heavy Ion Collider is the first Long Island-based organization and the first Department of Energy (DOE) Office of Science facility to achieve this level of recognition.

BNL continues its strong commitment to pollution prevention. Through the Process Evaluation Project, the Laboratory has identified new waste reduction opportunities. In 1999, pollution prevention projects saved over $1,600,000 and reduced, recycled, or reused over 16,000,000 pounds of materials, including 12,850,000 pounds of water conserved through chiller replacement.

COMPLIANCE WITH ENVIRONMENTAL REGULATIONS

BNL is subject to more than 50 sets of federal, state, and local environmental regulations; 60 site-specific permits; and a number of other binding agreements. The Laboratory is committed to achieving and maintaining full compliance with these environmental requirements and agreements. In 1999, BNL operated in compliance with the vast majority of applicable regulations, and programs are in place to address areas for improvement. The Laboratory also achieved additional reductions in emissions that can affect global warming and acid rain, such as nitrogen oxides, carbon monoxide, and sulfur dioxide. Four portable extinguishers were taken out of service and 68 pounds of Halon 1211 were recovered for reuse. Approximately 1,700 pounds of ozone-depleting refrigerants were also recovered for recycling.

With the exception of two minor pH excursions, all discharges complied with the effluent limitations specified in the New York State Pollutant Discharge Elimination System permit. Nine reportable spills of petroleum products subject to offsite regulatory reporting requirements occurred; all were cleaned to the satisfaction of the New York State Department of Environmental Conservation. BNL's potable water system met all drinking water requirements.

Laboratory operations and environmental protection programs were reviewed and audited extensively by a number of organizations in 1999. The U.S. Environmental Protection Agency, New York State Department of Environmental Conservation, and the Suffolk County Department of Health Services conducted compliance inspections; the Department of Energy conducted audits and program reviews; and BNL conducted a number of self-assessments. No citations resulted from 1999 inspections.

ENVIRONMENTAL MONITORING

BNL maintains a comprehensive monitoring program, including ambient and emission-point air monitoring stations, river water checkpoints, and a large network of groundwater monitoring wells. The monitoring system provides the information to ensure compliance with regulatory and permit conditions, as well as the early detection and correction of unexpected conditions.

During 1999, BNL collected and analyzed about 5,000 environmental samples. Total air emissions and radiological air quality met Clean Air Act and DOE standards in 1999. In 1999, BNL collected groundwater samples from 589 monitoring wells during 2,122 individual sampling events. Six known significant volatile organic compound plumes and eight radionuclide plumes were tracked and evaluated. Due to enhancements in the groundwater monitoring system, a narrow, previously unknown tritium plume was discovered near a beam deflector at the Alternating Gradient Synchrotron. The plume is now being carefully monitored. During 1999, average gross alpha and beta activity at the Sewage Treatment Plant outfall was within the range typical of background surface waters. Very low levels of Cesium-137 continue to be found in the STP effluent due to historical operations. All wastewater effluents met applicable discharge standards for organic and inorganic parameters.

BNL has a wildlife management program to protect and manage flora and fauna and their habitats. Local deer and fish are monitored for contamination from historical activities. Consistent with data from previous years, deer residing on the BNL site had concentrations of cesium-137 higher than those observed in offsite deer. The New York State Department of Health conducted a risk evaluation and concluded that the low levels of contamination do not justify imposing any restrictions on hunting near BNL. Fish collected from the Peconic River at the BNL boundary continue to show radionuclide concentrations that are slightly higher than control samples, though 1999 data are consistent with a pattern of decreasing concentration levels expected to continue over time. There was no sampling for local farm grown produce in 1999; however, during the previous ten years of monitoring, no Laboratory-generated radionuclides have ever been detected.

ENVIRONMENTAL RESTORATION

During 1999, five onsite and one offsite groundwater remediation systems removed approximately 634 pounds of volatile organic compounds and returned approximately 757 million gallons of treated water to the Upper Glacial aquifer. Remediation systems are decreasing volatile organic compound concentrations near the southern boundary of the site. Other significant restoration activities are ongoing.

RADIOLOGICAL DOSE ASSESSMENT

The evaluation of potential radioactive dose to the public showed that radiological dose attributable to Laboratory operations was far below the limits established by federal regulations. Direct measurement of external radiation levels confirmed that exposure rates at the site boundary were consistent with background levels observed throughout New York State. The ambient air radiation measured in the vicinity was within natural background level. Consumption of local fish and deer would also result in exposure well below EPA limits. There is no significant dose from drinking water.

The hypothetical Maximally Exposed Individual, defined as residing at the northeast boundary of BNL, breathing the air, and consuming 15 pounds of fish and 64 pounds of deer meat from onsite sources would receive 4.58 mrem per year of the total effective dose equivalent from inhalation and ingestion pathways. This is an extremely unlikely worst case scenario, but was calculated to show that the dose from all pathways would still be less than 5 percent of the 100 mrem per year dose limit set by DOE for the general public . The average annual dose from man-made, cosmic, terrestrial, and ingestion paths, and radon is 360 mrem.

QUALITY ASSURANCE

BNL follows strict quality control measures for its environmental monitoring programs, and the analytical data presented in this report are of high quality. Quality control is ensured in both the collection and analysis of environmental samples. The Laboratory uses its onsite Analytical Services Laboratory (ASL) and four offsite contractor laboratories to analyze environmental samples. The oversight of laboratory analyses involves proficiency testing, auditing, and ensuring adherence to a quality assurance program. All analytical laboratories are New York State-certified. The two primary laboratories reporting radiological analytical data in this SER each scored between 90 and 100 percent satisfactory results in both state and federal performance evaluation programs. For nonradiological performance evaluation testing, the ASL and the three BNL contractor laboratories each scored over 90 percent in the New York State Environmental Laboratory Approval Program evaluations.

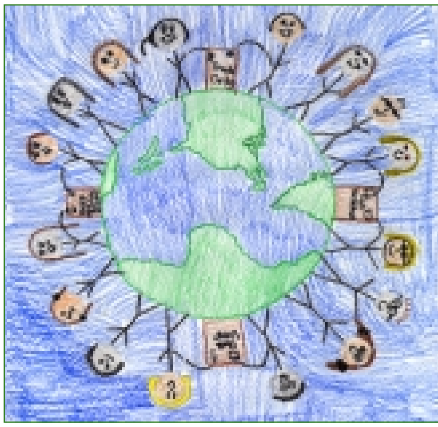
OUTREACH AND COMMUNICATION

BNL conducted a number of public outreach activities including presentations and meetings with the public; regular communications with the local, state, and federal regulators and elected officials; and routine interactions with the business and educational community. In 1999, BNL hosted more than 20,000 student visitors and another 4,900 people visited the Laboratory through its Summer Sunday programs. To highlight the cutting-edge environmental research conducted at the Laboratory and provide information regarding cleanup initiatives, the Laboratory hosted an Environmental Fair, which drew over 3,000 visitors.

CONCLUSION

The last two years have been a turning point for BNL, and this SER documents the progress the Laboratory has made during 1999 in achieving its environmental stewardship goals. The problems that resulted from the Laboratory's first 50 years of operations cannot be fixed in one year, but BNL is now on the right path to continue its world-class research in an environmentally responsible culture and in a clean, restored environment.

CHAPTER 1



Introduction

Brookhaven National Laboratory, a U.S. Department of Energy national laboratory, is world renowned for its leading-edge scientific research. In order to conduct this research in a safe and environmentally responsible manner, BNL has a comprehensive environmental protection program and is building a world class Environmental Management System. The Site Environmental Report is prepared annually by the Laboratory to summarize the status of environmental programs and performance. This report also describes any impacts that BNL research operations may have on the environment.

Brookhaven National Laboratory is located on 5,265 acres of pine barrens in Suffolk County in the center of Long Island, New York. In order to understand the Laboratory's environmental programs, activities, and impacts, it is important to know about its facilities, the ecosystem where it resides, and the human populations nearby. Chapter 1 discusses local site characteristics in terms of human population, geology, hydrology, climate, and ecological resources in order to place the following chapters in perspective.

1.1 PURPOSE OF THE 1999 SITE ENVIRONMENTAL REPORT

The U.S. Department of Energy (DOE) requires its facilities, including Brookhaven National Laboratory (BNL), to report on their environmental performance on an annual basis. The 1999 Site Environmental Report (SER) is prepared in accordance with DOE Order 231.1 (1995) and DOE Order 5400.1 (1988). The Site Environmental Report summarizes the programs, results, and status of BNL's environmental protection programs for calendar year 1999. The programs include environmental management, pollution prevention, and compliance assurance.

The SER also serves a larger function beyond complying with DOE requirements. BNL has been preparing SERs since 1968; consequently, these reports are a continuing record of the Laboratory's environmental activities and impacts. The SER serves as a tool to communicate information to staff, DOE, regulators, and the public. A condensed version of the SER, referred to as the Summary Report, is also available (see inside front cover for ordering information). The Summary Report, which clearly summarizes the technical content of the SER, is used to provide information to visitors, students, and members of the public in support of BNL's educational and community outreach programs.

1.2 THE MISSION AND HISTORY OF BROOKHAVEN NATIONAL LABORATORY

BNL is operated for DOE by Brookhaven Science Associates (BSA), a not-for-profit partnership of the 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 entered into an agreement with DOE under contract DE-AC02-98CH10886 and began operating the Laboratory on March 1, 1998. Prior to that, from 1947-1998, BNL was operated by Associated Universities Incorporated (AUI).

Approximately 3,000 resident scientists and operations staff work at BNL. In addition, more than 4,000 academic and industrial researchers from all over the world visit the site each year to participate in scientific collaborations. BNL's annual budget is approximately $400 million with about 88 percent of the funding coming from DOE. The remainder is from other domestic and international scientific and industrial clients. The majority of the Laboratory's budget directly supports the local economy. An independent Suffolk County Planning Commission report concluded that BNL's operating, procurement, payroll, construction, medical benefits, and technology-transfer spending spreads throughout Long Island's economy, making the Laboratory vital to the Island's economic health (Kamer 1995).

BNL's research initially focused on advanced physics, but it has since expanded into chemistry, materials science, biology, medicine, and environmental research. The Laboratory's large and unique scientific facilities make this research possible, providing the tools for BNL scientists and visiting researchers to extend the boundaries of knowledge and technology.

BNL's broad mission is to produce excellent science and advanced technology in a safe, environmentally responsible manner with the cooperation, support, and appropriate involvement of the community. Specifically, the elements of the BNL mission, which support the DOE strategic missions, are to

- conceive, design, construct, and operate complex, leading-edge, user-oriented facilities in a safe and environmentally responsible manner that is responsive to the DOE and the needs of the international community of users;
- carry out basic and applied research in long-term programs at the frontier of science in support of DOE missions;
- develop advanced technologies that address national needs and to transfer them to other organizations and to the commercial sector; and
- 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 was founded in 1947 by the Atomic Energy Commission and operated by AUI on the site of the U.S. Army's former Camp Upton. 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.

The Laboratory's scientific history began in 1950 with the operation of the Brookhaven Graphite Research Reactor (BGRR), a research reactor used for peaceful scientific exploration in the fields of medicine, biology, chemistry, physics, and nuclear engineering. The BGRR operated until 1969 and is now in the process of decommissioning. Its capacity was replaced and surpassed in 1965 by the High Flux Beam Reactor (HFBR), which provided neutrons to researchers of all disciplines, from solid state physics to art history. During a scheduled maintenance shutdown in 1997, a leak in HFBR's spent fuel storage pool was discovered. In November 1999, the Secretary of Energy made a decision to permanently close the HFBR.

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 (MRC) in 1958, the Brookhaven Medical Research Reactor (BMRR) in 1959, and the Brookhaven Linac Isotope Producer (BLIP) in 1973. Chemists and physicians teamed up to view the inner workings of the brain in 1977 with the advent of Positron Emission Tomography (PET) cameras. Two more imaging techniques were added to the PET research efforts to form the Center for Imaging and Neuroscience in 1996. These facilities are all currently operating.

High energy particle physics research began in 1952 with the Cosmotron, the first particle physics accelerator to achieve billion-electron-volt energies. Work at the Cosmotron resulted in a Nobel Prize-winning discovery in physics in 1957. In 1960, the Alternating Gradient Synchrotron (AGS), a large accelerator, was built to surpass the Cosmotron's capabilities (see Figure 1-1). It has yielded many discoveries on new particles and phenomena, for which BNL researchers were awarded three more Nobel Prizes in physics in 1976, 1980, and 1988. The AGS continues to operate. Another accelerator, the Tandem Van de Graaff, began operating in 1970 and is still operating. In 1982, the National Synchrotron Light Source (NSLS) began operation (see Figure 1-2). The NSLS guides charged particles in an orbit. As the electrons spin inside a hollow donut-shaped tube called an electron storage ring, they give off light called synchrotron light. This light, which can be detected by specialized instruments, is used to study the properties of matter.

Brookhaven's newest accelerator facility is the Relativistic Heavy Ion Collider (RHIC), which was completed in 1999 (see Figure 1-3). The RHIC is designed to recreate a state of matter that scientists believe existed moments after the universe was formed. RHIC is an

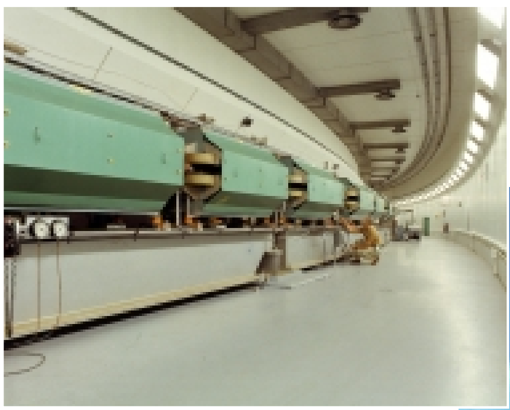


Figure 1-1. Alternating Gradient Synchrotron Facility. View inside the Alternating Gradient Synchrotron Facility, which produced three Nobel Prizes in Physics.

Figure 1-2. National Synchrotron Light Source. Scientists at the National Synchrotron Light Source study the properties of matter using charged particles and synchrotron light.

example of Brookhaven's commitment to fully integrate today's world class science with world class protection of the environment. This was exemplified when RHIC's operations received ISO 14001 Environmental Management System certification in August 1999 (see Chapter 2 for details).

Historical waste management practices at the Laboratory led to releases of chemicals and radioactive materials that resulted in soil and groundwater contamination. In 1989, BNL joined a number of Long Island sites when it was added to the federal Comprehensive Environmental Response, Compensation & Liability Act (CERCLA) National Priorities List, a listing of environmentally contaminated sites nationwide identified for priority cleanup (see Chapter 2 for details on the Laboratory's environmental restoration program progress).

This 1999 SER represents the first full calendar year of new site management. In November 1998, BNL issued a policy on integrating environmental stewardship into all facets of the Laboratory's mission and management of programs in a manner that protects the ecosystem and public health. Figure 1-4 shows BNL's Environmental Stewardship Policy, which represents the highest level of commitment to conducting research and operational activities in a manner that protects the environment. This SER describes BNL's progress and challenges in achieving its environmental stewardship goals. The problems that resulted from the Laboratory's first 50 years of operations cannot be fixed in one year, but BNL is now on the right path to continue its world class research in an environmentally responsible culture and in a clean and restored environment.

1.3 SITE LOCATION AND LOCAL POPULATION

BNL is located near the geographical center of Suffolk County, Long Island, about 60 miles east of New York City (Figure 1-5). About a third of the 1.37 million people that reside in Suffolk County live in Brookhaven Township where the Laboratory is situated (LIPA 1999). Figure 1-6 shows the distribution of the resident population on Long Island. As with all town-

Figure 1-3. Relativistic Heavy Ion Collider. RHIC received ISO 14001 certification for its Environmental Management System in 1999.

Environmental Stewardship Policy

It is Brookhaven National Laboratory's (BNL's) policy to integrate environmental stewardship into all facets of the Laboratory's missions. We will manage our programs in a manner that protects the ecosystem and public health.

In support of this policy, BNL makes the following commitments:

- ♦ We are committed to achieving compliance with applicable environmental requirements.
- ♦ In consideration of the potential impacts of our activities on the environment, we will integrate pollution prevention/waste minimization, resource conservation, and compliance into all of our planning and decision-making. We will adopt cost-effective practices that eliminate, minimize or mitigate environmental impacts.
- ♦ We will define, prioritize, and aggressively correct and clean up existing environmental problems.
- ♦ We will work to continually improve our environmental management system and performance. We will establish appropriate environmental objectives and performance indicators to guide these efforts and measure our progress.
- ♦ We will maintain a positive, proactive, and constructive relationship with our neighbors in the community, regulators, DOE, and our other stakeholders. We will openly communicate with stakeholders on our progress and performance.

In addition to my annual review of BNL's progress on environmental goals and adherence to this policy, I invite all interested parties to provide me with input on our performance relative to this policy, and the policy itself.

John H. Marburger

John H. Marburger, Laboratory Director

11/19/98
Date

Figure 1-4. BNL's Environmental Stewardship Policy.

ships of Long Island, there has been an increase in residential housing in the Brookhaven Township in recent years, a trend that is expected to continue. Approximately eight thousand people live within 0.3 miles of the Laboratory's boundaries. Figure 1-7 shows the approximate resident population surrounding the site within a one-third mile radius, as well as the housing capacity for onsite residents and visitors.

More than 75 percent of BNL's 3,000 employees live within a 15-mile radius of the Laboratory (Figure 1-8). In addition, many of the 4,000 visiting scientists live onsite in dormitories, apartments, and guesthouses during their visit. Adding to the onsite staff and visiting scientists, BNL Public Affairs recorded over 27,000 local students and other members of the public visiting the Laboratory in 1999 to participate in educational and public outreach activities.

1.4 FACILITY AND OPERATIONS DESCRIPTION

Most of the principal facilities are located near the center of the BNL's 5,265 acre (8.23 square mile) site. The developed area is approximately 1,650 acres, consisting of about

- ♦ 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 occupied by outlying facilities, such as the Sewage Treatment Plant, research agricultural fields, housing, and fire breaks; and
- ♦ 400 acres of roads, parking lots, and connecting areas.

The balance of the site, approximately 3,600 acres, is largely wooded and represents native pine barren ecology (see section 1.7 of this chapter and Chapter 6 for more information).

The major scientific facilities are shown and briefly described in Figure 1-9. As noted earlier,

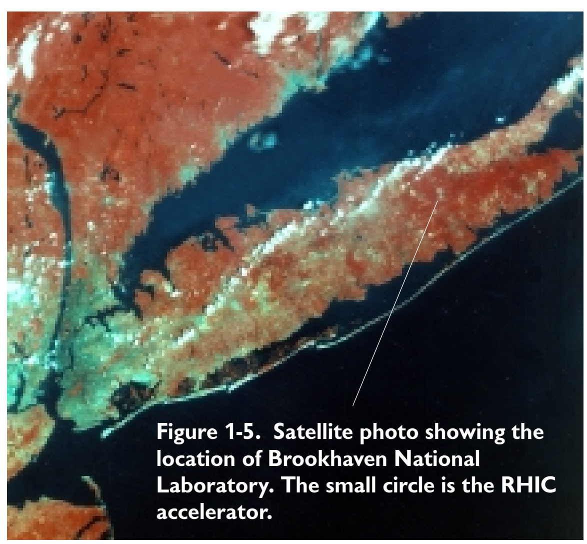


Figure 1-5. Satellite photo showing the location of Brookhaven National Laboratory. The small circle is the RHIC accelerator.

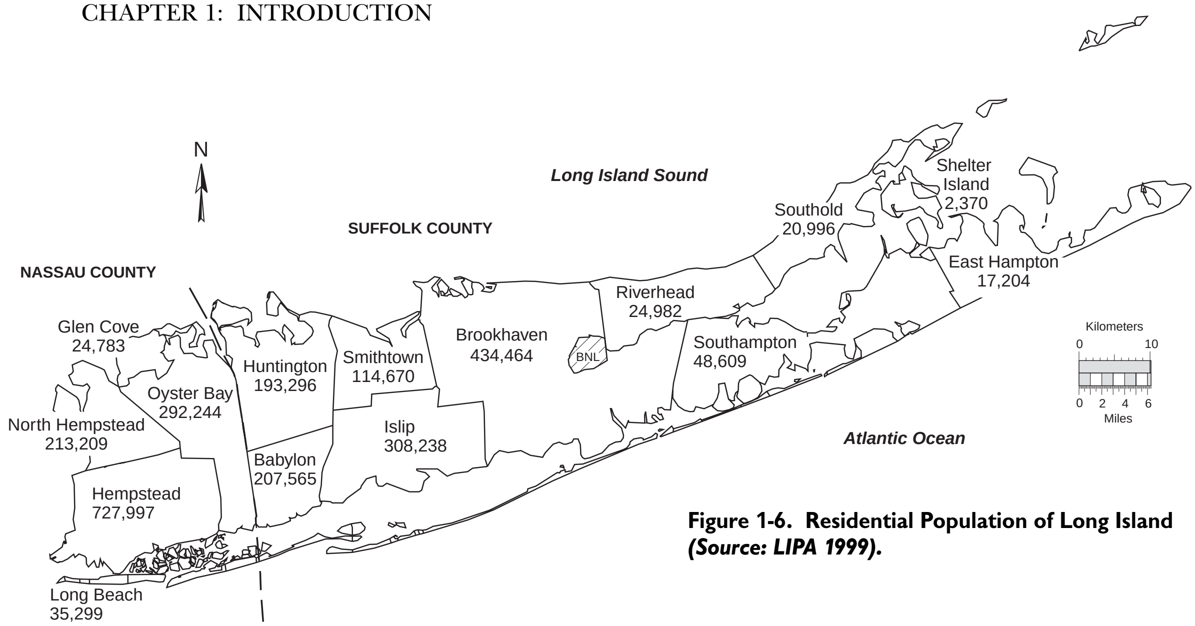


Figure 1-6. Residential Population of Long Island *(Source: LIPA 1999).*

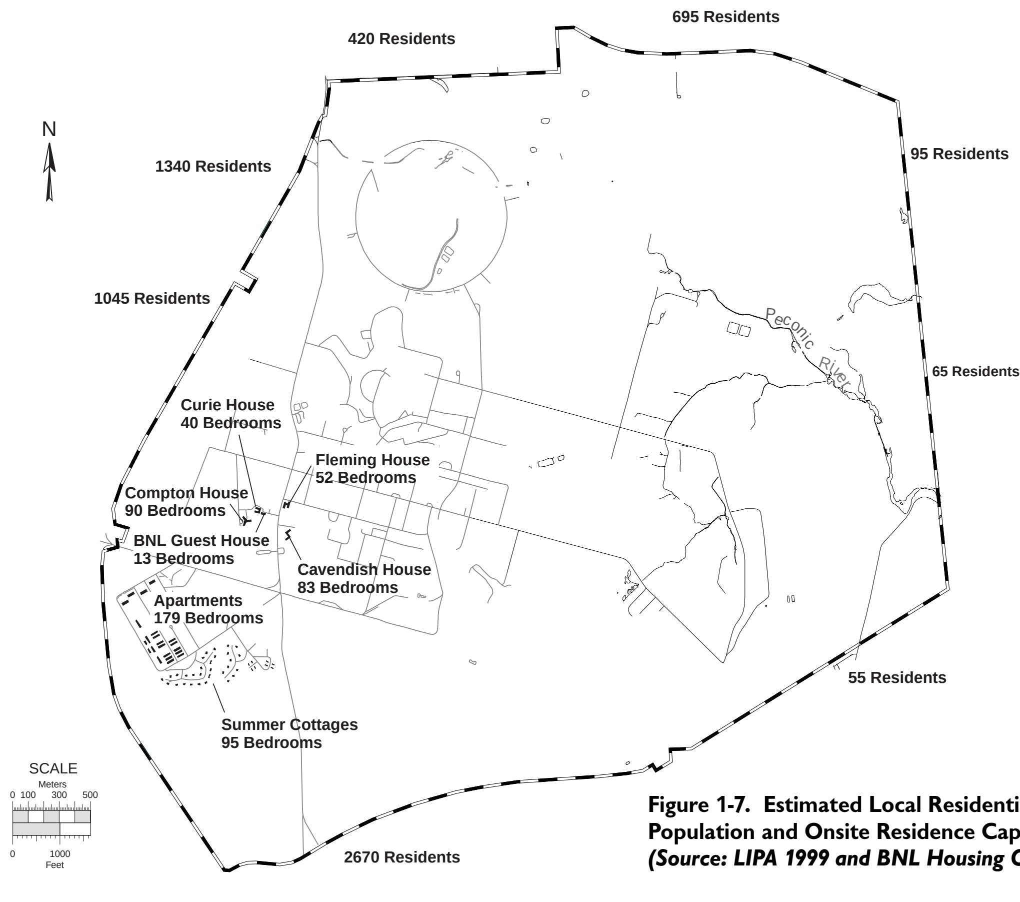


Figure 1-7. Estimated Local Residential Population and Onsite Residence Capacity *(Source: LIPA 1999 and BNL Housing Office).*

two major facilities, both reactors, are no longer operational at BNL: the BGRR and the HFBR. The BGRR was shut down in 1969 and is currently undergoing decommissioning. The HFBR ceased operation in 1997 and was permanently closed in 1999.

In addition to the scientific facilities, numerous other facilities support BNL's science and technology mission by providing basic utility and environmental services:

♦ *Water Treatment Plant.* The Water Treatment Plant is a potable water treatment facility with a capacity of 5 million gallons per day. Potable water is obtained from three wells located along the western boundary of the developed site and 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 are at or below New York State drinking water standards.

- ♦ *Central Chilled Water Plant.* This facility provides chilled water for air conditioning and process refrigeration for the entire site via a network of underground piping. The plant has a large refrigeration capacity with once-through cooling, which reduces the necessity for local refrigeration plants.
- ♦ *Central Steam Facility.* The Central Steam Facility is a dual fuel-fired plant that provides high-pressure steam for both facility and process heating for the entire site. Natural gas is the primary fuel. Steam is conveyed to the user facilities through a network of underground piping. Condensate is collected and returned to the facility for reuse as a water and energy conservation measure.
- ♦ *Major Petroleum Facility.* The Major Petroleum Facility provides reserve fuel for the Central Steam Facility during times of peak operation. This facility has a total capacity of 1.8 million gallons for storing predominately No. 6 fuel oil. The 1997 conversion of the boilers at the Central Steam Facility to natural gas has significantly reduced BNL's reliance on oil as a source of fuel. The conversion reduced sulfur dioxide emissions by 95,000 pounds and nitrogen oxide emissions by 120,000 pounds per year.
- ♦ *Sewage Treatment Plant.* The Sewage Treatment Plant receives sanitary and certain process wastewater from BNL facilities for treatment prior to discharge into the Peconic River, similar to the operations of a municipal sewage treatment plant. The Sewage Treatment Plant has a design capacity of 3.0 million gallons per day. The effluent is monitored and controlled under a permit issued by the New York State Department of Environmental Conservation. See Chapter 3 for additional information on this facility and associated environmental permits.
- ♦ *Waste Management Facility.* The Waste Management Facility is a state-of-the-art complex for managing the wastes generated from BNL's research and operation activities. This facility, which opened in December 1997, was built with advanced environmental protection systems and features. The Waste Management Facility houses two areas permitted by the New York State Department of Environmental Conservation for storing and treating hazardous wastes, prior to shipment offsite for treatment and disposal at other permitted treatment, storage, and disposal facilities. See Chapter 2 for more information on waste management.

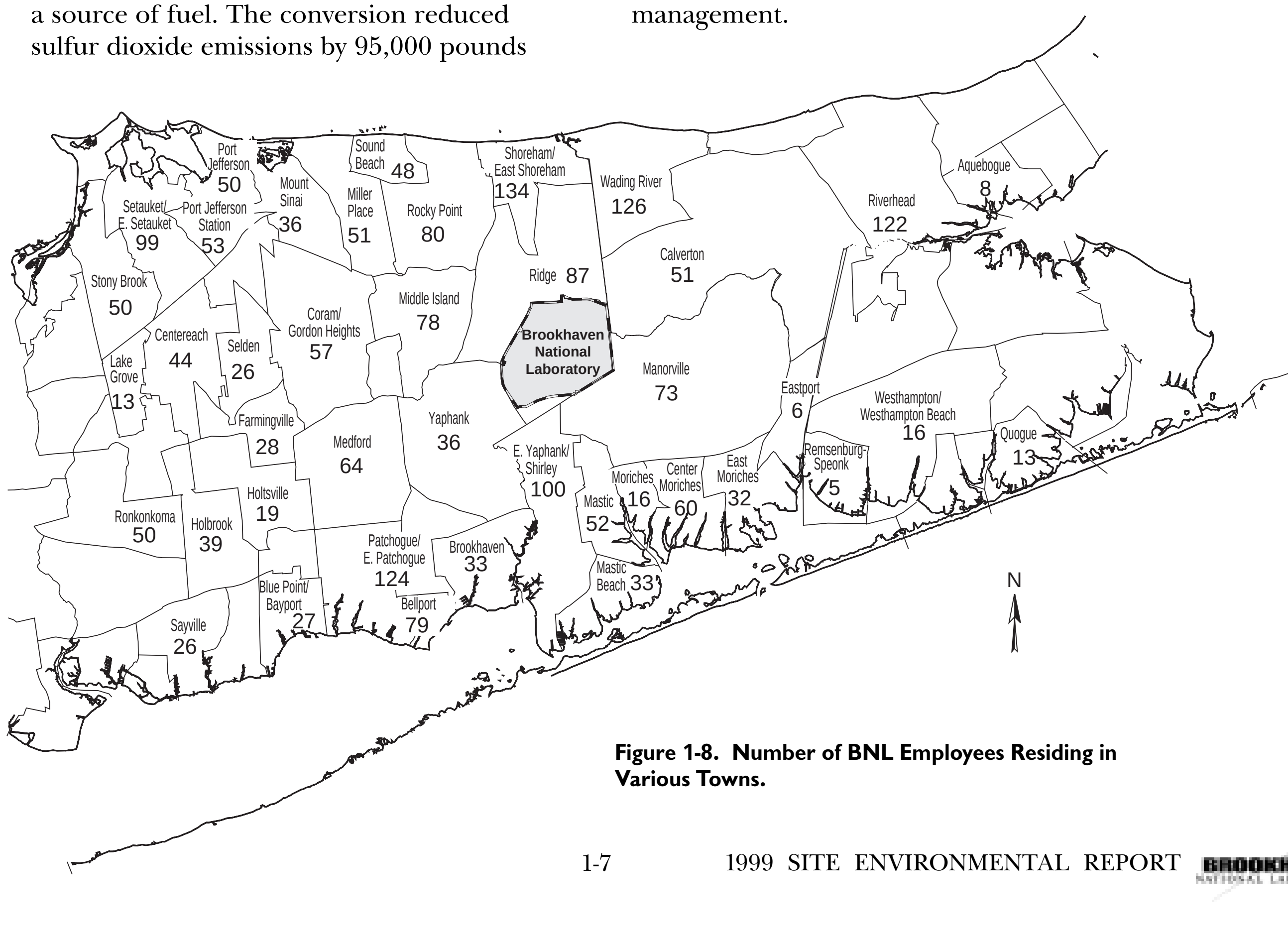


Figure 1-8. Number of BNL Employees Residing in Various Towns.

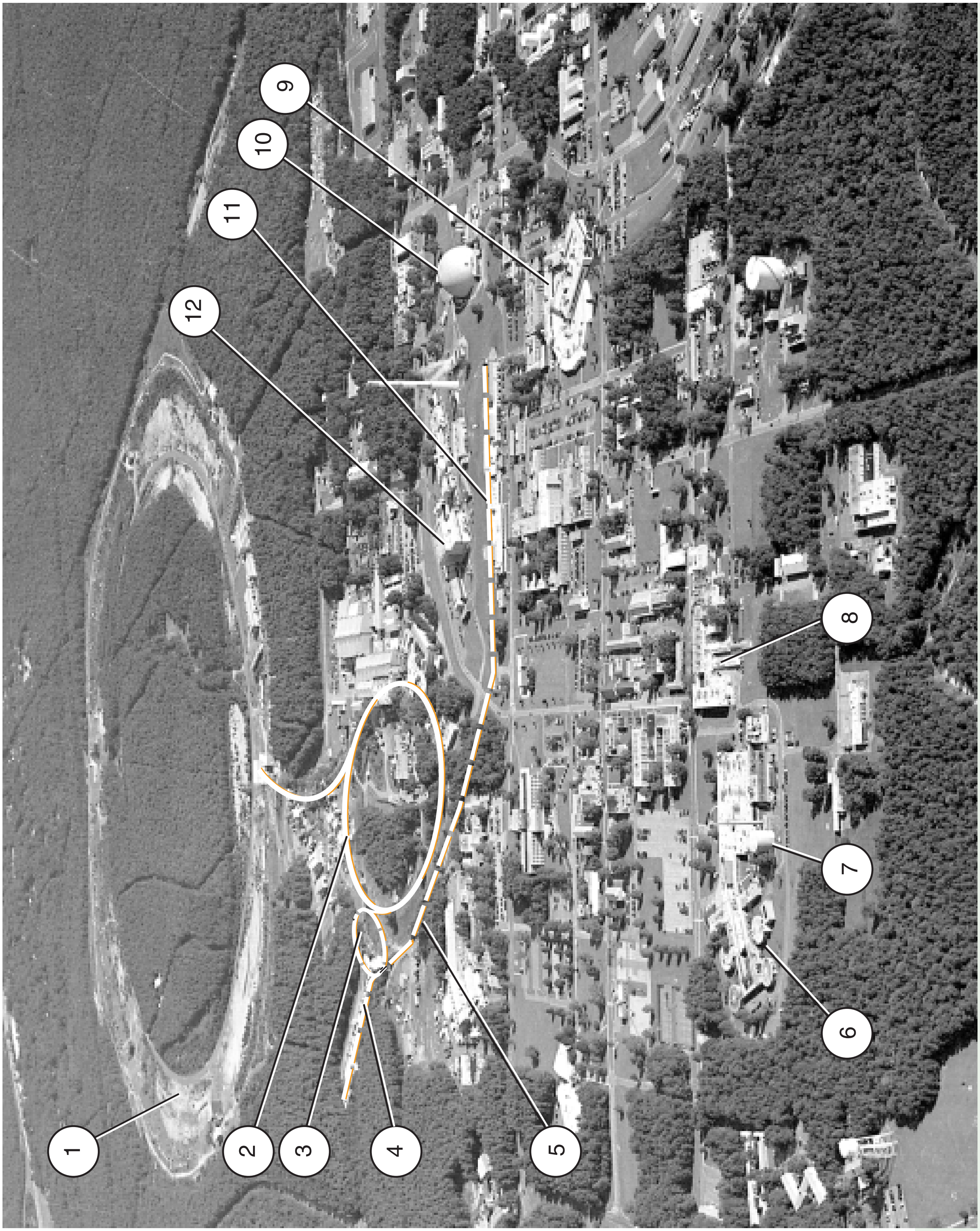

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Figure 1-9. Major Brookhaven Scientific Facilities.

1. RELATIVISTIC HEAVY ION COLLIDER (RHIC)

To be operating soon, RHIC is one of the world's largest and most powerful accelerators. RHIC's main physics mission is to study particles smaller than atoms.

2. ALTERNATING GRADIENT SYNCHROTRON (AGS)

The AGS is used for high-energy physics research and accelerates protons to energies up to 30 GeV, and heavy-ion beams to 15 GeV. A 200 MeV Linear Accelerator, described below, serves as a proton injector for the AGS 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 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 makes beams of polarized protons for the AGS and, when it becomes operational, for the Relativistic Heavy Ion Collider (RHIC). 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 at BNL on new diagnostic and therapeutic radiopharmaceuticals.

5. HEAVY ION TRANSFER LINE (HITL)

The HITL connects the Tandem Van de Graaff and the AGS. This interconnection permits ions of intermediate mass to be injected into the AGS where they can be accelerated to an energy of 15 GeV/amu. 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. It produces neutrons in an optimal energy range for experimental treatment of a type of brain cancer known as glioblastoma multiforme.

8. SCANNING TRANSMISSION ELECTRON MICROSCOPE (STEM)

This facility includes two microscopes, STEM 1 and STEM 3, used for biological research. Both powerful 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 for 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 closed 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 for physics experiments.

12. BROOKHAVEN GRAPHITE RESEARCH REACTOR (BGRR)

No longer in operation, the BGRR was used to research cancer therapy methods such as boron neutron capture therapy.

1.5 GEOLOGY AND HYDROLOGY

BNL lies 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. The Peconic River both recharges to, and receives water from, the sole source aquifer system underneath Long Island, depending on the position of the water table relative to the base of the riverbed. In times of sustained drought, the river water typically recharges to groundwater while with normal to above-normal precipitation, the river receives water from the aquifer. In general, the terrain of the site is gently rolling, with elevations varying between 44 and 120 feet above sea level. Depth to groundwater from the surface of the land ranges from five feet near the Peconic River to about 80 feet in the higher elevation areas in the central and western portions of the site.

This groundwater system is a source of drinking water for both on and offsite private and public supply wells. Since it has a history of significant groundwater contamination from both BNL and non-BNL sources, EPA has classified this area as a “vulnerable groundwater system.”

BNL uses approximately 2.6 million gallons per day of groundwater to meet potable water needs and heating and cooling requirements. Approximately 74 percent of the total water is returned to the aquifer through onsite recharge basins. About 19 percent is discharged into the Peconic River. Human consumption, evaporation (cooling tower and wind losses), and sewer line losses account for the remaining seven percent. An additional 0.6 million gallons per day of groundwater are pumped from remediation wells for treatment and then returned to the aquifer by the use of recharge basins.

The hydrology of this area is very 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. This region and the water it contains is called 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 recharge rate (22 inches per year) that varies seasonally.

The BNL site was also identified by the Long Island Regional Planning Board and Suffolk County as being part of a deep-flow recharge zone for Long Island groundwater (Koppelman 1978, SCDHS 1987). This finding indicates that precipitation and surface water that recharge within this zone have the potential to replenish the deep aquifer systems lying below the Upper Glacial Aquifer. It is estimated that up to two-fifths of the recharge from rainfall moves into the deeper aquifers. The extent to which groundwater at the BNL 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). In general, these deeper aquifers discharge to the Atlantic Ocean or to the Long Island Sound.

Groundwater flow direction across the BNL site is influenced by natural drainage systems moving eastward along the Peconic River, southeast towards the Forge River and south toward the Carmans River. This causes the flow direction of the groundwater to vary significantly and frequently in the industrial areas onsite. Two natural groundwater divides have been identified near the BNL site (Scorca *et al.* 1999). One is located approximately 0.5 mile north of BNL and a second transects portions of the site when the water table is high (i.e., when the aquifer flows into the stream bed). These define the boundaries of the area contributing groundwater to the Peconic River watershed.

In most areas at BNL, the horizontal velocity of groundwater is approximately 0.75-1.2 feet per day (Geraghty and Miller 1996). In general terms, it takes approximately 20 to 22 years for groundwater to travel from the central, developed area of the site to the BNL southern boundary.

See Chapter 7 for details on BNL’s comprehensive groundwater protection and management program.

1.6 CLIMATIC DATA

The prevailing ground level winds at BNL are from the southwest during the summer, from the northwest during the winter, and about equal from these two directions during the spring and fall (Nagle 1975, Nagle 1978). Figure 1-10 shows the 1999 annual wind rose for BNL, which depicts the annual frequency distribution of wind speed and direction, measured on an onsite meteorological tower at heights of 30 and 300 feet.

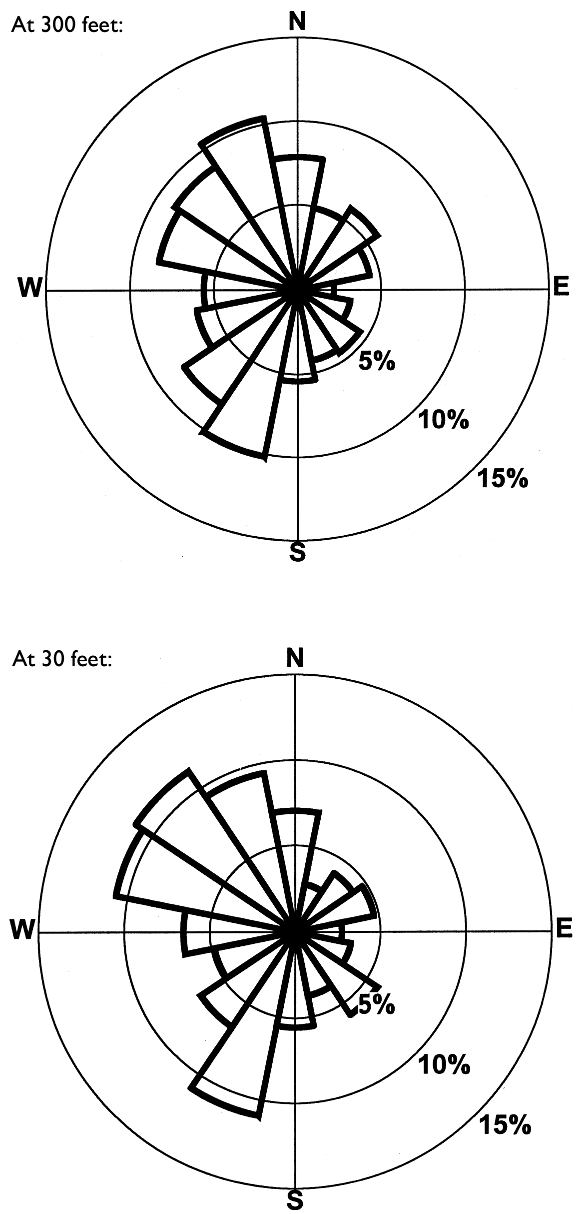
The total precipitation for 1999 was 51.72 inches. Most of the precipitation was received from January through March and August through October, with a very dry spring and early summer. Precipitation in 1999 was 3.26 inches above the 50-year annual average. Figures 1-11 and 1-12 present the 1999 monthly and the 50-year annual precipitation data, respectively.

The monthly mean temperature in 1999 was 52.7°F, ranging from a monthly mean low temperature of 32.2°F in January to a monthly mean high temperature of 76.3°F in July. The average annual mean temperature for 1999 was 2.8°F above the 50-year annual average, continuing a trend of increasing annual temperatures. In general, using a linear average, temperatures at BNL have increased 1.86°F over the last 50 years, compared to a worldwide average surface temperature increase of 0.5-0.6°F (Jones *et al.* 1999). Figures 1-13 and 1-14 show the 1999 temperatures and the historical annual mean temperatures, respectively.

1.7 ECOLOGICAL RESOURCES

BNL is located in the oak/chestnut forest region of the Coastal Plain. BNL property constitutes five percent of the 100,000-acre pine barrens of Long Island. As noted before, because of the general topography and porous soil, the land is very well drained and generally there is 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 major regulated wetlands onsite. Thus, a mosaic of wet and dry areas on the site correlates with variations in topography and depth to the water table. Vegetation onsite is in various stages of succession, which reflects a history of disturbances to the area. The past disturbances with the most impact were land clearing (the land was cleared extensively when the site was Camp Upton), fire, local flooding, and draining. Part of the Peconic River running through BNL's property was designated "scenic" in accordance with the New York State's Wild, Scenic, and Recreational River System Act (New York State 1972).

Over 230 plant species have been identified onsite. The fifteen mammal species endemic to the site include species common to mixed hardwood forests and open grassland habitats. The white-tailed deer density is at least 100 per



Explanation: The arrows formed by the wedges indicate wind direction. Each concentric circle represents a 5% frequency. The wind direction was measured at heights of 30 feet and 300 feet. For example, this diagram indicates that the predominant wind direction at 30 feet in 1999 was from the northwest.

Figure 1-10. Annual Wind Rose for 1999.

square mile (Thomlinson 1993). At least 85 species of birds are known to nest at BNL and an additional 130 species have been documented as "visiting" the site. These numbers are a result of BNL's location within the Atlantic Flyway and the scrub/shrub habitats that offer food and rest to migratory songbirds. Open fields bordered by hardwood forests at the recreation complex are excellent hunting areas for hawks. Permanently flooded retention basins and other watercourses support amphibians and aquatic reptiles. Nine amphibian and ten reptile species have been identified. Ecological studies at the BNL site have confirmed thirteen breed-

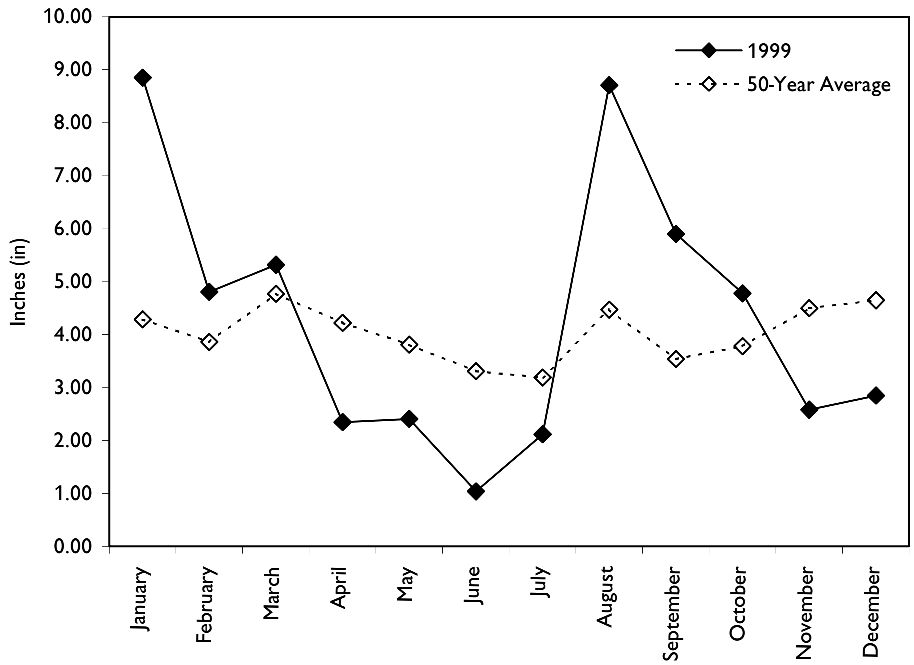


Figure 1-11. 1999 Monthly Precipitation versus 50-Year Monthly Average.

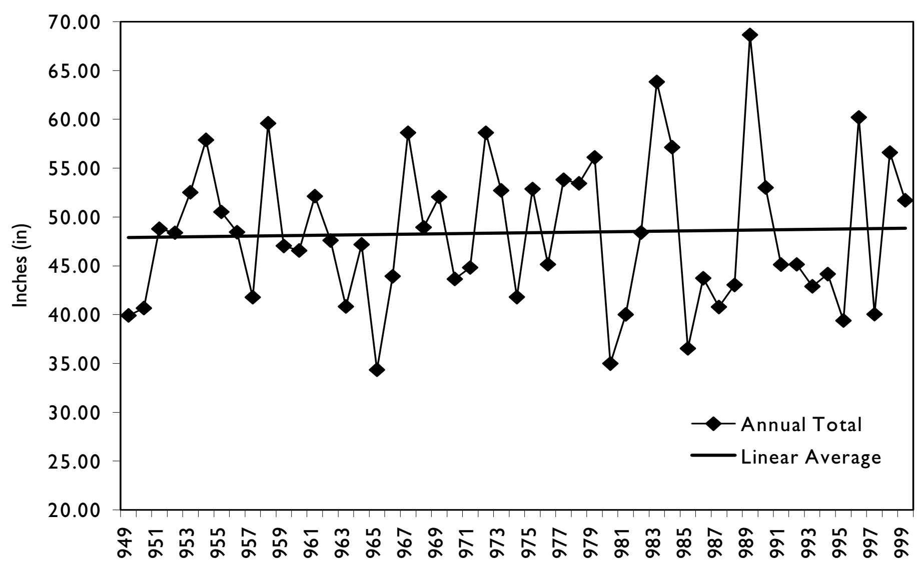


Figure 1-12 Fifty-Year Annual Precipitation Trend.

ing sites for the New York State endangered eastern tiger salamander (*Ambystoma tigrinum*) in BNL's vernal pools and some recharge basins. Nine species of fish have also been identified at BNL. The banded sunfish (*Eanneacanthus obesus*) was listed as a state threatened species in 1999 by the New York State Department of Environmental Conservation. It lives solely within the Peconic River system, including the portion of the river onsite (Scheibel 1990). One New York State-threatened plant is found onsite: the stiff goldenrod (*Solidago rigida*). A discussion of the Laboratory's wildlife protection strategy can be found in Chapter 6.

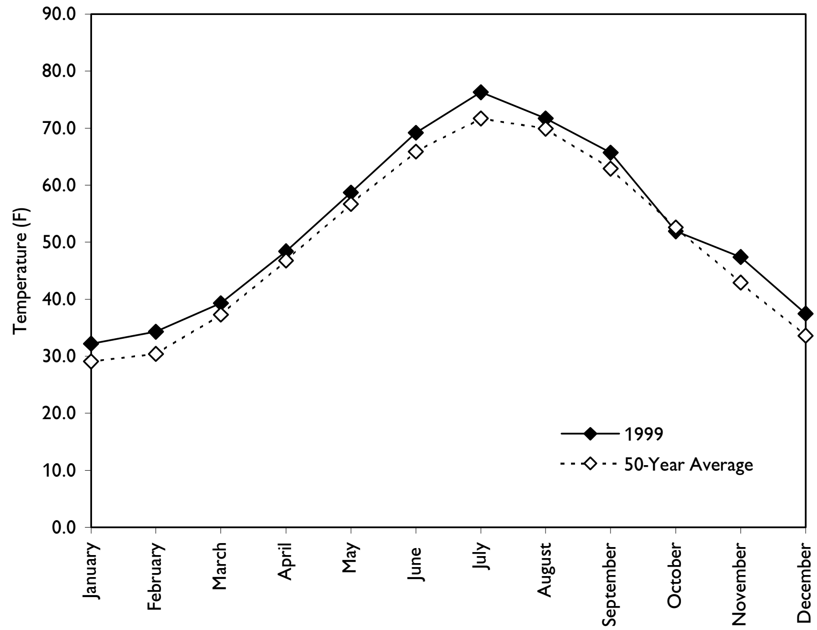


Figure 1-13. 1999 Monthly Mean Temperature versus 50-Year Monthly Average.

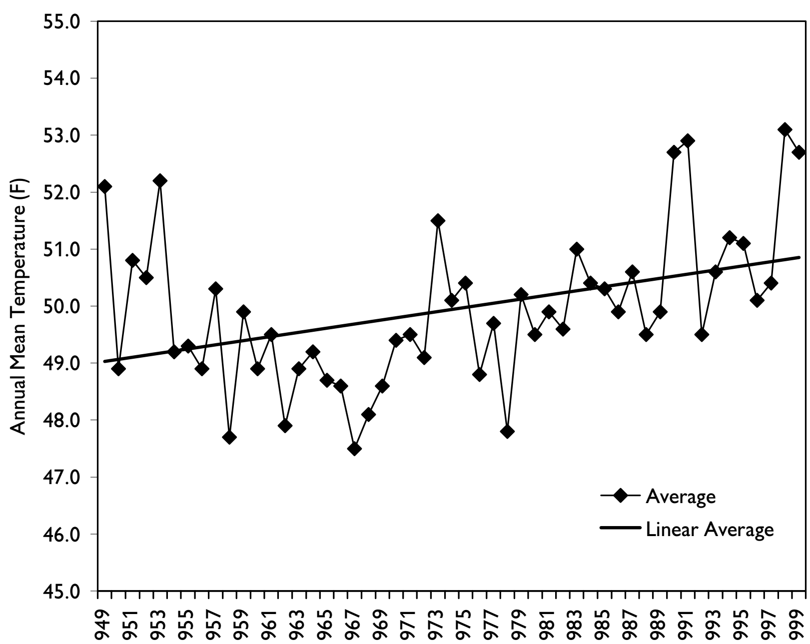


Figure 1-14. Fifty-Year Annual Mean Temperature Trend.

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Environmental Management System

In 1999, Brookhaven National Laboratory continued to develop and implement an Environmental Management System to ensure that it operates in an environmentally responsible manner. The Laboratory's Environmental Management System is consistent with the International Standards Organization 14001 Standard, with increased emphasis in the areas of compliance assurance, pollution prevention, and community outreach. Compliance and environmental considerations are being integrated into the planning, decision-making, and implementation phases of all site activities. Organizational changes have been made to strengthen environmental programs.

The Facility Review Project has continued to define, prioritize, and remedy historical problems. Industrial and experimental processes onsite were evaluated for compliance and pollution prevention opportunities. An extensive program to monitor environmental quality is in place.

BNL now has an unprecedented level of knowledge of current operations and potential environmental vulnerabilities. Pollution prevention projects have saved more than $1,600,000 and resulted in the reduction or reuse of over 16,000,000 pounds of industrial and hazardous waste in 1999. The Relativistic Heavy Ion Collider facility was officially certified to the International Standards Organization 14001 Standard, becoming the first Long Island-based operation and the first DOE Office of Science facility to achieve this level of recognition. The Laboratory is openly communicating with neighbors, regulators, employees, and other interested parties on environmental issues and progress.

2.1 ENVIRONMENTAL STEWARDSHIP UNDER BROOKHAVEN SCIENCE ASSOCIATES (BSA)

BNL continues to develop and implement an Environmental Management System (EMS) under the new leadership of BSA. An EMS is a systematic methodology for managing the environmental aspects of an organization's operations. It is part of the Laboratory's overall management system that includes organizational structure, planning activities, responsibilities, practices, procedures, processes, and resources for developing, implementing, achieving, reviewing, and maintaining BNL's Environmental Stewardship Policy.

BNL has pursued a multi-pronged approach to address historical and current problems and to prevent future problems.

2.1.1 ORGANIZATIONAL CHANGES

One key to the success of this approach is leadership. When BSA assumed management of the BNL operating contract in March of 1998, they brought in several high-level managers, and a new Laboratory Director, Dr. John Marburger. Environmental protection and communication functions were formerly several layers down in the organizational structure. BSA created three new directorates that report directly to the Laboratory Director:

- *Community Involvement, Government and Public Affairs*. This directorate is responsible for coordinating internal and external communications, community relations, government relations, and museum programs.
- *Environment, Safety, Health and Quality*. Within this organization, a separate Environmental Services Division was established to integrate environmental protection programs.
- *Environmental Management*. This directorate includes a division that ensures the proper management of hazardous and radioactive waste and another division that provides for the cleanup of historical contamination onsite.

BNL also implemented an Environmental Compliance Representative program. These environmental professionals are deployed to the research and operational organizations full time. Embedding environmental professionals in the line organizations is improving compliance with environmental laws, regulations, and policy. The Environmental Compliance Representatives are currently tasked with supporting the process reviews described below, assisting in the development and implementation of the Environmental Management System within line organizations, and providing technical support to researchers and facility managers. Upon project completion, they will transition to sitewide technical support roles. In this capacity, they will help implement systems for continual improvement of environmental performance, with emphasis on pollution prevention.

Expectations for staff and management have been more clearly defined. In the past, as is often the case, responsibility for environment, safety and health had been relegated to the support organizations. Now, under the BSA management model, senior management has clearly communicated their expectation that all line managers are to take full responsibility for environment, safety, and health performance, and that line managers and staff will be held accountable. Every BNL employee was required to develop a Roles, Responsibilities, Accountabilities, and Authorities (R2A2) document signed by the employee, their supervisor, and the supervisor's manager. Specifics on environment, safety and health performance expectations are included in each employee's R2A2.

BSA also developed and funded a set of projects designed to integrate environmental stewardship into all facets of the Laboratory's missions. The managers selected for the projects have had the full support of upper management. Four of these key projects are described below.

2.1.2 ADDRESSING THE PAST: THE FACILITY REVIEW PROJECT

BNL has had an active Environmental Restoration Program onsite since 1989, when the site was placed on the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) National Priorities List (see description in section 2.6 below). However, after a tritium leak from the High Flux Beam Reactor spent fuel storage pool and strontium-90 contamination emanating from a sump at the inactive Brookhaven Graphic Research Reactor were discovered in 1997, BNL senior management realized that that an understanding of potential environmental vulnerabilities onsite was incomplete. To assess and address historical problems, BNL initiated the *Facility Review Project* in April of 1997. The Facilities 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 including tanks, pipes, sumps, cesspools, storage areas, historical discharges, and current and past operating practices. Twenty-eight individuals from fifteen other DOE facilities provided high-level support during the review.

Over 1,628 issues that had the potential to impact the environment were identified. BNL worked closely with the Suffolk County Department of Health Services to identify and prioritize the issues. The highest priority was assigned to issues with the potential to impact groundwater. The Laboratory is now in the process of further defining and remedying the problems. A database shared between BNL and Suffolk County tracks progress. The 75 highest priority issues that had the potential to have a negative impact on groundwater above drinking water standards are expected to be dispositioned (either closed out or integrated into another ongoing program) during 2000. In 2000, the Laboratory also expects to disposition approximately 45 percent of the other operational issues with the potential to impact groundwater to a lesser degree.

2.1.3 ADDRESSING THE PRESENT: THE PROCESS EVALUATION PROJECT

DOE signed a voluntary Memorandum of Agreement (MOA) with the U.S. Environmental Protection Agency (EPA) on March 23, 1998 (EPA/DOE 1998). One of the MOA requirements was "to evaluate all experimental and industrial-type operations at BNL for the purpose of identifying all waste streams produced at BNL" on a very aggressive schedule. All high priority processes were to be evaluated within one year, with the balance completed the following year. BNL realized that this effort could provide an unprecedented level of knowledge of operations, and form a strong technical basis for other environmental improvement programs. The scope was expanded by BNL and efforts were "projectized" into the *Process Evaluation Project*. A process mapping technique was used to develop flow diagrams showing all inputs and outputs (see Figure 2-1, an example of a process map for x-ray film developing operations). Process inputs are the materials used in a process. Process outputs are a multimedia evaluation of wastes, effluents, and air emissions produced in a process. A formal regulatory determination of all outputs (waste description, determination, and handling) was conducted. Pollution prevention opportunities

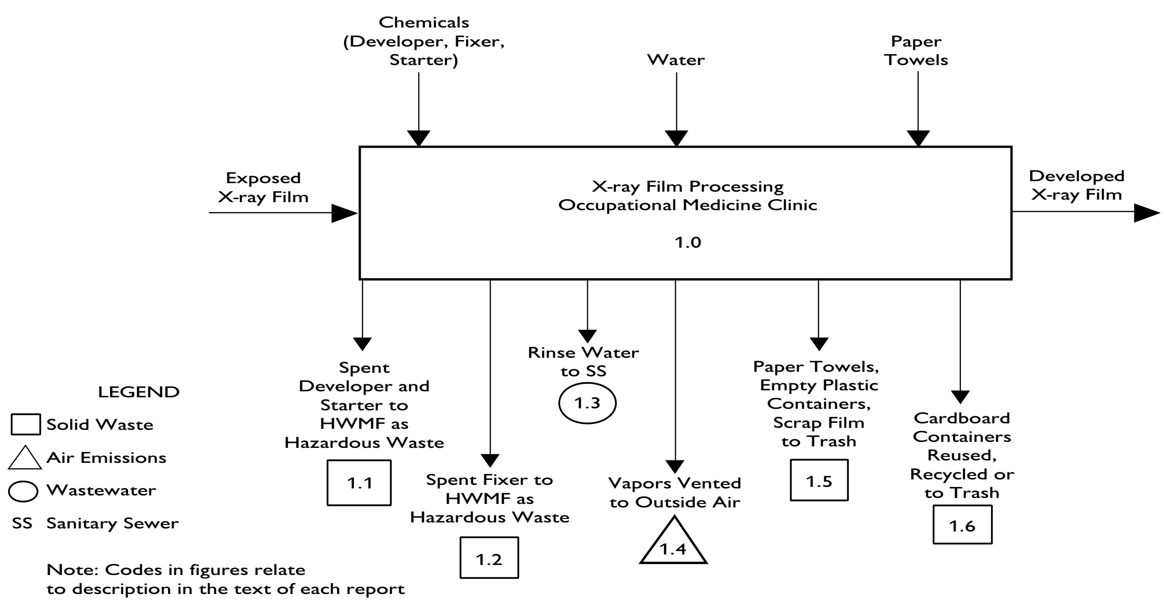

Figure 2-1. Sample Process Flow Diagram from Process Evaluation Project.

and best management practices were identified and are being evaluated. In total, over 145 industrial processes (e.g., machining, painting, electronics) and 1,821 research experiments were evaluated, ahead of the schedule established in the MOA. Approximately 170 corrective actions were identified and are being tracked to closure. Over 245 pollution prevention opportunities were identified, and all are being evaluated or have already been implemented. The approximate cost of $1,600,000 was borne by the line organizations (60 percent) and overhead funding (40 percent).

2.1.4 ADDRESSING THE FUTURE: THE ENVIRONMENTAL MANAGEMENT SYSTEM PROJECT

The MOA also required that BNL establish an Environmental Management System. BNL's EMS uses the International Standards Organization (ISO) 14001 as a model. ISO 14001 is a consensus standard developed by an international consortium of industry, government, and environmental groups. It identifies requirements for a system to

- define and prioritize what needs protection and how to do it;
- monitor, measure, and communicate what is done and how it is done; and
- continually improve approaches and systems for environmental protection.

The Laboratory's EMS is consistent with the international standard. Additionally, in response to EPA's concerns, there is increased emphasis in the areas of compliance assurance, pollution prevention and community outreach.

Again, BNL decided to go above and beyond what the Agreement and the DOE operating contract required, by electing to ultimately register to the ISO 14001 Standard, as opposed to self-declaring that they had a conforming system. Under the *Environmental Management System Project*, BNL is pursuing a phased approach, by first registering high profile, select facilities, and then seeking to register the entire Laboratory to the ISO 14001 Standard in 2001. The registration process involves rigorous audits by an American National Standards Institute Registrar Accreditation Board organization. The auditors evaluate BNL's conformance to the standard, whether the program is effectively implemented, and whether an effective assessment and corrective action program is in place. While the significance of ISO 14001 registration may not be as meaningful to the general public as it is to the environmental and regulatory community, BNL believes that it is important from a trust and credibility standpoint to undergo the independent, third party review. The ISO 14001 EMS is a valuable blueprint and registration is a recognized mechanism that the outside world can judge.

2.2 EMS IMPLEMENTATION

BNL has committed more than $2,700,000 to this three-year project. The goal of the project is to fundamentally and systematically change the way the Laboratory operates. The ultimate goal of the EMS is to ensure that Laboratory's programs are managed in an environmentally responsible manner that protects the ecosystem and human health.

Under the EMS project, existing systems were identified and are being enhanced, revamped and integrated. The 17 major elements of an ISO 14001 EMS are listed in Table 2-1, along with a summary of how BNL plans to satisfy each element. Figure 2-2 shows the relationship between program elements.

2.2.1 ENVIRONMENTAL STEWARDSHIP POLICY

During the first year of the EMS project (which was completed in July 1999), BNL developed institutional requirements. One of the early steps was developing and communicating an environmental policy (see Figure 1-4 in Chapter 1). The policy articulates high level commitments and is the cornerstone of BNL's EMS. This Environmental Stewardship policy is posted throughout the Laboratory and on the BNL website. A hard copy was also sent to all employees with a letter from the Laboratory Director, outlining his personal commitment to environmental protection and his expectation that all staff would participate in this way of doing business.

The Environmental Stewardship policy contains the following goals and commitments:

- Achieve and maintain compliance with applicable environmental requirements. These requirements include over 50 sets of local, state and federal laws, and regulations and approximately 60 operating permits.
- Integrate pollution prevention, waste minimization and resource conservation into Laboratory activities during the planning, decision-making, and implementation phases. Conserve natural resources. Ensure that environ-

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

Environmental Policy	BNL reaffirmed the commitments in its environmental policy: compliance, pollution prevention, cleanup, community outreach, and continual improvement. This policy is used as a framework for planning and action.
Environmental Aspects	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, water • Historical monuments/cultural resources • Environmental noise • Odors • Disturbances to endangered species/protected habitats • Soil activation • Historical contamination When operations at BNL have an environmental aspect, the organization implements an EMS to eliminate or minimize any potential impact. The elements of the EMS are described in this table.
Legal and Other Requirements	New or revised requirements (e.g. new regulations) are analyzed to determine their applicability to the Laboratory, and to determine whether actions are required to achieve compliance. This may involve developing or revising Laboratory documents, developing specific work instructions, administering training, installing engineered controls, or increasing monitoring.
Objectives and Targets	BNL establishes environmental objectives and performance measures to drive improvements to the EMS and environmental performance. They focus on the environmental aspects that can have a significant impact and/or reflect stakeholder concerns, and are aligned with commitments made in the environmental policy. The 1999 objectives and targets include: • Achieving excellent performance in environmental protection (e.g., minimal permit exceedances, spills, tritium releases) • Timely completion of key environmental improvement projects (e.g., Process Evaluation, EMS, Groundwater, Wildlife Management, Environmental Restoration) • Waste minimization and elimination of legacy wastes • Enhancing the responsiveness and effectiveness of Laboratory communications with stakeholders on environmental monitoring results.
Environmental Management Program	Organizations within BNL develop action plans detailing how they will achieve their objectives and targets, and commit the needed resources to successfully implement the plan. BNL also has a budgeting system designed to ensure that priorities are balanced, and that adequate resources are invested in environmental programs.
Structure and Responsibility	All employees at BNL have specific roles and responsibilities in key areas including environmental protection. The Assistant Laboratory Director for the Environment, Safety, Health and Quality Directorate leads the environmental protection efforts and is responsible for coordinating the implementation of the EMS within BNL and reporting on the performance to senior management. He utilizes the staff of the Environmental Services Division to accomplish this task.
Training and Awareness	BNL developed a comprehensive environmental training program in 1999, and initiated the training of staff, visitors, and contractors to ensure they are competent to carry out their environmental responsibilities. This training program includes general environmental awareness for all employees; regulatory compliance training for selected ES&H staff; and specific courses for managers, internal assessors, EMS implementation teams, and operations personnel whose work can impact the environment.
Communication	BNL continues to improve processes for internal and external communications on environmental issues. The Laboratoy seeks input from interested parties, such as community members, activists, civic organizations, elected officials and regulators, through a Citizens Advisory Committee and/or the Brookhaven Executive Roundtable.
EMS Documentation	A major initiative to develop and document Laboratory wide environmental requirements was completed. A web-based system called the Standards Based Management System (SBMS) provides access to regulatory requirements, Laboratory-wide procedures, and manuals that define for staff how to control processes and work performed 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 system records. When facilities require additional procedures to control their work, document control protocols are implemented to ensure that workers have access to the current versions of work instructions.

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

Operational Control	Through the Process Evaluation Project and EMS implementation, operations at the Laboratory are evaluated for adequacy of controls in preventing impacts to the environment. As needed, additional administrative or engineered controls are identified, and plans for upgrades and improvements are being developed.
Emergency Preparedness	BNL has a program to provide time critical 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 is important to ensure effectiveness of controls, adherence to regulatory requirements, and timely identification and implementation of corrective measures. BNL has a comprehensive, site-wide environmental monitoring program that results in an annual summary of its environmental performance in this Site Environmental Report and in reports to regulatory agencies. In addition, BNL tracks and trends its progress and performance in achieving its environmental objectives and performance measures.
Nonconformance and Corrective and Preventative Actions	BNL continues improving processes to identify and correct problems. This includes development of a lessons learned program to prevent recurrences and a robust self-assessment program.
Records	EMS-related records, including audit and training records, are maintained to ensure integrity, to protect them from loss, and to facilitate retrieval.
EMS Audit	Audits are conducted to periodically verify that the EMS is operating as intended. These audits, conducted as part of the sitewide self-assessment program, are designed to ensure that any nonconformance to the ISO 14001 Standard is identified and addressed. In addition, the Process Evaluation Project completed a regulatory compliance evaluation of all high priority processes in 1999, and initiated compliance evaluations of all remaining industrial operations and experiments onsite.
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 its environmental goals. This review also identifies, as necessary, the need for changes and continual improvement of the EMS.

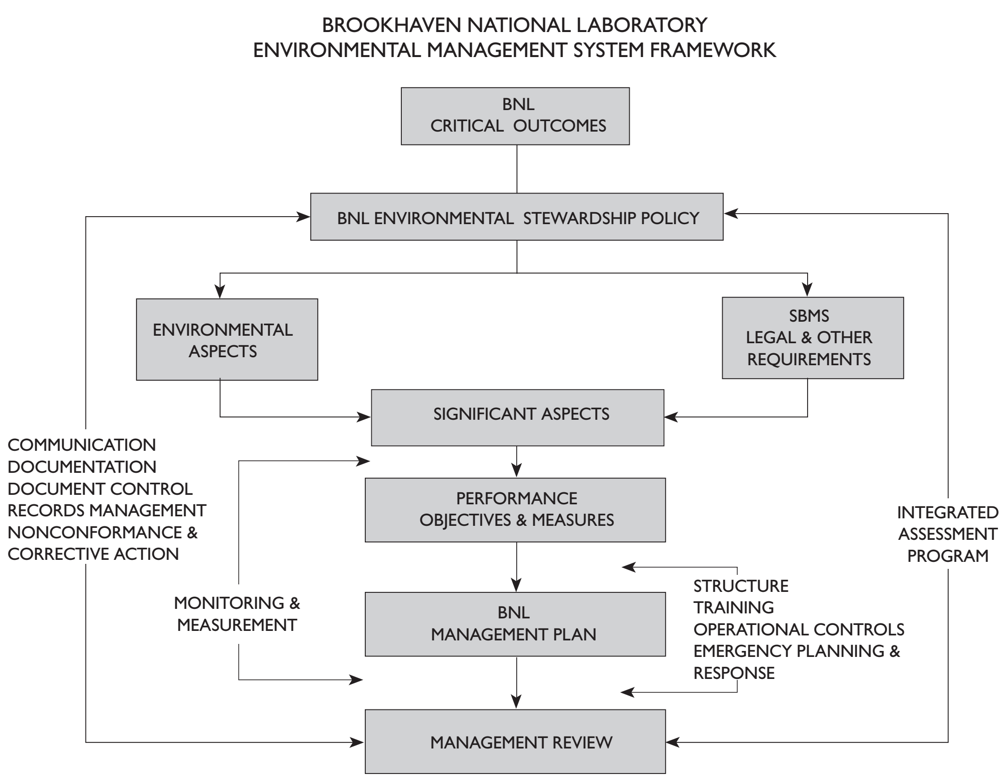


Figure 2-2. Key Elements of the BNL Environmental Management System.

mental emissions, effluents, and waste generation are As Low As Reasonably Achievable (a concept known as “Environmental-ALARA”).
- Define, prioritize and remedy existing environmental problems. This commitment encompasses removal or treatment of contamination caused by historical practices, as well as 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.
- Emphasize continual improvement. Employ proactive measures to prevent problems. When problems do occur, investigate the root cause and take corrective actions as appropriate.
- Openly communicate with neighbors, regulators, employees, and organizations about program progress and performance.

2.2.2 STANDARDS BASED MANAGEMENT SYSTEM (SBMS)

In order to implement the commitments in the policy, BNL improved on a tool called SBMS that had been developed by Pacific Northwest National Laboratory. SBMS is a web-based system designed to deliver requirements and guidance to all staff in a user-friendly format. All Labwide procedures reside in this system. The information provided focuses on what staff need to know to do their work in an environmentally responsible manner, and translates the requirements into plain English. Up-to-date “Subject Areas” were developed on 26 environmental topics. These Subject Areas were developed by teams of researchers and environmental protection professionals, with input from regulatory agencies. Figure 2-3 lists the environmental regulatory compliance and EMS-supporting Subject Areas. Existing standards for work and research planning and control were also upgraded to ensure that reviews by qualified ES&H staff occur early in the planning process, and that adequate measures to control hazards and risks are incorporated during the design phase.

2.2.3 PILOT FACILITIES

In 1999 the requirements described in section 2.2.2 were tested and validated in three pilot facilities. The facilities that volunteered to participate in the pilot phase of the EMS project implementation were the Relativistic Heavy Ion Collider (RHIC) Project, the Reactor Division, and Waste Management Program. Two of the three pilot facilities were independently verified as conforming to the ISO 14001 Standard by September 1, 1999. In 1999, the third pilot facility, RHIC, was officially certified to the ISO 14001 Standard by an independent accredited registrar, becoming the first Long Island-based operation and the first DOE Office of Science facility to achieve this level of recognition (see the certificate reproduced in Figure 2-4). After incorporating improvements recommended by

Titles of EMS Subject Areas

COMPLIANCE SUBJECT AREAS

Pollution Prevention and Waste Minimization
NEPA & Cultural Resource Evaluation
Environmental Monitoring
Non-radioactive Airborne Emissions
Radioactive Airborne Emissions
Drinking Water
Liquid Effluents
Underground Injection Control (UIC)
Storage and Transfer of Hazardous Materials
Oil/PCB Management
Hazardous Waste Management
Radioactive Waste Management
Mixed Waste Management
Regulated Medical Waste
Spill Response

EMS SUPPORT SUBJECT AREAS

Identification of Significant Environmental Aspects and Impacts
Environmental Evaluation of Industrial Processes & Experiments
Requirements Management
Requesting SBMS Variances
Correspondence and Commitment Tracking
Laboratory-wide Procedures and Guidelines Development
Internal, Controlled Documents
Calibration
Nonconformance and Corrective and Preventive Action
Records Management
Environmental Assessments

Figure 2-3. Environmental Management System Subject Areas in the Standards Based Management System.

NSF International Strategic Registrations, Ltd.

A Subsidiary of NSF International
2100 Commonwealth Boulevard, Suite 100, Ann Arbor, Michigan 48105
(888) NSF-9000

NSF-ISR

Certificate of Registration

This certifies that the Environmental Management System of

BROOKHAVEN NATIONAL LABORATORY

Corporate Address:	Site Address:
Building 1005 / P.O. Box 5000 Upton, NY 11973-5000 Phone: (516) 344-3465 Fax: (516) 282-7618 Contact: Ms. Susan L.K. Briggs	Relativistic Heavy Ion Collider Building 1005 / P.O. Box 5000 Upton, NY 11973-5000

has been assessed by NSF-ISR and found to be compliant to the following standard(s):

ISO 14001:1996

Scope of Registration:
The scope of registration includes the Environmental Management System for the Relativistic Heavy Ion Collider (RHIC) Project (not all of BNL) operated by Brookhaven Science Associates and construction and commissioning of the Collider and Experiments. Also included are related activities encompassing superconducting magnet research & development, production of Collider magnets, and superconducting magnets for the Large Hadron Collider and other magnet R&D projects. Routine operation of the injector complex including the AGS Department and the U.S. Department of Energy are not included in the scope of this registration.

Industrial Classification:
SIC Code: 8999

NSF

Environmental Management System Registered to ISO 14001:1996

Authorized Registration and Accreditation Marks

Randy A. Dougherty, President, NSF - ISR

Certificate Number: 69521-E1
Certificate Issue Date: 08/25/99
Date of Initial Registration: 08/25/99

Figure 2-4. RHIC ISO 14001 Registration Certificate.

the pilots, the requirements were rolled out to the rest of the Laboratory. Deployment of the EMS throughout the balance of facilities at BNL began in July 1999 and is scheduled to be completed by October 2000. As noted above, BNL will pursue ISO 14001 certification at select organizations (Collider-Accelerator Department, Reactor Division, Brookhaven Linear Isotope Producer, Environmental Restoration Division and Waste Management Facility) and undergo an internal independent verification of conformance at the remaining facilities.

2.2.4 STAFF TRAINING AND AWARENESS

Extensive training on EMS program requirements was provided to staff whose responsibilities involved environmental protection. In total, almost 9,000 hours of environmental training were provided to staff from 1998-1999. All staff and visiting scientists working at BNL for more than two months are now required to take a computer-based training course developed by BNL to provide a basic level of environmental awareness. The course discusses the EMS, reviews the environmental requirements at a high level, and describes the impacts of non-compliance. Contractors and short-term visitors are also provided a modified training program covering the key points. Teams responsible for coordinating the implementation of the EMS within each organizational unit were provided in depth training on ISO 14001 requirements and techniques for effective implementation. To support the Laboratory's Integrated Assessment Program (see section 2.3.2, below), select individuals were trained to perform EMS assessments. Finally, the top three levels of management were required to attend overview training on the EMS. In addition to training on EMS requirements, training sessions were conducted to introduce key staff to the environmental compliance requirements of the newly developed Subject Areas. This training was presented by subject matter experts from the BNL environmental protection program. It was an excellent opportunity to communicate the requirements to affected staff and answer questions on applicability and implementation.

2.3 EMS CONTINUAL IMPROVEMENT

BNL's EMS includes a commitment to continual improvement. The EMS is part of a sitewide integrated environment, safety and health system. It is interdependent with other management systems.

2.3.1 PERFORMANCE BASED MANAGEMENT SYSTEM

The Performance Based Management System is a method of developing, aligning, balancing and deploying Laboratory strategic objectives. The system drives the improvement agenda of BNL by establishing a prioritized set of incentivized performance objectives. Objectives include

- ♦ instituting mechanisms for assigning responsibility at all relevant levels of the organization, starting with senior management;
- ♦ implementing suggested actions for improvement;
- ♦ establishing clearly defined expectations and performance objectives; and
- ♦ routinely assessing progress against these objectives, in order to focus efforts and resources on relevant and important areas.

This approach helps employees understand how their work relates to Laboratory-level performance objectives so they can align their efforts toward achieving BNL missions. It also ensures that Laboratory operations are conducted in accordance with the expectations established by the Department of Energy and Laboratory management.

2.3.2 INTEGRATED ASSESSMENT PROGRAM

The Integrated Assessment Program was established to identify strengths and weaknesses in performance and areas for improvement. It is designed to contribute to and promote ongoing improvement in performance. The primary elements of BNL's Integrated Assessment Program are listed below.

- ♦ *Self-assessment* is the evaluation of internal processes and performance. The goal of a self-assessment program is to identify strengths and opportunities for improvement. The environmental portion of the self-assessment can include such items as assuring progress towards achieving performance goals. Examples include measuring progress on pollution prevention, or ensuring that operations are conducted in accordance with established requirements by auditing for environmental compliance. Under the self-assessment program, areas for improvement are identified and tracked to completion.
- ♦ *Peer Review* is a process to evaluate and independently verify the adequacy of engineering designs and operational controls, as well as the accuracy of documents.
- ♦ *Independent Oversight* is a mechanism to independently verify the effectiveness, efficiency and adequacy of the self-assessment programs. Special investigations are also conducted to identify the root causes of problems, corrective actions and lessons learned.
- ♦ *Internal Audit* is the process of examining and evaluating the adequacy and effectiveness of the BSA internal management controls. These audits focus on business systems.

The Integrated Assessment Program is augmented by programmatic, external audits conducted by DOE. In addition, corporate offices for Battelle Memorial Institute and BSA subcontractors perform periodic independent reviews. As noted above, ISO registration audits are conducted by an independent third party. BNL is also subject to extensive oversight by external regulatory agencies (see Chapter 3). Results of all assessment activities were considered in the development of the applicable sections of this report.

2.4 ENVIRONMENTAL MANAGEMENT PROGRAMS

BNL has a number of programs designed to protect the environment. Some of the key programs are described below.

2.4.1 GROUNDWATER PROTECTION PROGRAM

BNL has developed a groundwater protection program that focuses on preventing impacts to groundwater and restoring groundwater quality. Whereas groundwater protection programs at most sites rely solely on groundwater monitoring, at BNL monitoring is used mainly as a tool to determine whether operational or engineered controls are effectively protecting groundwater. In 1997, most of the existing 700 wells onsite were associated with environmental restoration. In conjunction with the Facility Review Project, BNL conducted a thorough review of all active and operational areas onsite that could potentially impact groundwater, and added 84 new wells to monitor those areas. BNL has also developed a groundwater contingency plan that defines an orderly process for taking corrective actions quickly in response to unexpected monitoring results. A key element of that plan and the groundwater program is full and timely disclosure to interested parties. Chapter 7 provides additional details about the Groundwater Protection Program and monitoring results.

2.4.2 WASTE MANAGEMENT FACILITIES AND PROGRAM

The goal of BNL's waste management program is safe and efficient management of waste from generation to ultimate disposal. The program emphasizes pollution prevention/ waste minimization (see section 2.4.3). It ensures that there is a defined pathway and budget for disposing of any waste generated, and also that facilities comply with applicable regulatory and permit requirements.

BNL has a Waste Management Facility and Waste Concentration Facility. The Waste Management Facility is a permitted waste storage facility (New York State Department of Environmental Conservation [NYSDEC] Permit No. 1-422-00032/00102-0) consisting of four operations buildings: 855, 860, 865, and 870. See Figure 2-5 for photographs and a description of how each of these buildings is used.

A waste compactor in Building 865 became available for use in 1999. The waste compactor can be used to

Bldg. 860
Offices for technical and professional staff. Staff provide support to facilitate pick-up, storage, and offsite disposal of hazardous, radioactive, and mixed waste.

HAZARDOUS WASTE MANAGEMENT

Bldg. 855 is used for the storage of site generated industrial, hazardous and Polychlorinated Biphenyl (PCB) solid, liquid, and gaseous wastes. This building was designed and built to provide tertiary containment for stored wastes to prevent environmental contamination should a spill occur. This was accomplished through the use of sealed concrete and an impervious liner placed under the building that exceeds regulatory requirements.

Wastes are typically generated in quantities of five gallons or less from various research and maintenance activities. These wastes are typically stored in containment trays placed on shelves within secondarily contained storage rooms, referred to as lab pack rooms. Wastes stored in these rooms are segregated by hazard class to prevent incompatible materials from reacting.

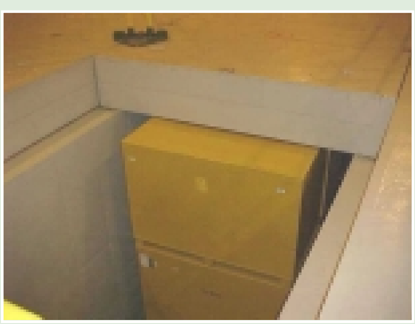
Some wastes are collected in 55-gallon drums, such as liquid wastes from photographic processing and waste oils, and are stored in drum storage bays. These bays provide the space needed to maneuver and inspect larger containers. As in the lab pack rooms, wastes are placed into the drum storage bays by hazard class to segregate incompatible materials. Containment is provided by concrete floors that are coated with a chemically resistant sealant and pitched to sealed collection sumps.

RADIOACTIVE WASTE MANAGEMENT

Bldg. 865 is used for the sorting, repackaging, and temporary storage of solid low level radioactive wastes generated by site research and maintenance activities. Typical radioactive wastes consist of paper, plastic, glass, and metal.

Most radioactive wastes are received at the Waste Management Facility in plastic bags. After receipt, most of these bags are consolidated into metal bins where they may be further consolidated through compaction. Metals, glass, and heavy objects that could puncture a bag are sometimes packaged directly into these bins or other appropriate containers.

Bldg. 865 contains a compactor for the consolidation of dry, compactible wastes. Bins containing bags of radioactive waste or other compactible materials can be placed directly into this compactor to reduce the volume of the waste by a factor of almost 20. This helps to reduce disposal costs and conserves limited space at the offsite disposal facility.



Prior to shipment offsite, bins containing the waste are stored in below-grade concrete vaults. The bins are inserted into and removed from these vaults by an overhead crane. Only solid radioactive wastes are stored in this building.

MIXED WASTE MANAGEMENT

Bldg. 870 is used for the storage of mixed wastes. These are wastes that are both hazardous and radioactive. This building was designed similar to the Hazardous Waste Storage building, Bldg. 855. Most mixed wastes are generated by research activities and are typically in quantities of 5 gallons or less.

The building is comprised of storage bays that provide secondary containment. Small waste items are stored in containment trays on shelves located within these bays. Typical mixed wastes include radioactively contaminated acids and alcohols, mercury-containing apparatus, and lead used in shielding applications. Mixed wastes are stored in this building prior to offsite treatment and/or disposal.

Figure 2-5. BNL Waste Management Facilities.

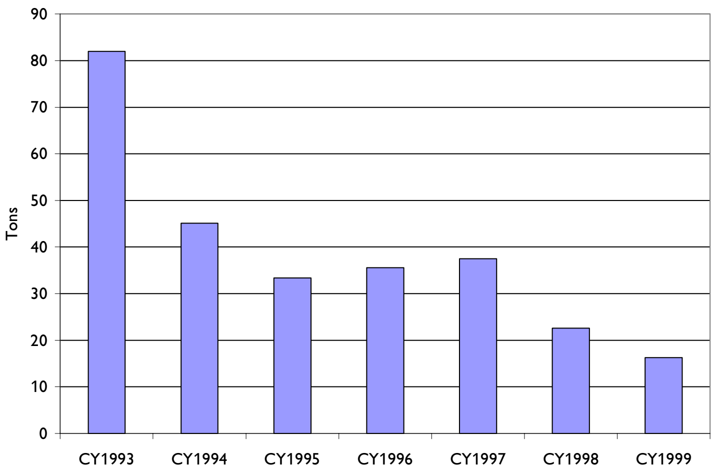


Figure 2-6. Routine Hazardous Waste Generation Trend from 1993-1999.

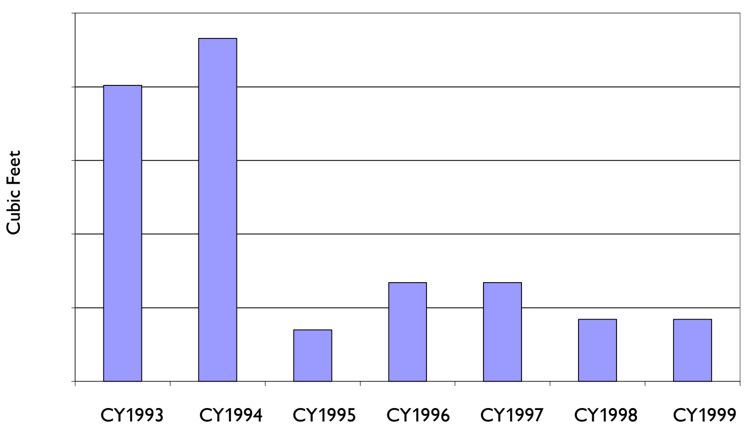


Figure 2-7. Routine Mixed Waste Generation Trend from 1993-1999.

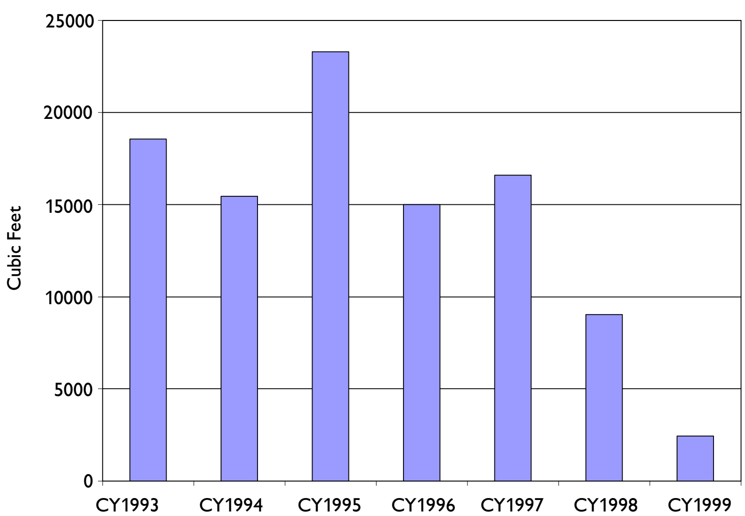


Figure 2-8. Routine Radioactive Waste Generation Trend from 1993-1999.

consolidate and reduce the volume of radioactive wastes such as paper, plastic, glass, and some metals. Compaction will increase packaging efficiency to minimize waste disposal costs and conserve limited space at the disposal facility.

BNL plans to complete an upgrade to Building 865 in 2000 with the construction of a hot cell. The hot cell will allow management of high-activity radioactive wastes in a more cost effective manner.

The Waste Concentration Facility (Building 811) and the Tritiated Water Evaporator (Building 802) are used to manage liquid wastes. Bulk quantities of radioactively contaminated aqueous liquids are stored in Building 811. These liquids are stored in permitted tanks for either onsite processing or offsite treatment and disposal. Building 802 processing consists of evaporating tritiated liquids, which have been treated for the removal of heavy radioisotopes, under the controls imposed by an existing air permit.

There were two upgrades to liquid waste management facilities in 1999. Building 810, an annex to the Waste Concentration Facility, was constructed to improve radioactive liquid transfers. The transfers will be performed in a controlled environment with secondary containment. This annex can also accommodate a second processing unit to concentrate and remove radioactive particles from liquids, which will minimize the amount of waste for treatment or disposal. The Tritiated Water Evaporator was upgraded by replacing the existing evaporating unit with a more energy efficient unit.

In addition to the Waste Management and Waste Concentration Facilities, BNL has twenty 90-Day Hazardous Waste Accumulation Areas. There are also approximately 240 Hazardous Waste Satellite Accumulation Areas, where small quantities of hazardous waste are stored at or near the point of generation. The BNL waste management program manages hazardous and radioactive wastes generated by the Laboratory.

In 1999 BNL generated the following quantities and types of waste from routine operations. (Construction/demolition wastes, environmental restoration wastes, legacy waste, PCB waste, and other wastes determined to be non-routine are not included in these totals or in Figures 2-6 through 2-8.)

- ♦ Hazardous Waste: 14.4 tons
- ♦ Mixed Waste: 0.8 tons

- ♦ Radioactive Waste: 2,427 cubic feet
- ♦ Regulated and Toxic Substances Control Act Waste: 1.9 tons

These quantities represent significant reductions.

2.4.3 POLLUTION PREVENTION/WASTE MINIMIZATION

A strong Pollution Prevention/Waste Minimization (P2) Program is another essential element of the EMS. The BNL P2 Program reflects national and DOE pollution prevention goals and policies, and represents an ongoing effort to make pollution prevention and waste minimization an integral part of the BNL operating philosophy.

Key elements of the P2 program are the following:

- ♦ Eliminating or reducing wastes, effluents, and emissions at the source where possible; and ensuring that environmental effluents, emissions and wastes are As Low As Reasonably Achievable.
- ♦ Procuring environmentally preferable products (also known as “affirmative procurement”).
- ♦ Conserving natural resources and energy.
- ♦ Reusing and recycling materials.
- ♦ Achieving or exceeding BNL/DOE waste minimization, pollution prevention, recycling, and affirmative procurement goals.
- ♦ Complying with applicable requirements (e.g., New York State Hazardous Waste Reduction Goal, Executive Orders).
- ♦ Reducing waste management costs.
- ♦ Identifying funding mechanisms for evaluation and implementation of P2 opportunities.
- ♦ Implementing P2 projects.
- ♦ Improving employee and community outreach and awareness of pollution prevention goals, plans, and progress.

The EMS provides a mechanism for systematically evaluating and implementing value-added pollution prevention opportunities at the Laboratory.

The sustained efforts of the BNL pollution prevention and recycling programs have achieved significant reductions in waste generated by routine operations. From 1993-1999, BNL reduced hazardous waste generation by 80 percent, mixed waste by 79 percent and radioactive waste by 87 percent. Figures 2-6, 2-7, and 2-8 show the trends for these key waste streams.

Implementation of P2 opportunities, recycling programs and conservation initiatives have significantly reduced both waste volumes and management costs. In 1999 alone, these efforts have resulted in over $1,600,000 in cost savings and over 16,000,000 pounds of materials being reduced, recycled, or reused. The 16,000,000 pounds includes 12,850,000 pounds of water conserved through replacement of chillers. Table 2-2 describes the projects that were implemented in 1999, 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 recycling program involves all employees. Office staff collect paper in designated containers in their work space. Custodial staff collect and consolidate recycled paper to central locations, where it is shipped to the recycling facility. In 1999, BNL collected over 370 tons of paper for recycling. In addition to paper, the recycling program collects many other kinds of materials, including cardboard, bottles and cans, tires, 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 these materials recycled in 1999 and the trends since 1992.

2.4.4 WATER CONSERVATION PROGRAM

BNL has a strong water conservation program and has achieved dramatic reductions in water usage. Figure 2-9 shows the five-year trend of water consumption. A comparison of 1999 and 1998 flow figures shows a 180,000,000 gallon reduction in water use for 1999 alone. The reduction of process cooling at the AGS provided the most significant savings. The conversion of the AGS cooling water system to the domestic water supply was completed in 1999. The final component of this project was the addition of a thermostatically controlled throttling valve. By measuring the outlet temperature of the cooling water, the valve is either opened or closed to maximize the temperature rise and to minimize water flow. The full effect of the Phase I Non-Contact Cooling Water Reduction project that was completed in 1998 was also realized in 1999.

The Laboratory is proceeding with Phase II of a Non-Contact Cooling Water Reduction project. The goals of this project are to reduce the consumption of potable water, and reduce

Table 2-2. 1999 Pollution Prevention, Waste Reduction, and Recycling Projects Summary.

Project Description	Reduced, Reused, Recycled or Conserved	Pounds Reduced, Reused, Recycled or Conserved in 1999	Waste Type	Potential Costs for Treatment and Disposal	Cost of Prevention, Reduction, or Recycle	Estimated Cost Benefit	Project Description Details
Paint -1,800 gallons of excess material	Reused	18,000	Hazardous Waste	$12,000	$0	$18,000	1,800 gallons of paint were donated to the Town of Brookhaven for reuse. Material consisted of colors no longer used and small batches of specialty paints. Disposal cost would have been an estimated $12,000. Internal handling, characterization, and transportation costs to disposition as waste would have been an estimated $6,000.
3 Chillers for Cooling Water Systems	Conserved	12,850,000	Wastewater	$2,040	$0	$2,040	During clean out of the Oceanography building, three chillers were identified as available and were reused by Central Shops to replace once-through cooling water systems. Estimated water conservation is 1.5 million gallons, assuming flow rates of 5 GPM and operation for 10 weeks/year for the three systems (12.85 million lbs. of water). Estimated cost for supplying and then disposing of water is $1.35/1,000 gallons.
Millipore RO System	Reused	200	Sanitary	$200	$0	$2,000	During clean out of the Oceanography building, a reverse osmosis system was scheduled for removal and disposal as trash. The system was described in an email to ES&H Coordinators, resulting in a use being identified for biology experiments at the National Synchrotron Light Source. A new system would have cost approximately $1,800.
Lead Bricks for Hot Cell	Reused	172,000	Mixed Waste	$405,725	$100,000	$305,725	Reused over 7,000 radioactive lead bricks for shielding in the hot cell under construction for waste management. Avoided cost of disposal as mixed waste is estimated at $405,725 ($2/lbs. for disposal x 172,000 lbs., plus $61,725 for packaging, handling, and transportation). Project eliminated potential environmental impact of storing radioactive waste bricks.
Waste Oil	Source Reduction	3,500	Hazardous Waste	$6,000	$0	$20,000	350 gallons of waste oil contaminated with chlorinated compounds required disposal as hazardous waste at a cost of $6,000 plus handling. Source of chlorinated compound contamination was identified and replaced with non-chlorinated substitute. Waste oil is now removed free of charge and used for energy recovery. Estimate three batches per year.

continued on next page

Table 2-2. 1999 Pollution Prevention, Waste Reduction, and Recycling Projects Summary *(continued)*.

Project Description	Reduced, Reused, Recycled or Conserved	Pounds Reduced, Reused, Recycled or Conserved in 1999	Waste Type	Potential Costs for Treatment and Disposal	Cost of Prevention, Reduction, or Recycle	Estimated Cost Benefit	Project Description Details
Deionization System Regeneration Wastes	Source Reduction	1,000	Hazardous Waste	$1,000	$9,000	$3,000	Installed a deionization system on the make-up water supply at NSLS cooling water system, allowing longer periods between regeneration of resins. Reduces approximately 110 gallons of hazardous waste, and reduces labor costs by decreasing frequency of regeneration (estimated $2,000 cost avoidance).
Purge Water Low-Flow, Low-Purge Well Sampling	Source Reduction	1,164,000	Radioactive and Hazardous Wastes	$450,000	$23,000	$820,000	Project involved procurement of low-flow, low-purge well sampling equipment and training of sampling team. Eliminates approximately 137,000 gallons (or 1,164,000 lbs.) of contaminated purge water at an estimated cost of $450,000 for treatment and disposal, and reduces labor costs by an estimated $370,000.
Fluorescent Lamps	Recycling	82,248	Hazardous Waste	$109,000	$25,000	$84,000	A total of 41,124 fluorescent bulbs were sent to Mercury Technologies Inc, for recycling in 1999. Estimating 2 lbs./bulb, or a total of 82,248 lbs. of bulbs, disposal of crushed bulbs as mercury waste would have cost approximately $300/drum plus $300/drum labor (crushing, packaging, characterization). At 500 lbs./drum of crushed bulbs, 165 drums of bulbs would have required disposal ($99,000 for crushing/disposal). Transportation is estimated at $10,000, for a total avoided cost of $109,000.
Fluorescent Lamps	Source Reduction	69,500	Hazardous Waste	$91,740	$40,000	$51,740	29,775 low mercury bulbs were purchased to replace mercury-containing bulbs. Low mercury bulbs can be disposed of at the local landfill as sanitary waste, thus avoiding generation of hazardous waste. At 2 lbs./bulb, 69,500 lbs. of hazardous waste were avoided. Fluorescent bulbs that are hazardous waste cost approximately $1.32/lbs to dispose of, for a total avoided cost of $91,740.
PCB Ballasts	Source Reduction	265	PCB Waste	$1,300	$13,000	$56,000	Proactively removed PCB ballasts in lighting systems. Replacement as a project avoids replacement on a one-by-one basis when a leak occurs. Project cost to replace 53 units estimated at $13,000. Response to a leaker (spill response, sampling, cleanup) estimated at $1,300 or $68,900 for 53 units.

continued on next page

Table 2-2. 1999 Pollution Prevention, Waste Reduction, and Recycling Projects Summary *(concluded)*.

Project Description	Reduced,Reused, Recycled or Conserved	Pounds Reduced, Reused, Recycled or Conserved in 1999	Waste Type	Potential Costs for Treatment and Disposal	Cost of Prevention, Reduction, or Recycle	Estimated Cost Benefit	Project Description Details
Blasocut Machining Coolant	Recycled/Reused	30,385	Industrial Waste	$24,180	$0	$24,180	Central Shops Division operates a recycling system that reclaims Blasocut machining coolant and supplies it labwide. 3,570 gallons (or 65 drums) of Blasocut lubricant were recycled in 1999. Recycling involves aeration, centrifuge, and filtration. Avoids cost of disposal as industrial waste ($300/drum = $19,500), plus handling, characterization, shipping and an avoided cost of procurement of 3 drums of concentrate for a total savings of $24,180. Cost of recycling is estimated to be the same as cost of procurement and preparation of proper dilution for use.
AGS Ion Exchange regeneration wastewater	Source Reduction	127,500	Radioactive	$160,000	$192,000	$136,000	This was a multi-year implementation completed in 1999. Retrofitted ion exchange systems so resins could be removed and disposed as low lead waste, instead of regenerating them. Regeneration produced ~15,000 gallons of radioactive wastewater annually at an estimated cost of $160,000/yr. Resin removal will produce ~130 cubic feet of resin for disposal instead at an estimated cost of $24,000/yr, for a yearly savings of $136,000/yr. (127,500 lbs. ≅15,000 gal).
Cylinders returned to Suppliers from Chemistry Dept	Recycle	565	Hazardous Waste	$25,425	$3,390	$22,035	Returned 113 cylinders from Chemistry Dept tosupplier at a cost of $30/cyclinder, avoiding cost of disposal at an estimated cost of $225/cylinder.
Lead Acid Batteries	Recycled	2,200	Hazardous Waste	$5,000	$0	$5,000	Estimate 50 lbs./battery and five per drum for disposal as hazardous waste at $450/drum plus handling and shipping.
Office Paper	Recycled	740,000	Sanitary Waste	$29,600	$0	$29,600	Estimate $80/ton for disposal as trash.
Cardboard	Recycled	248,000	Sanitary Waste	$9,920	$0	$9,920	Estimate $80/ton for disposal as trash.
Scrap Metal	Recycled	126,000	Sanitary Waste	$5,000	$0	$5,000	Estimate $80/ton for disposal as trash.
Bottles/Cans	Recycled	42,200	Sanitary Waste	$1,690	$0	$1,690	Estimate $80/ton for disposal as trash.
Tires	Recycled	30,400	Sanitary Waste	$1,216	$0	$1,216	Estimate $80/ton for disposal as trash.
Construction Debris	Recycled	704,000	Sanitary Waste	$19,500	$0	$19,500	Estimate $80/ton for disposal as trash.
Antifreeze	Recycled	1,232	Industrial Waste	$1,500	$0	$1,500	Estimate 3 drums for disposal as industrial waste liquid.
Used Motor Oil	Recycled	30,345	Industrial Waste	$30,000	$0	$30,000	Estimate of 70 drums (3,570 gallons) at $450/drum plus characterization, handling packaging and shipping
Lead	Recycled	1,400	Hazardous Waste	$2,000	$0	$2,000	Estimate 3 drums for disposal as hazardous waste.
TOTALS		**16,444,940**		**$1,394,036**	**$405,390**	**$1,650,146**	

Table 2-3. 1999 Recycling Program Summary.

Recycled Material	1992	1993	1994	1995	1996	1997	1998	1999
Mixed Paper	155	136	197	220	106	196	204	370
Cardboard	21	81	164	85	101	103	97	124
Bottles/Cans	12.4	12.4	17.6	11	14.9	21.4	21.8	21.1
Tires	9	21	7	11	17	18.6	11.5	15.2
Construction Debris	809	495	495	627	837	799	527	352
Used Motor Oil (gallons)	—	—	4,000	3,350	4,275	4,600	3,810	3,570
Metals	201	210	33	153	158	266	64	47
Lead	—	—	—	—	—	4.4	3.7	0.7
Automotive Batteries	—	5	0.81	0.72	6.8	4.3	2.1	1.1
Printer/Toner Cartridges (units)	—	—	—	—	—	—	1,480/175	1,575/510
Fluorescent bulbs (units)	—	—	—	—	13,664	12,846	867	41,124
Blasocut Coolant (gallons)	—	—	—	—	—	—	—	3,575
Antifreeze (gallons)	—	—	—	—	55	276	448	145

Notes:
All Units are tons unless otherwise noted.
— denotes either not recycled in that year or data not available.

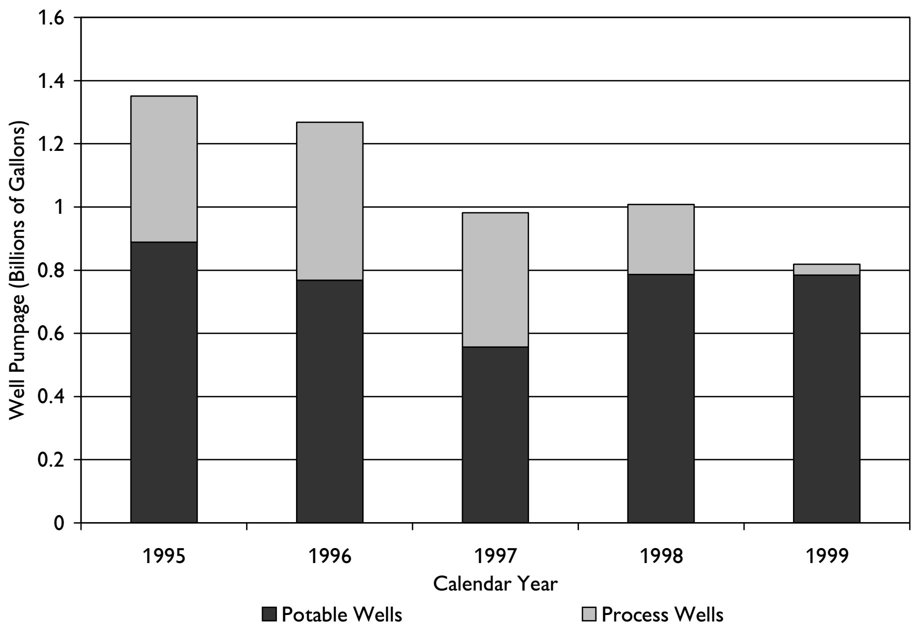


Figure 2-9. Water Consumption Trend 1995-1999.

the impacts of clean water discharges on the operations of the Sewage Treatment Plant. These goals will be achieved by either the replacement of the water cooling system with a closed-loop cooling medium (e.g., chilled water), or by rerouting clean water discharges to recharge basins that then replenish the groundwater supply. In 1999, plans and specifications were drafted to reduce once through cooling water use in Buildings 463 and 535. These plans will be finalized in 2000. Implementation of these improvements will be initiated in the fall so that cooling of facilities is not impacted during construction.

A secondary benefit of the AGS water conversion program was the reduction in equipment maintenance and the improved quality of the water discharge. Under the former cooling system, main magnet heat exchangers at the AGS were back-flushed several times weekly to remove iron deposits. Using the potable water, these exchangers are now backflushed no more than twice each year. Performance of the recharge basin that receives this discharge has improved as a result. The basin was previously scraped every 12-18 months to remove iron scale that clogs soil pores and prevents leaching. The basin has not been scraped in two years and leaching efficiency is still high.

2.4.5 ENERGY MANAGEMENT AND CONSERVATION

Many of the BNL scientific experiments use particle beams generated and accelerated by electricity with the particles controlled and aligned by large electromagnets. The Laboratory spends over $22 million for energy each year. To help deal with large energy expenditures, as well as meet DOE goals for energy conservation, BNL's Energy Management Group was established in 1979. It is responsible for the development, implementation and coordination of BNL's energy management plan.

Energy initiatives that took place in 1999 included the following:

- ♦ Completion of a new efficient steam absorption chiller at BNL's Central Chilled Water Facility, which is estimated to save over 60,000 mmbtu/year in energy and over $150,000/year in energy costs. (Note: This cost avoidance is not reflected in Table 2-2.)
- ♦ Initiation of a Controls System Optimization Project for five buildings. This project will recommission the existing energy management control system, reestablish proper scheduling and control points, and add new energy saving features. Based on recent experience, a 10 percent reduction in energy use is expected.
- ♦ Substantial completion of a steam station/manhole insulation project. In steam stations, the piping, valves and other components where original insulation had been damaged or removed will be reinsulated. New removable insulation jackets will be installed in manhole valves and expansion joints. This project will reduce energy loss and improve conditions in the spaces by reducing the temperature, thus providing a safer working environment.
- ♦ Substantial completion of a lighting project to replace incandescent exit signs that contain tritium with light emitting diode (LED) signs. The tritium signs were taken out of service and returned to the manufacturer, eliminating the risk of radioactive release. The manufacturer exchanged the tritium signs with highly efficient and environmentally benign LED signs, at a cost savings.
- ♦ Initiation of a Side-Stream Filtration Project at the Central Chilled Water Facility. Under this project, a filter system will be installed to remove fine particulates in water. If not removed, small particles can attach to various water system components and result in corrosion and buildup of scale. This in turn reduces the heat transfer capability of the heat exchange surfaces, which increases energy use. It also degrades the system, causing premature failures.

Together, these projects are estimated to save over $1 million/year in energy costs each year and help further progress towards the DOE energy goals.

DOE Order 430.2 (1996), *In-House Energy Management*, set a goal to demonstrate, on an annual basis, continual cost-effective improvement in reducing building energy use per square foot and increasing energy efficiency in industrial facilities. Success is measured by comparing current year consumption to the prior year. Energy management initiatives have been very successful at BNL. Laboratory energy-use per square foot of building for 1999 was 28 percent less than in 1985, well ahead of the DOE goal of a 20 percent reduction by 2000 (see Figure 2-10).

2.4.6 EMPLOYEE TRIP REDUCTION PLAN (RIDESHARE)

BNL has had a rideshare program since 1995. This program was developed to comply with the Employee Travel Reduction Program rule (17 NYCRR 38). The New York State Department of Transportation repealed the rule in September 1996, in effect making employer participation in the program voluntary. Although the program is voluntary, BNL continues to assist employees in finding suitable rideshare partners by maintaining a ride-matching database. The Laboratory still provides a guaranteed ride service for program participants, and continues to subsidize the cost of a defensive-driver course for employees active in ridesharing partnerships.

2.5 ENVIRONMENTAL MONITORING

The Laboratory has established a comprehensive, multi-media environmental monitoring program to determine whether current BNL operations affect the environment and to ensure compliance with environmental permit require-

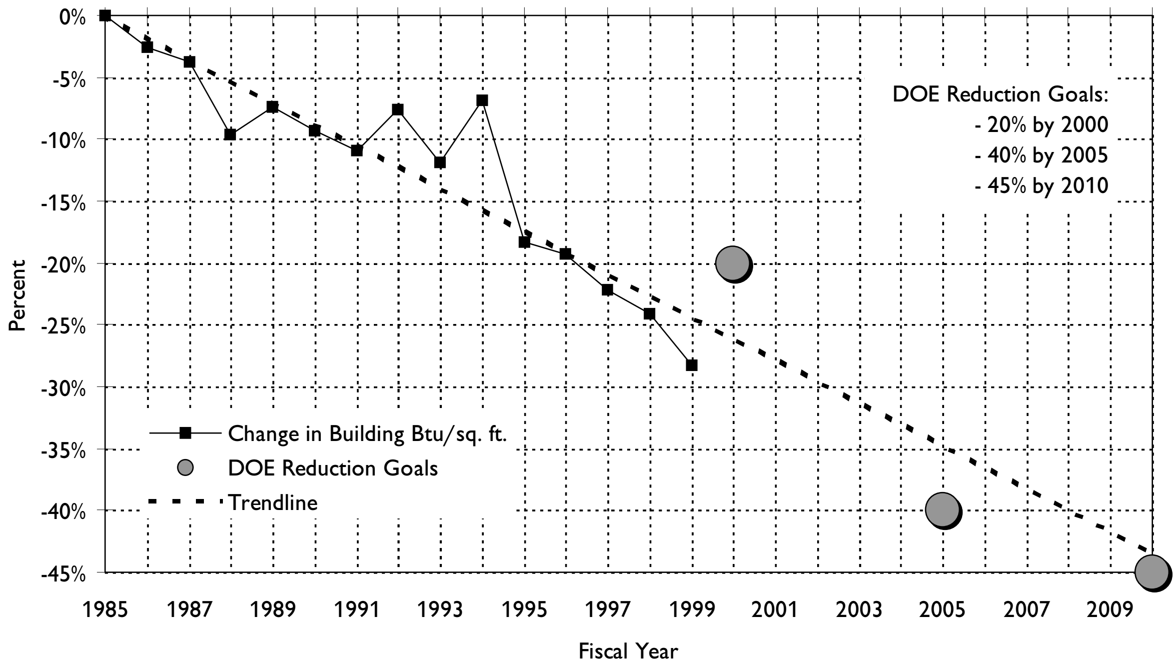


Figure 2-10. Building Energy Performance Since 1985.

ments. The monitoring program is reviewed, and revised as necessary, on an annual basis to reflect changes in permit requirements, changes in facility-specific monitoring activities, and the need to increase or decrease monitoring based upon the review of previous analytical results. As required under DOE Order 5400.1 (1988), an Environmental Monitoring Plan outlines annual sampling goals by specific media and frequency. Over 4,729 samples were collected in 1999 as part of the Environmental Monitoring Program, as shown in Table 2-4.

The monitoring 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. There are three components to the environmental monitoring program:

- ♦ *Compliance monitoring* is conducted to ensure that wastewater effluent, 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 New York State equivalents).
- ♦ *Restoration monitoring* is performed to determine overall impacts of past operations, to delineate the real extent of contamination, and to ensure that remedial systems are performing as designed (under CERCLA and Resource Conservation and Recovery Act).
- ♦ *Surveillance monitoring* is conducted to ensure there are no negative impacts on the environment from Laboratory operations (under DOE Order 5400.1).

These programs can be broken down further by the relevant law or requirement (e.g., State Pollutant Discharge Elimination System [SPDES] or Clean Air Act) and even further by specific environmental media and type of analysis. Control or background (reference) samples are also collected in order to compare BNL results to areas that could not have been impacted by BNL operations.

2.5.1 COMPLIANCE MONITORING

Compliance monitoring is performed in accordance with environmental requirements (permits, regulations, etc.). These requirements may be separated into three categories: air, wastewater and groundwater.

- ♦ 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 or continuous sample collection equipment

Table 2-4. BNL 1999 Sampling Program - Summary of Samples Collected Sorted by Media.

Media	No. of Samples Collected in 1999	Purpose
Groundwater	2,122	Monitoring is performed under the Environmental Restoration and Environmental Surveillance programs to evaluate any impacts of past and present operations on groundwater quality.
Air - Tritium	613	Silica gel cartridges are used to collect atmospheric moisture for subsequent tritium analysis. These data are used to assess tritium levels downwind of the reactors. Due to several years of no detection, monitoring was reduced from weekly to monthly in several areas of the site in 1999.
Air - Particulate	486	Gamma analysis is performed on samples of particulate matter collected from air samples. The purpose is to verify that there has been no impact from BNL operations.
Air - Charcoal	191	Charcoal samples are used to assess for radioiodines, which could be released in reactor emissions.
Potable Water	214	Potable water wells and the BNL distribution system are monitored routinely for chemical and radiological parameters to ensure compliance with SDWA requirements and for environmental surveillance purposes.
Fauna	27	Fish and deer are routinely monitored to assess impacts on wildlife associated with past BNL operations.
Flora	4	Since the primary pathway from soils to fauna is via ingestion, vegetation is sampled to assess uptake of contaminants by plants, and hence to fauna. Monitoring in 1999 consisted of collection of saltwater flora.
Onsite Recharge Basins	128	Recharge basins used for wastewater and stormwater disposal are monitored in accordance with SPDES requirements and for environmental surveillance purposes.
Sewage Treatment Plant	691	The STP influent and effluent and several Peconic River stations downstream are monitored routinely for organic, inorganic, and radiological parameters to assess BNL impacts on the estuary.
Precipitation	10	Precipitation samples are routinely collected from two locations to determine impacts of Laboratory emissions on rainfall.
Soils	243	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 in conjunction with Environmental Restoration investigative work.
Total Samples Collected in 1999	**4,729**	

is installed and maintained at these facilities, as required by permit conditions. Analytical data are reported routinely to the permitting authority (see Chapter 3 for details).

- ♦ Wastewater discharges are subject to Clean Water Act permit monitoring requirements. Monitoring is performed at the point of discharge, and is used to ensure that the effluent complies with release limits. Thirteen point source discharges are monitored under the BNL program: three from the Environmental Restoration (ER) program, and ten under the SPDES program. Samples are collected daily, weekly, monthly, or quarterly as required by permit conditions, and monitored for organics, inorganics and radiological parameters. Monthly reports are filed with the permitting agency, which provide analytical results and an assessment of compliance for that reporting period.
- ♦ 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 Resource Conservation and Recovery Act 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 (see Chapter 3 for details).

2.5.2 ENVIRONMENTAL SURVEILLANCE MONITORING

The focus of the environmental surveillance program is to assess potential environmental impacts resulting from routine facility operations. This program includes collection of ambient air, surface water, groundwater, flora, fauna, and precipitation samples. Samples are analyzed for radiological, organic, and inorganic contaminants. Additionally this program performs routine review of data collected by thermoluminescent dosimeters (devices to measure radioactive exposure) placed onsite and offsite.

2.5.3 ENVIRONMENTAL RESTORATION MONITORING

Monitoring performed under the ER program is conducted to determine if past operations released or deposited contaminants in the environment or otherwise resulted in degradation of environmental media. This program typically includes collection of soil and groundwater samples in order to determine the lateral and vertical extent of the contaminated area. These samples are analyzed for organics, inorganics and radiological contaminants and the analytical results compared with recognized guidance or background concentrations. Areas where impacts have been confirmed are fully characterized and if necessary, remediated to mitigate continual impacts. Follow-up monitoring of groundwater is conducted in accordance with a Record of Decision.

The results of monitoring and the analysis of the monitoring data are the subject of the remainder of this Site Environmental 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 most of the data shown in this report.

2.6 ENVIRONMENTAL RESTORATION (ER) PROGRAM

In 1980 the U.S. Congress enacted the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA, also known as Superfund) to ensure that sites with historical contamination were cleaned up, and to hold the responsible party liable for the cleanup. CERCLA established the National Priorities List (also known as the NPL). The NPL is a list of sites nationwide where cleanup of past contamination is required. In November 1989, BNL was included as one of more than 30 sites on the NPL that are located on Long Island. Much of the contamination at BNL is due to past accidental spills and practices for handling chemical and radiological material storage and disposal.

BNL follows the process mandated by CERCLA, which includes

- ♦ conducting a *Preliminary Assessment* (review of historical documents, interviews with employees, site reconnaissance),
- ♦ doing a *Site Inspection* (which often includes sampling),
- ♦ conducting a *Remedial Investigation* (to characterize the nature, the extent of contamination and the existing risks),
- ♦ preparing a *Feasibility Study* (to present remedial action alternatives and evaluate alternatives),
- ♦ issuing a *Record of Decision* (to present DOE, EPA and NYSDEC remedy/corrective action), and
- ♦ performing *Remedial Design/Remedial Action* (which includes final design, construction specifications and carrying out the remedy selected).

At each step, EPA distinguishes between sites that do or do not require further action, based on threat to human health and the environment. An expedited cleanup action, called a *Removal Action*, can also be conducted. This only requires an *Engineering Evaluation/Cost Analysis*. This document evaluates and recommends specific cleanup actions. See Figure 2-11 for a flow chart that illustrates the CERCLA process.

The Laboratory's ER program has been characterizing and removing sources of contamination (e.g., underground tanks and pools) or treating the groundwater and soil contamination resulting from past BNL practices. ER groundwater cleanup efforts have included monitoring of existing groundwater wells, overseeing the installation of new, permanent groundwater monitoring wells, installing groundwater treatment systems and extension of public water service. During 1999, 757,000,000 gallons of groundwater were treated, and at least 634 pounds of volatile organics were removed. Since the first system started operating in December of 1996, a total of 1,566 pounds of volatile organic compounds have been removed from almost two billion gallons of groundwater. (See Chapter 7 for more information.) BNL has identified contami-

Environmental Restoration Cleanup Process

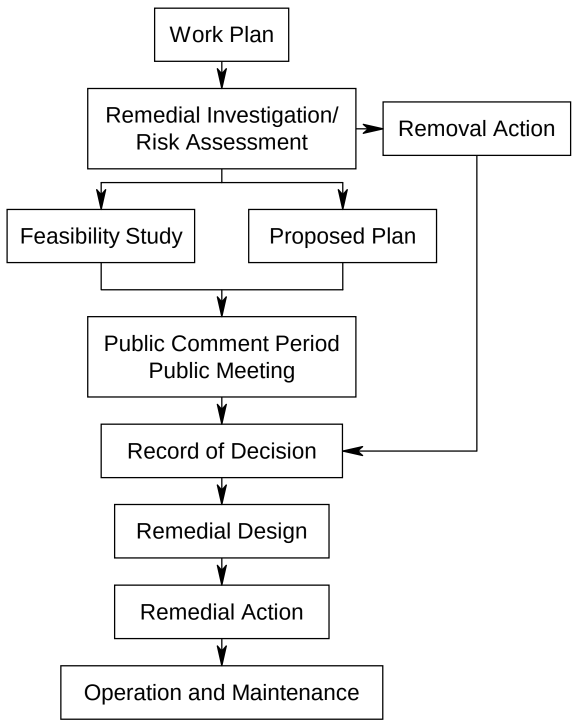


Figure 2-11. Flowchart of the CERCLA Process.

nated soils through extensive surveys and sampling. These studies have resulted in various projects involving soil removal and treatment. Several landfills have been capped and fifty-five waste pits have been excavated. Some of the excavated waste has been sent to an offsite licensed facility; the other wastes are being stored onsite and managed, awaiting final disposition.

2.6.1 ENVIRONMENTAL RESTORATION PROGRAM PROGRESS BY OPERABLE UNIT (OU)

Historical facility records and sampling have been used to determine where contamination might be present on the site today. These areas were geographically grouped into Operable Units (OU) (see *Areas of Concern at BNL, Upton, New York - A Reference Handbook.* [BNL 1988a]). Table 2-5 provides a description of each OU (I - VII) and the ER actions taken during 1999. Photographs in Figures 2-12 through 2-15 show ER activities conducted during 1999. See Chapter 7 for a more detailed discussion of groundwater monitoring and restoration programs.

2.6.1.1 OPERABLE UNIT V – THE PECONIC RIVER

Significant progress was made in OU V during 1999. Samples for plutonium and related radionuclides were collected from

- ♦ sludge in out-of-service sewer line (now capped) that once led to the the Sewage Treatment Plant;
- ♦ soils at the Sewage Treatment Plant;
- ♦ groundwater in the vicinity of and downgradient of the Sewage Treatment Plant and at background reference locations (18-30 miles west of BNL);
- ♦ surface water and sediment in the Peconic River (which receives BNL's treated sewage effluent) and in the Connetquot River (which was used as a reference location); and
- ♦ fish from the Peconic River.

BNL analytical results agreed closely with results from split samples analyzed by the EPA, the NYSDEC, the Suffolk County Department of Health Services and the DOE's Environmental Measurements Laboratory. Plutonium was detected in all media at levels below those requiring health-based cleanup levels. The results were shared with the regulatory agencies, the community, civic organizations and advisory councils (BNL 2000).

Some community members and stakeholders have advocated phytoremediation, which uses plants to extract contaminants from sediment. In the spring of 1999, an evaluation of phytoremediation in the Peconic River was completed by the two industry leaders in this technology. According to studies, although phytoremediation is a promising innovative technology, application of it to sediments in the Peconic River and associated wetlands has several limitations. Phytoremediation may not be effective at meeting the cleanup goals for all contaminants to be removed from the Peconic River, since much of the area proposed for cleanup is heavily vegetated and would require excavation to clear the area for phytoremediation studies. Also, prolonged time periods may be necessary to reach cleanup goals, if they were achievable, for some contaminants such as copper.

In September, the Final Feasibility Study of engineering alternatives for OU V cleanup was placed in the Administrative Record for public review. A final report of the plutonium sampling results was placed in the Administrative Record on 2/4/00. See Chapter 7, pages 26-31

Table 2-5. Environmental Restoration Program Progress by Operable Unit.

Operable Unit or Project	Description and *Contamination Type*	1999 CERCLA Actions
Operable Unit I	Former Hazardous Waste Management Area, Landfills, and Disposal Pits *Radiological soil contamination, primarily cesium-137*	• Regulatory approval of the Operable Unit I Record of Decision (ROD) • Completed addendum to the Sampling Plan for the OU I wooded wetlands and collected and analyzed samples • Completed Treatablitiy Studies Report and sludge removal from the Bldg. 811 underground storage tank waste • Processed 1,000 cubic yards of debris from the Chemical Holes for disposal • Treated 5,000 gallons of decontamination fluids for low level strontium-90 • Treated and disposed 150 lbs. of liquid mercury • Continued operation of the OU I South Boundary Pump and Treat System (formerly RA V)
Operable Unit II/VII	AGS Scrapyard and Soil Contamination *Radiological soil contamination, primarily cesium-137 and strontium-90*	• Action Memorandum for the Brookhaven LINAC Isotope Producer (BLIP) project revised and submitted to DOE • Regulatory approval of the Operable Unit I Record of Decision (included OU II AOCs)
Operable Unit III	Potable Supply Wells/Spills *Chemical and radiological groundwater contamination, primarily VOCs, tritium and strontium-90*	*Remedial Investigation/Feasibility Study (RI/FS)* • Held public comment period and meetings for RI/FS • Continued review and revision of the OU III ROD *Onsite Actions* • Completed 90% Design of the groundwater treatment system for VOCs in the Former Scrapyard & Drum Storage Area south of Bldg. 96 • Excavated 340 cubic yards of PCB-contaminated soil in the Former Scrapyard & Drum Storage Area • Completed shipment of contaminated soils from Bldg. 830 • Completed the removal of two underground storage tanks and excavation of contaminated soil from Bldg. 830 • Treated over 80,000 gallons of groundwater and removed over 61 pounds of carbon tetrachloride • Continued operation of the OU III South Boundary Groundwater Pump and Treat System • Removed 757 million gallons of water and 634 lbs. of VOCs from all treatment systems from the aquifer during 1999 *Offsite Actions* • Construction of the first offsite groundwater treatment system was completed and system startup began in September 1999 *HFBR Tritium* • Installed 46 geoprobe wells, 11 vertical profiles, and 11 monitoring wells to monitor the HFBR tritium plume • Continued operation of the tritium pump and recharge system
Operable Unit IV	Central Steam Facility Spill and Bldg. 650 Sump Outfall *Chemical and radiological soil and groundwater contamination*	• Continued operations, maintenance, and monitoring at the Air Sparge/Soil Vapor Extraction System (AS/SVE) • Bldg. 650 Groundwater Modeling Report was presented to the Suffolk County Department of Health Services • Continued interim remedial monitoring for the Bldg. 650 Sump and Sump Outfall Area
Operable Unit V	Sewage Treatment Plant and Peconic River *Heavy metal and radiological sediment and soil contamination, primarily mercury, silver, copper, and cesium-137*	• Completed the OU V Feasibility Study Report • In May 1999, completed additional radiological sampling of water and sediments from the Peconic River, groundwater from wells in the vicinity of and downgradient of the Sewage Treatment Plant, and soils from the Sewage Treatment Plant, and sludge in retired and capped sewer pipes • Held four information sessions to inform residents of sampling results

continued on next page

Table 2-5. Environmental Restoration Program Progress by Operable Unit *(continued)*.

Operable Unit or Project	Description and *Contamination Type*	1999 CERCLA Actions
Operable Unit VI	Biology Fields *Pesticide groundwater contamination- ethylenedibromide (EDB)*	• Continued revisions on the OU VI ROD • Developed preliminary action plan to include a contingency remedy in addition to monitoring • Installed two vertical profile wells and two permanent monitoring wells
Groundwater Monitoring	Ongoing Sitewide Project	• Completed the 1998 ER Sitewide Groundwater Monitoring Report • Completed the BNL Groundwater Monitoring Program Quality Assurance Project Plan • Collected and analyzed over 1,300 groundwater samples from 16 monitoring programs
Brookhaven Graphite Research Reactor (BGRR)	*Radiologically contaminated water and fans, primarily cesium-137.*	• Completed the Baseline for the BGRR Decommissioning Project • Completed the BGRR Project Management Plan • Removed temporary walls from the BGRR high bay area to restore the facility for decommissioning planning and characterization of components and areas • Disposed of 35,500 gallons of contaminated water removed from the below ground ducts • Removed the first of five primary air handling fans weighing approximately 23,000 lbs. • Entered into the administrative record, the DOE approved CERCLA Time Critical Removal Action Memorandum for removal of the Pile Fan Sump, piping, and associated soils

of the *Site Environmental Report for Calendar Year 1997* (BNL 1999) for additional information on this sampling project.

2.7 COMMUNICATION AND COMMUNITY INVOLVEMENT

After the High Flux Beam Reactor tritium incident in 1997 (see the *Tritium Remediation Project, High Flux Beam Reactor, Summary Report* [BNL 1998b] for more information), the New York State Attorney General stated that he believed that BNL needed to "step outside the Laboratory's gates and demonstrate a commitment to the entire Long Island community" (Vacco 1998). All programs described in this chapter emphasize timely, ongoing and meaningful communication with stakeholders on findings and progress. The Laboratory continues efforts to improve working relationships with regulatory agencies by sharing information and working to resolve issues on plans, priorities, and corrective actions. BNL has maintained an open door policy with the regulators. For example, Suffolk County and Region II EPA have liaison staff with offices located at the Laboratory. Quarterly meetings are held with EPA on the MOA projects and other operations of interest. Biweekly meetings are held with Suffolk County on the Facility Review Project.

BSA has invested tens of millions of dollars in programs geared towards improving the Laboratory's environmental systems and performance. The MOA demonstrated BNL's willingness to make major changes in its programs, and involve the regulators at every step along the way. DOE and BNL have entered into several other Consent Orders/Agreements (described in Chapter 3) with the regulators to address compliance concerns. BNL project and senior managers have made communicating regularly on progress and honoring commitments a high priority. The Laboratory Director's frequent presence at meetings with the regulators and the community demonstrates his personal commitment to environmental stewardship.

BNL has also established a Community Advisory Council, similar to those at other DOE sites undergoing environmental restoration. The Council consists of representatives from 32 varied stakeholder organizations, including civic, business, union, health, education, and environmental groups. The Council advises the Laboratory Director and sets its own agenda. In addition, DOE established the Brookhaven Executive Roundtable. The Roundtable is made up of representatives from elected officials and regulatory agencies. The Roundtable provides a forum for updating members and the public on

◀ **Figure 2-12. Groundwater Treatment System.** In September 1999, BNL celebrated the start-up of the first offsite groundwater treatment system. This system, located in an industrial park just south of the Laboratory, uses in-well air stripping to remove chemicals from area groundwater.

Figure 2-13. Soil Removal. ▶ In October 1999, a layer of soil approximately six inches deep containing PCBs was removed from the Building 96 area.

Figure 2-14. Soil and Groundwater Sampling. ▶ In April 1999, as part of the Operable Unit V plutonium investigation, soil and groundwater samples were taken at BNL's Sewage Treatment Plant and analyzed for radionuclides.

◀ **Figure 2-15. Sediment Sampling.** In the spring of 1999, sediment samples were taken from locations along a 17-mile stretch of the Peconic River between BNL and the town of Riverhead. These samples were analyzed for plutonium and other radionuclides.

issues that may be of interest to them. The Laboratory offers to make subject matter experts available to give presentations and to respond to questions and concerns in real time to these groups and other outside organizations. BNL also has an Envoy Program, which builds on relationships that BNL employees have established within community organizations, as a way to communicate to a broader audience.

Other public outreach activities include monthly briefings to local civic associations; meetings and presentations to local, state and federal regulators and elected officials; and regular interactions with the business and educational community. In 1999, BNL hosted more than 20,000 student visitors, and another 4,900 people visited the Laboratory through its Summer Sunday programs. To highlight the cutting-edge environmental research conducted at the Laboratory and provide information regarding cleanup initiatives, the Laboratory hosted an Environmental Fair, which drew over 3,000 visitors. The Laboratory also issues press releases, publishes the *Brookhaven Bulletin* (a weekly employee newsletter) and *cleanupdate* (a periodic newsletter on environmental cleanup), and issues e-mail updates to inform the public and staff about environmental activities.

This annual Site Environmental Report summarizes BNL's environmental program and performance for the 1999 calendar year. The Laboratory is exploring other mechanisms to communicate data in a more user friendly, visual and timely manner. A great deal of information about BNL's environmental programs is already on BNL's website. Environmental project plans, status reports, procedures, and more are accessible to the general public on the Internet at <http://www.esh.bnl.gov/esd/>.

2.8 ENVIRONMENTAL STEWARDSHIP AT BNL TODAY

BNL now has an unprecedented knowledge of potential environmental vulnerabilities and current operations. Compliance assurance programs described in Chapter 3 are improving BNL's compliance status. Pollution prevention projects have resulted in millions of dollars of cost savings/costs avoided, and have prevented millions of pounds of waste from being generated or disposed. In 1999 the RHIC facility was officially certified to the ISO 14001 Standard. In 1999 BNL also received an overall "Excellent" performance rating from DOE.

The Laboratory is openly communicating with neighbors, regulators, employees and other interested parties on issues and progress. BNL must continue to deliver on commitments and demonstrate real improvements in their environmental performance in order to regain the stakeholders' trust.

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

EXPLORING EARTH'S MYSTERIES
...PROTECTING ITS FUTURE

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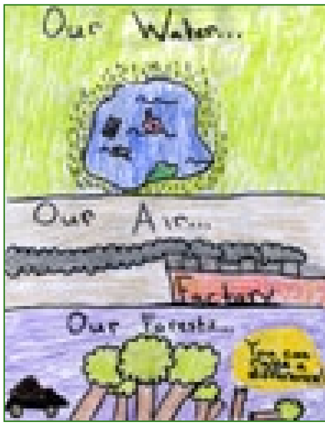

Compliance Status

Brookhaven National Laboratory is subject to more than 50 sets of federal, state, and local environmental regulations and 60 site-specific permits. In 1999 BNL operated in compliance with the vast majority of these regulations, and programs are in place to address areas for improvement.

Emissions that affect global warming and acid rain, such as nitrogen oxides, carbon monoxide, and sulfur dioxide, were within permit limits. Four portable fire extinguishers were taken out of service from which 68 pounds of Halon 1211 was recovered for reuse. Approximately 1,700 pounds of ozone-depleting refrigerants were also recovered for recycling.

With the exception of two minor pH excursions at Outfall 005, all wastewater discharges complied with the effluent limitations specified in BNL's State Pollutant Discharge Elimination System permit. Nine reportable spills of petroleum products occurred; all but one were under 3 gallons, and all were cleaned up to the satisfaction of the New York State Department of Environmental Conservation. No semi-volatile or floating petroleum products were detected in groundwater at the Major Petroleum Facility.

External audits in 1999 included the New York State Department of Environmental Conservation review of petroleum storage, hazardous waste, and air emissions from the Central Steam Plant; the U.S. Environmental Protection Agency audit of air program quality assurance; and the Suffolk County Department of Health Service's quarterly sewage treatment plant, routine site, and annual potable water system inspections. No citations resulted from these 1999 inspections. The BNL potable water system was found to comply with all drinking water requirements.

3.1 COMPLIANCE WITH ENVIRONMENTAL REQUIREMENTS

The federal, state, and local environmental statutes and regulations that BNL operates under are summarized in Table 3-1, along with a discussion of BNL's compliance status with regard to each requirement.

3.2 ENVIRONMENTAL PERMITS

Many processes and facilities at BNL operate under permits issued by environmental regulatory agencies. These permits include:

- State Pollutant Discharge Elimination System (SPDES) permit
- Major Petroleum Facility (MPF) license
- Resource Conservation and Recovery Act (RCRA) permit for the Waste Management Facility
- Registration certificate from the New York State Department of Environmental Conservation (NYSDEC) for tanks storing bulk quantities of hazardous substances
- NYSDEC certificates for two registered gasoline vapor recovery systems
- Eight radiological emission authorizations issued under the National Emission Standards for Hazardous Air Pollutants (NESHAPs) by the U.S. Environmental Protection Agency (EPA)
- Forty-six Certificates to Operate air emission sources from the NYSDEC.

Table 3-2 provides a summary of these permits. The table is organized by building number and then by type of permit. In addition to those listed, the operation of six groundwater pump and treat systems installed under the Interagency Agreement are authorized under SPDES and air emission equivalency permits.

In addition to the operating permits, permits are periodically acquired for construction activities. These include well-point dewatering, Wild Scenic and Recreational River System Act, and freshwater wetland permits. In 1999 a dewatering permit was issued for construction of sewage pumping stations at the Relativistic Heavy Ion Collider (RHIC) and a freshwater wetlands permit was renewed for construction of the RHIC ring.

3.2.1 NEW OR MODIFIED PERMITS

3.2.1.1 STATE POLLUTANT DISCHARGE ELIMINATION SYSTEM (SPDES)

In July 1999 BNL submitted a request to renew the BNL SPDES permit. This request was approved on September 9, 1999. The renewed permit is unchanged from the draft permit received in 1998 and authorizes discharges from the BNL Sewage Treatment Plant (STP) to the Peconic River, and discharges of cooling and storm water to recharge basins including those from the Relativistic Heavy Ion Collider (RHIC) facilities. Routine inspections by the SCDHS and monitoring of the STP showed that the facility consistently met effluent criteria and operational requirements.

3.2.1.2 AIR

Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Operable Unit (OU) I. In December 1998 the NYSDEC approved an equivalency permit application for operation of a high vacuum thermal desorption unit for processing mercury-contaminated mixed wastes recovered from the OU I Chemical Holes area. The unit did not operate during 1999.

Clean Air Act Title V. Under the Clean Air Act (CAA), BNL is defined as a major source of criteria pollutant emissions and is required to obtain a Title V operating permit under the CAA. This permit will consolidate all emission sources and all of the applicable federal and state regulatory requirements into a single document. This permit application was filed in December 1998. Table 3-3 provides a description of the 16 emission units identified in BNL's application, along with a summary of the regulatory requirements that apply.

After completing an initial quality assurance review of the Title V application, NYSDEC forwarded an Administrative Error Report to BNL in June 1999. The report identified administrative errors that BNL needed to address before the application could be considered complete. All of the administrative errors are being addressed, and BNL expects to submit a corrected application to the NYSDEC by February 15, 2000.

3.3 NATIONAL ENVIRONMENTAL POLICY ACT (NEPA)

Provisions in NEPA require federal agencies to follow a prescribed process to evaluate the impacts of proposed major federal activities on the environment before an irreversible commitment of resources is made. During 1999, environmental evaluations were completed for 73 proposed projects. Of these, 54 were considered minor actions requiring no additional documentation, and 19 projects were addressed through submission of Environmental Evaluation Notification Forms to the U.S. Department of Energy (DOE). In 1999, DOE determined that an Environmental Assessment should be prepared to address proposed upgrades to the National Synchrotron Light Source, Accelerator Test Facility, and the Source Development Lab. Preliminary work on the Environmental Assessment began in 1999 and the document is scheduled for completion late in 2000. In November 1999, DOE decided to permanently close the High Flux Beam Reactor (HFBR), and discontinued the review of the Draft Environmental Impact Statement.

3.4 CULTURAL RESOURCE MANAGEMENT

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

The Laboratory currently has three structures or sites that have been either determined to be eligible for listing (the Brookhaven Graphite Research Reactor [BGRR] complex and World War I training trenches associated with Camp Upton), or may be eligible (the Cosmotron). During 1999, activities associated with cultural resource management included the completion of the annual Department of Interior questionnaire regarding historic/ cultural resources; the development and submission of a Request for Determination of Eligibility for the BGRR complex; the Determination of Effects Finding for the BGRR; and a draft Memorandum of Agreement (MOA) for Mitigation of the Decommissioning of the BGRR. In November 1999 the New York State Historic Preservation Officer concurred with BNL's determination of eligibility and determination of effects regarding the BGRR. They also agreed that the draft MOA should be negotiated and finalized for the mitigation of effects. The Laboratory also developed a schedule for development of a Cultural Resources Management Plan that was submitted to the DOE Brookhaven Group Office for review. A cultural resource management plan will allow BNL to efficiently manage historic structures/features located on BNL property and will provide for a standard set of treatments related to historic properties. In 2000, BNL will finalize the MOA regarding the BGRR, begin developing the mitigation packages associated with the MOA, and continue the process of identifying and evaluating BNL properties for their historic value.

3.5 CLEAN AIR ACT (CAA)

The objectives of the CAA (administered by the 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 nonradioactive air emissions sources that are subject to federal or state regulations. The following subsections describe the most significant sources and the methods used to comply with the applicable regulatory requirements.

3.5.1.1 REASONABLE AVAILABLE CONTROL TECHNOLOGY (RACT)

New York State RACT requirements establish emission standards for oxides of nitrogen (NOx) for boilers with maximum operating heat inputs greater than or equal to 14.5 MW (50 MMBtu/hr). Compliance with these requirements is dependent upon the size of the boilers. Boilers with a maximum operating heat input between 50 and 250 MMBtu/hr can demonstrate compliance using periodic emissions tests or by using continuous emissions monitoring. Emission tests conducted in 1995 confirmed that BNL Boilers 1A and 5, both of which have maximum operating heat inputs less than 250 MMBtu/hr, met the NOx emissions standards when burning low nitrogen and sulfur content residual fuel (below 0.3 percent). To ensure continued compliance, an outside contractor laboratory analyzed composite samples of fuel deliveries, collected quarterly, to confirm the fuel-bound nitrogen and sulfur contents. Compliance with the 0.30 lbs/MMBtu NO_x emissions standards for Boilers 6 and 7 was demonstrated by continuous emission monitoring of flue gas. For the year, NOx emissions from Boilers 6 and 7 averaged 0.082 lbs/

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

Regulator: Statute	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 the remediation of releases of hazardous substances and the remediation of inactive hazardous waste disposal sites.	In 1989 BNL entered into a tri-party agreement between EPA, NYSDEC, and DOE. Remediation of the BNL site is conducted by the Environmental Restoration Program in accordance with milestones established under this agreement.	2.6
EPA: 10 CFR 1021 40 CFR 1021 40 CFR 1500-1508	The National Environmental Policy Act **(NEPA)** requires federal agencies to follow a prescribed process to evaluatethe impacts of proposed major federal actions and alternatives on the environment before an irreversible commitment of resources is made. DOE codified its implementation of NEPA in 10 CFR 1021.	BNL is in full compliance with the NEPA requirements.	3.3
Advisory Council on Historic Preservation: 36 CFR 60 36 CFR 63 36 CFR 79 36 CFR 800	The National Historic Preservation Act identifies, evaluates and protects historic properties eligible for listing in the National Register of Historic Places. Historic properties can be archeological sites, historic structures, or historic document records or objects.	In April 1991 three locations at BNL (the Brookhaven Graphite Research Reactor, the former Cyclotron Complex, and the World War I experimental foxhole trenches) were identified by the New York State Historic Preservation Office (SHPO) as potentially eligible for inclusion in the National Register of Historic Places. Any activities involving these facilities are identified utilizing the NEPA process and an evaluation is initiated to determine if the proposed action would impact the features that extend eligibility to these facilities. To date, no actions have been proposed which have required additional consultation with the SHPO. Compliance with the intent of these laws has been achieved by BNL, although program implementation has not been fully developed beyond the NEPA process.	3.4
EPA: 40 CFR 50 – 80 40 CFR 82 NYSDEC: 6 NYCRR 200 – 258 6 NYCRR 307	The Clean Air Act **(CAA)** and the New York State Environmental Conservation Law regulate the release of air pollutants through the use of permits and air quality limits.	All air emission sources have permits or have been exempted under the New York State air program. Emissions of radionuclides are regulated by the EPA, under National Emission Standards for Hazardous Air Pollutants **(NESHAPs)** authorizations.	3.5
EPA: 40 CFR 109 –140 40 CFR 230 – 231 40 CFR 401 40 CFR 403 NYSDEC: 6 NYCRR 700 – 703 6 NYCRR 750 – 758	The Clean Water Act **(CWA)** and corresponding New York State Environmental Conservation Law seek to improve the quality of the waters of the US/State by implementing a permitting program and establishing water quality standards.	Wastewater discharges are permitted by NYSDEC. Permitted discharges include treated sanitary waste, cooling tower, and stormwater discharges. With the exception of two minor excursions, these discharges met the State Pollutant Discharge Elimination System permit limits in 1999.	3.6
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. Safe Drinking Water Act requirements are enforced by the Suffolk County Department of Health Services.	BNL maintains a community water supply. This water supply meets all primary and secondary drinking water standards as well as operational and maintenance requirements.	3.7
EPA: 40 CFR 112 40 CFR 302 40 CFR 370 40 CFR 372	The Oil Pollution Act, Emergency Planning and Community Right to Know Act **(EPCRA)**, and the Superfund Amendment Reauthorization Act **(SARA)** require that facilities storing large quantities of petroleum products and/or chemicals prepare emergency planning documents and report this storage to the EPA.	Since facilities at BNL store or use chemicals or petroleum in quantities exceeding deminimus quantities, BNL is subject to these requirements. BNL will be updating the facility Response Plan required by 40 CFR 112.	3.8.1 3.8.2
EPA: 40 CFR 280 NYSDEC: 6 NYCRR 595 – 597 6 NYCRR 611 – 613 SCDHS: SCSC Article 12	Federal, state and local regulations regulate the storage of chemicals and petroleum products to prevent releases of these materials to the environment.	BNL is subject to a vast set of regulations governing storage of chemicals, petroleum products, and wastes. These 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 is working towards achieving full conformance to county codes.	3.8.3 3.8.4 3.8.5 3.8.6

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

Regulator: Statute	Regulatory Program Description	Compliance Status	Report Reference Sections
EPA: 40 CFR 260 – 280 NYSDEC: 6 NYCRR 360 – 374	The Resource Conservation and Recovery Act **(RCRA)** and New York State Solid Waste Disposal Act govern the generation storage, handling, and disposal of hazardous wastes.	BNL is defined as a large quantity generator of hazardous waste and has two permitted storage facilities. While almost all wastes are handled and disposed in accordance with all federal and state requirements, audits have identified several violations. These are being addressed by corrective action plans.	3.9
EPA: 40 CFR 700 – 766	The Toxic Substances Control Act **(TSCA)** regulates the manufacture, use, and distribution of all regulated substances.	BNL manages all TSCA-regulated materials, including PCBs, in compliance with all requirements.	3.10
EPA: 40 CFR 162 – 171 NYSDEC: 6 NYCRR 320 – 329	The Federal Insecticide, Fungicide, and Rodenticide Act **(FIFRA)** and corresponding New York State regulations govern the manufacture and use of biocides; specifically the use, storage, and disposal of pesticides and herbicides, and pesticide containers and residuals.	BNL maintains certified pesticide applicators for the application of pesticides and herbicides site-wide. Each applicator attends training as needed to maintain all certifications current. Annual reports detailing the quantity and types of pesticides applied are filed by each applicator each year by February 1st.	3.11
U.S. Fish and Wildlife Service: 50 CFR 11 NYSDEC: 6 NYCRR 182	The Endangered Species Act and corresponding New York State regulation prohibit activities that would jeopardize the continued existence of an endangered or threatened species, or cause adverse modification to a critical habitat.	One endangered species has been identified onsite (the tiger salamander) and one New York State Species of Special Concern (the banded sunfish). The Laboratory is preparing a Wildlife Management Plan that outlines activities to protect species and enhance their habitats.	3.13

Notes:
EPA = U.S. Environmental Protection Agency
CFR = U.S. Code of Federal Regulations
NYSDEC = New York State Department of Environmental Conservation
NYCRR = New York Codes, Rules, and Regulations
NYSDOH = New York State Department of Health
SCDHS = Suffolk County Department of Health Services
SCSC = Suffolk County Sanitary Code

MMBtu and 0.122 lbs/MMBtu respectively, and there were no recorded exceedances of the NOx emissions standard for either boiler. In 1999 natural gas was the predominant fuel burned in the two boilers.

3.5.1.2 HALON

Halon 1211 and 1301 recovery/recycling equipment purchased in 1998 is used to comply with the halon recovery and recycling requirements of 40 CFR 82, Subpart H. These halon recovery/recycling devices are used when portable fire extinguishers or fixed systems are removed from service and during periodic hydrostatic testing of halon cylinders. In 1999 four Halon 1211 portable fire extinguishers were replaced with ABC dry chemical extinguishers. Approximately 68 pounds of Halon 1211 were recovered from these extinguishers and is currently stored in a receiving tank for future use.

3.5.1.3 OZONE DEPLETING SUBSTANCES

All refrigerant recovery and recycling equipment used by refrigerant service technicians are certified to meet refrigerant evacuation levels specified by 40 CFR 82.158. Approximately 1,600 pounds of R-11, two pounds of R-12, and 97 pounds of R-22 were recovered and reclaimed for future use from equipment that was serviced during 1999. The R-11 was recovered from a 275-ton centrifugal chiller that was dismantled and replaced with a new 255-ton R-123 unit. Under the preventative maintenance program managed by the BNL Maintenance Management Center, refrigeration and air conditioning equipment containing ozone-depleting substances is regularly inspected and maintained. As a matter of practice, if a refrigerant leak is found, technicians will either immediately repair the leak or will isolate the leak and prepare a work order for the needed repairs. This standard practice exceeds the leak repair provisions of 40 CFR 82.156.

3.5.2 NATIONAL EMISSION STANDARDS FOR HAZARDOUS AIR POLLUTANTS (NESHAPS)

In 1970 the CAA established standards to protect the general public from pollutants which may result in an increase in mortality or

Table 3–2. BNL Environmental Permits.

Bldg. or Facility Designation	Process/Equipment Description	Permitting Agency and Division*	Permit Number	Expiration Date
197	welding shop	NYSDEC-Air Quality	472200 3491 19704	04-01-00
197	epoxy coating/curing exhaust	NYSDEC-Air Quality	472200 3491 19708	06-08-98[a]
206	cyclone G-10	NYSDEC-Air Quality	472200 3491 20601	04-01-00
207	belt sander	NYSDEC-Air Quality	472200 3491 20701	04-01-00
244	cyclone collector	NYSDEC-Air Quality	472200 3491 24401	01-28-99[a]
422	cyclone collector	NYSDEC-Air Quality	472200 3491 42202	11-29-96[a]
422	cyclone collector	NYSDEC-Air Quality	472200 3491 42203	11-29-96[a]
423	stage II vapor recovery	NYSDEC-Air Quality	472200 D365 WG	09-27-95[b]
423	welding hood	NYSDEC-Air Quality	472200 3491 42305	05-15-01
458	paint spray booth	NYSDEC-Air Quality	472200 3491 45801	04-23-97[a]
462	machining, grinding exhaust	NYSDEC-Air Quality	472200 3491 46201	11-29-96[a]
462	machining, grinding exhaust	NYSDEC-Air Quality	472200 3491 46202	11-29-96[a]
473	vapor degreaser/ fume hood	NYSDEC-Air Quality	472200 3491 47301	03-22-96[c]
479	cyclone G-10	NYSDEC-Air Quality	472200 3491 47905	04-01-00
490	Inhalation Toxicology Facility	NYSDEC-NESHAPs	472200 3491 49001	05-15-01
490	Inhalation Toxicology Facility	NYSDEC-Air Quality	472200 3491 49002	05-15-0[d]
490	lead alloy melting	NYSDEC-Air Quality	472200 3491 49003	05-15-01
490	milling machine/block cutter	NYSDEC-Air Quality	472200 3491 49004	05-15-01
510	metal cutting exhaust	NYSDEC-Air Quality	472200 3491 51002	09-30-98[a]
510	calorimeter enclosure	EPA - NESHAPs	BNL-689-01	None
526	polymer mix booth	NYSDEC-Air Quality	472200 3491 52601	04-01-00
526	polymer weighing	NYSDEC-Air Quality	472200 3491 52602	04-01-00
535B	plating tank	NYSDEC-Air Quality	472200 3491 53501	04-01-00
535B	etching machine	NYSDEC-Air Quality	472200 3491 53502	04-01-00
535B	PC board process	NYSDEC-Air Quality	472200 3491 53503	05-15-01
535B	welding hood	NYSDEC-Air Quality	472200 3491 53504	09-30-98[a]
555	scrubber	NYSDEC-Air Quality	472200 3491 55501	04-01-00[d]
555	scrubber	NYSDEC-Air Quality	472200 3491 55502	04-01-00[d]
610	combustion unit	NYSDEC-Air Quality	472200 3491 6101A	05-15-01
610	combustion unit	NYSDEC-Air Quality	472200 3491 61005	05-15-01
610	combustion unit	NYSDEC-Air Quality	472200 3491 61006	05-15-01
610	combustion unit	NYSDEC-Air Quality	472200 3491 61007	12-18-02
630	stage II vapor recovery	NYSDEC-Air Quality	472200 D366 WG	09-27-95[b]
703	machining exhaust	NYSDEC-Air Quality	472200 3491 70301	05-15-01
705	building ventilation	EPA - NESHAPs	BNL-288-01	None
820	accelerator test facility	EPA - NESHAPs	BNL-589-01	None
865	lead melting pot	NYSDEC Air Quality	472200 3491 86501	01-14-03
902	spray booth exhaust	NYSDEC-Air Quality	472200 3491 90201	09-30-98[a]
902	belt sander	NYSDEC-Air Quality	472200 3491 90202	05-15-01
902	sanding, cutting, drilling	NYSDEC-Air Quality	472200 3491 90203	05-15-01
902	brazing/soldering exhaust	NYSDEC-Air Quality	472200 3491 90204	05-15-01
902	painting/soldering exhaust	NYSDEC-Air Quality	472200 3491 90205	05-15-01
903	cyclone G-10	NYSDEC-Air Quality	472200 3491 90302	04-01-00
903	brazing process exhaust	NYSDEC-Air Quality	472200 3491 90303	09-30-98[a]
905	machining exhaust	NYSDEC-Air Quality	472200 3491 90503	05-15-01
919A	solder exhaust	NYSDEC-Air Quality	472200 3491 91903	05-15-01
922	cyclone exhaust	NYSDEC-Air Quality	472200 3491 92201	04-01-00
923	electronic equip. cleaning	NYSDEC-Air Quality	submitted 3-93,	status pending
924	spray booth exhaust	NYSDEC-Air Quality	472200 3491 92401	09-30-98[e]
924	magnet coil production press	NYSDEC-Air Quality	472200 3491 92402	05-15-01
924	machining exhaust	NYSDEC-Air Quality	472200 3491 92403	05-03-98
930	electroplating/acid etching	NYSDEC-Air Quality	472200 3491 93001	05-15-01[e]
930	bead blaster	NYSDEC-Air Quality	472200 3491 93002	05-15-01
AGS Booster[1]	accelerator	EPA - NESHAPs	BNL-188-01	None
RHIC[2]	accelerator	EPA - NESHAPs	BNL-389-01	None
RTF[3]		EPA - NESHAPs	BNL-489-01	None

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Table 3–2. BNL Environmental Permits ***(continued)*****.**

Bldg. or Facility Designation	Process/Equipment Description	Permitting Agency and Division*	Permit Number	Expiration Date
REF/NBF[(4)]		EPA - NESHAPs	BNL-789-01	None
CSF[(5)]	major petroleum facility	NYSDEC-Water Quality	1-1700	03-31-02
STP(c) & RCB[(6)]	sewage plant & recharge basins	NYSDEC-Water Quality	NY-0005835	03-01-00
WMF[(7)]	waste management	NYSDEC-Hazardous Waste	NYS ID No 1-4722-00032/00102-0	07-12-05
BNL Site	chem tanks-HSBSRC[(8)]	NYSDEC	1-000263	07-27-01

Notes:
* NYSDEC=New York State Department of Conservation
EPA=U.S. Environmental Protection Agency
NESHAPs=National Emission Standards for Hazardous Air Pollutants
NYSDEC= New York State Department of Environmental Conservation

[(a)] Permits for processes with past due expiration dates have been extended until NYSDEC approves BNL's Title V permit or until NYSDEC reclassifies the processes as exempt and trivial pursuant to 6 NYCRR 201 provisions.
[(b)] Renewal submitted 9-6-95, NYSDEC has indicated the process is subject to registration only.
[(c)] The vapor/sonic degreaser and fume hood shared a common exhaust stack. The degreaser has been removed. The fume hood is still used for aerosol spray coating and wipe cleaning of parts.
[(d)] Process is not in service.
[(e)] Process removed from service.

[(1)] Alternating Gradient Synchrotron
[(2)] Relativistic Heavy Ion Collider
[(3)] Radiation Therapy Facility
[(4)] Radiation Effects Facility/ Neutral Beam Facility
[(5)] Central Steam Facility
[(6)] Sewage Treatment Plant & Recharge Basins
[(7)] New Waste Management Facility
[(8)] Hazardous Substance Bulk Storage Registration Certificate.

an increase in serious irreversible or incapacitating illnesses. These regulations were updated o protect against the effects of these pollutants, a program to limit emissions of 189 toxic air pollutants was developed. This program included: a precise list of regulated contaminants, schedule for implementation of control requirements, aggressive technology based emission standards, industry specific requirements, special permitting provisions, and a program to address accidental releases.

3.5.2.1 MAXIMUM AVAILABLE CONTROL TECHNOLOGY

During preparation of the BNL Title V Phase II application, staff examined existing state and federal regulations that are 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 standards are applicable to BNL operations.

3.5.2.2 ASBESTOS

As required, BNL provided advance notice to the EPA Region II office for two construction projects involving the removal of regulated asbestos-containing materials. The Laboratory also provided the EPA with an annual notice of unscheduled small renovations for 1999. During 1999, 1,453 linear feet of pipe asbestos insulation and 1,692 square feet of asbestos surface material were removed and disposed of in accordance with applicable requirements.

3.5.2.3 RADIOACTIVE AIRBORNE EMISSIONS

In 1999 the maximum offsite dose due to airborne radioactive emissions from the Laboratory continued to be far below the 10 mrem annual dose limit in 40 CFR 61, Subpart H (See Chapter 4 for more information on the estimated dose). The dose to the Maximally Exposed Individual resulting from airborne emissions, calculated using EPA's CAP88-PC (CAA Assessment Package-1999) model was 0.13 mrem. All data pertaining to radiological air emissions and dose calculations were transmitted to the EPA on schedule, in fulfillment of the June 30 annual reporting requirement.

3.6 CLEAN WATER ACT (CWA)

The generation and disposal of wastewater effluents by Laboratory operations are regulated under the CWA, as implemented by NYSDEC and under DOE Order 5400.5. The goal of the CWA is to achieve a level of water quality which promotes the propagation of fish, shellfish, and wildlife; provide waters suitable for recreational purposes; and to eliminate the discharge of pollutants. New York State was delegated CWA authority in 1975. The NYSDEC

Table 3-3. Title V Permit Application Emission Units.

Emission Unit ID	Emission Unit Description	Applicable Regulations	Summary of Requirements
U45801	Unit is a paint spray booth used to apply protective and decorative coatings to miscellaneous metal parts and room furnishings.	6 NYCRR 228	Establishes volatile organic compound content limits for coatings based on the type of surfaces coated.
U49001	Unit has three walk-in enclosures used for research on processes to treat fireproofing products by chemically converting asbestos containing material into a non-regulated asbestos-free product. Redundant High Efficiency Particulate Arrestor (HEPA) filters are used in the exhaust system. Caustic and acidic aerosols generated by the process are controlled by a wet scrubber device.	40 CFR 61 Subpart M	Requires the use of HEPA filters certified to remove at least 99.97 percent of 0.3 micron particles and daily visual monitoring of potential source of asbestos emissions including air cleaning devices and process equipment.
U49003	Unit has a lead melting machine, a milling machine, and a block cutter used to fabricate block shielding for patients who receive treatment at the Radiation Therapy Facility. The shielding, is styrofoam and lead alloy used to protect against unwanted radiation. Particulates are collected in a fabric filter.	6 NYCRR 200 6 NYCRR 212	Requires emission control devices to be operated and maintained properly. Limits particulate emissions to 0.05 grains/dry standard cubic foot, for emission sources whose permit to construct was received by the New York State Department of Environmental Conservation after July 1, 1973.
U61005	Unit is two Central Steam Facility, commercial-institutional sized boilers. Boiler 1A, a midsize boiler, has a nominal heat capacity of 16.4 MW (56.7 MMBtu/hr) used for peaking and intermittent loads. Boiler 5, a large boiler with nominal heat capacity of 65.3MW (225 MMBtu/hr), is used to meet winter baseloads. Boiler 5 can burn oil or natural gas.	6 NYCRR 225-1 6 NYCRR 225-2 6 NYCRR 227-1 6 NYCRR 227-2	Limits sulfur content of fuel oils. Limits contaminants in waste oil burned. Establishes opacity limits for boilers. Establishes NOx emission limits for large and midsize boilers that burn natural gas and oil.
U61006	Unit is a commercial-institutional sized boiler with a nominal heat capacity of 42.6 MW (147 MMBtu/hr) located at the Central Steam Facility. Boiler 6 has dual fuel firing capabilities that allow it to burn oil or natural gas.	6 NYCRR 225-1 6 NYCRR 225-2 6 NYCRR 227-1 6 NYCRR 227-2 40 CFR 60 Subpart Db	Limits sulfur content of fuel oils. Limits contaminants in wasteoil burned. Establishes opacity limits for boilers Establishes NOx emission limits for large and midsize boilers burning natural gas and oil. Requires continuous monitoring systems to measure NOx emissions.
U61007	Unit is a Central Steam Facility commercial-institutional sized boiler with a nominal heat capacity of 42.6 MW (147 MMBtu/hr) built in 1996. Constructed after June 19 1986, it requires continuous emission monitoring for opacity. This boiler has dual fuel firing capabilities allowing it to burn oil or natural gas.	6 NYCRR 225-1 6 NYCRR 225-2 6 NYCRR 227-1 6 NYCRR 227-2 40 CFR 60 Subpart Db	Limits sulfur content of fuel oils. Limits contaminants in wasteoil burned. Establishes opacity limits for boilers. Limits NOx emission for large and midsize boilers. Requires continuous monitoring systems to measure NOx emissions.
UFLEET	Unit is BNL's fleet of vehicles of 244 gasoline powered vehicles with gross vehicle weight ratings (GVWRs) of 8,500 pounds or less, and 46 gasoline powered vehicles with GVWRs greater than 8,500 pounds. The remaining fleet vehicles are exempt from Part 217.	6 NYCRR 217	Sets inspection and maintenance requirements for gasoline and diesel powered vehicles. Emission and safety inspections are done at Building 630; maintenance and repairs at the vehicle maintenance shop.
UFUELS	Unit is two onsite gasoline refueling facilities. Building 630 is contractor operated servicing employee vehicles. The facility has three pumps that dispense low, medium and high octane grades of gasoline. Building 423, is a refueling facility for BNL fleet gasoline powered vehicles with two pumps dispensing low octane gasoline. Underground storage tanks at both facilities have Stage I and Stage II engineering controls.	6 NYCRR 225-3 6 NYCRR 230	Limits the Reid vapor pressure of gasoline from May 1st to September 15th, oxygen content October 1st to April 30th, and re-quires the sale of reformulated gas all year. Specifies Stage I and Stage II engineering controls at all refueling stations that pump more than 120,000 gallons annually.
UHALON	Unit has 589 portable Halon 1211 fire extinguishers, 135 Halon 1301 cylinders with 39 fixed total flooding fire suppression systems and three Halon 1301 reserve tanks.	40 CFR 80 Subpart H	Requires the use of certified technicians and halon recovery equipment to test, service, main-tain, repair, or dispose halon-containing equipment.

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Table 3-3. Title V Permit Application ***(continued)*****.**

Emission Unit ID	Emission Unit Description	Applicable Regulations	Summary of Requirements
UINSIG	Unit has a magnet coil coating operation, the Printed Circuit Board Laboratory, an operation for etching magnet end blocks, and a small scale printed circuit board etching and electroplating operation.	6 NYCRR 201-6	Requires maintenance of records to verify aggregate emissions of criteria pollutants and hazardous air pollutants from all sources are below levels established in Section 201-6.3.
ULEADM	Unit is a soft metal pot furnace installed at the new Waste Management Facility used to recycle lead shielding.	6 NYCRR 200	Requires emission control devices be operated and maintained properly.
ULITHO	Unit includes two lithographic offset printing machines used to print BNL's published materials.	6 NYCRR 234	Limits the volatile organic compound content of solutions used in printing.
UMETAL	Unit has 16 cold cleaning operations in various site locations to clean metal parts.	6 NYCRR 226	Specifies administrative and operating requirements for this equipment.
UMVACS	Unit covers BNL fleet vehicles equipped with air conditioners.	40 CFR 80 Subpart B	Requires certified technicians to use refrigerant recovery equipment when vehicle air conditioners are serviced or repaired.
URADEF	Unit covers onsite activities and operations that generate radioactive airborne emissions.	40 CFR 61 Subpart H	Sets monitoring requirements for emissions of radionuclides so that public does not receive dose higher than 10 mrem/yr.
URFRIG	Unit includes 21 centrifugal chillers, 38 reciprocating chillers, 4 rotary screw chillers, 193 split air conditioning units, and 245 package air conditioning units.	40 CFR 80 Subpart F	Requires certified technicians to use refrigerant recovery equipment when cooling units are serviced, repaired or disposed.

Notes:
CFR= U.S. Code of Federal Regulations
NYCRR= New York Codes, Rules, and Regulations

SPDES permit provides the basis for regulating 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. This permit provides monitoring requirements and specifies effluent limits for fourteen outfalls:

- ♦ Outfall 001 is the discharge of treated effluent from the STP to the Peconic River.
- ♦ Outfalls 002 – 005, 002A, 002B, 006A, 006B, 008, 010 and 011 are recharge basins used for the discharge of cooling tower blowdown, once-through cooling water, and/or stormwater. There was no monitoring of Outfalls 002A and 002B in 1999 since these discharges did not operate.
- ♦ Outfall 007 is backwash water from the Water Treatment Plant 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.

The permit renewal is issued for a period of five years and will expire on March 1, 2005.

3.6.1 BNL SEWAGE TREATMENT PLANT (STP) OUTFALL 001

Sanitary and process wastewater generated by Laboratory operations are conveyed to the STP for treatment prior to discharge to the Peconic River. The STP provides tertiary treatment of sanitary and process wastewater (i.e., biological reduction of organic matter and reduction of nitrogen). This treatment process became fully functional in 1998. Efforts were extended to maximize nitrogen removal in 1999; however, to improve nitrogen removal, higher concentrations of organic matter would be required to support the organisms that effect this process. Due to the low concentration of organic matter in BNL sewage, only nominal improvements were achieved. Regardless of these achievements, the concentration of nitrogen in the STP discharge has always been below the 10 mg/L limit.

A summary of the monitoring results for the STP discharge at Outfall 001 is provided in Table 3-4. This table shows that the Laboratory

Table 3-4. 1999 Analytical Results for Wastewater Discharges to Outfall 001 (Sewage Treatment Plant).

Analyte	Minimum	Maximum	Min. Monitoring Frequency	SPDES Limit	No. of Exceedances	Percent Compliance*
Max. Temperature (°F)	48	78.8	Daily	90	0	100
pH (SU)	6.4	8.2	Continuous Recorder	Min. 5.8 Max. 9.0	0 0	100 100
Avg. 5 day Biological Oxygen Demand (BOD) (mg/L)	< 2	< 5.5	Twice Monthly	Avg. 10	0	100
Max. 5 day BOD (mg/L)	< 2	9	Twice Monthly	Max. 20	0	100
% BOD Removal	> 87	> 98	Monthly	85	0	100
Avg. Total Suspended Solids (TSS) (mg/L)	< 4	< 10	Twice Monthly	Avg.10	0	100
Max. TSS (mg/L)	< 4	< 10	Twice Monthly	Max. 20	0	100
% TSS Removal	> 84	> 99	Monthly	85	0	100
Settleable Solids (ml/L)	0	0	Daily	0.1	0	100
Ammonia Nitrogen (mg/L)	< 0.05	1.3	Twice Monthly	2	0	100
Total Nitrogen (mg/L)	3.9	8.05	Twice Monthly	10	0	100
Total Phosphorus (mg/L) (1)	1.1	1.3	Twice Monthly	NA(2)	0	100
Cyanide (μg/L)	< 5	< 10	Twice Monthly	100	0	100
Copper (mg/L)	0.031	0.088	Twice Monthly	0.15	0	100
Iron (mg/L)	0.078	0.23	Twice Monthly	0.37	0	100
Lead (mg/L)	< 0.001	0.005	Twice Monthly	0.019	0	100
Nickel (mg/L)	0.002	0.006	Twice Monthly	0.11	0	100
Silver (mg/L)	< 0.0006	0.007	Twice Monthly	0.015	0	100
Zinc (mg/L)	0.025	0.1	Twice Monthly	0.1	0	100
Mercury (mg/L)	< 0.0001	0.0003	Twice Monthly	0.0008	0	100
Toluene (μg/L)	< 1	< 1	Twice Monthly	5	0	100
Methylene Chloride (μg/L)	< 1	1	Twice Monthly	5	0	100
1,1,1-Trichloroethane (μg/L)	< 1	< 1	Twice Monthly	5	0	100
2-Butanone (μg/L)	< 1	< 5	Twice Monthly	50	0	100
PCBs (μg/L)(3)	< 0.065	< 0.065	Quarterly	NA	0	100
Max. Flow (MGD)	0.65	2.2	Continuous Recorder	Max. 2.3	0	100
Avg. Flow (MGD)	0.527	0.760	Continuous Recorder	NA	0	100
Avg. Fecal Coliform (MPN/100 ml)(4)	<2	12.3	Twice Monthly	200	0	100
Max Fecal Coliform (MPN/100 ml)	<2	30	Twice Monthly	400	0	100

Notes:
See Figure 5-6 for location of Outfall 001.

$$\text{*Percent Compliance} = \frac{\text{Total No. Samples} - \text{Total No. Exceedances}}{\text{Total No of Samples}} \times 100$$

(1) Monitoring started in July
(2) NA=Not Applicable
(3) Monitoring started in September
(4) MPN=Most Probable Number

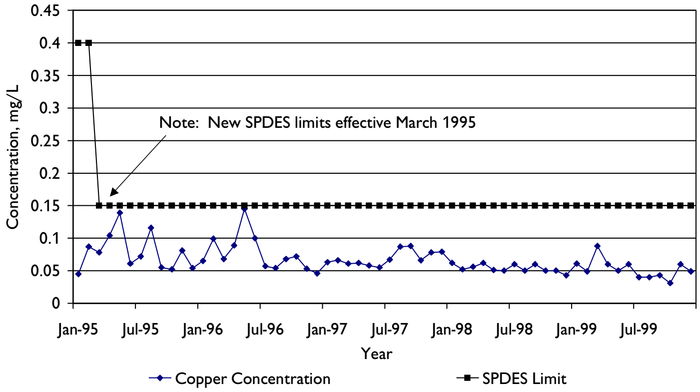


Figure 3-1. Maximum Concentration of Copper Discharged from the BNL STP, 1995-1999.

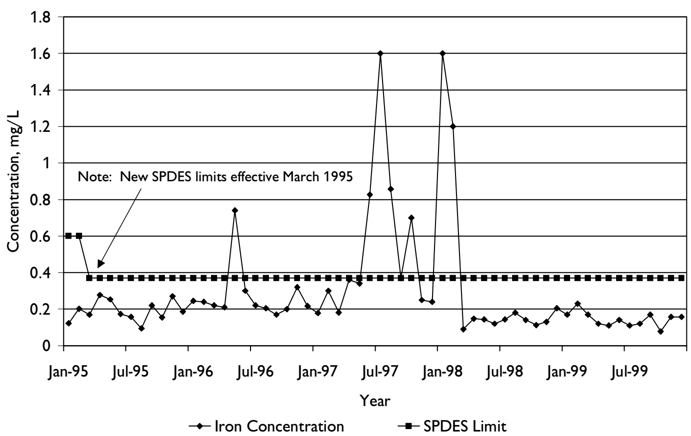


Figure 3-2. Maximum Concentration of Iron Discharged from the BNL STP, 1995-1999.

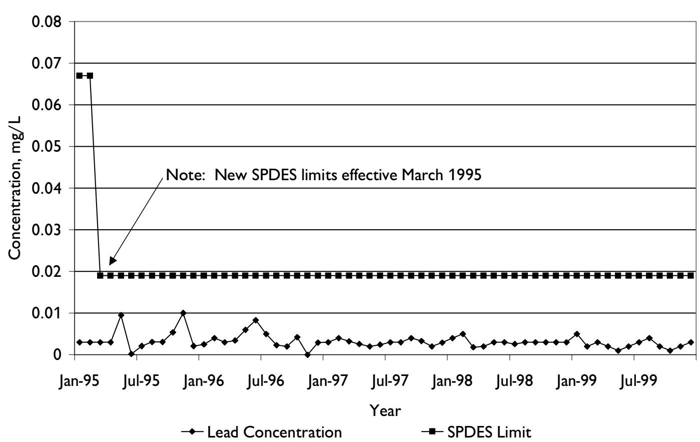


Figure 3-3. Maximum Concentration of Lead Discharged from the BNL STP, 1995-1999.

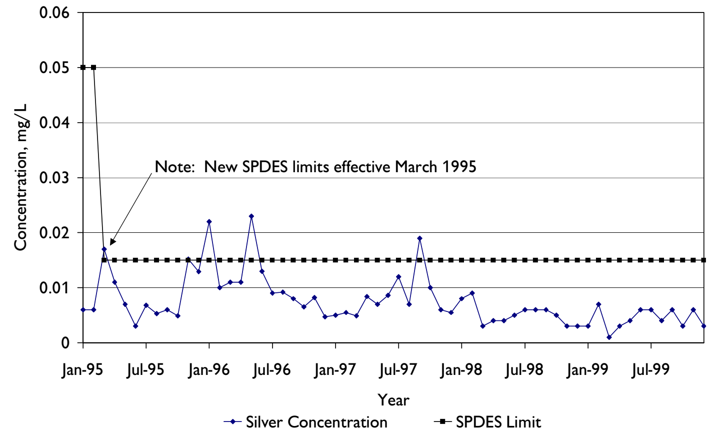


Figure 3-4. Maximum Concentration of Silver Discharged from the BNL STP, 1995-1999.

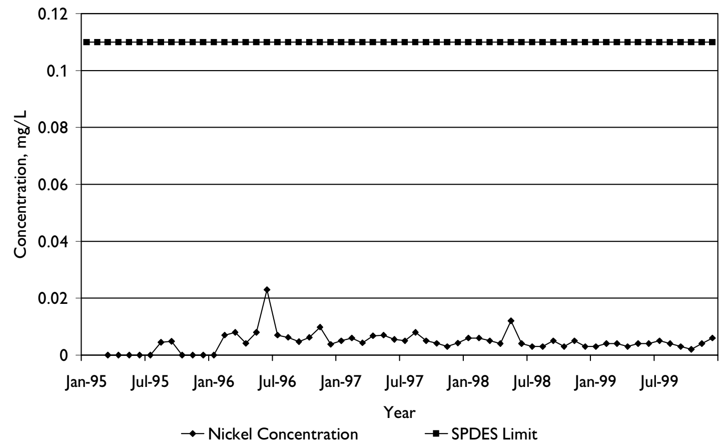


Figure 3-5. Maximum Concentration of Nickel Discharged from the BNL STP, 1995-1999.

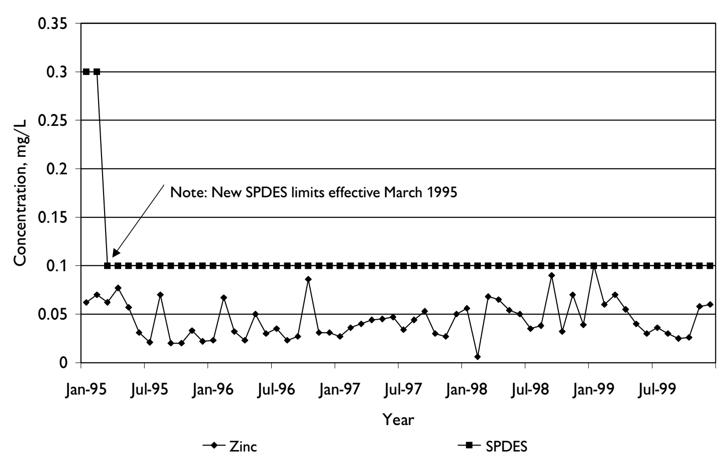


Figure 3-6. Maximum Concentration of Zinc Discharged from the BNL STP, 1995-1999.

was in full compliance with all parameters in 1999. Figures 3-1 through 3-6 plot five-year trends for the maximum monthly concentralver, nickel, and zinc in the STP discharge. The relevant SPDES permit limits are also shown.

3.6.2 CHRONIC TOXICITY TESTING

The chronic toxicity testing program initiated in 1993 for the STP effluent was continued in 1999. Samples were collected in March, June, September, and December and submitted to a contractor laboratory for testing. As required by the SPDES permit, this program consists of performing seven-day, Tier II chronic toxicity tests of the BNL STP effluent. Two fresh water organisms, water fleas (*Ceriodaphnia dubia*) and fathead minnows (*Pimephales promelas*), were used for testing. Sets of ten animals were 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 were measured and compared to untreated animals (i.e., controls). The test results were transmitted to NYSDEC for review.

Review of the toxicity data showed there was no acute toxicity exhibited for either organism, nor were any chronic effects, such as changes in growth weight, noted for the minnow. The rate of reproduction for the water fleas raised in the pure STP effluent was, however, lower than the control group in three of the four tests. A “No Observable Effect Concentration” of 25 percent was reported in two of the tests and 50 percent in the third. There was no chronic toxicity exhibited in the fourth test. Due to the low hardness of the BNL well water, osmotic effects were suspected of contributing to the noted toxicity. Testing conducted in December included treating a sample of the water with a solution of sodium bicarbonate to mitigate these effects. When this was done, there was no significant difference in reproduction rates between the treated and untreated sample. However, it should also be noted that there was no toxicity exhibited in either sample. Due to the variability in the toxicity results, testing will continue through 2000.

3.6.3 BNL RECHARGE BASINS AND STORMWATER OUTFALLS 002 - 008 AND 010

Outfalls 002 - 008 and 010 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. There are no monitoring requirements imposed for Outfalls 009 and 011. Monitoring of Outfalls 02A and 002B was not performed in 1999 since the cooling towers contributing to these effluents did not operate. Table 3-5 summarizes the monitoring requirements along with performance results for 1999.

The two pH excursions were recorded at Outfall 005 during the summer months. Elevated pH in the BNL domestic water system and evaporation were the primary contributing causes of these excursions. In 1997, a corrosion control study recommended that to minimize dissolution of lead from soldered joints of plumbing pipes, the pH of the BNL domestic water system should be maintained at 8.0 or higher. To increase the pH, hydroxides (either calcium or sodium) were added to the well water. In 1998 the Laboratory completed a project to divert a significant quantity of once-through cooling water from the sanitary waste system to Outfall 005. The diverted wastewater flows over an asphalt culvert before it reaches the monitoring station. Evaporation of the wastewater as it traverses this culvert results in a higher hydroxide concentration and a subsequent increase in pH. Monitoring of the discharge upstream of the culvert showed the wastewater pH to be consistently less than the limit of 8.5. Inspection of the culvert showed white residue (salt) deposited on the asphalt. This deposit was the hydroxide residue remaining from the evaporated water. These deposits build up until they are washed away by rainwater. Extended periods of drought result in higher hydroxide concentrations and higher pH. Since Long Island groundwater is naturally slightly acidic (pH = 5.5), the discharge of slightly alkaline wastewater would not have a detrimental impact on groundwater quality.

3.7 SAFE DRINKING WATER ACT (SDWA)

The distribution and supply of drinking water is regulated under the federal SDWA. In New York State, implementation of the SDWA is delegated to the New York State Department of Health (NYSDOH) and administered by the SCDHS. Since BNL provides potable water to more than 15 service connections, it is subject to the requirements for a public water supply.

Table 3-5. 1999 Analytical Results for Waste Water Discharges to Outfalls 002 - 008 and 010.

Analyte		Outfall 002	Outfall 003	Outfall 004	Outfall 005	Outfall 006A	Outfall 006B	Outfall 007	Outfall 008	Outfall 010	SPDES Limit	No. of Exceedances
Flow	N	CR	CR[a]	CR	CR	CR	CR	CR	11	10	NA	0
(MGD)	Min.	0.044	0.21	0.008	0.04	0.02	0.02	0	0	0		
	Max.	0.47	3.5	0.75	0.48	0.126	0.4	0.4	3.6	2.2		
pH	Min.	7.1	5.8	5.8	6.3	7.3	7.0	6.7	6.2	6.0		
(SU)	Max.	8.5	8.1	6.5	8.9	8.7	8.3	8.5	7.7	7.7	8.5, 9.0[b]	2
Oil and	N	12	12	NR	12	12	12	NR	11	10		
Grease	Min.	< 5	< 5	NR	< 5	< 5	< 5	NR	< 5	< 5		
(mg/L)	Max.	< 5	5	NR	< 5	< 5	< 5	NR	5	< 5	15	0
Copper	N	NR	NR	NR	4	NR	NR	NR	NR	NR		
(mg/L)	Min.	NR	NR	NR	0.006	NR	NR	NR	NR	NR		
	Max.	NR	NR	NR	0.015	NR	NR	NR	NR	NR	1	0
Zinc	N	NR	4	NR	NR	NR	NR	NR	NR	NR		
(mg/L)	Min.	NR	< 0.006	NR	NR	NR	NR	NR	NR	NR		
	Max	NR	0.013	NR	NR	NR	NR	NR	NR	NR	5	0
Iron (total)	N	NR	NR	NR	NR	NR	NR	5	NR	NR		
(mg/L)	Min.	NR	NR	NR	NR	NR	NR	138	NR	NR	NA	0
	Max.	NR	NR	NR	NR	NR	NR	762	NR	NR		
Iron (dissolved)	N	NR	NR	NR	NR	NR	NR	5	NR	NR		
(mg/L)	Min.	NR	NR	NR	NR	NR	NR	0.2	NR	NR		
	Max.	NR	NR	NR	NR	NR	NR	2.5	NR	NR	NA	0
Chloroform	N	4	NR	NR	NR	NR	NR	NR	NR	NR		
(mg/L)	Min.	< 1	NR	NR	NR	NR	NR	NR	NR	NR		
	Max.	7	NR	NR	NR	NR	NR	NR	NR	NR	7	0
Bromo-	N	4	NR	NR	NR	NR	NR	NR	NR	NR		
dichloromethane	Min.	< 1	NR	NR	NR	NR	NR	NR	NR	NR		
(mg/L)	Max.	0.006	NR	NR	NR	NR	NR	NR	NR	NR	5	0
1,1,1-trichloroethane	N	4	4	4	NR	NR	NR	NR	11	NR		
(mg/L)	Min.	< 1	< 1	< 1	NR	NR	NR	NR	< 1	NR		
	Max.	< 1	< 1	< 1	NR	NR	NR	NR	< 1	NR	5	0
1,1-dicloroethylene	N	NR	NR	4	NR	NR	NR	NR	11	NR		
(mg/L)	Min.	NR	NR	< 1	NR	NR	NR	NR	< 1	NR		
	Max.	NR	NR	< 1	NR	NR	NR	NR	< 1	NR	5	0
Dibromo-nitrilo-	N	NR	3	NR	NR	NR	NR	NR	NR	NR		
propionimide	Min.	NR	< 0.005	NR	NR	NR	NR	NR	NR	NR		
(mg/L)	Max.	NR	< 0.45	NR	NR	NR	NR	NR	NR	NR	0.5	
Hydroxyethylidene-	N	4	4	NR	4	4	4	NR	NR	NR		
diphosphonic Acid	Min.	< 0.05	< 0.05	NR	< 0.005	< 0.05	< 0.05	NR	NR	NR		
(mg/L)	Max.	0.05	< 0.05	NR	< 0.05	< 0.05	< 0.05	NR	NR	NR	0.5	0
Tolyltriazole	N	4	4	NR	4	4	4	NR	NR	NR		
(mg/L)	Min.	< 0.005	< 0.005	NR	< 0.005	< 0.005	< 0.005	NR	NR	NR		
	Max.	0.09	0.061	NR	< 0.005	0.058	0.131	NR	NR	NR	0.2	0

Notes:
See Figure 5-6 for locations of outfalls.
There are no monitoring requirements for Outfall 009.
N=Number of Samples
CR=Continuous Recorder
MGD=Million Gallons per Day
NR=Analysis Is Not Required
SU=Standard Unit
[a] Flow estimated for part of year due to problems with continuous chart recorder.
[b] Permit pH limit was 8.5 for all stations until 6/11/99 when it was raised to 9.0 for Outfalls 002, 003, 006A, 006B, and 007.

Monitoring requirements are prescribed annually by SCDHS, and a Potable Water Sampling and Analysis Plan is prepared to comply with these requirements. With regard to protection of the water system, containment is the desired method of protecting a public water system. This includes the installation of cross-connection control devices at the interface between the facility and the domestic water main to prevent potentially contaminated facility water from entering the distribution system.

3.7.1 POTABLE WATER

BNL maintains six wells for the distribution of potable water. All wells are treated with activated carbon or air stripping to remove volatile organic compounds to meet drinking water standards. Three of the six wells are also treated to reduce naturally occurring iron.

BNL monitors potable wells regularly for bacteria, inorganics, organics, and pesticides as required by NYSDOH regulations. BNL also voluntarily monitors drinking water supplies for radiological contaminants. Tables 3-6 and 3-7 provide the potable water supply monitoring data for 1999. Table 3-6 shows that color and iron exceeded drinking water standards in three of the wells at the wellhead prior to distribution. Treatment at the Water Treatment Plant effectively reduced these contaminants below drinking water standards, as evidenced by the distribution system monitoring results. At the point of consumption, all drinking water supplies complied with drinking water standards during 1999. Section 7.3 of Chapter 7 provides additional data on environmental surveillance testing performed on potable wells. The additional testing exceeds the minimum SDWA testing requirements.

3.7.2 CROSS-CONNECTION CONTROL

The SDWA requires that public water suppliers implement practices to protect the public water supply from sanitary hazards, including the protection of potable water supply connections to systems containing hazardous substances (i.e., cross-connections). Such practices include the implementation of a rigorous cross-connection control program. Cross-connection control is the preferred method of protecting a public water system and includes the installation of cross-connection control devices at the interface between a facility and the domestic water main. Installation of cross-connection control devices is required at all facilities where hazardous materials are used in a manner that could result in the introduction of these hazardous substances into the domestic water system under any condition. In addition, cross-connection controls at the point of use are also recommended to protect other users within a specific facility from hazards that might be posed by other facility operations.

BNL has installed and maintains over 150 cross-connection control devices at interfaces to the potable water main and secondary control devices at the point of use. One hundred thirty-five cross-connection control units were tested in 1999. Any problems noted in these units were immediately corrected, and the devices were retested to ensure viability. To ensure that all cross-connection control devices onsite are tested annually, new requirements were imposed through the development of Standards Based Management System Subject Areas.

3.7.3 UNDERGROUND INJECTION CONTROL

Underground Injection Control (UIC) is regulated under the SDWA. Proper management of UIC devices is key to the protection of underground sources of drinking water. In New York State, the UIC program is implemented through the EPA, since the NYSDEC did not adopt the new UIC regulatory requirements. The NYSDEC had already implemented a similar program through its CWA initiative. At BNL, UICs consist of drywells, cesspools, septic tanks, and leaching fields, all of which are classified by EPA as Class V injection wells. Under the UIC program, all Class V injection wells must be included in an inventory maintained with the EPA.

During 1999, a rigorous project to inventory and close unnecessary UICs was implemented. Under this project, 29 UICs were officially closed. The closure of the UICs included the collection and analysis of bottom sediment samples and submittal of formal documentation to the EPA requesting closure authorization. Only one of the 29 UICs required mitigation of low-level petroleum contamination prior to closure. Analytical results for the one UIC showed it to contain total petroleum hydrocarbons at levels exceeding background. These were excavated and the UIC successfully closed in 1999. The 94 remaining UICs were subse-

Table 3-6. Potable Water Wells and Potable Distribution System: 1999 Bacteriological, Inorganic Chemical, and Radiological Analytical Data.

Compound	Well No. 4 (FD)	Well No. 6 (FF)	Well No. 7 (FG)	Well No. 10 (FO)	Well No. 11 (FP)	Well No. 12 (FQ)	Potable Distribution Sample	NYS DWS
Water Quality Indicators								
Total Coliform	ND	ND	ND	ND	ND	ND	ND	Negative
Color (Units)	* 30	* 60	< 5	< 5	< 5	< 5	< 5	15
Odor (Units)	0	0	0	0	0	0	0	3
Cyanide (µg/L)	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	NS
Conductivity (µmhos)	NO	NO	NO	247	252	225	220	NS
Chlorides (mg/L)	12.6	14.6	21.4	15.0	20.6	14.8	18.8	250
Sulfates (mg/L)	7.8	9.1	11.3	11.4	13.0	10.0	10.1	250
Nitrates (mg/L)	0.25	0.27	0.34	0.56	0.59	0.40	0.40	10
Ammonia (mg/L)	< 0.05	< 0.05	< 0.05	<0.05	< 0.05	< 0.05	< 0.05	NS
pH (SU)	NO	NO	NO	6.6	6.4	6.5	6.7	NS
MBAS (mg/L)	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.04	NS
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 (mg/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)	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	2.2
Iron (mg/L)	*1.7	* 4.4	* 0.70	< 0.02	< 0.02	0.05	0.03	0.3
Lead (µg/L)	< 0.2	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	15
Manganese (mg/L)	0.22	0.10	0.05	12.4	< 0.01	< 0.01	< 0.01	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	0.08	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	0.1
Selenium (µg/L)	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	10.0
Sodium (mg/L)	9.7	9.6	14.6	12.4	12.9	11.7	21.2	NS
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)	< 0.8	0.9	< 0.86	< 0.86	< 0.86	< 0.86	ANR	15.0
Gross Beta Activity (pCi/L)	< 2.1	7.9	< 2.1	2.64	< 2.1	2.8	ANR	50.0
Tritium (pCi/L)	< 339	< 339	< 339	< 339	< 339	< 339	ANR	20,000
Strontium-90 (pCi/L)	< 2.0	2.74	< 2.0	< 2.0	< 2.0	< 2.0	ANR	8.0
Other								
Asbestos (M.Fibers/L)	ANR	ANR	ANR	ANR	ANR	ANR	< 0.42	7
Calcium (mg/L)	ANR	ANR	ANR	ANR	ANR	ANR	11.6	NS
Alkalinity (mg/L)	ANR	ANR	ANR	ANR	ANR	ANR	60.3	NS

Notes:
See Chapter 7, Figure 7-7 for Well locations.
This table contains the maximum concentration (minimum pH value) reported by the analytical laboratory.
ND=Not Detected
NS=DWS Not Specified
NO=Not Operational
MBAS=Methylene Blue Active Substances
ANR=Analysis Not Required
*Wells are treated at the Water Treatment Plant for color and iron reduction prior to site distribution.

quently inventoried and included in an UIC Area Permit application submitted to the EPA for approval in September 1999.

3.8 SPILL PREVENTION, EMERGENCY PLANNING, AND REPORTING

Several federal, state, and local regulations involve the management of storage facilities containing chemicals, petroleum, and other hazardous materials that are applicable to BNL. These regulations include specifications for storage facilities, release reporting requirements, and release planning document requirements.

3.8.1 SPILL PREVENTION CONTROL AND COUNTERMEASURES (SPCC) PLAN

BNL was in full compliance with the SPCC requirements in 1999. The Laboratory must maintain a SPCC Plan as a condition of its

Table 3-7. Potable Water Wells: 1999 Principal Organic Compounds, Synthetic Organic Chemicals, and Micro-Extractables Analytical Data.

Compound	WTP Effluent (F2)	Well No. 4 (FD)	Well No. 6 (FF)	Well No. 7 (FG)	Well No.10 (FO)	Well No. 11 (FP)	Well No. 12 (FQ)	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
Fluorotrichloromethane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,1-dichloroethene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Dichloromethane	< 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	0.5[(a)]	0.7[(a)]	< MDL	0.5	< 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
1,1,2-trichloroethane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,2-dichloropropane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Dibromomethane	< MDL	< MDL	< MDL	< MDL	< 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	4.6	1.2	< MDL	5.0	0.6	< MDL	0.6	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	ND	ND	ND	ND	ND	ND	ND	5
2-chlorotoluene	ND	ND	ND	ND	ND	ND	ND	5
4-chlorotoluene	ND	ND	ND	ND	ND	ND	ND	5
1,3-dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	5
1,4-dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	5
1,2-dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	5
1,2,4-trichlorobenzene	ND	ND	ND	ND	ND	ND	ND	5
Hexachlorobutadiene	ND	ND	ND	ND	ND	ND	ND	5
1,2,3-trichlorobenzene	ND	ND	ND	ND	ND	ND	ND	5
Benzene	ND	ND	ND	ND	ND	ND	ND	5
Toluene	ND	ND	ND	ND	ND	ND	ND	5
Ethylbenzene	ND	ND	ND	ND	ND	ND	ND	5
m-xylene	ND	ND	ND	ND	0.7[(b)]	ND	ND	5
p-xylene	ND	ND	ND	ND	0.7[(b)]	ND	ND	5
o-xylene	ND	ND	ND	ND	ND	ND	ND	5
Styrene	ND	ND	ND	ND	ND	ND	ND	5
Isopropylbenezene	ND	ND	ND	ND	ND	ND	ND	5
n-propylbenzene	ND	ND	ND	ND	ND	ND	ND	5
1,3,5-trimethylbenzene	ND	ND	ND	ND	ND	ND	ND	5
tert-butylbenzene	ND	ND	ND	ND	ND	ND	ND	5
1,2,4-trimethylbenzene	ND	ND	ND	ND	ND	ND	ND	5
sec-butylbenzene	ND	ND	ND	ND	ND	ND	ND	5
p-isopropyltoluene	ND	ND	ND	ND	ND	ND	ND	5
n-butylbenzene	ND	ND	ND	ND	ND	ND	ND	5

continued on next page

Table 3-7. Potable Water Wells: 1999 Principal Organic Compounds, Synthetic Organic Chemicals, and Micro-Extractables Analytical Data *(continued)*.

Compound	WTP Effluent (F2)	Well No. 4 (FD)	Well No. 6 (FF)	Well No. 7 (FG)	Well No.10 (FO)	Well No. 11 (FP)	Well No. 12 (FQ)	NYS DWS
	µg/L							
methyl tert. Butylether	ND	ND	ND	ND	ND	ND	ND	50
Lindane	ND	ND	ND	ND	ND	ND	ND	0.2
Heptaclor	ND	ND	ND	ND	ND	ND	ND	0.4
Aldrin	ND	ND	ND	ND	ND	ND	ND	5
Heptachlor Epoxide	ND	ND	ND	ND	ND	ND	ND	0.2
Dieldrin	ND	ND	ND	ND	ND	ND	ND	5
Endrin	ND	ND	ND	ND	ND	ND	ND	0.2
Methoxychlor	ND	ND	ND	ND	ND	ND	ND	40
Toxaphene	ND	ND	ND	ND	ND	ND	ND	3
Chlordane	ND	ND	ND	ND	ND	ND	ND	2
Total PCBs	ND	ND	ND	ND	ND	ND	ND	0.5
2,4,5,-TP (Silvex)	ND	ND	ND	ND	ND	ND	ND	10
Dinoseb	ND	ND	ND	ND	ND	ND	ND	50
Dalapon	ND	ND	ND	ND	ND	ND	ND	50
Pichloram	ND	ND	ND	ND	ND	ND	ND	50
Dicamba	ND	ND	ND	ND	ND	ND	ND	50
Pentachlorophenol	ND	ND	ND	ND	ND	ND	ND	1
Hexachlorcyclopentadiene	ND	ND	ND	ND	ND	ND	ND	5
Di(2-ethylhexyl)Phthalate	ND	ND	ND	ND	ND	ND	ND	50
Di(2-ethylhexyl)Adipate	ND	ND	ND	ND	ND	ND	ND	50
Hexachlorobenzene	ND	ND	ND	ND	ND	ND	ND	5
Benzo(A)Pyrene	ND	ND	ND	ND	ND	ND	ND	50
Aldicarb Sulfone	ND	ND	ND	ND	ND	ND	ND	NS
Aldicarb Sulfoxide	ND	ND	ND	ND	ND	ND	ND	NS
Aldicarb	ND	ND	ND	ND	ND	ND	ND	NS
Oxamyl	ND	ND	ND	ND	ND	ND	ND	50
3-Hydroxycarbofuran	ND	ND	ND	ND	ND	ND	ND	50
Carbofuran	ND	ND	ND	ND	ND	ND	ND	40
Carbaryl	ND	ND	ND	ND	ND	ND	ND	50
Total Aldicarbs	ND	ND	ND	ND	ND	ND	ND	NS
Glyphosate	ND	ND	ND	ND	ND	ND	ND	50
Diquat	ND	ND	ND	ND	ND	ND	ND	50
Ethylene Dibromide	ND	ND	ND	ND	ND	ND	ND	0.05
Dibromochloropropane	ND	ND	ND	ND	ND	ND	ND	0.2
2,4,-D	ND	ND	ND	ND	ND	ND	ND	50
Perchlorate	ND	ND	ND	ND	ND	ND	ND	NS
Alachor	ND	ND	ND	ND	ND	ND	ND	2
Simazine	ND	ND	ND	ND	ND	ND	ND	50
Atrazine	ND	ND	ND	ND	ND	ND	ND	3
Metolachor	ND	ND	ND	ND	ND	ND	ND	50
Metribuzin	ND	ND	ND	ND	ND	ND	ND	50
Butachlor	ND	ND	ND	ND	ND	ND	ND	50
Propachlor	ND	ND	ND	ND	ND	ND	ND	50

Notes:

For compliance determination with New York State Department of Health standards, potable wells were analyzed quarterly during the year by H2M Labs, Inc., a NYS certified contract laboratory.

The minimum detection limits for Principal Organic Compound analytes are 0.5 µg/L. Minimum detection limits for Synthetic Organic Chemicals, Pesticides and Micro-extractables are compound-specific, and in all cases are less than the New York State Department of Health drinking water standard (NYS DWS).

All concentrarions are the maximum values reported by the contractor laboratory.

WTP=Water Treatment Plant
<MDL=Less than the minimum detection limit
ND=Not Detected at the minimum detection limit
NS=Drinking Water Standard Not Specified

[a] Water obtained from wells 4, 6, and 7 is treated at the WTP prior to site distribution. The concentration of 1,1,1-trichloroethane in the WTP effluent (F2) met all drinking water standards.

[b] Reported Value represents total for both compounds.

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 or remedial actions that would be taken in the event of a petroleum release. The plan also provides information regarding the design of storage facilities, release prevention measures, and provides maps showing the location of all storage facilities. The SPCC Plan is maintained on file with NYSDEC, EPA, and DOE. The plan is updated triennially and is due for updating in 2000.

3.8.2 EMERGENCY PLANNING AND COMMUNITY RIGHT TO KNOW ACT (EPCRA) AND THE SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT (SARA) TITLE III REPORTING REQUIREMENTS

EPCRA and Title III of SARA require reporting of inventories and releases to a local emergency planning committee and the state emergency response commission for certain chemicals that exceed reporting thresholds. BNL fully complied with these requirements in 1999. The Laboratory submitted the required reports under EPCRA Sections 302-303, 304, 311-312. In 1999, there were no chemical releases that were subject to release reporting requirements under Section 313.

3.8.3 SPILL RESPONSE, REPORTABLE RELEASES AND OCCURRENCES

If a spill occurs, BNL personnel are required to immediately contact the onsite Fire Rescue Group. The Fire Rescue Group is trained in responding to releases of hazardous materials. The first step in a spill response is to contain and control any release, and to notify additional response personnel (BNL environmental professionals, industrial hygienists, etc.). Environmental professionals reporting to the scene assess the spill for environmental impact and determine reportability. Any release of petroleum products to soils or surface water is reportable to both NYSDEC and SCDHS. In addition, releases of petroleum products greater than five gallons to outdoor impermeable surfaces or containment areas are also reported.

Spills of chemicals in quantities greater than Comprehensive Environmental Response, Compensation & Liability Act (CERCLA) reportable quantities are reportable to the National Response Center, NYSDEC, and SCDHS. Remediation of the spill is conducted as appropriate. For example, if a piece of heavy equipment ruptured a hydraulic line resulting in a release of hydraulic oil to the soil, immediate actions would be taken to stop the leak, and then the contaminated soil would be excavated and containerized for offsite disposal.

During 1999, there were 36 spills, of which only nine met external agency reporting criteria. One of these spills was discovered during the demolition of an old petroleum pumping station located at the Major Petroleum Facility. This release most likely did not occur in 1999. All reportable spills were remediated or otherwise addressed to the satisfaction of NYSDEC; and all contaminated residuals were collected, containerized, and disposed. The remainder of the reportable spills was small (typically less than 3 gallons) and were also immediately cleaned up.

Table 3-8 provides information on the reportable spills, including the date of the spill, material involved, and quantity. It also includes a summary of the cause and corrective action taken. In addition, the table notes if the spill was reportable to DOE through the Occurrence Reporting and Processing System (ORPS).

In addition to the one spill noted in Table 3-8 as reported through ORPS, there were six other incidents reported to DOE through ORPS that were environmental in nature. These included a discovery of groundwater contaminated with tritium at the Alternating Gradient Synchrotron facility (at the g-2), water intrusion at RHIC, a short-term release of untreated air emissions from a soil vapor extraction system, the potential release of gasoline to groundwater, a small fire at a remediation site, and a small fire at one of the experimental facilities. All of these incidents were addressed through the identification and implementation of corrective actions geared towards correcting the root cause. A formal investigation was conducted in response to the groundwater discovery at the AGS that is fully described in Chapter 7. There were no onsite or offsite environmental consequences arising from the remaining ORPS incidents. Table 3-9 provides a description of each of these occurrences.

3.8.4 MAJOR PETROLEUM FACILITY (MPF)

BNL is in full compliance with its MPF License requirements. The storage of 2.3 million gallons of petroleum products (princi-

Table 3-8. Summary of 1999 Chemical and Oil Spill Reports.

Incident Number	Date	Material	Quantity	ORPS* Report	Source/Cause and Corrective Actions
99-03	03/04/99	Blaso-Cut (Water Soluble Cutting Fluid)	Unknown	No	While performing routine maintenance on a horizontal bridge mill (AWEA PD400), personnel noticed an aluminum drip pan had developed leaks. Inspection of the pan showed that the concrete floor had eroded the aluminum and that a seam weld had cracked. Inspection of the concrete pit beneath the pan showed that oil had seeped into the concrete. Subsequent investigation showed that soils beneath the pit had been impacted by the spill. Soil samples were collected and further evaluation is needed by the NYSDEC before remediation is complete.
99-05	1/17/99	Petroleum	< 1 gallon	No	During an inspection of maintenance work on recharge basin HN, an oily sheen was noted in the water pooled behind the overflow weir. Personnel erected a boom in the v-notched weir and down gradient of the weir to capture the floating oil as it passed over the weir. The sheen was probably the result of snow melt run-off from parking lots and roadways, since inspection of several storm drains that are connected to the basin revealed no apparent point source for the oil.
99-07	03/25/99	Diesel Fuel	~1 Quart	No	An emergency generator was being used to supply power to Bldg. 526/527 during the repair of the main electrical feeder. During operation a fuel injector developed a leak which resulted in the release of diesel fuel to the ground. There were no impacts to any water systems. All contaminated soils were containerized for offsite disposal.
99-08	03/29/99	Hydraulic Oil/ Diesel Fuel	< 3 gal.	No	While responding to a tank alarm at Bldg. 610, personnel noticed an area of dead vegetation along the east side of an above-grade, emergency, generator, storage tank. Further investigation revealed a mild oil odor and oil staining of the soil. All contaminated soils were containerized for offsite disposal.
99-15	05/24/99	Fuel Oil No. 6	~30 gal.	Yes	During excavation of pit to the south of Bldg. 610, water and floating product were discovered. Excavation was performed due to historical information of past operations in this area. All visible water was suctioned out and affected soils were removed and containerized separately for offsite disposal. Historic groundwater contamination from this source is possible.
99-26	09/16/99	Dielectric Fluid	< 1 lb.	No	Dielectric fluid leaked onto the floor of Room 09 in Bldg. 902 when a light ballast burnt out. After discovery, the leaking ballast was removed, containerized, and labeled for disposal for offsite disposal. A 4’ x 4’ area around the spill was cordoned off and labeled in accordance with 40 CFR Part 761 requirements. The one tile visibly affected by the spill along with three adjacent tiles were also removed for offsite disposal. After the tiles were removed, a wipe sample was taken from the concrete sub-floor to confirm that Part 761 clean-up criteria had been satisfied.
99-28	09/17/99	Diesel Fuel	~1/2 cup	No	In preparation for Hurricane Floyd, a diesel-powered pump was stationed outside Bldg. 911 to remove accumulated water and prevent intrusion into the AGS ring. During inspection, it was noticed that fuel oil was leaking from the fuel tank due to solar heat expansion. Soils affected by the spill were excavated and containerized for offsite disposal.
99-29	09/24/99	Motor oil	2-3 quarts	No	An employee accidentally backed his personal vehicle into an imbedded stake located behind Bldg. 490, which punctured the oil pan. Speedi-dry was used on affected areas of pavement and containerized along with affected soils for offsite disposal.
99-30	10/08/99	Fuel	< 1 gal.	No	A backhoe operated by a contractor company leaked fuel while parked and also after it was moved to a new location. The spills were not reported by the contractor but discovered by BNL personnel. Speedi-dry was used on affected areas of pavement and containerized along with affected soils for offsite disposal.

*Occurrence Reporting and Processing System

Table 3-9. Summary of 1999 Environmental Occurrence Reports.

ORPS* ID	Date of Occurrence	Occurrence Description	Status
CH-BH-BNL-NSLS-1999-0001	1/25/99	A power supply associated with the NSLS linear accelerator caught fire. The cause of the fire was determined to be a capacitor which did not meet manufacturer's specifications. Failure was due to extended internal arcing and the combustible nature of the capacitor materials.	All corrective actions are complete. The report is awaiting DOE approval.
CH-BH-BNL-BNL-1999-0001	1/04/99	Heavy rains resulted in flooding of an experimental facility at RHIC. Analysis of the incident revealed no impacts to the experiment.	All corrective actions are complete and the report approved by the DOE.
CH-BH-BNL-BNL-1999-0008	3/4/99	During maintenance of a milling machine, the machine operator noticed cutting coolant had leaked outside the secondary containment device. Further inspection showed that the concrete depression containing the containment vessel was cracked. Investigation showed low level oil contamination of the soils around the concrete. There were no impacts to groundwater.	The investigation has been completed and the results forwarded to the New York State Department of Environmental Conservation (NYSDEC) for review.
CH-BH-BNL-BNL-1999-0010	3/30/99	The NYSDEC issued an Notice of Violation for a hazardous waste inspection conducted in 1998. See Section 3.9 for a discussion of this occurrence.	All corrective actions have been completed and the report approved by DOE.
CH-BH-BNL-BNL-1999-0020	10/12/99	Wastes collected from the glass holes project were containerized for offsite disposal. During the containerization process, the waste was shredded. A container containing a mixture of sodium and potassium was shredded and bagged. Once exposed to atmospheric conditions the mixture reacted exothermically with the air resulting in a small fire.	All corrective actions are complete. The report is awaiting DOE approval
CH-BH-BNL-BNL-1999-0026	11/20/99	During dismantlement of the fire extinguisher test stand for the winter, water contained in the apparatus was discharged to a stormwater drywell. Since gasoline is used in the testing, fears that residual gasoline may be present prompted this report. Analysis of soil samples collected from the base of the drywell showed no evidence of gasoline products (i.e., aromatic hydrocarbons).	All corrective actions are complete. The report is awaiting DOE approval.

*Occurrence Reporting and Processing System

pally No. 6 Fuel Oil) subjects BNL to licensing by NYSDEC. The current license was renewed in 1997. The license requires BNL to monitor groundwater in the vicinity of the seven active storage tanks (ranging in size from 60,000 to 600,000 gallons), which are all aboveground. Monitoring consists of monthly checks for floating products, and twice-yearly tests for semivolatile organic compounds. There were no contaminants or floating products found in the groundwater wells that monitor the MPF in 1999. (See Chapter 7 for additional information on groundwater monitoring results.) An inspection of this facility was conducted by NYSDEC on November 15. This inspection noted four conditions that required immediate corrective actions and one recommendation. All conditions were addressed with NYSDEC concurrence on the corrective actions. The corrective actions included repair of a secondary containment liner near the base of one of the tanks, performance of a cathodic protection system test, remediation of a petroleum release, and the evaluation of a request to include all petroleum tanks at the site on the MPF license. With regard to the last item, the NYSDEC agreed, after reviewing prior documentation, that all tanks need not be included on the license.

3.8.5 CHEMICAL BULK STORAGE

All underground tanks, and all aboveground tanks larger than 185 gallons that store specific chemical substances listed in 6NYCRR Part 597 must be registered with NYSDEC. BNL's registration was renewed in July 1999. Nine tanks used for the storage of sodium hypochlorite for potable water treatment were added to this registration in 1999. In total, BNL has 18 registered tanks: 16 aboveground tanks storing water treatment chemicals (for cooling towers, wastewater, or potable water treatment) and two for storing gallium trichloride used in neutrino experiments. The tanks range in size from 475 to 2,000 gallons. In 1999, to conform with bulk storage requirements, secondary containment trays were installed at each storage facility for off-loading operations. These trays, in conjunction with standardized procedures, provide containment in the event of a leak or hose failure during the filling of tanks.

3.8.6 SUFFOLK COUNTY SANITARY CODE ARTICLE 12

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

There are 516 BNL storage facilities listed in the Suffolk County tanks database. Another 48 CERCLA tanks are not regulated under Article 12. The database lists active as well as inactive storage tanks, and tanks of unknown status (e.g., whether removed or existing). Storage facilities listed in the database include facilities storing fuel (some of which are also regulated under the MPF license), wastewater, chemicals, and facilities needed to support radiological research.

As of the end of 1999, 70 of the tanks listed in the Suffolk County database fully conformed with all Article 12 administrative, maintenance, and technical requirements. Approximately 374 of the other tanks require administrative corrective actions (e.g., corrected registrations, submittal of as-built design plans to SCDHS, proper labeling, etc.) or maintenance (e.g., replacement of light bulbs). Less than one-quarter of these facilities were found to be in technical nonconformance with Article 12 requirements (e.g., no secondary containment, high-level detection). BNL is working with SCDHS to establish an acceptable plan to upgrade or close these storage facilities.

BNL has an ongoing program to upgrade and/or replace existing facilities to conform with Article 12 requirements. During 1999, significant efforts were expended to address many of the administrative nonconformances such as tank labeling and tank "registrations." In November 1999 registration documents were submitted for 110 storage facilities, and all tanks were inspected for proper labeling. Plans for upgrades to nine former drum storage areas located at cooling tower treatment stations were also submitted for review. Upgrades of the HFBR piping systems were completed and approved by the SCDHS. Upgrades to achieve full conformance to Article 12 requirements will continue through 2003.

3.9 RESOURCE CONSERVATION AND RECOVERY ACT (RCRA)

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 "cradle to grave," or from the point of generation to final disposal. In New York State, the RCRA program is delegated to NYSDEC by EPA, which still maintains an oversight role. BNL is considered a large quantity generator, and also has a RCRA permit to store hazardous wastes for one year prior to offsite shipment for treatment and disposal. As noted in Chapter 2, BNL has a number of 90-day storage and satellite accumulation areas. During 1999, BNL was inspected by NYSDEC for compliance with the hazardous waste requirements and was not cited for any violations. Some compliance issues were noted during BNL internal assessments, and all were documented and promptly corrected.

On March 29, 1999, NYSDEC issued a consent order for violations of state hazardous waste requirements discovered during the 1998 annual inspection. Three violations were noted: a missing land disposal restriction code on a manifest, missing communication device at a 90-day storage area, and late submittal of closure certificate for the former waste management facility. All violations were immediately corrected. A penalty of $2,250.00 was assessed by NYSDEC and paid by Brookhaven Science Associates. Additionally, in 1999, BNL continued negotiation of the EPA consent order issued in 1997. The order was finalized and an administrative penalty of $17,500.00 paid.

3.9.1 RCRA/TOXIC SUBSTANCES CONTROL ACT (TSCA) WASTE MORATORIUM

On May 17, 1991 DOE instituted a waste moratorium directing all DOE facilities to cease offsite shipments of RCRA/TSCA-regulated wastes that originated in radiologically-controlled areas. To address this DOE-wide issue, BNL developed a DOE-approved waste certification program for all nonradioactive RCRA/ TSCA wastes generated by BNL. The program uses process knowledge, analytical procedures, and standard survey techniques to ensure RCRA/TSCA wastes shipped offsite to nonradioactive disposal facilities are free from radioactivity. Generators of waste are required to document and certify all results associated with the program. The moratorium was fully lifted by DOE in 1995 when BNL received final approval of its waste certification program.

3.9.2 FEDERAL FACILITIES COMPLIANCE ACT (FFCA) SITE TREATMENT PLAN FOR MIXED WASTE

Mixed wastes are wastes that are both hazardous (under RCRA) and radioactive. The FFCA, issued in 1992, requires DOE to work with local regulators to develop a site treatment plan to manage mixed waste. Development of the plan had two purposes: (1) to identify available treatment technologies and disposal facilities (DOE or commercial) able to manage mixed waste produced at federal facilities; and (2) to develop a schedule for treatment and disposal of these waste streams.

BNL updates its Site Treatment Plan annually and submits it to NYSDEC. The update documents the current mixed waste inventory, and describes efforts BNL has undertaken to seek new commercial treatment and disposal outlets for various waste streams. One initiative that BNL has supported is DOE's Broad Spectrum Procurement. This initiative provides DOE facilities with a mechanism to treat small quantities of mixed waste that might not normally meet treatment facility minimum volume requirements. Treatment and disposal outlets approved under the Broad Spectrum Procurement are available for use throughout the DOE complex.

3.10 TOXIC SUBSTANCE CONTROL ACT (TSCA)

The storage, handling, and use of PCBs (Polychlorinated Biphenyls) are regulated under the Toxic Substances Control Act. All equipment containing PCBs must be inventoried, with the exception of small capacitors (less than 3 lbs.) and items where the concentration of the PCB source material is less than 50 ppm. This inventory is updated by July 1st of each year. Capacitors manufactured prior to 1970 that are believed to be oil filled, but where the existence of PCBs cannot be verified through an investigation of manufacturer's records, are handled as if they contain PCBs. All PCB articles and/or PCB-contaminated equipment must be labeled. BNL responds to any PCB spill in accordance with emergency response procedures. BNL was in compliance with TSCA requirements in 1999.

BNL maintains an EPA authorization to conduct research using PCBs. A statement regarding the status of this research is reported to EPA annually. There was no research conducted in 1999.

3.11 FEDERAL INSECTICIDE FUNGICIDE AND RODENTICIDE ACT (FIFRA)

BNL is in full compliance with FIFRA requirements. Pesticide storage and application is regulated under FIFRA. (Note: Pesticides include herbicides.) Most 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). Pesticides are also applied to agricultural research fields onsite. Pesticide use is minimized wherever possible (e.g., through spot treatment of weeds). All pesticides are applied by New York State-certified applicators. By February 1, each applicator files an annual report with NYSDEC detailing pesticide use for the previous year.

3.12 FLOODPLAINS/WETLANDS AND WILD AND SCENIC RECREATIONAL RIVERS AND OTHER SPECIAL 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 as either scenic or recreational under the Wild, Scenic and Recreational River System Act by NYSDEC. BNL also has six major areas regulated as wetlands and a number of vernal (seasonal) pools onsite. Construction and/or modification activities performed within these areas require permits from the NYSDEC.

Activities that could require review under these natural resource programs are identified during the NEPA process. 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 impact 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.

Two activities were continued in 1999 that required special permits. The first project was the construction of pumping stations for conveying sanitary waste and stormwater from RHIC facilities to the central collection system. While the majority of the construction was completed in 1998, a modification to the permit was requested in 1999 to permit the construction of a pump station at the eight o'clock station. This modification was approved and the pump station installed. The second project involved the installation of a geomembrane and soil shielding at the RHIC ten o'clock station. This application was approved in April 1999 and the construction was completed. To address other projects within the Peconic River corridor, a meeting was held with NYSDEC to review upcoming projects and regulatory requirements. During this meeting, plans for installing security fences, sewers and stormwater drainage systems, and vertical drainage wells for relieving hydrostatic pressures at RHIC were discussed. The NYSDEC expressed interest in seeing plans and specifications for all projects falling within one-half mile of the Peconic River.

3.13 ENDANGERED SPECIES

In 1999, NYSDEC revised its list of endangered, threatened, and 'species of special concern.' The tiger salamander (*Ambystoma tigrinum tigrinum*) is the only state endangered species found at BNL. Tiger salamanders are listed in New York State as endangered because populations have declined as a result of loss of habitat through development, road mortality during breeding migration, introduction of predatory fish into breeding sites, historical collection for bait and pet trade, water level fluctuations, pollution, and general disturbance of breeding sites. BNL has prepared a Wildlife Management Plan to formalize the strategy and actions needed to protect the 13 confirmed tiger salamander breeding locations onsite. The strategy includes identifying and mapping habitats, monitoring, improving breeding sites, and controlling activities that could impact breeding.

The banded sunfish (*Enneacanthus obesus*) is found in the Peconic River onsite at BNL. The banded sunfish is listed as a state threatened species within New York State. The reason for this status is that the only remaining population of the banded sunfish is located on eastern Long Island. Measures being taken by BNL to protect the banded sunfish and its habitat include

- eliminating, reducing, or controlling pollutant discharges;
- upgrading the STP to reduce nitrogen loading in the Peconic (completed in 1998);
- monitoring populations and water quality;
- maintaining adequate flow in the river and creating deep pools to enable the fish to survive drought;
- controlling disturbances; and
- culling predator species during sampling activities.

BNL also has eight species onsite that are listed as 'species of special concern.' 'Species of special concern' have no protection under the state endangered species laws, but may be protected under other state and federal laws (i.e., Migratory Bird Treaty Act). However, the state monitors 'species of special concern' and manages their populations and habitats, where practical, to ensure that they do not become threatened or endangered. Those 'species of special concern' found at BNL include the marbled salamander (*Ambystoma opacum*), spotted turtle (*Clemmys guttata*), eastern box turtle (*Terrapene carolina*), eastern hognosed snake (*Heterodon platyrhinos*), horned lark (*Eremophila alpestris*), whip-poor-will (*Caprimulgus vociferus*), vesper sparrow (*Pooecetes gramineus*), and grasshopper sparrow (*Ammodramus savannarum*). 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 onsite. The eastern hognosed snake has only been seen onsite once, in 1994 (LMS 1995). BNL will be evaluating bird populations as part of the management strategy outlined in the Wildlife Management Plan. Data concerning 'species of special concern' will be used appropriately in making management decisions regarding those species. In addition to the above bird species, 19 other bird species listed as 'species of special concern' and two federally threatened species have been observed onsite or flying over the site during spring and fall migrations.

BNL has 17 plant species protected under state law. One is a threatened plant, stiff goldenrod (*Solidago rigida*), and one is a rare plant, narrow-leafed bush clover (*Lespedeza augustifolia*). The other 15 species are considered to be 'exploitably vulnerable' which means that they may become threatened or endangered if causal factors resulting in population declines continue. These plants are currently protected on BNL due to the large areas of undeveloped pine barrens habitat onsite. Locations of these rare plants must be determined, populations estimated and management requirements established. Management of protected plants will be included in the future revisions of the Wildlife Management Plan. 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 at least nine occasions in 1999. These inspections are summarized below. BNL also has a comprehensive self assessment program as described in section 2.2.1 of Chapter 2. As of 1998, the SCDHS has had two staff members residing at BNL. Personnel from the SCDHS perform routine inspections of facilities and inspect storage facility removals and installations as part of their everyday activities.

3.14.1 INSPECTIONS BY REGULATORY AGENCIES

- *Hazardous Waste*. NYSDEC conducted a RCRA/hazardous waste compliance inspection in June-July 1999. No deficiencies were noted.
- *Air Compliance*. NYSDEC conducted an annual inspection of the Central Steam Facility in March 1999. Additionally, the EPA conducted a quality assurance (QA) review of the Central Steam Facility in August 1999. The EPA found the BNL QA program to be complete and commended the Laboratory for its QA practices. There were no findings or issues identified during either of these inspections.
- *Potable Water*. SCDHS conducts annual inspections of the BNL potable water system to collect samples and ensure that facilities are maintained. There were no findings in 1999, and all sample results were below drinking water standards, except for iron, which is naturally occurring. As noted in section 3.7.1, BNL treats the drinking water supply prior to consumption to remove iron.
- *Sewage Treatment Plant (STP).* SCDHS conducts quarterly inspections of the BNL STP. In 1999 there were no performance or operational issues associated with the treatment plant itself. SCDHS deficiencies included an inoperable high-level alarm and some minor painting needed for a fuel storage tank. All deficiencies were immediately corrected.
- *Major Petroleum Facility (MPF).* The MPF is inspected annually by NYSDEC. There were four minor issues identified during this inspection that required corrective actions. All were mitigated within 30 days of the official written notification.

3.14.2 DEPARTMENT OF ENERGY (DOE): DOE-HEADQUARTERS, CHICAGO, AND BROOKHAVEN GROUP OFFICE (BHG)

DOE Headquarters: DOE Headquarters conducted an Integrated Safety Management Evaluation in 1999. The follow-up review focused on the adequacy of current integrated management systems and the adequacy of the efforts to develop safety management systems necessary to meet the DOE requirements. They noted that the DOE Office of Science, BHG, and BNL had demonstrated a commitment to implementing integrated safety management and had made significant improvements to the Laboratory's environment, safety and health management systems. Particular improvements included clarification of roles, responsibilities, authorities, and accountabilities; balanced priorities; and BHG oversight capabilities.

DOE Brookhaven Group Office: The DOE BHG continued to strengthen their oversight program during 1999 and conducted compliance assessments of the following environment programs: NESHAPs, RCRA, chemical safety, sealed sources, and emergency exercises. Several concerns, areas for improvement, and/or program inadequacies were identified during these assessments. Corrective action plans were prepared and are being implemented for each of the concerns or weaknesses identified.

3.14.3 ENFORCEMENT ACTIONS AND MOA'S

In 1999, the NYSDEC issued a consent order to BNL for violations of RCRA requirements discovered during the 1998 annual inspection. The order cited three issues of non-compliance: (1) untimely submittal of closure documentation for the former hazardous waste management facility, (2) missing land disposal restriction codes in a manifest, and (3) a missing communication device at a 90-day storage area. The order assessed a penalty of $2,250.00 against BNL. All issues were corrected and the fee paid in 1999. In 1997, EPA proposed a Consent Order with a proposed penalty as a result of a multi-media compliance inspection conducted in 1997. Negotiations on the terms of this Order continued in 1999 and the Order was finalized in 1999. Also in 1999, the pro-

Table 3-10. 1999 Status of Existing Agreements and Enforcement Actions Issued to BNL.

Number	Title	Parties	Effective Date	Status
C1-8975-03-99	Consent Order	NYSDEC and BNL	3/24/99	NYSDEC cited BNL two administrative and one technical noncompliances with hazardous waste regulations. They were: late submittal of a closure certificate for the former Hazardous Waste Management Facility, a missing land disposal restriction code on a manifest, and the unavailability of a communication device in a 90-day storage area. All deficiencies were corrected and a penalty of $2,250.00 was paid to NYSDEC.
Not Applicable	Federal Facilities Compliance Agreement (FFCA) on mixed waste	NYSDEC and DOE	1992	The FFCA requires that a site treatment plan to manage mixed wastes be written and updated annually. BNL is in compliance with this requirement.
Docket No. II-RCRA-98-0202	EPA Administrative Order Resource Conservation and Recovery Act	DOE and EPA	02/25/98	As a result of negotiations between EPA and BNL representatives (specifically DOE and Associated Universities, Inc.), BNL agreed to conduct several Supplemental Environmental Projects (SEPs) to settle the complaint. The SEPs were initiated in 1998. In 1999 the Order was finalized and settled. An administrative penalty of $17,500.00 was paid to EPA.
Index No. 113-98-0	Compliance Order — Clean Air Act	EPA and DOE	02/24/98	BNL, DOE, and EPA met in May 1998 to review and clarify the issues presented in this Order. Documentation necessary to support Laboratory operations was submitted to the EPA prior to the issuance of the Order. There was no further activity in 1999.
Not Applicable	Notice of Noncompliance — Toxic Substances Control Act	EPA and DOE	02/12/98	All required information was submitted to EPA on 10/6/98; The Waste Management Division implemented a revised Hazardous Waste Control Form in 1999. There was no additional activity regarding this Notice in 1999.
Docket No. UIC-AO-98-01	Administrative Order on Consent - Safe Drinking Water Act	EPA and DOE	3/4/98	A meeting was held with the EPA in May 1998 to review the Order, associated deliverables and an application for an Area Permit that was filed in December 1997. A second meeting was held in March 1999 to finalize deliverables. This Order was finalized in September 1999. All corrective measures were completed by September 30, 1999.
I-CERCLA-FFA-00201	Federal Facility Agreement under the Comprehensive Environmental Response, Compensation and Liability Act 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 Comprehensive Environmental Response, Compensation and Liability Act, Resource Conservation and Recovery Act, and the National Environmental Policy Act . All IAG scheduled milestones were met in 1999.
Not Applicable	Suffolk County Agreement	SCDHS, DOE, and BNL	Originally signed on 9/23/87	This Agreement was formalized to ensure that the storage and handling of toxic and hazardous materials at BNL is consistent with the technical requirements of Suffolk County codes.
Not Applicable	Memorandum of Agreement (MOA) by and between the U.S. Environmental Protection Agency and the U.S. Department of Energy	EPA and DOE	03/23/98	BNL is currently in full compliance with the terms of the MOA. Phase I of the MOA covered the EPA multimedia inspection. Phase II required an evaluation of processes, and Phase III required implementation of an Environmental Management System and first year of audits. See Chapter 2 for further discussion.

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

posed Administrative Order on UIC compliance was finalized and a schedule for submitting a UIC Area Permit application formalized. No other issues were identified by the EPA in 1999.

EPA and DOE signed a voluntary MOA on March 23, 1998. (See Chapter 2 for a discussion of the MOA.) During 1999, BNL continues to be in full compliance with the terms of the MOA.

All existing enforcement actions and Memorandums of Agreement are listed in Table 3-10, along with a summary of their status.

REFERENCES

DOE Order 5400.5. 1990. *Radiation Protection of the Public and the Environment.* U.S. Department of Energy, Washington, D.C. Change 2: 1-7-93.

Lawler, Matusky, & Skelly Engineers (LMS). 1995. *Phase II Sitewide Biological Inventory Report.* Prepared for the Office of Environmental Restoration, Brookhaven National Laboratory, Upton, New York.

CHAPTER 4

Air Quality

Brookhaven National Laboratory performs continuous emissions sampling at several facilities to ensure compliance with requirements of the Clean Air Act. In addition to facility emission monitoring, environmental air sampling is conducted to verify local air quality. Information regarding radiological and regulated, nonradiological air releases for 1999 is presented in this chapter. Ambient radiological air quality data collected at various onsite locations are also discussed.

In 1999, the Brookhaven Medical Research Reactor, the High Flux Beam Reactor, and the Brookhaven Linac Isotope Producer were the most significant contributors to the site's radiological air emissions. Total radionuclide emissions were consistent with those of recent years. Over the course of 1999, a total of 1,672 Ci (62 TBq) of airborne radioactive material was released from these facilities. Gaseous argon-41 (a short-lived radionuclide) from the Brookhaven Medical Research Reactor accounted for 98 percent of this total.

Natural gas has been the predominant fuel burned at the Central Steam Facility since three boilers were converted to dual-fuel (oil/natural gas) firing capability in 1997. As a result of the conversion, facility emissions of particulate matter, nitrogen oxides (NO_X), and sulfur dioxide (SO_2) have declined by 8.9 tons, 51.4 tons, and 92.3 tons, respectively, relative to 1996 levels.

4.1 RADIOLOGICAL AIRBORNE EMISSIONS

Federal air quality laws and U.S. DOE regulations governing the release of airborne radioactive material include 40 CFR 61 Subpart H (the National Air Emission Standards for Hazardous Air Pollutants or NESHAPs), and DOE Orders 5400.1, *General Environmental Protection Program* (1989) and 5400.5, *Radiation Protection of the Public and the Environment* (1990). Under NESHAPs Subpart H, a section of the federal Clean Air Act (CAA), facilities whose emissions have the potential to deliver a radiation dose of greater than 0.1 mrem/year (1 µSv/year) to a member of the public must be continuously monitored. There are five facilities that fall into this category (see sections 4.1.1-4.1.5 below). Figure 4-1 indicates the location of each of the monitored facilities within the BNL site. Facilities which fall below this value require only periodic, confirmatory monitoring. Annual emissions are discussed in the following sections. The associated dose calculations are presented in Chapter 8.

4.1.1 BROOKHAVEN MEDICAL RESEARCH REACTOR (BMRR)

The BMRR is fueled with enriched uranium, moderated and cooled by light water, and is operated intermittently at power levels up to 3 megawatts (MW) (thermal). To cool the neutron reflector surrounding the core of the BMRR reactor vessel, air from the interior of the containment building is used. When air is drawn through the reflector, it is exposed to a neutron field that causes the argon component

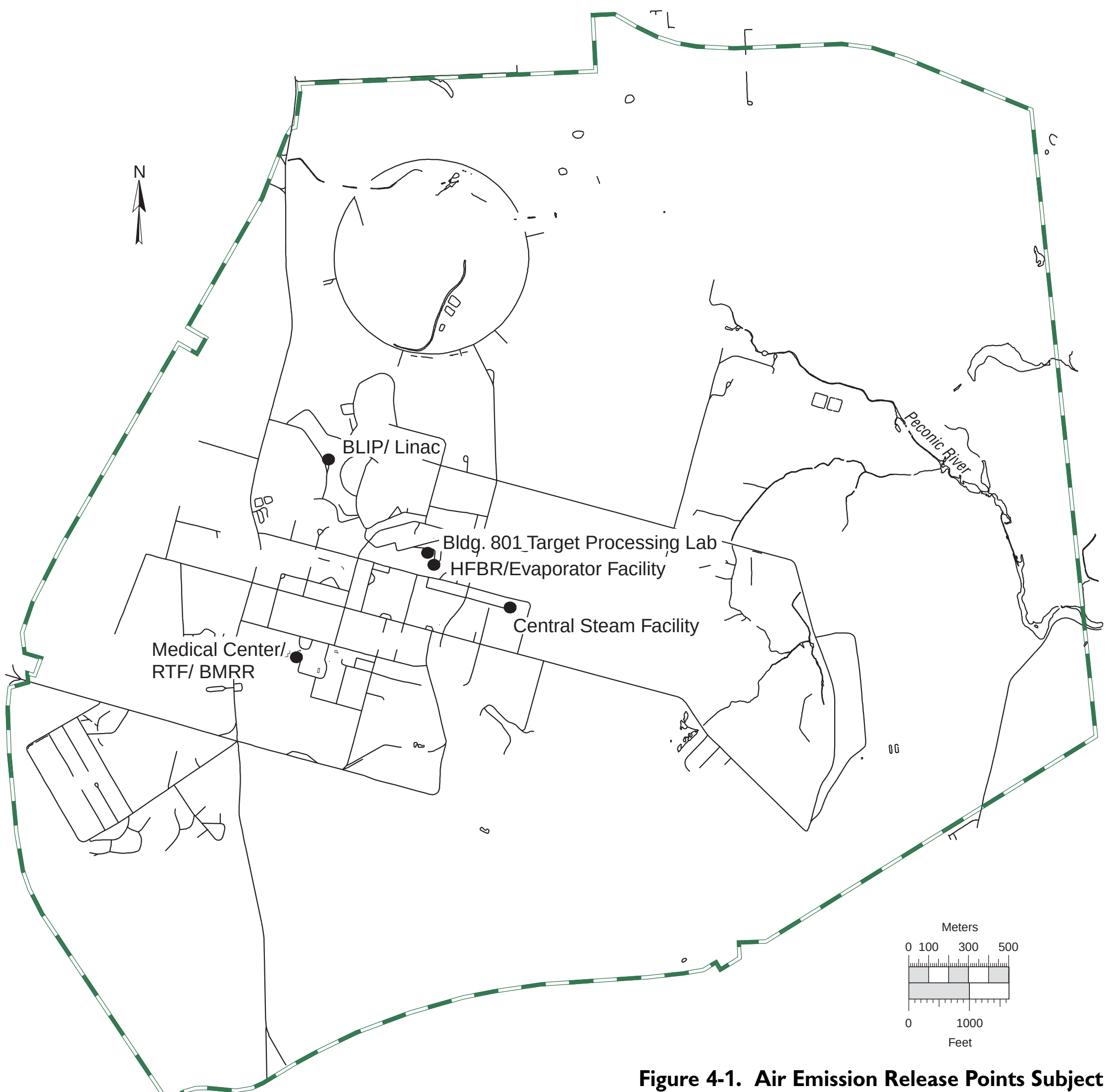


Figure 4-1. Air Emission Release Points Subject to Continuous Monitoring.

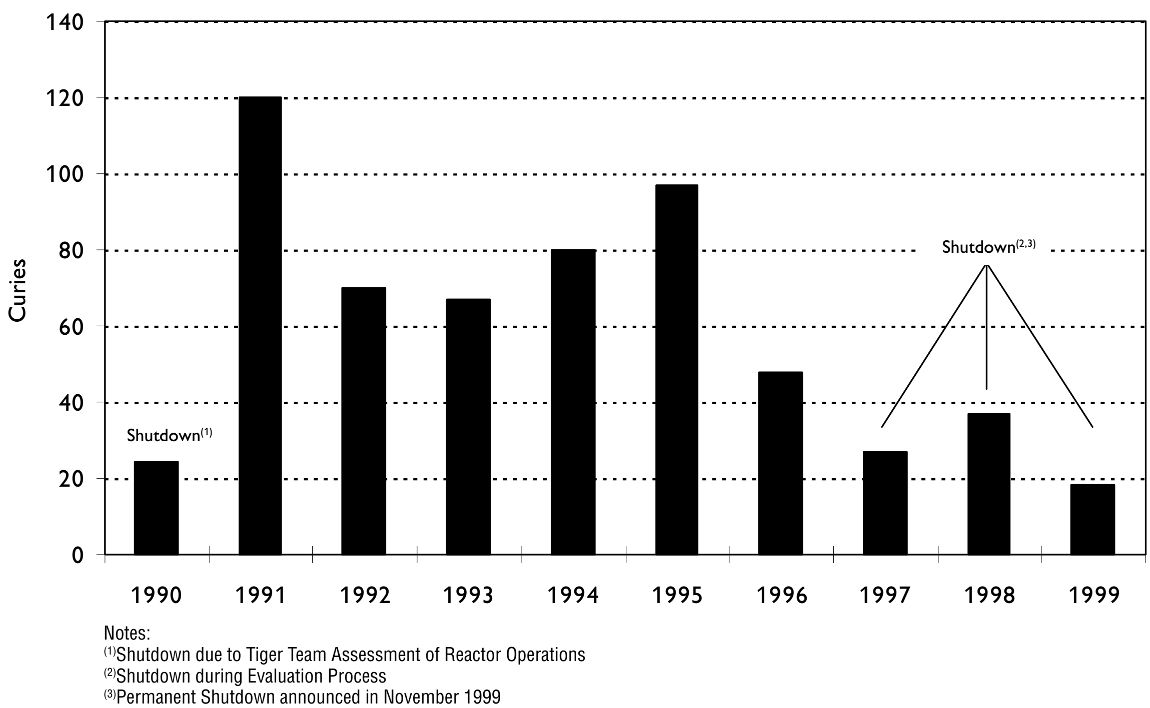
of the air to become radioactive. This radioactive form is known as argon-41. It is a chemically inert gas with a short half-life ($t_{1/2}$) of 1.8 hours. After passage through the reflector, the air is routed through a roughing filter and a high efficiency particulate air (HEPA) filter to remove any particulate matter, and finally, a charcoal filter for the removal of radioiodines produced by the fissioning of fuel. Following filtration, the air is exhausted to a 150-foot stack adjacent to the reactor containment building.

A real-time monitor is in place to track argon-41 air emissions, while passive filter media are used to collect and quantify radioiodines and particulates. Because non-argon radionuclide concentrations in the air emissions are of a much lower concentration and total activity, they contribute less than 10 percent of the total public dose resulting from the BMRR's air emissions. In accordance with NESHAPs, these radionuclides are sampled on a periodic basis to confirm that their concentrations remain consistent with expected levels.

In 1999 the BMRR released 1,640 Ci (61 TBq) of argon-41 to the atmosphere. This value is consistent with this facility's emissions totals for previous years. Argon-41 consistently constitutes the greatest fraction of all radionuclide activity released from the BNL site.

4.1.2 HIGH FLUX BEAM REACTOR (HFBR)

Following the discovery of an underground plume of tritium emanating from the spent fuel storage pool, the HFBR was in a stand-by mode from January 1997 until November 1999, when DOE announced that it would be permanently shut down. The storage pool was drained in December 1997 to prevent additional leakage as well as to facilitate repairs. When the HFBR was operational, it used heavy water as a neutron moderator and fuel coolant. (Heavy water, or D_2O, is water that is 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 ($t_{1/2}$ = 12.3 years). In a shut-down mode, tritium continues to be released from the HFBR even though the reactor vessel has been de-fueled because the vessel and associated cooling loops remain filled with heavy water. Tritiated water vapor (abbreviated HTO) is released from the vessel and associated piping systems via diffusion at valve seals and other system penetrations



Notes:
(1)Shutdown due to Tiger Team Assessment of Reactor Operations
(2)Shutdown during Evaluation Process
(3)Permanent Shutdown announced in November 1999

Figure 4-2. HFBR Airborne Tritium Emissions, Ten Year Trend.

to building air where it is routed to the facility's 320-ft stack. Concentrations of HTO in air emissions are determined by the use of an integrating silica gel absorbent. In 1999, 18 Ci (0.7 TBq) of airborne HTO were released from the HFBR (see trend plot shown in Figure 4-2).

4.1.3 BROOKHAVEN LINAC ISOTOPE PRODUCER (BLIP)

Protons from the Linear Accelerator (LINAC) are sent via an underground beam tunnel to the BLIP where they strike various target metals (see Figure 4-3). These metals, which become activated by the proton beam, are then transferred to the Building 801 Target Processing Laboratory for later use in radio-pharmaceutical production. During irradiation, the targets are cooled by a continuously recirculating water system. Several radioisotopes are produced in the cooling water; the most significant of which is gaseous oxygen-15, a radionuclide with a very short half-life of 123 seconds. This isotope is released as an airborne emission.

In 1999, the operation of the BLIP was limited to the months of January and December. During this period, a total of 12 Ci (0.5 TBq) of oxygen-15 was released as an airborne emission. Other radionuclides such as tritium and beryllium-7 were released in much smaller quantities. See Table 4-1 for a complete listing.

4.1.4 EVAPORATOR FACILITY

The Building 802b Evaporator Facility was constructed to reduce the total amount of tritiated water released to the Peconic River from BNL operations. Wastewater processing began in 1995.

Figure 4-3. Brookhaven LINAC Isotope Producer (BLIP).

Table 4-1. Airborne Radionuclide Releases from Monitored Facilities in 1999.

Facility	Nuclide	Half-life	Ci Released
BMRR	Ar-41[(1)]	1.8 h	1.64E+03
Bldg. 801 Target Processing Laboratory	Co-60	5.2 y	8.90E-07
	Rb-86	18.6 d	1.38E-05
	Se-75	120 d	1.93E-05
	Ti-44	62.2 y	3.97E-07
HFBR	Zn-65	244 d	1.67E-06
	Cs-137	30 y	3.37E-08
	H-3	12.3 y	1.81E+01
BLIP	O-15	2 m	1.23E+01
	H-3	12.3 y	4.31E-02
	Be-7	53 d	5.49E-06
Evaporator Facility	Be-7	53 d	4.76E-04
	Co-56	79 d	2.99E-06
	Co-57	271 d	3.01E-05
	Co-58	71 d	1.81E-05
	Co-60	5.2 y	2.41E-05
	Cs-137	30 y	5.31E-05
	H-3	12.3 y	1.98E+00
	Mn-54	312 d	1.91E-05
	Na-22	15 d	1.35E-06
	Rb-86	18.6 d	8.57E-05
	Se-75	120 d	2.13E-06
	Zn-65	244 d	4.44E-04

Notes:
See Figure 4-1for facility locations
Half-life abbreviations: m = minutes h = hours d = days y = years
Ci = 3.7E+10 Bq.
BMRR=Brookhaven Medical Research Reactor
HFBR=High Flux Beam Reactor
BLIP=Brookhaven LINAC Isotope Producer
(1) While other nuclides are released from the BMRR, none contribute > 10% of the total public dose due to BMRR air emissions. See text for discussion.

Liquid waste generated onsite that contains residual radiological material is accumulated at the Building 811 Waste Concentration Facility (WCF). At the WCF, suspended solids and a high percentage of radionuclides are removed from the liquid using a reverse osmosis process. However, because of its chemical properties, tritium is not removed. The tritiated water which remains following waste concentration is delivered to the Evaporator Facility in Building 802b where it is converted to steam and released as an airborne emission. This method is preferable to release via surface water because (1) there is virtually no potential to influence the groundwater aquifer, and (2) the potential for this tritium to contribute to an offsite dose is minimized by atmospheric dispersion. The emission is directed to the same stack used by the HFBR for building air exhaust.

In 1999, 2 Ci (73 GBq) of HTO were released as an airborne emission from the Evaporator Facility. Since the waste concentration process does not remove all other radionuclides with complete efficiency, radionuclides other than tritium are released at much lower activity levels (see Table 4-1 for a listing). The activity values listed in the table are estimated since facility emissions are tracked using an inventory system. Liquid shipments to the Evaporator Facility are sampled and analyzed prior to delivery to determine actual radionuclide concentrations. The total emissions for a water tanker delivery are calculated by computing the product of the radionuclide concentrations and the total volume of water evaporated. This method is very conservative since some fraction of the chemically reactive radionuclides bind to the interior surfaces of the boiler system; hence, airborne releases and projected doses from this facility are most likely overestimated.

4.1.5 BUILDING 801 TARGET PROCESSING LABORATORY

Target metals irradiated at the BLIP facility are transported to the Building 801 Target Processing Laboratory where the useful isotopes are chemically extracted for radiopharmaceutical production. Airborne radionuclides released during the extraction process are drawn through multi-stage HEPA and charcoal filters and then vented to the HFBR stack (see Table 4-1 for isotopes and quantities). Radionuclide quantities released from this facility annually are small, typically in the microcurie range. Isotopes released to the atmosphere from Building 801 operations are not significant contributors to the site perimeter dose via the airborne pathway (less than one percent).

4.1.6 ADDITIONAL MINOR SOURCES

There are several research departments within BNL conducting work which involves very small quantities of radioactive materials (in the microcurie to millicurie range). Typically, fume hoods designated for use with radioactive materials are used. Operations such as transferring material between containers, pipetting, and chemical compound labeling are typical of the work conducted within the hoods. Due to the use of filters, the nature of the work conducted, and the small quantities involved, these operations have a very low potential for atmospheric release of any environmentally significant quantity of radioactive material. Compliance with NESHAPs is demonstrated through the use of an inventory system that allows an upper estimate of potential releases to be calculated. Facilities which demonstrate compliance in this way include buildings 463, 555, 318, 490, 490A, 703W and 830. A wide range of research operations are hosted in these buildings including work in the fields of biology, chemistry, medicine, applied science, and advanced technology.

4.1.7 PREVIOUSLY UNCHARACTERIZED RADIOLOGICAL AIR EMISSION SOURCES EVALUATED IN 1999

A number of new Environmental Restoration Program operations and other key facility processes which produce radiological air emissions were evaluated in 1999. Since all environmental restoration activities covered under CERCLA must conform to the substantive requirements of NESHAPS Subpart H, those activities with the potential to emit radiological emissions were assessed for dose potential. The CAP88-PC dose modeling program was used to estimate the maximum public dose which could be associated with these activities (see Chapter 8 for more information on this program). This modeling program is explicitly designed to model continuous airborne radiological emissions which occur over the course of a single year, and is not well suited for estimating short-term or acute releases such as those found with the environmental restoration activities. Given this limitation, these evaluations treat these potential emission sources as if they were continuous annual sources that do not end with the cessation of environmental restoration activities. The conclusions of the assessments are discussed below.

4.1.7.1 BUILDING 811 TANK REMEDIATION

This environmental restoration activity included the removal, processing, packaging, transportation, and disposal of radioactively contaminated sludge from underground storage tanks and diatomaceous earth lab pack waste from Building 811. The effective dose equivalent to the maximally exposed individual was estimated at 4.09E-2 millirem per year by the CAP88-PC modeling program.

During the operation, a localized ambient air sampling program was instituted to quantify actual rather than estimated emissions. The results of this sampling program consistently reported the activity from gamma-emitting isotopes as much lower than the conservatively estimated source terms used in the CAP-88 modeling program. Gross alpha and gross beta activities are not used by the CAP88-PC program in estimating effective dose equivalent, however, they were used in this instance as part of a screening mechanism to demonstrate that the concentrations near a potential receptor would not be detectable.

Air sampling within the tent (a HEPA ventilated enclosure erected above the work area) showed average gross alpha and beta activity concentrations of 2.6 and 114 pCi/m^3, respectively. Background concentrations of airborne gross alpha activity are usually less than 0.002 pCi/m^3 (7.4 E-5 Bq/m^3), while airborne beta activity from naturally-occurring radionuclides is typically between 0.005 and 0.02 pCi/m^3. When the particulate removal efficiency of the HEPA filters (99.99 percent) is taken into consideration, the gross activity concentrations outside of the tent due to the tank removal work would be measurably lower than the monitoring system's minimum detection limit (MDL), confirming that this work did not constitute a source of public exposure approaching the NESHAPs Subpart H limit.

4.1.7.2 BUILDING 830 RADIOACTIVE TANK SIZING OPERATION

Sludge from two tanks previously used for radioactive waste storage was removed and the tanks were cut into pieces small enough to fit within waste shipment containers. Since the cutting operations had the potential to generate airborne radionuclides, this work was performed within a tent enclosure. The tent was serviced by two HEPA filtration units, which exhausted external to the enclosure to minimize airborne radioactivity within the work area. It was estimated that 0.07 pounds of the total 3.5 pounds of residual sludge was available for release in each tank. Analysis of the sludge reported strontium-90, thorium-228 and 230, cesium-137, cobalt-60, and americium-241 in the microcurie per gram range. The effective dose equivalent to the maximally exposed individual resulting from this waste tank sizing operation was estimated at 9.15E-9 millirem per year by the CAP88-PC modeling program. This is a statistically insignificant value.

4.1.7.3 POSITRON EMISSION TOMOGRAPHY (PET) CARBON-11 RELEASE

Positron Emission Tomography (PET) is a technology that measures metabolism in the brain, thereby providing images that reflect the functioning of a subject's brain. To visually document changes in the brain, a PET research subject is injected with a short-lived radioactive isotope that is attached to one of a number of compounds that bind to specific brain sites. The amount of radiotracer is similar to that administered in nuclear medicine procedures. The radiotracer emits energy that is recorded by detectors in the PET instrument, which signal the location and concentration to a computer. The computer translates these data into an image of brain activity as the brain actually functions.

In 1999, a one-time-only release of carbon-11, resulting from the synthesis of 10 millicuries of carbon-11 methyl iodine in preparation of positron emission tomography, was evaluated for compliance with the NESHAP air emission standards prior to release. These emissions were released from the Building 491 (BMRR) stack. Under conservative assumptions, the effective dose equivalent to the maximally exposed individual was estimated at 4.0 E-7 millirem per year by the CAP88-PC modeling program, which is a statistically insignificant value.

4.1.7.4 CHEMICAL/ANIMAL AND GLASS HOLES PIT REMEDIATION

The chemical/animal pits were used for the disposal of chemical containers, glassware, and animal carcasses from the late 1950s to 1966, while the glass holes pit was used for the disposal of laboratory glassware and chemical containers from 1966 to 1981. Debris recovered from these areas after the environmental restoration contractors completed excavation activities included numerous plastic, metal, glass, and wood items. During 1999, a hopper conveyor system that fed into a shredder was used to further characterize the debris, reduce the volume of debris, package the debris, and to ensure that processed materials transported for offsite disposal met the disposal facility's acceptance criteria. Potential radiological contaminants in the debris included americium-241, cesium-137, and europium isotopes 152, 154, and 155. This operation did not have a dedicated ventilation system, precluding applicability of the CAP88-PC modeling program.

During the operation, a localized ambient air sampling program was instituted to quantify actual rather than estimated emissions. The results of this sampling program consistently showed activity from gamma-emitting isotopes in concentrations of pico-curies per cubic meter. At these levels, the dose was negligible in comparison to the dose limit of 10 millirem per year established under NESHAPs.

Gross alpha and gross beta measurements were used in this instance as part of a screening mechanism to demonstrate that the concentrations near a potential receptor would not be detectable. Ambient air sampling from the immediate work area showed average gross alpha and beta activity concentrations of 0.075 and 0.86 pCi/m^3, respectively. Background concentrations of airborne gross alpha activity are usually less than 0.002 pCi/m^3 (7.4 E-5 Bq/m^3), while airborne beta activity from naturally occurring radionuclides is typically between 0.005 and 0.02 pCi/m^3. Average gross alpha and gross beta activity concentrations were measurably lower than the monitoring system's MDLs but still higher than typical background concentrations.

4.1.7.5 BGRR PILE FAN SUMP REMOVAL AND FAN HOUSE DECONTAMINATION

The BGRR operated from 1950 to 1969 producing neutrons for scientific research. The BGRR decommissioning project, which commenced in 1999, is removing or isolating areas of the BGRR facility that contain hazardous materials and/or radioactive contamination to reduce any potential risk to public health, workers, and the environment. BGRR environmental restoration activities in 1999 included the removal of a concrete sump and its associated piping, and the remediation of the surrounding soils. Primary cooling fans numbers 1 through 5 and secondary and auxiliary fans were also removed. In addition, related remediation work inside the reactor building was initiated.

Radionuclides present in the source term inventory included tritium; cobalt-60; europium-152, 154, and 155; yttrium-90; strontium-90; cesium-137; uranium-233, 234, 235, and 238; neptunium-237; plutonium-238, 239, 240, and 241; americium-241. The CAP88-PC model was used, and it was determined that this remedial action project would result in a hypothetical maximally exposed individual receiving less than 3.0 E -04 millirem per year from these activities.

Actual airborne emissions were quantified through a localized air sampling program during the course of the operations. The results of this sampling program consistently reported the activity from gamma-emitting isotopes as much lower than the conservatively estimated source terms used in the CAP88-PC modeling program.

Gross alpha and gross beta activities are not used by the CAP88-PC program in estimating effective dose equivalent, however, they were used in this instance as part of a screening mechanism to demonstrate that the concentration near a potential receptor would not be detectable.

The ambient air sampling from the immediate work area reported an average gross alpha activity concentration of 0.034 pCi/m^3 (1.26 E-3 Bq/m^3) and an average gross beta activity concentration of 0.078 pCi/m^3 (2.89E-3 Bq/m^3). These results are slightly higher than the respective average MDLs of 7.12E-3 pCi/m^3 (2.63E-4 Bq/m^3) for gross alpha and 2.50E-2 pCi/m^3 (9.25E-5 Bq/m^3) for gross beta. According to 40 CFR 61 Appendix D methods for estimating radionuclide emissions to the atmosphere, a release fraction of 1E-3 may be applied to particulates released through a dedicated exhaust system. Applying this factor, the estimated gross alpha and gross beta activity concentrations to the atmosphere were 3.4.E-5 pCi/m^3 (1.2 E-6 Bq/m^3) and 7.8 E-5 pCi/m^3 (2.8E-6 Bq/m^3), respectively, or well below the MDLs.

4.1.7.6 HIGH VACUUM THERMAL DESORPTION FOR CHEMICAL HOLES PROJECT

This project involved processing mercury contaminated mixed waste recovered from the chemical holes area. The isotopes contained in the radiological component of the waste were identified as cesium-137; europium-152 and 154; plutonium-238 and 239; radium-226; thorium-232; uranium-234, 235, and 238; and americium-241. Under the most conservative assumptions, the effective dose equivalent to the maximally exposed individual was estimated at 6.54 millirem per year by the CAP88-PC modeling program. Exhaust from the thermal desorption chamber passes through a series of engineering controls before they are released to the ambient air. The controls include two water cooled impingers (two 30-gallon carbon steel vessels filled with water chilled to 35 - 45°F) to condense out mercury vapors, two in-series carbon beds to recover any residual mercury vapors, and finally, two HEPA filters to trap any particulate matter. Since the CAP88-PC modeling did not take into account the effectiveness of the engineering controls in reducing particulate emissions, environmental restoration personnel will collect ambient air samples using a continuous flow portable sampler equipped with a radionuclide filter. The samples are to be collected and analyzed for alpha, beta, and gamma radiation after the unit commences operation in January 2000.

4.1.7.7 WASTE MANAGEMENT RECLAMATION BUILDING

The Reclamation Building (Building 865) is the primary facility for handling radioactive waste materials. The building is designed to receive bulk radioactive waste of various sizes and configurations, and then to disassemble, decontaminate, reduce the volume, temporarily store, and properly package the wastes for shipment offsite. The following is a brief description of six areas or pieces of equipment that were installed to meet these functions.

- ♦*Lead Melting Area.* A lead melter capable of melting contaminated lead shielding and components is located in this area. This unit has not been placed into operation since its installation. When fully operational, molten slag which contains the bulk of contamination will be skimmed off, and the molten lead will be recast in molds for reuse as shielding blocks, provided acceptable radiation levels are achieved through the decontamination process.
- ♦*Equipment Decon Bath*. When operational, the surfaces of contaminated materials will be cleaned in the bath using non-hazardous cleaning agents. After the materials are cleaned, they will be dried and stored.
- ♦*Fume Hood*. Radioactive wastes are inspected, sorted and repacked in a room. Any airborne emissions generated during the different handling steps are exhausted through a fume hood equipped with a HEPA filter.
- ♦*Carbon Dioxide Blaster Room*. In this room frozen carbon dioxide pellets will be propelled under pressure to remove surface and fixed contamination from equipment and waste materials. This unit has not been placed into operation since its installation
- ♦*Plasma Cutting Torch*. This torch will be used to cut metal waste of various geometries to reduce the volume of the waste and to ensure that it fits into standard radwaste shipping containers. This unit has not been placed into operation since its installation.
- ♦*Waste Compactor*. The compactor uses a 500,000-pound hydraulic ram to reduce the volume of contaminated paper product and miscellaneous metal items. This unit has not been placed into operation since its installation.

Since each of these waste-handling activities has the potential for generating radioactive airborne emissions, the ventilation exhaust systems for each is equipped with a HEPA filter. Ordinarily, radionuclide emissions for these types of intermittent, low dose potential (i.e., less than 0.1 mrem/year to the maximally exposed individual) operations are estimated using 40 CFR 61 Appendix D methods through knowledge of the radionuclides in the waste and their quantities. However, exact source terms for the types of wastes processed in the Reclamation Building are often not readily available, making such an estimate difficult. Therefore, sampling systems were designed for each exhaust stack to directly and continuously monitor radioactive emissions during waste handling operations. This level of monitoring is greater than what is prescribed under NESHAPs Subpart H for these types of sources.

Each monitoring system was designed to comply with specific requirements of 40 CFR 61.93(b), particularly those for periodic measurement of flow rate, monitoring of the effluent by direct extraction, and monitoring the effluent using representative samples that are withdrawn continuously when the waste handling equipment is operational. Installation of the stack monitoring systems commenced in 1999 and is expected to be completed by March 2000.

4.1.8 STATUS OF RADIOLOGICAL AIR EMISSION SOURCES EVALUATED IN 1998

4.1.8.1 LINEAR ACCELERATOR (LINAC)

Due to the energy of the protons accelerated by the LINAC, the production of airborne radionuclides through air activation and/or spallation interactions is possible. The most significant production point of airborne radionuclides inside the tunnel occurs where the beam crosses an air gap as it enters the BLIP vacuum system. Radioactive products were available for atmospheric release prior to 1999 via the tunnel ventilation exhaust stack, located adjacent to the BLIP building. Although identified as a source of airborne radionuclides in 1998, the exhaust system servicing the LINAC tunnel has since been removed from service. The LINAC tunnel emissions are no longer vented at any stack point and the radionuclides now decay in place inside the tunnel.

4.1.8.2 AGS COOLING TOWER #2

Magnets used to steer the AGS particle beam experience significant heating and are cooled via a recirculating, non-contact water loop. Under certain conditions, such as high energy proton operations, low concentrations of radioactive elements may be produced in the cooling water when it circulates in the vicinity of the beam line. Radioisotopes which exist as gases may be liberated from the water when exposed to air during circulation in the outdoor cooling tower. These gaseous isotopes can constitute an airborne emission. The radionuclides which are likely to be released via this mechanism include oxygen-14 ($t_{1/2}$ = 1.2 min.), oxygen-15 ($t_{1/2}$ = 2.1 min.), nitrogen-13 ($t_{1/2}$ = 10 min.), and carbon-11 ($t_{1/2}$ = 20 min.). Tritium is also present and may be emitted from the tower as water vapor in microcurie quantities per year. Cooling Tower #2 processes activated cooling water from the AGS C-line. The C-line is one of several beam lines (labeled alphabetically) that branch off from the AGS ring. This beam line received no beam and did not operate in 1999. Therefore, there were no emissions from this cooling tower in 1999.

4.2 AIR MONITORING FOR RADIONUCLIDES

As part of the environmental monitoring program, an array of stations is in place around the BNL site to collect air samples which are

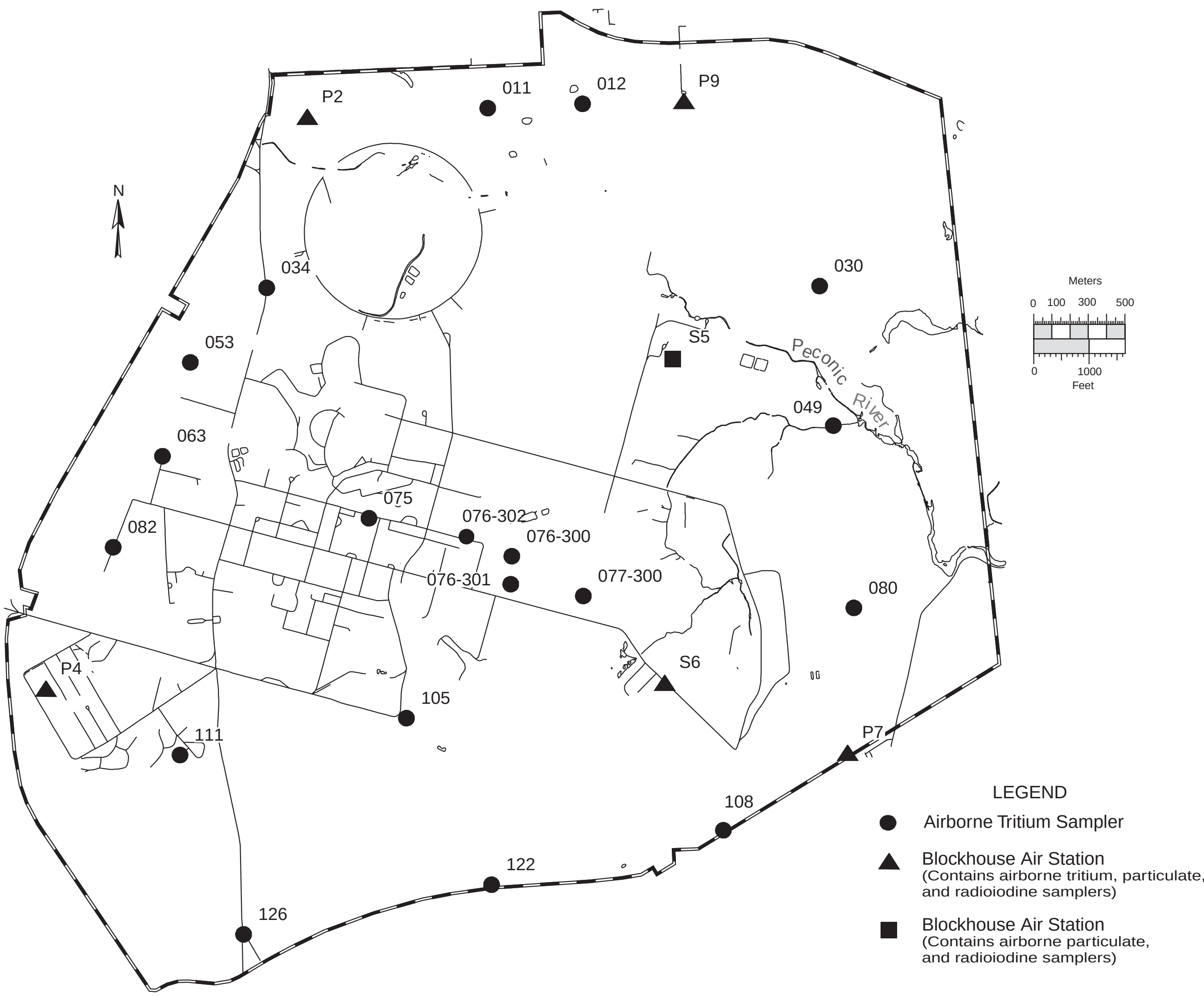


Figure 4-4. Onsite Air Monitoring Stations.

used to determine radiological air quality. Six samplers are located in dedicated blockhouses (see Figure 4-4 for locations). The blockhouses are fenced for security purposes to control access and protect costly sampling equipment. At each blockhouse, glass-fiber filter paper is used to capture airborne particulate matter, charcoal cartridges are used to collect potential radioiodines (none were detected in 1999), and silica-gel tubes are used to collect water vapor for tritium analysis (with the exception of Station S5 which does not contain a tritium sampler). Filter paper is collected weekly and analyzed for gross alpha and beta activity using a gas-flow proportional counter. Since April 1999 silica-gel samples have been collected one week a month for processing by liquid scintillation analysis. Before that, silica-gel samples were collected weekly. Multiple years worth of sampling data with results below the MDL were the basis for reducing sampling frequency. Charcoal cartridges were collected monthly and analyzed by gamma spectroscopy. In addition to the blockhouses, 19 pole-mounted, battery-powered silica-gel samplers (used for tritium analysis) are located throughout the site, primarily along the site boundary.

In addition to these samples, the New York State Department of Health (NYSDOH) received duplicate filter samples that were collected at Station P7, located at the southeast boundary. These samples were collected on a weekly basis and analyzed by an independent NYSDOH Laboratory for gross beta activity. Analytical results were comparable to those collected by BNL and were reported in the document called *Environmental Radiation In New York State* (NYSDOH 1993). Analytical results for gross beta reported by the NYSDOH were between 0.005 and 0.02 pCi/m^3, while Station P7 results averaged 0.0178 pCi/m^3 (see Table 4-2).

4.2.1 GROSS ALPHA AND BETA ACTIVITY

Particulate filter analytical results are reported in Table 4-2. Annual average gross alpha and beta airborne activity levels were equal to 0.001 pCi/m^3 (0.04 mBq/m^3) and 0.015 pCi/m^3 (0.6 mBq/m^3), respectively. Annual gross beta activity trends recorded at Station P7 are plotted in Figure 4-5; the results at this location are typical for the site. The trend shows seasonal variation of concentrations within a range that is representative of natural background levels. Note however that gross alpha activity is not plotted because the vast majority of results were below the MDL. Measurable activity is primarily due to radionuclide decay products associated with natural uranium and thorium.

Table 4-2. Gross Activity Detected in Air Particulate Filters in 1999.

Sample Station		Gross Alpha (pCi/m^3)	Gross Beta (pCi/m^3)
P2	N	51	51
	Max.	0.0127 ± 0.0015	0.0403 ± 0.0027
	Avg.	0.0007 ± 0.0005	0.0139± 0.0017
	NAD	4	51
P4	N	51	51
	Max.	0.0253 ± 0.0028	0.0544 ± 0.0039
	Avg.	0.0013 ± 0.0005	0.0166 ± 0.0025
	NAD	5	51
P7	N	51	51
	Max.	0.0287 ± 0.0022	0.0512 ± 0.0027
	Avg.	0.0010 ± 0.0011	0.0178± 0.0028
	NAD	5	51
P9	N	52	52
	Max.	0.0127 ± 0.0015	0.0317 ± 0.0023
	Avg.	0.0008 ± 0.0005	0.0134 ± 0.0014
	NAD	3	52
S5	N	52	52
	Max.	0.0139 ± 0.0017	0.0340± 0.0025
	Avg.	0.0007 ± 0.0005	0.0139± 0.0018
	NAD	5	52
S6	N	52	52
	Max.	0.0170 ± 0.0017	0.0360 ± 0.0024
	Avg.	0.0009 ± 0.0006	0.0147 ± 0.0017
	NAD	6	52

Notes:
See Figure 4-4 for sample station locations.
All values shown with a 95% confidence interval.
N=Number of samples collected.
NAD=Number of samples with results above the minimum detection limit.

As part of a state-wide monitoring program, the NYSDOH also collects air samples in Albany, New York, a control location with no potential to be influenced by nuclear facility emissions. The NYSDOH reports that typical airborne gross beta activity at that location varies between 0.005 and 0.025 pCi/m^3 (0.2 to 0.9 mBq/m^3). Sample results measured at BNL generally fall well within this range, demonstrating that onsite radiological air quality is consistent with that observed in locations in New York State not located near radiological facilities.

4.2.2 AIRBORNE TRITIUM

Airborne tritium in the form of HTO is monitored throughout the BNL site. Nineteen

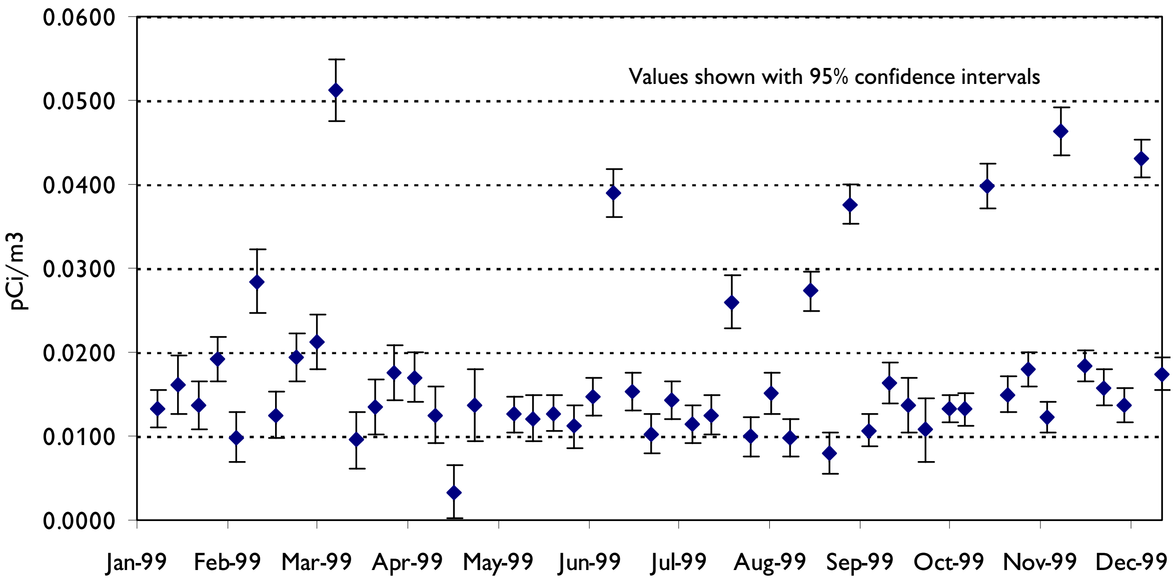


Figure 4-5. Airborne Gross Beta Concentration Trend Recorded at Station P7.

monitors (not including those which monitor the Removal Action V ([RA V]) recharge basin – see section 4.2.2.1 below) are located at or near the property boundary (see Figure 4-4 for locations). HTO is collected by using a pump that draws air through a column of silica gel, a water-absorbent medium. The absorbed water is recovered in the BNL Analytical Services Laboratory and analyzed using liquid scintillation counting techniques.

Table 4-3 lists the number of validated samples collected at each location, the maximum value observed and the annual average concentration. Validated samples are those which were not rejected due to equipment malfunction or other factors (e.g., a battery failure in the sampler, frozen or super-saturated gel, or the loss of sample during laboratory preparation). In 1999 the frequency of airborne tritium sampling was reduced from a weekly basis to a monthly basis. This reduction in sampling frequency was based on results from many successive years where the air sampling stations showed no detectable evidence of tritium. While one location (S6) showed a maximum value which was above the typical detection limit of about 4 pCi/m^3 (0.15 Bq/m^3), the remainder of the sample results were below the MDL. These data demonstrated that there was no significant difference in ambient tritium concentrations onsite or at the site boundary.

Table 4-3. 1999 Ambient Airborne Tritium Measurements.

Sample Station	Wind Sector	Validated Samples	Maximum (pCi/m^3)	Average (pCi/m^3)
P9	NE	20	2.9 ± 2.2	0.1 ± 0.5
011	NNE	21	<3.7	-0.1 ± 0.5
012	NNE	19	<1.5	-0.1 ± 0.3
P2	NNW	21	<1.5	-0.2 ± 0.3
030	ENE	20	<3.9	-0.3 ± 0.5
034	NNW	20	<5.6	0.0 ± 0.5
049	E	17	<3.2	-0.1 ± 0.6
053	NW	20	<6.7	0.0 ± 0.7
063	W	21	<3.8	0.1 ± 0.4
075	SW	18	<5.0	0.1 ± 0.5
076-302	ESE	11	<3.7	0.6 ± 0.4
080	ESE	16	<2.1	-0.3 ± 0.4
082	W	18	<4.2	0.3 ± 0.7
S6	SE	21	70.3 ± 5.2	16.0 ± 5.9
P7	ESE	22	<4.4	0.3 ± 0.4
105	S	17	<4.5	-0.1 ± 0.5
108	SE	19	<2.4	0.2 ± 0.4
P4	WSW	21	<3.9	0.0 ± 0.3
111	SW	18	<3.9	-0.1 ± 0.4
122	SSE	21	<4.2	-0.2 ± 0.4
126	SSW	17	<7.4	-0.3 ± 0.4
Grand Average				0.7 ± 0.3

Notes:
See Figure 4-4 for station locations.
All values reported with a 95% confidence interval.
Typical detection limit for tritium is 1- 5 pCi/m^3.
DOE Order 5400.5 air Derived Concentration Guide: 100,000 pCi/m^3.

Table 4-4. 1999 Ambient Tritium Monitoring Results at RA V Recharge Basin.

Location	Validated Samples	Detections	Maximum (pCi/m³)	Average (pCi/m³)
Northeast corner of basin (076-300)	20	1	2.8 ± 3.1	0.5 ± 0.5
Southeast corner of basin (076-301)	12	0	< 3.9	-0.2 ± 1.5
National Weather Service Building (077-300)	22	0	< 6.9	0.1 ± 0.7

Notes:
See Figure 4-4 for locations of recharge basins.
Typical minmum detection limit for tritium is between 1 and 5 pci/m^3.

With the exception of Station S6, which is located adjacent to the former Hazardous Waste Management Facility, all annual average concentrations were observed to be below the MDL. The maximum concentration recorded at Station S6 was 70 pCi/m^3 (2.6 Bq/m^3). The higher values observed at this station may have been due to its proximity to the former Hazardous Waste Management Facility. By comparison, the DOE Order 5400.5 derived concentration guide for tritium in air is 100,000 pCi/m^3 (3.7 kBq/m^3). The airborne derived concentration guide is the concentration of a radionuclide in air which, if inhaled at that level for one year, would result in an effective dose equivalent of 100 mrem (1 mSv) to the exposed individual.

As compared with 1998, observed concentrations of tritium at the sampling stations were consistently lower in 1999. This is probably explained by the fact that releases of HTO from the HFBR dropped by more than fifty percent from 37 Ci (1.4 TBq) in 1998 to 18 Ci (0.7 TBq) in 1999.

4.2.2.1 REMOVAL ACTION V (RA V) RECHARGE BASIN

In 1997, an interim pump-and-recharge system was constructed to control the leading edge of the plume of tritium associated with the leakage of the spent-fuel storage pool at the HFBR. Three extraction wells are being used to pump groundwater containing both tritium and volatile organic compounds from approximately 150 feet below ground surface to carbon filtration units, and ultimately to the RA V recharge basin, located 3,000 feet to the north of the plume edge. (The volatile organic compounds being treated by this system are from sources unrelated to the HFBR.) Using assumptions which later proved to be very conservative, the recharge basin was evaluated as a potential air emission source for NESHAPs compliance prior to the start of pumping operations (see the section 5.1.6.1 of the BNL *Site Environmental Report for Calendar Year 1997* [BNL 1999] for a discussion of that evaluation).

Airborne HTO monitoring in the vicinity of the RA V recharge basin continued in 1999. Two monitors are installed immediately adjacent to the basin at the northeast and southeast corners, the downwind directions of the predominant winds on site (see BNL wind rose in Figure 1-10). An additional station was placed near the National Weather Service building, approximately 0.2 mile to the east of the basin. As can be seen in Table 4-4, only one of 54 validated samples showed results greater than the MDL, but at a value consistent with what was observed throughout the site. This is as expected since direct analysis of the basin water showed tritium values which were rarely above the MDL of about 350 pCi/L (13 Bq/L). Since the recharge basin airborne tritium surveillance began in 1997, the majority of tritium samples obtained at the recharge basins were reported below the MDL. Consequently, in calendar year 1999, the frequency of sampling was reduced from a weekly basis to once per month.

4.3 NONRADIOLOGICAL AIRBORNE EMISSIONS

Various state and federal regulations covering nonradiological releases require facilities to conduct periodic or continuous emissions monitoring in order to demonstrate compliance with emission limits. BNL has several emission sources subject to state and/or federal regulatory requirements that do not require emissions monitoring (see Chapter 3 for more details). The Central Steam Facility (CSF) is the only BNL emission source required to monitor nonradiological emissions.

The CSF supplies steam for heating and cooling to BNL major facilities through an underground steam distribution and condensate grid. The location of the CSF is shown in Figure

4-1. The combustion units at the CSF are designated as Boiler Nos. 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 was installed in 1965, and has a heat input of 65.3 MW (225 MMBtu/hr). The newest units, Boilers No. 6 and 7 were installed in 1984 and 1996, respectively. Each of these boilers have heat inputs of 42.6 MW (147 MMBtu/hr).

Because of their design, heat inputs, and dates of installation, Boiler Nos. 6 and 7 are subject to Title 6 of the New York Code of Rules and Regulations (NYCRR) Part 227-2, and the New Source Performance Standard, 40 CFR 60 Subpart Db. As such, these boilers are equipped with continuous emissions monitors for nitrogen oxides (NO_X). Boiler No. 7 emissions are also continuously monitored for opacity. To measure combustion efficiency, Boiler Nos. 6 and 7 are also monitored for carbon dioxide (CO_2). Continuous emissions monitoring results from the two boilers are reported on a quarterly basis to the U.S. Environmental Protection Agency and the New York State Department of Environmental Conservation.

During the summer of 1999, a new Continuous Emission Monitoring System (CEMS) was installed for Boiler No. 6. Before the installation of the new system, emissions from Boiler No. 6 were monitored by a time-share system that electronically switched between stacks to continuously monitor flue gas concentrations of CO_2 and NO_X in Boilers 6 and 7. The original CEMS is now dedicated to Boiler No. 7. Components of the new system include new analyzers for carbon monoxide (CO), CO_2 and NO_X emissions and a new data acquisition system. The three new analyzers and the data acquisition system are mounted in a temperature-controlled cabinet outside the CSF control room (see Figure 4-6). After installation of the new system was completed, the performance of the analyzers was tested in accordance with 40 CFR 60 Appendix B specifications. The new dedicated system ensures greater operational flexibility to the CSF in the event of a CEMS malfunction.

From May 1 to September 15 (the peak ozone period), compliance with the 0.30 lbs/MMBtu NOx emissions standard is demonstrated by calculating the 24-hour average emission rate from CEMS readings and comparing the value to the emission standard. The remainder of the year, the calculated 30-day rolling average CEMS emissions rate is used to establish compliance. In 1999 there were no measured exceedances of the NO_X emission standard for either boiler.

Figure 4-6. Central Steam Facility Continuous Emission Monitoring Analyzers.

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 No. 5, and natural gas trains were installed to connect the gas main to Boiler Nos. 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.

Due to the use of natural gas as the primary fuel, annual particulate, NO_X, and SO_2 emissions at the CSF have dropped significantly from totals in 1996, when natural gas was not yet available for burning (see Table 4-5). In

Table 4-5. Central Steam Facility Fuel Use and Emissions.

Year	Annual Fuel Use: # 6 Oil (10^3 gals)	# 2 Oil (10^3 gals)	Natural Gas (10^6 ft^3)	Emissions: TSP (tons)	NO_x (tons)	SO_2 (tons)	VOCs (tons)
1996	4,782.55	52.77	0.00	14.0	104.9	109.0	0.7
1997	3,303.43	10.23	190.65	13.7	83.5	75.1	1.0
1998	354.28	9.44	596.17	2.7	75.1	8.9	1.7
1999	682.76	2.77	614.98	5.1	53.5	16.7	1.8

Notes:
TSP=Total Suspended Particulates
VOCs=Volatile Organic Compounds

1999, emissions of particulates, NO_X, and SO_2 were 8.9 tons, 51.4 tons, and 92.3 tons lower than the respective totals recorded in 1996. Meanwhile, since volatile organic compound (VOC) emissions produced by natural gas combustion are higher than those from burning residual oil (i.e., #6 oil), VOC emissions rose by 0.9 tons from 1996 to 1999. On an equivalent-heat input basis, particulate emissions at the CSF have fallen by 9.2 tons, NO_X emissions have dropped by 53.6 tons, and SO_2 emissions are down by 94.7 tons over the same period.

REFERENCES

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DOE Order 5400.5. 1990. *Radiation Protection of the Public and the Environment.* U.S. Department of Energy, Washington, D.C. Change 2: 1-7-93.

NYSDOH. 1993. *Environmental Radiation in New York State 1993.* Bureau of Environmental Radiation Protection, New York State Department of Health, Albany, New York.

Water Quality

Some facilities at Brookhaven National Laboratory discharge or have the potential to discharge radioactive, organic and/or inorganic contaminants in liquid effluents. Effluent monitoring is conducted to ensure that these discharges comply with all applicable requirements and that the public and environment are protected.

During 1999, at the Sewage Treatment Plant outfall, average gross alpha and beta activity was within the range typical of background surface waters. Improved wastewater management combined with the shutdown of the High Flux Beam Reactor resulted in the smallest release of tritium since such measurements began in 1966. The majority of the daily samples had tritium concentrations that were below the minimum detection limit. Average cesium-137 concentrations in the Sewage Treatment Plant effluent were less than one percent of the drinking water standards.

Chemical monitoring of the Sewage Treatment Plant effluent shows that all organic and inorganic parameters were within State Pollutant Discharge Elimination System effluent limitations or other applicable standards. Inorganic data from upstream, downstream, and control locations not affected by Sewage Treatment Plant discharges continue to show that elevated amounts of aluminum, copper, lead, iron and zinc detected within the river are a result of natural geology, and are not influenced by Sewage Treatment Plant effluent. Low pH is also due to natural causes.

5.1 SURFACE WATER

Treated wastewater from the BNL sewage treatment plant is discharged into the headwaters of the Peconic River. This discharge is a New York State Department of Environmental Conservation (NYSDEC) permitted point source discharge. Effluent limitations are based upon the state receiving water quality standards and 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 point of discharge. Additionally the Carmans River is monitored as a background control location for comparative purposes. To assess true background Peconic River water quality, an offsite upstream location was monitored in 1999. This location (designated Station HY) is located just west of the William Floyd Parkway.

5.2 SANITARY SYSTEM EFFLUENTS

On the BNL site, the Peconic River is an intermittent stream. The Sewage Treatment Plant's (STP) Peconic River outfall is a discharge point operating under a State Pollutant Discharge Elimination System (SPDES) permit. Figure 5-1 shows a schematic of the STP and STP sampling locations. Offsite flow only occurs during periods of sustained precipitation, typically in the spring. During 1999, offsite flow was recorded from January through mid-May.

The BNL STP treatment system includes: primary clarification to remove settleable solids and floatable materials, aerobic oxidation for secondary removal of biological matter and nitrification of ammonia, secondary clarification, intermittent sand filtration for final effluent polishing, and ultraviolet disinfection for bacterial control prior to discharge to the Peconic River. During the aeration process, the oxygen minimizer causes the microorganisms to use nitrate-bound oxygen for respiration, which liberates nitrogen gas, thus reducing the concentration of nitrogen in the STP discharge. Nitrogen provides nutrients for plant growth; consequently, plant growth within the Peconic has been extensive. Since plants require oxygen for survival during night hours, too much plant life can deprive a water system of oxygen needed by fish and other aquatic organisms for survival. By reducing the concentration of

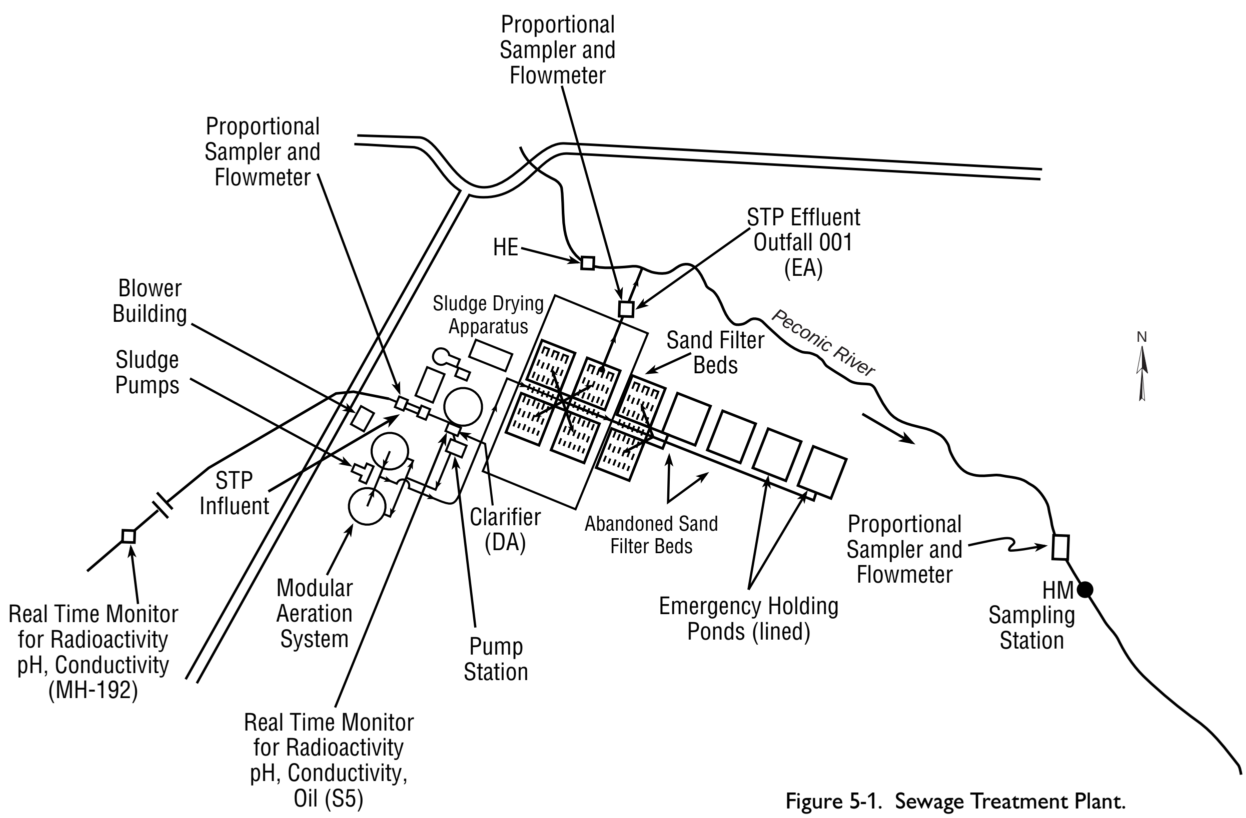


Figure 5-1. Sewage Treatment Plant.

nitrogen in the STP discharge, plant growth within the river remains in balance with the nutrients provided by natural sources. During 1999, efforts were taken to try to improve the denitrification process by tightly controlling the oxygen and biomass levels in the aeration chamber. Due to the already low nitrogen levels and low biomass concentration in the STP effluent, minimal improvement was seen. Efforts continue to maximize the denitrification process and limit nitrogen releases to the Peconic.

Real-time monitoring of the clarifier influent for radioactivity, pH, and conductivity takes place at two locations: about 1.1 miles upstream of the STP and just prior to the point where the influent enters the primary clarifier. The upstream station provides at least 30 minutes advance warning to the STP operator if wastewater that could exceed BNL effluent release criteria or SPDES limits has entered the sewer system. Effluent leaving the clarifier is monitored a third time for radioactivity. Influent/effluent that does not meet BNL and/or SPDES effluent release criteria is diverted to one of two lined hold-up ponds. The total combined capacity of the two holding ponds exceeds seven million gallons. Diversion continues until the effluent quality meets the permit limits or release criteria. The requirements for treating the effluent diverted to the holding ponds are evaluated and, if necessary, the waste is treated before being reintroduced into the sanitary waste stream at a rate that ensures compliance with SPDES permit limits or BNL administrative release criteria.

Solids separated in the clarifiers are pumped to a digester, where they are reduced in volume by anaerobic bacteria. Periodically a fraction of the sludge is emptied into a drying bed. The drying bed uses solar energy to dry the watery sludge to a semi-solid cake. Since the dried sludge contains very low levels of radioactivity, it is containerized for offsite disposal at an authorized facility.

5.2.1 SANITARY SYSTEM EFFLUENT – RADIOLOGICAL

As noted in the previous section, STP effluent is sampled at the output of the primary clarifier (Station DA) and at the Peconic River Outfall (Station EA). At each location, daily samples are collected on a flow-proportional basis; that is, for every thousand gallons of water treated several hundred milliliters of sample are collected and composited into a 5-gallon collection container. These samples are analyzed for gross alpha, gross beta and tritium activity. The samples collected from these locations are also composited and analyzed for gamma-emitting radionuclides and strontium-90 on a monthly basis.

The Safe Drinking Water Act (SDWA) specifies that no individual may receive an annual dose greater than 4 mrem per year from radionuclides present in drinking water. Although the Peconic River is not used as a direct source of potable water, the stringent drinking water standards are applied for comparison purposes. Under the SDWA, the annual average, gross alpha activity limit is 15 pCi/L (0.6 Bq/L) (including radium-226, but excluding radon and uranium). The SDWA also stipulates a 50-pCi/L (1.85 Bq/L) gross beta activity screening level, above which nuclide-specific analysis is required. BNL goes beyond this basic screening requirement by performing nuclide-specific analysis regardless of the gross beta activity. Other specified limits are 20,000 pCi/L (740 Bq/L) for tritium and 8 pCi/L for strontium-90. For all other radionuclides, derived concentration guides found in DOE Order 5400.5, *Radiation Protection of the Public and the Environment,* are used to determine the concentration of the nuclide, which, if continuously ingested over a calendar year, would produce an effective dose equivalent of 4 mrem. These values are shown at the bottom of Tables 5-1 and 5-2 under "SDWA Limit."

Gross activity measurements are used as a screening tool for detecting the presence of radioactivity. Annual average gross alpha and beta activity in the STP effluent has remained consistent with background levels for many years. This continued to be the case in 1999. Average gross alpha and beta activity at the STP Outfall was 1.4 ± 0.2 pCi/L (0.05 ± 0.01 Bq/L) and 7.5 ± 0.9 pCi/L (0.3 ± 0.03 Bq/L), respectively. See Table 5-1 for complete gross activity data.

Sporadically throughout the year, gamma spectroscopy analysis detected beta/gamma-emitting radionuclides in the STP influent and effluent, although at levels that were close to or below the minimum detection limits (MDLs) for the analytical method (see Table 5-2). The presence of cesium-137 in the STP effluent is due to the continued leaching of very small amounts of cesium-137 from the sand filter beds. This radionuclide was deposited during

Table 5-1. Tritium and Gross Activity Results at the Sewage Treatment Plant (1999).

	Flow (L)	Tritium Maximum (pCi/L)	Tritium Average (pCi/L)	Gross Alpha Maximum (pCi/L)	Gross Alpha Average (pCi/L)	Gross Beta Maximum (pCi/L)	Gross Beta Average (pCi/L)
STP Outfall							
January	4.91E+07	< 313	5 ± 41	3.0 ± 2.1	1.2 ± 0.4	14.4 ± 5.9	6.2 ± 1.4
February	4.20E+07	308 ± 199	34 ± 155	3.2 ± 2.2	1.3 ± 0.5	13.4 ± 6.0	6.1 ± 1.9
March	5.00E+07	380 ± 202	109 ± 45	6.3 ± 2.7	2.3 ± 0.7	18.7 ± 6.4	8.0 ± 1.6
April	4.87E+07	419 ± 204	100 ± 71	5.7 ± 2.7	1.9 ± 0.7	13.9 ± 5.8	8.4 ± 1.6
May	4.56E+07	343 ± 193	89 ± 49	6.5 ± 2.9	1.8 ± 0.8	13.0 ± 5.5	7.2 ± 1.2
June	5.79E+07	478 ± 224	62 ± 60	4.4 ± 2.3	1.5 ± 0.7	12.4 ± 5.6	7.0 ± 1.1
July	6.62E+07	402 ± 229	127 ± 78	5.1 ± 2.5	2.1 ± 0.7	12.9 ± 5.4	6.8 ± 1.6
August	7.56E+07	389 ± 187	140 ± 59	5.3 ± 2.4	2.0 ± 0.7	13.0 ± 5.6	7.0 ± 1.1
September	6.29E+07	450 ± 205	199 ± 61	11.2 ± 3.5	3.2 ± 1.2	14.1 ± 5.9	7.9 ± 1.4
October	5.42E+07	1,290 ± 239	288 ± 140	5.2 ± 2.4	1.9 ± 0.6	11.7 ± 5.5	7.0 ± 0.9
November	5.31E+07	360 ± 216	189 ± 39	7.7 ± 2.7	2.0 ± 0.9	23.5 ± 6.5	13.2 ± 2.7
December	4.45E+07	1,490 ± 267	352 ± 210	5.8 ± 2.7	2.0 ± 0.7	11.3 ± 5.6	6.8 ± 1.1
Annual Average			142 ± 30		2.0 ± 0.2		7.6 ± 0.5
STP Clarifier							
January	6.05E+07	< 307	14 ± 46	2.8 ± 1.8	1.0 ± 0.5	11.6 ± 5.7	6.1 ± 1.2
February	5.61E+07	511 ± 227	35 ± 138	3.1 ± 2.1	0.9 ± 0.4	9.8 ± 5.5	5.7 ± 1.2
March	7.12E+07	< 311	108 ± 48	2.8 ± 1.8	0.9 ± 0.4	16.3 ± 6.0	6.7 ± 1.5
April	6.90E+07	416 ± 220	91 ± 69	4.8 ± 2.2	1.1 ± 0.6	14.7 ± 5.6	7.0 ± 1.3
May	5.53E+07	< 315	43 ± 49	6.7 ± 2.9	0.9 ± 0.7	10.8 ± 5.9	6.6 ± 1.1
June	7.58E+07	< 330	49 ± 45	2.9 ± 1.7	1.1 ± 0.5	11.6 ± 5.5	6.2 ± 1.1
July	8.09E+07	378 ± 241	149 ± 70	5.3 ± 2.5	1.6 ± 0.7	13.1 ± 6.1	6.5 ± 1.2
August	9.22E+07	579 ± 207	127 ± 85	4.9 ± 2.1	1.4 ± 0.7	15.2 ± 5.6	6.8 ± 1.5
September	6.74E+07	376 ± 208	161 ± 48	9.7 ± 3.1	2.8 ± 1.1	16.1 ± 6.0	7.2 ± 1.4
October	5.98E+07	1,130 ± 237	310 ± 142	2.9 ± 2.0	1.1 ± 0.4	11.2 ± 5.5	6.2 ± 1.2
November	6.16E+07	394 ± 187	217 ± 51	7.5 ± 2.9	1.7 ± 0.8	102.0 ± 10.1	17.6 ± 9.5
December	5.65E+07	1,920 ± 279	282 ± 203	5.7 ± 2.8	1.7 ± 0.6	13.0 ± 5.6	8.6 ± 0.9
Annual Average			133 ± 30		1.4 ± 0.2		7.5 ± 0.9
Total Release	6.50E+08		109 mCi		0.1 mCi		5.1 mCi
SDWA Limit (pCi/L)			20,000		15.0		50.0
Typical MDL (pCi/L)			336		3.0		9.0

Notes:
All values shown with a 95% confidence interval.
SCWA=Safe Drinking Water Act
MDL=Minimum Detection Limit

historic releases to the site sanitary system. This is better illustrated when comparing cesium-137 detected in STP influent and effluent: detections of cesium-137 in the influent are low and infrequent, whereas detections in effluent are measurably higher and seen consistently. Total cesium-137 released at the STP outfall during the year was less than 0.5 mCi. The maximum concentration in STP effluent was approximately one-half of one percent (0.5%) of the drinking water standard. In fact, cesium-137 concentrations in influent and effluent have been decreasing since 1990, as shown in Figure 5-2.

Stronitum-90 was detected in both the STP influent and effluent monthly composite samples on two occasions, although at low levels. The largest single value of strontium-90 recorded for a monthly composite influent sample was 2.82 ± 0.1 pCi/L (0.1 ± 0.004 Bq/L) or 35 percent of the drinking water standard of 8 pCi/L. The largest strontium-90 value for an STP effluent sample was 1.2 ± 0.17 pCi/L or 15 percent of the drinking water standard. These values are slightly higher than 1998 values, but are consistent with previous years. The increased concentrations resulted from a project to clean the sanitary sewers. While processes were implemented to collect the wash water and sludges dislodged from the sanitary system during cleaning, some were carried downstream to the STP. Strontium-90 was discharged from BNL facilities in the 1950s and 1960s, and has remained resident in sludges contained in the sanitary piping system. The goal of the sanitary

Table 5-2. Gamma-Emitting Radionuclides and Strontium-90 Detected at the Sewage Treatment Plant (1999).

	Flow (L)	Co-60 (pCi/L)	Cs-137 (pCi/L)	Be-7 (pCi/L)	Na-22 (pCi/L)	Sr-90 (pCi/L)
STP Clarifier						
January	6.05E+07	ND	ND	ND	ND	< 0.69
February	5.61E+07	ND	ND	ND	ND	< 0.33
March	7.12E+07	ND	ND	ND	ND	0.56 ± 0.22
April	6.90E+07	ND	ND	ND	ND	< 0.37
May	5.53E+07	ND	ND	ND	ND	< 0.34
June	7.58E+07	ND	ND	ND	ND	< 0.73
July	8.09E+07	ND	ND	ND	ND	< 0.37
August	9.22E+07	ND	0.68 ± 0.25	11.30 ± 8.66	ND	< 0.16
September	6.74E+07	ND	ND	ND	ND	< 0.17
October	5.98E+07	ND	ND	ND	ND	< 0.16
November	6.16E+07	ND	ND	ND	ND	2.82 ± 0.16
December	5.65E+07	ND	ND	ND	ND	< 0.17
STP Outfall						
January	4.91E+07	ND	0.40 ± 0.10	ND	0.16 ± 0.06	< 0.70
February	4.20E+07	ND	0.43 ± 0.09	ND	ND	< 0.21
March	5.00E+07	ND	0.37 ± 0.08	ND	ND	< 0.69
April	4.87E+07	ND	0.39 ± 0.11	ND	ND	< 0.33
May	4.56E+07	0.51 ± 0.37	0.62 ± 0.58	ND	ND	0.35 ± 0.22
June	5.79E+07	ND	0.62 ± 0.20	ND	ND	< 0.37
July	6.62E+07	ND	0.43 ± 0.11	ND	ND	< 0.34
August	7.56E+07	ND	0.65 ± 0.37	ND	ND	< 0.17
September	6.29E+07	ND	0.38 ± 0.21	ND	ND	< 0.16
October	5.42E+07	ND	0.36 ± 0.10	ND	ND	< 0.16
November	5.31E+07	ND	ND	ND	ND	1.20 ± 0.17
December	4.45E+07	ND	ND	ND	ND	< 0.15
Total Release		0.023 mCi	0.26 mCi	0 mCi	0.008 mCi	0.08 mCi
DOE Order 5400.5 DCG (pCi/L)		5,000	3,000	50,000	10,000	1,000
SDWA Limit (pCi/L)		100	200	6,000	400	8

Notes:
All values shown with a 95% confidence interval.
ND=Not Detected

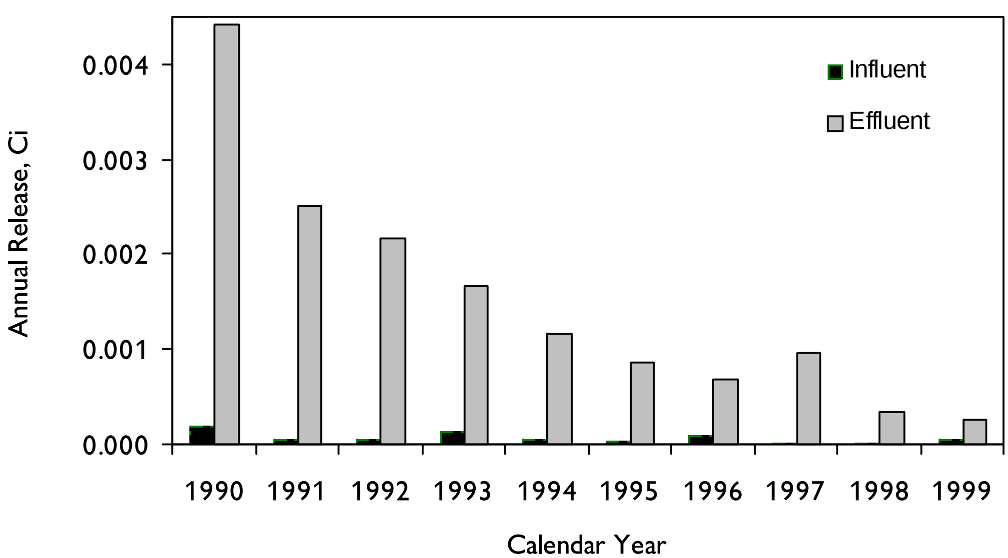


Figure 5-2. Cs-137 Trend in STP Influent and Effluent, 1990 – 1999.

sewer-cleaning project is to remove the residual activity and ultimately reduce the concentrations into and released from the STP.

Tritium detected at the STP originates with either High Flux Beam Reactor (HFBR) sanitary system releases, or small, infrequent batch releases which meet BNL discharge criteria. Tritium continues to be released from the HFBR although at very low concentrations due to evaporative losses of primary coolant and condensation within the air conditioning units. A plot of 1999 tritium concentrations recorded in the STP effluent is presented in Figure 5-3. A 10-year trend plot of annual average tritium concentrations measured in the Peconic is shown in Figure 5-4. Annual average concentrations have been declining since 1995.

In 1999, the annual average tritium concentration as measured at the Peconic River outfall (EA, Outfall 001) was 133 pCi/L (4.9 Bq/L), a value which is below the typical MDL of 350 pCi/L (13.0 Bq/L). A total source term of 0.11 Ci of tritium was released during the year. This is the lowest annual release of tritium to the Peconic River observed since routine measurements began in 1966 (see Figure 5-5). This is attributable to improved wastewater handling procedures at the HFBR, the shutdown of the HFBR, and the use of the Building 802 Evaporator Facility for management of wastewater containing low-level tritium concentrations. The maximum concentration of tritium was 1,920 pCi/L. Sporadically, tritium was detected at elevated concentrations in both the STP influent and effluent. These detections are most likely due to increased releases from the HFBR maintenance activities. During maintenance of the primary cooling system, tritium in the form of water vapor is released to the containment building. These releases result in higher airborne tritium concentration in the HFBR and; consequently more tritium is released via air handling systems to the STP.

5.2.2 SANITARY SYSTEM EFFLUENT - NONRADIOLOGICAL

In addition to the compliance monitoring discussed in Chapter 3, the effluent from the STP is also monitored under the environmental surveillance program for field measured parameters (temperature, specific conductivity, pH, and dissolved oxygen), water quality (anions: chlorides, nitrates and sulfates) and inorganic parameters (i.e., metals). Daily composite samples are collected using a flow-proportional refrigerated sampling device (ISCO Model 1600). In 1999, the practice of preparing a monthly composite sample from the individual daily composites was replaced by analyzing individual daily composites. This new method of sample collection is also consistent with SPDES permit monitoring requirements. The BNL Analytical Services Laboratory analyzes these composite samples for metals and anions. In 1998, the Analytical Services Laboratory expanded its inorganic analytical capabilities by adding an inductively coupled plasma/mass spectrometer. This instrument effectively increased the routine inorganic analyte list to 19 parameters. In 1999, two additional parameters were added to the routine list of analytes. Grab samples were also collected at the clarifier effluent and the STP outfall and monitored for field-measured parameters including pH, conductivity, temperature, and dissolved oxygen. Daily influent and effluent logs are also maintained by the STP operators for flow, pH, temperature, and settleable solids as part of routine monitoring of STP operations.

Table 5-3 summarizes the water quality and metals analytical results for the STP samples. Comparison of the effluent data to the SPDES effluent limitations (or other applicable standard) shows that all analytical parameters were within SPDES effluent permit limits (see also the compliance data in Chapter 3).

Grab samples were also collected monthly from the STP discharge and analyzed for volatile organic compounds. A single detection of diethyl ether at 10 ppb was reported for June. This compound was not detected at any other times during the year. There are no effluent standards or water quality standards associated with diethyl ether. The NYSDEC has established a generic standard of 50 ppb for all unspecified organic compounds. No other organic compounds were detected in the STP discharge during 1999.

5.3 ASSESSMENTS OF PROCESS-SPECIFIC WASTEWATER

Wastewater that may potentially contain constituents above SPDES permit limits or groundwater discharge standards is held and characterized to determine the appropriate means of disposal. The analytical results are compared with the appropriate limit, and the wastewater released only if the discharge would not jeopardize the quality of the effluent.

The SPDES permit includes requirements

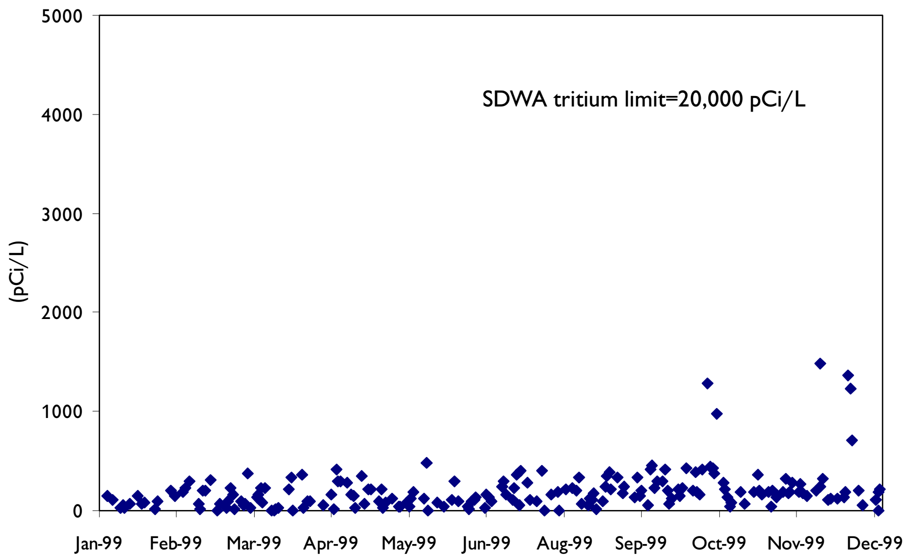
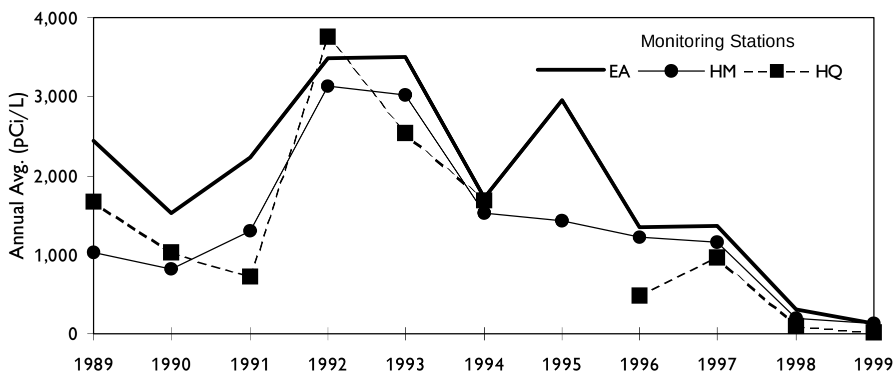


Figure 5-3. 1999 STP Effluent Tritium Concentrations.



Note: There were no samples collected at Monitoring Station HQ in 1995 due to low water table conditions.

Figure 5-4. STP/Peconic River Annual Average Tritium Concentrations 1989 – 1999.

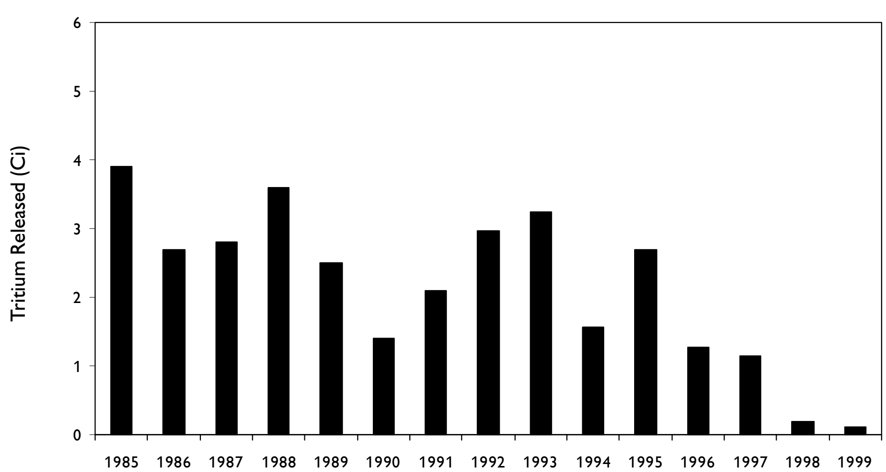


Figure 5-5. Tritium Released to the Peconic River, 15 Year Trend 1985 - 1999.

Table 5-3. Sewage Treatment Plant (STP) Average Water Quality and Metals Data (1999).

	STP Influent				STP Effluent				SPDES Limit or Ambient Water Quality Standard*
	No. of Samples	Min	Max	Avg	No. of Samples	Min	Max	Avg	
pH (SU)(1)	235	6.1	7.8	NA	230	6.1	7.5	NA	5.8 - 9.0
Conductivity (umhos/cm)(2)					230	6.7	386	258	NA
Temperature (°C)(1,2)					230	4.4	27.2	16.9	NA
Dissolved Oxygen (mg/L)	NA	NA	NA	NA	230	5.7	14.8	9.3	NA
Chlorides (mg/L)	12	21.9	39.5	27.6	12	25	45	33	NA
Nitrate as N (mg/L)	12	1.1	3.7	2.6	12	2.5	6.6	5.9	10 (Total N)
Sulfates (mg/L)	12	12	16	14	12	13.1	16.7	15	250 (GA)
Aluminum (ug/L)	12	37.4	1281	210.6	12	14.7	118.2	35.9	100 (Ionic)
Antimony (ug/L)	12	< 0.88	< 0.88	< 0.88	12	< 0.88	< 0.88	< 0.88	3 (GA)
Arsenic (ug/L)	12	< 3	< 3	< 3	12	< 3	< 3	< 3	150 (Dissolved)
Barium (ug/L)	12	20.5	133.6	37.1	12	12.5	24.9	16.4	1000 (GA)
Beryllium (ug/L)	12	< 0.66	< 0.66	< 0.66	12	< 0.66	< 0.66	< 0.66	11 (Acid Soluble)
Cadmium (ug/L)	12	< 1.1	2	< 1.1	12	< 1.1	< 1.1	< 1.1	1.1 (Dissolved)
Chromium (ug/L)	12	< 1	16.3	2.9	12	< 1	3.5	1.1	34.4 (Dissolved)
Cobalt (ug/L)	12	0.25	1.6	0.7	12	0.18	0.47	0.35	5 (Acid Soluble)
Copper (ug/L)	12	31.6	608.5	121.9	12	30.2	60.2	45.9	150 (SPDES)
Iron (ug/L)	12	< 0.075	4400	957	12	< 75	234	101	370 (SPDES)
Mercury (ug/L)	12	< 0.2	4.7	0.9	12	< 0.2	0.8	< 0.2	0.8 (SPDES)
Manganese (ug/L)	12	8.5	29.4	13.8	12	1.9	12	4.6	300 (GA)
Molybdenum (ug/L)	12	< 5	28.4	< 5	12	< 5	< 5	< 5	NA
Sodium (mg/L)	12	29.6	38	33.6	12	30.6	39.3	35.8	NA
Nickel (ug/L)	12	1.8	15.9	4.7	12	2.4	4.7	3.3	110 (SPDES)
Lead (ug/L)	12	2.9	50.2	11.9	12	< 1.3	2.5	< 1.3	19 (SPDES)
Selenium (ug/L)	12	< 5	5	< 5	12	< 5	< 5	< 5	4.6 (Dissolved)
Silver (ug/L)	12	< 1	5.9	< 1	12	< 1	3.7	2	15 (SPDES)
Thallium (ug/L)	12	< 0.66	< 0.66	< 0.66	12	< 0.66	< 0.66	< 0.66	8 (Acid Soluble)
Vanadium (ug/L)	12	< 5.5	17.2	< 5.5	12	< 5.5	10.2	< 5.5	14 (Acid Soluble)
Zinc (ug/L)	12	< 4.0	228.2	77	12	< 4	55.6	32.4	100 (SPDES)

Notes:
See Figure 5-1 for locations of the the STP Influent and Effluent
All analytical results were generated using total recoverable analytical techniques.
*Unless otherwise provided, the reference standard is Class C surface water.
For Class C standards, the solubility state for the metal is provided.
SPDES=State Pollutant Discharge Elimination System
NA=Not Applicable or Not Analyzed
GA=Class GA (groundwater) Ambient Water Quality Standard
(1)The pH and temperature values reported are based upon analysis of daily grab samples.
(2)Continuously monitored by STP operators.

for the quarterly sampling and analysis of process-specific wastewater discharged from the photographic developing operations in Building 197B, the printed-circuit-board fabrication operations conducted in Building 535B, the metal cleaning operations in Building 498, cooling tower discharges from Building 902, and miscellaneous satellite boiler blowdown. These operations were monitored for contaminants such as inorganic elements (i.e., metals), cyanide, and volatile and semi-volatile organic compounds. Analyses of these waste streams showed that, while several contributed contaminants to the STP in concentrations exceeding SPDES permitted levels, the ranges of concentrations of these wastes were comparable to typical STP influent levels and are effectively treated at the STP prior to release. Consequently, these discharges had little to no impact on the STP effluent water quality.

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 sewer. These process wastewaters typically included: ion-exchange column regeneration wastes, primary closed-loop cooling water systems, 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 compared to the SPDES and radiological effluent limits. If the concentrations were within limits, authorization for sewer disposal was granted; if not, alternate means of disposal were pursued. Any waste that contained hazardous levels of contaminants or elevated radiological contamination was sent to the waste management facility for disposal.

5.4 RECHARGE BASINS

Figure 5-6 depicts the locations of BNL's recharge basins. An overall schematic of water use at BNL is shown in Figure 5-7.

Nine recharge basins are used for the management of once-through cooling water, cooling tower blowdown, and stormwater runoff, and are described below. Outfalls 002A and 002B did not operate in 1999.

- ♦ Recharge Basins HN and HT receive once-through cooling water discharges generated at the Alternating Gradient Synchrotron (AGS) as well as cooling tower blowdown and storm water runoff.
- ♦ Recharge Basin HS receives predominantly storm water runoff, once-through cooling water from Bldg. 555, and minimal cooling tower blowdown from the National Synchrotron Light Source.
- ♦ Basin HX receives Water Treatment Plant filter backwash water.
- ♦ Basin HP receives once-through cooling water from the Brookhaven Medical Research Reactor (BMRR).
- ♦ Recharge Basin HO receives cooling water and cooling tower discharges from the AGS and HFBR, and stormwater runoff. At the AGS, a polyelectrolyte and dispersant were added to the cooling water supply to keep the naturally-occurring iron in solution and prevent surface deposition within the heat exchangers. In order to improve heat exchanger efficiency, the AGS switched from well water to the domestic water system in

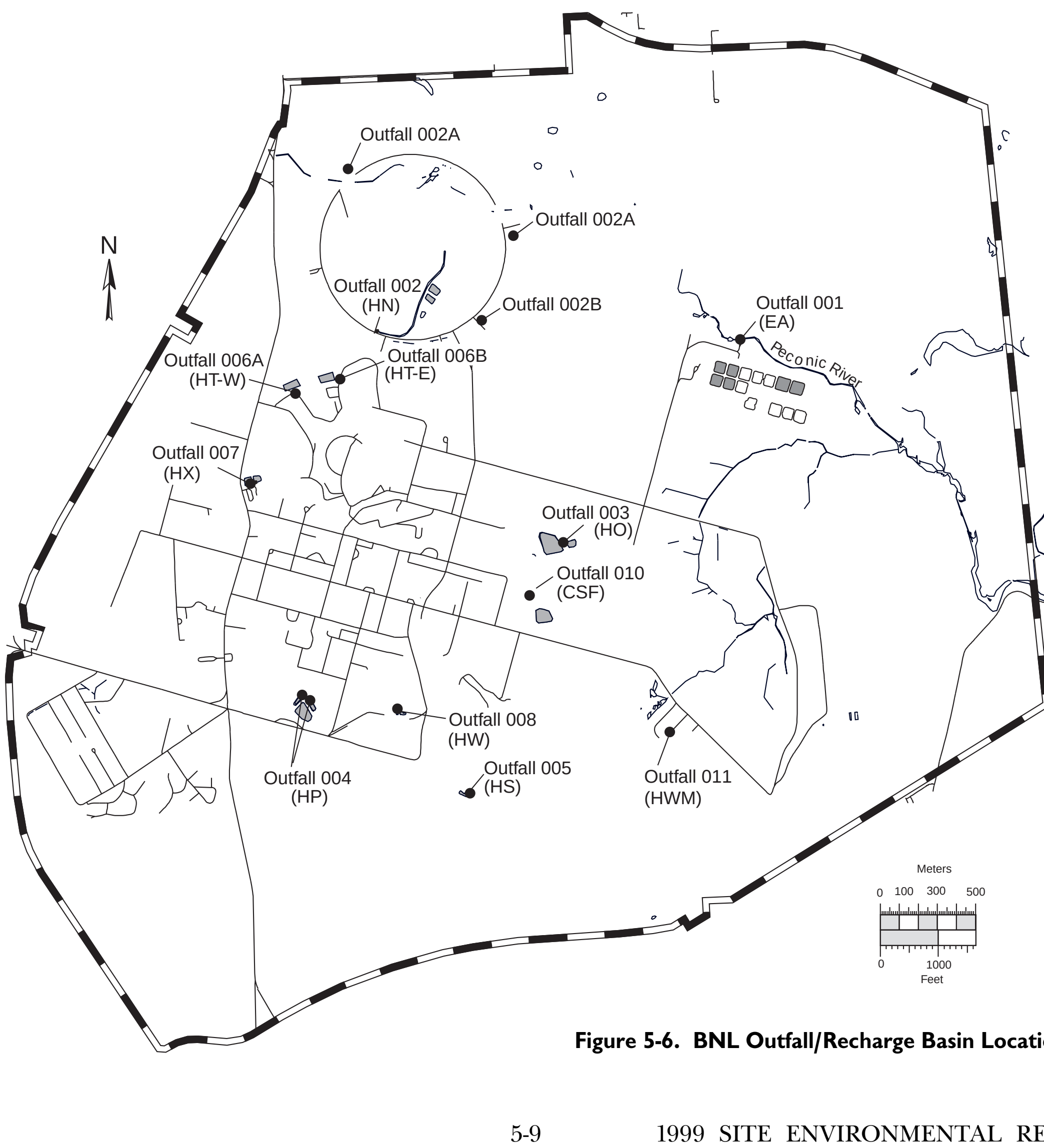


Figure 5-6. BNL Outfall/Recharge Basin Locations.

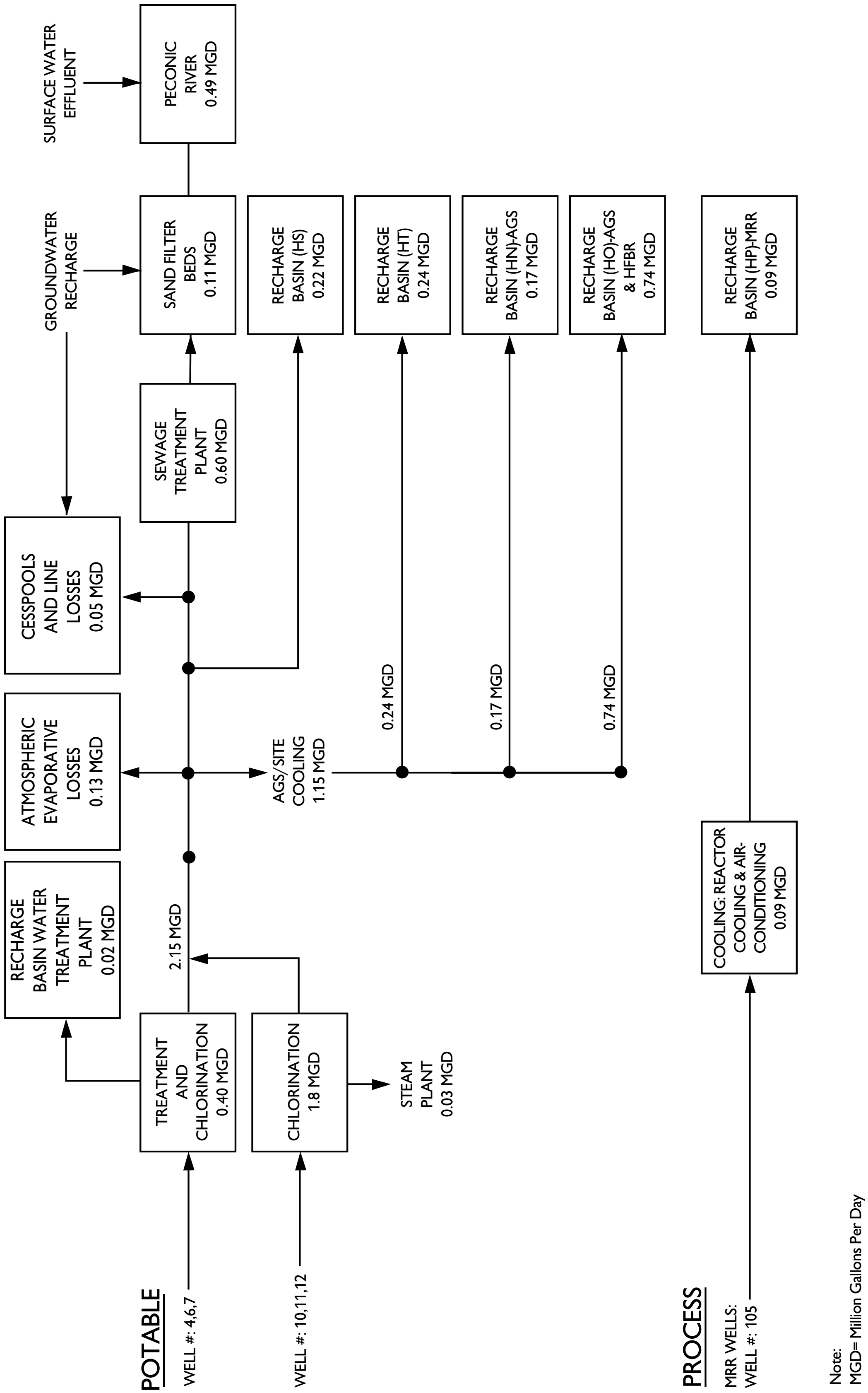


Figure 5-7. Brookhaven National Laboratory Schematic of Water Use and Flow for 1999.

August 1998. Additionally, in 1999 a temperature-controlled discharge valve was installed at the AGS to conserve water. The installation of this valve and the shutdown of the HFBR resulted in the lowest rate of discharge to this recharge basin. Approximately 0.7 MGD of water was discharged as compared to 1.1 MGD in prior years.

- In addition, several other recharge areas were used exclusively for discharging stormwater runoff; including Basin HW (Outfall 008), the Central Steam Facility stormwater outlet (Outfall 010) and the stormwater outlet in the former Waste Management Facility (Outfall 011).

Each of the recharge basins is a permitted point source discharge under BNL's SPDES permit. Where required, each outfall was equipped with a flow monitoring station. Weekly recordings of flow were maintained, along with records of pH, conductivity, and temperature. The specifics of the SPDES compliance-monitoring program are provided in Chapter 3. To supplement the SPDES compliance sampling program, samples were also collected routinely and analyzed under the environmental monitoring program for volatile organic compounds (VOCs), metals, and anions. During 1999, water samples were collected from Basins HN, HO, HP, HS, HT, HW, and the Central Steam Facility stormwater outfall. Since the Water Treatment Plant had minimal operations in 1999, there were no discharges to Recharge Basin HX.

5.4.1 RECHARGE BASINS - RADIOLOGICAL ANALYSES

Discharges to the recharge basins were sampled throughout the year to determine concentrations of gross activity, gamma-emitting radionuclides and tritium (if any). Radiological results for water samples collected at the recharge basins are presented in Table 5-4. There were no elevated gross activity levels nor tritium observed in any basin. No gamma-emitting radionuclides attributable to BNL operations were detected.

5.4.2 RECHARGE BASINS - NONRADIOLOGICAL ANALYSES

To determine the overall impact of the recharge basin discharges on the environment, the data from samples collected from the discharges were compared to groundwater discharge standards promulgated under Title 6 of the New York Code of 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 (i.e., 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. For VOCs, low concentrations of disinfection by-products were routinely detected in several discharges, as expected, including bromoform, chloroform, dibromochloromethane, and dichlorobromomethane. Concentrations ranged from non-detectable to a maximum of 23 ppb. Sodium hypochlorite and bromine used to control algae in cooling towers were responsible for the formation of these compounds. Acetone was also detected sporadically in several samples across BNL at concentrations up to 6 ppb. With the exception of a single detection of xylene (19 ppb) in Recharge Basin HN, there were no organic compounds detected in these discharges. Xylene is a compound found commonly in gasoline. Its presence in this discharge may have been due to parking lot runoff.

The analytical data in Tables 5-5 and 5-6 showed that most parameters, except for aluminum, antimony, cobalt, iron, and lead, complied with the respective groundwater discharge or water quality standards. Aluminum, antimony, cobalt, iron, and lead are typically found in stormwater discharges, most likely due to the suspension of natural sediments. Local soils contain naturally occurring concentrations of these elements and when these samples are acidified, these elements become dissolved. Iron is also present in Long Island groundwater at concentrations that exceeded the groundwater effluent limit. Groundwater used in and discharged from once-through heat exchangers at the AGS and Brookhaven Medical Research Reactor was the source of the elevated iron levels found in these basins. The pH measured at several of the recharge basins was typically outside the groundwater effluent standard of 6.5 – 8.5 Standard Units. The pH of local groundwater is known to be lower than the standard, and thus was the most likely cause of low pH observations. High pH excursions are the result of discharges of domestic water used in once-through heat exchange systems. To minimize corrosion of piping systems, the pH of the domestic water system is maintained between 8.0 – 8.5 Standard Units. Periodically, the pH of

Table 5-4. Radiological Analysis Results for Onsite Recharge Basin Samples (1999).

Basin		Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Tritium (pCi/L)	Sr-90 (pCi/L)
HN	N	5	5	5	2
	Max.	1.8 ± 0.6	4.3 ± 1.2	< 327	< 0.2
	Avg.	0.4 ± 1.0	2.9 ± 1.4	174 ± 51	-0.1 ± 0.1
HO	N	7	7	7	2
	Max.	4.6 ± 1.1	5.5 ± 1.5	< 316	<0.4
	Avg.	1.5 ± 1.6	2.9 ± 1.1	49 ± 118	-0.1 ± 0.1
HP	N	3	3	3	NS
	Max.	1.5 ± 0.6	6.3 ± 1.4	< 332	
	Avg.	0.6 ± 0.7	5.0 ± 1.1	60 ± 14	
HS	N	4	4	4	NS
	Max.	2.4 ± 0.7	6.5 ± 1.5	< 332	
	Avg.	1.4 ± 1.2	4.7 ± 1.0	-5 ± 65	
HT-E	N	5	5	5	2
	Max.	1.6 ± 0.6	4.6 ± 1.4	< 316	0.9 ± 0.2
	Avg.	0.1 ± 0.8	2.3 ± 1.9	78 ± 97	-0.4 ± 1.8
HT-W	N	5	5	4	2
	Max.	1.8 ± 0.6	4.6 ± 1.2	< 327	<0.7
	Avg.	-0.1 ± 1.0	2.2 ± 2.4	113 ± 36	-1.8 ± 0.7
HW	N	1	1	NS	NS
	Max.	0.9	2.5		
	Avg.	0.9	2.5		
CSF	N	1	1	1	NS
	Max.	< 0.8	10.8	< 332	
	Avg.	0.3	10.8	106	
SDWA Limit		15	50	20,000	8

Notes:
See Figure 5-6 for locations of Outfall/Recharge Basins.
All values reported with a 95% confidence interval.
Negative numbers occur when measured value is lower than background.
N = Number of samples collected for analysis.
NS = Not sampled for this analyte.
CSF = Central Steam Facility
SDWA=Safe Drinking Water Act

the system exceeded 8.5 causing the pH of the cooling water releases to exceed permitted levels. Under the SPDES program, the effluent limit for these discharges was raised by the NYSDEC to 9.0 in recognition of the high pH of the domestic water system.

5.4.3 STORMWATER ASSESSMENT

With the exception of Recharge Basins HP and HX, all recharge basins receive stormwater runoff. At BNL, stormwater is managed by collecting runoff from paved surfaces, roofs and other impermeable surfaces and directing it to the recharge basins via underground piping and abovegrade, vegetated swales. Recharge Basin HS receives the majority of the stormwater runoff from the central developed portion of the BNL site (all properties south of Cornell Avenue and east of Railroad Avenue). Basins HN and HT-E receive runoff from the AGS and portions of the RHIC and Basin HO receives runoff from the BGRR and HFBR areas. As previously indicated, Basin HW and Basin CSF receive only stormwater runoff, HW from both the warehouse area and the CSF from the steam plant.

Stormwater runoff from the BNL site typically has elevated levels of inorganics and low pH. The inorganics are attributable to high sediment content and natural occurrence of these elements in native soils. The concentration of lead in one sample collected from the Central Steam Facility was much higher than that seen at other areas of BNL. High concentrations of lead have also been detected in soil samples, but at concentrations that were less than local and federal action levels. Suspension of these soils was the most likely cause of the elevated lead concentrations in the runoff.

Table 5-5. Water Quality Data for Onsite Recharge Basins (1999).

Recharge Basin		pH (SU)	Conductivity (µS/cm)	Temperature (°C)	Chlorides (mg/L)	Sulfates (mg/L)	Nitrate as N* (mg/L)
HN	N	19	10	19	5	5	5
(RHIC Recharge)	Min.	6.9	60	4.1	< 4	< 4	< 1
	Max.	8.7	313	24.1	22.1	13.7	1.2
	Avg.	NA	172	14.1	14.2	9.0	< 1
HO	N	16	7	16	7	7	7
(AGS-HFBR)	Min.	7.1	144	8.9	14.5	8.2	< 1
	Max.	8.3	249	23.6	21.1	14.8	1.2
	Avg.	NA	176	16.4	17.0	10.9	< 1
HP	N	6	3	6	3	3	3
(BMRR)	Min.	5.8	179	12.3	33.0	14.4	< 1
	Max.	6.5	211	23.7	37.0	18.7	1.4
	Avg.	NA	196	15.6	35.4	15.9	< 1
HS	N	17	8	17	4	4	4
(Stormwater)	Min.	5.7	74	1.2	5.9	6.0	< 1
	Max.	8.9	248	28.9	33.2	16.3	1.5
	Avg.	NA	160	13.6	18.7	11.4	< 1
HT-E	N	18	9	18	5	5	5
(AGS)	Min.	6.2	111	4.5	15.9	10.1	< 1
	Max.	8.2	247	22.3	20.1	14.0	1.2
	Avg.	NA	183	15.7	18.12	11.6	< 1
HT-W	N	17	8	17	5	5	5
(LINAC)	Min.	6.8	152	4.0	17.0	11.5	< 1
	Max.	8.4	241	26.1	24.6	17.2	1.5
	Avg.	NA	193	16.7	20.5	13.2	< 1
HW	N	12	4	12	4	4	4
(Weaver Rd.)	Min.	7.0	28	2.9	< 4	< 4	< 1
	Max.	7.7	260	23.8	4.5	5.2	< 1
	Avg.	NA	94	13.6	< 4	< 4	< 1
CSF	N	9	3	9	3	3	3
(Stormwater)	Min.	6.0	44	4.3	< 4	< 4	< 1
	Max.	7.7	258	23.8	55.7	4.9	< 1
	Avg.	NA	118	13.6	18.6	< 4	< 1
NYSDEC							
Effluent Standard		6.5 - 8.5	SNS	SNS	500	500	20
Typical MDL		NA	10	NA	4	4	1

Notes:
See Figure 5-6 for locations of Recharge Basins.
*The holding times specified by the EPA were exceeded for several of these samples.
N=No. of samples
NA=Not Applicable
SNS=Effluent Standard Not Specified
MDL=Minimum Detection Limit

RHIC=Relativistic Heavy Ion Collier
AGS/HFBR=Alternating Gradient Synchrotron/High Flux Beam Reactor
BMRR=Brookhaven Medical Research Reactor
CSF=Central Steam Facility
NYSDEC=New York Sate Department of Environmental Conservation

5.5 PECONIC RIVER SURVEILLANCE

Several locations were monitored along the Peconic River to assess the overall quality of the river water and to assess the impact of BNL discharges. Sampling points along the Peconic River are identified in Figure 5-8. In total, ten stations are monitored: three upstream and seven downstream of the STP outfall. Of the seven downstream locations, four are offsite (HA, HB, HC, HR), two are directly downstream of the STP discharge (HMn, HQ), and one is along a typically dry tributary to the river (HMs) and is not influenced by STP discharges. In addition, a river station along the Carmans River is also monitored as a control location (HH). All locations are monitored for radiologi-

Table 5-6. Metals Data for Onsite Recharge Basins (1999).

Recharge Basin	N		Ag ug/L	Al ug/L	As ug/L	Ba ug/L	Be ug/L	Cd ug/L	Co ug/L	Cr ug/L	Cu ug/L	Fe mg/L	Hg ug/L	Mn ug/L	Mo ug/L	Na mg/L	Ni ug/L	Pb ug/L	Sb ug/L	Se ug/L	Tl ug/L	V ug/L	Zn ug/L
HN	5	Min.	< 1.0	87.9	< 3.0	10.4	< 0.66	< 1.1	0.2	< 1.0	22.5	0.15	< 0.2	6.1	< 5.0	4.0	< 1.1	1.3	< 0.88	< 5	< 0.66	< 5.5	21.2
(RHIC)		Max.	< 1.0	168.7	< 3.0	28.3	< 0.66	< 1.1	0.6	1.6	89.1	2.8	< 0.2	134.2	< 5.0	35.3	1.6	8.1	< 0.88	< 5	< 0.66	< 5.5	66.0
		Avg.	< 1.0	121.0	< 3.0	20.9	< 0.66	< 1.1	0.3	< 1.0	56.6	0.7	< 0.2	36.6	< 5.0	19.2	< 1.1	3.4	< 0.88	< 5	< 0.66	< 5.5	43.3
HO	7	Min.	< 1.0	5.7	< 3.0	18.4	< 0.66	< 1.1	< 0.12	< 1.0	2.9	< 0.075	< 0.2	2.7	< 5.0	13.5	< 1.1	< 1.3	< 0.88	< 5	< 0.66	< 5.5	< 4.0
(AGS/HFBR)		Max.	< 1.0	39.7	< 3.0	29.4	< 0.66	< 1.1	0.16	< 1.0	9.3	0.24	< 0.2	25.0	< 5.0	27.8	< 1.1	< 1.3	< 0.88	< 5	< 0.66	< 5.5	22.5
		Avg.	< 1.0	22.6	< 3.0	21.5	< 0.66	< 1.1	< 0.12	< 1.0	6.4	< 0.075	< 0.2	11.1	< 5.0	21.9	< 1.1	< 1.3	< 0.88	< 5	< 0.66	< 5.5	11.9
HP	3	Min.	< 1.0	3.4	< 3.0	37.7	< 0.66	< 1.1	0.17	< 1.0	3.5	< 0.075	< 0.2	53.5	< 5.0	18.1	< 1.1	< 1.3	< 0.88	< 5.0	< 0.66	< 5.5	< 4.0
(BMRR)		Max.	< 1.0	328.7	< 3.0	61.0	< 0.66	< 1.1	0.48	< 1.0	7.5	1.00	< 0.2	102.1	< 5.0	19.8	< 1.1	< 1.3	< 0.88	< 5.0	< 0.66	< 5.5	36.4
		Avg.	< 1.0	112.8	< 3.0	48.1	< 0.66	< 1.1	0.28	< 1.0	4.9	0.36	< 0.2	70.1	< 5.0	18.9	< 1.1	< 1.3	< 0.88	< 5.0	< 0.66	< 5.5	15.0
HS	3	Min.	< 1.0	90.7	< 3.0	12.0	< 0.66	< 1.1	< 0.12	< 1.0	14.9	0.08	< 0.2	2.5	< 5.0	5.8	< 1.1	1.3	< 0.88	< 5.0	< 0.66	< 5.5	< 4.0
(Stormwater)		Max.	< 1.0	66.9	< 3.0	29.7	< 0.66	< 1.1	0.18	< 1.0	18.9	0.14	< 0.2	4.8	< 5.0	32.2	1.2	3.6	< 0.88	< 5.0	< 0.66	< 5.5	34.8
		Avg.	< 1.0	24.5	< 3.0	22.4	< 0.66	< 1.1	< 0.12	< 1.0	16.6	0.12	< 0.2	2.5	< 5.0	20.4	< 1.1	2.2	< 0.88	< 5.0	< 0.66	< 5.5	16.2
HTE	5	Min.	< 1.0	6.8	< 3.0	16.8	< 0.66	< 1.1	< 0.12	< 1.0	8.4	< 0.075	< 0.2	< 2.0	< 5.0	22.8	< 1.1	< 1.3	< 0.88	< 5.0	< 0.66	< 5.5	< 4.0
(AGS)		Max.	< 1.0	79.7	< 3.0	32.5	< 0.66	< 1.1	0.13	1.1	17.1	0.15	< 0.2	5.9	< 5.0	29.2	< 1.1	3.1	< 0.88	< 5.0	< 0.66	< 5.5	23.8
		Avg.	< 1.0	34.4	< 3.0	24.7	< 0.66	< 1.1	< 0.12	< 1.0	12.6	< 0.075	< 0.2	2.9	< 5.0	24.9	< 1.1	< 1.3	< 0.88	< 5.0	< 0.66	< 5.5	8.8
HT-W	5	Min.	< 1.0	10.8	< 3.0	19.5	< 0.66	< 1.1	< 0.12	< 1.0	16.0	< 0.075	< 0.2	< 2.0	< 5.0	24.3	< 1.1	< 1.3	< 0.88	< 5.0	< 0.66	< 5.5	7.6
(LINAC)		Max.	< 1.0	51.6	< 3.0	31.2	< 0.66	< 1.1	0.14	1.9	28.0	0.1	< 0.2	11.6	< 5.0	36.1	< 1.1	1.4	< 0.88	< 5.0	< 0.66	< 5.5	27.5
		Avg.	< 1.0	29.2	< 3.0	24.2	< 0.66	< 1.1	< 0.12	< 1.0	22.3	0.1	< 0.2	4.2	< 5.0	28.1	< 1.1	< 1.3	< 0.88	< 5.0	< 0.66	< 5.5	17.9
HW	4	Min.	< 1.0	< 2.2	< 3.0	7.0	< 0.66	< 1.1	0.2	< 1.0	9.7	< 0.075	< 0.2	< 2.0	< 5.0	1.5	2.1	< 1.3	< 0.88	< 5.0	< 0.66	< 5.5	21.9
(Weaver Rd.)		Max.	< 1.0	983.7	< 3.0	18.5	< 0.66	2.2	0.8	8.7	93.0	1.04	< 0.2	20.7	10	2.2	5.5	34.0	1.2	< 5.0	< 0.66	6.1	4,060.0
		Avg.	< 1.0	447.3	< 3.0	11.5	< 0.66	1.3	0.6	3.7	42.6	0.42	< 0.2	11.8	< 5.0	2.0	3.8	23.2	< 0.88	< 5.0	< 0.66	< 5.5	75.0
CSF	3	Min.	< 1.0	2,170.8	< 3.0	16.3	< 0.66	< 1.1	1.0	4.5	51.6	1.4	< 0.2	27.9	< 5.0	1.7	8.2	18.0	< 0.88	< 5.0	< 0.66	25.3	44.9
(Stormwater)		Max.	6.7	8,616.0	3.1	118.6	< 0.66	2.6	6.7	23.2	199.9	8.8	< 0.2	128.9	< 5.0	26.5	131.0	1,880.0	25.8	< 5.0	< 0.66	342.4	295.0
		Avg.	2.2	4,414.3	< 3.0	53.0	< 0.66	< 1.1	3.1	10.8	142.1	4.1	< 0.2	63.9	< 5.0	10.1	50.2	639.7	9.0	< 5.0	< 0.66	131.8	136.8
NYSDEC Effluent Limitation or AWQS			50	2,000	50	2,000	SNS	10	5	100	1,000	0.6	1.4	600	SNS	SNS	200	50	6	20	SNS	SNS	5,000
Typical MDL			1	2.2	3	1.8	0.66	1.1	0.12	1	2	15	0.2	2	5	1	1.1	1.3	0.88	5	0.66	5.5	4

Notes:
See Figure 5-6 for locations of Recharge Basins.
N=No. of samples
AWQS=Ambient Water Quality Standard
SNS=Effluent Standard Not Specified
MDL=Minimum Detection Limit

RHIC=Relativistic Heavy Ion Collider
AGS/HFBR=Alternating Gradient Synchrotron/High Flux Beam Reactor
BMRR=Brookhaven Medical Research Reactor
CSF=Central Steam Facility
NYSDEC=New York State Department of Conservation

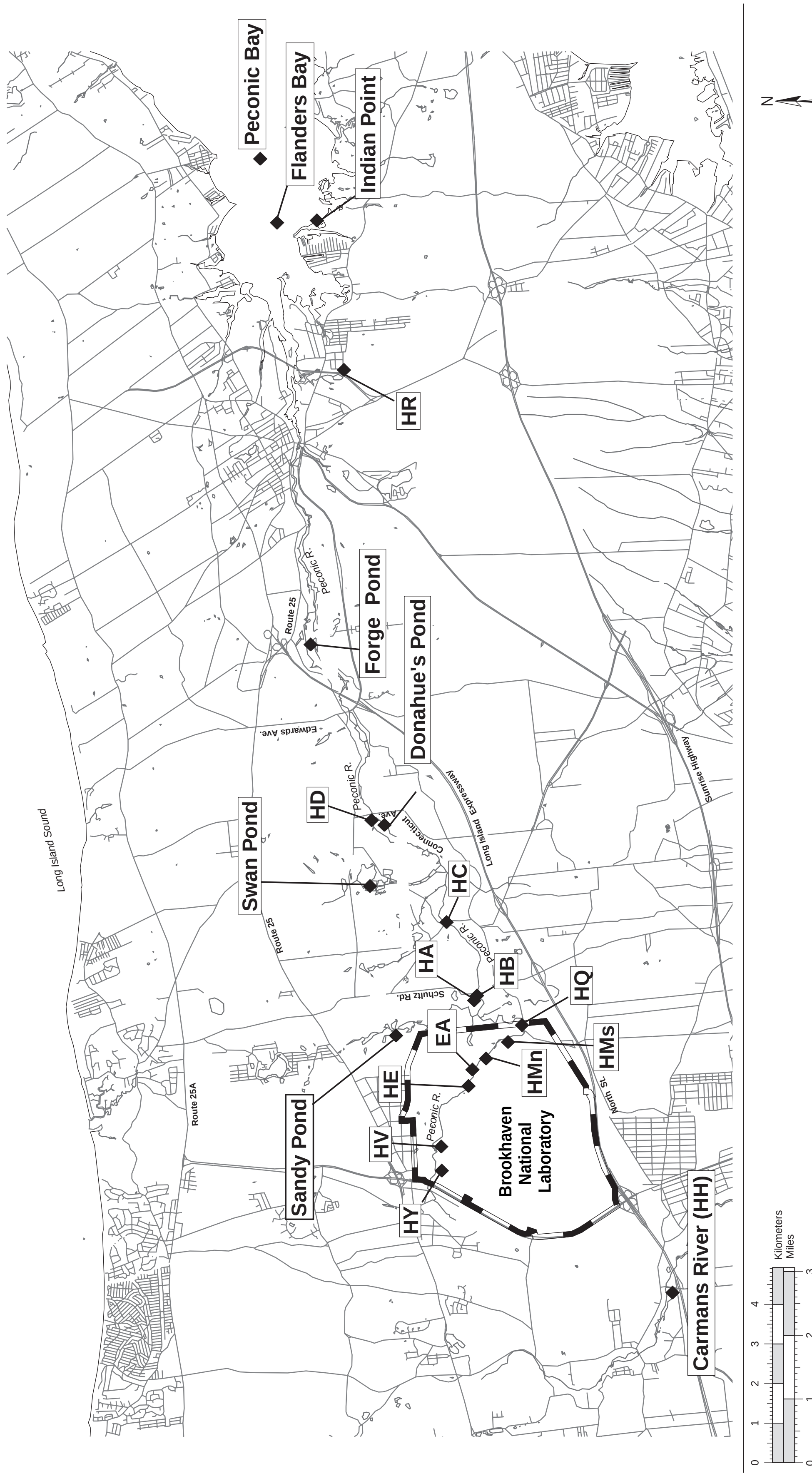


Figure 5-8. Surface Water Sampling Stations.

cal and nonradiological parameters on a routine basis. In addition, to assess the river quality upstream of the BNL site, two additional monitoring stations were added in 1999. Upstream stations now include: Station HE which is located immediately upstream of the STP discharge; Station HV, located onsite and just inside the RHIC ring at the 10 o'clock location; and Station HY, located onsite and east of the William Floyd Parkway.

5.5.1 PECONIC RIVER - RADIOLOGICAL ANALYSES

Radionuclide measurements were performed on surface water samples collected from the Peconic River at all ten locations: Station HMn, 0.5 miles downstream of the STP Outfall; Station HMs, a typically dry tributary of the Peconic River; Station HQ, 1.2 miles downstream from the STP; Stations HA and HB, 3.1 miles downstream; Station HC, 4.3 miles downstream; Station HR in Riverhead, 13 miles downstream from the STP Outfall; Station HV, located just east of the 10 o'clock Experimental Hall in the RHIC ring; and Station HY located offsite just west of the William Floyd Parkway. The Carmans River in North Shirley was also sampled as a control location (Station HH) as it is not influenced by BNL liquid effluents.

Routine samples at Stations HMn and HQ were collected three times per week, as flow permitted. Station HE was collected monthly in 1999, as flow permitted. Since February 1995, these three locations have been equipped with Parshall flumes that allow automated flow-proportional sampling and volume measurements. All other sites were sampled quarterly by collecting instantaneous grab samples, as flow allowed.

The radiological data results for Peconic River surface water sampling are summarized in Table 5-7. Radiological analysis of upstream water samples showed that gross alpha and beta activities were occasionally detected at low levels at all three locations.

- ♦ A single value of 19.8 ± 1.6 pCi/L gross alpha was reported at Station HE in August.
- ♦ The maximum beta activity detected at Station HE was 23.1 ± 1.9 pCi/L which was consistent with the upstream offsite (i.e., background) measurements of 23.8 ± 2.0 pCi/L collected at Station HY.
- ♦ Although occasional detectable levels of gross alpha and gross beta activity were reported at Station HMn, the annual averages were equivalent to background levels.The maximum values for gross alpha and gross beta at Station HMn were 21.7 ± 4.5 and 26.2 ± 6.6 pCi/L respectively.
- ♦ Tritium was not detected in any of the upstream stations and was rarely found above detection limits at Station HMn.
- ♦ Strontium-90 was detected at Station HE at a maximum concentration of 0.96 pCi/L, which is approximately 12% of the drinking water standard. Concentrations of strontium-90 downstream of the STP discharge were less than half the upstream concentration and barely above the detection limits. All average concentrations were at or below the MDLs.

Samples at Station HQ (located at the eastern site boundary) were collected for gross alpha and gross beta activity, strontium-90, and tritium analyses.

- ♦ The annual average gross alpha and gross beta activity values were below typical MDLs. Maximum values were consistent with upstream levels.
- ♦ All tritium concentrations recorded were below the detection levels reflecting the trend recorded at the STP outfall. Tritium was not detected in any quarterly Peconic River sample collected beyond the BNL site.
- ♦ Similarly, average gross alpha and beta concentrations were either non-detectable or consistent with background concentrations.
- ♦ No gamma-emitting radionuclides attributable to BNL operations were detected throughout the Peconic River system.

5.5.2 PECONIC RIVER - NONRADIOLOGICAL ANALYSES

Organic and inorganic analytical data for Peconic River and Carmans River samples are summarized in Tables 5-8 and 5-9. During 1999, these samples were analyzed for water quality parameters (i.e., pH, temperature, conductivity, and dissolved oxygen), anions (i.e., chlorides, sulfates, and nitrates), metals, and VOCs. No VOCs were routinely detected in river water samples above the MDLs, although low concentrations were reported for acetone (11 ppb or less) and 2-butanone (2 ppb or less) at several locations. Due to the level of detection and the ubiquitous nature of these compounds in the analytical laboratory, the presence of these compounds was questionable. Several semi-volatile compounds (1,2,3- and 1,2,4-trichlorobenzene, hexachlorobutadiene and naphthalene) were detected in a single grab

Table 5-7. Radiological Analysis of Peconic River Water Samples (1999).

Sample Station	Geographic Location		Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Tritium (pCi/L)	Sr-90 (pCi/L)
HY	Peconic River (Headwaters)	N	5.0	5.0	4	NS
	Onsite, west of the RHIC ring	Max.	2.2 ± 0.6	23.8 ± 2.0	< 332	
		Avg.	0.9 ± 0.8	7.7 ± 7.1	-80 ± 116	
HV	Peconic River (Headwaters)	N	4.0	4.0	4	NS
	Onsite, inside the RHIC ring	Max.	1.4 ± 0.6	9.9 ± 1.6	< 327	
		Avg.	0.6 ± 0.5	4.3 ± 3.2	5 ± 104	
HE	Peconic River,	N	9	9	9	8
	Upstream of STP	Max.	19.8 ± 1.6	23.1 ± 1.9	< 316	0.96 ± 0.15
	Outfall	Avg.	2.8 ± 3.9	2.3 ± 6.0	-33 ± 79	0.31 ± 0.40
HM-N	Peconic River,	N	152	152	152	4
	0.7 km from STP,	Max.	21.7 ± 4.5	26.2 ± 6.6	1160 ± 229	0.20 ± 0.96
	Onsite	Avg.	2.1 ± 0.4	7.3 ± 0.7	132 ± 33	-0.40 ± 0.90
HM-S	Peconic River	N	4	4	3	4
	tributary, Onsite	Max.	1.1 ± 0.6	6.3 ± 1.4	< 316	0.40 ± 0.18
		Avg.	0.5 ± 0.4	-1.3 ± 7.4	112 ± 151	-0.30 ± 0.70
HQ[(1)]	Peconic River,	N	62	62	62	2
	BNL site boundary	Max.	5.1 ± 2.4	19.7 ± 5.8	< 328	0.30 ± 0.14
		Avg.	1.6 ± 0.3	7.9 ± 0.9	23 ± 32	-1.00 ± 1.70
HA	Peconic River,	N	4	4	3	NS
	Offsite	Max.	< 1.0	79.5 ± 3.0	< 327	
		Avg.	0.4 ± 0.2	21.0 ± 1.4	-43 ± 2	
HB	Peconic River,	N	4	4	3	NS
	Offsite	Max.	1.5 ± 0.6	11.0 ± 1.6	< 327	
		Avg.	0.4 ± 0.6	3.9 ± 4.1	-35 ± 105	
HC	Peconic River,	N	4	4	3	NS
	Offsite	Max.	0.9 ± 0.6	3.6 ± 1.4	< 327	
		Avg.	0.1 ± 0.5	2.3 ± 0.7	-4 ± 49	
HR	Peconic River,	N	4	4	4	NS
	Riverhead	Max.	< 0.9	5.8 ± 1.5	< 327	
		Avg.	0.0 ± 0.4	3.7 ± 1.3	-57 ± 66	
HH	Carmans River	N	4	4	4	NS
	(Control Location)	Max.	< 0.9	3.5 ± 1.3	< 332	
		Avg.	0.1 ± 0.5	2.2 ± 1.0	23 ± 70	
SDWA Limit			15.0	50.0	20,000	8

Notes:
See Figure 5-8 for sample station locations.
No gamma-emitting anthropogenic radionuclides were detected in Peconic River water samples in 1999.
All values shown with a 95% confidence interval.
Negative numbers occur when the measured value is lower than background.
Station HM-N and HQ Sr-90 analysis results based on composite samples, all others collected as grab samples.
N=Number of samples analyzed
NS=Not Sampled for this analyte
SDWA=Safe Drinking Water Act
(1)Station HQ was dry for 6 months during 1999.

sample collected at Station HQ in January. These compounds were not found in any sample collected upstream or downstream of this location. Due to the location of this station and the absence of these compounds upstream, these compounds are not expected to be the result of BNL operations but may be the result of road runoff.

Comparison of Peconic River water quality data collected upstream and downstream showed water quality parameters to be consistent throughout the river system. These data were also consistent with the Carmans River control location. The pH measured at these background locations was very low due to the low pH of precipitation and groundwater and the formation of humic acids from decaying organic matter. As the spring rains mix with the decaying matter, these acids lower the already low pH of precipitation, resulting in a pH of as low as 3.0.

Ambient water quality standards for metallic elements are based upon their solubility state.

Table 5-8. Water Quality Data for Surface Water Samples Collected Along the Peconic and Carmans Rivers (1999).

River	Sample Station		pH (SU)	Conductivity (μS/cm)	Temp. (°C)	Chlorides (mg/L)	Sulfates (mg/L)	Nitrates as N (mg/L)
Peconic	HE	N	15	15	15	9	9	9
		Min.	5.0	51	2.3	6.4	5	< 1
		Max.	7.6	230	45.5	21.3	30.1	4.8
		Avg.	NA	83	12.0	9.7	11.1	< 1
	HMn	N	154	154	154	12	12	12
		Min.	6.1	119	0.0	20	11.6	2.8
		Max.	7.1	345	25.4	37.1	15.8	5.9
		Avg.	NA	222	13.0	28.6	13.5	4.3
	HMs	N	4	4	4	4	4	4
		Min.	3.6	91	4.6	5.7	< 4	< 1
		Max.	3.9	143	17.9	7.5	12	< 1
		Avg.	NA	107	8.1	6.4	7	< 1
	HQ	N	60	60	60	4	4	4
		Min.	5.9	107	0.2	12.5	7.5	< 1
		Max.	7.8	260	17.5	40.1	13.1	2.2
		Avg.	NA	180	7.0	25.7	11.2	< 1
	HA	N	4	4	4	4	4	4
		Mini.	4.3	49	2.9	6.1	< 4	< 1
		Max.	7.9	61	25.5	9.6	7.5	< 1
		Avg.	NA	55	13.8	7.6	< 4	< 1
	HB	N	4	4	4	4	4	4
		Min.	6.0	54	3.1	7.8	<4	< 1
		Max.	7.2	63	24.4	8.9	6.8	< 1
		Avg.	NA	59	13.6	8.4	< 4	< 1
	HC	N	4	4	4	4	4	4
		Min.	6.2	60	3.6	9.3	< 4	< 1
		Max.	7.1	71	29.8	10.6	8.2	< 1
		Avg.	NA	67	15.7	10.0	4.7	< 1
	HR	N	4	4	4	4	4	4
		Min.	7.0	10	3.8	13.6	9.6	< 1
		Max.	7.3	115	28.9	15.4	10.7	< 1
		Avg.	NA	86	16.1	14.4	10.0	< 1
	HV	N	4	4	4	NS	NS	NS
		Min.	4.7	160	4.0			
		Max.	6.1	280	21.9			
		Avg.	NA	229	12.8			
	HY	N	5	5	5	NS	NS	NS
		Min.	5.3	40	2.1			
		Max.	7.8	765	22.5			
		Avg.	NA	229	12.3			
Carmans (Control Location)	HH	N	4	4	4	4	4	4
		Min.	6.2	152	4.7	21.8	10.2	1.1
		Max.	7.2	157	24.3	23.7	12.6	1.6
		Avg.	NA	155	14.2	22.5	11.3	1.5
NYSDEC AWQS[(a)]			6.5 - 8.5	SNS	SNS	250	250	10
Typical MDL			NA	10	NA	4	4	1

Notes:
See Figure 5-8 for sample station locations.
N=No. of samples
NA=Not Applicable
NS=Not Sampled
SNS=Standard Not Specified
MDL=Minimum Detection Limit
[(a)]Since there are no Class C Surface Water Ambient Water Quality Standards (AWQS) for these compounds, the AWQS for Groundwater is provided, if specified.

Table 5-9. Metals Concentration Data for Surface Water Samples Collected Along the Peconic and Carmans Rivers (1999).

River	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	Ni µg/L	Na mg/L	Pb µg/L	Sb µg/L	Se µg/L	Tl µg/L	V µg/L	Zn µg/L
Peconic	HE	9	Min.	< 1.0	27.2	< 3.0	15.5	< 0.66	< 1.1	0.35	< 1.0	< 2.0	< 75	< 0.2	3.6	< 5.0	< 1.1	4.8	< 1.3	< 0.88	< 5.0	< 0.66	< 5.5	17.1
			Max.	1.6	905.2	< 3.0	56.5	< 0.66	< 1.1	2.45	3.6	96.8	4144	< 0.2	480.8	< 5.0	6.7	30.0	8.0	3.13	< 5.0	< 0.66	6.1	99.5
			Avg.	< 1.0	457.5	< 3.0	27.5	< 0.66	< 1.1	1.27	1.1	23.8	427	< 0.2	163.8	< 5.0	3.1	8.5	2.6	< 0.88	< 5.0	< 0.66	< 5.5	44.6
	HMn	12	Min.	< 1.0	24.4	< 3.0	11.4	< 0.66	< 1.1	0.30	< 1.0	24.6	< 75	< 0.2	2.5	< 5.0	2.6	24.7	< 1.3	< 0.88	< 5.0	< 0.66	< 5.5	12.1
			Max.	4.3	1503.0	< 3.0	43.7	< 0.66	1.2	2.96	7.1	296.1	2600	1.7	129.2	< 5.0	6.5	39.3	26.6	< 0.88	< 5.0	< 0.66	10.8	162.6
			Avg.	1.6	236.9	< 3.0	18.4	< 0.66	< 1.1	0.60	2.0	64.6	400	0.2	20.5	< 5.0	3.2	32.2	4.6	< 0.88	< 5.0	< 0.66	3.3	43.2
	HMs	4	Min.	< 1.0	768.3	< 3.0	19.5	< 0.66	< 1.1	0.40	< 1.0	< 2.0	200	< 0.2	29.1	< 5.0	1.1	3.4	< 1.3	< 0.88	< 5.0	< 0.66	< 5.5	24.3
			Max.	< 1.0	1138.0	< 3.0	25.3	< 0.66	< 1.1	0.50	3.8	19.8	500	< 0.2	46.8	< 5.0	1.6	4.2	2.9	7.74	< 5.0	< 0.66	< 5.5	31.8
			Avg.	< 1.0	914.2	< 3.0	22.2	< 0.66	< 1.1	0.50	< 1.0	5.0	300	< 0.2	40.0	< 5.0	1.3	3.6	< 1.3	1.90	< 5.0	< 0.66	< 5.5	27.5
	HQ	5	Min.	< 1.0	101.6	< 3.0	8.9	< 0.66	< 1.1	0.27	< 1.0	15.7	200	< 0.2	5.0	< 5.0	2.9	19.3	< 1.3	< 0.88	< 5.0	< 0.66	< 5.5	21.0
			Max.	1.4	181.3	< 3.0	10.9	< 0.66	< 1.1	0.46	3.3	78.6	2900	< 0.2	16.9	< 5.0	8.4	29.1	2.2	< 0.88	< 5.0	< 0.66	< 5.5	284.9
			Avg.	< 1.0	153.5	< 3.0	9.9	< 0.66	< 1.1	0.38	1.2	33.8	800	< 0.2	10.8	< 5.0	4.5	24.0	< 1.3	< 0.88	< 5.0	< 0.66	< 5.5	81.7
	HA	4	Min.	< 1.0	89.4	< 3.0	11.0	< 0.66	< 1.1	< 0.12	< 1.0	< 2.0	200	< 0.2	13.4	< 5.0	< 1.1	3.9	< 1.3	< 0.88	< 5.0	< 0.66	< 5.5	< 4.0
			Max.	< 1.0	330.0	< 3.0	21.4	< 0.66	< 1.1	1.70	3.9	57.8	3400	< 0.2	110.7	10	4.4	7.2	15.7	3.14	< 5.0	< 0.66	< 5.5	38.1
			Avg.	< 1.0	184.0	< 3.0	17.5	< 0.66	< 1.1	0.68	1.5	19.8	1700	< 0.2	63.7	< 5.0	1.5	5.1	5.4	< 0.88	< 5.0	< 0.66	< 5.5	19.7
	HB	4	Min.	< 1.0	76.5	< 3.0	15.7	< 0.66	< 1.1	< 0.12	< 1.0	< 2.0	400	< 0.2	14.6	< 5.0	< 1.1	4.9	< 1.3	< 0.88	< 5.0	< 0.66	< 5.5	< 4.0
			Max.	< 1.0	207.4	4.2	21.6	< 0.66	< 1.1	0.51	3.7	63.8	5784	0.3	124.0	< 5.0	2.7	6.3	5.2	1.50	< 5.0	< 0.66	< 5.5	28.9
			Avg.	< 1.0	149.6	< 3.0	18.5	< 0.66	< 1.1	0.33	1.3	22.7	1448	< 0.2	76.0	< 5.0	< 1.1	5.5	2.5	< 0.88	< 5.0	< 0.66	< 5.5	15.5
	HC	4	Min.	< 1.0	48.7	< 3.0	11.5	< 0.66	< 1.1	< 0.12	< 1.0	< 2.0	500	< 0.2	20.4	< 5.0	< 1.1	5.4	< 1.3	< 0.88	< 5.0	< 0.66	< 5.5	< 4.0
			Max.	< 1.0	118.1	< 3.0	33.3	< 0.66	< 1.1	0.31	4.9	15.3	4200	0.3	152.7	< 5.0	1.4	6.9	4.2	2.80	< 5.0	< 0.66	< 5.5	28.8
			Avg.	< 1.0	80.4	< 3.0	18.2	< 0.66	< 1.1	0.20	1.2	3.8	2100	< 0.2	56.1	< 5.0	< 1.1	6.2	2.2	< 0.88	< 5.0	< 0.66	< 5.5	13.6
	HR	4	Min.	< 1.0	62.8	< 3.0	15.6	< 0.66	< 1.1	0.13	< 1.0	< 2.0	500	< 0.2	43.5	< 5.0	< 1.1	9.0	< 1.3	< 0.88	< 5.0	< 0.66	< 5.5	< 4.0
			Max.	< 1.0	215.3	< 3.0	39.0	< 0.66	< 1.1	0.40	3.6	17.7	1900	0.3	182.5	< 5.0	2.1	10.5	3.5	< 0.88	< 5.0	< 0.66	< 5.5	33.7
			Avg.	< 1.0	127.8	< 3.0	25.4	< 0.66	< 1.1	0.22	< 1.0	5.1	1000	< 0.2	85.3	< 5.0	< 1.1	9.8	1.7	< 0.88	< 5.0	< 0.66	< 5.5	13.0
Carmans (Control Location)	HH	4	Min.	< 1.0	41.6	< 3.0	31.5	< 0.66	< 1.1	< 0.12	< 1.0	< 2.0	300	< 0.2	56.9	< 5.0	< 1.1	14.3	< 1.32	< 0.88	< 5.0	< 0.66	< 5.5	< 4.0
			Max.	< 1.0	57.8	< 3.0	39.8	< 0.66	< 1.1	0.24	< 1.0	2.2	700	0.5	105.3	< 5.0	< 1.1	15.4	1.35	< 0.88	< 5.0	< 0.66	< 5.5	16.9
			Avg.	< 1.0	47.5	< 3.0	35.1	< 0.66	< 1.1	0.14	< 1.0	< 2.0	500	< 0.2	79.6	< 5.0	< 1.1	15.0	< 1.32	< 0.88	< 5.0	< 0.66	< 5.5	7.7
NYSDEC AWQS				0.1	100	150	SNS	11	1.1	5	34	4	300	0.2	SNS	SNS	23	SNS	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	75	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.
N=No. of samples
NYSDEC AWQS=New York State Department of Conservation Ambient Water Quality Standard for Class C Surface Water
SNS=Standard Not Specified for these elements for Class C waters
Solubility State abbreviations: I=Ionic form, D=Dissolved form, AS=Acid Soluble
MDL=Minimum Detection Limit

Certain metals are only biologically available to river organisms if they are in a dissolved or ionic state, while others are toxic in any form (i.e., dissolved and particulate combined). In 1999, the BNL monitoring program assessed water samples for only the dissolved and particulate form. Use of this form is more conservative. Examination of the metals data showed that aluminum, copper, lead, iron and zinc were present in concentrations which exceeded ambient water quality standards at upstream, downstream and, in some instances, the Carmans River stations. Though these elements were routinely detected in the STP discharge, the presence of these elements at upstream locations and locations not directly influenced by STP discharges was evidence of natural contributions. In 2000, samples will be collected and analyzed for both solubility states to permit better comparison to water quality standards.

Based upon the 1999 nonradiological data, the Peconic River water quality is comparable to other local fresh water rivers and is of consistent quality both upstream and downstream of the BNL STP discharge. Radiological data for the year shows no evidence of BNL operations downstream of the BNL site. Low concentrations of tritium were detected at the STP outfall, but only sporadic detections were found at the first monitoring station downstream.

REFERENCES

DOE Order 5400.5. 1990. *Radiation Protection of the Public and the Environment.* U.S. Department of Energy, Washington, D.C. Change 2: 1-7-93.

Flora and Fauna

Brookhaven National Laboratory has a wildlife management program to protect and manage flora and fauna and their habitats. The Laboratory's wildlife management strategy is based on an understanding of the resources onsite, ensuring compliance with applicable regulations, protecting and monitoring the ecosystem, research, and communication. Monitoring to determine whether current or historical activities have impacted wildlife is part of this program. In 1999, deer and fish sampling results were consistent with previous years. Deer residing on the BNL site were found to contain concentrations of cesium-137 higher than those observed in offsite deer. Fish from the Peconic River collected at the BNL boundary continue to show a slightly elevated radionuclide content compared to control samples. Radionuclide levels in fish continue to decrease compared to historical values. Although there was no sampling for local farm grown produce in 1999, historical analyses of farm produce reported in BNL Site Environmental Reports over the past ten years has indicated that no Laboratory-generated radionuclides have been detected.

6.1 WILDLIFE MANAGEMENT PROGRAM

The purpose of the wildlife management program at BNL is to promote stewardship of the natural resources found at the Laboratory, as well as to integrate natural resource protection with the Laboratory's mission. In 1998 BNL developed a Wildlife Management Plan that describes the program strategy, elements, and planned activities. This plan was updated in 1999 to incorporate comments from the U.S. Environmental Protection Agency (EPA) and the New York State Department of Environmental Conservation (NYSDEC) (Naidu 1999). The plan and related natural resources information about the Laboratory can be found at the Environmental Services Division website at <http://www.esh.bnl.gov/wildlife/>. The program elements and some of the associated activities are summarized below.

6.1.1 IDENTIFICATION AND MAPPING OF NATURAL RESOURCES

An understanding of the environmental baseline is the starting point for wildlife management planning. The Central Pine Barrens Commission conducted a natural resources inventory of the BNL site based on data collected from 1970 to 1990. This mapping process has identified environmentally sensitive areas and significant wildlife communities. BNL is in the process of updating this inventory.

As noted in Chapter 1, a wide variety of vegetation, birds, reptiles, amphibians, and mammals reside onsite at BNL. There is only one New York State endangered species that inhabits BNL property: the tiger salamander (*Ambystoma tigrinum*) (see Figure 6-1). Two New York State threatened species have been identified: the banded sunfish (*Enneacanthus obesus*) (see Figure 6-2) and the stiff goldenrod (*Solidago rigida*) plant. In addition, several species that inhabit the BNL site, or visit during migration, are listed as "rare," "species of special concern," or 'exploitably vulnerable' (see Table 6-1).

6.1.2 HABITAT PROTECTION AND ENHANCEMENT

Activities to eliminate or minimize negative impacts 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. Access to critical habitats is restricted. A map of tiger salamander breeding locations is maintained and reviewed when new projects are proposed to ensure that the projects do not negatively affect the breeding areas. (This map is "Confidential" and limited in its distribution in order to protect the tiger salamander from being exploited.) In some cases, habitats are enhanced to improve survival or increase populations. Routine activities (e.g., road maintenance) that are not expected to impact habitats are permitted to proceed.

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

Common Name	Scientific Name	State Status
Fish		
Banded sunfish	*Enniacanthus obesus*	T
Amphibians		
Eastern tiger salamander	*Ambystoma tigrinum tigrinum*	E
Marbled salamander	*Ambystoma opacum*	SC
Reptiles		
Spotted turtle	*Clemmys guttata*	SC
Eastern box turtle	*Terrapene carolina*	SC
Eastern hognose snake	*Heterodon platyrhinos*	SC
Birds *(nesting or common)*		
Horned lark	*Eremophila alpestris*	SC
Whip-poor-will	*Caprimulgus vociferus*	SC
Vesper sparrow	*Pooecetes gramineus*	SC
Grasshopper sparrow	*Ammodramus savannarum*	SC
Plants		
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 pennsylvanica*	V
Cinnamon fern	*Osmunda cinnamomera*	V
Clayton's fern	*Osmunda claytoniana*	V
Royal fern	*Osmunda regalis*	V
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:
Information based on 6 NYCRR 182, 6 NYCRR 193, and BNL survey data.
No federally listed threatened or endangered species are known to occur at BNL.
E=endangered
T=threatened
SC=species of special concern
R=rare
V=exploitably vulnerable

Efforts to protect the tiger salamander include determining when adult salamanders are migrating toward breeding locations, when metamorphosis has been completed, and when juveniles are migrating after metamorphosis. During these times, construction and/or maintenance activities near tiger salamander habitats are required to be reviewed by BNL environmental protection staff, and every effort is made to minimize impacts. Water quality testing is conducted as part of the routine monitoring of water basins. These data are used to assess the quality of water prior to the breeding cycle. In cooperation with NYSDEC, limited habitat surveys were conducted in 1999 during the tiger salamander breeding season. In 2000, more comprehensive surveys of known and suspected tiger salamander habitats will be conducted. The results of these surveys will help determine the length of the breeding period and provide the information needed to determine a window for construction activities in and around the breeding areas. The information may also identify changes in site use that are needed and possible activities that could be affecting this species. The map of the breeding areas will be updated periodically to include any new observations.

Figure 6-1. Tiger Salamander *(Ambystoma tigrinum)*, a New York State listed endangered species. The salamander was released immediately after the photograph was taken.

Banded sunfish protection efforts include ensuring that adequate flow of the 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. The banded sunfish is shown in Figure 6-2.

BNL's Wildlife Management Plan also calls for habitat enhancement. In 1999, all readily available data were compiled to establish BNL's bird list. A total of 216 species have been identified at BNL since 1948, of which at least 85 are known to nest onsite. Some of these nesting birds have shown declines in their populations nationwide over the past 30 years. In 2000, the Laboratory plans to establish permanent bird survey routes through various habitats, allowing for consistent monitoring of songbird populations. Bluebirds have been identified as one of the declining species of migratory birds in North America. This decline is due to loss of habitat and nest site competition by the European starling. In 2000, BNL plans to install 20 to 40 bluebird boxes around open grassland areas of the site to enhance the bluebird population. Once the boxes are installed, they will be monitored two to three times during the breeding season to determine use and nesting success.

Figure 6-2. Banded Sunfish *(Enneacanthus obesus)*, a New York State "special concern" species. This live specimen was returned to the water body immediately after the photograph was taken. (Scale shown in this picture is in centimeters.)

6.1.3 POPULATION MANAGEMENT

BNL also manages other species populations as necessary to ensure that they are sustained and to control invasive species. For example, the Laboratory monitors populations of "species of interest," such as the wild turkey. The onsite population of wild turkeys is estimated to be between 60 and 80 birds (see Figure 6-3). The wild turkeys onsite are apparently doing well, as approximately one third of the estimated population is composed of juvenile birds. Updated population reports are periodically sent to NYSDEC to assist with their population estimates. The population will continue to be monitored to determine reproductive success.

BNL is currently updating information on the onsite deer population. Since there are no natural predators onsite and hunting is not permitted at BNL, there are no significant pressures on the population to migrate beyond their typical home range of approximately one mile. A 1992 study indicated that the population of deer onsite exceeded 700, or approximately 100 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. Overpopulation can affect both animal and human health (e.g., deer ticks transmit Lyme disease), decrease species diversity such as song birds (due to selective grazing and destruction of habitat), and can also result in increased property damage and traffic accidents as animals forage into developed areas for food. Reduction of property damage due to deer/vehicle collisions is one aspect considered in planning deer population management. In 1999, there were four deer/vehicle collisions reported. This was down from 12 reported collisions in 1997, after property adjacent to the lab was cleared for development, and 6 reported collisions in 1998. Options for managing the deer population are being evaluated, and BNL will work with state regulators and the community if active management (such as culling the herd) is deemed necessary.

Figure 6-3. Wild Turkeys are commonly seen at BNL.

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 are adequately evaluated and addressed. BNL will continue to use NEPA, or NEPA-like values under the Comprehensive Environmental Response, Compensation and Liability Act program, as the process for identifying potential environmental impacts associated with site activities (especially physical alterations). As appropriate, stakeholders such as the EPA, NYSDEC, Suffolk County Department of Health Services (SCDHS), the Nature Conservancy, the Town of Brookhaven, the Community Advisory Council, and local environmental advocacy groups are involved in reviewing projects which have potential environmental impacts.

6.2 MONITORING ACTIVITIES

6.2.1 DEER SAMPLING

Deer in New York State typically grow to large sizes, with average weights of males at approximately 150 pounds; females are slightly less at about 100 pounds. However, deer on Long Island tend to be much smaller in size, with an average weight of less than 80 pounds. The available meat on local deer ranges from 20 to 40 pounds per deer.

In 1999, as in recent years, an offsite deer sampling program was again conducted in cooperation with the NYSDEC Wildlife Branch. NYSDEC samples provide data on deer moving beyond BNL boundaries where they can be legally hunted. This program also provides control data on deer living in locations that are distant from BNL. The total number of samples obtained near the BNL site was again very limited in 1999, as in past years, due to a low response rate from hunters approached for samples at state checkpoints. In all, eight deer samples were obtained onsite and eight were gathered from offsite locations.

BNL has been monitoring radionuclide levels in deer onsite since 1992. Onsite samples were collected primarily from deer killed in automotive incidents. Samples were analyzed for gamma-emitting radionuclides; the results are shown in Table 6-2. It was previously established that deer taken on the BNL site contain concentrations of cesium-137 (half-life = 30 years) at levels above those taken from offsite. This is most likely the result of deer grazing on vegetation growing in soils where elevated cesium-137 levels are known to exist. Cesium-137 in these soils can be transferred to aboveground plant matter via root uptake, where it then becomes available to browsing animals. Remediation of contaminated soil areas is being addressed as part of the site environmental restoration program. All data taken since 1992 are presented in Table 6-3 and was used to show the distribution of cesium-137 levels in deer versus distance from the Lab. The cesium-137 concentration in deer meat samples taken within one mile of the Laboratory boundary is approximately the same as in samples taken onsite. Cesium-137 concentrations decrease sharply beyond one mile from the site (see Figure 6-4). This indicates that deer feeding on Laboratory property have the potential to migrate offsite

Table 6-2. Radiological Analysis of Deer Tissue (1999).

Location	Collect Date	Tissue	K-40 (pCi/g,wet)	Cs-137 (pCi/g, wet)
BNL				
Yale Road across from first entrance to garage	01/04/99	Flesh	5.78 ± 1.35	7.47 ± 1.49
Mobile Trailer Park/5-8	01/18/99	Liver	2.80 ± 0.51	2.22 ± 0.40
Mobile Trailer Park/5-8	01/18/99	Flesh	2.87 ± 0.65	8.11 ± 1.44
Mobile Trailer Park/5-8*	01/18/99	Flesh	2.64 ± 0.47	9.69 ± 1.66
Southeast of Child Development Center	02/18/99	Tumor	1.41 ± 0.37	0.35 ± 0.08
Southeast of Child Development Center	02/18/99	Flesh	2.17 ± 0.37	0.72 ± 0.12
Main gate-South Bound Lane	03/19/99	Flesh	5.42 ± 1.19	2.90 ± 0.58
Main gate-South Bound Lane*	03/19/99	Flesh	2.41 ± 0.42	0.26 ± 0.05
Main gate-South Bound Lane*	03/19/99	Flesh	2.05 ± 0.35	0.94 ± 0.16
Main gate-South Bound Lane*	03/19/99	Flesh	2.43 ± 0.95	0.29 ± 0.10
Main gate-South Bound Lane	03/19/99	Liver	2.69 ± 0.46	1.22 ± 0.21
Intersection of Railroad/Cornell Ave., East of 701	03/20/99	Liver	2.33 ± 0.56	0.05 ± 0.02
Intersection of Railroad/Cornell Ave., East of 701	03/20/99	Flesh	3.25 ± 0.55	0.17 ± 0.03
West side of Bldg. 815	04/19/99	Flesh	3.20 ± 0.55	0.08 ± 0.02
Bldg.1005 inside of RHIC Ring	04/27/99	Flesh	2.88 ± 0.48	0.75 ± 0.13
Bldg.1005 inside of RHIC Ring	04/27/99	Liver	1.79 ± 0.33	0.19 ± 0.04
Intersection of Princeton/Southgate Rd.	06/11/99	Flesh	2.52 ± 0.42	0.30 ± 0.05
Intersection of Princeton/Southgate Rd.	06/11/99	Liver	1.19 ± 0.22	0.10 ± 0.02
Offsite				
Mashomack, Shelter Island	01/06/99	Flesh	2.37 ± 0.42	0.85 ± 0.15
1/3 Mile N. of Rt. 25, Ridge Rd.	01/06/99	Flesh	3.8 ± 0.64	0.61 ± 0.15
Breslin Property (Wm. Floyd)	01/08/99	Flesh	2.15 ± 0.37	3.55 ± 0.61
Noyak, Town of Southhampton	01/18/99	Flesh	2.19 ± 0.39	ND
Rt. 25, 100 yds. west of main entrance to Brookhaven Shooting Range	02/16/99	Flesh	2.22 ± 0.38	2.34 ± 0.39
Ridge Road, 200 feet North of School	03/19/99	Flesh	2.82 ± 0.47	0.26 ± 0.05
Rt. 25, 100 yds west of main entrance	03/23/99	Flesh	2.97 ± 0.52	2.91 ± 0.50
Wm. Floyd Pkwy, 1/4 mile South of Main gate	10/22/99	Flesh	2.24 ± 0.41	3.52 ± 0.60
Wm. Floyd Pkwy, 1/4 mile South of Main gate*	10/22/99	Flesh	2.07 ± 0.38	3.55 ± 0.59
Wm. Floyd Pkwy, 1/4 mile South of Main gate	10/22/99	Liver	2.22 ± 0.25	0.78 ± 0.13
BNL Flesh Average	12 Samples		3.14 ± 0.65	2.64 ± 0.49
Offsite Flesh Average	9 Samples		2.54 ± 0.44	1.95 ± 0.34
BNL Liver Average	5 Samples		2.16 ± 0.42	0.76 ± 0.14
Offsite Liver Average	1 Sample		2.22 ± 0.25	0.78 ± 0.13

Notes:
All values shown with a 95% confidence interval.
All summary statistics include duplicate analysis results.
ND = Not Detected.
*Duplicate analysis, a second sample from the same animal.

Table 6-3. Radiological Analysis of Deer Tissue (Historical Data 1992 - 1999).

Year	Location	Distance (miles)	Tissue	K-40 (pCi/g, wet)	Cs-137 (pCi/g, wet)
1992	BNL	0	Flesh	7.72	6.15
1992	BNL	0	Liver	1.88	1.12
1996	BNL	0	Flesh	2.86 ± 0.51	1.01 ± 0.18
1996	BNL	0	Liver	2.11 ± 0.41	0.65 ± 0.12
1996	BNL	0	Flesh	2.70 ± 0.44	5.14 ± 0.88
1996	BNL	0	Flesh	3.34 ± 0.56	6.66 ± 1.12
1996	BNL	0	Liver	3.30 ± 0.91	2.53 ± 0.50
1996	BNL	0	Liver	3.06 ± 0.92	2.11 ± 0.40
1996	BNL	0	Liver	3.07 ± 0.65	1.56 ± 0.28
1996	BNL	0	Flesh	3.01 ± 0.51	5.61 ± 0.95
1996	BNL	0	Flesh	3.68 ± 1.15	11.74 ± 2.27
1996	BNL	0	Liver	2.45 ± 0.89	3.36 ± 0.88
1997	BNL	0	Flesh	2.51 ± 0.48	0.23 ± 0.05
1997	BNL	0	Liver	3.51 ± 0.98	0.50 ± 0.12
1997	BNL	0	Flesh	3.27 ± 0.58	1.35 ± 0.24
1997	BNL	0	Liver	2.24 ± 0.41	0.41 ± 0.07
1997	BNL	0	Flesh	2.81 ± 0.68	2.39 ± 0.56
1997	BNL	0	Liver	1.68 ± 0.30	0.21 ± 0.04
1997	BNL	0	Flesh	3.19 ± 0.54	0.19 ± 0.04
1997	BNL	0	Liver	1.84 ± 0.33	0.03 ± 0.01
1997	BNL	0	Flesh	2.81 ± 0.47	6.04 ± 1.03
1997	BNL	0	Liver	2.21 ± 0.40	3.73 ± 0.64
1997	BNL	0	Flesh	3.58 ± 0.60	1.04 ± 0.16
1997	BNL	0	Liver	1.68 ± 0.29	0.16 ± 0.03
1998	BNL	0	Flesh	1.86 ± 0.32	ND
1998	BNL	0	Liver	2.84 ± 0.53	ND
1998	BNL	0	Flesh	5.26 ± 1.58	0.24 ± 0.15
1998	BNL	0	Liver	3.19 ± 2.21	ND
1998	BNL	0	Flesh	4.07 ± 0.97	ND
1998	BNL	0	Liver	1.77 ± 0.43	ND
1998	BNL	0	Flesh	4.15 ± 1.05	8.79 ± 1.54
1998	BNL*	0	Flesh	2.51 ± 0.44	7.01 ± 1.21
1998	BNL	0	Flesh	2.22 ± 0.42	1.92 ± 0.32
1998	BNL	0	Liver	4.72 ± 1.15	14.59 ± 2.88
1998	BNL	0	Flesh	2.55 ± 0.43	6.56 ± 1.10
1998	BNL	0	Liver	2.11 ± 0.48	1.85 ± 0.42
1998	BNL Lilco Substation	0	Flesh	3.80 ± 0.66	0.24 ± 0.05
1999	BNL	0	Flesh	5.78 ± 1.35	7.47 ± 1.49
1999	BNL	0	Tumor	1.41 ± 0.37	0.35 ± 0.08
1999	BNL	0	Flesh	2.17 ± 0.37	0.72 ± 0.12
1999	BNL	0	Flesh	5.42 ± 1.19	2.90 ± 0.58
1999	BNL	0	Flesh	2.41 ± 0.42	0.26 ± 0.05
1999	BNL	0	Flesh	2.05 ± 0.35	0.94 ± 0.16
1999	BNL	0	Flesh	2.43 ± 0.95	0.29 ± 0.10
1999	BNL	0	Liver	2.69 ± 0.46	1.22 ± 0.21
1999	BNL	0	Liver	2.33 ± 0.56	0.05 ± 0.02
1999	BNL	0	Flesh	3.25 ± 0.55	0.17 ± 0.03
1999	BNL	0	Flesh	3.20 ± 0.55	0.08 ± 0.02
1999	BNL	0	Flesh	2.88 ± 0.48	0.75 ± 0.13
1999	BNL	0	Liver	1.79 ± 0.33	0.19 ± 0.04
1999	BNL	0	Flesh	2.52 ± 0.42	0.30 ± 0.05
1999	BNL	0	Liver	1.19 ± 0.22	0.10 ± 0.02
1999	Mobile Trailer Park/5-8	0	Liver	2.80 ± 0.51	2.22 ± 0.40
1999	BNL*	0	Flesh	2.64 ± 0.47	9.69 ± 1.66
1999	BNL	0	Flesh	2.87 ± 0.65	8.11 ± 1.44
1999	Breslin Property (Wm. Floyd)	0.1	Flesh	2.15 ± 0.37	3.55 ± 0.61
1999	Wm. Floyd Pkwy, 1/4 mile South of main gate	0.1	Flesh	2.24 ± 0.41	3.52 ± 0.60
1999	Wm. Floyd Pkwy, 1/4 mile South of main gate*	0.1	Flesh	2.07 ± 0.38	3.55 ± 0.59
1999	Wm. Floyd Pkwy, 1/4 mile South of main gate	0.1	Liver	2.22 ± 0.25	0.78 ± 0.13
1998	Wm. Floyd Pkwy, 1/4 mile N. of BNL	0.25	Liver	1.15 ± 0.21	ND
1998	Wm. Floyd Pkwy, 1/4 mile N. of BNL*	0.25	Liver	1.86 ± 0.54	0.35 ± 0.08
1998	Wm. Floyd Pkwy, 1/4 mile N. of BNL	0.25	Flesh	3.20 ± 0.76	ND
1997	1/2 mile SW of Shultz	0.75	Flesh	1.94 ± 0.33	4.71 ± 0.80
1998	Middle Island Conservation Center	1	Flesh	6.32 ± 1.46	3.20 ± 0.65
1998	Middle Island Conservation Center	1	Liver	0.99 ± 0.16	0.26 ± 0.04

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Table 6-3. Radiological Analysis of Deer Tissue (Historical Data 1992 - 1999) *(continued)*.

Year	Location	Distance (miles)	Tissue	K-40 (pCi/g, wet)	Cs-137 (pCi/g, wet)
1999	Rt. 25, 100 yds. west of main entrance to Brookhaven Shooting Range	1	Flesh	2.22 ± 0.38	2.34 ± 0.39
1999	Rt. 25, 100 yds. west of main entrance	1	Flesh	2.97 ± 0.52	2.91 ± 0.50
1999	1/3 mile N. of Rt. 25, Ridge Rd.	1.33	Flesh	3.80 ± 0.64	0.61 ± 0.15
1998	Brookhaven State Park	1.5	Liver	2.29 ± 0.39	ND
1998	Wm. Floyd Pkwy, 1 mile N. of Rt.25	1.5	Flesh	2.24 ± 0.50	ND
1998	Brookhaven State Park	1.5	Liver	3.34 ± 1.42	0.41 ± 0.18
1998	Brookhaven State Park*	1.5	Liver	2.84 ± 1.00	ND
1998	Brookhaven State Park	1.5	Thyroid	21.23 ± 18.14	4.3 ± 2.87
1998	Brookhaven Sate Park	1.5	Flesh	3.12 ± 0.74	2.14 ± 0.4
1998	Brookhaven Sate Park	1.5	Liver	2.15 ± 0.58	0.27 ± 0.06
1998	Brookhaven State Park	1.5	Flesh	2.63 ± 0.60	0.99 ± 0.18
1998	Brookhaven State Park	1.5	Liver	4.44 ± 1.22	2.16 ± 0.45
1999	Ridge Road, 200 feet N of School	1.5	Flesh	2.82 ± 0.47	0.26 ± 0.05
1996	Yaphank	3.3	Liver	1.33 ± 0.37	0.44 ± 0.09
1998	Camp Wawepea, Ridge	5	Liver	2.23 ± 0.39	ND
1998	Camp Wawepea, Ridge*	5	Liver	2.70 ± 1.26	0.14 ± 0.14
1998	Ridge 5 miles N. of 25	5.5	Flesh	2.40 ± 0.64	ND
1998	Intersection Rt. 111/Rt.51	8.5	Flesh	2.26 ± 0.47	0.53 ± 0.1
1998	Intersection Rt. 111/Rt.51*	8.5	Flesh	2.50 ± 0.42	0.66 ± 0.11
1996	Hubbard Park	20	Liver	2.62 ± 1.63	0.35 ± 0.14
1996	Mattituck	21	Liver	3.77 ± 1.07	ND
1996	Southampton	25	Flesh	2.41 ± 0.47	ND
1999	Noyak, Town of Southhampton	25	Flesh	2.19 ± 0.39	ND
1996	North Sea	26	Flesh	2.01 ± 0.38	ND
1996	Watermill	29	Liver	2.14 ± 0.39	0.08 ± 0.02
1998	Bridgehampton	30	Flesh	2.81 ± 0.53	0.05 ± 0.02
1996	Shelter Island	33	Liver	3.06 ± 0.76	0.10 ± 0.04
1996	Shelter Island	33	Flesh	2.25 ± 0.39	0.9 ± 0.16
1999	Mashomack, Shelter Island	33	Flesh	2.37 ± 0.42	0.85 ± 0.15
1996	East Hampton	38	Liver	3.00 ± 0.59	0.15 ± 0.04
BNL Flesh Average		32	Samples	3.30 ± 0.66	3.22 ± 0.57
Offsite Flesh Average		22	Samples	2.68 ± 0.53	1.40 ± 0.25
BNL Liver Average		22	Samples	2.48 ± 0.64	1.66 ± 0.34
Offsite Liver Average		17	Samples	2.48 ± 0.72	0.32 ± 0.08

Notes:
All values except 1992 data shown with a 95% confidence interval.
All summary statistics include duplicate analysis results.
ND = Not Detected
*Duplicate analysis, a second sample from the same animal.

and also supports the estimates of the deer home range being one square mile.

The maximum onsite concentration of cesium-137 detected in all hind meat samples was 9.69 pCi/g (0.36 Bq/g) wet weight (the concentration prior to drying for analysis). The arithmetic average concentration of all samples of hind meat in which cesium-137 was detected was 2.88 pCi/g (0.11 Bq/g). This may be compared with the maximum and average hind meat cesium-137 concentrations recorded in offsite samples of 3.55 and 1.95 pCi/g (0.13 and 0.07 Bq/g), respectively. Maximum and average cesium-137 concentrations in liver samples from deer collected onsite show a similar pattern of elevation. Figure 6-5 shows the ranges of cesium-137 concentrations in hind samples from onsite deer collected since 1996.

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

With respect to the health of the onsite deer population, the International Atomic Energy Agency (IAEA) has concluded that

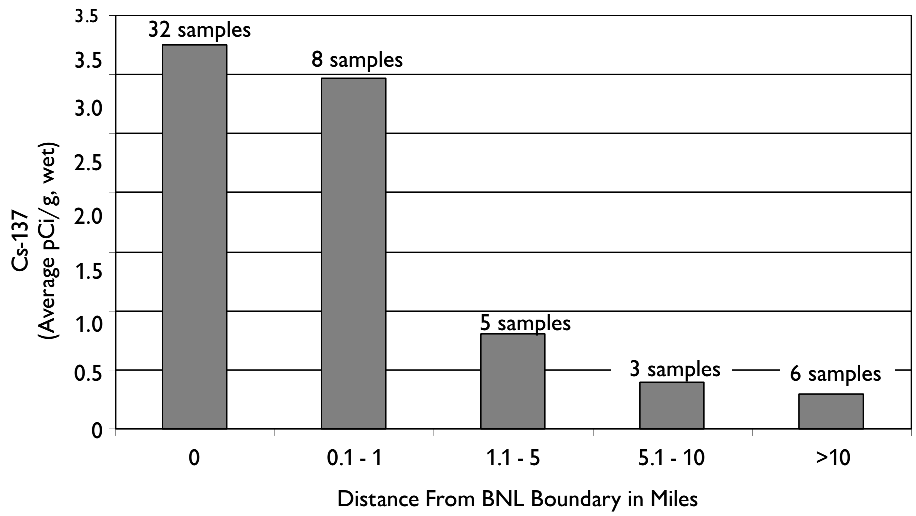

Figure 6-4. Geographical Distribution for Cs-137 in Deer Meat in Relation to BNL Property, 1996-1999.

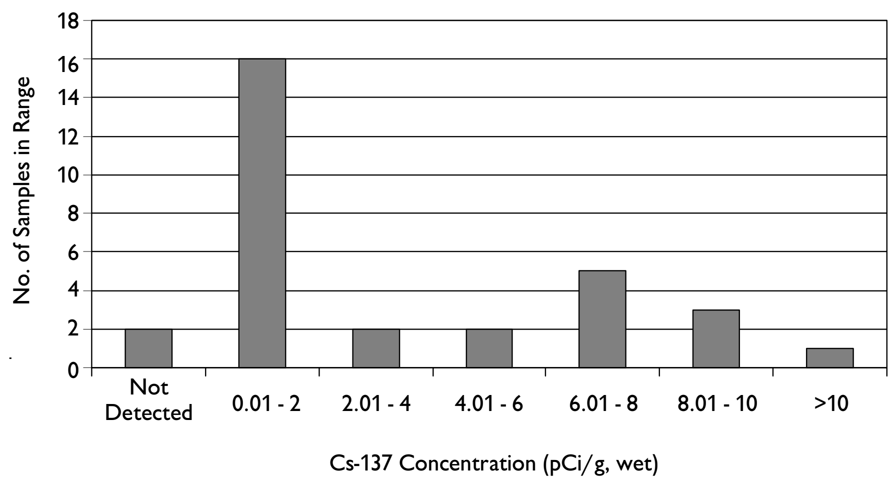

Figure 6-5. Distribution for Cs-137 Concentration Ranges in Deer Meat From BNL Site Since 1996.

chronic dose rates of 100 millirad per day (1 mGy/d), 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 cesium-137 at the highest levels observed to date would carry a total body burden of about 0.2 μCi (0.007 MBq). Under these conditions, an animal would receive an absorbed dose of approximately 3 millirad per day (0.03 mGy/d), which is only 3 percent of the threshold evaluated by the IAEA. Deer observed and sampled onsite appear to be healthy.

6.2.2 FISH SAMPLING

BNL, in collaboration with the NYSDEC Fisheries Division, maintains an ongoing program for the collection of fish from the Peconic River and surrounding fresh water bodies. In 1999 various species of fish were collected from onsite portions of the Peconic River, as well as from offsite locations such as Donahue's Pond and Forge Pond (see Figure 5-8 in Chapter 5 for geographic locations). Figure 6-6 is a photograph of fish sampling activities. No control locations, such as Carmans River, were sampled in 1999 by BNL. The control

Figure 6-6. Environmental Sampling of Yellow Perch *(Perca flavescens)* Using a Gill Net.

location sampling data used in this report was provided to BNL by SCDHS.

6.2.2.1 RADIOLOGICAL ANALYSIS OF FISH

Brown bullhead (*Ictalurus nebulosus*), chain pickerel (*Esox niger*), largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), pumpkinseed *(Lepomis gibbosus*), and yellow perch (*Perca flavescens*) species were collected in 1999 by BNL and SCDHS for radiological analysis. Gamma spectroscopy analysis was performed on both BNL and SCDHS samples, and alpha spectroscopy analysis was performed on SCDHS samples. Specific information regarding the sampling point, species collected, and analytical results is presented in Table 6-4 (gamma data) and Table 6-5 (alpha data). All sample results are presented as wet weight concentrations.

Additionally, fish collected by the NYSDEC Fisheries Division in the spring of 1998 were analyzed in 1999 as part of the environmental restoration program's plutonium sampling project. The fish samples underwent both alpha and gamma spectroscopy. No americium-241, plutonium-238, plutonium-239/240, or uranium-235 were detected in any of the fish collected from the Peconic River. Cesium-137, uranium-233/234 and uranium-238 were detected at low levels. Cesium-137 was detected in all samples with the highest value detected being 0.70 ± 0.13 pCi/g (0.03 ± 0.005 Bq/g). The highest level of uranium-233/234 detected was in a brown bullhead taken at North Street with a value of 0.006 ± 0.002 pCi/g (0.21 ± 0.07 mBq/g).

Table 6-4. Radiological Analysis (Gamma Data) of Fish from the Peconic River System and Control Locations (BNL and Suffolk County Data 1999).

Fish/Sample Type	K-40 (pCi/g, wet)	Cs-137 (pCi/g, wet)
BNL EA - HMn		
Yellow Perch (whole)	3.58 ± 0.11	0.37 ± 0.20
Chain Pickerel (flesh)	4.09 ± 0.04	0.70 ± 0.13
Chain Pickerel (bone/viscera)	1.81 ± 0.10	0.53 ± 0.13
Chain Pickerel (whole)*	2.40	0.52
Chain Pickerel (whole)*	2.70	0.36
Chain Pickerel (whole)*	2.70	0.38
Brown Bullhead (whole)	2.20 ± 0.04	0.48 ± 0.09
Brown Bullhead (whole)*	2.50	0.35
Brown Bullhead (whole)*	2.40	0.39
Brown Bullhead (whole)*	2.50	0.42
Brown Bullhead (whole)*	2.30	0.32
Brown Bullhead (whole)*	2.20	0.34
Donahue's Pond		
Largemouth Bass (flesh)	1.36 ± 0.05	0.10 ± 0.02
Largemouth Bass (bone/viscera)	4.11 ± 0.07	0.38 ± 0.10
Largemouth Bass (whole)*	2.50	0.21
Largemouth Bass (whole)*	2.50	0.12
Largemouth Bass (whole)*	2.50	0.17
Largemouth Bass (whole)*	2.60	0.15
Largemouth Bass (whole)*	2.40	0.19
Pumpkin Seed (flesh)	2.86 ± 0.06	0.20 ± 0.06
Pumpkin Seed (bone/viscera)	1.85 ± 0.06	0.10 ± 0.02
Bluegill (whole)*	2.20	0.11
Bluegill (whole)*	2.10	0.12
Bluegill (whole)*	2.30	0.15
Bluegill (whole)*	2.20	0.15
Bluegill (whole)*	2.10	0.18
Brown Bullhead (whole)*	2.50	0.14
Brown Bullhead (whole)*	2.70	0.19
Forge Pond		
Bluegill (flesh)	3.12 ± 0.04	0.11 ± 0.03
Bluegill (bone/viscera)	1.89 ± 0.05	0.06 ± 0.02
Bluegill (whole)*	2.30	0.05
Bluegill (whole)*	2.10	0.05
Bluegill (whole)*	2.30	0.05
Bluegill (whole)*	2.60	0.07
Bluegill (whole)*	2.30	0.07
Bluegill (whole)*	2.00	0.07
Largemouth Bass (whole)*	2.70	0.09
Largemouth Bass (whole)*	2.50	0.08
Largemouth Bass (whole)* D	2.40	0.08
Largemouth Bass (whole)*	2.50	0.08
Largemouth Bass (whole)*	2.30	0.15
Largemouth Bass (whole)*	2.50	0.10
Largemouth Bass (whole)*	2.20	0.06
Connetquot River (Control)		
Pumpkin Seed (whole)*	1.60	ND
Pumpkin Seed (whole)*	2.60	0.01
Pumpkin Seed (whole)*	2.50	ND
Bluegill (whole)*	2.00	ND
Bluegill (whole)*	2.40	ND
Brown Bullhead (whole)*	2.50	ND
Largemouth Bass (whole)*	2.50	0.02
Largemouth Bass (whole)*D	2.40	0.01
Largemouth Bass (whole)*	3.10	0.02

Notes:
All BNL values shown with a 95% confidence interval.
* Suffolk County data (provided without confidence interval information).
D=Duplicate
ND=Not Detected

Table 6-5. Radiological Data (Alpha Analysis) of Fish From the Peconic River and Control Locations (Data provided by Suffolk County Department of Health Services 1999).

Species	Am-241 pCi/g, wet	U-238 pCi/g, wet	U-234 pCi/g, wet
Forge Pond			
Bluegill	ND	ND	ND
Bluegill	ND	0.0012 ± 0.0007	0.0011 ± 0.0007
Bluegill	ND	ND	ND
Bluegill	ND	ND	ND
Bluegill	ND	ND	ND
Largemouth Bass	ND	0.0010 ± 0.0005	0.0010 ± 0.0005
Largemouth Bass	ND	0.0014 ± 0.0006	0.1113 ± 0.0006
Largemouth Bass	ND	ND	ND
Largemouth Bass	ND	ND	ND
Largemouth Bass	ND	ND	ND
Brown Bullhead	ND	ND	ND
Donahue's Pond			
Bluegill	ND	0.0012 ± 0.0008	ND
Bluegill	ND	0.005 ± 0.0005	0.008 ± 0.0006
Bluegill	ND	0.0012 ± 0.0007	0.0019 ± 0.0009
Bluegill	ND	0.0004 ± 0.0003	0.006 ± 0.0003
Bluegill	ND	0.0007 ± 0.0004	0.0008 ± 0.0004
Largemouth Bass	ND	ND	ND
Largemouth Bass	ND	ND	ND
Largemouth Bass	ND	ND	ND
Largemouth Bass	ND	ND	ND
Largemouth Bass	ND	ND	ND
Brown Bullhead	ND	0.0006 ± 0.0003	0.0004 ± 0.0003
Brown Bullhead	ND	0.0006 ± 0.0003	0.0007 ± 0.0004
BNL-STP			
Brown Bullhead	0.0021 ± 0.0008	0.0008 ± 0.0004	0.0020 ± 0.0007
Brown Bullhead*	TNR	0.0018 ± 0.0009	0.0020 ± 0.001
Brown Bullhead	0.0008 ± 0.0005	0.0013 ± 0.0005	0.0022 ± 0.0008
Brown Bullhead	0.0018 ± 0.0007	0.008 ± 0.0004	0.0014 ± 0.0005
Brown Bullhead*	0.0017 ± 0.0008	0.0004 ± 0.0004	0.0022 ± 0.0009
Brown Bullhead	0.0022 ± 0.0009	0.0006 ± 0.0003	0.0013 ± 0.0005
Brown Bullhead*	0.0015 ± 0.0008	0.0007 ± 0.0005	0.0018 ± 0.0008
Brown Bullhead	0.0036 ± 0.0013	0.0013 ± 0.0006	0.0018 ± 0.0007
Chain Pickerel	0.0004 ± 0.0003	ND	ND
Chain Pickerel	TNR	0.0012 ± 0.0005	0.0006 ± 0.0003
Chain Pickerel	ND	0.0005 ± 0.0003	0.0008 ± 0.0004
Connetquot River (Control)			
Pumpkin Seed	ND	0.0019 ± 0.0009	0.0029 ± 0.0012
Pumpkin Seed*	ND	ND	ND
Pumpkin Seed	ND	0.0007 ± 0.0003	0.0008 ± 0.0003
Pumpkin Seed	ND	ND	0.0008 ± 0.0004
Pumpkin Seed	ND	ND	ND
Bluegill	ND	0.0013 ± 0.0007	0.0013 ± 0.0007
Bluegill	ND	0.0005 ± 0.0003	0.0005 ± 0.0003
Largemouth Bass	ND	ND	ND
Largemouth Bass	ND	ND	ND
Brown Bullhead	ND	ND	ND

Notes:
All samples were whole fish
ND=Not Detected
TNR=Test Not Run
*Indicates duplicate sample

A uranium-238 value of 0.008 ± 0.002 pCi/g (0.31 mBq/g ± 0.07) was detected in a sample of bone/viscera from onsite samples. For more detail on the project results, refer to the *Plutonium Contamination Characterization and Radiological Dose and Risk Assessment Report* that was placed in the Administrative Record for public review in February 2000 (BNL 2000) and can be found in the BNL Research Library and several local public libraries.

In general, all 1999 BNL and SCDHS data agree with the exception of americium-241. Data from SCDHS showed no evidence of plutonium-238, plutonium-239/240, or uranium-235, which was consistent with BNL data. Data did show detection of cesium-137, uranium-233/234, and uranium-238, as well as very low levels of americium-241. Levels of cesium-137 reported by the SCDHS were at levels comparable to those detected by BNL's surveillance monitoring program. The highest level of cesium-137 seen in SCDHS onsite data 0.52 pCi/g (19 mBq/g) was in a chain pickerel, and is comparable to BNL data for the same area (see Table 6-4). Uranium-233/234 and uranium-238 values were comparable to, or lower than, levels detected by the plutonium study. SCDHS detected americium-241 at very low levels in the Peconic River fish taken onsite. The levels detected were just above the minimum detection limit of 0.001 pCi/g (0.037 mBq/g), with the highest level of 0.0036 pCi/g (0.13mBq/g) detected in a brown bullhead. Americium-241 levels found in brown bullheads are shown in Figure 6-7.

Data for fish are generated from small sample numbers and each sample may have been a composite sample (composed of several small fish) due to weight requirements needed to obtain accurate radiological analysis. Analyses performed by the SCDHS utilized the whole fish for testing in order to represent the consumption of the whole fish by some members of the public; analyses performed by BNL were done separately on the flesh and skin, the viscera and bones, and occasionally the whole fish. Segregating the tissues provides information regarding the localization of radionuclides in certain parts of a fish, as different radionuclides tend to concentrate in different tissues due to their specific chemical characteristics. Segregated analysis also allows for more realistic dose calculations since different radionuclides may become localized in different discrete

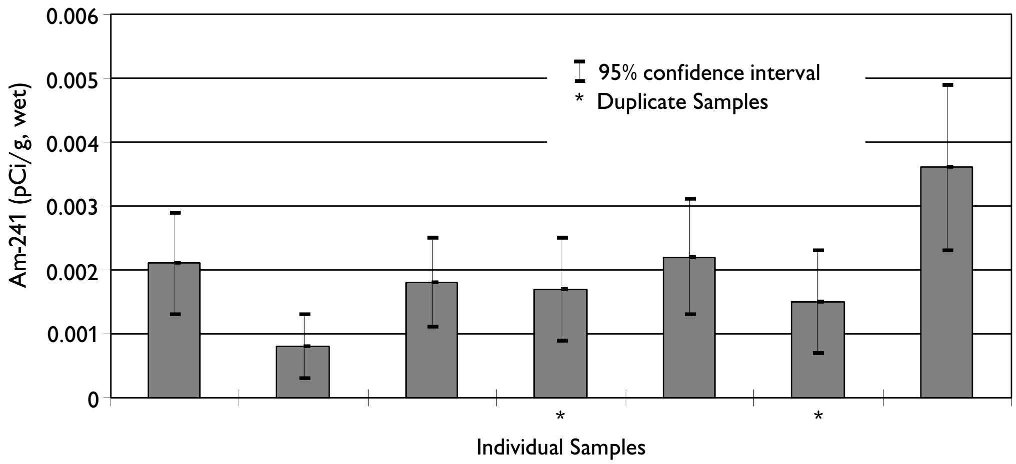

Figure 6-7. Am-241 in Individual Brown Bullhead Catfish Samples Taken From the BNL Site During 1999.

tissues; and, therefore, if the tissue in which a radionuclide concentrates is considered by most consumers to be inedible (e.g., bones and viscera), the source of intake can be eliminated.

Concentrations of naturally occurring potassium-40 (a radionuclide common to soil and vegetation) were observed to be very consistent between Peconic River and control location fish, validating the comparability of the data. The only anthropogenic (man-made) radionuclide found in any fish sample, control or otherwise, was cesium-137.

Some cesium-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 control location fish. In the past, cesium-137 values up to 0.43 pCi/g (16 mBq/g) were found in yellow perch flesh taken from Swan Pond. In order to account for the different feeding habits and weights of various species, it is important to compare species with similar feeding habits to each other. In general cesium-137 concentrations in bullheads collected near the BNL Sewage Treatment Plant outfall were elevated in comparison to the control locations. The elevations became less pronounced with increasing distance from the Sewage Treatment Plant outfall (see the Donahue's Pond and Forge Pond values in Table 6-4).

Though it is clear from discharge records and sediment sampling that historical BNL operations have contributed to anthropogenic radionuclide levels in the Peconic River system, most of these radionuclides (with the exception of tritium) were released between the late 1950's and early 1970's. Radionuclides in Peconic River fish have been measured since 1974 by the NYSDOH. Both the NYSDOH and BNL data indicate a continuing decrease in radionuclide concentrations in all fish species over time (NYSDOH 1996). This is due to a lack of significant new radioactive discharges and the radioactive decay of materials discharged in the past.

6.2.2.2 NONRADIOLOGICAL ANALYSIS OF FISH AND SHELLFISH

In 1997, under the Operable Unit (OU) V remediation program, the BNL environmental restoration program conducted sampling and analysis of fish samples from the Peconic River for metals, pesticides, and PCBs (see the BNL *Site Environmental Report for Calendar Year 1997* [BNL 1999] for more information). Results indicated that the levels found were not considered to have any health impacts on fish or human. However, DOE directed that the sampling of fish for pesticides, metals, and PCBs should be incorporated into the annual environmental sampling program. This analysis was conducted in 1999, and the results were compared to the 1997 data as an extension of the 1997 survey. It should be noted that the 1997 sampling was performed during the April-May period, while in 1999 sampling was performed during the September-December period. This makes the comparison more tenuous, as seasonal variations in feeding and energy consumption by fish can be significant.

Table 6-6. Metals Analysis of Fish and Shellfish From the Peconic River and Control Locations (1999).

Location	Matrix	Arsenic	Barium	Cadmium	Chromium	Copper	Lead	Manganese	Mercury	Nickel	Selenium	Silver	Zinc	Sodium	Iron
									ppm (µg/g) (wet weight)						
Seaford, NY (Control)	Clams (flesh)	2.12	0.25	<MDL	0.27	4.71	0.53	10.19	0.04	1.31	<MDL	0.23	28.68	13,442	38.8
Seaford, NY (Control)	Clams (flesh)	2.61	0.23	<MDL	0.23	5.59	0.55	11.93	0.05	1.60	<MDL	0.44	36.89	16,489	48.3
Peconic Bay	Clams (flesh)	1.94	<MDL	0.1	<MDL	1.68	<MDL	3.40	<MDL	0.75	<MDL	0.41	6.00	5,869	11.8
Flanders Bay	Clams (flesh)	0.94	0.25	0.12	<MDL	2.09	<MDL	7.85	<MDL	0.45	<MDL	0.61	9.09	5,838	32.3
Forge Pond	Bluegill flesh	<MDL	2.21	<MDL	<MDL	0.59	<MDL	3.29	0.09	0.15	<MDL	<MDL	21.62	770	<MDL
Donahue's Pond	Largemouth Bass (flesh)	0.91	0.24	0.12	<MDL	2.05	<MDL	7.54	<MDL	0.42	<MDL	0.20	8.74	5,709	31.5
Donahue's Pond	Pumpkin Seed (flesh)	<MDL	0.73	<MDL	<MDL	0.62	<MDL	1.02	0.15	0.10	<MDL	<MDL	15.55	768	<MDL
BNL Site: EA to HMn	Chain Pickerel (flesh)	<MDL	1.62	<MDL	<MDL	1.30	<MDL	2.24	0.10	<MDL	<MDL	0.35	21.15	658	8.63
BNL Site: EA to HMn	Bullhead (flesh)	<MDL	2.11	<MDL	<MDL	2.15	<MDL	2.04	0.40	0.18	<MDL	<MDL	14.25	1,376	39.3
MDL (varies by sample aliquot)		0.30	0.18	0.066	0.10	0.20	0.132	0.20	0.02	0.11	0.50	0.10	0.40	100	7.5

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

Table 6-7. Pesticide Analysis of Fish and Shellfish From the Peconic River and Control Locations (1999).

Pesticide	Seaford, NY (Control) *clams*	Seaford, NY (Control) *clams (duplicate)*	Peconic Bay *clams*	Flanders Bay *clams*	Forge Pond *Bluegill*	Donahue's Pond *Largemouth Bass*	Donahue's Pond *Pumpkin Seed*	BNL EA to HMn *Pickerel*	BNL EA to HMn *Bullhead*
	ppm (μg/g) (wet weight)								
alpha-BHC	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.00097
beta-BHC	0.005	0.0017	0.0017	0.0019	0.0017	0.0017	0.0017	0.0017	0.0017
delta-BHC	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017
gamma-BHC(Lindane)	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017
Heptachlor	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0019
Aldrin	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017
Heptachlor epoxide	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017
Endosulfan I	0.0016	0.0014	0.0017	0.00094	0.0017	0.0017	0.0017	0.0017	0.0017
Dieldrin	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033	0.007
4,4'-DDE	0.0033	0.0033	0.0033	0.0033	0.002	0.0024	0.003	0.0071	0.022
Endrin	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033
Endosulfan II	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033	0.0048
4,4'-DDD	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033	0.0022	0.0033	0.017
Endosulfan sulfate	0.0033	0.0033	0.0033	0.0028	0.0033	0.0033	0.0033	0.0033	0.0033
4,4'-DDT	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033
Methoxychlor	0.017	0.014	0.017	0.017	0.017	0.017	0.017	0.017	0.017
Endrin ketone	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033
Endrin aldehyde	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033	0.0054	0.019
alpha-Chlordane	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.011
gamma-Chlordane	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0015	0.015
Toxaphene	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17

Notes:
See Chapter 5, Figure 5-8 for locations.
All values given a qualifer "J," which indicates that the values were estimated above instrument detection limit but below method detection limit.

Table 6-6 shows the concentration levels of metals in fish and shellfish (clams) for 1999. None of the metal concentrations were considered to be capable of impacting the health of the consumers of such fish or clams. In comparing the metals results between 1997 and 1999 for those species that were analyzed during both periods, it was found that mercury levels in the 1997 onsite samples were higher than those found in 1999. This could be the result of seasonal difference in the sampling (spring vs. summer) and/or significant differences in the size of fish caught during the different seasons.

Table 6-7 shows the concentration levels of pesticides in fish for 1999. The levels do not exceed any standards that constitute health impacts on the consumers of such fish and, therefore, are not considered harmful. The data from 1997 were compared to that observed in 1999 for concentration of pesticides in fish. The compounds selected for the comparison, DDD and alpha-chlordane, were the pesticides that were analyzed in both years. The results indicated no significant differences in concentrations between the 1997 and 1999 samples.

Table 6-8 shows the concentration levels of PCBs in fish for 1999. Concentrations found in offsite fish indicated that the levels were at or below the minimum detection limit. However, a significant reduction in the principal PCB component, AROCLOR 1254, was noted in the 1999 samples when compared to the 1997 samples. AROCLOR 1254 was the PCB historically used in transformers and other electrical equipment at BNL. At the observed levels, these concentrations do not pose any health hazards to the consumers of fish containing PCBs.

6.2.3 MARINE/ESTUARINE SAMPLING

Annual sampling for clams, sediment, and seawater in the Peconic Bay, Flanders Bay, Indian Point, and Seaford (control location) was continued in 1999. Stakeholder concern that BNL's discharges have affected the clamming industry prompted the Laboratory to continue this sampling program. The NYSDEC Marine Fisheries Branch has continued to assist BNL in coordinating the sampling with local baymen. Table 6-9 summarizes the radiological data. The naturally-occurring radionuclide potassium-40

Table 6-8. PCB Analysis of Fish and Shellfish From the Peconic River and Control Locations (1999).

PCB	Seaford, NY (Control) *clams*	Seaford, NY (Control) *clams (duplicate)*	Peconic Bay *clams*	Flanders Bay *clams*	Forge Pond *Bluegill*	Donahue's Pond *Largemouth Bass*	Donahue's Pond *Pumpkin Seed*	BNL EA to HMn *Pickerel*	BNL EA to HMn *Bullhead*
					ppm (μg/g) (wet weight)				
Aroclor -1016	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033
Aroclor -1221	0.067	0.067	0.067	0.067	0.067	0.067	0.067	0.067	0.067
Aroclor -1232	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033
Aroclor -1242	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033
Aroclor -1248	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033
Aroclor -1254	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.224*	0.610*
Aroclor -1260	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.047	0.170

Notes:
See Chapter 5, Figure 5-8 for locations.
All values were accorded a qualifer "J," indicating that they were estimated values, except as indicated next to the number as (*), which indicates that it is a real number.

Table 6-9. Radiological Analysis Results for Shellfish, Aquatic Vegetation, Marine Waters, and Sediment (1999).

Location	K-40 (pCi/g, wet)	Cs-137 (pCi/g, wet)
Peconic Bay		
Clams (flesh)	0.72 ± 0.16	ND
Sea Water	0.22 ± 0.04	ND
Sediment	1.32 ± 0.26	ND
Flanders Bay		
Clams (flesh)	9.21 ± 2.14	ND
Sea Water	0.33 ± 0.05	ND
Sediment	0.94 ± 0.18	0.01 ± 0.01
Seaford, NY (control)		
Clams (flesh)	1.63 ± 0.43	ND
Clams (flesh)*	0.82 ± 0.32	ND
Indian Point		
Salicornia	2.23 ± 1.15	ND
Spartina patens	3.23 ± 1.49	ND
Spartina alternaflora	2.84 ± 0.82	ND
High tide brush	4.42 ± 0.95	ND

Notes:
All values shown with a 95% confidence interval.
ND=Not Detected
*Duplicate sample

continues to be the only radionuclide observed in these samples. Additionally, in 1999, estuarine vegetation located in the Indian Point area was sampled. The results also indicated that potassium-40 was the only radionuclide observed. No BNL-generated radionuclides have been detected since sampling began in 1992.

6.2.4 VEGETATION SAMPLING

No farm vegetable samples were collected from the farms surrounding BNL for radiological analysis in 1999. However, analysis of farm produce data reported in BNL Site Environmental Report over the past ten years indicates only the presence of naturally-occurring potassium-40 at levels that are typical of these types of samples. No radionuclides attributable to BNL operations have ever been observed.

6.2.5 PECONIC RIVER SEDIMENT SAMPLING

Sampling of the Peconic River sediments for radionuclides was conducted during 1999 as part of the sampling project reported in section 2.6.1.1 of Chapter 2. Although the project was focussed on plutonium 238, other radionuclides were analyzed including americium-241, cesium-137, plutonium-239/240, uranium-233/234, uranium-235, and uranium-238. The plutonium findings for the Peconic River are summarized below. For more detailed information on the media and radionuclides evaluated for this project, see the Plutonium Report (BNL 2000), which was placed in the Administrative Record for public review in February 2000.

Plutonium found in the environment has two potential sources: (1) fallout of plutonium released during atmospheric testing of nuclear weapons, and (2) reactor operations. Atmospheric fallout has been distributed globally and has been measured on Long Island in both soils and sediment. The potential source of reactor-related plutonium and related radionuclides would be the Brookhaven Graphite Research

Reactor, which ceased operations in 1969 and is in the process of being decontaminated and decommissioned. Plutonium levels in onsite sections of the Peconic River were found to be elevated above those in another Long Island river, the Connetquot River, which was used as a reference river (i.e., control location not impacted by BNL operations). The plutonium concentration decreased as the distance downstream of the Sewage Treatment Plant increased, with most of the downstream station concentration levels being comparable in range to Connetquot River samples. As determined by the plutonium risk assessment, all Peconic River levels were below those posing a threat to human health and do not, therefore, require cleanup.

Plutonium was, however, found in areas with elevated levels of metals in both the onsite and near offsite sections of the Peconic River, which have been proposed for cleanup. Plans for the removal of the sediment above cleanup goals for the metals will further reduce the already low levels of plutonium in the river. Refer to the detailed report in the Administrative Record for additional plutonium project information (BNL 2000).

6.3 TOXICITY TESTING AT THE SEWAGE TREATMENT PLANT

Under the State Pollutant Discharge Elimination System discharge permit, BNL conducts toxicity testing for the Sewage Treatment Plant effluent. Two species are evaluated - the fathead minnow (*Pimephales promelas*) and the water flea (*Ceriodaphnia dubia*). Results from this testing program are presented in Chapter 3.

6.4 PRECIPITATION MONITORING

As part of the environmental monitoring program, precipitation samples are collected approximately quarterly at Stations P4 and S5 (see Figure 4-4 for station locations) and analyzed for radioactive content. Five samples were taken from each of these two stations in 1999. Gross alpha activity measurements above the minimum detection limit were seen on two samples, one from each location. The sample from the P4 location showed 5.3 pCi/L activity while the sample from the S5 location had an activity level of 9.1 pCi/L. Both of these values are within the range of historic values reported for gross alpha activity. Gross beta activity was measured in four samples at each of the sampling locations. Location P4 had a maximum activity level of 11.9 pCi/L with an average of 5.7 pCi/L. Location S5 had a maximum of 11.1 pCi/L with the average activity being 5.3 pCi/L. Gross beta activity values were within the range of values seen historically at these two locations. Tritium was not detected in any of the samples from either location.

6.5 WILDLIFE MANAGEMENT EDUCATION, OUTREACH, AND RESEARCH

BNL sponsors a variety of educational and outreach activities on natural resources. These programs are designed to provide an understanding of the ecosystem and foster interest in science. They are conducted at the Laboratory in collaboration with DOE, local agencies, and local high schools and colleges. Ecological research is also conducted onsite to update the current natural resources inventory, gain a better understanding of the ecosystem, and guide management planning.

In 1998, a Smithtown High School student completed a follow-up study of the BNL Gamma Forest (Superina 1998). The Gamma Forest research project, which began in 1961, examined the effects of long-term irradiation on a forest ecosystem. No evaluations of the area had been done since the project terminated in 1979. In the 1998 follow-up study, an innovative method of depicting population and habitat relationships, in particular with regard to sediment chemistry and types, was developed. The results of this study were presented at the annual Pine Barrens Research Forum that was held at BNL in 1999.

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Groundwater Protection

The Brookhaven National Laboratory Groundwater Protection Management Program is made up of four elements: prevention, monitoring, restoration, and communication. In addition to implementing aggressive pollution prevention measures to protect groundwater resources, BNL has established an extensive groundwater monitoring well network to verify that prevention and restoration activities are effective. In 1999, BNL collected groundwater samples from 589 monitoring wells during 2,122 individual sampling events. Six significant volatile organic compound plumes and eight radionuclide plumes were tracked and evaluated. During 1999, five onsite and one offsite groundwater remediation systems removed approximately 634 pounds of volatile organic compounds and returned approximately 757 million gallons of treated water to the Upper Glacial aquifer.

7.1 THE BNL GROUNDWATER PROTECTION MANAGEMENT PROGRAM

DOE Order 5400.1 (1988), *General Environmental Protection Program,* requires development and implementation of a groundwater protection program. The primary goal of the BNL 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. The BNL Groundwater Protection Program includes policy, strategy, requirements and regulations applicable to groundwater protection (Paquette *et al.* 1998). As shown in Figure 7-1, the BNL Groundwater Protection Program consists of four interconnecting elements: (1) preventing pollution of the groundwater, (2) monitoring the effectiveness of engineered/administrative controls at operating facilities and groundwater treatment systems, (3) restoration of the environment by cleaning up contaminated soil and groundwater, and (4) communicating with interested parties on groundwater protection issues.

Figure 7-1. BNL's Groundwater Protection Program.

Prevention

BNL has initiated a three-phased project to: (1) identify past or current activities with the potential to affect environmental quality, (2) conduct 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/waste minimization, resource conservation, and compliance into planning, decision-making and implementation, and (3) develop and implement an Environmental Management System. These activities 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, 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 (i.e., reducing the toxicity and volume of chemicals in use or storage).

Monitoring

BNL has an extensive groundwater-monitoring network designed to evaluate groundwater contamination from historical and current operations. Groundwater monitoring is a means of verifying that protection and restoration efforts are working. Groundwater monitoring is being conducted under two programs - the Environmental Monitoring Program designed to satisfy DOE and New York State monitoring requirements for active research and support facilities, and the Environmental Restoration (ER) program for monitoring related to BNL's obligations under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). These programs are coordinated to ensure completeness and to prevent any duplication of effort in the installation and abandonment of wells, and the sampling and analysis of groundwater. Furthermore, data quality objectives; plans and procedures; sampling and analysis; quality assurance; data management; and well installation; maintenance and abandonment programs are being integrated to optimize the groundwater monitoring system and to ensure that water quality data are available for review and interpretation in a timely manner. In 1999, there were no major changes to BNL's groundwater monitoring program in terms of number of wells sampled, frequency of sampling or specific analytes tested.

Restoration

BNL was added to the National Priorities List in 1989 (see Chapter 2 for a discussion of the BNL's ER program). Twenty-nine Areas of Concern (AOC) have been grouped into six Operable Units (OU). Remedial Investigation/ Feasibility Studies have been conducted for each OU. A primary goal of the ER program is remediating soil and groundwater contamination, and preventing additional groundwater contamination from migrating offsite. To that end, contaminant sources (e.g., contaminated soil, underground tanks) are being removed or remediated to prevent further contamination of groundwater. All remediation work is carried out under the Interagency Agreement (IAG) between the U.S. Environmental Protection Agency (EPA), New York State Department of Environmental Conservation (NYSDEC) and DOE.

Communication

BNL has a community involvement, government and public affairs program to ensure that BNL communicates with the community in a consistent, timely and accurate manner. The majority of communications regarding groundwater protection have been associated with the ER program. A number of communication mechanisms are in place, such as web pages, mailings, public meetings, briefings, and roundtable discussions.

7.2 GROUNDWATER MONITORING

Groundwater monitoring program elements include: installing monitoring wells; planning and scheduling; quality assurance; sample collection; sample analysis; data verification, validation and interpretation; and reporting. Monitoring wells are generally used to monitor specific facilities where degradation of the groundwater is known or suspected to have occurred, to fulfill regulatory permit requirements, to assess the quality of groundwater entering or leaving the BNL site, and to ensure that corrective measures designed to protect and restore groundwater are, in fact, working.

The groundwater beneath the BNL site is considered by New York State as Class GA groundwater. Class GA groundwater is defined as a source of potable water supply and suitable for drinking. As such, federal drinking water standards, New York State Drinking Water Standards (NYS DWS), and NYS Ambient Water Quality Standards (NYS AWQS) for Class GA groundwater have been used as groundwater protection and remediation goals. The BNL groundwater surveillance program uses monitoring wells (which are not utilized for drinking water supply) to monitor 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. BNL evaluates the potential impact of radiological and non-radiological levels of contamination by comparing analytical results to New York State and DOE reference levels and background water quality levels. Non-radiological analytical results from groundwater samples collected from surveillance wells are usually compared to NYSDEC AWQS. Radiological data are compared to NYS DWS (for tritium, gross beta, and Sr-90), NYS AWQS (for gross alpha and radium-226/228), 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 of 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 the timely investigation into the identification and remediation of the source.

Groundwater quality at BNL is routinely monitored through a network of approximately 460 onsite and 115 offsite surveillance wells (see Figures 7-2 and 7-3). In addition to groundwater quality assessments, water levels are routinely measured in over 650 onsite and offsite wells to assess variations in directions and velocities of groundwater flow. Groundwater flow directions in the vicinity of BNL are shown on Figure 7-4.

Active and inactive facilities that have groundwater monitoring programs include the following: the Sewage Treatment Plant/Peconic River area, Biology Agricultural Fields, Former Hazardous Waste Management Facility (HWMF), new Waste Management Facility (WMF), two former landfill areas, Central Steam Facility/ Major Petroleum Facility (CSF/MPF), Alternating Gradient Synchrotron (AGS), Waste Concentration Facility (WCF), Supply and Material, and several other smaller facilities. As the result of detailed groundwater investigations conducted

Figure 7-2. Sampling a Groundwater Monitoring Well.

over the past fifteen years, six significant VOC plumes and six radionuclide plumes have been identified (Figures 7-5 and 7-6).

7.3 SUPPLEMENTAL MONITORING PROGRAM FOR POTABLE AND PROCESS SUPPLY WELLS

Groundwater quality is also routinely monitored at all active potable supply wells and process supply wells. Because of the proximity of BNL's potable supply wells to known or suspected groundwater contamination plumes and source areas, BNL conducts a supplemental potable supply well monitoring program that exceeds the monitoring required by the SDWA (see Chapter 3 for more details). This program also evaluates the quality of water obtained from process supply wells that is used to provide water for non-potable uses (secondary cooling water and biological experiments). In 1999 samples were collected and analyzed for radionuclides (e.g., gross alpha, gross beta, gamma, Sr-90, and tritium), and VOCs (consisting of the volatile halogenated aliphatic hydrocarbons and aromatic hydrocarbons). These samples serve both as a quality control on contractor laboratory analyses of compliance samples and as an additional source of data used in evaluating groundwater quality.

The BNL supply well network consists of six potable supply wells (Wells 4, 6, 7, 10, 11, and 12) and five secondary cooling/process water supply wells (Wells 9, 101, 102, 103, and 105). All supply wells are screened entirely within the Upper Glacial aquifer (Figure 7-7). In 1999, process wells 101, 102, and 103 were not used since the AGS used domestic water for cooling purposes. Well 9 supplied process water to a facility where biological research on fish is conducted. Secondary cooling water for the Brookhaven Medical Research Reactor was supplied exclusively from Well 105.

In 1999, with the exception of a single detection of 1,1,1-trichloroethane in Well 9, all VOC analytes were less than the ambient water quality standards. Well 9 has historically exhibited concentrations above this standard and is located within a known plume of 1,1,1-trichloroethane. This plume is monitored as part of the Environmental Restoration program – Operable Unit III. All radiological analytes were well within drinking water standards.

7.3.1 NONRADIOLOGICAL RESULTS

Samples collected from supply Wells 9, 10, 12 and 105 were analyzed for VOCs followed EPA Standard Method 624. This method analyzes for 37 organic compounds, including halogenated and aromatic hydrocarbons. The only parameters detected above minimum detection limits (MDL) were chloroform, 1,1,1-trichloroethane, and dichloroethylene. The chemical 1,1,1-trichloroethane was detected in Well 9 at 7.2

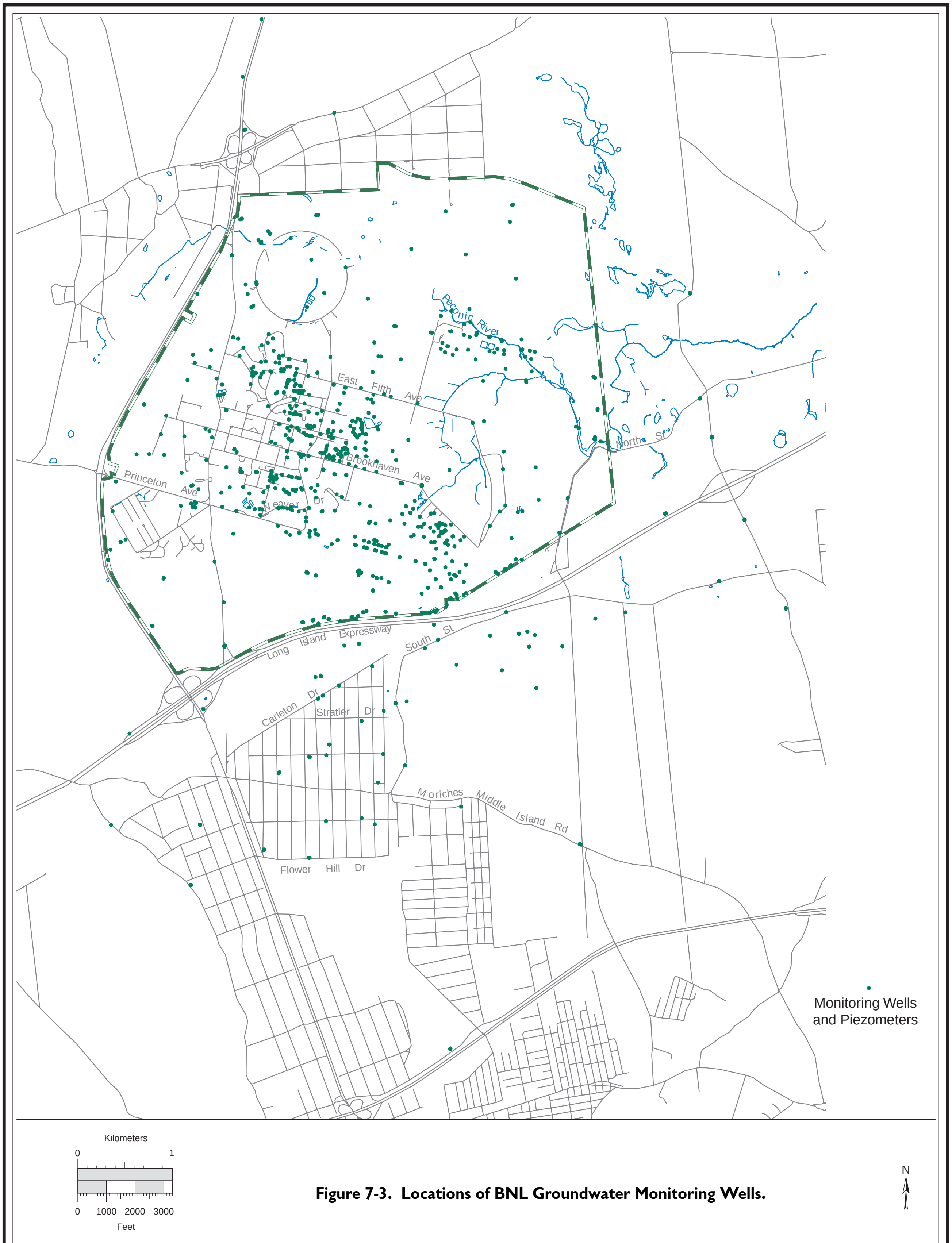

Figure 7-3. Locations of BNL Groundwater Monitoring Wells.

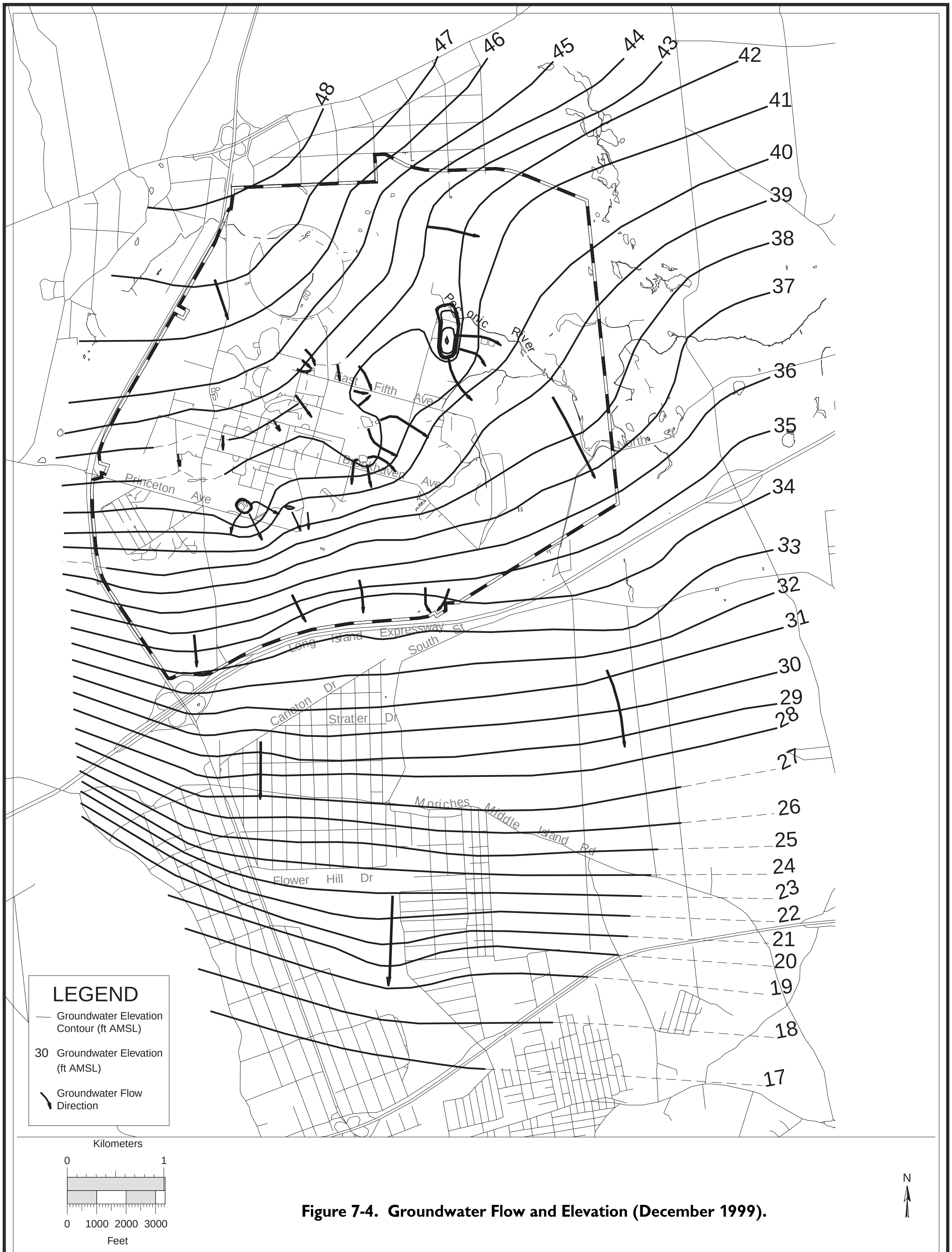

Figure 7-4. Groundwater Flow and Elevation (December 1999).

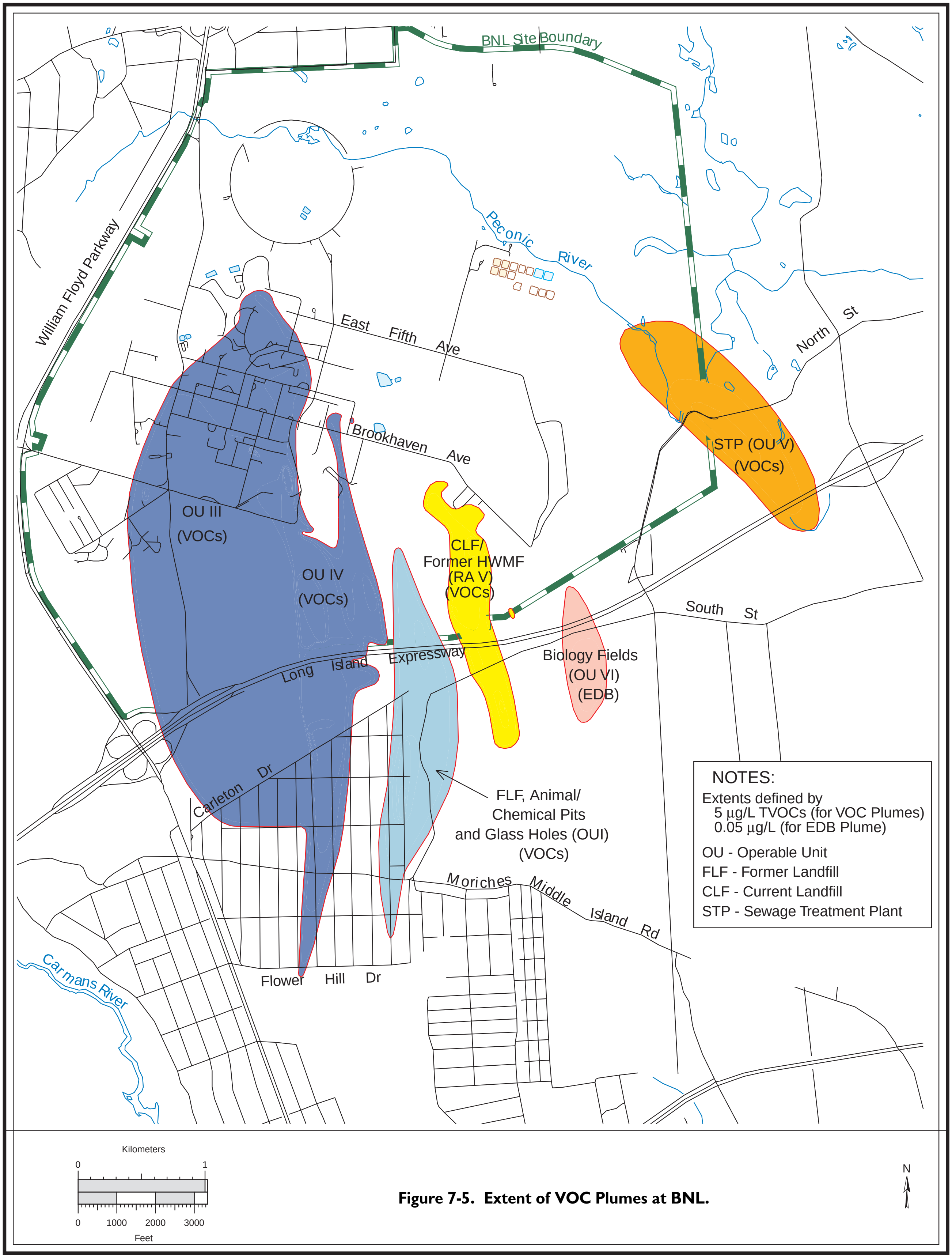

Figure 7-5. Extent of VOC Plumes at BNL.

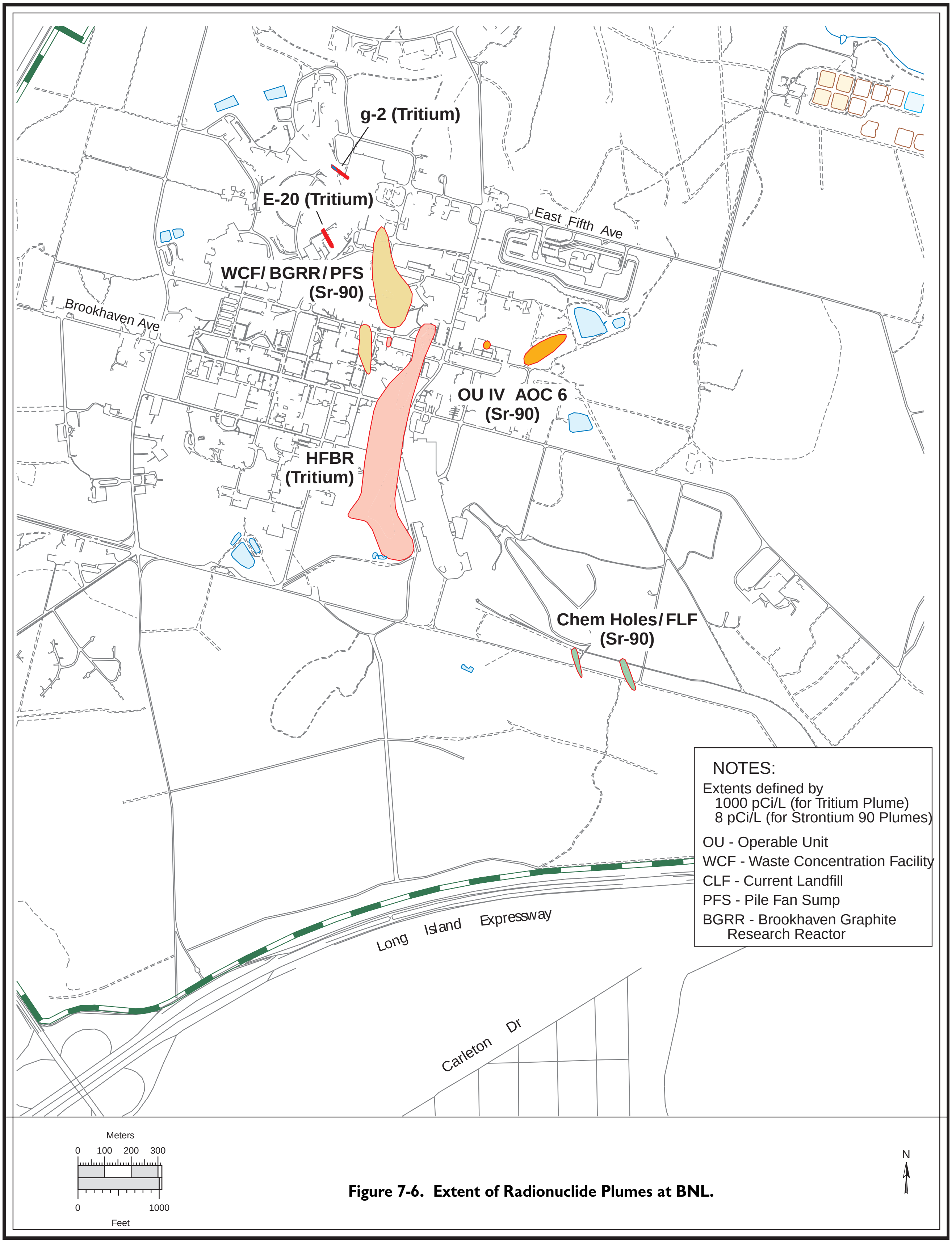

Figure 7-6. Extent of Radionuclide Plumes at BNL.

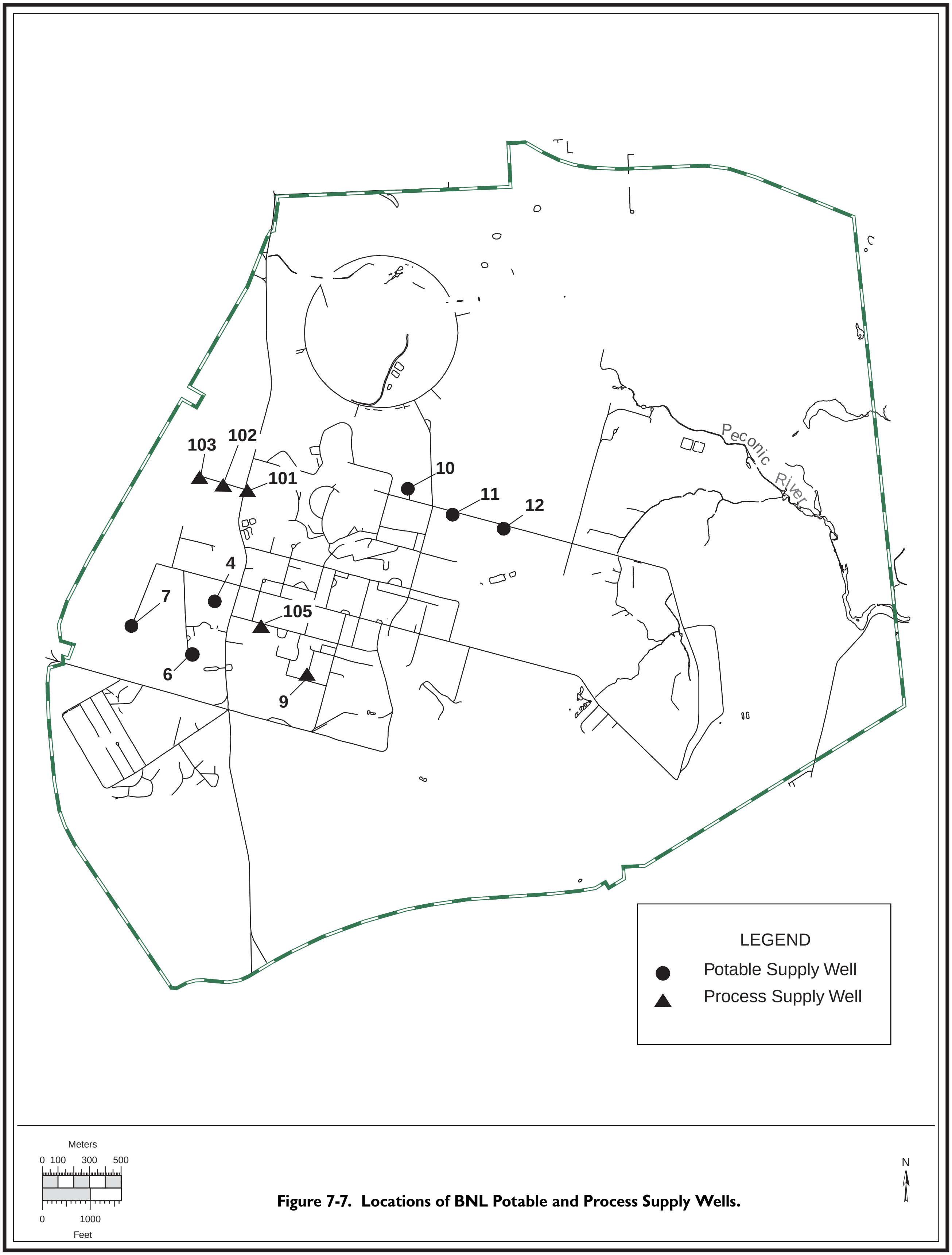

Figure 7-7. Locations of BNL Potable and Process Supply Wells.

micrograms per liter (µg/L), which exceeds the ambient water quality standard of 5 µg/L. Well 9 is located within a known area of contamination and is included in the Operable Unit III study area. This concentration of 1,1,1-trichloroethane does not interfere with the fish experimentation for which the water is used.

Chloroform was found in most wells, with concentrations ranging from trace levels (i.e., < 2 µg/L) to a maximum of 4 µg/L. All chloroform concentrations were equal to or below the ambient water quality standard of 7 µg/L and well below the drinking water standard of 100 µg/L.

Dichloroethylene was detected in Well 9 at a maximum concentration of 2.9 µg/L, which is less than the drinking water standard of 5 µg/L.

7.3.2 RADIOLOGICAL RESULTS

Potable and process well water was sampled and analyzed for gross alpha and gross beta activity, tritium, and Sr-90; the results are listed in Table 7-1. Nuclide-specific gamma spectroscopy was also performed, supplementing the requirements of the SDWA, which does not strictly require this analysis unless gross beta activity exceeds 50 pCi/L. In response to employee concerns regarding the radiological content of the BNL potable water system, the total number of samples collected in 1999 was increased from previous years, to a maximum of ten times for Well 12. This well was in operation for the entire year and provided the majority of the drinking water for the site. Wells 4, 6, 7, 10, and 11 are less frequently used; consequently, they were sampled less frequently.

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 man-made gamma-emitting radionuclides were observed above the minimum detection limit in any of the potable wells sampled. Throughout the year, process Wells 9 and 105 also showed radiological results that were consistent with background environmental values.

Compliance with the SDWA is based on the analytical results obtained from an annual composite of four quarterly samples or the average of the analyses of four quarterly samples. Compliance is demonstrated if

- the annual average gross alpha activity is less than 15 pCi/L,
- gross beta activity is less than 50 pCi/L,
- strontium concentrations are less than 8 pCi/L,
- tritium concentrations are less than 20,000 pCi/L, and
- the total effective dose equivalent for all detected radionuclides combined is less than 4 mrem in a year.

During 1999, all of these criteria were satisfied, and therefore, the BNL potable water system was in full compliance with the radiological requirements of 40 CFR 141.

7.4 ENVIRONMENTAL RESTORATION (ER) GROUNDWATER MONITORING PROGRAM

The mission of the ER groundwater monitoring program is to monitor the various contaminant plumes located onsite and offsite, as well as to monitor the progress that the groundwater treatment systems are making on plume remediation. The long-term groundwater monitoring projects coordinated under the ER monitoring program are designed to address the following issues:

1. Pre-Record of Decision (pre-ROD) Monitoring: Addresses the short-term monitoring of plumes to track their movement following the Remedial Investigation characterization and prior to remediation;
2. Post-Record of Decision (post-ROD) Monitoring: Addresses the long-term monitoring of plumes to track their movement following the initiation of remediation systems. This monitoring includes

- Source Removal Effectiveness: The monitoring of wells installed to verify that remediation projects, such as the capping of previously used landfills, are performing to specifications,
- Treatment System Performance: The monitoring of active pump-and-treat systems to verify that they are effectively capturing and removing contaminants, as well as the monitoring of plumes undergoing passive remediation (i.e., natural attenuation) to verify that natural processes are effective in reducing contaminant concentrations, and
- Outpost (Sentinel Well) Detection Monitoring: The monitoring of wells located between the leading edge of contaminant plumes and a potential receptor, to give early warning of the arrival of the leading edge of the plume and trigger contingency remedial actions.

The groundwater monitoring information described below provides an overview of ER groundwater monitoring and remediation activities for 1999. During this period, a total of 505 groundwater surveillance wells were moni-

Table 7-1. Potable and Process Well Radiological Analytical Results for 1999.

Well ID*		Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Tritium (pCi/L)	Sr-90 (pCi/L)
Potable Wells					
4 (FD)	N	6	6	7	2
	Max.	1.8 ± 0.6	7.9 ± 1.6	< 339	< 0.41
	Avg.	0.4 ± 0.7	2.3 ± 2.1	54 ± 116	0.14 ± 0.34
6 (FF)	N	7	7	8	2
	Max.	1.5 ± 0.6	7.9 ± 1.5	348 ± 210	2.74 ± 0.49
	Avg.	0.4 ± 0.5	2.3 ± 2.0	53 ± 108	1.42 ± 1.83
7 (FG)	N	6	6	6	2
	Max.	< 0.8	52.9 ± 2.6	< 339	< 0.411
	Avg.	0.1 ± 0.3	9.7 ± 15.5	20 ± 124	-0.006 ± 0.005
10 (FO)	N	8	8	9	2
	Max.	2.3 ± 0.7	6.2 ± 1.5	< 316	< 0.37
	Avg.	0.5 ± 0.6	2.3 ± 1.2	88 ± 97	0.07 ± 0.06
11 (FP)	N	9	9	11	3
	Max.	2.1 ± 0.7	6.3 ± 1.5	< 331	< 0.38
	Avg.	0.2 ± 0.6	2.6 ± 1.6	20 ± 71	0.11 ± 0.31
12 (FQ)	N	10	10	12	2
	Max.	1.2 ± 0.6	7.8 ± 1.6	< 316	< 0.51
	Avg.	-0.1 ± 0.4	1.8 ± 1.6	41 ± 75	0.14 ± 0.16
Tap Water	N	243	243	243	NS
Bldg. 490 (FN)	Max.	11.7 ± 3.5	11.4 ± 5.7	451 ± 197	
	Avg.	1.9 ± 0.2	3.7 ± 0.3	-20 ± 16	
Process Wells					
105 (FL)	N	1	1	2	NS
	Max.	6.0	-0.8	< 316	
	Avg.	6.0	-0.8	29 ± 154	
9 (FM)	N	1	1	2	NS
	Max.	-1.0	-1.1	< 316	
	Avg.	-1.0	-1.1	0 ± 87	
SDWA Limit		15[(a)]	50[(b)]	20,000	8

Notes:
All values shown with 95% confidence interval.
No anthropogenic gamma-emitting radionuclides were detected in samples collected from these wells in 1999.
N=Number of samples collected.
NS=Not sampled for this analyte.
SDWA=Safe Drinking Water Act
* Historic ID shown in parentheses.
[(a)] Excluding radon and uranium.
[(b)] Screening level above which analysis for individual radionuclides is required.

tored during approximately 1,800 individual sampling events. All wells sampled during 1999 are listed in Appendix E. Detailed analytical results for each sample obtained under the ER program are provided in the *1999 BNL Groundwater Monitoring Report* (Dorsch *et al.* 2000). Detailed information about the performance of the remediation systems and recommendations for potential adjustments to the systems are presented in the Operational Reports for the individual systems briefly described below.

Maps showing the main VOC and radionuclide plumes are provided as Figures 7-5 and 7-6. For each significant contaminant source area and plume described below, 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. Associated cross sections showing the vertical distribution/extent of contamination, as well as the hydrogeology are described in the *1999 BNL Groundwater Monitoring Report*. Because significant changes in contaminant concentrations are typically not observed during the course of the year, a single representative monitoring period (i.e., one quarterly sampling period) was chosen for each plume.

7.4.1 BACKGROUND MONITORING

Ambient (or background) groundwater quality for the BNL site is monitored through a network of 13 wells located in the northern portion of the site and in offsite areas to the north. The site background wells provide information on the chemical and radiological 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 of contamination that may be located upgradient of the BNL site.

There were no significant detections of VOCs in background wells. The highest concentration detected was chloroform at 2.1 µg/L in Well 000-120, which is a shallow Upper Glacial aquifer well, located immediately north of the northwest corner of the site. The ambient water quality standard for chloroform is 7 µg/L. Historically, low concentrations of VOCs have been detected in background Wells 017-03, 017-04, 018-03 and 018-04. All radionuclide concentrations were consistent with ambient (natural) levels.

7.4.2 OPERABLE UNIT (OU) I

7.4.2.1 FORMER LANDFILL, ANIMAL/CHEMICAL PITS AND GLASS HOLES

The Former Landfill area was initially used by the U.S. Army during World Wars I and II. Then BNL used the southeast corner of the landfill from 1947 through 1966 for 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 disposed of in shallow pits in an area directly east of the Former Landfill. From 1966 through 1981, BNL disposed of used glassware in shallow pits located directly north of these chemical/animal pits.

A network of eight monitoring wells is used to monitor the Former Landfill area. The monitoring program for the Former Landfill is designed in accordance with post-closure operation and maintenance requirements specified in 6 NYCRR Part 360, "Solid Waste Management Facilities." These requirements specify that the well network be monitored quarterly for a minimum of five years, after which time BNL may petition NYSDEC to modify the frequency and types of analyses based on supporting data. The objective of this program is to monitor radiological and nonradiological contamination in the shallow Upper Glacial aquifer immediately downgradient of the landfill. The program was initiated following the capping of the Former Landfill in November 1996, to verify whether the cap effectively prevents the continued leaching of contaminants from the landfill and 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 I/IV Pre-ROD Monitoring Program.

Volatile Organic Compounds

The areal extent of VOC contamination from the Former Landfill - Animal/Chemical Pits and Glass Holes area is shown on Figure 7-8. The primary chemical contaminants observed in the Former Landfill - Animal/Chemical Pits and Glass Holes plume are carbon tetrachloride (CT), 1,1,1-trichlorethane (TCA), 1,1-dichlroethylene (DCE), trichlorethylene (TCE), tetrachloroethylene (PCE) and chloroform. These individual constituents were observed in wells extending from the Former Landfill source areas to the southern site boundary at concentrations generally less than 50 µg/L. (Note: the NYS AWQS for most of these VOCs is 5 µg/L; the standard for chloroform is 7 µg/L.) The same constituents also appear in the segment of the plume located south of the southern site boundary. The plume is approximately 9,700 feet in length from the Former Landfill source areas to just south of Crestwood Drive, and approximately 1,600 feet at its maximum width, as defined by areas having Total Volatile Organic Compound (TVOC) concentrations greater than 5 µg/L. (Note: A TVOC concentration is the sum of all individual VOC concentrations detected in a given sample.) The segment of the plume with >50 µg/L concentrations is approximately 700 feet wide. The area of the plume showing the highest TVOC concentration is located offsite near Sleepy Hollow Drive. This segment of the plume is comprised primarily of CT, with a maximum TVOC concentration of 397 µg/L detected in Well 000-154 in November 1999. In general, VOCs are found in the shallow Glacial aquifer in the vicinity of the Former Landfill, Animal/Chemical Pits and Glass Holes area, in the middle Upper Glacial aquifer at the southern site boundary, and in the deep Upper Glacial aquifer south of BNL. For a more detailed discussion on the vertical distribution of VOC contamination, see the 1999 BNL Groundwater Monitoring Report (Dorsch *et al.* 2000).

Wells 106-25 (located onsite in the Middle Road area) and 115-32 (located at the site boundary) displayed declining TVOC concentrations in 1999, following increasing trends during 1998 (see Figure 7-8). In both wells, the decline in VOC concentrations is probably due to the migration of high concentration "slugs" of PCE past these wells. Offsite Well 000-154 (located in the high concentration segment of the plume) displayed fluctuating TVOC concentrations in 1999 after showing a steady decline in 1998. A similar trend has been observed for offsite Well 000-108.

A comparison of the TVOC plume distribution from 1997 through 1999 is shown on Figure 7-9. Comparison of the groundwater data indicates that the capping of the Former Landfill in November 1996 and the excavation of the Chemical/Animal Pits and Glass Holes in September 1997 have contributed to the decline of TVOC concentrations to below 5 µg/L in shallow wells located near the source areas. Since 1997, TVOC concentrations greater than 500 µg/L that were observed in the vicinity of Stratler Drive, Shirley, have declined. Although part of this decline is due to natural degradation and dispersion of the plume with time, the high TVOC concentration portion of the plume has probably migrated south of Well 000-154. Monitoring Wells 000-153 and 800-63 have been positioned to detect this high contamination zone as it continues to move south.

Radionuclides

Strontium-90 (Sr-90) has been routinely detected in groundwater in the Former Landfill, Animal/Chemical Pits and Glass Holes areas at concentrations above the drinking water standard of 8 pCi/L (specifically in Wells 106-16, 106-13, 097-03 and 097-64). There are two Sr-90 plumes (as defined by the 8 pCi/L standard) that are located close to the source areas. One plume originates from the Former Landfill and the second originates from the Animal/Chemical Pits area (Figure 7-10). Well 106-16, located immediately downgradient of the Animal/Chemical pits area, showed a maximum concentration of 2,540 pCi/L in November 1999. Historical trends in Sr-90 concentration for wells 097-64, 106-16, and 106-50 are presented in Figure 7-10. The leading edge of the Animal/Chemical Pits Sr-90 plume has migrated towards Well 106-50 (located approximately 450 feet downgradient) as evidenced by increasing Sr-90 concentrations in this well through 1999.

7.4.2.2 CURRENT LANDFILL

The Current Landfill operated from 1967 through 1990. 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 latter 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 situated 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 O&M requirements.

Volatile Organic Compounds

Although VOCs continue to be routinely detected in wells located immediately downgradient of the landfill, their concentrations continued to decrease in response to the capping of the landfill. The highest TVOC concentration observed during 1999 was 65 µg/L, detected in Well 087-23. Well 087-23 is a

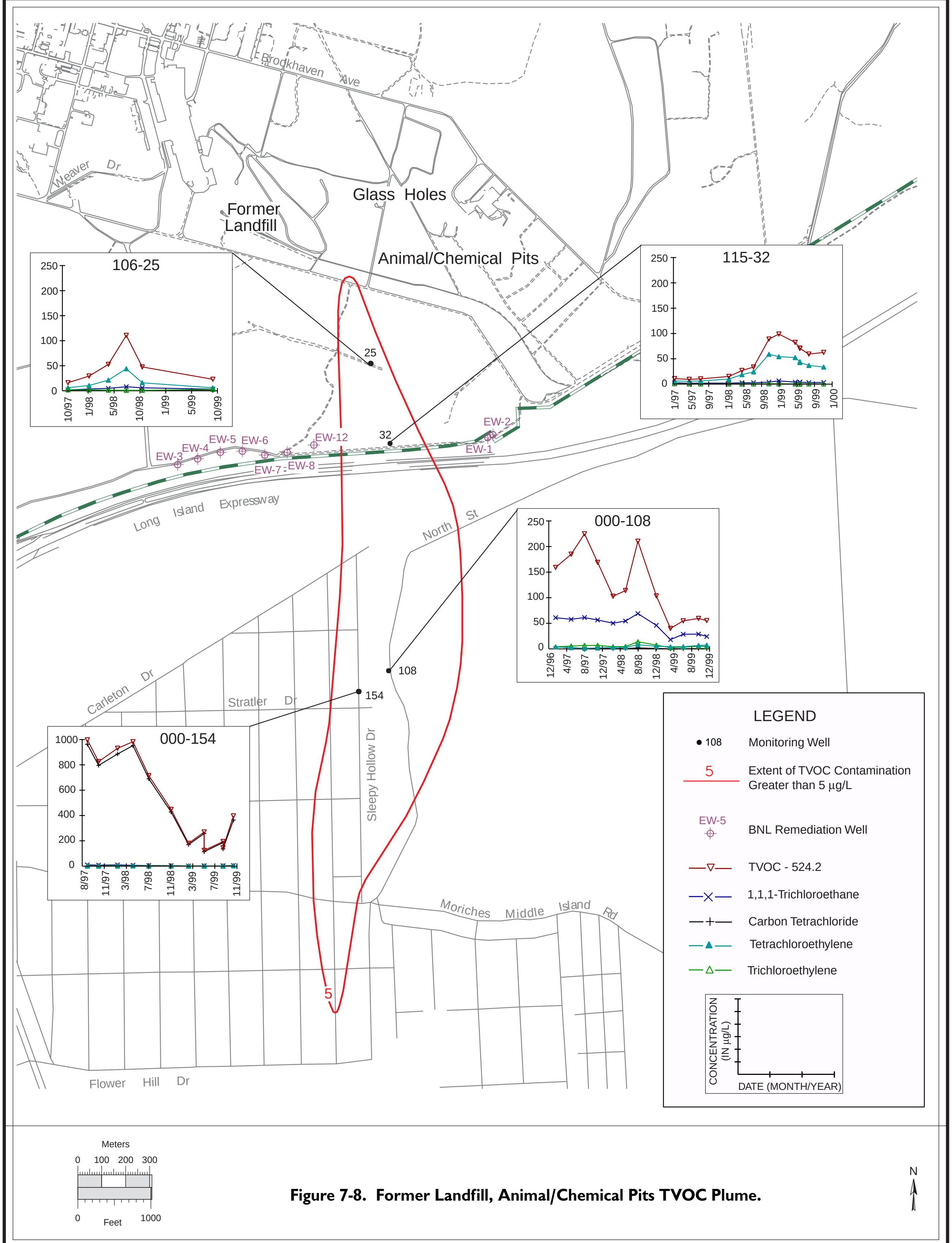

Figure 7-8. Former Landfill, Animal/Chemical Pits TVOC Plume.

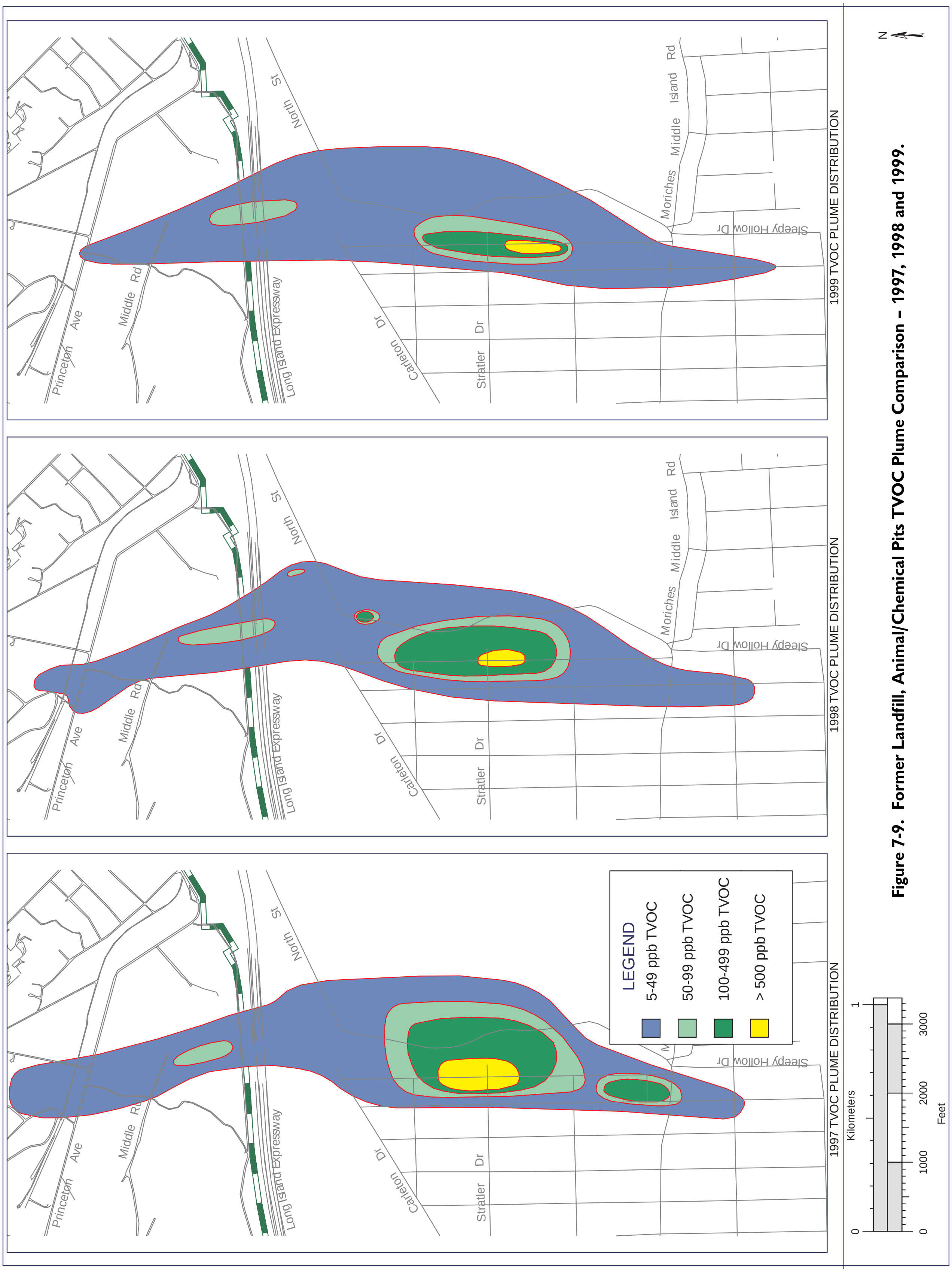

Figure 7-9. Former Landfill, Animal/Chemical Pits TVOC Plume Comparison – 1997, 1998 and 1999.

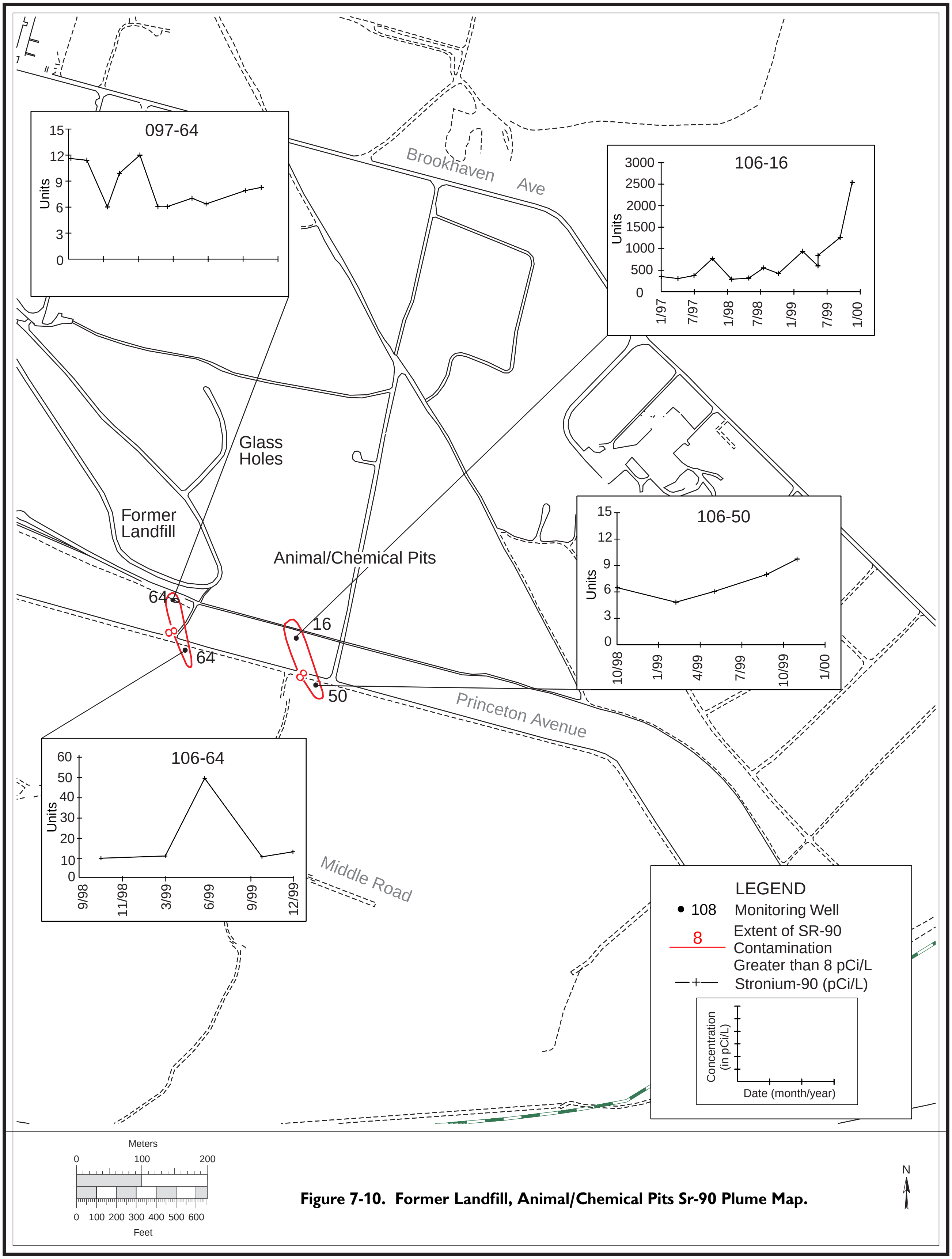

Figure 7-10. Former Landfill, Animal/Chemical Pits Sr-90 Plume Map.

shallow water table well located just south of the southwest corner of the landfill. Concentrations in downgradient Wells 088-22 and 088-109, which exhibited TVOC concentrations of greater then 500 µg/L during 1998, were non-detect and 35 µg/L respectively during 1999.

A detailed discussion of the groundwater monitoring results for the Current Landfill area are included in the *1999 Environmental Monitoring Report - Current and Former Landfill Areas* (BNL 2000a).

Radionuclides

As in previous years, low levels of tritium and Sr-90 were detected in Current Landfill monitoring wells during 1999, but at concentrations well below their applicable drinking water standards. The highest tritium value was 2,325 pCi/L in Well 088-110, whereas the highest Sr-90 value was 2.2 pCi/L detected in Well 088-21.

7.4.2.3 FORMER HAZARDOUS WASTE MANAGEMENT FACILITY (HWMF) AND DOWNGRADIENT SECTION OF CURRENT LANDFILL PLUME

Groundwater contamination originating from the former HWMF and the downgradient section of the Current Landfill plume is being monitored under the Removal Action V (RA V) program. Until 1997, the former HWMF was BNL's central Resource Conservation and Recovery Act receiving facility for processing, neutralizing, and storing hazardous and radioactive wastes before offsite disposal. As the result of past waste handling and storage practices, groundwater at the former HWMF are contaminated with both chemicals and radionuclides at concentrations that exceed NYS AWQS or DWS.

The Current Landfill and former HWMF plumes become commingled south of the HWMF due, at least partially, to historical pumping and recharge effects of the former Spray Aeration System, which operated from 1985 to 1990. The Spray Aeration System was designed to treat VOC-contaminated groundwater originating from the HWMF. The Current Landfill/HWMF plume is currently 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 (the RA V Treatment System is described in Section 7.4.7). This system provides hydraulic containment of those onsite portions of the plume that have TVOC concentrations greater than 50 µg/L.

The RA V monitoring program uses a network of 54 monitoring wells located in areas downgradient of the Current Landfill and HWMF. This monitoring program is specifically designed to

- ♦ Monitor the VOC and radiological contamination of groundwater in the shallow zone of the Upper Glacial aquifer at, and immediately adjacent to, the HWMF,
- ♦ Monitor the VOC and radiological contaminant plumes located south of the Current Landfill and HWMF that have been commingled south of the HWMF, and
- ♦ Evaluate the effectiveness of the RA V groundwater pump-and-treat system that was initiated in December 1996 at the southern site boundary (extraction wells EW-1 and EW-2). The monitoring program provides information necessary to characterize the effects of this treatment system on the contaminant plume, and provide the data necessary to make decisions on the future operations of the system.

For a detailed description of the remediation system and its effects on the VOC plume, readers are referred to the *RA V Groundwater Treatment Annual Operations Report 1999* (BNL 2000b). A detailed discussion of the groundwater monitoring results for the Current Landfill/HWMF area is included in the *1999 BNL Groundwater Monitoring Report* (Dorsch *et al.* 2000).

Volatile Organic Compounds

TVOC concentration distributions for the Current Landfill/HWMF plume are shown in Figure 7-11. The primary VOCs found onsite include chloroethane, TCA , and DCA; whereas TCA, DCE, TCE, and chloroform are found in the offsite portion of the plume. The Current Landfill/HWMF plume, as defined by TVOC concentrations greater than 5 µg/L, extends from the Current Landfill south to an area south of North Street, a distance of approximately 7,150 feet. The plume is approximately 1,100 feet wide at its maximum (as defined by concentrations >5 µg/L). The higher concentration portion of the plume (i.e., where concentrations are >50 µg/L) is approximately 800 feet wide. Chloroethane, TCA, and DCA are detected in the shallow Upper Glacial aquifer near the source areas, and in the deep Upper Glacial aquifer at the site boundary and offsite. TCA, DCE, TCE, and chloroform are found in the middle to deep

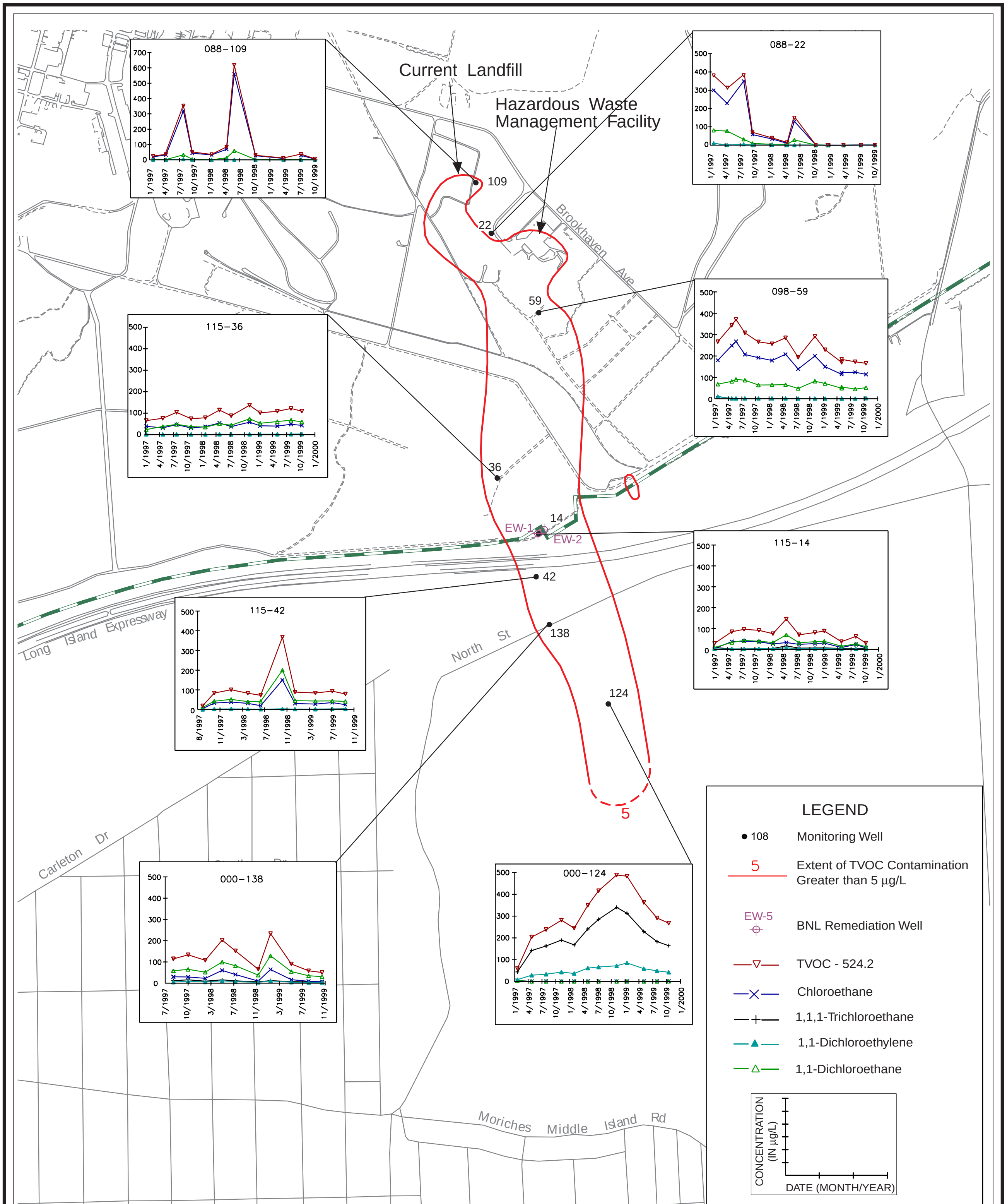

Figure 7-11. Former Waste Management Facility/Current Landfill TVOC Plume Map.

Upper Glacial aquifer offsite south of North Street. Cross sectional views of the plume are presented in the *1999 BNL Groundwater Monitoring Report* (Dorsch *et al.* 2000).

Time-vs.-VOC concentration trend plots for key wells within the Current Landfill/HWMF plume are provided on Figure 7-11. TVOC concentrations in Current Landfill Wells 088-109 and 088-22 continued to display decreasing levels. Wells 098-59 and 115-36 (located between the source areas and the site boundary) displayed slightly decreasing TVOC concentrations during 1999. Well 115-14, located close to the extraction system has maintained a low, and steady TVOC concentration. TVOC concentrations trended downward in 1999 for offsite wells 115-42, 000-124, and 000-138.

There have been several distinct changes in the distribution of the plume from 1997 through 1999 as shown on Figure 7-12. In general, the width of the plume has significantly decreased. The onsite reduction in plume width can be attributed to the effects of the pump-and-treat system located at the site boundary (for additional details on this system, refer to the *RA V Groundwater Treatment Annual Operations Report* (2000b). The apparent reduction of plume width in offsite areas is the result of improved definition of the plume using temporary wells installed during 1998. Hydraulic control of the plume at the site boundary has been achieved as evidenced by the groundwater flow patterns in this area, and the decrease in contaminant concentrations in Well 000-138 located downgradient of the extraction wells. The decrease in high concentrations immediately south of the former HWMF and offsite south of North Street may be a function of those portions of the plume having migrated to a position in between monitoring locations. The downgradient extent of the Current Landfill/HWMF plume is estimated based on temporary well data obtained during the 1998 groundwater characterization effort in conjunction with knowledge of the groundwater flow system through groundwater modeling and mapping efforts.

Radionuclides

During 1999, tritium was detected in several wells, but at concentrations below the drinking water standard of 20,000 pCi/L. The maximum observed tritium concentration was 4,331 pCi/L in a sample from Well 115-29 located near the south boundary extraction system. With the exception of Well 115-29, most of the Current Landfill/HWMF wells displayed decreasing tritium concentration trends during 1999. Although tritium concentrations in Well 088-26 (located inside the HWMF) have historically exceeded the 20,000 pCi/L drinking water standard, the maximum observed concentration during 1999 was only 2,183 pCi/L.

Although Sr-90 was detected in a number of wells located within or immediately downgradient of the HWMF, all concentrations were below the drinking water standard of 8 pCi/L. The highest Sr-90 concentration (6.3 pCi/L) was detected in Well 088-26 (located within the HWMF area). Additional groundwater characterization work is planned for CY 2000 to confirm the extent of Sr-90 contamination in the HWMF area. There were no gross alpha/beta results or gamma-emitting radionuclides detected above standards and/or screening levels during 1999.

7.4.3 OPERABLE UNIT (OU) III

The monitoring well network established to monitor the OU III VOC and radionuclide source areas and resulting contaminant plumes is composed of approximately 180 monitoring wells positioned from the north-central portion of the site to the southern site boundary and offsite. 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 (CT) Underground Storage Tank area, former Building 96 area, and the Supply and Materiel area.
- Monitor the tritium plume associated with the High Flux Beam Reactor (HFBR) and Sr-90 plumes associated with the Waste Concentration Facility and the formerly operated Brookhaven Graphite Research Reactor (BGRR).
- Evaluate the effectiveness of the OU III south boundary groundwater pump-and-treat system initiated in June 1997 (extraction wells EW-3 through EW-8). This monitoring program characterizes the effects of the pumping on the contaminant plume, and provides the data necessary for making decisions on the future operations of the extraction wells.

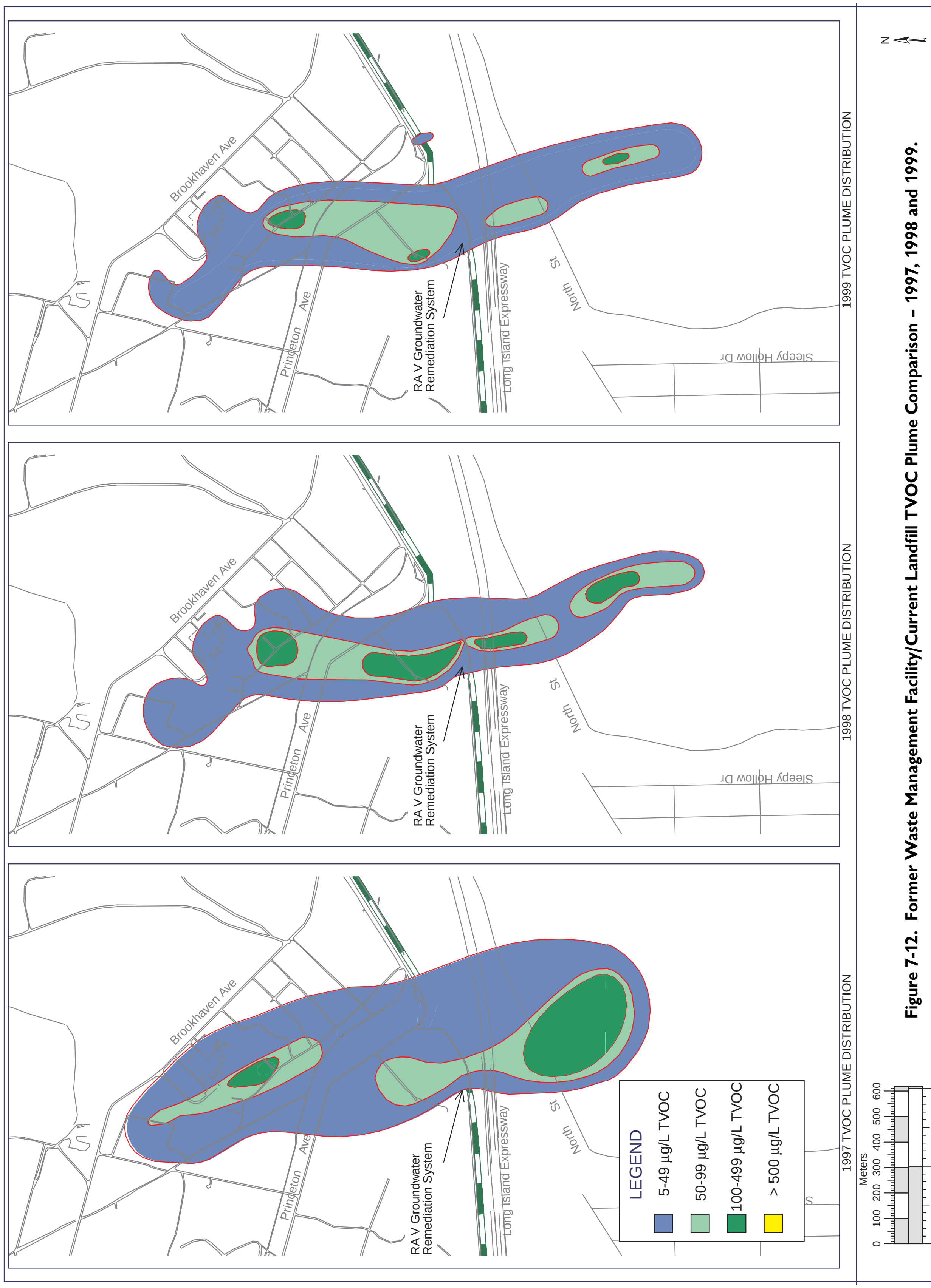

Figure 7-12. Former Waste Management Facility/Current Landfill TVOC Plume Comparison – 1997, 1998 and 1999.

- ♦ Monitor the offsite segment of the plume and "outpost" wells located to the south (downgradient) of the defined extent of the offsite VOC plume to provide data on future downgradient migration of the plume. Outpost wells are also situated in the southwestern portion of BNL, directly upgradient of the Suffolk County Water Authority's Parr Village Well Field located near the William Floyd Parkway. These wells are used to verify groundwater quality south of the BNL apartment areas, and they would also provide an early warning if contaminants from BNL were to migrate toward the Suffolk County Water Authority wells.

Volatile Organic Compounds

Figure 7-13 shows the areal extent of the OU III VOC plume and the OU IV VOC plume. The two plumes are so close to each other that it is difficult to represent them as distinct, separate plumes. The OU III VOC plume extends from the AGS Complex area in the central part of the site south to the vicinity of Flower Hill Drive in North Shirley, a distance of approximately 17,600 feet (Figure 7-13). The plume is approximately 5,000 feet at its maximum width, as defined by TVOC concentrations >5 µg/L. The higher concentration portion of the plume (i.e., containing concentrations >50 µg/L) is approximately 1,900 feet wide near the BNL southern boundary.

The OU III VOC plume is actually comprised of multiple commingled plumes originating from several sources. To determine the extent of VOC contamination, monitoring well data from 11 separate ER and Environmental Surveillance (ES) monitoring programs were evaluated. These monitoring programs include the OU III Central area, Southern Boundary area, Carbon Tetrachloride Plume, former Building 96 area, AS-Industrial Park area, Offsite Program, select downgradient wells from the HFBR Tritium Monitoring Program, Alternating Gradient Synchrotron Complex area, and the Motor Pool and Service Station areas. The primary VOCs detected in onsite monitoring wells include CT, TCA, and PCE; whereas CT and PCE are the primary VOCs detected in offsite groundwater. In general, PCE, TCA, and CT are observed in the shallow portions of the Upper Glacial aquifer in the central portion of BNL and in the deep Upper Glacial aquifer at the southern boundary and offsite areas. Samples from deep wells located near the offsite Industrial Park indicate that there is CT contamination in the Upper Magothy aquifer.

During 1999, wells displaying the highest VOC concentrations (i.e., greater than 1,000 µg/L) include the former Building 96 area, the former CT underground storage tank area (Figure 7-14), areas near the South Boundary Treatment System, and the offsite Industrial Park Treatment System area. Trend plots showing changes in VOC concentrations for key OU III monitoring wells are presented on Figures 7-15 and 7-16. A comparison of the OU III plume distribution from 1997 through 1999 is provided on Figure 7-17.

The VOC plume in the former Building 96 area consists primarily of PCE, and lower concentrations of TCA, with TVOC concentrations up to 4,390 µg/L. During 1999, design work was initiated for an in-well air sparging system to remediate the Building 96 source area. This groundwater treatment system is expected to be operational in CY 2000.

In April 1998, an inactive underground storage tank used for the storage of CT was excavated and removed. Although groundwater samples collected from a nearby well had shown low-level concentrations of CT since 1995, samples collected in June 1998 revealed levels approaching 100,000 µg/L. The ambient water quality standard for CT is 5 µg/L. It is now apparent that the increase in contaminant concentration was probably due to the spillage of residual CT during removal of the underground storage tank. Since 1998, the leading edge of the CT plume has migrated approximately 300 feet downgradient from the former underground storage tank area (see Figure 7-14). The highest CT concentrations (up to 7,290 µg/L) were detected in Well 085-161 located approximately 100 feet downgradient of the former underground storage tank area. Concentrations drop to 375 µg/L in Well 085-17. Figure 7-14 provides time-vs.-carbon tetrachloride trend plots for the wells in this area. The effects of the pump-and-treat system on the source area are apparent in the sharp decline in VOC concentrations at Well 085-98 (see Section 7.4.7 for a description of the treatment system). Additional monitoring wells will be installed in CY 2000 to address the leading edge of this plume.

TVOC concentrations greater than 1,000 µg/L extend from the Middle Road to the

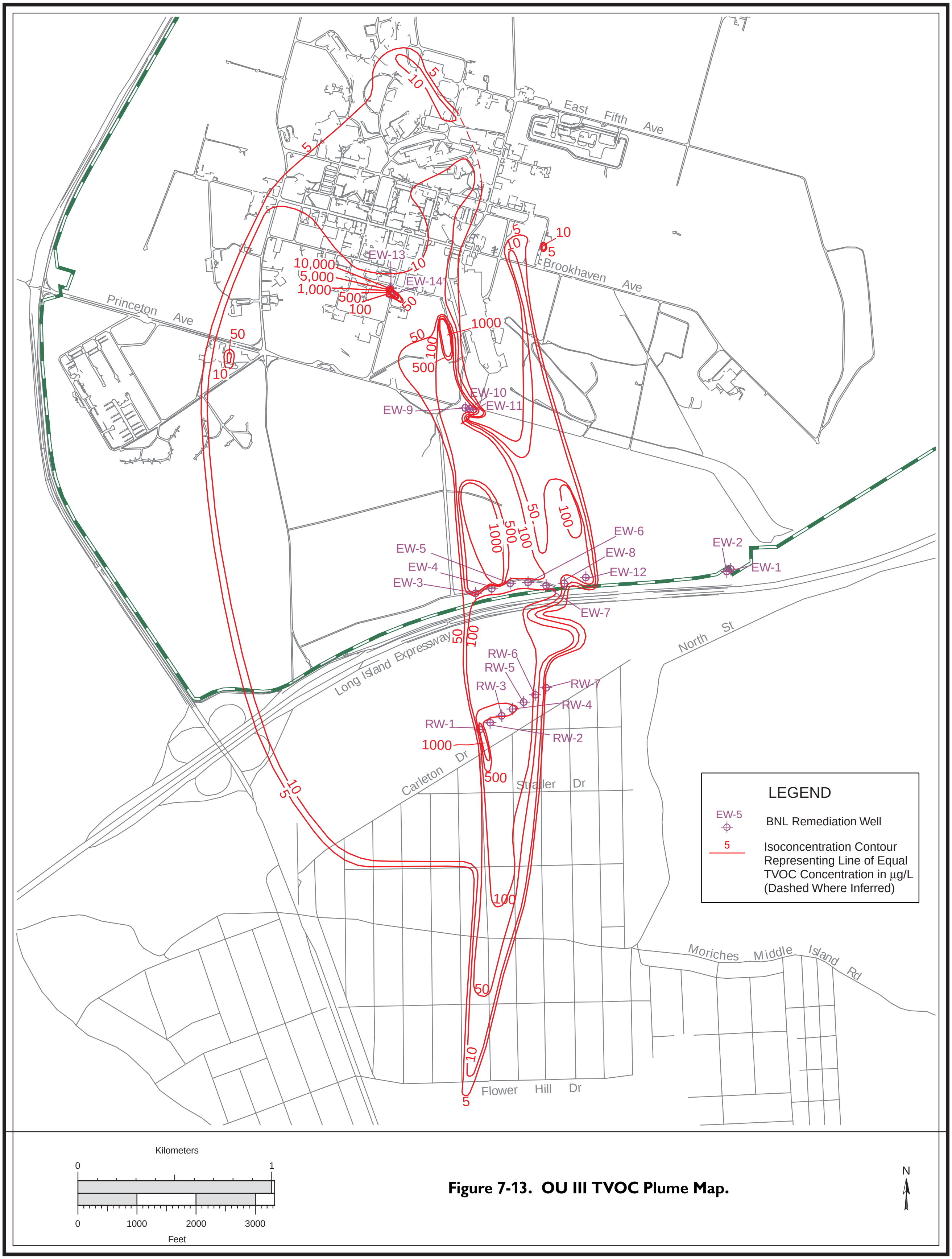

Figure 7-13. OU III TVOC Plume Map.

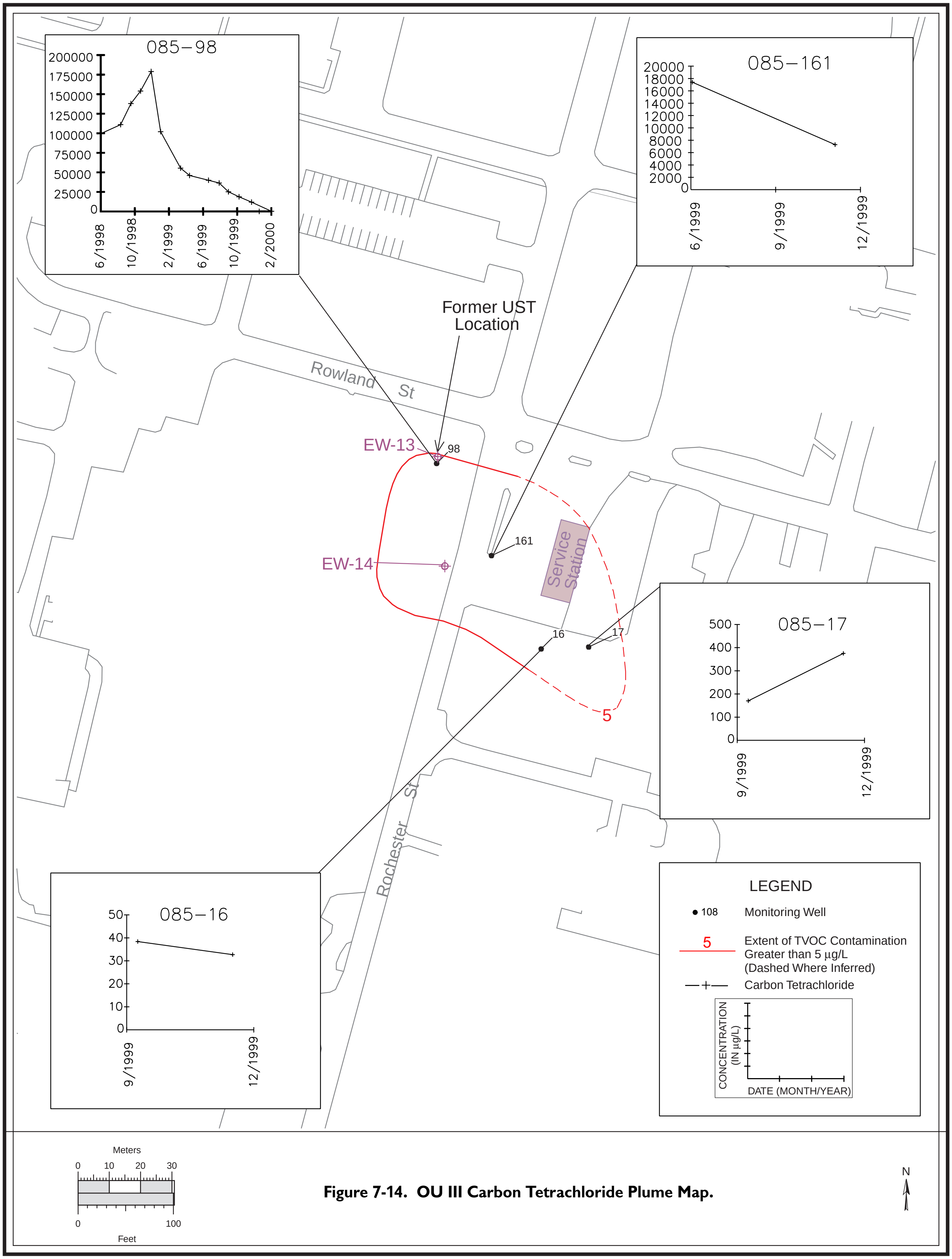

Figure 7-14. OU III Carbon Tetrachloride Plume Map.

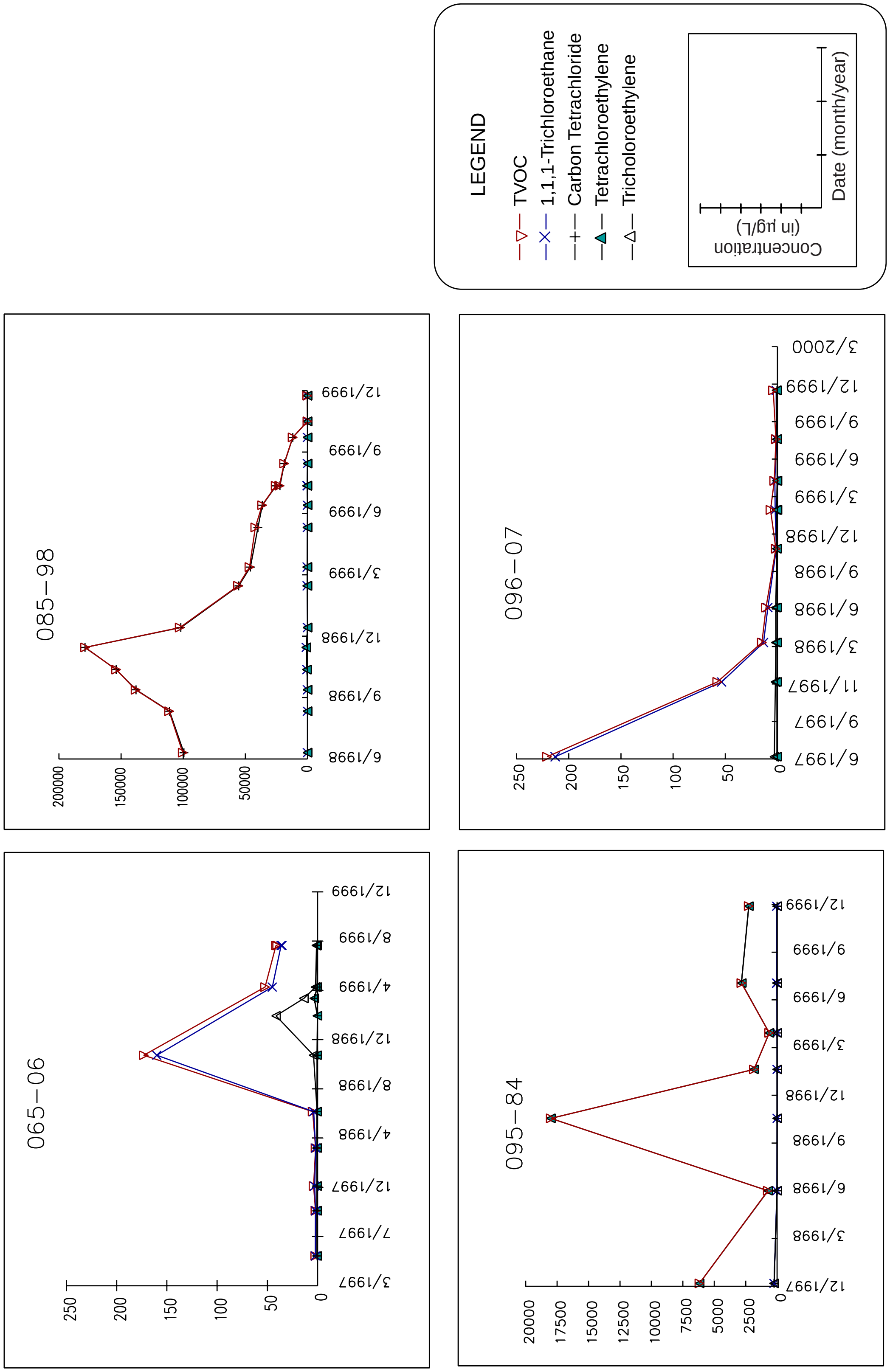

Figure 7-15. Time-vs.-VOC concentration trend plots for key wells in the OU III plume (central area): Well 065-06 located downgradient of the AGS area; Well 085-98 located downgradient of the carbon tetrachloride spill area; Well 095-84 located in the former Building 96 area; and Well 096-07 located downgradient of the Supply and Materiel Building 208.

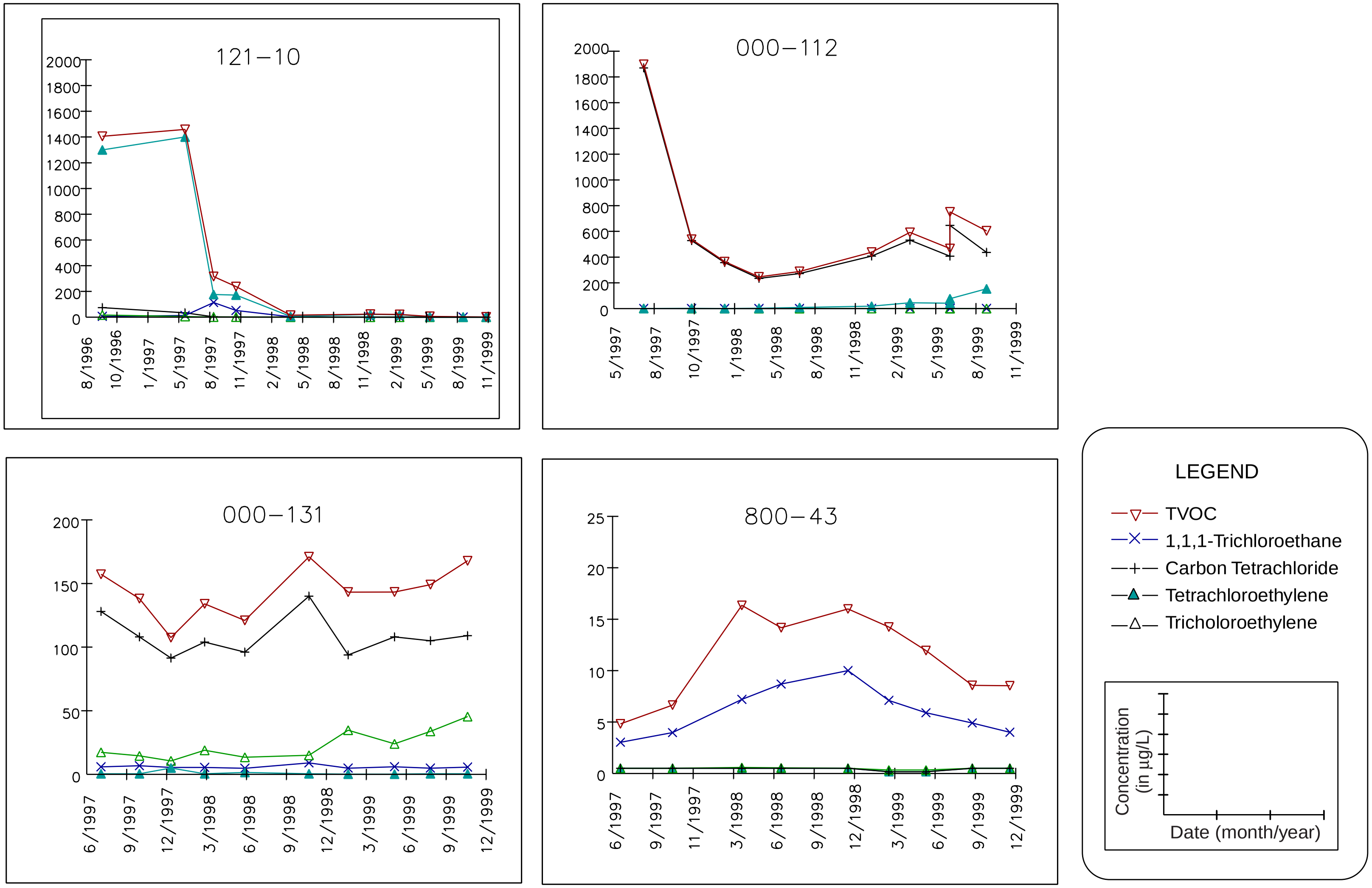

Figure 7-16. Time-vs.-VOC concentration trend plots for key wells in the OU III plume (southern boundary and offsite areas): Well 121-10 located at the BNL southern boundary; Well 000-112 located offsite near the Brookhaven Industrial Park; Well 000-131 located on Waldorf Drive; and Well 800-43 located near Flower Hill Drive near leading edge of the OU III plume.

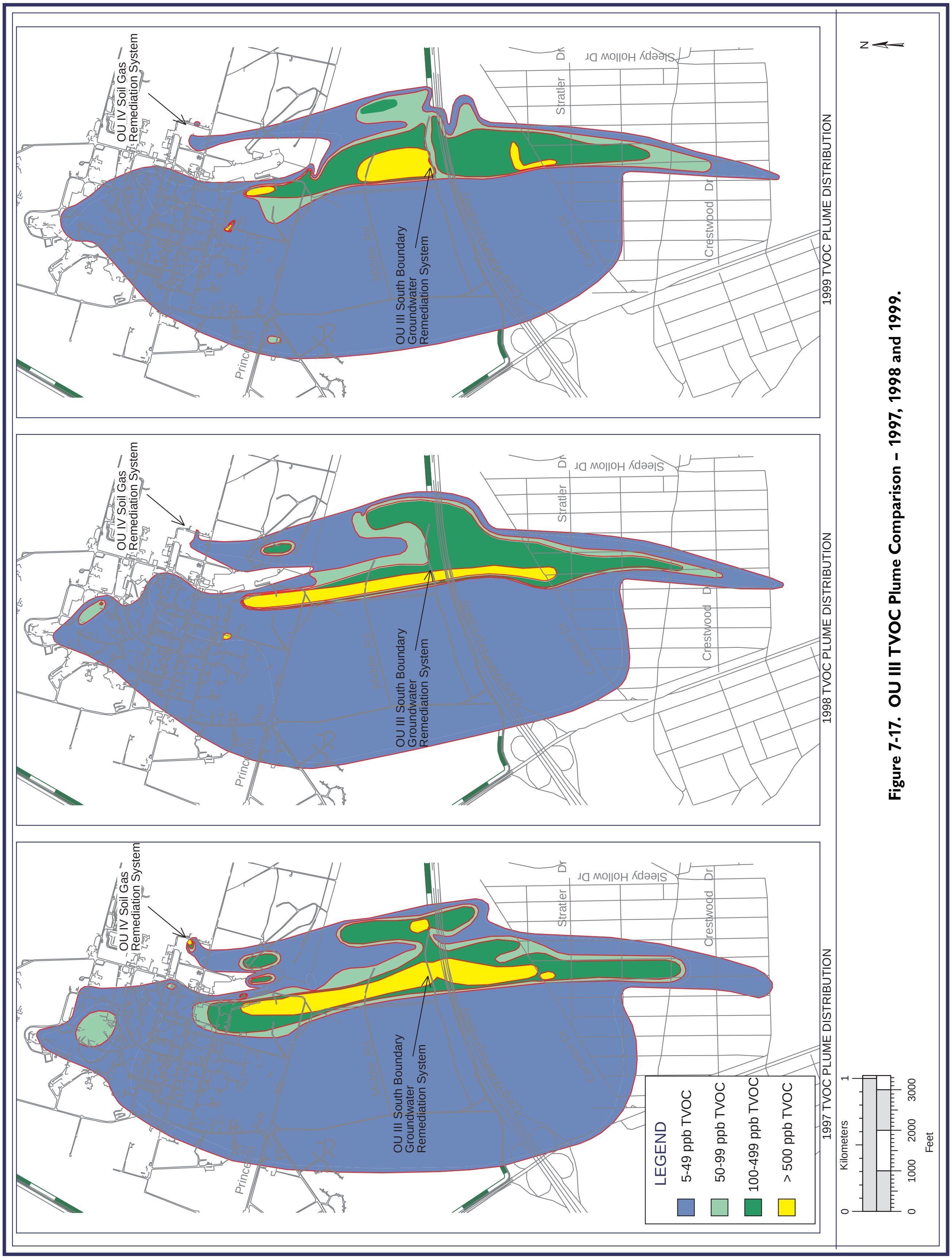

Figure 7-17. OU III TVOC Plume Comparison – 1997, 1998 and 1999.

South Boundary Treatment System area. Concentrations ranged from 1,044 µg/L in wells located near the Middle Road (i.e., Wells 113-08 and 113-11) to 1,213 µg/L in Well 121-13, which is located immediately upgradient of the southern boundary extraction system. Wells located south of the southern boundary extraction system have continued to display either reductions in concentrations or are maintaining already low concentrations (<200 µg/L). These low concentrations can be attributed to the positive effects of the extraction system. A seventh extraction well (EW-12) was installed during 1999 to provide better hydraulic control of the eastern portion of the plume, which consists of contaminants originating from the OU IV source area (See Figure 7-26). The *CY 1999 OU III Pump-and-Treat System Annual Report* (BNL 2000c) contains detailed information on system operations and progress on the remediation effort.

A TVOC plume with concentrations greater than 1,000 µg/L extends from the offsite Industrial Park area to Carleton Drive in North Shirley. This plume, which consists primarily of CT, is located in the upper portion of the Magothy aquifer. The highest CT concentrations were found in samples from Wells 000-249 and 000-130, with maximum concentrations of 1,011 µg/L and 5,485 µg/L, respectively. A groundwater treatment system, consisting of seven in-well air stripping treatment wells, was installed in the industrial park located south of BNL in 1999. The purpose of the in-well air stripping wells is to treat VOC contamination located in the deep Upper Glacial aquifer. Thirty-six monitoring wells were also installed in this area to monitor the effects of the system (i.e., hydraulic control and changes in VOC concentrations). The OU III Off Site Removal Action groundwater treatment system went into operation on September 29, 1999. Details on the system start-up and technology can be found in the report *OU III Off site Removal Action System Start-Up Report* (BNL 2000d). Additional characterization to define the extent of CT contamination in the Magothy aquifer is planned in CY 2000.

Compared to previous years, VOC concentrations increased in HFBR Tritium Plume extraction well EW-9 (located on Princeton Avenue), with annual average TVOC concentrations increasing from 79 µg/L in 1998 to 298 µg/L in 1999. This increase can be attributed to slight changes in groundwater flow directions caused by site-wide pumping and recharge effects, and the continued operation of the extraction wells. These combined effects have apparently shifted higher concentration portions of the OU III plume (originating from the former Building 96 area) to the east. Details on the treatment of VOC contamination can be found in the *Tritium Pump and Recharge System Annual Evaluation Report* (BNL 2000e).

7.4.3.1 HFBR TRITIUM PLUME

Following the January 1997 discovery of tritium in wells south of the HFBR, it was determined that the HFBR's spent fuel pool was leaking tritiated water at a rate of approximately six to nine gallons per day. To prevent additional release of tritiated water, the HFBR's spent-fuel pool was completely emptied in December 1997. An extensive groundwater investigation has demonstrated that the tritium plume remains completely onsite, and an interim remediation system was designed to control the leading edge of the plume.

During 1999, additional groundwater characterization work was conducted to provide an updated picture of the high concentration portion of the plume located immediately downgradient of the HFBR, and to enhance the downgradient monitoring well network. Figure 7-18 shows the HFBR tritium plume. The plume (defined by tritium concentrations greater than 1,000 pCi/L) extends from the HFBR to a location immediately north of Weaver Drive, a distance of approximately 3,000 feet. (Note: The drinking water standard for tritium is 20,000 pCi/L.) The plume is approximately 600 feet wide at its maximum. Tritium is detected in the shallow Upper Glacial aquifer near the HFBR source area, and in the deep Upper Glacial aquifer just to the north of Weaver Drive.

There are two areas of the tritium plume with concentrations greater than 20,000 pCi/L. One segment extends from the HFBR to Brookhaven Avenue, and the second smaller area is located between Weaver Drive and Rowland Street. The area of the plume containing the highest concentrations continues to be located in a narrow band extending from the HFBR south to the vicinity of Brookhaven Avenue (see Figure 7-18). Concentrations greater than 500,000 pCi/L were found from the HFBR south to a point just north of Temple Place. The highest tritium concentration was

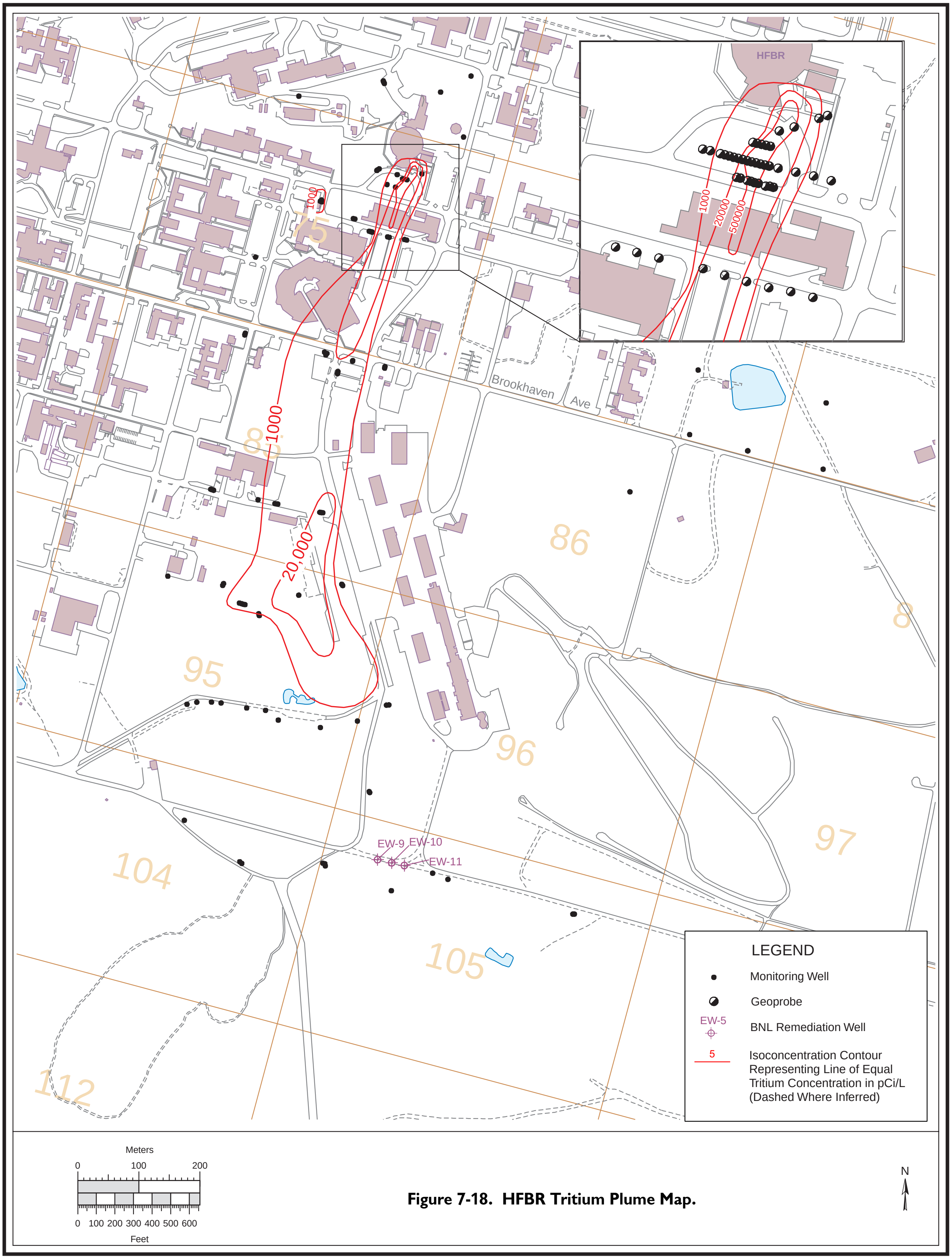

Figure 7-18. HFBR Tritium Plume Map.

5,034,561 pCi/L, detected in a temporary well installed approximately 150 feet south of the HFBR (north of Cornell Avenue). The second area where tritium concentrations exceeded 20,000 pCi/L is located south of Rowland Street and centered on Wells 085-78 (maximum concentration of 63,261 pCi/L) and Well 095-48 (maximum concentration of 51,898 pCi/L). It appears that the remediation system has had a positive effect on further reducing the low level tritium concentrations previously detected in the area south of Weaver Drive. There has been no significant downgradient migration of tritium between 1997 and 1999; and Well 105-44, which is located immediately downgradient of the tritium pump and treat system, showed a significant decline in tritium concentration during 1999.

Historical tritium trends are presented in Figure 7-19. Data collected during 1999 indicate that the tritium plume has shifted to the east in response to artificial influences on the groundwater flow field (i.e., influence caused by supply well pumping and water recharge). This eastward shift is discernable when comparing tritium concentration trends from 1997 through 1999. Wells that were initially located within the plume either showed continual concentration declines or remained at or just above detection limits (Wells 075-11, 075-12, 075-43, 075-45, 075-44, 075-85, 085-71, 085-72, and 095-44). However, tritium concentrations have increased in wells that were located to the east of the high concentration portions of the plume in 1997 (Wells 085-67, 085-78, and 095-48). Figure 7-20 shows a comparison of the 1997 and 1999 plume distribution. A detailed analysis of the flow conditions in this area of the site was performed as part of the *Monitored Natural Attenuation (MNA) Work Plan for the HFBR Tritium Plume* (BNL 1999a).

7.4.3.2 WASTE CONCENTRATION FACILITY (WCF) AND BROOKHAVEN GRAPHITE RESEARCH REACTOR (BGRR)/PILE FAN SUMP AREAS

Historical waste handling operations at the WCF, and operations at the former BGRR and its associated Pile Fan Sump, resulted in the release of Sr-90 to the groundwater below these facilities. Following an extensive characterization effort in 1997 utilizing temporary wells, a permanent monitoring-well network was installed in the spring of 1999. The newly installed wells supplemented available existing wells monitored under the OU III (AOC 29 HFBR) program and wells previously installed under the OU III Remedial Investigation. The distribution of Sr-90 contamination in these source areas is shown on Figure 7-21.

Two separate and distinct areas of Sr-90 contamination are recognized. The more significant of the two areas can be traced from the WCF area south to the area just north of Cornell Avenue, a distance of approximately 1,300 feet. The width of this plume, as defined by Sr-90 concentrations that exceed the 8 pCi/L drinking water standard, is approximately 400 feet. The vertical extent of contamination is confined to the shallow and middle portion of the Upper Glacial aquifer. The highest concentration associated with the WCF plume is in shallow Well 065-175, at a concentration of 361 pCi/L. It is noted that a portion of this plume is composed of Sr-90 that was released in the Building 801 and nearby Pile Fan Sump area. This contamination is detected in shallow Upper Glacial aquifer wells located directly downgradient of the Building 801/Pile Fan Sump area. The highest concentration associated with the Building 801/Pile Fan Sump portion of the plume is in shallow Well 065-172, at a concentration of 49 pCi/L.

The second area of Sr-90 contamination is located approximately 400 feet south of the BGRR near Cornell Avenue. This plume, defined by Sr-90 concentrations greater than 8 pCi/L, extends approximately 550 feet to an area just north of Brookhaven Avenue and is less than 200 feet wide. The highest concentration associated with the BGRR plume was detected in Well 075-202, at a concentration of 42.9 pCi/L.

7.4.4 OPERABLE UNIT (OU) 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).

7.4.4.1 1977 OIL-SOLVENT SPILL SITE (AOC5)

In 1977, approximately 25,000 gallons of a mixture of Number 6 fuel oil and mineral spirits was released from a ruptured pipe used to transfer the contents from an underground storage tank to aboveground storage tanks at the Central Steam Facility (CSF). In addition, several small spills of Number 6 fuel oil from the CSF fuel unloading area were documented between 1988 and 1993; and it is suspected that

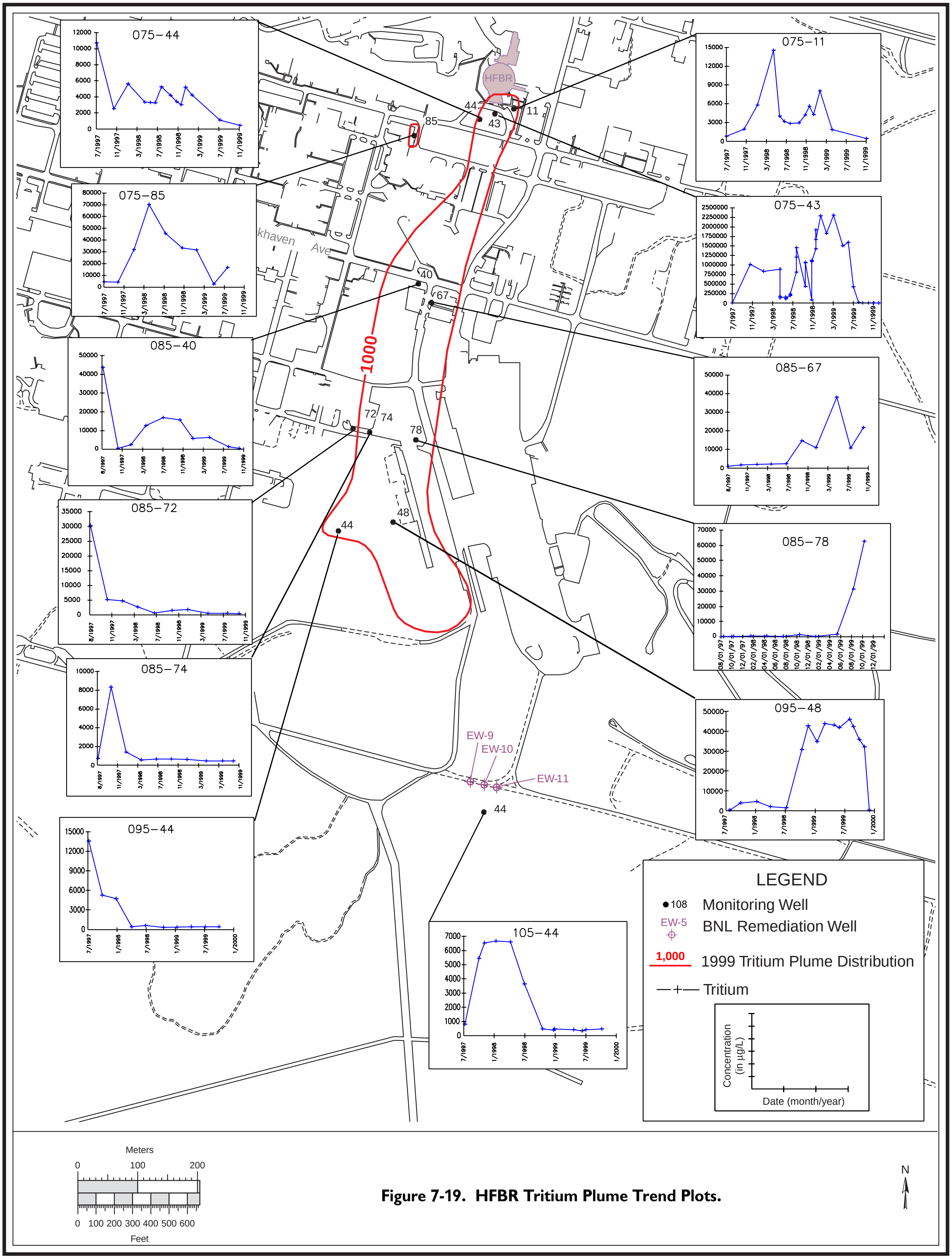

Figure 7-19. HFBR Tritium Plume Trend Plots.

Figure 7-20. HFBR Tritium Plume Comparison – 1997 and 1999.

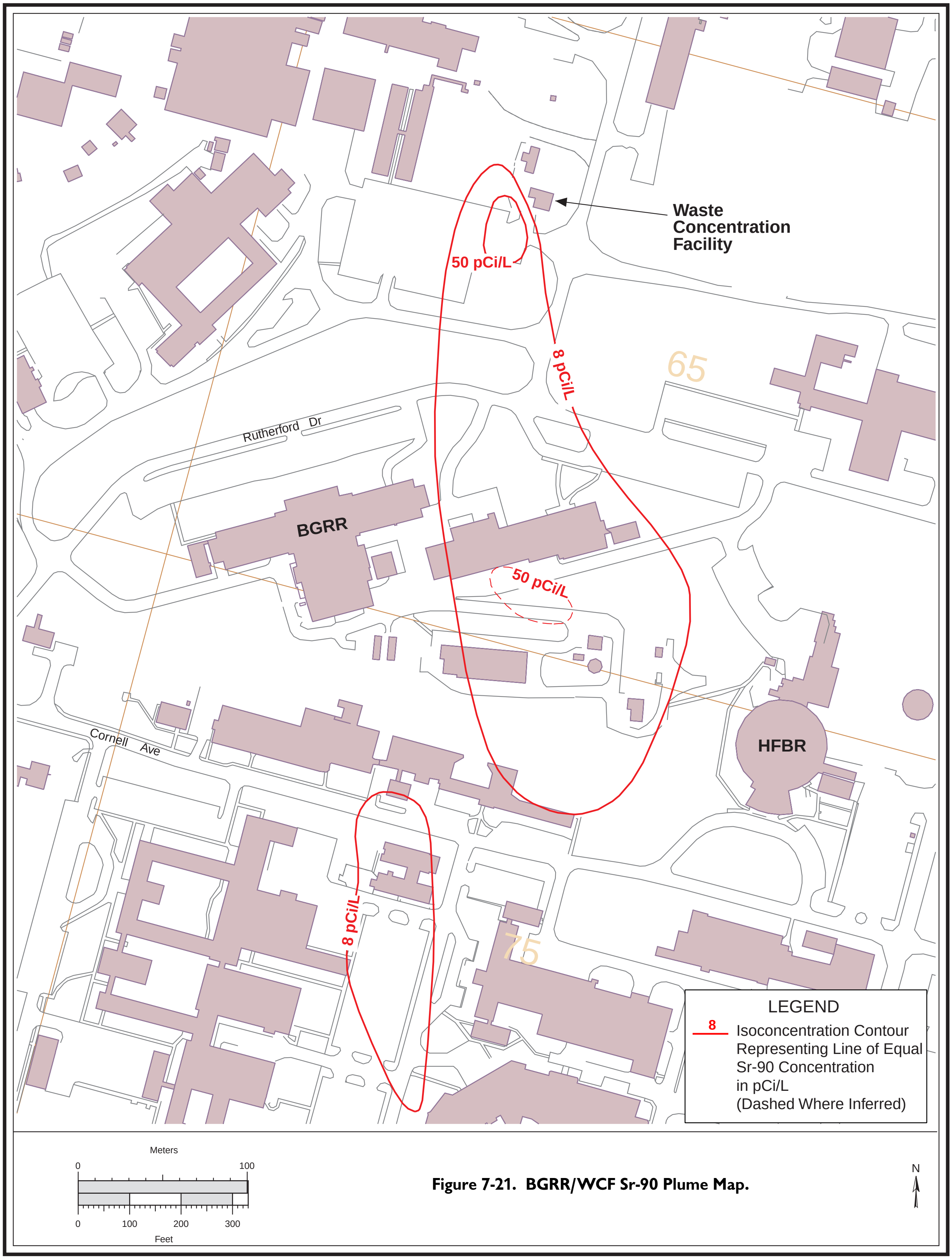

Figure 7-21. BGRR/WCF Sr-90 Plume Map.

small volumes of solvents, such as PCE, have been released to the ground in the vicinity of the CSF. Eighteen wells are used to monitor this area. VOC contamination originating from the CSF area is currently monitored under two programs: the OU IV 1977 spill area cleanup program (AOC 5) and the OU I/IV program which monitors the downgradient (south of Brookhaven Avenue) component of the OU IV plume.

The areal extent of OU IV VOC contamination is shown in Figure 7-13. The OU IV plume, as defined by TVOC concentrations greater than 5 µg/L, extends from the 1977 Waste Oil Solvent Spill area in the north to an off site area between the southern site boundary and Carleton Drive, a distance of approximately 6,200 feet. The plume is approximately 1,000 feet wide. The width of the higher concentration segments of the plume (i.e., having TVOC concentrations >50 µg/L) is approximately 700 feet. In general, VOCs are present in the Shallow Glacial aquifer near the 1977 spill area and in the Deep Glacial aquifer at the southern site boundary and offsite areas.

The OU IV plume is composed of the solvents TCA, PCE, DCE, and TCE, and oil products (consisting of toluene, ethylbenzene, and xylene). Although the main source area appears to be in the vicinity of the 1977 spill, the detection of low levels of TCA and PCE in several upgradient wells indicates that some of the contamination originates from historical spills that occurred in the nearby CSF and Building 650 areas. Whereas TCA, PCE, DEC, and TCE have migrated considerable distances, the presence of toluene, ethylbenzene and xylene is highly localized to the source area. An air sparging/soil vapor extraction system (AS/SVE) has been in operation since November 1997 to remediate VOC and semi-VOC contamination of soils and groundwater near the spill site (see section 7.4.7). Compared to pre-November 1997 VOC concentration data (when TVOC concentrations were typically >1,000 µg/L), the highest TVOC concentration during 1999 was 13 µg/L detected in well 076-08. Therefore, the AS/SVE remediation system has been highly effective in reducing VOC concentrations within the source area.

In the downgradient portion of the OU IV plume, the highest VOC concentrations during 1999 were found in the area between Princeton Avenue and the southern site boundary. The plume in this area is composed primarily of TCA, DCE, and TCE, with TVOC concentrations up to 298 µg/L. In addition, during the fourth quarter of 1999, VOCs were detected in the upper Magothy aquifer in Wells 122-05 and 122-24 at 99 µg/L and 87 µg/L, respectively. Additional characterization of contamination within the upper Magothy aquifer will be conducted during CY 2000.

Figure 7-22 contains time-vs.-VOC concentration trend plots for select wells in the OU IV plume. The reduction in VOC concentrations in the 1977 spill area since November 1997 start up of the AS/SVE system can be clearly seen in source area Well 076-04. Well 096-07 (Supply and Materiel area) and Well 105-06 (Princeton Avenue) have also shown marked VOC concentration reductions since 1997. These concentration reductions can be attributed to either the migration of contaminant "slugs" downgradient and beyond these wells or the change in the groundwater flow field in the area and the resulting eastward shift of the plume. Operation of the OU III Southern Boundary treatment system has resulted in a significant lowering of TVOC concentrations. A seventh extraction well, EW-12 was installed during 1999 to enhance the existing pump-and-treat system and provides hydraulic control for the OU IV plume (see Figure 7-28). Pumping of EW-12 started in late December 1999. The *CY 1999 OU III Pump-and-Treat System Annual Report* (BNL 2000c) contains detailed information on system operations and remediation progress.

The changes in the OU IV plume distribution from 1997 through 1999 are shown on Figure 7-17, which depicts the combined OU III and OU IV plumes. The higher concentration segments of the plume have undergone reductions as a result of remediation both at the source area and the site boundary.

7.4.4.2 BUILDING 650 AND 650 SUMP OUTFALL AREAS (AOC 6)

In the Building 650 area, Sr-90 concentrations in Well 076-28 showed an increase to levels above the 8 pCi/L drinking water standard for the first time in its monitoring history (Figure 7-23), with a maximum Sr-90 concentration of 14.9 pCi/L. Previous Sr-90 concentrations detected in this well had ranged up to 5 pCi/L. Well 76-28 is located adjacent to the Building 650 sump/decontamination pad and downgradient of a former underground storage

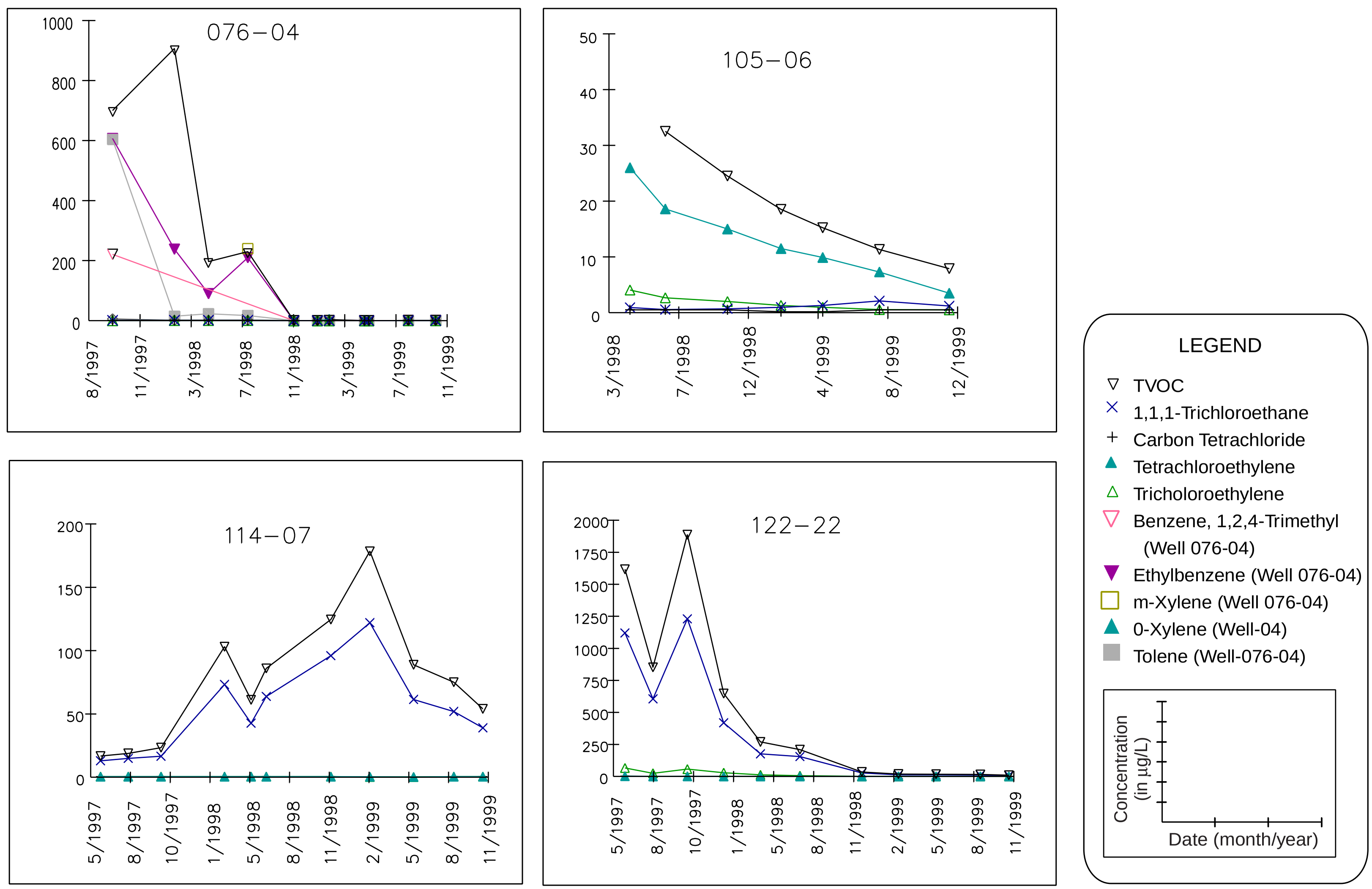

Figure 7-22. Time-vs.-VOC Concentration Trend Plots for Key Wells in the OU IV VOC Plume. Well 076-04 located near the 1977 oil/solvent spill area; Well 105-06 located on eastern Princeton Avenue; Well, 114-07 and 122-22 located along the BNL southern boundary.

tank area. The Sr-90 detected in Well 076-28 probably originates from contaminated soils associated with decontamination pad and storage tank operations. Strontium-90 was not detectable in samples from three wells located downgradient of Building 650 (Wells 076-25, 076-317, and 076-373), nor in upgradient Well 076-314.

Soil and groundwater contamination at the Building 650 Sump Outfall is due to the historical discharge of radionuclides to the Building 650 sump. Historically, Sr-90 has been detected at concentrations above the 8 pCi/L drinking water standard in a number of the wells located downgradient of the outfall. Figure 7-23 shows the areal extent of the Sr-90 plume, as well as time-vs.-Sr-90 concentration trend plots for key wells in this area. Compared to its 1998 position, little movement of the Sr-90 plume was evident in 1999. During 1999, Sr-90 concentrations exceeded the drinking water standard in three wells located within 500 feet of the Outfall, with the highest concentration observed in Well 076-13 at a concentration of 60 pCi/L. Wells 076-28, 076-13 and 076-263 showed declining Sr-90 trends during 1999. In late 1999, additional wells were installed downgradient of the previously defined extent of contamination to allow for future evaluation of Sr-90 plume migration. (Note: Although the new wells were not sampled until February 2000, the resulting analytical data were utilized for purposes of constructing the plume distribution map presented on Figure 7-23.)

7.4.5 OPERABLE UNIT (OU) V, EASTERN PLUME

The OU V monitoring program uses 34 monitoring wells located downgradient of the Sewage Treatment Plant (STP). These wells monitor VOC and tritium contamination resulting from historical releases at the STP. Surveillance of present groundwater quality at the STP is performed as part of the BNL Environmental Surveillance (ES) program (see section 7.5).

Volatile Organic Compounds, Metals and Pesticides

The areal extent of VOC contamination is shown on Figure 7-24. It is noted that historical temporary well data were used to supplement the definition of the extent of VOC contamination. The primary chemical contaminants found in the OU V Eastern VOC plume are TCE and TCA. The ambient water quality standard for these both of these compounds is 5 µg/L. The Eastern VOC plume, defined by TVOC concentrations greater than 5 µg/L, extends from a location southeast of the STP to the Long Island Expressway offsite, a distance of approximately 5,300 feet. The plume is approximately 1,100 feet wide. During 1999, the highest TVOC concentration was 22 µg/L, detected in Well 061-05 located at the site boundary near North Street. The plume degrades to less than 13 µg/L (TVOC) near the Long Island Expressway. Vertically, the VOCs are restricted to the deep portions of the Upper Glacial aquifer.

Samples from key OU V wells were analyzed for Target Analyte List (TAL) Metals, and samples from offsite wells were analyzed for pesticides/PCBs. All of the inorganic contaminants of concern initially identified during the OU V Remedial Investigation/Feasibility Study, including mercury and hexavalent chromium, were not detected during 1999. Although trace amounts of the pesticides 4,4''-DDD and 4,4''-DDT were detected in several offsite wells during 1998, all samples collected during 1999 were non-detect for these compounds.

Time-vs.-VOC concentration trend plots for key OU V wells are also provided on Figure 7-24. Monitoring Wells 049-06, 050-01, and 061-05 all showed decreasing trends in VOC concentrations during 1999. Well 000-122 (located near the leading edge of the plume) showed a very slight increase in VOC concentrations. VOC concentrations in Well 049-06, located near the interpreted trailing edge of the plume during 1998, dropped to below the 5 µg/L in 1999. The changes in plume distribution from 1997 through 1999 are presented on Figure 7-25. The higher concentration middle portion of the plume (i.e., with TVOC concentrations >20 µg/L) during 1998 has probably migrated south of well 061-05 and is presently situated in between available monitoring points.

Radionuclides

Detectable levels of tritium were found in a number of wells located near the BNL's southeastern site boundary and several offsite wells. However, the concentrations were well below the drinking water standard of 20,000 pCi/L. In wells located near the southeastern site boundary, the maximum tritium concentration was detected in Well 50-02, at a concentration of 2,175 pCi/L. In offsite wells monitored

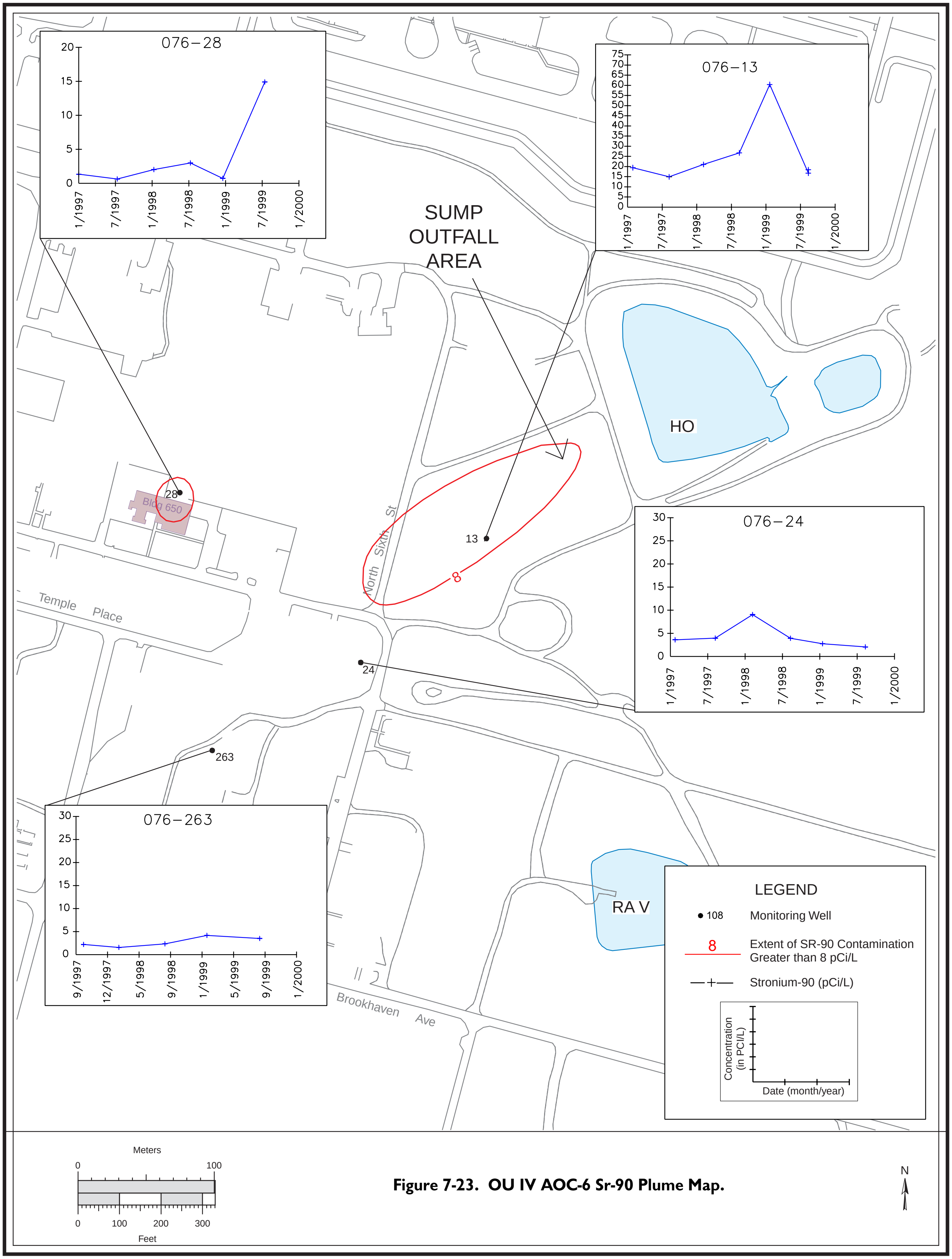

Figure 7-23. OU IV AOC-6 Sr-90 Plume Map.

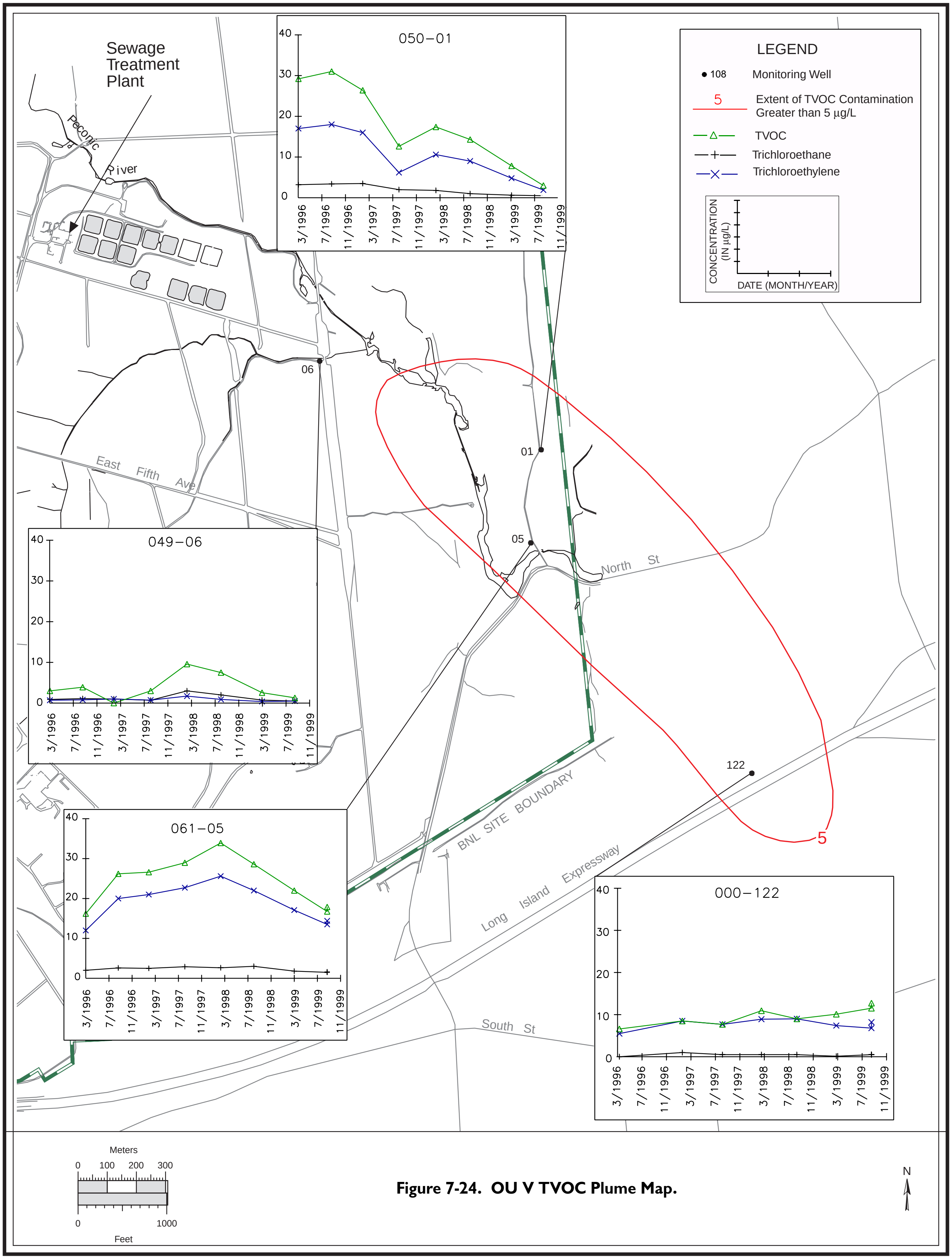

Figure 7-24. OU V TVOC Plume Map.

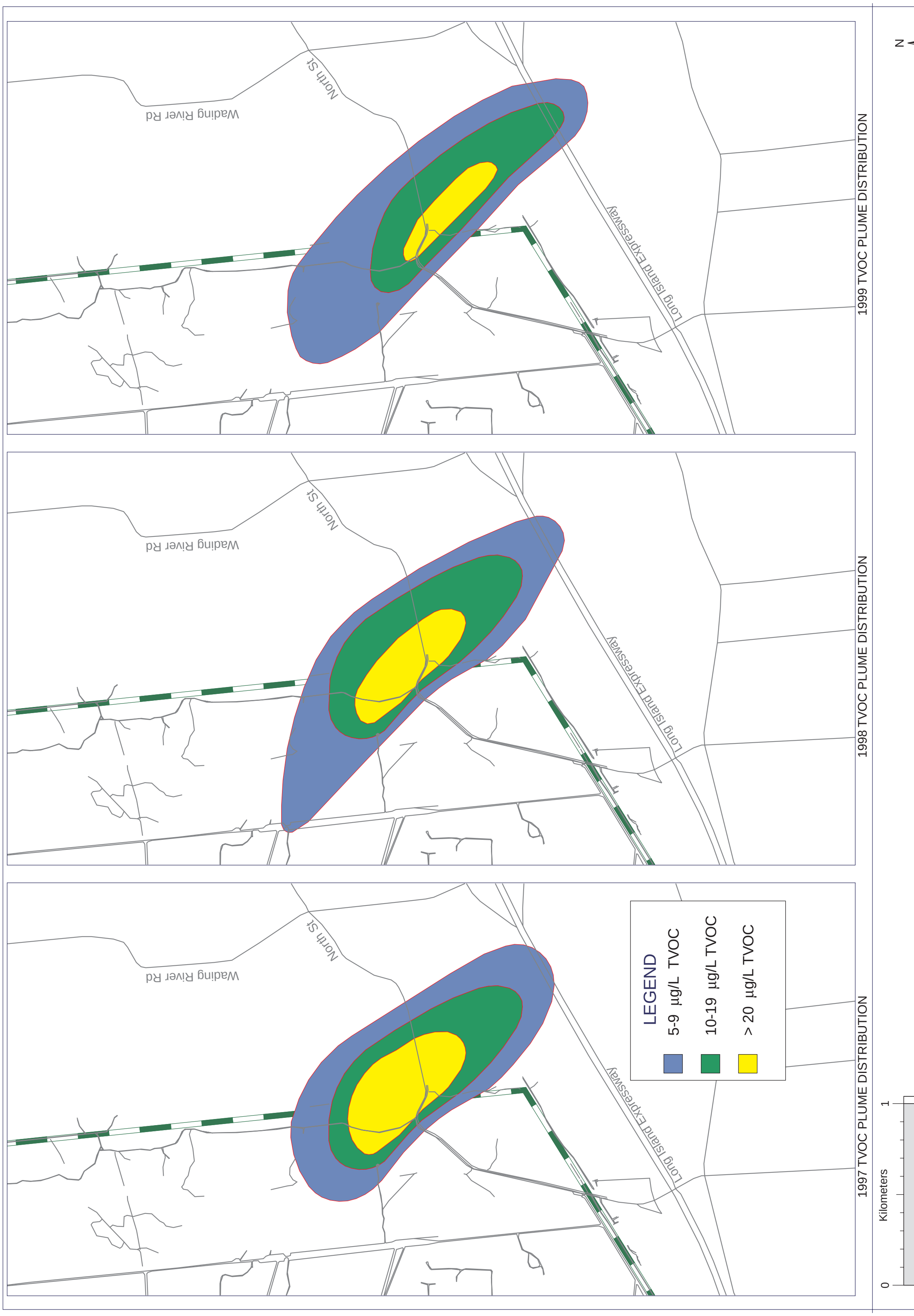

Figure 7-25. OU V TVOC Plume Comparison – 1997, 1998 and 1999.

during 1999, tritium was either non-detectable or just slightly above detection limits. (Note: the typical detection limit for tritium is 400 pCi/L.) The maximum offsite tritium concentration was 979 pCi/L, detected in Well 000-122 located near the Long Island Expressway. A detailed discussion on the distribution of tritium within the OU V plume is provided in the *1999 Groundwater Monitoring Report* (Dorsch *et al.* 2000).

7.4.6 OPERABLE UNIT (OU) VI, BIOLOGY FIELDS

Ethylene dibromide (EDB) was used as a fumigant in the BNL Biology Department's agricultural fields located 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 drinking water standard for EDB) extends approximately 3,500 feet, from near BNL's southeastern site boundary to an area south of the Long Island Expressway (see Figure 7-26). EDB is the only contaminant of concern for the Biology Fields plume. The width of the plume is approximately 1,100 feet. During 1999, the off site portion of the EDB plume was further defined by using temporary vertical profile wells and new permanent monitoring wells.

During 1999, the highest EDB concentration was found in offsite Well 000-175 (located south of North Street) at 4.2 µg/L. Vertically, EDB is found in the deep Upper Glacial aquifer at the southern site boundary and in offsite areas. EDB concentration trends for representative wells are also shown on Figure 7-26. Offsite Wells 000-110, 000-175, and 000-209 all showed increasing EDB concentration trends through September and a return to lower concentrations by December. Figure 7-27 shows a comparison of the EDB plume from 1997 through 1999. The important changes in the plume are the downgradient migration of both the trailing edge of the plume and the area of highest EDB concentrations. The 1998 and 1999 plume boundaries depicted on Figure 7-27 are based on a significantly greater coverage of offsite wells that were installed in 1998 and 1999.

7.4.7 GROUNDWATER TREATMENT SYSTEMS

The primary mission of BNL's ER Program is remediating soil and groundwater contamination, and preventing additional contamination from migrating off the BNL site. To that end, six groundwater treatment systems are presently operating at BNL, and a seventh system will be operational in 2000. Figure 7-28 shows the locations of these treatment systems. The following is a brief description of the groundwater treatment systems that were operational during 1999 along with a summary of their performance. Table 7-2 provides a summary of pounds of VOCs removed and gallons of water treated since the first treatment system became operational in 1997.

OU III South Boundary Remediation System

Construction of the OU III pump-and-treat system was completed in June 1997. The system uses six wells to extract VOC-contaminated groundwater that originated from a number of sources located in the developed central portion of the BNL site. The water is pumped approximately one mile north to an air-stripping tower located near the Medical Department complex, where air from a powerful blower separates the VOCs from the water. The removal efficiency is close to 100 percent. No VOCs were detected above the minimum detection limit (typically 0.5 µg/L) in treated water samples. The clean water is discharged to a nearby recharge basin, and the VOCs stripped from the water are released into the air at concentrations below state and federal emissions standards. The system processes approximately 600 gallons of water per minute. During 1999, approximately 327 pounds of VOCs were removed from the groundwater, and 336,300,000 gallons of treated groundwater were returned to the aquifer.

OU III Offsite Groundwater Treatment System

The OU III Offsite groundwater remediation system became operational in the summer of 1999. The system was constructed south of the BNL site to remove VOC contamination that has migrated to an industrial area located between the Long Island Expressway and the residential areas of North Shirley. This remediation system consists of a series of innovative "in-well stripping" wells that use the same air stripping treatment concept as the OU III South Boundary Remediation System, but all treatment and recharge occurs within the well. Within each well, contaminated water is pumped from a deep well screen to a treatment system located near the top of the well, where VOCs are stripped from the water. The treated

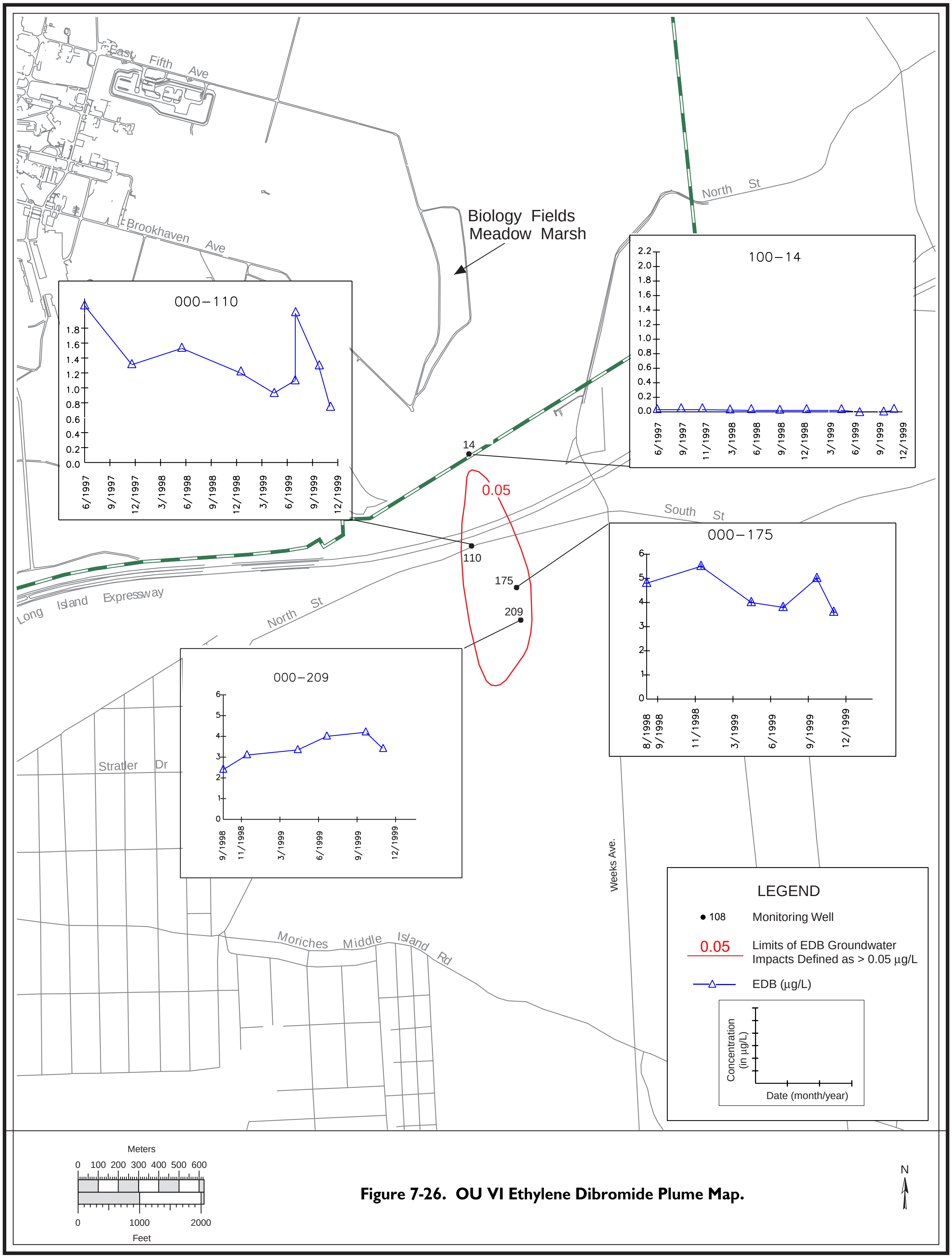

Figure 7-26. OU VI Ethylene Dibromide Plume Map.

Figure 7-27. OU VI EDB Plume Comparison – 1997, 1998, and 1999.

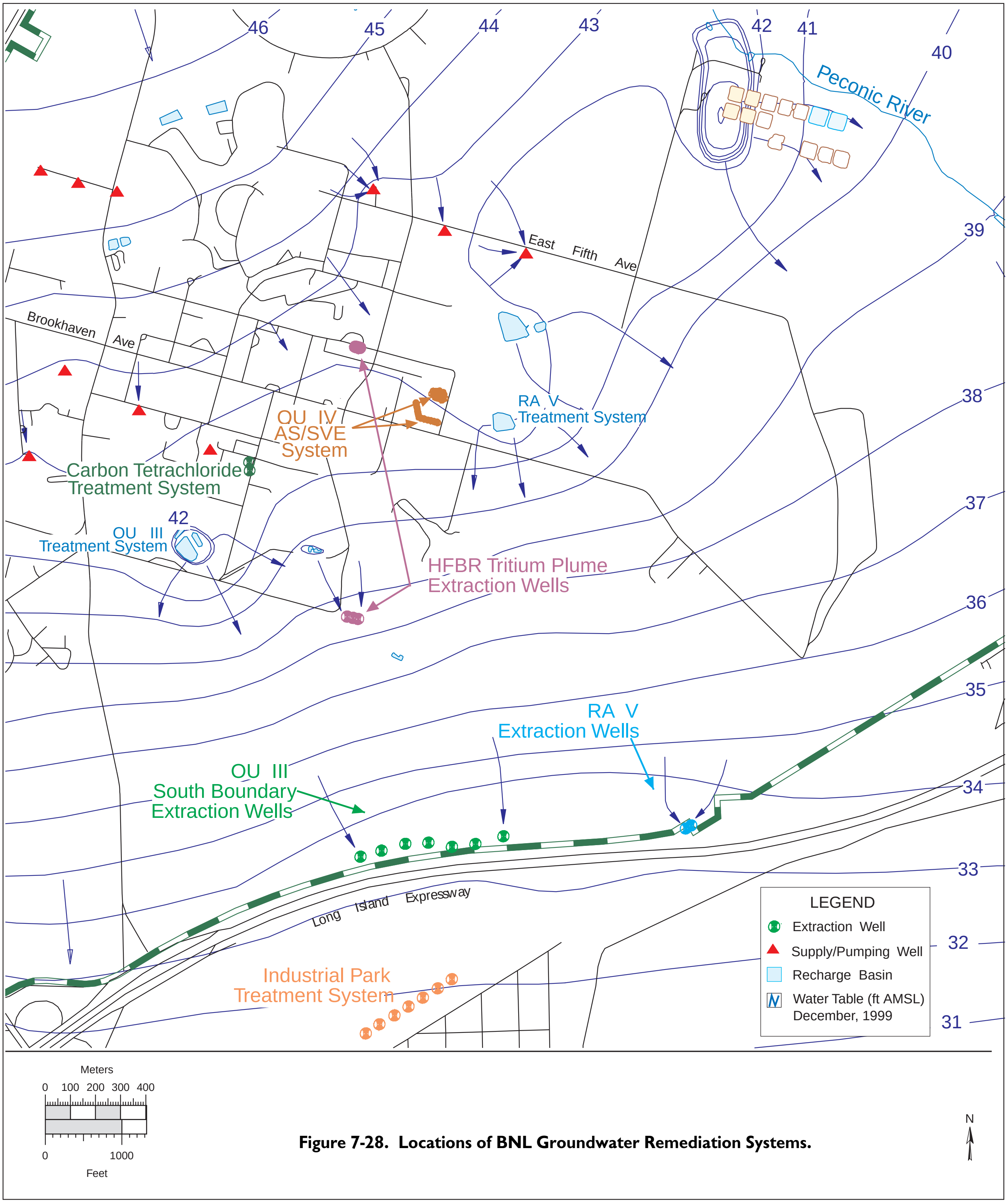

Figure 7-28. Locations of BNL Groundwater Remediation Systems.

Table 7-2. BNL Groundwater Remediation Systems Treatment Summary for 1997 through 1999.

Remediation System	1997		1998		1999	
	Water Treated (gals.)	VOCs Removed (lbs.)	Water Treated (gals.)	VOCs Removed (lbs.)	Water Treated (gals.)	VOCs Removed (lbs.)
OU III South Boundary	166,000,000	340	335,000,000	405	336,300,400	354
OU III Off-site	(a)	—	(a)	—	35,300,000	63
Carbon Tetrachloride	(a)	—	(a)	—	6,900,000	112
RA V	340,000,000	120	342,000,000	46	314,000,000	29
HFBR Tritium Plume	63,000,000	16	63,000,000	20	64,000,000	68
OU IV AS/SVE	(b)	12	(b)	19	(b)	8
Total	569,000,000	488	740,000,000	490	756,500,000	634

Notes:
(a) Treatment system not installed/operational during this time.
(b) Air Sparging/Soil Vapor Extraction system performance measured by pounds of VOC removed per cubic foot of air treated.

water is then routed to a shallower screened section of the same well where it re-enters the aquifer. The VOC vapors are captured by a granular carbon filter. During 1999, approximately 63 pounds of VOCs were removed from 35,300,000 gallons of groundwater.

OU I (RA V) South Boundary Remediation System

This pump-and-treat system was completed in December 1996. The system uses two extraction wells to remove contaminated groundwater that originated from the Current Landfill (now closed and capped) and the former HWMF. The water is pumped approximately one mile north to an air stripper. This system processes more than 700 gallons of water per minute. Like the OU III South Boundary Remediation System, the RA V system removes close to 100 percent of the chemical contamination. No VOCs were detected above the MDL in treated water samples. The clean water is discharged to a nearby recharge basin, and the VOCs stripped from the water are released into the air at concentrations below state and federal emissions standards. During 1999, approximately 29 pounds of VOCs were removed from the groundwater, and 314,000,000 gallons of treated groundwater were returned to the aquifer.

OU III Carbon Tetrachloride Treatment System

A groundwater remediation system consisting of two extraction wells screened in the shallow Upper Glacial Aquifer began operations on October 6, 1999 to address the carbon tetrachloride released during the removal of an underground storage tank in early 1998. Groundwater extracted from this area is treated with carbon filtration and recharged back into the aquifer through an unlined drainage swale to Recharge Basin HS located south of Princeton Avenue. Details on this groundwater treatment system can be found in the *OU III Carbon Tetrachloride Pump and Treat System Start-Up Report* (BNL 2000c). During 1999, approximately 112 pounds of VOCs were removed, and 6,900,000 gallons of treated water were recharged to the Upper Glacial aquifer.

OU III HFBR Tritium Plume Remediation System

This groundwater pump and recharge system was constructed as an interim remedial action after the HFBR tritium plume was discovered, and has operated since May 1997. Three groundwater extraction wells were installed approximately 3,500 feet south of the HFBR. Groundwater is pumped from the aquifer at a rate of about 50 gallons per minute and piped north to a treatment facility adjacent to the RA V treatment system. Because the water also contains VOCs that originate from another sources (possibly the former Building 96 area), the water is treated by passing it through a granular carbon filter to remove the VOCs before discharging the water to the RA V recharge basin. No VOCs were detected above the minimum detection limit in treated water samples; and tritium was not detected in samples collected at the influent to the treatment system (i.e., concentrations <500 pCi/L). This interim remediation system is designed to prevent the further southward migration of the HFBR tritium plume while long-term remediation options are evaluated and implemented. During 1999, the granular activated carbon filters removed approximately 68 pounds of VOCs, and 64,000,000 gallons of treated water were recharged to the aquifer system.

OU IV Air Sparging/Soil Vapor Extraction System

This remediation system, which has operated since November 1997, combines two technologies to remove VOC and semi-VOC contaminants from soil and groundwater located near the BNL Central Steam Facility. The system uses air sparging and soil vapor extraction that forces pressurized air into the groundwater to "bubble" or strip the volatile compounds out of the water and soil and into a vapor phase. Powerful vacuum pumps then recover the resulting vapors and pipe them to a nearby treatment facility where the VOC vapors are removed by a granular carbon filter system before the air is released into the atmosphere. During 1999, approximately eight pounds of contaminants were removed from the soil and groundwater.

7.5 ENVIRONMENTAL SURVEILLANCE (ES) PROGRAM (NON-CERCLA)

BNL's Environmental Surveillance (ES) Program includes groundwater monitoring at active research facilities (i.e., research reactor areas, accelerator beam stop and target areas, greenhouse areas) and support facilities (i.e., fuel storage facilities and water treatment facilities). In September 1998, BNL finalized a *Groundwater Monitoring Improvements Plan* (Paquette 1998) that identified active research and support facilities requiring improved groundwater monitoring programs. As a result of this evaluation, 84 new, permanent groundwater monitoring wells were installed on a prioritized basis during 1999 and early 2000. During 1999, 93 groundwater surveillance wells were monitored during 318 individual sampling events. All wells sampled during 1999 are listed in Appendix E. Results for these programs are summarized below. For detailed descriptions and maps related to the ES monitoring programs, refer to the *1999 BNL Groundwater Monitoring Report* (Dorsch *et al.* 2000).

7.5.1 RESEARCH FACILITIES

7.5.1.1 ALTERNATING GRADIENT SYNCHROTRON (AGS) 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, have been produced by the interaction of these secondary particles with the soils that surround these experimental areas. Furthermore, historical surface spills and discharges of solvents to cesspools and recharge basins near the AGS have contaminated soils and groundwater with VOCs. VOC contamination is monitored under the ER program's OU III Central Areas Project (see section 7.4.3).

During 1999, 32 groundwater monitoring wells were used to evaluate groundwater quality near potential soil activation areas located 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, and the new J-10 Beam Stop). Twenty-four of these wells were installed as part of the Groundwater Monitoring Improvements project. The enhanced groundwater monitoring program detected two tritium plumes that originated from the g-2 experimental area and the former E-20 Catcher region of the AGS Ring.

New monitoring wells installed approximately 250 feet downgradient of the g-2 experimental area detected the presence of a tritium and sodium-22 plume originating from activated soil shielding. A sample from the new g-2 area Well 054-067 collected in October 1999 had a tritium concentration of 41,700 pCi/L (approximately twice the drinking water standard of 20,000 pCi/L). Sodium-22 was not detected in the sample. In November 1999, BNL installed 18 temporary wells to determine the extent of the contamination and verify the location of the source (Figure 7-29). A sample from temporary Well 054-116, located approximately 70 feet downgradient of an area where the soil-shield was activated, had a tritium concentration of 1,800,000 pCi/L. Tritium concentrations in temporary Well 054-111 located approximately 120 feet downgradient of the soil activation area, were approximately 1,500,000 pCi/L. Results from samples collected from temporary wells installed near permanent Well 054-67 showed tritium concentrations up to 33,000 pCi/L. Tritium was not detected in three temporary wells installed directly upgradient of the g-2 soil-shield activation area. The highest level of sodium-22 was detected in Well 054-116, at a concentration of 60 pCi/L (or 15% of the 400 pCi/L drinking water standard). In December 1999, an impermeable cap was installed over the g-2 soil activation area to prevent rainwater infiltration and the continued leaching the

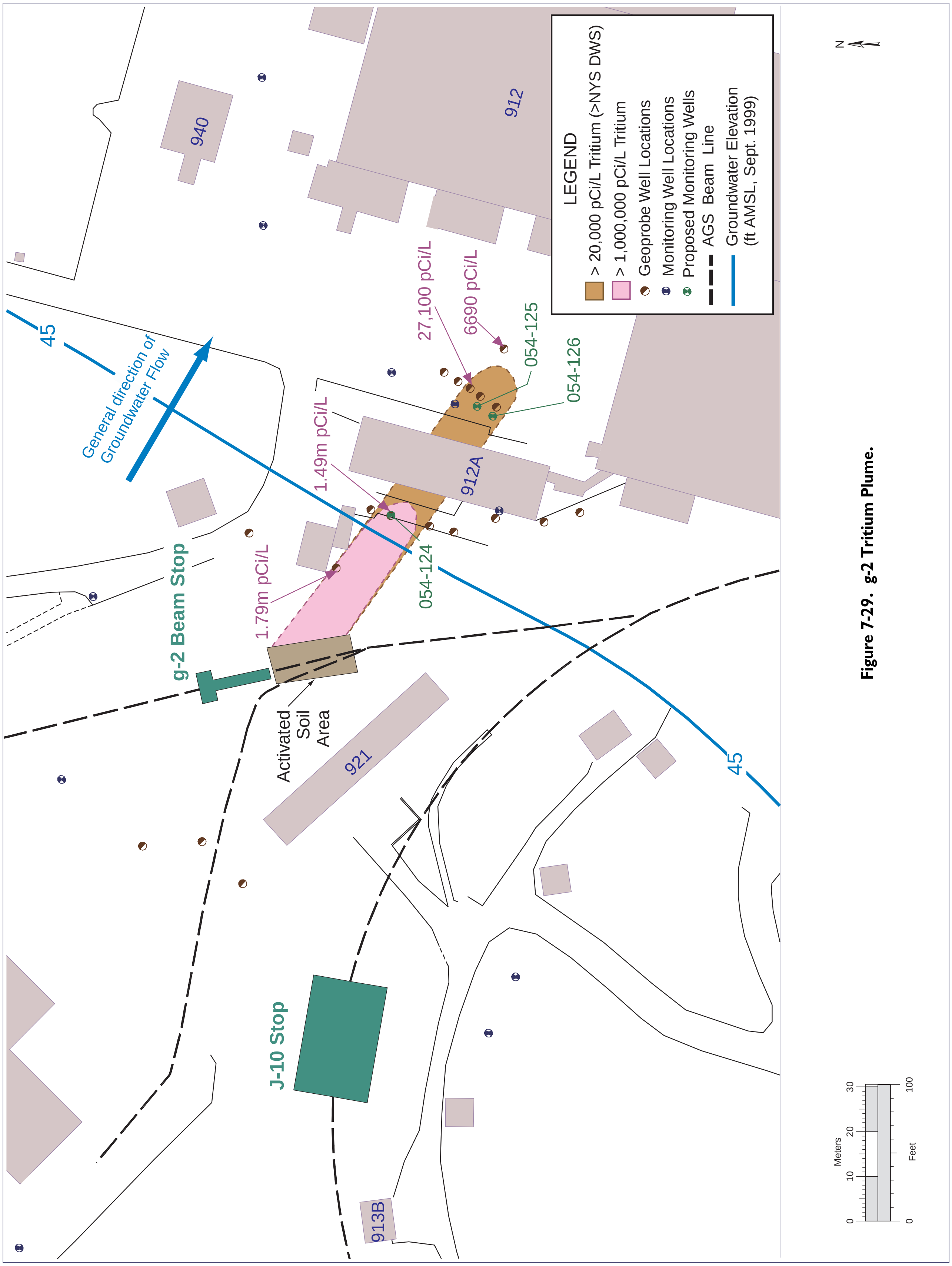

Figure 7-29. g-2 Tritium Plume.

radionuclides out of the soils and into groundwater.

A new well (064-65) installed approximately 100 feet downgradient of the former E-20 Catcher area of the AGS detected a narrow plume of tritium and sodium-22 originating from activated soil used as shielding near the former beam catcher. During 1999, tritium and sodium-22 were detected in Well 064-56 at maximum concentrations of 5,800 pCi/L and 219 pCi/L, respectively. To further evaluate the extent of contamination, four Geoprobe wells were installed in January 2000. The highest levels of tritium and sodium-22 were found in Geoprobe Well 064-065 with concentrations of 40,400 pCi/L and 704 pCi/L, respectively. This well was installed approximately 12 feet southwest of permanent Well 064-56. These data indicate that at a distance of approximately 100 feet downgradient of the E-20 Catcher, the zone of elevated tritium and sodium-22 is estimated to be approximately 20 to 30 feet wide and situated within 10 feet of the water table (approximately 30 to 40 feet below land surface). During CY 2000, BNL will install an impermeable cap over the E-20 Catcher soil activation area to prevent rainwater infiltration and the continued leaching the radionuclides out of the soils and into groundwater.

Low levels of tritium and sodium-22 were also detected in new shallow wells installed downgradient of Building 912 (the AGS's main experimental hall) and the former U-Line Target area. In wells located downgradient of Building 912, tritium concentrations ranged from non-detectable to 2,120 pCi/L and sodium-22 concentrations ranged from non-detectable to 32.6 pCi/L. In Well 054-69, located approximately 500 feet downgradient of the former U-Line Target area, tritium and sodium-22 were detected at maximum concentrations of 1,130 pCi/L and 38.3 pCi/L, respectively.

7.5.1.2 BROOKHAVEN LINAC ISOTOPE PRODUCER (BLIP)

The BLIP facility is located at the southern end of the Linear Accelerator (LINAC). When the BLIP is operating, the LINAC delivers a beam of protons that impinges on a series of eight targets located within the BLIP target vessel. During irradiation, activation of the soils immediately outside of the vessel occurs due to the creation of secondary particles produced at the target. In February 1998, elevated levels of tritium and sodium-22 were detected in wells located downgradient of BLIP. Maximum tritium and sodium-22 concentrations (52,000 pCi/L and 151 pCi/L, respectively) were detected in temporary wells installed approximately 20 feet downgradient of BLIP. To prevent rainwater from infiltrating the activated soils below the building, the BLIP building's roof drains were redirected away from the building, paved areas were resealed, and an extensive gunnite (cement) cap was installed on three sides of the building.

Results from six new groundwater monitoring wells installed in 1999 indicate that the corrective actions noted above have been highly effective in preventing rainwater infiltration through the contaminated soils. Maximum tritium and sodium-22 concentrations in new permanent wells located 20 feet downgradient of the BLIP facility were only 2,450 pCi/L and 14 pCi/L, respectively. Remnants of the higher concentration plume initially observed in 1998 were detected in Well 064-50, which is located approximately 100 feet downgradient of BLIP. A sample collected from Well 064-50 in March 1999 had tritium and sodium-22 concentrations of 18,700 pCi/L and 72 pCi/L, respectively. However, subsequent samples from Well 064-50 had tritium and sodium-22 concentrations of less than 1,000 pCi/L and 40 pCi/L, respectively. These results indicate that the corrective actions taken in 1998 (e.g., connecting roof drains, sealing paved areas, and construction of a cement cap) have been effective in preventing rainwater from infiltrating the activated soils, and washing out the tritium and sodium-22 from the soils and into the groundwater.

7.5.1.3 RELATIVISTIC HEAVY ION COLLIDER (RHIC)

Within the RHIC facility, there are two areas where radionuclides may be produced in the soils outside of the collider tunnel. The first area contains two beam stops that are located at the 10 o'clock position of the ring, and the second contains two collimators that are located at the 8 o'clock region. When RHIC becomes operational, secondary particles created at the internal beam stop and collimator areas will have the potential to activate the soils immediately surrounding those areas.

Metals and Water Quality Parameters

During 1999, quarterly groundwater samples were collected from twelve new RHIC monitoring wells to evaluate pre-operational metals and water quality parameter concentrations. Metals analyses of the groundwater samples indicate the presence of naturally occurring aluminum, iron and manganese at concentrations that exceed New York State ambient water quality standards. Most of these elevated concentrations were observed in samples collected from RHIC beam stop area wells (Wells 025-03, 025-05, 025-06, and 025-08). These metals originate from naturally occurring clay minerals that are prevalent in the near-surface soils located near the Peconic River. Analysis of samples for water quality parameters (e.g., chlorides, sulfates and nitrates) indicate that all concentrations are below ambient water quality standards.

Radionuclides

During 1999, groundwater samples were collected to evaluate pre-operational radionuclide concentrations. Analytical results indicate that all radionuclide concentrations are below applicable drinking water standards and are consistent with background levels. Slightly elevated gross beta concentrations (up to 26.5 pCi/L) were detected in samples from Well 025-05, which is located downgradient of RHIC's southern beam stop. The elevated gross beta values are probably due to potassium-40, which was also detected at concentrations up to 26.7 pCi/L. The potassium-40 found in the water samples is likely to have originated from naturally occurring clay minerals that are prevalent in the near-surface soils adjacent to the Peconic River.

7.5.1.4 BROOKHAVEN MEDICAL RESEARCH REACTOR (BMRR)

During a 1997 investigation to evaluate groundwater quality near the BMRR, a tritium plume with a maximum concentration of approximately one-half the 20,000-pCi/L drinking water standard was identified. The maximum tritium concentration during 1997 was 11,800 pCi/L in wells installed directly downgradient (within 30 feet) of the facility. The tritium is believed to have originated from the historical discharge of small amounts of BMRR primary cooling water to a basement floor drain and sump system that may have 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 (non-radioactive) cooling water until 1997. The infiltration of this water may have promoted the movement of residual tritium from the soils surrounding the floor drain piping system to the groundwater. The floor drains were permanently sealed in 1998 to prevent any accidental future releases to the underlying soils.

During 1999, groundwater samples were collected from one upgradient and three downgradient wells on a quarterly basis. As in previous years, tritium concentrations continued to be below the drinking water standard of 20,000 pCi/L. Detectable levels of tritium were observed in all three downgradient wells, with the maximum value of 17,100 pCi/L in Well 084-27. A slightly elevated gross beta concentration of 26.3 pCi/L was detected in the December 1999 sample from downgradient Well 084-27. The elevated gross beta values are probably due to potassium-40, which was also detected at a concentration of 25.4 pCi/L. The potassium-40 that was detected in the water sample is likely to have originated from naturally occurring clay minerals.

7.5.2 SUPPORT FACILITIES

7.5.2.1 SEWAGE TREATMENT PLANT (STP) AREA

As described in Chapters 1 and 3, the STP processes sanitary sewage for BNL facilities. Approximately 15 percent of the water released to the STP's filter beds is lost either to evaporation or to direct groundwater recharge; the remaining water is discharged to the Peconic River. Past radiological and chemical releases to the sanitary system contaminated soils, sediments, and groundwater in the STP and Peconic River areas. During 1999, the STP groundwater monitoring program used 12 shallow Upper Glacial aquifer wells to evaluate groundwater quality near the plant's filter beds and along the Peconic River from the STP discharge point to the site boundary.

Volatile Organic Compounds, Metals and Water Quality Parameters

As noted earlier, groundwater quality impacts resulting from historical STP discharges are currently being monitored as part of the OU V monitoring program using wells that are located at the site boundary and offsite areas (see Section 7.4.5). The STP facility monitoring program on the other hand, is designed to evaluate whether current operations are impacting groundwater quality. The 12 wells used under this program are situated close to the

STP's sand filter beds and along the Peconic River. During 1999, groundwater samples were analyzed for water quality, VOCs, and metals. In all groundwater samples, water quality parameters (i.e., chlorides, sulfates and nitrate) were within the applicable New York State ambient water quality standards. Iron levels exceeded ambient water quality standard of 0.3 mg/L in three wells (038-01, 038-03, and 039-06), with maximum concentrations ranging from 0.32 mg/L to 1.8 mg/L. Three wells (039-06, 039-07, and 039-08) had sodium concentrations above the NYS AWQS of 20 mg/L, with maximum concentrations ranging from 20.1 mg/L to 33.1 mg/L. A sample from one well (038-03) had a zinc value of 0.54 mg/L, which exceeded the ambient water quality standard of 0.3 mg/L. Whereas the elevated iron and zinc concentrations may be due to naturally occurring sediments surrounding the wells, the sodium levels are likely due to road salting operations. No VOCs were detected above NYS AWQS in any of the STP area wells.

Radionuclides

For groundwater in the area surrounding the STP, gross alpha and gross beta activity values were below drinking water standards, and were typical of background values. However, gross beta activities were slightly elevated in Well 038-03 (located near the filter beds) with a maximum recorded value of 41.7 pCi/L. Because these wells are screened near shallow clay deposits, the slightly elevated gross beta values are likely due to naturally occurring potassium-40 from clay minerals introduced into the samples during collection. Monitoring results indicated a tritium concentration of 356 pCi/L in one sampled from filter bed area Well 039-08. However, this value is extremely close to the minimum detection limit (for that analysis) of 327 pCi/L. When the 95 percent confidence intervals are considered, these two values are not statistically different from the MDL and do not, therefore, represent a clear detection of tritium. No other man-made radionuclides were detected in groundwater in this area.

7.5.2.2 WATER TREATMENT PLANT (WTP)

At the direction of the NYSDEC, five shallow Upper Glacial aquifer surveillance wells were installed at the WTP in 1993 to assess potential leaching of iron from the plant's recharge basins into the groundwater. Naturally high levels of iron in the groundwater pumped for potable and process supply are removed at the WTP, and the precipitated iron is discharged to the recharge basins.

Metals and Water Quality Parameters

During 1999, one set of groundwater samples was collected from the five WTP area wells, and analyzed for water quality and metals. As in previous years, all water quality parameters (i.e., chlorides, sulfates, and nitrate) and most metals concentrations, including iron, were below the applicable NYS AWQS. Sodium was detected at a concentration of 26.9 mg/L in the sample collected from Well 063-01 (the NYS AWQS for sodium is 20 mg/L).

7.5.2.3 BUILDING 423 (MOTOR POOL)

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 underground storage tanks, and waste oil is stored in one, 500-gallon capacity underground storage tank. Although the underground storage tanks and associated distribution lines meet Suffolk County Article 12 requirements for secondary containment, leak detection, and high level alarms, BNL initiated a groundwater monitoring program in 1996 to ensure that potential leakage would be detected if a tank alarm system failed. Following the discovery of a hydraulic oil spill in Building 423 and a historical oil spill immediately south of the nearby Site Maintenance Facility Building 326, BNL entered into a spill response (stipulation) agreement with NYSDEC. As part of this agreement, BNL installed six new groundwater surveillance wells in early 1999.

During 1999, groundwater samples were analyzed for VOCs and semi-VOCs on a quarterly basis, and the wells were checked monthly for floating petroleum product. None of the target compounds associated with gasoline or oil spills were detected in the samples, and no floating product was observed. However, the solvent TCA was detected at concentrations above New York State ambient water quality standard of 5 µg/L in all four wells located downgradient of Building 326 (see Figure 7-30). The maximum TCA concentration was detected in Well 102-10 at 50 µg/L. TCA was not detected in the upgradient well. The presence of TCA in these samples is the result of historical solvent spillage in the Motor Pool and Site

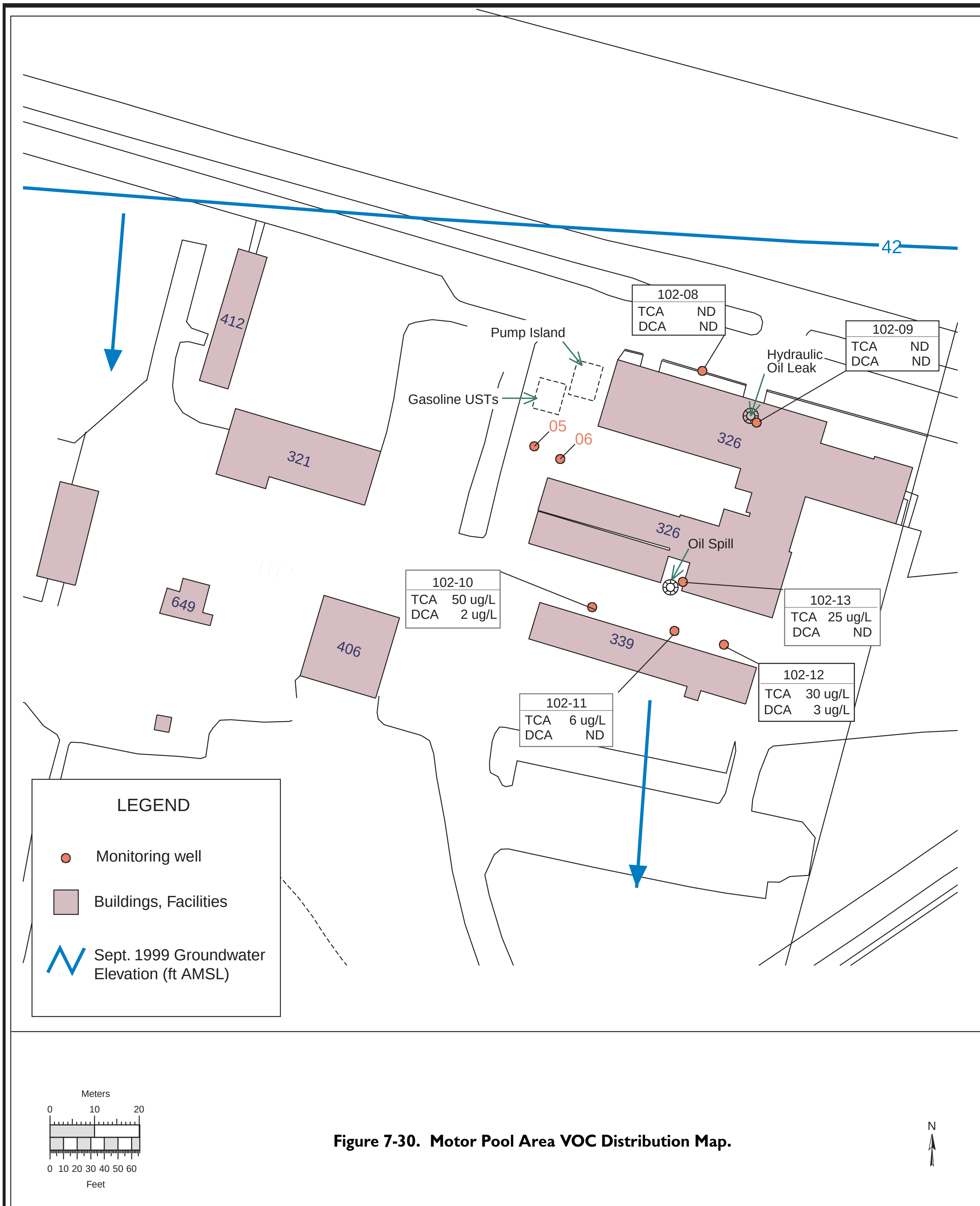

Figure 7-30. Motor Pool Area VOC Distribution Map.

Maintenance area, and is not associated with current operations.

7.5.2.4 ONSITE 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 and one 6,000-gallon capacity underground storage tanks, and waste oil is stored in one 500-gallon capacity underground storage tank. Although the storage tanks and associated distribution lines meet Suffolk County Article 12 requirements for secondary containment, leak detection, and high level alarms, BNL initiated a groundwater monitoring program in 1996 to ensure that potential leakage would be detected if a tank alarm system failed.

During 1999, groundwater samples were collected from the two shallow Upper Glacial aquifer surveillance wells (085-16 and 085-17) and analyzed for VOCs. The wells were also checked for floating petroleum product. Carbon tetrachloride was detected at concentrations exceeding NYS AWQS in both wells, with a maximum concentration of 503 µg/L detected in Well 085-17. PCE was also detected in Well 085-17, at a maximum concentration of 5.1 µg/L. The fuel additive MTBE was not detected in either of the wells, and no floating product was observed. Whereas the PCE is likely associated with historical degreasing operations at the service station, the substantial increase in carbon tetrachloride concentrations compared to previous years (with levels <10 µg/L), is due to the advancement of a carbon tetrachloride plume originating from an underground storage tank that was located approximately 280 feet upgradient of Well 085-17 (see section 7.4.3).

7.5.2.5 MAJOR PETROLEUM FACILITY (MPF)

The Central Steam Facility supplies steam for heating to all major facilities of the Laboratory through an underground distribution system. The MPF is the holding area for most fuels used at the Central Steam Facility. Five shallow Upper Glacial aquifer wells monitoring the MPF were installed as part of the licensing requirements for this facility, and are screened across the water table so that free product (i.e., oil floating on top of the groundwater) could be detected. The surveillance wells at the CSF were installed primarily to monitor groundwater contamination resulting from a 1977 leak of approximately 23,000 gallons of Alternative Liquid Fuel (a fuel oil/spent solvent mixture). The CSF/MPF area has been the subject of an Remedial Investigation/Feasibility Study, and has been undergoing active soil and groundwater remediation since the winter of 1997 (see Section 7.4.4.1).

In accordance with the NYSDEC operating license, the five MPF wells were sampled monthly in 1999 for floating petroleum products, and semiannually for polynuclear aromatics and base-neutral extractable compounds (EPA Method 625). As in previous years, no fuel oil-related compounds were detected, and no floating petroleum products were observed.

7.5.2.6 NEW WASTE MANAGEMENT FACILITY (WMF)

In 1997, BNL began operating a new WMF. The new WMF is designed and operated in a manner that meets all applicable federal, state and local environmental protection requirements. Nevertheless, BNL established a groundwater monitoring program as a secondary means of verifying the effectiveness of the facility's administrative and engineered controls. The new WMF is monitored by eight shallow Upper Glacial aquifer wells. During 1999, groundwater samples were collected quarterly and analyzed for VOCs, radioactivity, metals, and water quality.

Volatile Organic Compounds, Metals and Water Quality Parameters

In 1999, all water quality and most metals concentrations were below the applicable NYS AWQS. Sodium was detected at concentrations above the NYS AWQS of 20 mg/L in upgradient Wells 055-10 and 066-07 (26.9 mg/L and 21.6 mg/L, respectively). Silver was detected above the NYS AWQS of 0.01 mg/L in one sample from downgradient Well 056-23, with a concentration of 0.1 mg/L. Although low levels of chloroform and TCA (up to 2.3 µg/L and 3.8 µg/L, respectively) were detected in a number of the WMF wells, all VOC concentrations were below applicable NYS AWQS. It is believed that the trace amounts of TCA are due to historical releases in upgradient areas, whereas the chloroform is likely to be related to the use of water treatment chemicals in the potable and process water that is routinely discharged to nearby Recharge Basin HO.

Radionuclides

With one exception, in 1999 gross activity levels in these samples were typical of ambient (background) levels. Slightly elevated gross beta concentrations were observed in upgradient Well 066-07 and downgradient Well 056-21, at maximum concentrations of 21.3 pCi/L and 19.2 pCi/L, respectively. Low levels of cobalt-60 were detected in samples collected from Well 066-07, with a maximum concentration of 8.8 pCi/L (the drinking water standard for cobalt-60 is 200 pCi/L). The source of the cobalt-60 is an underground storage tank leak that occurred at Building 830 in 1988. Monitoring results indicated a tritium concentration of 334 pCi/L in one sampled from upgradient Well 066-07. However, this value is extremely close to the minimum detection limit of 306 pCi/L. When the 95 percent confidence intervals are considered, this value is not statistically different from the minimum detection limit and does not, therefore, represent a clear detection of tritium.

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Radiological Dose Assessment

During 1999, potential radiological doses to members of the public from ambient air, liquid, and gaseous effluents from Brookhaven National Laboratory sources were evaluated to determine compliance with regulations and limits. The potential doses were based on calculations using 1999 emission data, fauna sampling data, and conservative intake and exposure assumptions. All doses resulting from the internal deposition of radionuclides are expressed as 50-year committed effective dose equivalents.

In 1999, there was minimal radiological dose impact above natural background levels to members of the public and the environment from BNL operations. The ambient external radiation measured in the surrounding area with BNL's offsite thermoluminescent dosimeter network was 71 mrem (0.71 mSv) per year, which is within the natural background exposure range observed throughout New York State. The effective dose equivalent to the maximally exposed individual from BNL air emission sources was calculated to be 0.13 mrem (1.3 µSv). The U.S. Environmental Protection Agency air emission pathway dose limit is 10 mrem, and therefore, by comparison, demonstrating that BNL sources contributed an insignificant dose. The effective dose equivalent from consumption of fish taken exclusively from the Peconic River would result in a dose of 0.3 mrem (3 µSv), and consumption of deer meat taken exclusively from the BNL site would result in 4.2 mrem (42 µSv). In comparison, the average effective dose equivalent from eating various foods that contained naturally occurring radionuclides would result in 40 mrem (0.4 mSv) per year.

8.1 AMBIENT RADIATION MEASUREMENTS

BNL measures environmental background radiation through a network of onsite and offsite dosimeter units. These units, called thermoluminescent dosimeters, or TLDs, measure beta/gamma radiation originating from cosmic and terrestrial sources (see Appendix C for sources) as well as any contribution from Laboratory operations. Calcium fluoride type (CaF2:Dy) TLDs were used. There were a total of 31 onsite locations that had TLDs in place (see Figure 8-1 for locations). In addition to the dosimeters located on BNL property, 20 offsite locations were also monitored in 1999 (see Figure 8-2 for locations). The offsite TLD measurements provide background comparison values and are used to determine whether BNL operations had an impact on the ambient external radiation levels of the surrounding area.

Onsite 1999 TLD data are summarized in Table 8-1. The quarterly average dose was lowest (14 mrem or 0.14 mSv) at location 011-400 and highest (26 mrem or 0.26 mSv) at the 075-402 location. The average onsite TLD reading was 19 mrem (0.19 mSv), whereas the average background TLD reading was 21 mrem (0.21 mSv). The location 054-400 reading was higher than normal for the first and fourth quarter of 1999. After investigation it was determined that readings were elevated due to the sky-shine

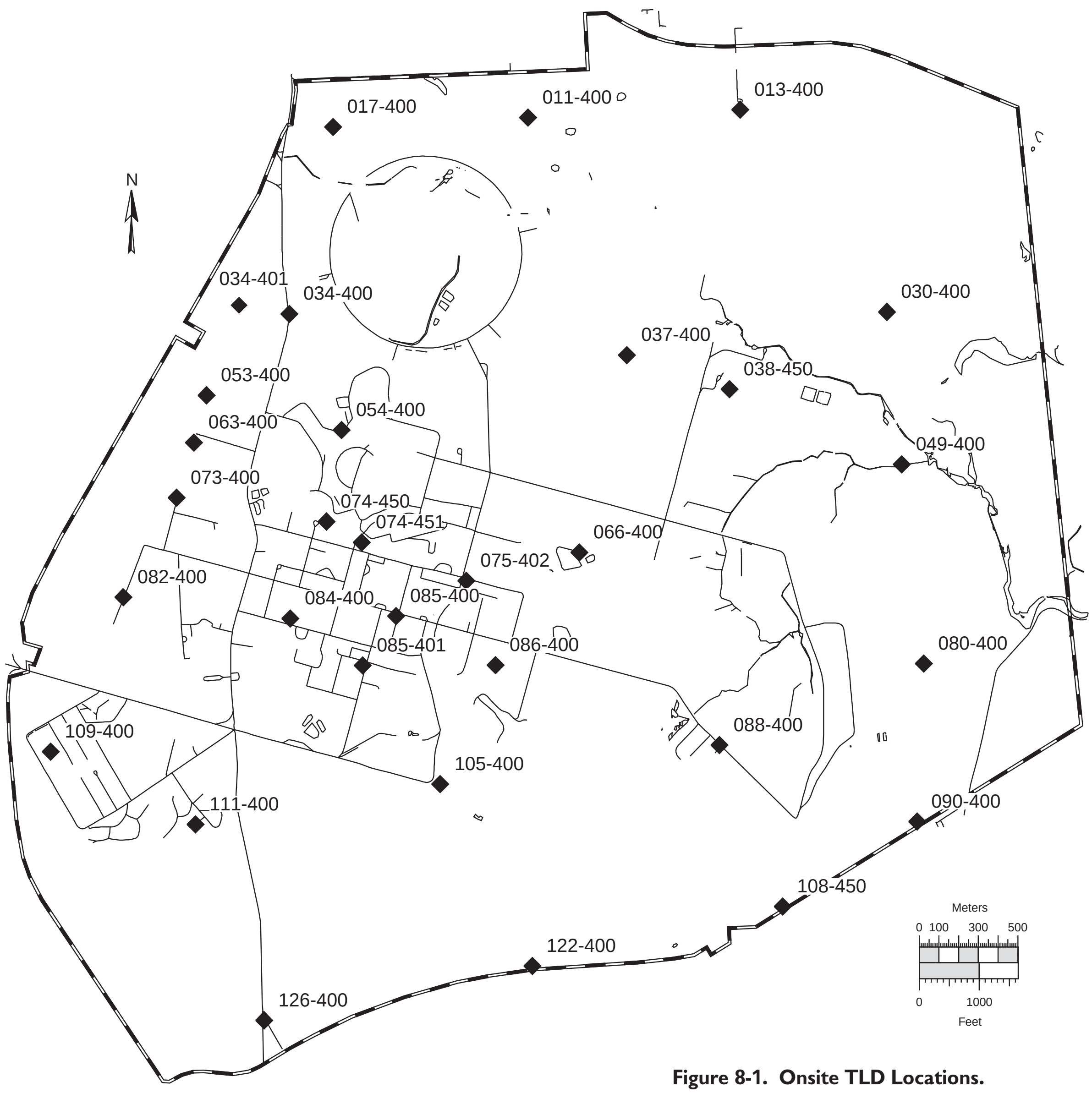

Figure 8-1. Onsite TLD Locations.

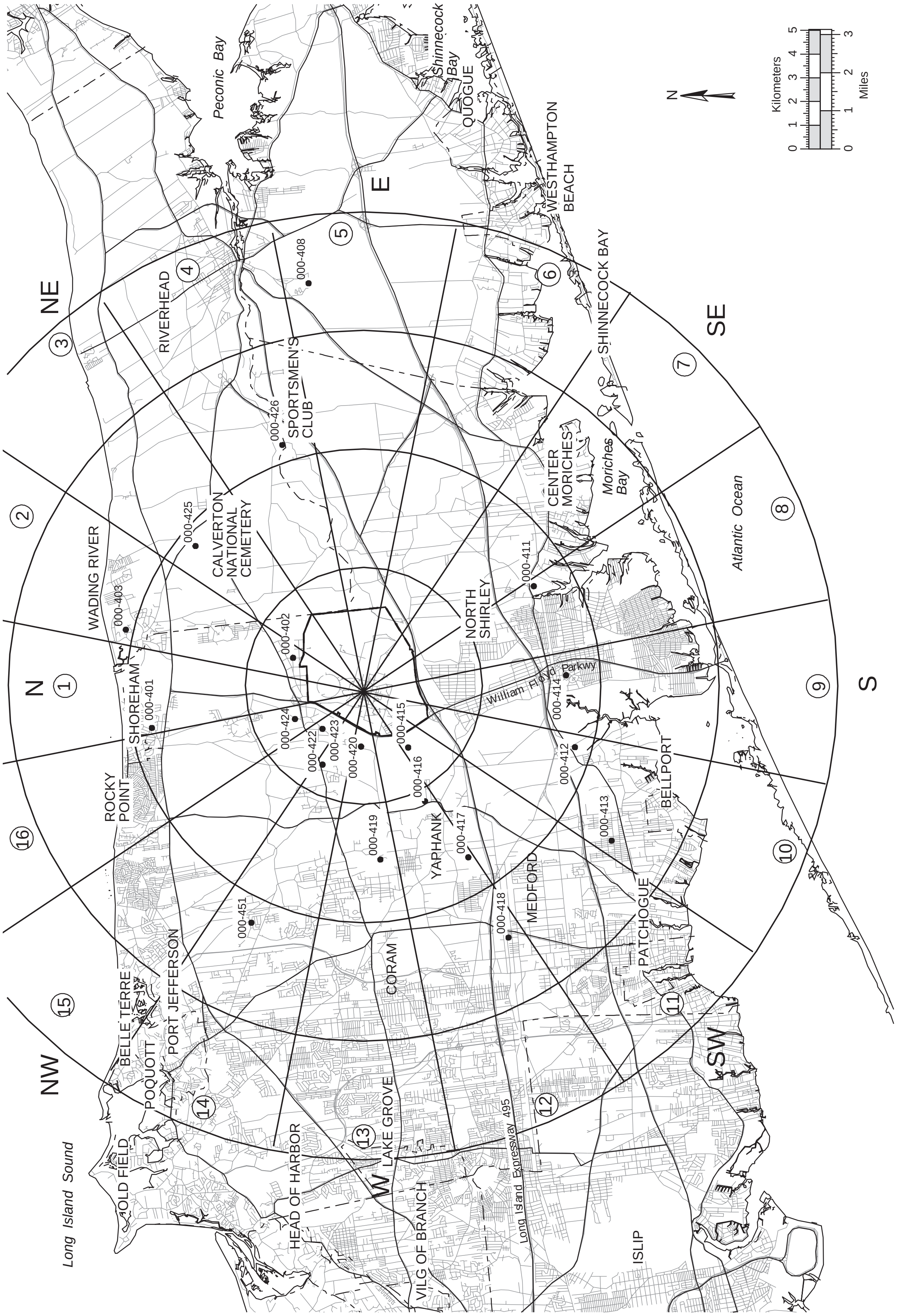

Figure 8-2. Offsite TLD Locations.

Table 8-1. Onsite Ambient Radiation Measurements (1999).

Station	1st Quarter (mrem)	2nd Quarter (mrem)	3rd Quarter (mrem)	4th Quarter (mrem)	Average (mrem)	Annual Dose* (mrem/yr)
011-400	14.0	14.1	13.1	(a)	13.8	65.4
013-400	17.0	17.8	19.9	16.8	17.9	52.5
017-400	15.0	16.4	18.6	16.0	16.5	48.0
030-400	15.8	16.7	18.8	16.3	16.9	49.1
034-400	17.5	17.8	19.7	16.8	17.9	52.3
034-401	19.0	20.3	22.0	19.8	20.3	58.9
037-400	17.4	18.7	20.6	17.8	18.6	54.0
038-450	16.6	16.8	19.4	(a)	17.6	66.9
049-400	15.4	14.9	19.3	15.9	16.4	47.1
053-400	18.6	19.4	21.2	19.4	19.6	56.7
063-400	18.6	18.8	20.7	19.0	19.3	55.7
066-400	15.3	16.5	(b)	14.0	15.3	57.0
073-400	19.1	20.9	22.0	20.1	20.5	59.1
074-450	19.9	19.4	22.6	19.8	20.4	59.3
074-451	17.9	18.4	19.9	17.7	18.5	53.4
075-402	33.9	23.8	24.9	22.4	26.3	79.2
080-400	18.0	18.4	20.5	18.7	18.9	54.2
082-400	19.8	19.2	21.5	19.5	20.0	57.9
084-400	17.6	18.0	20.2	17.3	18.3	53.5
085-400	17.5	17.9	20.5	17.5	18.4	53.6
085-401	17.8	16.5	20.9	16.8	18.0	52.9
086-400	18.3	18.7	21.1	19.0	19.3	55.3
090-400	17.3	18.4	20.1	17.3	18.3	53.1
105-400	18.2	18.9	21.2	19.0	19.3	55.4
108-450	18.0	20.0	20.9	19.3	19.6	56.1
109-400	17.4	18.3	20.0	17.2	18.2	53.4
111-400	17.6	18.0	20.0	17.1	18.2	53.3
122-400	16.7	17.0	19.4	16.6	17.4	50.5
126-400	17.8	18.0	20.8	(c)	18.9	71.7
054-400	179.3(d)	17.4(d)	20.0(d)	99.5(d)	71.9(d)	207.6(d)
088-400	82.2(d)	68.9(d)	60.3(d)	58.5(d)	67.5(d)	200.9(d)
075-000 (Background)	17.3	21.1	16.6	28.0	20.8	57.2
Average	18.0	18.2	20.4	18.0	18.6	56.4
Median	17.6	18.3	20.5	17.6	18.4	54.2
Population Std. Dev.	3.3	1.8	1.9	1.7	2.1	6.8

Notes:
See Figure 8-1 for station locations.
*Dose rate normalized to 365 day year.
(a) Sample vandalized
(b) Harshaw error
(c) No data available
(d) Results not included in any statistics.

phenomenon observed during the operation of the Alternating Gradient Synchrotron. The 1999 first and fourth quarter results for location 054-400 were not included in the statistics because they would bias the average; and, therefore, it would be prudent to observe them individually for each quarter. The 088-400 location TLD average reading was 68 mrem because of its proximity to the waste management site.

Offsite 1999 TLD data are summarized in Table 8-2. The average annual offsite external radiation dose was 71 ± 7 mrem (0.71 ± 0.07 mSv). This is consistent with the annual dose rates of 67 ± 5 mrem (0.67 ± 0.05 mSv) and 70 ± 5 mrem (0.7 ± 0.05 mSv) measured in 1997 and 1998, respectively. These values are statistically indistinguishable from one another and are within the normal background exposure range typical of the northeastern part of the United States (NCRP 1987). This indicates that BNL operations had no measurable effect on local ambient radiation exposure levels.

8.1.1 BUILDING 650 SUMP OUTFALL

From approximately 1959 to 1969, decontamination of radiologically-contaminated heavy

Table 8-2. Offsite Ambient Radiation Measurements (1999).

Station	1st Quarter (mrem)	2nd Quarter (mrem)	3rd Quarter (mrem)	4th Quarter (mrem)	Average (mrem)	Annual Dose* (mrem/yr)
000-401	14.5	15.3	23.4	16.0	17.3	66.5
000-402	18.6	19.0	21.5	17.9	19.3	75.6
000-403	20.0	20.1	23.0	18.9	20.5	79.7
000-408	17.5	17.3	19.5	(a)	18.1	63.2
000-411	18.3	18.3	21.2	18.7	19.1	71.6
000-412	20.0	19.8	22.2	(a)	20.7	73.6
000-413	18.8	19.0	20.0	18.1	19.0	73.4
000-414	18.2	18.7	21.0	19.2	19.3	73.9
000-415	17.0	16.0	19.0	15.6	16.9	64.3
000-416	16.1	15.4	18.1	15.7	16.3	63.9
000-417	18.2	17.8	19.1	18.3	18.4	73.1
000-418	18.2	19.3	19.9	16.6	18.5	70.2
000-419	17.5	16.4	20.3	16.9	17.8	68.5
000-420	17.9	18.1	20.9	18.9	19.0	72.7
000-422	19.4	22.5	20.8	21.2	21.0	81.8
000-423	16.4	17.4	20.5	16.7	17.8	71.0
000-424	17.8	17.7	20.6	18.0	18.5	71.0
000-425	20.1	20.4	22.0	20.2	20.7	79.3
000-426	17.9	18.0	20.5	18.8	18.8	72.1
000-451	(b)	20.4	21.7	(a)	21.1	51.1
075-000 Background	17.3	21.1	16.6	28.0	20.8	57.2
Average	18.0	18.4	20.8	18.0	18.9	70.8
Median	18.2	18.2	20.7	18.1	18.9	71.9
Population Std. Dev.	1.4	1.8	1.3	1.5	1.3	6.8

Notes:
See Figure 8-2 for station locations.
*Dose rate normalized to 365 day year.
(a) Sample not returned
(b) Error occured in processing of TLD .

equipment was performed on a concrete pad adjacent to Building 650. The drainage from this pad was contained in underground storage tanks. In 1969 it was determined that under certain valve conditions, liquid from the underground tanks was inadvertently being routed to a depression in a wooded area approximately 800 feet northeast of Building 650. This depression is referred to as the Building 650 Sump Outfall. The sump outfall is a source of localized radiological soil and groundwater contamination that is being remediated under the environmental restoration program (Operable Unit [OU] IV, Area of Concern [AOC] 6). Radionuclides identified in the soil in this area include strontium-90, cesium-137, and isotopes of europium and plutonium.

In 1997, as part of the OU IV Interim Remedy Plan, the outfall was fenced to exclude pedestrian traffic, and a network of 16 TLDs, Lithium Fluoride type (LiF:Mg,Ti), was installed to monitor gamma radiation exposure levels in the area (see Figure 8-3). Four fence perimeter dosimeters were also installed, as well as two background dosimeters located onsite in an area not influenced by AOC 6 or other site radiation sources. In 1998, five locations were added to this TLD network: C5, D5, E3, E4, and E5. These TLDs were added when elevated readings from dosimeters D2 through D4 indicated that influence of the radionuclides related to the Building 650 Sump Outfall probably also extended to the southeast, just beyond the existing network. The new stations were installed to monitor this area, though previous soil sampling and fence dosimeter showed that radionuclides related to Building 650 were localized within the fenced area.

Consistent with the previous year, 1999 data from the Building 650 Sump Outfall TLD network indicated that the highest concentration of radionuclides was located in the area of position C4, where an annual dose rate of

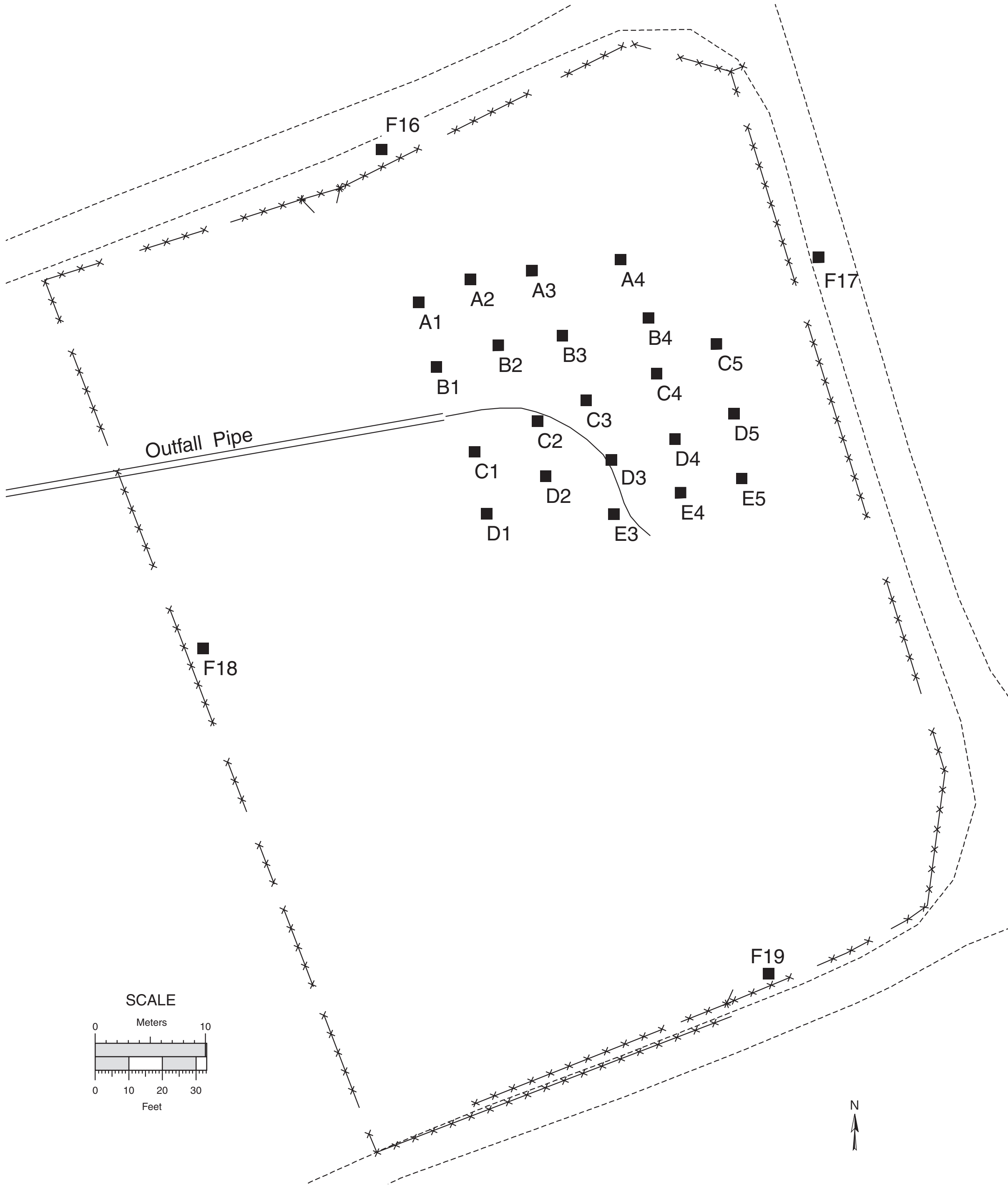

Figure 8-3. Building 650 Sump Outfall TLD Network.

1.4 rem (14 mSv) was recorded (Table 8-3). The annual dose rate south of the C4 monitoring grid decreased to 0.8 rem (8 mSv) at the D4 location. The annual dose rate decreased to 0.3 rem (3 mSv) at the B3 grid. Fence dosimeters showed no elevated dose rates and were consistent with the two distant background TLDs, demonstrating that the radiation field generated by the Building 650 Sump Outfall contaminants were limited to the immediate area of the outfall itself. Due to the localization of contaminants, the Building 650 Sump Outfall was not an exposure hazard for either site workers or members of the public.

Table 8-3. Building 650 Sump Outfall TLD Network Data (1999).

Location	1st Quarter (mrem)	2nd Quarter (mrem)	3rd Quarter (mrem)	4th Quarter (mrem)	Annual Dose* (mrem/yr)
A1	19.6	19.8	19.6	20.5	79
A2	71.9	75.8	66.4	75.0	289
A3	27.1	25.2	27.0	25.9	105
A4	21.1	20.4	20.7	20.7	83
B1	17.6	18.4	17.2	17.6	71
B2	34.4	38.4	37.9	33.4	144
B3	78.3	79.1	79.9	78.7	316
B4	39.7	39.4	38.6	38.3	156
C1	20.7	21.5	22.0	21.9	86
C2	48.9	47.9	48.2	48.4	193
C3	173.8	173.8	175.2	168.9	692
C4	367.3	344.7	355.0	342.6	1,410
C5	34.5	33.0	33.1	31.9	133
D1	22.9	19.2	20.9	20.1	83
D2	29.0	31.5	30.4	31.6	123
D3	115.5	129.6	129.4	119.4	494
D4	195.6	191.9	194.1	187.0	769
D5	61.1	59.7	60.7	59.3	241
E3	101.1	99.7	101.1	99.8	402
E4	156.1	141.3	144.7	136.1	578
E5	104.9	96.8	74.3	99.8	376
F16 (Fence N)	14.0	13.4	14.1	14.2	56
F19 (Fence S)	13.3	12.3	12.5	13.4	52
F17 (Fence E)	15.8	14.2	15.1	14.4	60
F18 (Fence W)	15	14.3	15.1	NA	44
Background #1(1)	17.2	15.0	16.2	16.3	65
Background #2(1)	16.1	19.3	16.4	13.9	66

Notes:
See Figure 8-3 for locations
*Dose rate normalized to a 365-day year.
NA=Not Available
(1)Distant background locations.

8.2 AIR EMISSIONS

BNL operations were subjected to the requirements of 40 CFR Part 61, Subpart H, National Emission Standards for Hazardous Air Pollutants (NESHAPs). This U.S. Environmental Protection (EPA) rule establishes national policy regarding the airborne emission of radionuclides. It specifies the monitoring and reporting requirements for various types of radionuclides and establishes the public dose limit for the airborne pathway as 10 mrem (0.1 mSv) per year.

8.2.1 AIR DISPERSION MODEL

Compliance with NESHAPs regulations was demonstrated through the use of the EPA's CAP88-PC (Clean Air Act Assessment Package-1988) computer model. The CAP88-PC model uses a Gaussian plume equation to estimate the average dispersion of radionuclides released from elevated stacks or area sources (EPA 1992). The program computes radionuclide concentrations in air, rates of deposition on ground surfaces, and concentrations in food (where applicable) to arrive at a final value for projected dose at the specified distance from the release point. The program supplies both the calculated effective dose equivalent (EDE) to the maximally exposed individual (MEI) and the collective population dose within a 50-mile radius of the emission source. This model provides very conservative dose estimates 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 site.

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 also used. Weather data are supplied by measurements from BNL's meteorological tower. Data include wind speed, direction, frequency, and temperature. For this emission assessment year, wind data recorded during 1999 were used. Population data for the surrounding area are based on customer records of the Long Island Power Authority (LIPA 1999). Since visiting researchers and their families may reside at the onsite apartment area for extended periods of time, these residents are also considered in the population file used for dose assessment.

8.2.2 EFFECTIVE DOSE EQUIVALENT CALCULATIONS - AIRBORNE PATHWAY

In 1999, the effective dose equivalent to the MEI from all radiological airborne emission sources combined was 0.13 mrem (1 μSv). The MEI is a hypothetical member of the public who resides at the BNL boundary in the downwind direction. Argon-41 (gaseous, half-life=1.8 hours) released from the Brookhaven Medical Research Reactor (BMRR) was the major contributor of this dose. By comparison, this is only one percent of the EPA airborne dose limit of 10 mrem (0.1 mSv) and is statistically insignificant to the effective dose equivalent received annually from natural background radiation. The MEI dose projected for emissions from each facility is shown in Table 8-4.

8.3 EFFECTIVE DOSE EQUIVALENT CALCULATIONS-FISH CONSUMPTION

Calculations were also made to determine the potential dose to an individual consuming fish taken exclusively from the Peconic River. As discussed in Chapter 6, fish from the Peconic River and Peconic-fed water bodies continue to be analyzed for radiological content because of known historical radionuclide discharges from the BNL Sewage Treatment Plant. These releases occurred primarily in the 1950s and 1960s. In 1999, fish samples collected from the Peconic River were analyzed for gamma-emitting radionuclides; only potassium-40 and cesium-137 were above the minimum detection limit. The maximum concentration of cesium-137 (0.70 ± 0.13 pCi/g or 26 ± 4.8 mBq/g, wet weight) was detected in Chain Pickerel flesh samples. When bone and viscera were analyzed, the concentration was found to be 0.53 ± 0.13 pCi/g (19.6 ± 4.8 mBq/g) wet weight. The measured concentration in a Yellow Perch from the same location, analyzed as a whole sample, was 0.37 ±0.20 pCi/g (13.7 ± 7.4 mBq/g) wet weight. The average concentration of 0.42 ± 0.09 pCi/g (16 ± 3 mBq/g) of Cs-137 for Chain Pickerel (whole) was used for dose calculations.

For dose evaluation, a maximally exposed individual is assumed to eat 15 pounds of fish during the course of the year (NYSDOH 1996). Exclusive consumption of Chain Pickerel at the rate and concentration given above would result in an EDE of 0.25 mrem (3 µSv) due to cesium-137 concentrations. By comparison, the average individual EDE caused by the ingestion of naturally occurring radionuclides in the U.S. is about 40 mrem (400 µSv) per year (NCRP 1987). Analyses results from shellfish, aquatic vegetation, marine waters, and sediments demonstrated that radionuclides were not detected above the minimum detection levels.

Table 8-4. Maximally Exposed Individual EDE From Air Emissions (1999).

Building	Facility or Process	MEI Dose (mrem)
491	Brookhaven Medical Research Reactor	1.3E-01
750	High Flux Beam Reactor	9.2E-05
931	Brookhaven LINAC Isotope Producer	2.8E-05
801	Target Processing Lab	7.1E-07
750	Evaporator Facility	4.2E-05
—	Relativistic Heavy Ion Collider	ND
942	Alternating Gradient Synchrotron Booster	0.0(a)
490	Radiation Therapy Facility	2.2E-04(b)
820	Accelerator Test Facility	ND(c)
938	Radiation Effects Facility/NBTF	ND(d)
510	Calorimeter Enclosure	ND(e)
463	Biology Facility	6.9E-09(e)
555	Chemistry Facility	1.3E-10(e)
830	Environmental & Waste Management	3.1E-11(e)
490D	Environmental Biology	ND(e)
490	Medical Research Center	5.8E-08(e)
703	Analytical Laboratory	ND(e)
Total from BNL Operations		0.13 mrem
EPA Limit		10 mrem

Notes:
"Dose" as used in this table means committed effective dose equivalent.
ND=No Dose- facility not operational or no source in 1999.
(a) Booster ventilation system prevents air release through continuous air recirculation.
(b) Based on conservative engineering calulations.
(c) This has become a zero-release facility since original permit application.
(d) This facility is no longer in use, it produces no radioactive air emissions.
(e) All doses based on emissions calculated using 40 CFR 61, Appendix D methodology.

8.4 EFFECTIVE DOSE EQUIVALENT CALCULATIONS - DEER MEAT CONSUMPTION

As discussed in Chapter 6, measurements were made of flesh samples collected from deer taken on BNL property as well as from offsite locations. Cesium-137 was detected in the flesh samples from onsite deer at concentrations higher than those found in comparable offsite deer. The onsite average concentration found in the flesh sample was 2.88 ± 0.53 pCi/g (0.11 ± 0.02 Bq/g) wet weight. In comparison, the offsite deer flesh sample had 1.95 ± 0.34 pCi/g (0.07 ± 0.01Bq/g) wet weight of cesium-137. While onsite sport hunting is not permitted, there are no physical barriers preventing deer from migrating beyond the site boundary. It is, therefore, conceivable that hunters may occasionally take a deer that resides predominantly on the BNL site.

In March 1999, the New York State Department of Health (NYSDOH) Bureau of Environmental Radiation Protection issued a report examining the possible dose impacts to members of the public who consume deer that have grazed extensively on the BNL site (NYSDOH 1999). In the NYSDOH report, a 10 mrem/year dose was used as the limit for deer meat consumption. The annual consumption rate of venison was estimated using the EPA's Exposure Factors Handbook, which gives the average intake of game meat (for those who consume it) as approximately 1.1 grams per day per kilogram of body weight (EPA 1996). For a 154-pound individual, this corresponds to about 64 pounds of venison consumed per year. The same assumptions have been adopted for this report.

The potential dose from deer meat consumption has been calculated using the arithmetic average of the cesium concentrations measured in flesh samples collected onsite. The dose calculation uses a wet weight average concentration (i.e., the concentration in the flesh sample prior to drying for analysis), which was equal to 2.88 pCi/g (0.11 Bq/g). Under the stated assumptions, the committed EDE due to consumption of local deer meat would be equal to 4.2 mrem (42 µSv) per year. By comparison, the average EDE from eating foods that contain naturally occurring radionuclides is 40 mrem (0.4 mSv) per year (NCRP 1987).

8.5 COLLECTIVE EFFECTIVE DOSE EQUIVALENT

Collective EDE, a value used to estimate potential health risks to a population, is the summation of the calculated EDE for each individual multiplied by the number of individuals in the population being considered.

Assuming that the total number of individuals who routinely consume fish taken from portions of the Peconic River close to the BNL site was equal to 625, the collective EDE from this pathway was 156 person-mrem (1.5 person-mSv). This value was based on the maximum fish concentrations discussed in section 8.3 above. In comparison, the collective EDE to the same population from consumption of naturally occurring radionuclides in food is 25,000 person-mrem (250 person-mSv) annually.

Since onsite deer hunting was prohibited, the individual dose estimate from meat consumption calculated in section 8.4 is based on average cesium-137 concentrations. Deer moving beyond BNL boundaries can be legally hunted and consumed resulting in collective dose. However, the number of people consuming deer meat in the vicinity of BNL was not tracked within the one-mile radius of BNL; therefore, the collective dose from deer meat consumption could not be calculated.

For the air exposure pathway, the CAP88-PC computer model provides collective EDE estimates using population data for the area within a 50-mile radius of the BNL site. The population data are broken into the number of people living within each of the 16 compass sectors at 10-mile radial intervals. Again, argon-41 emitted from the BMRR was the largest contributor to the total collective dose at 4,649 person-mrem (46 person-mSv). This constituted 99 percent of the total collective dose resulting from BNL operations projected for the population within a 50-mile radius of BNL.

8.6 SUMMARY AND CONCLUSION

Calculations of EDE from all BNL facilities that have the potential to release radionuclides to the atmosphere indicated that radiological

Table 8-5. Summary of Potential Dose from All Environmental Pathways (1999).

Pathway	Primary Contributing Radionuclide	Maximally Exposed Individual EDE (mrem)	Regulatory Pathway Limit (mrem)	Collective EDE (person-mrem)
Inhalation	Ar-41	0.13	10	4,649
Fish Consumption(1)	Cs-137	0.25	NS	156
Deer Meat Consumption(2)	Cs-137	4.2	NS	NA
Drinking Water(3)	NA	NA	NA	NA

Notes:
Because all doses in this table are calculated rather than measured, they are potential doses.
EDE=Effective Dose Equivalent.
NS=None Currently Specified.
NA=Not Applicable
(1)Fish dose calculation is based on measured Cs-137 concentration only. Sr-90 analyses were not performed in 1999. Calculation assumes a consumption of 15 lbs./yr.
(2)Deer Meat Dose is based on average onsite deer concentration. Calculation assumes a consumption of 64 lbs./yr.
(3)No drinking water dose projected following connection of public water supply to homes adjacent to BNL.

doses attributable to Laboratory operations were well below the limits established by federal regulations (see Table 8-5). Direct measurement of external radiation levels by TLD confirmed that exposure rates at the site boundary were consistent with background levels observed throughout New York State (NYSDOH 1993).

Additionally, it was assumed there was no internal dose to the public from the drinking water ingestion pathway since public water supply hookups have been provided to site neighbors.

The EDE calculations presented in this chapter were based on the maximally exposed individual for each scenario using the stated assumptions. Given this, it was not plausible that any single person could receive a radiological dose equal to the sum of these individual pathways. For this to occur, an individual would be required to breathe air and consume fish and deer at the radionuclide concentrations calculated or observed in all samples collected in 1999.

The hypothetical maximally exposed individual, defined as residing at the northeast boundary of BNL, breathing the air, and consuming 15 pounds of fish and 64 pounds of deer meat from onsite sources would receive 4.58 mrem/yr. of the total effective dose equivalent from inhalation and ingestion pathways (dose from drinking water is zero). This is an extremely unlikely worst case scenario, but was calculated to show that the dose from all pathways would still be less than 5 percent of 100 mrem/yr. dose limit set by DOE for the general public. The average annual dose from man-made, cosmic, terrestrial and ingestion paths, and radon is 360 mrem (NCRP 1987). These MEI doses demonstrate that in 1999 there was minimal radiological dose impact above the natural background to the public and the environment from BNL operations.

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Quality Assurance

Brookhaven National Laboratory conducts sampling activities designed to monitor groundwater, air, surface water characteristics, effluent discharges, flora, and fauna throughout the site and the surrounding area. Quality assurance is an integral part of every function at BNL. A program is in place to ensure that all environmental monitoring data meet appropriate quality assurance requirements. Review of the quality assurance measures at BNL presented in this chapter confirms that the analytical data reported in the 1999 Site Environmental Report are reliable.

Brookhaven National Laboratory uses its onsite Analytical Services Laboratory and four offsite contractor laboratories to analyze environmental samples. The oversight of laboratory analyses involves proficiency testing, auditing, and ensuring adherence to a quality assurance program. The New York State certified laboratories that perform analyses are included in this report.

The Analytical Services Laboratory performs approximately 5,000 radiological and nonradiological (chemical) analyses per year on environmental samples, and also supervises contracts with other laboratories. Quality control is maintained through daily instrument calibration, efficiency and background checks, and testing for precision and accuracy.

The two primary laboratories reporting radiological analytical data each scored between 90 and 100 percent satisfactory results in both state and federal performance evaluation programs. For nonradiological performance evaluation testing, the ASL and the three BNL contractor laboratories each scored over 90 percent in the 1999 New York State Environmental Laboratory Approval Program evaluations. Over all, analytical data reported for 1999 are of high quality.

9.1 QUALITY ASSURANCE

This chapter discusses the quality assurance measures at Brookhaven National Laboratory. It is extremely important that environmental data used for reporting and decision making is accurate. A program is in place to ensure that all environmental monitoring data are reliable and meet appropriate quality assurance (QA) requirements.

Environmental samples at BNL are analyzed by an onsite laboratory, the Analytical Services Lab (ASL). BNL also procures and maintains contracts with offsite laboratories: General Engineering Lab (GEL) (Charleston, SC) for radiological and nonradiological analytes; H2M Lab (Melville, NY) for nonradiological analytes; Severn-Trent Lab (STL) (Monroe, CT) and Chemtex Lab (Port Arthur, TX) for select nonradiological analytes. All analytical laboratories are New York State certified and subject to audits. The process of selecting laboratories involves an evaluation of past performance evaluation (PE) testing results, pre-selection bidding, post selection auditing, and adherence to its own quality assurance program (QAP).

The ASL performs approximately 5,000 radiological and nonradiological (chemical) analyses per year on environmental samples. Routine quality control (QC) procedures followed by the ASL include daily instrument calibrations, efficiency and background checks, and standard tests for precision and accuracy.

As in prior years, the ASL and three contractor laboratories participated in several national and state PE testing programs. Results of those PE tests provide information on the quality of a laboratory's results.

Figures 9-1 and 9-2 summarize the overall 1999 scores of the ASL and the three contractor laboratories that participated in the U.S. Department of Energy (DOE) Quality Assessment Program for radiological analytes, Environmental Resources Associates (ERA) performance evaluations, or the New York State Department of Health (NYSDOH) Environmental Laboratory Approval Program (ELAP). All performance evaluation testing results reported by each participating analytical laboratory during 1999 are summarized in Figures 9-1 and 9-2 and presented in detail in Table F-2 through Table F-17 (see Appendix F). The bar graphs of Figures 9-1 and 9-2 show radiological and nonradiological results (as percentage scores) that were acceptable, within warning limits, or unacceptable for each analytical laboratory, and by PE testing program. A 'warning' or 'check for error' is considered satisfactory, being within two and three standard deviations of the target value, and an 'unacceptable' result is greater than three standard deviations of the target value. An 'overall satisfactory' score is the sum of results rated as acceptable and those rated as 'warning,' divided by the total number of results reported.

During 1999, BNL's overall satisfactory radiological scores were comparable to those of its offsite contractor laboratory (GEL), with a 90 to 95 percent rate of satisfactory radiological results. For nonradiological results, the overall rate of satisfactory results ranged from 91 to 99 percent for BNL, H2M, and STL. Performance evaluation testing data are not presented for Chemtex Laboratory because NYSDOH does not provide performance testing for these analytes.

9.2 THE BNL ENVIRONMENTAL MONITORING QUALITY ASSURANCE PROGRAM

Responsibility for quality at BNL starts with the Laboratory Director and extends down through the entire organization. The BNL Quality Assurance Program coordinates and evaluates QA implementation at the Laboratory and provides professional assistance to the departments and divisions. The objectives of BNL's environmental monitoring QA program are to ensure proper planning, organization, direction, control, and support in order to achieve the objectives of the environmental program. Overall performance is reviewed and evaluated using a rigorous assessment process described in the following sections of this chapter. This QA program was developed to ensure compliance with requirements established by the U.S Department of Energy in DOE in Order 414.1 (1998), *Quality Assurance,* and DOE Order 5400.1 (1988), *General Environmental Protection Program*.

9.3 SCOPE OF THE ENVIRONMENTAL MONITORING QUALITY ASSURANCE PROGRAM

BNL has adopted or adapted program elements specified in DOE Order 414.1, as well as the additional environmental QA requirements of DOE Order 5400.1, into sampling, analysis, and data handling activities. QA practices and procedures are documented in manuals and a comprehensive set of detailed,

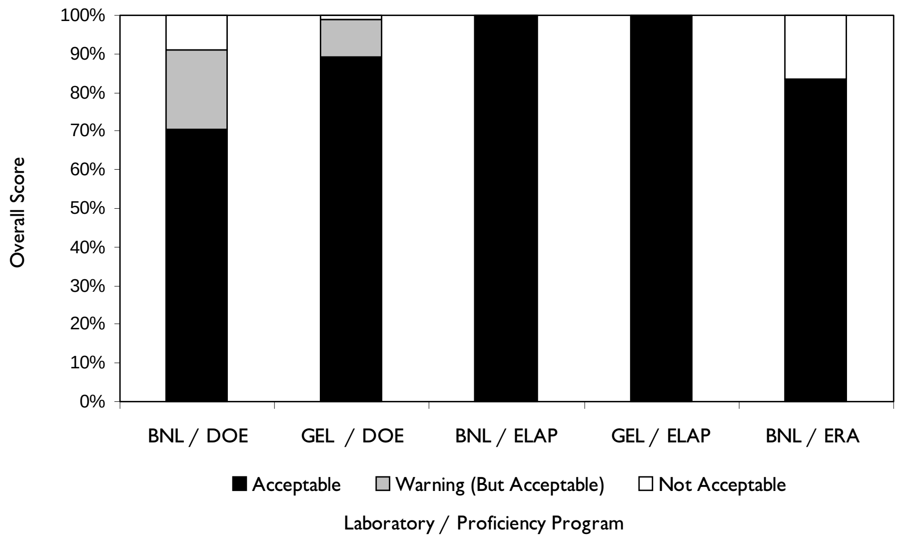

Figure 9-1. Summary of 1999 Performance Evaluation Scores in DOE, NYSDOH ELAP, and ERA Radiological Programs.

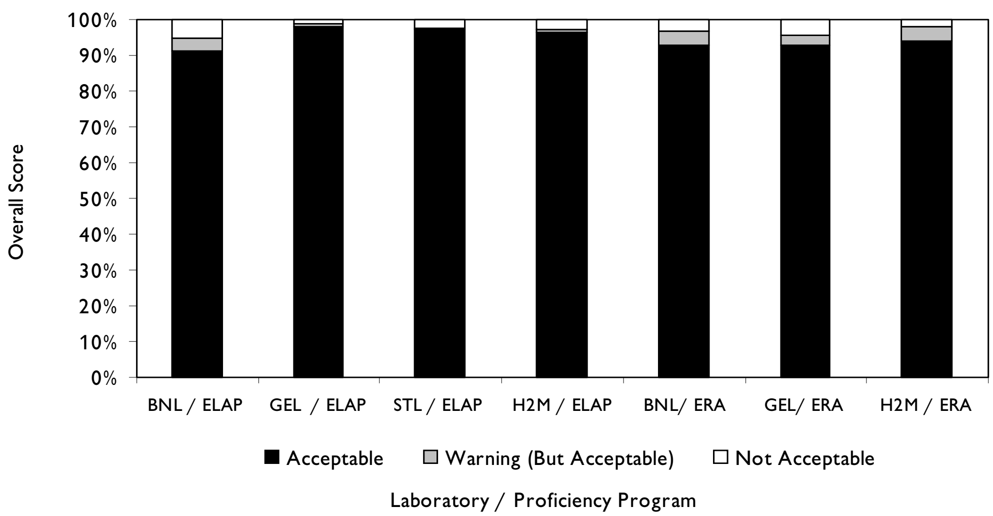

Figure 9-2. Summary of 1999 Performance Evaluation Scores in NYSDOH ELAP and ERA Nonradiological Programs.

internal Environmental Monitoring Standard Operating Procedures (EM-SOPs) (BNL 1999a).

BNL ensures that environmental media are sampled and analyzed in a way that provides representative, defensible data. The QA program supports this activity by incorporating quality assurance elements in environmental monitoring programs such as field sampling designs, documented procedures, chain-of-custody, a calibration/standardization program, acceptance criteria, statistical data analyses, QA software and data processing systems. Whenever discrepancies are found in these elements or when failures in PE testing occur, a nonconformance report is typically generated by the laboratory. Corrective actions are then made when appropriate. The offsite contractor laboratories that perform radiological and chemical analyses for BNL are also required to maintain stringent QA programs.

In addition, BNL conducts a program of internal and external audits to verify the effectiveness of the environmental sampling, analysis, and database activities. Contractor laboratories are subject to audits by BNL personnel at the time of contract renewal. The BNL Quality Management Office, DOE Brookhaven Group, DOE Chicago Operations, regulatory agencies, and other independent parties periodically audit the environmental programs.

For sampling, SOPs have been established to calibrate field equipment, collect samples, and maintain chain-of-custody of all environmental samples. These SOPs ensure consistency between samples, whether they were collected by BNL employees or outside contractors. Quality control checks of sampling include the collection of field duplicates, matrix spike samples, field blanks, trip blanks, and equipment blanks. In addition, specific sampling methodologies (e.g., the low flow sampling technique) include quality control checks such as field analysis of stability parameters to ensure proper purging of monitoring wells.

For in-house analyses, SOPs have been established to calibrate instruments, analyze samples, and assess quality control. These procedures are consistent with U.S. Environmental Protection Agency (EPA) methodology and are described in Appendix D. Quality control checks are performed and include analysis of blanks or background concentrations; use of Amersham or National Institute for Standards and Technology (NIST) traceable standards; and analysis of reference standards, spiked samples, and duplicate samples. The ASL Supervisor, Quality Assurance Officer, or Group Leader review all analytical and quality control results before the data are reported.

9.4 QUALITY ASSURANCE PROGRAM FOR GROUNDWATER MONITORING ACTIVITIES

This section describes the QA requirements for activities that were conducted as part of the 1999 BNL groundwater monitoring program. Sample analyses for environmental restoration sample data were performed by General Engineering Lab, under contract to BNL. Environmental surveillance groundwater data were analyzed by the ASL with two exceptions: the Major Petroleum Facility and the Motor Pool monitoring programs were sampled under NYSDEC permit requirements. The ASL is not certified by New York State for analysis of semivolatile organic compounds; therefore, samples are sent offsite to H2M Labs, Inc. The *BNL Groundwater Monitoring Program Quality Assurance Project Plan* (QAPP) (BNL 1999b) describes the QA program and QC requirements followed. The QAPP documents organizational structure, documentation requirements, sampling requirements, field QA/QC sample collection, acceptance criteria, sample custody requirements, data validation procedures, and general data handling procedures (database procedures).

9.4.1 SAMPLE COLLECTION PROCEDURES

The primary objectives of environmental groundwater sampling are to monitor groundwater quality, to identify the extent of contamination, and to identify potential receptors at risk. BNL has developed SOPs for all phases of sampling activities including field equipment calibration, chain-of-custody, sampling of monitoring wells, and waste handling requirements.

9.4.1.1 GROUNDWATER SAMPLING PROCEDURES

EM-SOP-302, *Low Purge Sampling of Monitoring Wells Using Dedicated Pumps*, was followed by field personnel collecting groundwater samples. Most of the wells in the monitoring program were equipped with dedicated pumps designed to collect water samples using a low flow process. When a well was designated to be sampled using the low flow process but a dedicated pump was not associated with the well, the procedures outlined in EM-SOP-307, *Low Purge Sampling of Monitoring Wells using Non-dedicated Pumps*, was used. The only exception was for the AOC29 High Flux Beam Reactor Program where procedures outlined in the *Natural Attenuation Monitoring Work Plan for the HFBR Tritium Plume* (BNL 1998) were followed.

9.4.2 FIELD QUALITY CONTROL SAMPLES

Field QC samples collected for the environmental monitoring program included trip blanks, field blanks, field duplicate samples, matrix spike/matrix spike duplicates, and equipment blanks.

The rationale for selection of specific field QC samples and minimum requirements for use in the environmental monitoring and surveillance programs are provided below and in EM-SOP-200, *Collection and Frequency of Field Quality Control Samples.*

Trip blanks consist of an aliquot of distilled water that is sealed in a sample bottle either by the analytical laboratory prior to shipping the sample bottles to BNL or prepared by the field sampling personnel. The trip blank is used to determine if any cross-contamination occurs between aqueous samples during shipment. Trip blanks are analyzed for volatile organic compounds only. The trip blanks were shipped to the analytical laboratory each day that field sampling for aqueous volatiles was conducted. They were collected in accordance with the procedure described in EM-SOP-200.

Field blanks were collected to evaluate potential cross-contamination of samples caused by sampling equipment. The frequency of collection was one field blank for every twenty samples shipped to the analytical laboratory or one per sampling round per project, whichever was more frequent. On any given day, the field blanks were analyzed for the same parameters as groundwater samples.

Field duplicate samples were analyzed to check reproducibility of the sampling and analytical results. EM-SOP-200 specifies the frequency of duplicate collection. Generally, groundwater duplicates were collected for five percent (one out of every 20 samples) of the total number of collected samples. Table F-1 (see Appendix F) summarizes the number of field duplicate samples collected. Field duplicate acceptability is based on EPA Region II guidelines. The relative percent difference for concentrations above the contract-required detection limit, or five times the reporting limit (depending on the reporting limit and analyte), must be below 20 percent for the duplicate to be acceptable.

Matrix spike/matrix spike duplicates for organic analysis were performed in order to determine if the sample matrix adversely affected the analysis. They were performed at a rate of approximately one per twenty samples collected.

Equipment blank samples were collected as needed to verify the effectiveness of the decontamination process for non-dedicated or reusable sampling equipment. Equipment rinsates were collected from the final rinse water generated using a laboratory-grade water source. When equipment rinsate collections are needed, these QC samples are collected at the frequency specified in EM-SOP-200.

9.4.3 FIELD SAMPLE HANDLING AND CUSTODY

In order to ensure the integrity of samples, a chain-of-custody is maintained and documented for all samples collected. A sample or evidence file is considered to be in the custody of a person if any of the following rules of custody are met: (a) the person has physical possession of the sample or file; (b) the sample or file is in view of the person after being in possession; (c) the sample or file is placed in a secure location by the custody holder; or (d) the sample or file is in a designated secure area.

9.4.3.1 FIELD SAMPLE CUSTODY REQUIREMENTS

The sampling team leader was responsible for the care and custody of the samples collected until they were transferred to a sample receiving group or an analytical laboratory. The sampling team member who maintained custody of the samples signed the chain-of-custody form when the samples were transferred to a sample receiving group or analytical laboratory. The appropriate sample relinquishment signatures and sample receipt signatures were documented on the chain-of-custody form. Field requirements were as follows:

(a) The chain-of-custody was generated at the point of sample generation.
(b) Samples were collected as specified in the QAPP or project-specific work plan.
(c) The information concerning the sample collection was recorded in a field log.
(d) Samples requiring refrigeration were placed immediately into a refrigerator and/or into a cooler with cooling media, and kept under the rules of custody.

9.4.3.2 SAMPLE TRACKING

Samples and results are tracked within the Environmental Information Management System (EIMS). Tracking was initiated when a sample was recorded on a chain-of-custody form. Copies of the chain-of-custody and supplemental forms were provided at least weekly to the project manager or his designee (sample coordinator) and forwarded to the data coordinator for entry into the EIMS.

9.4.3.3 SAMPLE DOCUMENTATION

The sample team is required to keep a field notebook. The field notebook is a bound, weatherproof logbook that was filled out at the location of sample collection. It contains sample designation, sample collection time, sample description, sample collection method, daily weather, field measurements, and other site-specific observations, as appropriate. The sample team also completes a sample collection log for every sample that is collected.

9.4.3.4 SAMPLE PRESERVATION, SAMPLE SHIPMENT, AND RECEIPT

Samples shipped to offsite laboratories were managed as follows. Prior to sample collection, the sampling team prepared all bottle labels and affixed them to the appropriate container type as defined in the QAPP. Appropriate preservatives are added to containers prior to sample collection or immediately after collection.

After sample collection by BNL or contractor personnel, the samples are preserved and maintained as required throughout shipment. If samples are sent via commercial carrier, a bill-of-lading (waybill) was used. Receipts for bills-of-lading and all other documentation of shipment were maintained as part of permanent custody documentation. Commercial carriers are not required to sign the chain-of-custody form.

9.4.4 DATA MANAGEMENT PROCEDURES

Data management procedures govern the tracking, validation, verification, and distribution of the analytical data. When samples are shipped to the laboratory, chain-of-custody information is entered into the EIMS. Following sample analysis, the laboratory provides the results to the project manager or their designee, and (when applicable) the validation subcontractor in accordance with its contract with BNL. Upon receipt of the hard copy analytical results from the laboratory, the sample coordinator/radiochemist verifies that the results were complete. The verification process includes a check for data package completeness as well as an evaluation of holding times and blank contamination. The Environmental Restoration program sends out approximately 20% of the samples collected for independent validation. The validation contractors used for this work were IT Corp., Inc. (Summerset, NJ) for non-radiological analyses and MJW (Williamsville, NY) for radiological analyses. ES Program samples are not subjected to the validation process.

9.4.4.1 VALIDATOR RESPONSIBILITIES

When a set of analytical results is validated by a validation subcontractor, the validator is responsible for the following data deliverables: (a) hard copy results to the project manager and (b) electronic data deliverables to the data coordinator.

9.5 ANALYSES PERFORMED OFFSITE

Samples collected for regulatory compliance purposes are analyzed by offsite contractor laboratories. Samples requiring semi-volatile organic analyses and toxicity characteristic leachate procedure (TCLP) samples are sent offsite. In addition, when demand exceeds ASL capacity, some strontium-90, metals, and polychlorinated biphenyls (PCBs) are sent to a contractor laboratory.

9.5.1 THE CONTRACT PROCESS

During 1999 BNL had four contracts with offsite laboratories. The contracts specify the analytes, methods, required detection limits, and deliverables (which include standard batch QA/QC performance checks). Successful bidders must also provide BNL with a copy of their QA/QC manual as well as their QAPP.

A contract for nonradiological sample analyses was established with H2M Laboratories, Inc., with an option for second and third year renewals. A second contract for nonradiological sample analyses was established with Chemtex Laboratory in order to provide special analytical services required to meet BNL discharge permit requirements for four analytes (these samples are wastewater samples collected from various recharge basins and one cooling tower).

Contracts for radiological and nonradiological analyses were established GEL and STL with an option for a second and third year renewals. Samples sent offsite for radiological analyses were those requiring either EPA methods or DOE standard methods that the ASL did not perform. Examples are strontium-90 and actinide analyses in soil, vegetation, animal tissue, and water.

The contractor laboratories were audited periodically by the ASL and/or Environmental Restoration program staff to verify competence in analytical methodology and implementation of a comprehensive QA program. During 1999, the ASL began contract renewal and bid processes for both GEL and H2M. The audits of these two laboratories, as well as for Chemtex, are planned for early 2000.

9.5.2 QA/QC VERIFICATION PERFORMED AT BNL

9.5.2.1 CONTRACTOR ANALYSES RESULTS VERIFICATION

Data packages for onsite samples sent out to a contractor laboratory were reviewed at BNL upon return by subject matter experts in either radiological analyses or analytical chemistry to ensure they complied with the contract specifications before the data was accepted and reported. In addition, data packages were examined to determine if samples exceeded holding times, if there were poor recoveries, if the proper method was used, and if field blanks were less than the method minimum detectable limit (MDL). Nonradiological data analyzed offsite were verified and validated using EPA Contract Laboratory Program guidelines (EPA 1990, 1996). Radiological packages were verified and validated using both BNL and DOE guidance documents (BNL 1997 and DOE 1994). Data packages, which were not validated, underwent data verification by the Environmental Restoration Division as per BNL SOPs. Results of the verifications were added to the EIMS.

9.5.2.2 IN-HOUSE ANALYSES RESULTS VALIDATION

The function of the ASL's QA Officer is to verify that all analytical batches fulfill internal QA/QC acceptance criteria. The criteria include: (a) precision, (b) accuracy, (c) recovery, (d) instrument background checks, and (e) stable instrument efficiency performance. All QA/QC data were reviewed before the results were reported. These criteria are fully described in the ASL's QAPP issued in May 1999 (BNL 1999c). The QA Officer and technical staff maintained the detailed QA/QC trend-charts included in this chapter.

9.6 ANALYSES PERFORMED ONSITE

The ASL performs radiological and nonradiological analyses in support of both environmental monitoring and facility operations. The ASL is certified by the New York State Department of Health (NYSDOH) for tritium, gross alpha/beta and gamma in potable and non-potable water analyses in several matrices, all of which are approved EPA methods.

ASL's nonradiological chemical group is certified by the NYSDOH ELAP to perform analyses utilizing EPA Methods 524 and 624 for volatile organic analytes, in potable and wastewaters, respectively. Thirty-seven volatile organic compounds (VOCs) are currently available for analysis with Method 624 (for ground and wastewaters), an addition of 26 over 1998. EPA Method 524 (for potable water) includes 63 organic analytes and was a new addition to the ASL's capabilities. Metals are analyzed utilizing both atomic absorption spectroscopy and inductively coupled plasma/mass spectroscopy EPA Methods. The number of certified metals in potable water doubled from 10 to 21 in 1999. In addition, the ASL is now certified for analyses of 17 metals (the entire ELAP list) in potable water, as well as 21 metals in wastewater.

Certification for three anions has been established for potable and wastewaters, using EPA Method 300. All analytical methods performed by the ASL are described in detail in Appendix D. The abbreviations used for purgeable organics that follow in Appendix F figures are: benzene (benz) , toluene (tol), xylene (xyl), ethylbenzene (E-benz), chloroform (Chlor), chlorobenzene (Cl-benz), methyl chloride (methly-Cl), 1,1-dichloroethylene (DCE), 1,1-dichloroethane (DCA), 1,1,1-trichloroethane (TCA), trichloroethylene (TCE), tetrachloroethylene (PCE) and carbon tetrachloride (CCl_4).

9.7 ASL'S INTERNAL QUALITY ASSURANCE PROGRAM

In May 1999, the ASL issued its QAPP (BNL 1999c) following EPA Region-V guidelines (EPA 1998). SOPs maintained by the ASL were also revised. The QA procedures followed at ASL include daily instrument calibrations, efficiency and background checks, and routine tests for precision and accuracy. A brief summary of the methods and results of these procedures follows.

9.7.1 ASL INSTRUMENT CALIBRATIONS

Figures F-1 through F-4 (see Appendix F) summarize the internal quality control checks for the ASL's radiological instruments. Figure F-1 shows the annual mean efficiencies, with a 99 percent confidence interval, for the ASL's alpha, beta, tritium, and strontium-90 analyzers. Efficiency is the measure by which radiological decaying events are converted into observable counts (counts per minute). Instrument efficiencies were determined daily, using a calibration standard, and averaged for the calendar year. The data points show the annual mean and one standard deviation for each analyzer. All analyzers exhibited stable behavior and there were no unusual occurrences with existing instrumentation.

Figure F-2 summarizes the variability in background counts experienced by each analyzer in 1999. Instrument background is used to determine the MDL of a radiological analyte. In

1999, there were no unusual drift and/or variability in instrument background for each type of analyzer, based on the mean background count-rates and one standard deviation.

Figure F-3 shows the mean, with 99 percent confidence intervals, for eight high-purity germanium gamma detectors. Each detector was calibrated for energy and instrument efficiency daily using a NIST traceable cesium-137 standard. Geometry efficiency calibrations are performed quarterly. Cesium-137 detection efficiencies for the eight detectors is illustrated on the graph, with the EPA acceptance limit of 1 keV shown as the upper and lower lines. The data showed that all eight gamma detectors performed well within the EPA acceptance limit during 1999.

Figure F-4 compares the mean, with a 99 percent confidence interval, for each strontium-90 detector. The plot shows that the mean detector efficiencies, using calibration standards, were within two percent of each other. Each of the weekly efficiency checks performed were within the five percent EPA acceptance limit. The graph is the summary of six months data because the unit was taken out of service and replaced with a new instrument in November 1999.

9.7.2 PRECISION AND ACCURACY

Precision is the percent difference between two measured values, whereas accuracy is the percent difference between a measured value and its known (expected) value. The relative percent difference (RPD) statistic is the measure of batch precision and is defined as the absolute difference between two results, divided by the average of both results, multiplied by 100. Typically, a radioactive tracer solution (i.e., spike) is added to either a routine sample or tap water sample as a means of determining both precision and accuracy. In the case of nonradiological analyses, a known amount of a given analyte is added to a sample, and the percent recovery is the measure of accuracy. The percent recovery is the ratio of the measured amount divided by the known (spiked) amount multiplied by 100.

9.7.2.1 NONRADIOLOGICAL: ORGANIC AND INORGANIC ANALYSES

Figure F-5 summarizes the internal quality control program for the ion chromatography and atomic absorption methods used for inorganic analyses. Figure F-5 presents the annual means and 99 percent confidence intervals for reference checks and continuing calibration check recoveries. There were 147 checks performed in 1999 for the 21 metals and three anions shown.

Figures F-6 shows the 1999 results of the ASL's internal quality control program for the gas chromatography/mass spectroscopy method used in the organic analyses. It summarizes the reference check recoveries for 14 primary VOCs. The recoveries are presented as the annual means, with 99 percent confidence intervals, for each of the VOCs. Mean recoveries and 99 percent confidence intervals for all 14 analytes were within their target ranges, that is, ± 20 percent.

Figure F-7 presents the means, with 99 percent confidence intervals, of surrogate recoveries for samples analyzed in 1999. The recovery range for 4-bromofluorobenzene (BFB) was 72 - 115 percent. The recovery ranges for toluene-d8 and dibromofluoromethane (DBFM) were 84 - 111 percent and 80 - 113 percent, respectively.

Figure F-8 shows the method precision for organic compounds processed by the ASL in 1999. The data are averages for about 20 batches, where precision was determined by analyzing samples in duplicate. The results for 11 compounds represent the average RPD and two standard deviations. All 11 analytes had relative percent difference within the ASL's internal acceptance limit of ± 20 percent. The two sigma uncertainties were all within the EPA acceptance criteria of ±20 percent.

9.7.2.2 RADIOLOGICAL: GROSS ALPHA/BETA AND TRITIUM

Figure F-9 summarizes the ASL's gross alpha and beta (GAB) precision for 270 batches processed in 1999. The figure shows the RPD statistics for each batch of GAB 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 criteria for batch precision is an RPD statistic less than 20 percent (for activity concentrations that are five times greater than the method MDL). During 1999, GAB batch precision was consistently within the acceptable range, except for one instance. In that instance, analytical results were rejected and the entire batch reanalyzed with no lost data. The rejection rate for GAB analyses performed in 1999 was 0.4 percent.

Figure F-10 summarizes the ASL's tritium precision for 307 batches processed in 1999. There were four rejected batches of tritium in 1999 representing a rejection rate of 1.3 percent. Each rejected batch was reprocessed and then passed quality control with no loss of data.

Figures F-11 and F-12 summarize the ASL's accuracy for GAB and tritium, respectively during 1999. Overall the ASL's rejection rate for approximately 577 analytical batches processed for both GAB and tritium was 1.3 percent.

Figure F-11 shows five of 270 cases where GAB accuracy failed the EPA's acceptance criteria of ± 25 percent for percent recovery. In those cases, results of the analytical batch were rejected and the batch reanalyzed. In no case was there a loss of analytical data. Figure F-12 shows the four of 307 cases where tritium batches were rejected because the percent recovery exceeded ± 25 percent. As with GAB, those tritium batches were reanalyzed with no loss of analytical data.

9.7.3 RADIOLOGICAL LABORATORY SWIPE TESTING

During 1999, contamination surveys were performed in all radiological labs of the ASL in order to monitor possible sample contamination by analytical equipment. A BNL radiological control technician performed the contamination surveys. Monthly surveys consisted of swipe-tests of all radiological laboratories as well as the ASL counting room. Weekly surveys, swipe-tests, and instrument surveillance were also performed on the ASL's "Controlled Area" hood and all pipettes used to dispense samples and reagents. On a quarterly basis, the BNL radiological control technician performed a Dose-Report Review. No measurable contamination was found during either monthly or weekly ASL surveys.

9.8 RESULTS OF PERFORMANCE EVALUATION TESTS

Effective December 21, 1998, the EPA's performance evaluation programs for both radiological and nonradiological analytes was terminated. Environmental Resources Associates (ERA), a private independent performance evaluation program, was chosen by the ASL as a replacement for the EPA's radiological and nonradiological Performance Evaluation Program. During 1999, the ASL, GEL, STL, and H2M participated in either the NYSDOH Environmental Laboratory Approval Program (ELAP) (for radiological and nonradiological proficiency evaluation testing) or the DOE Environment Measurements Laboratory (EML) Quality Assessment Program (radiological only).

9.8.1 RADIOLOGICAL ASSESSMENTS

Both the ASL and GEL participated in the DOE's EML Quality Assessment Program and the NYSDOH ELAP. The summaries that follow present the results of each analytical laboratory and their respective PE program.

Overall, the ASL's performance in the DOE EML performance evaluation program was satisfactory in 90.9 percent of the analyses performed on four matrices (air, vegetation, water, and soil), as shown in Table F-2 of Appendix F. Thirty-one of 44 analyses (70.4 percent) were within established EML limits showing acceptable agreement with the known value; nine results (20.4 percent) were within warning limits, demonstrating satisfactory agreement; four analyses (9.1 percent) fell outside the acceptance limits. Three of the four results that were not acceptable occurred in the March round of gamma testing in air filters. In late 1998 the DOE EML changed the filter size of their performance evaluation test samples. The ASL began to correct for the geometry change in the September 1999 round of testing. In 1999, the ASL also switched over to a four liter Maranelli™ configuration for gamma counting of water. After the changes in both air filter and gamma-in-water counting geometries, there was a significant reduction in the number of warning and unacceptable ASL results as compared to the 1998 SER.

On occasion, the ASL sent samples to GEL, an offsite contractor laboratory, for radiological analyses. GEL's performance in DOE's EML performance evaluation program is presented in Table F-3. GEL's performance in the DOE EML intercomparison study was acceptable or within warning limits in 99 percent of the analyses performed on the four matrices (air, vegetation, water, and soil). Eighty-four of 94 analyses (89.4 percent) were within EML's acceptance limit; nine of 94 analyses (9.6 percent) were within upper and lower warning limits, demonstrating satisfactory agreement; one analyses for uranium (1.1 percent) fell outside the acceptance limits.

The ASL's radiological results for the ELAP performance evaluation program were in 100 percent agreement for the four analyses shown in Table F-4. For the same performance evaluation program, GEL also scored 100 percent on the eight analytes shown in Table F-5.

The ASL also participated in several ERA radiological PE studies shown in Table F-6. The overall score on the six results performed in 1999 was 83.3 percent with one tritium unacceptable result. A review of internal QC checks suggested no apparent reason for the failure. However, the ASL had performed successfully in both March and September rounds of the DOE's EML intercomparison, as shown in Table F-2.

9.8.2 NONRADIOLOGICAL ASSESSMENTS

The ASL, GEL, STL, and H2M participated in the NYSDOH ELAP during 1999. The NYSDOH certifies laboratories for non-potable water and potable water. These results are summarized in Tables F-7 to F-16. Although not required for certification, H2M, GEL, and the ASL participated in the ERA water supply and water pollution studies. Only the ASL's performance evaluation data in the ERA program are presented in Appendix F. Summary results for ERA are included for GEL and H2M in Figure 9-2.

The ASL results for the NYSDOH ELAP for non-potable water are shown in Tables F-7. There were a total of 57 results reported with three unacceptable (5.3 percent), two marginal (3.5 percent), and 52 acceptable results (91.2 percent). The overall satisfactory score for the ASL in the ELAP non-potable water category was 94.7 percent.

GEL reported results for 370 analytes shown in Table F-8. For the NYSDOH ELAP non-potable water studies, there were six unacceptable (1.6 percent), three marginal (0.8 percent), and 361 acceptable (97.9 percent) results. This corresponds to an overall satisfactory score of 98.7 percent .

Table F-9 shows H2M's performance in the NYSDOH ELAP non-potable water studies for January and July 1999. There were 390 results reported with ten unacceptable (2.5 percent), six marginal (1.5 percent), and 374 acceptable (95.9 percent). The overall satisfactory score for H2M laboratory was 97.5 percent.

Table F-10 shows STL's s performance in the NYSDOH ELAP non-potable water studies for January and July 1999. There were 383 results reported with six unacceptable (1.6 percent), one marginal (0.3 percent). The overall satisfactory score for H2M laboratory was 98.2 percent.

In the potable water category of the NYSDOH ELAP, the ASL reported 146 results, shown in Table F-11. There were 142 acceptable (97.3 percent) and four unacceptable results, corresponding to an overall satisfactory score of 97.3 percent. GEL reported 170 results shown in Table F-12. There were 169 acceptable (99.4 percent), and one unacceptable result, corresponding to an overall satisfactory score of 99.4 percent. H2M reported 246 results shown in Table F-13. There were 239 acceptable and five warning results, corresponding to an overall satisfactory score of 97.2 percent.

Table F-14 shows STL's results for the NYSDOH ELAP potable water study. There were 111 acceptable (94.1 percent), one marginal (0.8 percent) and six unacceptable (5.1 percent) results, corresponding to an overall satisfactory score of 94.9 percent.

The ASL also participated in ERA's water pollution and water supply PE studies, as shown in Tables F-15 and F-16, respectively. The total number of results reported in both Tables F-15 and F-16 was 156. There were 145 acceptable (92.9 percent), six 'check for errors' (3.9 percent), and five not acceptable (3.2 percent) results. The overall satisfactory score for the ASL in ERA's water supply and water pollution studies was 96.9 percent.

No PE testing data are presented for Chemtex Laboratory. They only perform chemical analyses on the following analytes: dibromo-nitrilo-propionamide (DBNPA), tolytriazole (TTA), polypropylene-glycol-monobutyl-ether (PGME), and 1,1-hydroxyethylidene-diphosphonic acid (HEDP). Currently, no NYSDOH PE testing program includes these four analytes in its studies.

9.9 NEW INSTRUMENTATION AND NEW ANALYTICAL METHODS

In late November of 1999, the ASL took its Tennelec™ LB770 low-level beta counter out of service and replaced it with a state-of-the-art Tennelec™ 4110 system. This new detector is intended for low-level strontium and technetium measurements in environmental samples. The Tennelec™ 4110 underwent testing during the last two months of 1999 until it passed all QC tests. No environmental samples were impacted by this transition.

In January of 1999, the ASL applied to NYSDOH ELAP for "Broad Approval" certification of strontium-90 in water using a new crown-ether separation technology. Approval is pending. The ASL had conducted an intensive intercomparison study of this new method that was published in the June 1999 issue of *Health Physics Journal* (Scarpitta *et. al.* 1999). This radiochemical separation technique was also used in two program pilot projects, where BNL wastewaters contaminated with strontium-90 were remediated to near environmental levels using filter cartridges impregnated with this strontium-specific crown-ether material.

As was mentioned in section 9.6, the ASL more than doubled the number of nonradiological analytes that it is now certified for. These include the entire NYSDOH ELAP list for metals. Appendix D, Table D-1 lists the 74 analytes that the ASL is now certified for, and Table D-2 lists the 24 metals and anions that the ASL holds certification.

9.10 SUMMARY

Quality control data for BNL's ASL were presented in figures for instrument calibration, efficiency and background checks, and testing for precision and accuracy. Additional quality control data were presented for nonradiological analyses performed by the ASL. Overall, quality control checks were consistently within the EPA guidelines of ± 20 percent.

Detailed data on performance evaluation testing were also presented as tables that were summarized in this chapter. The two laboratories reporting radiological analytical data in the *1999 Site Environmental Report* (ASL and GEL) each scored between 90 and 100 percent satisfactory results in both state and federal performance evaluation programs. For nonradiological performance evaluation testing, the ASL and the three BNL contractor laboratories (H2M, GEL, and STL) each scored over 90 percent in the New York State Environmental Laboratory Approval Program evaluations.

Over all, analytical data reported for the *1999 Site Environmental Report* are 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.

AA	Atomic Absorption
AAS	Atomic Absorption Spectrometry
AGS	Alternating Gradient Synchrotron
ALARA	As Low As Reasonably Achievable
AMSL	Above Mean Sea Level
AOC	Area of Concern
AS/SVE	Air Sparging/Soil Vapor Extraction
ASL	Analytical Services Laboratory
AUI	Associated Universities Incorporated
AWQS	Ambient Water Quality Standard
BETX	Benzene, Ethylbenzene, Toluene, and Xylene
BF	4-Bromofluorobenzene
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
BSA	Brookhaven Science Associates, LLC
Btu	British Thermal Units
CAA	Clean Air Act
CAP	CAA Assessment Package
CEM	Continuous Emissions Monitoring
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
Ci	Curie
CLP	Contract Laboratory Protocol
CO	Certificate to Operate
CO_2	Carbon dioxide
COC	Chain of custody
CSF	Central Steam Facility
CT	Carbon tetrachloride
CWA	Clean Water Act
D_2O	Deuterium oxide (heavy water)
DCA	1,1-Dichloroethane
DCE	1,1-Dichloroethylene
DCG	Derived Concentration Guide
DDD	Dichlorodiphenyldichloroethane
DDT	Dichlorodiphenyltrichloroethane
DMR	Discharge Monitoring Report
DOE	U.S. Department of Energy
DOE BHG	U.S. Department of Energy, Brookhaven Group
DOE CH	U.S. Department of Energy, Chicago Operations Office
DOH	U.S. Department of Health
DQO	Data Quality Objective
DWS	Drinking Water Standards
EA	Environmental Assessment
ECR	Environmental Compliance Representative
EDB	Ethylene dibromide
EDE	Effective Dose Equivalent
EDTA	Ethylenediaminetetraacetic Acid
EIS	Environmental Impact Statement
ELAP	Environmental Laboratory Approval Program
EM	Environmental Monitoring
EML	Environment Measurements Laboratory
EMS	Environmental Management System
EMSL	Environmental Monitoring System Laboratory
EPA	U.S. Environmental Protection Agency
ER	Environmental Restoration
ERA	Environmental Resource Associates
ES&H	Environment, Safety, and Health
ESD	Environmental Services Division
ESH&Q	Environment, Safety, Health, and Quality
FS	Feasibility Study
GAB	Gross Alpha Beta
GC/MS	Gas Chromatography/Mass Spectrometry
GEL	General Engineering Lab
HEPA	High Efficiency Particulate Air
HFBR	High Flux Beam Reactor
HTO	Tritiated Water Vapor
HWMA	Hazardous Waste Management Area
HWMF	Hazardous Waste Management Facility (former)
IAG	Interagency Agreement
IAP	Integrated Assessment Program
ICP/MS	Inductively Coupled Plasma/Mass Spectrometry
ISO	International Standards Organization
LED	Light Emitting Diode
LIE	Long Island Expressway
LINAC	Linear accelerator
MACT	Maximum Available Control Technology

MBtu	Million British Thermal Units
MDL	Minimum Detection Limit
MEI	Maximally Exposed Individual
MGD	Million Gallons per Day
MOA	Memorandum of Agreement
MPF	Major Petroleum Facility
MRC	Medical Research Center
MSL	Mean Sea Level
MTBE	Methyl Tertiary Butyl Ether
MW	Megawatt
NA	Not Analyzed
ND	Not Detected or No Dose
NEPA	National Environmental Policy Act
NERL	National Environmental Radiation Laboratory
NESHAP	National Emission Standards for Hazardous Air Pollutants
NIST	National Institute for Standards and Technology
NO_2	Nitrogen dioxide
NO_X	Nitrogen Oxides
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NR	Not Reported
NS	Not Sampled
NSLS	National Synchrotron Light Source
NYCRR	New York Codes, Rules and Regulations
NYS	New York State
NYS AWQS	New York State Ambient Water Quality Standard
NYS DWS	New York State Drinking Water Standard
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
O_3	Ozone
O&M	Operation and Maintenance
ORPS	Occurrence Reporting and Processing System
OU	Operable Unit
P2	Pollution Prevention
PC	Permit to Construct
PCB	Polychlorinated biphenyl
PCE	Tetrachloroethylene (or Perchloroethylene)
PE	Performance Evaluation
ppb	parts per billion
ppm	parts per million
QA	Quality Assurance
QAP	Quality Assurance Program
QAPP	Quality Assurance Program Plan
QC	Quality Control
QM	Quality Management
R2A2	Roles, Responsibilities, Accountabilities, and Authorities
RA	Removal Action
RACT	Reasonable Available Control Technology
RCRA	Resource Conservation and Recovery Act
RHIC	Relativistic Heavy Ion Collider
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
RPD	Relative Percent Difference
SARA	Superfund Amendments and Reauthorization Act
SCDHS	Suffolk County Department of Health Services
SCWA	Suffolk County Water Authority
SDWA	Safe Drinking Water Act
SEP	Supplemental Environmental Project
SER	Site Environmental Report
SERC	State Emergency Response Committee
SHPO	State Historic Preservation Office
SO_2	Sulfur dioxide
SOP	Standard Operating Procedure
SPCC	Spill Prevention Control and Countermeasures
SPDES	State Pollutant Discharge Elimination System
STL	Severn Trent Laboratories
STP	Sewage Treatment Plant
SU	Standard Unit
Sv	Sievert
SVOC	Semivolatile Organic Compound
$t_{1/2}$	Half-life
TCA	1,1,1-Trichloroethane
TCE	Trichloroethylene
TCLP	Toxicity Characteristic Leaching Procedure
TLD	Thermoluminescent Dosimeter
TSCA	Toxic Substances Control Act
TVOC	Total Volatile Organic Compounds
UST	Underground Storage Tank
VOC	Volatile Organic Compound
WCF	Waste Concentration Facility
WM	Waste Management
WMF	Waste Management Facility
WP	Water Pollution
WQS	Water Quality Standard
WS	Water Supply
WSRRSA	Wild, Scenic, and Recreational River System Act
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. For definitions and descriptions of the various environmental regulations, see Chapter 3.

A

Accuracy - The degree of agreement of a measurement with an accepted reference or true value. It is 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 products - A material that has become radioactive through the process of activation.

Activity - Synonym for radioactivity.

Administrative Record - A collection of documents established in compliance with Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) program. Consists of information upon which the CERCLA lead agency bases 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. In general, the Administrative Record can also be the record for any enforcement case.

Aerosol - A gaseous suspension of very small particles of liquid or solid.

Air sparging - A method of extracting volatile organic compounds from the groundwater *in situ* (i.e., in place) using compressed air. The vapors are typically collected using a soil vapor extraction system.

Air stripping - A process whereby volatile organic chemicals are removed from contaminated water by forcing a stream of air through the water in a vessel. The contaminants are evaporated into the air stream. The air may be further treated before it is released into the atmosphere.

ALARA - As Low As Reasonably Achievable, a phrase that describes an approach to environmental protection 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 of 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 elements such as radon emit alpha radiation.

Ambient air - The surrounding atmosphere, usually the outside air, as it exists around people, animals, plants, and structures. It does not include the air immediately adjacent to emission sources.

Analyte - A constituent that is being analyzed.

Anion - A negatively charged ion, often written as a negative sign after an element symbol, such as Cl^-.

Anthropogenic radionuclides - Radionuclides produced as a result of human activity (i.e., human-made).

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.

Area of Concern (AOC) - Under the Comprehensive Environmental Response, Compensation and Liability Act (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 into the environment of a hazardous substance, pollutant, or contaminant (including radionuclides). 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, scrapyards, cesspools, and tanks and associated piping that are known to have caused a release into the environment or whose integrity has not been verified.

Atomic Absorption (AA) - A method used to determine the elemental spectroscopy composition of a sample. In this method, the sample is vaporized and the amount of light it absorbs is measured.

B

Background radiation - Radiation present in the environment as a result of naturally occurring radioactive materials, cosmic radiation, or human-made radiation sources, including fallout.

Becquerel (Bq) - A quantitative measure of radioactivity. This is an alternate measure of activity used internationally and with increasing frequency in the United States. One Bq of activity is equal to one nuclear decay per second. All references to quantities of radioactive material in this report are made in curies, followed in parentheses by the equivalent in Bq.

Beta radiation - Beta radiation is composed of charged particles emitted from a nucleus during radioactive decay, with a mass equal to 1/1837 that of a proton. 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, but may be stopped by materials such as aluminum or Lucite panels. Naturally occurring radioactive elements such as potassium-40 emit beta radiation.

Biochemical Oxygen Demand (BOD) - 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.

Blank - A control sample that is identical to the sample of interest, except that the analyte of interest is absent.

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).

C

Cap - A layer of material, such as clay or a synthetic material, 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).

Chain of custody (COC) - 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.

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.

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 potable water.

Closure - Under the Resource Conservation and Recovery Act (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.

Code of Federal Regulations (CFR) - A codification of all regulations developed and finalized by federal agencies in the Federal Register.

Collective effective dose equivalent - A measure of health risk to a population exposed to radiation. It is the sum of the effective dose equivalents of all individuals within an exposed population, frequently considered to be within 80 kilometers of an environmental release point. It is expressed in person-rem or person-sievert.

Committed effective dose equivalent - The total effective dose equivalent received over a 50 year period following the internal deposition of a radionuclide. It is expressed in rem or sieverts.

Composite sample - A sample of an environmental media that contains a certain number of sample portions collected over a period of time. The samples may be collected from the same location or different locations. They may or may not be collected at equal time intervals over a predefined period of time (e.g., 24 hours).

Confidence interval - A numerical range within which the true value of a measurement or calculated value lies. In this report, radiological values are shown with a 95 percent confidence interval, i.e., there is a 95 percent probability that the true value of a measurement or calculated value lies within the specified range.

Contamination - Unwanted radioactive and/or hazardous material that is dispersed on or in equipment, structures, objects, air, soil, or water.

Controlled area - Any area to which access is controlled to protect individuals from exposure to radiation and radioactive materials.

Cooling water - Water that is used to cool machinery and equipment. Contact cooling water is any wastewater that contacts machinery or equipment to remove heat from the metal. Non-contact cooling water is water used for cooling purposes but has no direct contact with any process material or final product. Process wastewater cooling water is water used for cooling purposes that may have become contaminated through contact with process raw materials or final products.

Curie (Ci) - A quantitative measure of radioactivity. One Ci of activity is equal to 3.7×10^{10} decays per second.

D

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.

Department of Energy (DOE) - The federal agency that sponsors energy research and regulates nuclear materials used for weapons production. DOE has responsibility for the national laboratories and the science and research conducted at these laboratories, including BNL.

Derived Concentration Guide (DCG) - 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/immersion, water ingestion), would result in an effective dose equivalent of 100 mrem (1 mSv). The values have been established by DOE in Order 5400.5, "Radiation Protection of the Public and the Environment."

Disposal - Final placement or destruction of waste.

Dosimeter - A portable detection device for measuring the total accumulated exposure to ionizing radiation.

Downgradient - In the direction of groundwater flow from a designated area; analogous to "downstream."

E

Effective Dose Equivalent (EDE) - A value used to express the health risk from radiation exposure to a tissue or tissues 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. It is equal to the sum of the doses to different organs of the body multiplied by their respective weighting factors. It includes the sum of the effective dose equivalent due to radiation from sources external to the body and the committed effective dose equivalent due to the internal deposition of radionuclides. EDE is expressed in units of rem or sieverts.

Effluent - Any liquid discharged to the environment, including stormwater runoff at a site or facility.

Emission - Any gaseous or particulate matter discharge to the atmosphere

Environment - Surroundings in which an organization operates (including air, water, land, natural resources, flora, fauna, and humans) and their interrelation.

Environmental aspect - Elements of an organization's activities, products, or services that can interact with the environment.

Environmental Assessment (EA) - A report that identifies potentially significant environmental impacts from any federally approved or funded project that may change the physical environment. If an EA identifies a "significant" impact (as defined by the National Environmental Policy Act [NEPA]), an Environmental Impact Statement is required.

Environmental impact - Any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organization's activities, products, or services.

Environmental Impact Statement (EIS) - A detailed report, required by federal law, on the significant environmental impacts that a proposed major federal action would have on the environment. An EIS must be prepared by a government agency when a major federal action that will have significant environmental impacts is planned.

Environmental media - Includes air, groundwater, surface water, soil, flora and fauna.

Environmental monitoring or surveillance - Sampling for contaminants in air, water, sediments, soils, food stuffs, plants, and animals, either by directly measuring or by collecting and analyzing samples.

Environmental Protection Agency (EPA) - The federal agency responsible for developing and enforcing environmental laws. Although state regulatory agencies may be authorized to administer environmental regulatory programs, EPA retains oversight authority.

Ethylene Dibromide (EDB) - A colorless, nonflammable, heavy liquid with a sweetish 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.

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.

Feasibility Study (FS) - 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.

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 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.

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.

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 negatively affect 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 the Resource Conservation and Recovery Act (RCRA).

Heat Input - The heat derived from combustion of fuel in a steam generating unit and 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 non-radioactive isotope of hydrogen.

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 (e.g., 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 other sources (e.g., a sewage treatment plant).

Ionizing radiation - Any radiation capable of displacing electrons from atoms or molecules, thereby producing ions. Some examples are alpha, beta, gamma, x-rays, neutrons, and ultraviolet light. High doses of ionizing radiation may produce severe skin or tissue damage.

Isotope - Two or more forms of a chemical element having the same number of protons in the nucleus (or the same atomic number), but having different numbers of neutrons in the nucleus (or different atomic weights). Isotopes of a single element possess almost identical chemical properties.

L

Leach/leaching - The process by which soluble chemical components are dissolved and carried through soil by water or some other percolating liquid.

Liquid scintillation counter - An analytical instrument used to quantify tritium, carbon-14, and other beta-emitting radionuclides.

M

Maximally Exposed Individual (MEI) - The 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.

Mean Sea Level (MSL) - The average height of the sea for all stages of the tide. Used as a benchmark for establishing groundwater and other elevations.

Minimum Detection Limit (MDL) - 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 which have a reduced statistical confidence associated with them (less than 95 percent confidence).

Mixed waste - Waste that contains both a hazardous waste component regulated under Subtitle C of the Resource Conservation and Recovery Act (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.

N

Nuclide - A species of atom characterized by the number of protons and neutrons in the nucleus.

O

Onsite - 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 emissions (e.g., smoke) other than water reduce the transmission of light and obscure the view of an object in the background.

Operable Unit (OU) - 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 any actions that are concurrent, but located in different parts of a site. An operable unit can receive specific investigation and a particular remedy may be proposed. A Record of Decision (ROD) is prepared for each operable unit (*see* Record of Decision).

Outfall - The place where wastewater is discharged.

Oxides of Nitrogen (NO_x) - All oxides of nitrogen, except nitrous oxide, which is expressed as nitrogen dioxide (NO_2).

Ozone (O_3) - A very reactive form of oxygen formed naturally in the upper atmosphere and providing 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

Permit - An authorization issued by a federal, state or local regulatory agency. Permits are issued under a number of environmental regulatory programs, including the Resource Conservation and Recovery Act (RCRA), Clean Air Act (CAA), Clean Water Act (CWA), and Toxic Substances Control Act (TSCA). They grant permission to operate, to discharge, to construct, etc. Permit provisions may include emission/effluent limits and other requirements such as the use of pollution control devices, monitoring, recordkeeping and reporting. Also called a "license" or a "registration" 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 media, such as air, soil, water, or vegetation.

Pollution prevention (P2) - 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.

Polychlorinated biphenyls (PCBs) - 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.

Potable water - Water of sufficient quality for use as drinking water without endangering the health of people, plants, or animals.

Precision - The dispersion 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

Quality Assurance (QA) - Any action in environmental monitoring to ensure the reliability of monitoring and measurement data. Aspects of QA include procedures, inter-laboratory comparison studies, evaluations, and documentation.

Quality Control (QC) - The routine application of procedures in environmental monitoring 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.

R

Radioactive series - A succession of nuclides, 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.

Recharge - The process by which water is added to a zone of saturation (aquifer) from surface infiltration. An area where 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.

Record of Decision (ROD) - A document that records a regulator’s decision for the selected remedial action. The ROD also includes the 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.

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 exposure is assessed. This is a risk-based value used to estimate the potential health effects to an exposed individual or population.

Remedial (or remediation) alternatives - Options considered under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) for cleaning up contamination at a site, such as an Operable Unit (OU) or Area of Concern (AOC). Remedial actions are long-term activities that stop or substantially reduce releases, or prevent possible releases, of hazardous substances that are serious but not immediately life-threatening. See also Feasibility Study (FS) and Record of Decision (ROD).

Remedial Investigation (RI) - An investigation that includes extensive sampling and laboratory analyses to characterize the nature and extent of contamination, define the pathways of migration, and measure the degree of contamination in surface water, groundwater, soils, air, plants, and animals. Information gathered during the RI attempts to fully describe the contamination problem at the site so that the appropriate remedial action can be developed.

Removal actions (RA) or 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 Comprehensive Environmental Response, Compensation, and Recovery Act (CERCLA), and that are not inconsistent with the final remedial action. Under CERCLA or Superfund, the U.S. Environmental Protection Agency may respond to releases or threats of releases of hazardous substances by starting a removal action. The purpose of the removal action is to stabilize or clean up an incident or site that poses an immediate threat to public health or welfare. Removal actions differ from remedial actions. However, removal actions must contribute to the efficiency of future remedial actions.

Roughing filter - A filter used to remove large particulate matter from a wastewater stream prior to treatment, via ion exchange, adsorption or another refined treatment technique.

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.

Sediment - The layer of soil and minerals at the bottom of surface waters, such as streams, lakes, and rivers, that may contain contaminants.

Sensitivity - The minimum amount of an analyte that can be repeatedly detected by an instrument.

Sievert (Sv) - A unit for assessing the risk of human radiation exposure, used internationally and with increasing frequency in the United States. One sievert is equal to 100 rem.

Sludge - Semi-solid residue from industrial or water treatment processes.

Soil vapor extraction - An *in situ* method of extracting volatile organic chemicals from soil. The chemicals are extracted by applying a vacuum to the soil and collecting the air, which can be further treated to remove the chemicals or discharged to the atmosphere.

Sole source aquifer - An area defined by the U.S. Environmental Protection Agency where the only source of drinking water is groundwater.

Spallation - The process by which a high energy particle striking a nucleus causes fragments to be ejected from the nucleus. The resulting atom is usually radioactive.

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; the U.S. Department of Energy; and BNL staff.

State Pollution Discharge Elimination System (SPDES) - A permit issued by the state that regulates the discharge of wastewater. This permit specifies the maximum discharge limits for the parameters present in the particular discharge.

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.

T

Thermoluminescent Dosimeter (TLD) - A device used to measure radiation exposure to occupational workers or radiation levels in the environment.

Total Volatile Organic Compounds (TVOC) - A sum of all individual VOC concentrations detected in a given sample.

Trichloroethylene (TCE) (also, 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 to people when inhaled or ingested, or through skin contact, and can damage vital organs, especially the liver (*see also* Volatile Organic Compounds).

Tritium - The heaviest and only radioactive nuclide of hydrogen, with a half-life of 12.3 years. The very low energy of its radioactive decay (beta emitter) makes it one of the least hazardous radionuclides.

U

Underground Storage Tank (UST) - 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

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 spotted salamander) as it is too shallow to support fish, a major predator of amphibian larvae.

Volatile Organic Compounds (VOCs) - 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 their widespread industrial use, they are commonly found in soil and groundwater.

W

Waste minimization - An action that economically avoids or reduces the generation of waste by source reduction, reduces the toxicity of hazardous waste, improves energy usage, or recycling. This action is consistent with the general goal of minimizing present and future threats to human health, safety, and the environment. Associated with pollution prevention, but more likely to occur after the waste has already been generated.

Water table - The water-level surface below the ground at which the unsaturated zone ends and the saturated zone begins. It is the level to which a well that is screened in the unconfined aquifer would 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.

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

Radiological Data Methodologies

DOSE CALCULATION - ATMOSPHERIC RELEASE PATHWAY

Dispersion of airborne radioactive material was calculated for each of the 16 compass sectors using the CAP88-PC dose model. Site meteorology data from 1999 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 computer code, which calculates the total dose due to contributions from the immersion, inhalation, and ingestion pathways.

DOSE CALCULATION - FISH INGESTION PATHWAY

To estimate the effective dose equivalent from the fish consumption pathway, the following procedure was used:

- ♦ *Intake.* The average fish consumption for an individual engaged in recreational fishing in the Peconic River was based on a study done by the New York State Department of Health (NYSDOH 1996), which estimates the consumption rate at approximately 7 kg or 15 pounds per year (lbs/yr).
- ♦ *Activity in Flesh.* Radionuclide data for fish samples were all converted to picocuries per gram (pCi/g) wet weight; since this is the form in which the fish are caught and consumed.
- ♦ *Dose Factor.* DOE Order 5400.5 (1990) 50-year committed dose equivalent factors (in rem per microcurie [rem/µCi] intake) were applied. The factor for cesium-137 is 5.0E-02 rem/µCi.
- ♦ Calculation:

rem= ***Intake*** (7kg or 15 lbs. per year) ×
Activity in Flesh (µCi/kg) ×
Dose Factor (rem/µCi)

DOSE CALCULATION - DEER MEAT CONSUMPTION

This calculation is performed in exactly the same way as shown in the previous section. The same DOE Order 5400.5 dose conversion factors are used. The only change is the estimate of total pounds ingested in the course of a year. For deer meat, the consumption rate of 29 kg or 64 lbs/yr is based on the EPA Exposure Factors Handbook (EPA 1996).

RADIOLOGICAL DATA PROCESSING

Radiation events occur in a random fashion such that if a radioactive sample is counted multiple times, a distribution of results will be obtained. This spread, known as a Poisson distribution, will be centered about a mean value. If counted multiple times, the background activity of the instrument (the number of radiation events observed when no sample is present) will also be seen to have a distribution of values centered about a mean. The goal of a radiological analysis is to determine whether the sample in question contains activity in excess of the instrument or method blank background. Since the activity of the sample and the background are both Poisson distributed, subtraction of background activity from the measured sample activity results in a value, which may vary slightly from one analysis to the next. Therefore, the concept of a minimum detection limit (MDL) is established to determine the statistical likelihood that the sample contains activity that is truly greater than the instrument background.

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 which is greater than or equal to the MDL, there is 95 percent confidence that it represents the detection of true activity. Values, which are less than the MDL may be valid, but they have a reduced confidence associated with them. Therefore, all data are reported regardless of their value.

At very low sample activity levels, close to the instrument background, it is possible to obtain a sample result that is less than the background. When the background activity is subtracted from the sample activity to obtain a net value, a negative value results. In such a situation, a single radiation event observed during a counting period could have a significant effect on the result. Subsequent analysis may produce a net result that is positive. Therefore, all negative values are retained for

Table B-1. Typical Detection Limits for Gross Activity and Tritium Analyses.

Analysis	Matrix	Aliquot (mL)	MDL (pCi/L)
Gross alpha	water	100	4
		500	1
Gross beta	water	100	7
		500	3
Tritium	water	1	3,900
		7	380

Table B-2. Typical Minimum Detection Limits for Gamma Spectroscopy Analysis.

Nuclide	300 g soil (µCi/g)	300 ml water (µCi/mL)	12,000 ml water (µCi/mL)	3L Maranelli (µCi/mL)
Be-7	7E-8	1E-7	2E-09	1E-8
Na-22	9E-9	1E-8	2E-10	1E-9
K-40	2E-7	2E-7	4E-9	2E-8
Sc-48	1E-8	1E-8	2E-10	3E-8
Cr-51	8E-8	1E-7	2E-9	1E-8
Mn-54	8E-9	1E-8	2E-10	1E-9
Mn-56	2E-7	3E-7	5E-9	2E-8
Co-57	7E-9	9E-9	1E-10	1E-9
Co-60	1E-8	1E-8	2E-10	1E-9
Zn-65	2E-8	2E-8	5E-10	2E-9
Cs-134	1E-8	1E-8	2E-10	1E-9
Cs-137	9E-9	1E-8	2E-10	1E-9
Ra-226	3E-8	3E-8	5E-10	4E-8
Th-228	2E-8	3E-8	4E-10	1E-7
Br-82	1E-8	2E-8	3E-10	8E-8
I-131	9E-9	1E-8	2E-10	3E-9
I-133	1E-8	2E-8	3E-10	3E-9

Note:
All MDLs shown above are approximate. For gamma spectroscopy, the MDL of the analysis is dependent upon several variabales, such as the efficiency of the particular detector, the activity of the sample, etc. These factors will vary between analyses and instrumentation.

reporting as well. This data handling practice is consistent with the guidance provided in NCRP Report No. 58 (1985), *Handbook of Radioactivity Measurements Procedures* and DOE/EH-0173T (1991), *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance*. Typical MDLs for the various analyses performed on environmental and effluent samples are shown in Tables B-1, B-2, and B-3.

Average values are calculated using actual analysis results, regardless of whether they are

Table B-3. Typical Detection Limits for Chemical Analyses.

Constituent	BNL	Offsite
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 µmhos/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

Note: All concentrations in mg/L except where noted.

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.

REFERENCES

DOE Order 5400.5. 1990. *Radiation Protection of the Public and the Environment.* U.S. Department of Energy, Washington, D.C. Change 2: 1-7-93.

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EPA. 1996. *Food Ingestion Factors, Exposure Factors Handbook-Volume II.* EPA600P95002FB. U.S. Environmental Protection Agency. Washington, D.C.

NCRP Report No. 58. 1985. *Handbook of Radioactivity Measurements Procedures.* National Council on Radiation Protection and Measurements, Bethesda, Maryland.

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APPENDIX C:

Concepts of Radioactivity

INTRODUCTION

This section introduces some of the basic concepts of radioactivity. It is designed to provide the general reader with an overall understanding of the radiological sections of this report. A discussion of the analyses used to quantify radioactive material, the common sources of radioactivity in the environment, and how each contributes to an individual's radiation dose are provided. Some general statistical concepts are also presented, along with a discussion of radionuclides of environmental interest on the BNL site.

RADIOACTIVITY

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, or nucleus, surrounded by a cloud of negatively charged particles called electrons. Most atoms in the physical world are stable, meaning that they are not radioactive. However, some atoms possess excess energy, which causes them to be physically unstable. In order to become stable, an atom rids itself of this extra energy by casting it off in the form of charged particles or electromagnetic waves, known as radiation. The three most important types of radiation are described below.

COMMON TYPES OF RADIATION

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 radon emit alpha radiation.

BETA Beta radiation is composed of particles, which are identical to electrons. As a result, beta particles have a negative charge. Beta radiation is slightly more penetrating than alpha but may be stopped by materials such as aluminum foil and Lucite panels. They have 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. It is more penetrating than alpha or beta radiation, capable of passing through dense materials such as concrete. X-rays are essentially a form of gamma radiation.

NOMENCLATURE

Throughout this report, radioactive elements (also called radionuclides) are referred to by a name followed by a number, e.g., potassium-40. The number following the name of the element is called the mass of the element and is equal to the total number of particles contained in the nucleus of the atom. Another way to specify the identity of potassium-40 is by writing it as K-40, where 'K' is the chemical symbol for potassium as it appears in the standard Periodic Table of the Elements. This type of abbreviation is used in many of the data tables in this report.

DOSE UNITS

The amount of energy that radiation deposits in body tissue, when corrected for human risk factors, is referred to as dose equivalent or, more generally, as dose. Radiation doses are measured in units of rem. Since the rem is a fairly large unit, it is convenient to express most doses in terms of millirem (1,000 mrem = 1 rem). To give a sense of the size and importance of a 1 mrem dose, Figure C-1 indicates the number of mrem received by an individual in one year from natural and background sources. These values represent typical values for residents of the United States. Note that the alternate unit of dose measurement commonly used internationally and increasingly in the United States is the sievert, abbreviated Sv. One Sv is equivalent to 100 rem. Likewise, 1 millisievert (mSv) is equivalent to 100 mrem.

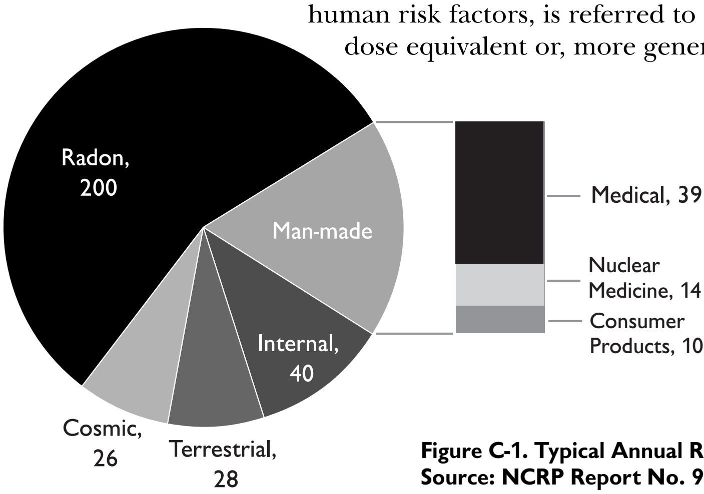

Figure C-1. Typical Annual Radiation Doses from Natural and Man-made Sources (mrem), Source: NCRP Report No. 93 (NCRP 1987).

SOURCES OF RADIATION

Radioactivity and radiation are part of the earth's natural environment. Human beings are exposed to radiation from a variety of common sources, the most significant of which are listed below.

COSMIC Cosmic radiation primarily consists of charged particles that originate in space, beyond the Earth's atmosphere. This includes 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. 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 present in the soil since the formation of the Earth about five billion years ago. Common radioactive elements contributing 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.

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. Human ingestion of radionuclides can occur when plant matter or animals that consume plant matter are eaten. Most exposure to inhaled radioactive material results from breathing the decay products of naturally occurring radon gas. The average dose from eating foods to a person living in the United States is about 40 mrem per year; the average dose from radon product inhalation is about 200 mrem per year.

MEDICAL Millions of people every year undergo medical procedures that utilize radiation. Such procedures include chest and dental x-rays, mammography, thallium heart stress tests, tumor irradiation therapies, and many others. The average dose from nuclear medicine and x-ray examination procedures in the United States is 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), tobacco products (containing polonium-210 and lead-210), and many others. The average dose from consumer products to a person living in the United States is 10 mrem per year.

TYPES OF RADIOLOGICAL ANALYSIS

The quality of environmental air, water, and soil with respect to radioactive material can be assessed using several types of analysis. The most common analyses are described as follows.

GROSS ALPHA Alpha particles are emitted 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 magnitude of alpha-emitting radionuclides that may be present in a sample.

GROSS BETA This is the same concept as described above, except that it applies to the measurement of beta particle activity.

TRITIUM Due to the nature of the radiation emitted from the tritium atom, it is detected and quantified by liquid scintillation counting method. (More information on tritium is included below.)

STRONTIUM-90 Due to the nature of the radiation emitted by strontium-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 strontium-90 is included below.)

GAMMA SPECTROSCOPY 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.

The unit used to express the quantity of radioactive material in a sample is the curie, abbreviated Ci. This is a measure of the rate at which radioactive atoms are transformed to stable atoms. Since the curie is a relatively large unit for measuring environmental samples, the picocurie (pCi) is often used. This unit is equal to one trillionth of a curie, or 0.037 decays per second. The alternate unit for quantifying radioactivity is the becquerel, abbreviated Bq. One Bq is equal to 1 decay per second.

STATISTICS

UNCERTAINTY Because the emission of radiation from an atom is a random process, a sample counted several times will yield a slightly different result each time; a single measurement is, therefore, not definitive. To account for this phenomenon, the concept of uncertainty is applied to radiological data. Each individual analysis result is shown in this report in the format of $x \pm y$, where x is the result and $\pm y$ is the 95 percent confidence interval of the result. That is, there is a 95 percent probability that the true value of x lies between $x + y$ and $x - y$. Conversely, there is a 5 percent probability that the true value of x lies outside of this range.

NEGATIVE VALUES Since natural radiation is present everywhere, uncontaminated environmental media such as soil, air, and water will show some degree of radioactivity. This has to be taken into consideration when analyzing a potentially contaminated sample. There must be a reasonable assurance that natural background radiation is not mistaken for contamination in an unknown sample. To address this, an instrument background is established prior to each unknown sample analysis. This is an analysis of a sample that is composed of the same material as the unknown, but that is known to be clean. When measuring the very small amounts of radioactive material typically encountered in environmental media, where only a few radiation events are counted, it is common for the sample result to be less than the instrument background. When the background is subtracted, a negative net value results, signifying that the sample contains no added radioactive material.

RADIONUCLIDES OF ENVIRONMENTAL INTEREST

STRONTIUM-90

Strontium-90 is a beta-emitting radionuclide with a half-life of 28 years (i.e., after 28 years only one half of the activity from the original remains). It is found in the environment principally as a result of fallout from aboveground nuclear weapons testing. (Fallout refers to the deposition of radionuclides on soils and water bodies as a result of being dispersed high into the Earth's atmosphere during nuclear explosions.) Strontium-90 released in the 1950s and early 1960s is still present in the environment today due to its lengthy half-life. Additionally, nations that were not signatories of the Nuclear Test Ban Treaty of 1963 have conducted tests that have contributed to the global strontium-90 inventory. This radionuclide was also released as a result of the 1986 Chernobyl accident in the former Soviet Union.

The data in this environmental report are reported by method of analysis. Because strontium-90 requires a unique method of analysis, it is reported as a separate parameter in the data tables. The level of sensitivity for detecting strontium-90 using state-of-the-art analysis methods is quite low (less than 1 pCi/L), which makes it possible to detect strontium-90 at levels that are indicative of the environmental sources described above.

TRITIUM

Among the radioactive materials that are used or produced at Brookhaven National Laboratory, 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 (1.5E5 TBq) per year are produced in the atmosphere in this way, with the total global quantity being about 70 million Ci (2.6E6 TBq) at any given time (NCRP 1979). As a result of the 1950s and early 1960s aboveground weapons testing program, 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 exit signs and wrist watches (exit signs may contain as much as 25 Ci [925 GBq] of tritium). It 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.

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 kBq/L) (NCRP 1979). Approximately the same concentration was measurable in precipitation. Today, the level of tritium in surface waters in New York State is below 200 pCi/L (7.4 kBq/L) (NYSDOH 1993), 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. This beta radiation is of a very low energy when compared to the emissions of other radioactive elements and it is easily stopped by the body's outer layer of dead skin cells; only when taken into the body can tritium cause an exposure. Because of its low energy radiation and short residence time in the body, the health threat posed by tritium is very small for most credible exposures.

Environmental tritium is found in two forms: (1) gaseous elemental tritium and (2) 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 short hand notation HTO). All tritium released from BNL sources is in the form of HTO.

CESIUM-137

Cesium-137 is a man-made, fission-produced radionuclide with a half-life of 30 years. It is found in the environment as a result of past aboveground nuclear weapons testing and can be observed in the upper levels of environmental soils at very low concentrations, usually less than 1 pCi/g (0.04 Bq/g). It is a beta-emitting radionuclide, but can be detected by gamma spectroscopy by the gamma emissions of its decay product, barium-137m.

SCIENTIFIC NOTATION

Since many of the numbers used in measurement and quantification in this report are either very large or very small, many zeroes are required to express their value. Because this is inconvenient, scientific notation is used as a kind of numerical shorthand. Scientific notation is based on the principle of representing numbers in multiples of ten. For example, the number one million could be written as 1,000,000. Alternatively, this number could be written in scientific notation as 1×10^6. That is, "one times ten raised to the sixth power." Since even this shorthand can be cumbersome, it can be reduced even further by using the capital letter E to stand for 10x, or "ten raised to the power of some value x." Using this notation, 1,000,000 would be represented as 1E6. Scientific notation is also used to represent very small numbers like 0.0001, which can be written as x 10^{-4} or 1E-4. This notation is used in some tables in this report.

PREFIXES

Another method of representing very large or very small numbers without the use of many zeroes is to use prefixes to represent multiples of ten. For example, the prefix milli- means that the value being represented is one thousandth of a whole unit, so that one milligram is equal to one thousandth of a gram.

DEFINITION OF RADIOLOGICAL TERMS

Radiological terms are used throughout this report where radiation and radioactive material are discussed. The definitions of commonly used radiological terms are found in Appendix A.

REFERENCES

NCRP. 1979. *Tritium in the Environment.* NCRP Report No. 62. National Council on Radiation Protection and Measurements. Bethesda, Maryland.

NCRP. 1987. *Ionizing Radiation Exposure of the Population of the United States.* NCRP Report No. 93. National Council on Radiation Protection and Measurements. Bethesda, Maryland.

NYSDOH. 1993. *Environmental Radiation in New York State.* Bureau of Environmental Radiation Protection, New York State Department of Health, Albany, New York.

Instrumentation and Analytical Methods

The Analytical Services Laboratory (ASL) is divided into radiological and nonradiological sections to facilitate 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 the analysis. All samples were collected and preserved by trained technicians according to appropriate referenced methods. Qualified and trained analysts performed different analyses.

RADIOLOGICAL ANALYTICAL METHODS

The ASL is certified by the New York State Department of Health (NYSDOH) to analyze gross alpha, gross beta, gamma, tritium, and strontium-90 (well waters). The following is a description of the radiological analytical methods.

Gross Alpha and Gross Beta Analysis - Water Matrix

Water samples are collected in four-liter polyethylene containers and preserved at the time of collection by acidification to pH 2 using nitric acid. If the samples are effluent or surface stream samples from locations DA, EA, HM, HQ, or Building 490 daily process samples, then 100 milliliters (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, which is rinsed to remove the solids. The combined solids and rinsate are transferred to a 5-cm diameter stainless-steel planchet, which is then evaporated to dryness. The planchettes are placed in a drying oven at 221°F for a minimum of two hours, removed to a desiccator and allowed to cool, and then weighed and 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 of which the count rate is subtracted from the raw data before computing net activity concentration. System performance is checked daily with National Institute for Standards and Technology (NIST) traceable standards: americium-241 for alpha and strontium-90 for beta. Laboratory duplicates and spiked duplicates are performed within each batch of samples to determine precision and accuracy, respectively.

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 15 liters per minute. At the end of the collection, the filters are returned to the analytical laboratory for assay. Filters are counted twice in a gas flow proportional counter for 50 minutes. The first count occurs immediately upon receipt in the analytical laboratory and is used to screen the samples for unusual levels of air particulate activity. The filters are then recounted approximately one week later. This delay permits the short-lived radon/thoron daughters to decay. The second analysis is used for environmental assessments. The first sample of each batch is a blank filter of which the count rate is subtracted from the raw data before calculating net activity concentration. System performance is checked daily with NIST traceable standards: americium-241 for alpha and strontium-90 for beta.

Tritium Analysis - Water Matrix

Water samples are collected in glass containers. No preservatives are added before collecting the sample. Effluent and surface stream samples from locations DA, EA, HM, HQ, or Building 490 daily process samples as well as groundwater samples are analyzed using a 7-mL aliquot. Potable water samples are distilled following the U.S. Environmental Protection Agency 906.0 method (EPA 1980) and a 7-mL aliquot analyzed. Liquid scintillation cocktail is then 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 are then 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 of which the count rate is subtracted from the raw data before calculating the net activity concentration. 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. Laboratory duplicates and spiked duplicates are performed within each batch of samples to determine precision and accuracy, respectively.

Tritium Analysis - Air Matrix

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 analytical laboratory for processing. It is heated in a glass manifold system. Effluent samples have dedicated glassware, as do environmental samples. 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. 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 then added to the aliquot so that the final volume in the counting vial is 17 mL. Samples are then 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 that the final volume is 11 mL. 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 of which the count rate is subtracted from the raw data before computing net activity concentration. 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. Laboratory duplicates and spiked duplicates are performed within each batch of samples to determine precision and accuracy, respectively.

Strontium-90 Analysis

Strontium-90 analyses are currently performed on water, soil, and aquatic biota samples. Groundwater samples are processed in-house using U.S. Department of Energy (DOE) method RP500 (DOE 1995), which utilizes a crown ether to selectively separate strontium from the acidified sample matrix. The strontium is then eluted using dilute nitric acid. The resulting eluent is evaporated on a 5-cm stainless steel planchet and the sample counted in a gas flow proportional counter. Samples are prepared in batches, and include 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 twice to verify strontium-90 and yttrium-90 in growth.

Potable water samples as well as samples of solids are shipped to a contractor laboratory, which is certified to perform the EPA 905.0 method (EPA 1980) for strontium-90 in drinking water. This method employs time-consuming and costly 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 a combination of gravimetric and strontium-85 standard addition techniques.

Gamma Spectroscopy Analysis

Surface, potable, and groundwater surveillance samples are typically collected in four-liter polyethylene containers and preserved at the time of collection by acidification to pH 2 using nitric acid. Samples are then measured into a 4-liter Marinelli™ beaker and counted on a calibrated gamma spectroscopy detector for 50,000 seconds. Air particulate filters and air charcoal canisters are counted directly on the calibrated gamma spectroscopy detector for 10,000 seconds. Soil, vegetation, and aquatic biota are all processed following collection. Typically, a 100-, 200-, or 300-gram aliquot 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 have been corrected for background and efficiency for each counting geometry used.

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 624, EPA 200.8, EPA 245.2, EPA 236.1, EPA 273.1, and EPA 300.0 methods (NYSDEC 1995). Tables D-1 and D-2 list the nonradiological NYSDOH ELAP certified analytes.

Purgeable Aromatics and Purgeable Halocarbons

Water samples are collected in 40-mL glass vials with removable Teflon™-lined caps without any headspace, and preserved with 1:1 HCl to pH <2.0. Samples are stored at 39°F and analyzed within 14 days. Thirty-seven 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 624 method (NYSDEC 1995) protocols using gas chromatograph/mass spectroscopy (GC/MS). There are currently two Hewlett-Packard™ GC/MS instruments used to analyze purgeable organic compounds. Since the groundwater under BNL is classified as a sole source aquifer under the Safe Drinking Water Act and Class GA groundwater by the NYSDEC, the detection limits reported for the compounds are below New York State drinking water standards and the ambient water quality standard. Even though the quality control results generated for the purgeable analysis meets the EPA 524.2 drinking water method requirements as groundwater, which is considered nonpotable until treated, EPA 624 method is used under the nonpotable water category.

The method involves 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 DB-624 capillary chromatographic column by back flushing the trap with helium. Individual compounds are separated with a temperature program of the gas chromatograph 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, and quantified by internal standard methods. The quantified data is supported by extensive quality assurance/quality control procedures, such as tuning the mass spectrometer to meet bromofluorobenzene criteria, initial and continuing calibrations verifying daily response factors, 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 50-100 mL glass containers with a Teflon™-lined lid and stored at 39° F 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 (NYSDEC 1995) and is targeted to identify and quantify seven different mixtures of PCB congeners in the 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, along with 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 PCBs. The PCBs found in the samples are identified and quantified by comparing the retention times and chromatographic patterns with the standards. Methods blanks, duplicates, spikes, calibration, and reference check standards are run as part of the quality assurance/quality control procedures.

Anions

Chloride, nitrate-N, and sulfate are analyzed using Dionex™ ion-chromatography (IC) with the ion suppression and conductivity detection

Table D-1. ASL Certified Organic Analytes

EPA 624 Analytes	EPA 524 Analytes	EPA 524 Analytes
Benzene-d6	Dichlorodifuoromethane	Bromoform
Chloromethane	Chloromethane	Isopropylbenzene
Vinyl Chloride	Vinyl Chloride	p-Bromofluorobenzene
Bromomethane	Bromomethane	Bromobenzene
Chloroethane	Chloroethane	1,1,2,2-Tetrachloroethane
Trichlorofluoromethane	Trichlorofluoromethane	n-Propylbenzene
1,1-Dichloroethene	1,1-Dichloroethene	1,2,3-Trichloropropane
Acetone	Acetone	2-Chlorotoluene
Methylene Chloride	Methylene Chloride	1,3,5-trimethylbenzene
trans-1,2-Dichloroethene	trans-1,2-Dichloroethene	4-Chlorotoluene
1,1-Dichloroethane	1,1-Dichloroethane	Tertbutylbenzene
2-Butanone	2,2-Dichloropropane	1,2,4-trimethylbenzene
Chloroform	cis-1,2-Dichloroethene	sec-Butylbenzene
1,1,1-Trichloroethane	Bromochloromethane	p-Isopropyltoluene
Dibromofluoromethane	2-Butanone	n-Butylbenzene
Carbon Tetrachloride	Chloroform	1,3-Dichlorobenzene
Benzene	1,1,1-Trichloroethane	1,4-Dichlorobenzene
1,2-Dichloroethane	Carbon Tetrachloride	1,2-Dichlorobenzene
Fluorobenzene	1,1-Dichloropropene	1,2-Dibromo-3-chloropropane
Trichloroethene	Benzene	1,2,4-Trichlorobenzene
1,2-Dichloropropane	1,2-Dichloroethane	Hexachlorobutadiene
Bromodichloromethane	Fluorobenzene	Naphthalene
Chloroethylvinyl ether	Trichloroethene	1,2,3-trichlorobenzene
4-Methyl-2-pentanone	1,2-Dichloropropane	
cis-1,3-Dichloropropene	Dibromomethane	
Toluene-d8	Bromodichloromethane	
Toluene	cis-1,3-Dichloropropene	
trans-1,3-Dichloropropene	4-Methyl-2-pentanone	
1,1,2-Trichloroethane	Toluene	
Tetrachloroethene	trans-1,3-Dichloropropene	
2-Hexanone	1,1,2-Trichloroethane	
Dibromochloromethane	Tetrachloroethene	
Chlorobenzene-d5	Tetrachloroethane	
Chlorobenzene	1,3-dichloropropane	
Ethylbenzene	Dibromochloromethane	
m\p-xylene	1,2-dibromoethane	
o-Xylene	Chlorobenzene-d5	
Bromoform	Chlorobenzene	
p-Bromofluorobenzene	Ethylbenzene	
1,1,2,2-Tetrachloroethane	1,1,1,2-Tetrachloroethane	
1,3-Dichlorobenzene	m\p-xylene	
1,4-Dichlorobenzene	o-Xylene	
1,2-Dichlorobenzene	Styrene	

technique. Samples from monitoring wells are collected in 100-mL polyethylene bottles, cooled to 39° F and analyzed within 28 days. For nitrate in drinking water analysis, samples are analyzed within 48 hours. Holding times were exceeded for nitrate analysis of some nonpotable monitoring well samples, but the depletion of nitrate is expected 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 conductivity meter.

Initially, the IC 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 the quality assurance/quality control procedures.

Table D-2. ASL Certified Metals and Anions

Metals	Method (ICP/MS)	Metals	Method (AAS)	Anions	Method (IC)
Aluminum	EPA 200.8	Iron	EPA 236.1	Chloride	EPA 300.0
Beryllium	EPA 200.8	Sodium	EPA 273.1	Nitrate	EPA 300.0
Vanadium	EPA 200.8	Mercury	EPA 245.2	Sulfate	EPA 300.0
Chromium	EPA 200.8				
Manganese	EPA 200.8				
Cobalt	EPA 200.8				
Nickel	EPA 200.8				
Copper	EPA 200.8				
Zinc	EPA 200.8				
Arsenic	EPA 200.8				
Selenium	EPA 200.8				
Silver	EPA 200.8				
Cadmium	EPA 200.8				
Barium	EPA 200.8				
Thallium	EPA 200.8				
Lead	EPA 200.8				
Molybdenum	EPA 200.8				
Antimony	EPA 200.8				

Notes:
ICP/MS=Inductively Coupled/Mass Spectrometry
AAS=Atomic Absorption Spectrometry
IC=Ion Chromatography

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 six 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 target element is passed through the flame. The atomized element absorbs the energy specific to that element from the cathode lamp and 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 comparing 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, there are 18 elements analyzed by the ICP/MS technique. Aqueous samples are nebulized, and introduced into a radio frequency argon plasma, at temperatures reaching 8,000° K. The desolvated, 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 by the use of 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, subpart 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 203° F for 2 hours to oxidize any organically bound and/or monovalent mercury to mercury (II) oxidation state. Excess oxidizing agent is destroyed 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. 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 the quality assurance/quality control procedures.

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EPA. 1980. *Prescribed Procedures for the Measurement of Radioactivity in Water*. EPA600480032. U.S. Environmental Protection Agency. Washington, D.C. August 1980.

NYSDEC. 1995. *Analytical Services Protocols*. Bureau of Technical Services and Research, New York State Department of Environmental Conservation. Albany, New York. October 1995.

Groundwater Monitoring Wells List for 1999

*Upgradient monitoring well
ER=Environmental Restoration
ES=Environmental Surveillance

OU I - HWMF/Current Landfill (RA-V)

077-02* ER	098-22 ER	099-04 ER	108-13 ER	115-15 ER	115-34 ER	000-124 ER
087-21* ER	098-30 ER	107-10 ER	108-14 ER	115-16 ER	115-35 ER	000-137 ER
088-13* ER	098-33 ER	107-23 ER	108-17 ER	115-28 ER	115-36 ER	000-138 ER
088-14* ER	098-58 ER	107-24 ER	108-18 ER	115-29 ER	115-41 ER	800-54 ER
088-20 ER	098-59 ER	107-25 ER	108-30 ER	115-30 ER	115-42 ER	
088-26 ER	098-61 ER	107-26 ER	115-03 ER	115-31 ER	116-05 ER	
098-19 ER	098-62 ER	108-08 ER	115-13 ER	115-32 ER	116-06 ER	
098-21 ER	098-63 ER	108-12 ER	115-14 ER	115-33 ER		

Total 51

OU I Current Landfill Post-Closure

087-09* ER	087-23 ER	087-26 ER	088-21 ER	088-23 ER	088-110 ER
087-11 ER	087-24 ER	087-27 ER	088-22 ER	088-109 ER	

Total 11

OU I Former Landfill Post-Closure

086-42* ER	087-22 ER	097-64 ER	097-277 ER	106-02 ER	106-30 ER
086-72 ER	097-17 ER				

Total 8

Chemical/Animal Holes Area

106-04 ER	106-16 ER	106-22 ER	106-43 ER	106-47 ER	106-62 ER
106-13 ER	106-17 ER	106-23 ER	106-44 ER	106-48 ER	106-63 ER
106-14 ER	106-20 ER	106-24 ER	106-45 ER	106-49 ER	106-64 ER
106-15 ER	106-21 ER	106-25 ER	106-46 ER	106-50 ER	114-01 ER

Total 24

AGS

044-02* ES	054-08 ES	054-65 ES	055-14 ES	064-51 ES	064-56 ES	065-123 ES
053-01* ES	054-10 ES	054-66 ES	055-15 ES	064-52 ES	065-120 ES	065-124 ES
054-01 ES	054-62 ES	054-67 ES	055-16 ES	064-53 ES	065-121 ES	065-125 ES
054-03 ES	054-63 ES	054-68 ES	064-01 ES	064-54 ES	065-122 ES	065-126 ES
054-07 ES	054-64 ES	054-69 ES	064-03 ES/ER	064-55 ES		

Total 33

RHIC

025-01 ES	025-03 ES	025-05 ES	025-07 ES	034-05 ES	043-01 ES	044-13 ES
025-02 ES	025-04 ES	025-06 ES	025-08 ES	034-06 ES	043-02 ES	044-14 ES

Total 14

BLIP

054-61 ES	064-02 ES	064-46 ES	064-47 ES	064-48 ES	064-49 ES	064-50 ES

Total 7

New Waste Management Facility

055-03 ES	056-21 ES	056-22 ES	056-23 ES	066-07 ES	066-83 ES	066-84 ES
055-10 ES						

Total 8

BMRR

084-12 ES	084-13 ES	084-27 ES	084-28 ES				
						Total	**4**

HFBR and Remediation System

065-01* ER	075-44 ER	076-172 ER	085-66 ER	085-78 ER	095-54 ER	104-25 ER	
065-37 ER	075-45 ER	076-173 ER	085-67 ER	086-09 ER	095-55 ER	105-07 ER	
065-38 ER	075-46 ER	076-174 ER	085-68 ER	095-42 ER	095-87 ER	105-22 ER	
065-39 ER	073-47 ER	076-175 ER	085-69 ER	095-43 ER	095-88 ER	105-23 ER	
065-40 ER	075-48 ER	076-177 ER	085-70 ER	095-44 ER	095-89 ER	105-24 ER	
065-41 ER	075-50 ER	077-10 ER	085-71 ER	095-45 ER	095-90 ER	105-29 ER	
075-11 ER	075-85 ER	077-11 ER	085-72 ER	095-46 ER	095-91 ER	105-42 ER	
075-12 ER	075-86 ER	085-01 ER	085-73 ER	095-47 ER	095-92 ER	105-43 ER	
075-39 ER	075-87 ER	085-02 ER	085-74 ER	095-48 ER	095-93 ER	105-44 ER	
075-40 ER	075-88 ER	085-39 ER	085-75 ER	095-51 ER	096-55 ER	113-08 ER	
075-41 ER	075-89 ER	085-40 ER	085-76 ER	095-52 ER	104-10 ER	113-09 ER	
075-42 ER	076-10 ER	085-41 ER	085-77 ER	095-53 ER	104-11 ER	113-11 ER	
075-43 ER	076-171 ER	085-65 ER					
						Total	**87**

Shotgun Range

046-01 ES	056-04 ES	056-05 ES	056-06 ES				
						Total	**4**

Water Treatment Plant Basin

063-01 ES	063-02 ES	063-03 ES	075-01 ES	075-02 ES			
						Total	**5**

BNL Gasoline Station

085-16 ES	085-17 ES						
						Total	**2**

BNL Motor Pool

102-05 ES	102-08 ES*	102-10 ES	102-12 ES	102-13 ES			
102-06 ES	102-09 ES	102-11 ES					
						Total	**8**

OU III - Central Sector

066-08 ER	075-01 ER	083-01 ER	085-13 ER	095-85 ER	105-25 ER	109-04 ER	
066-09 ER	075-02 ER	084-01 ER	085-97 ER	096-07 ER	105-44 ER	113-06 ER	
072-03 ER	075-09 ER	084-02 ER	085-98 ER	105-05 ER	106-19 ER	113-07 ER	
072-04 ER	075-10 ER	085-07 ER	095-84 ER	105-06 ER	109-03 ER		
						Total	**27**

OU III - Southern Boundary

114-06 ER	121-09 ER	121-14 ER	121-22 ER	122-09 ER	122-18 ER	124-02 ER	
114-07 ER	121-10 ER	121-18 ER	121-23 ER	122-10 ER	122-19 ER	126-01 ER	
121-06 ER	121-11 ER	121-19 ER	122-02 ER	122-15 ER	122-20 ER	130-02 ER	
121-07 ER	121-12 ER	121-20 ER	122-04 ER	122-16 ER	122-21 ER	130-03 ER	
121-08 ER	121-13 ER	121-21 ER	122-05 ER	122-17 ER	122-22 ER	130-04 ER	
						Total	**35**

OU III – Offsite

000-97 ER	000 102 ER	000-112 ER	000-131 ER	800-23 ER	800-43 ER	800-51 ER
000-98 ER	000-104 ER	000-114 ER	800-21 ER	800-40 ER	800-44 ER	800-52 ER
000-99 ER	000-105 ER	000-130 ER	800-22 ER	800-41 ER	800-50 ER	800-53 ER
000-101 ER	000-107 ER					

Total 23

OU III – Offsite Treatment Area

000-112 ER	000-248 ER	000-254 ER	000-260 ER	000-266 ER	000-271 ER	000-276 ER
000-114 ER	000-249 ER	000-255 ER	000-261 ER	000-267 ER	000-272 ER	000-277 ER
000-130 ER	000-250 ER	000-256 ER	000-262 ER	000-268 ER	000-273 ER	000-278 ER
000-245 ER	000-251 ER	000-257 ER	000-263 ER	000-269 ER	000-274 ER	000-279 ER
000-246 ER	000-252 ER	000-258 ER	000-264 ER	000-270 ER	000-275 ER	000-280 ER
000-247 ER	000-253 ER	000-259 ER	000-265 ER			

Total 39

OU III – BGRR/WCF Areas

065-03 ER	065-160 ER	065-167 ER	065-173 ER	075-09 ER	075-192 ER	075-198 ER
065-04 ER	065-161 ER	065-168 ER	065-174 ER	075-10 ER	075-193 ER	075-199 ER
065-06 ER	065-162 ER	065-169 ER	065-175 ER	075-188 ER	075-194 ER	075-200 ER
065-11 ER	065-163 ER	065-170 ER	065-176 ER	075-189 ER	075-195 ER	075-201 ER
065-18 ER	065-164 ER	065-171 ER	065-177 ER	075-190 ER	075-196 ER	075-202 ER
065-19 ER	065-165 ER	065-172 ER	065-178 ER	075-191 ER	075-197 ER	075-203 ER
065-20 ER	065-166 ER					

Total 44

SCWA Onsite Sentinel Wells - Wm. Floyd Well Field

109-03 ER	109-04 ER

Total 2

OU IV - Central Steam Facility

076-02* ER	076-05 ER	076-09 ER	076-22 ER	076-180 ER	076-183 ER	076-185 ER
076-24* ER/ES	076-06 ER	076-19 ER	076-178 ER	076-181 ER	076-184 ER	076-186 ER
076-04 ER	076-07 ER	076-21 ER	076-179 ER	076-182 ER		

Total 19

OU IV – Building 650 Outfall

066-17 ER	076-10 ER	076-24 ER	076-27 ER	076-169 ER	076-183 ER	076-263 ER
066-18 ER	076-13 ER	076-24 ER	076-167 ER	076-181 ER	076-184 ER	076-264 ER
076-07 ER	076-20 ER	076-26 ER	076-168 ER	076-182 ER	076-262 ER	076-265 ER
076-09 ER	076-22 ER					

Total 23

Major Petroleum Facility

076-25* ES/ER	076-16 ES	076-17 ES	076-18 ES	076-19 ES

Total 5

OU I/IV- Southern Plumes

000-108 ER	000-211 ER	000-215 ER	086-70 ER	106-55 ER	106-59 ER	800-60 ER
000-153 ER	000-212 ER	086-05 ER	106-53 ER	106-56 ER	800-59 ER	800-63 ER
000-154 ER	000-213 ER	086-43 ER	106-54 ER	106-58 ER		

Total 19

OU V - Sewage Treatment Plant & Offsite Plume

037-02* ER	038-05 ES	039-10 ES	050-02 ER	000-141 ER	600-15 ER	600-22 ER
037-03* ER	038-06 ES	041-01 ER	060-01 ER	000-142 ER	600-16 ER	600-23 ER
037-04* ER	039-05 ES	041-02 ER	061-03 ER	000-143 ER	600-18 ER	600-24 ER
038-01 ES	039-06 ES	041-03 ER	061-04 ER	000-144 ER	600-19 ER	600-25 ER
038-02 ES	039-07 ES	049-05 ER	061-05 ER	000-145 ER	600-20 ER	600-26 ER
038-03 ES	039-08 ES	049-06 ER	000-122 ER	000-146 ER	600-21 ER	600-27 ER
038-04 ES	039-09 ES	050-01 ER	000-123 ER	000-147 ER		
						Total 47

OU VI – EDB Plume

058-02* ER	099-10 ER	100-14 ER	000-174 ER	000-177 ER	000-180 ER	000-209 ER
089-13 ER	099-11 ER	000-110 ER	000-175 ER	000-178 ER	000-181 ER	800-24 ER
089-14 ER	100-12 ER	000-173 ER	000-176 ER	000-179 ER	000-201 ER	800-25 ER
099-06 ER	100-13 ER					
						Total 23

North Boundary - Background Wells

000-118 ER	000-120 ER	017-03 ER	018-01 ER	018-04 ER	034-02 ER	063-09 ER
000-119 ER	017-01 ER	017-04 ER	018-02 ER	018-05 ER	034-03 ER	
						Total 13

APPENDIX F:

Quality Control Tables

This Appendix presents the Figures and Tables for Chapter 9, Quality Control (QC). The figures summarize the results of daily QC checks performed by BNL's Analytical Services Laboratory (ASL) in 1999, whereas the tables show performance evaluation (PE) results for the ASL as well as three BNL contractor laboratories (H2M, GEL, and STL) that participated in national and/or state PE testing programs during 1999. Sections 9.6 and 9.7 of the SER describe the data shown in the 12 figures and 16 tables, respectively. The detailed data contained in the tables were also used to determine the overall PE score of each participating laboratory, for both radiological and nonradiological programs. The overall PE test scores (i.e., acceptable, warning and unacceptable) are summarized as bar graphs in Figures 9-1 and 9-2 of the text.

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FIGURES

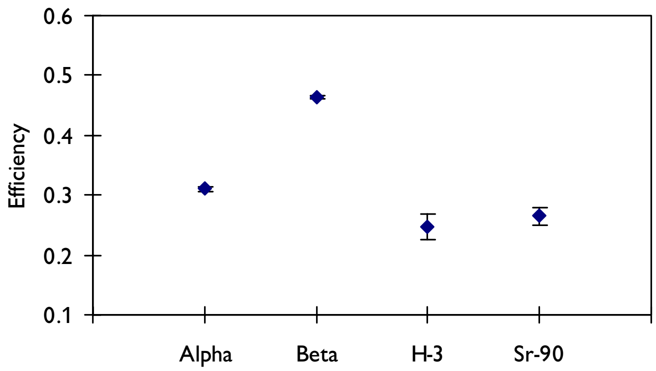


Figure F-1. ASL Instrument Efficiency Summary for 1999.

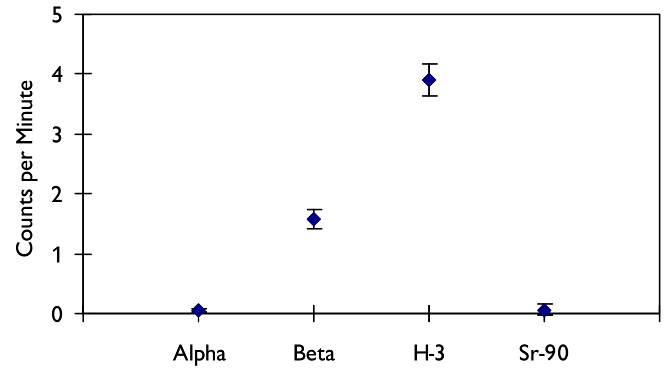


Figure F-2. ASL Instrument Background Summary for 1999.

Figure F-3. ASL Cesium-137 Energy Calibration Summary for 1999.

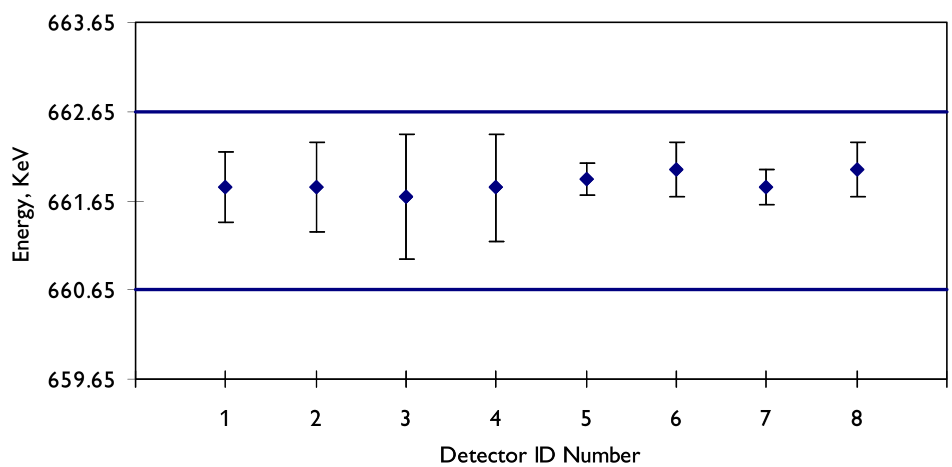
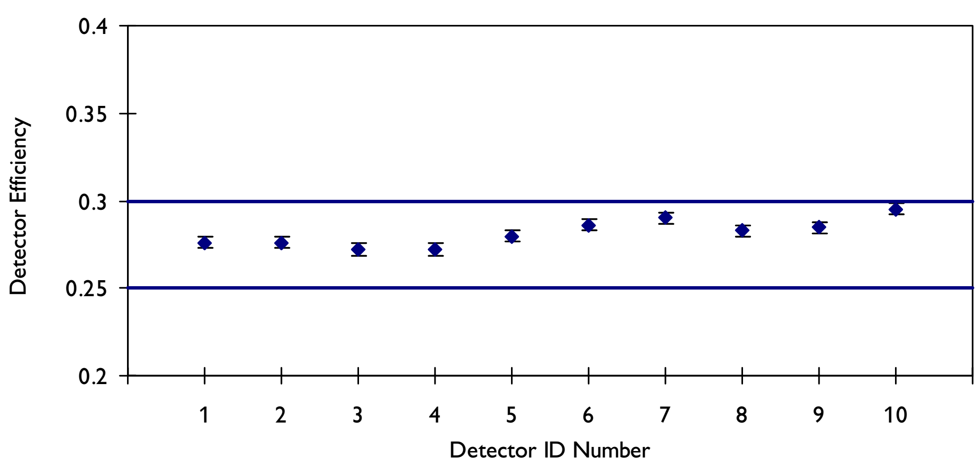


Figure F-4. ASL Strontium-90 Instrument Efficiency Summary for 1999 (7/8 Year).



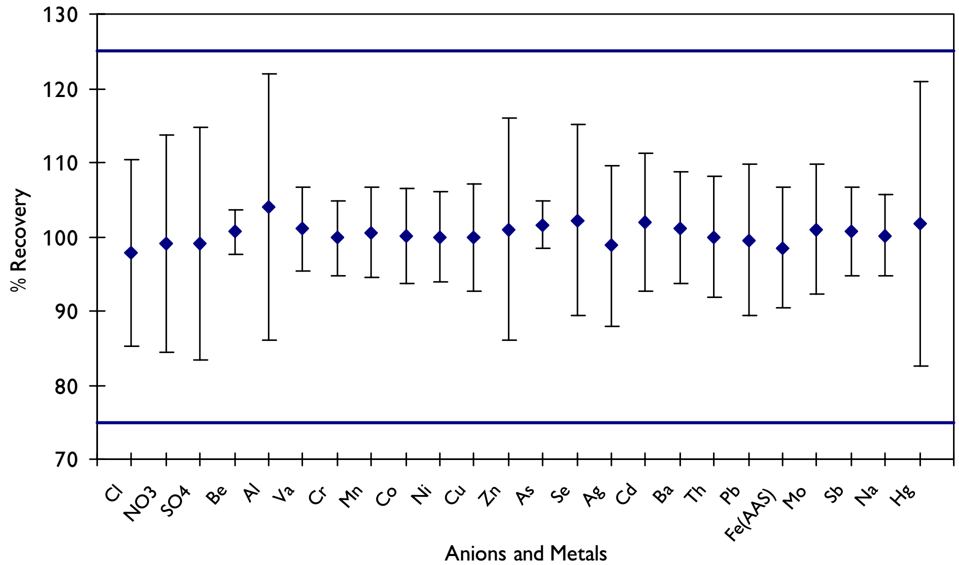


Figure F-5. ASL Recovery/Reference Check Summary for 1999 Inorganic Analyses.

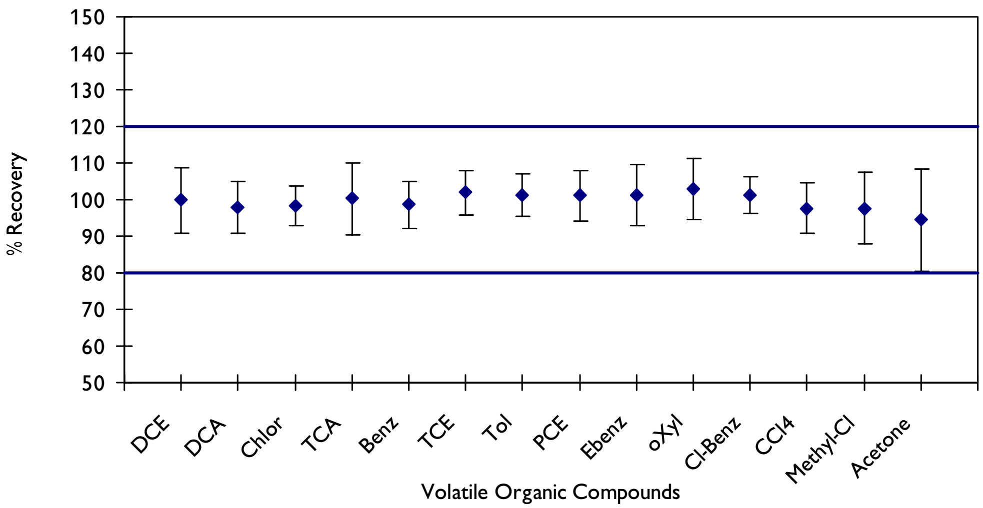


Figure F-6. ASL Surrogate and Spike Recovery Summaries for 1999 Organic Analyses.

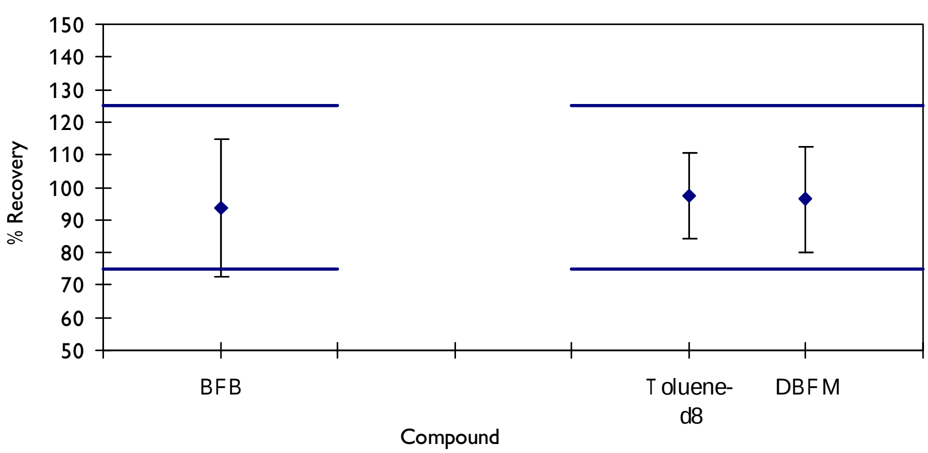


Figure F-7. ASL Matrix Spike Duplicate Summary for Organic Analyses in 1999.

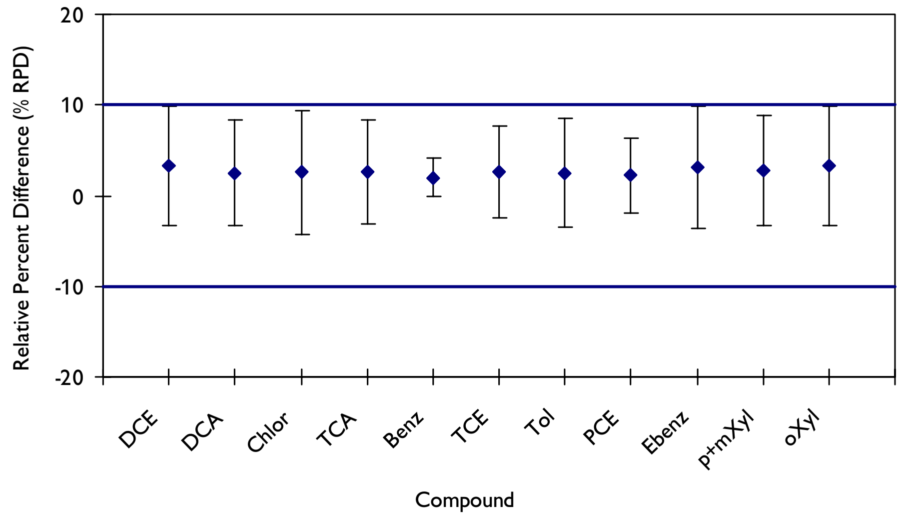


Figure F-8. ASL Matrix Spikes and Duplicates for 1999 Organic Analytes.

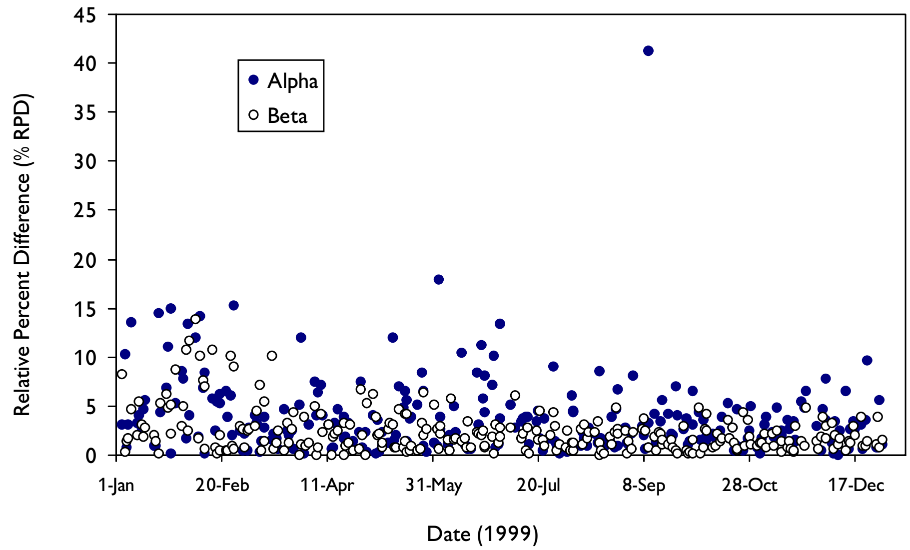


Figure F-9. ASL Gross Alpha and Beta Precision.

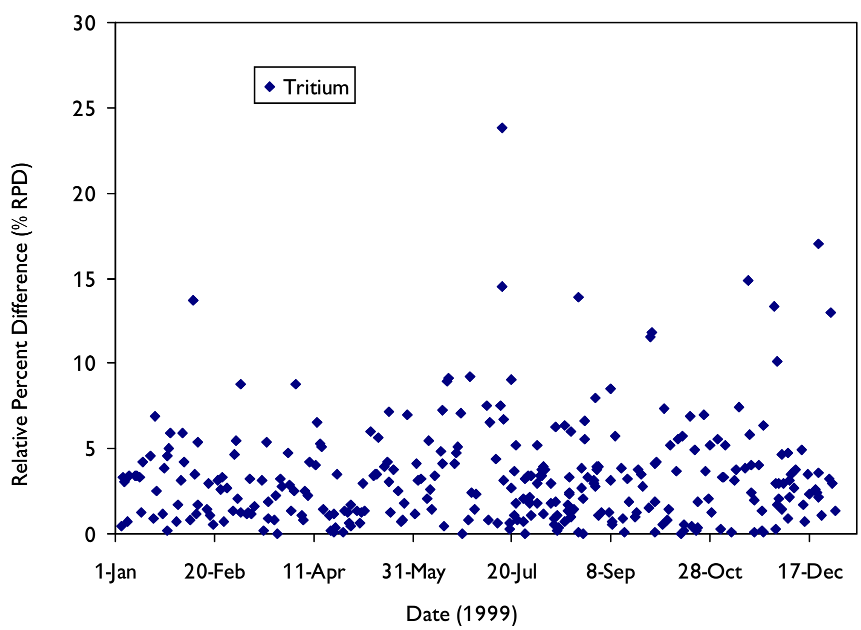


Figure F-10. ASL Tritium Precision.

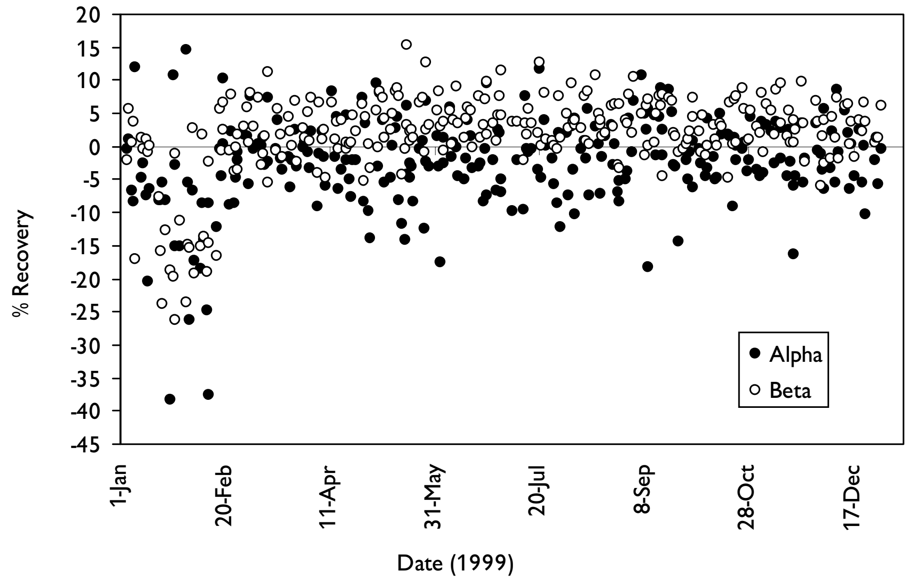


Figure F-11. ASL Alpha/Beta Accuracy.

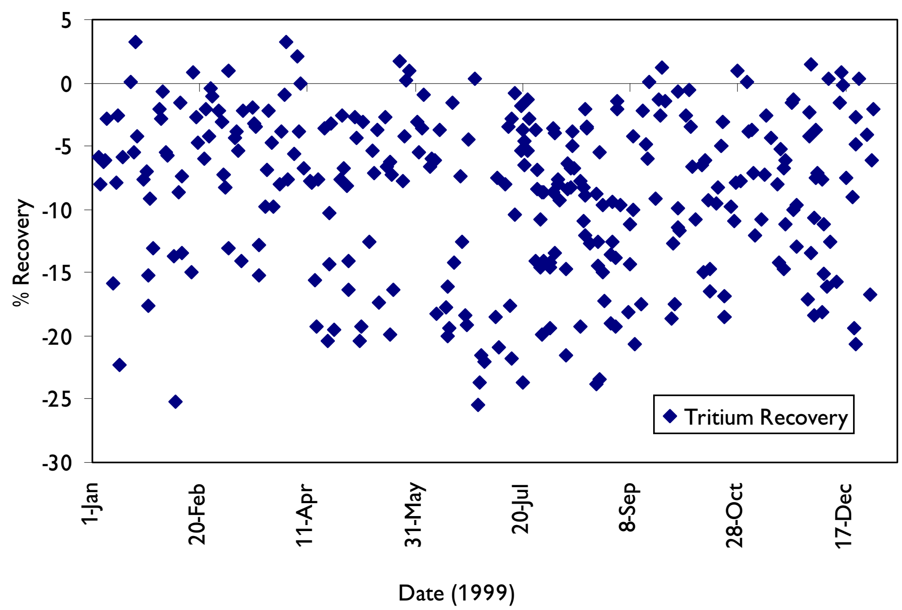


Figure F-12. ASL Tritium Accuracy.

TABLES

Table F-1. Groundwater Field Duplicate Results

Parameter	Number of Duplicates	Acceptable (a)	Percent Acceptable
Volatile Organic Compounds	42	42	100
Ethylene dibromide	23	23	100
Semivolatile Organic Compounds	5	5	100
Pesticides	4	4	100
Metals	9	9	100
Classical Chemistry	12	12	100
Tritium	27	26	96
Strontium 90	19	18	95
Gamma Spectroscopy	11	11	100
Gross Alpha/Beta	14	13	93

Notes:
(a) Acceptability of field duplicates is based on criteria established by EPA Region II.

Table F-2. BNL Quality Assessment Program Test #50 and #51 Results Environmental Measurements Laboratory (EML).

Matrix	Units	Isotope	Date	EML	BNL	Ratio (a)	Comments(b)
Air Filter	Bq/Filter	Alpha	Mar-99	1.61	1.47	0.91	
			Sep-99	2.77	2.37	0.86	
		Beta	Mar-99	1.56	1.41	0.90	
			Sep-99	2.66	2.43	0.91	
		Co-57	Mar-99	3.01	4.48	1.49	Not acceptable
			Sep-99	7.73	7.50	0.97	
		Co-60	Mar-99	4.96	5.51	1.11	Warning
			Sep-99	6.35	4.83	0.76	Warning
		Cs-137	Mar-99	6.05	9.18	1.52	Not acceptable
			Sep-99	6.43	6.77	1.05	
		Mn-54	Sep-99	7.91	8.07	1.02	
		Sb-125	Mar-99	3.59	5.81	1.39	Not acceptable
		Ru-106	Sep-99	5.50	4.63	0.84	
Soil	Bq/kg	Ac-228	Mar-99	47.15	40.33	0.86	Warning
			Sep-99	124.00	97.83	0.79	
		Bi-212	Sep-99	140.00	70.60	0.50	
		Bi-214	Mar-99	69.90	62.53	0.89	
			Sep-99	69.50	75.10	1.08	
		Cs-137	Mar-99	659.50	629.00	0.95	
			Sep-99	204.00	190.10	0.93	
		K-40	Mar-99	362.75	310.80	0.86	Warning
			Sep-99	780.00	669.70	0.86	Warning
		Pb-212	Mar-99	47.93	38.85	0.81	Warning
			Sep-99	127.00	118.37	0.93	
		Pb-214	Mar-99	71.00	68.45	0.96	
			Sep-99	72.00	79.70	1.11	
Vegetation	Bq/kg	Co-60	Mar-99	21.45	19.76	0.92	
			Sep-99	17.60	15.70	0.89	
		Cs-137	Mar-99	467.00	499.50	1.07	
			Sep-99	440.00	444.00	1.01	
		K-40	Mar-99	656.50	603.10	0.92	
			Sep-99	513.00	436.60	0.85	Warning
Water	Bq/L	Alpha	Mar-99	1090.00	1042.48	0.96	
			Sep-99	1580.00	1569.03	0.99	
		Beta	Mar-99	1100.00	1087.43	0.99	
			Sep-99	740.00	702.53	0.95	
		Co-60	Mar-99	51.10	54.02	1.06	
			Sep-99	52.40	53.93	1.03	
		Cs-137	Mar-99	39.38	40.70	1.03	
			Sep-99	76.00	77.60	1.02	
		H-3	Mar-99	121.08	158.52	1.31	Warning
			Sep-99	80.70	77.77	0.96	
		Sr-90	Mar-99	4.10	2.44	0.59	Not acceptable
			Sep-99	1.72	1.27	0.74	Warning

Notes:
(a) The Ratio is the lab result divided by the target value result.
(b) Comment column provides EML evaluation of analytical performance, which is based on control limits established from percentiles of historic data distributions. No comment indicates performance within acceptable limits. September results used the mean of ASL counts.

Table F-3. GEL Quality Assessment Program Test #50 and #51 Results Environmental Measurements Laboratory (EML).

Matrix	Units	Isotope	Date	EML	GEL	Ratio (a)	Comments (b)
Air Filter	Bq/Filter	Alpha	Mar-99	1.61	1.68	1.04	
			Sep-99	2.77	2.72	0.98	
		Beta	Mar-99	1.56	1.40	0.90	
			Sep-99	2.66	2.71	1.02	
		Co-57	Sep-99	7.73	7.79	1.01	
		Co-60	Mar-99	4.96	4.95	1.00	
			Sep-99	6.35	6.81	1.07	
		Cs-137	Mar-99	6.05	6.06	1.00	
			Sep-99	6.43	7.06	1.10	
		Mn-54	Sep-99	7.91	8.81	1.11	
		Ru-106	Sep-99	5.50	7.01	1.27	Warning
		Sr-90	Mar-99	0.64	0.55	0.86	
			Sep-99	0.34	0.34	1.01	
		Sb-125	Mar-99	3.59	3.65	1.02	
		U-234	Mar-99	0.06	0.07	1.17	
			Sep-99	0.07	0.07	1.05	
		U-238	Mar-99	0.06	0.07	1.11	
			Sep-99	0.07	0.08	1.15	
		μg U	Mar-99	4.95	5.49	1.11	
			Sep-99	5.23	5.84	1.12	
		Pu-238	Mar-99	0.27	0.29	1.07	
			Sep-99	0.10	0.08	0.85	Warning
		Pu-239	Mar-99	0.12	0.14	1.10	
			Sep-99	0.14	0.15	1.07	
		Am-241	Mar-99	0.13	0.18	1.33	
			Sep-99	0.13	0.11	0.83	Warning
Vegetation	Bq/kg	Co-60	Mar-99	21.45	20.91	0.97	
			Sep-99	17.60	18.40	1.05	
		Cs-137	Mar-99	467.00	462.69	0.99	
			Sep-99	440.00	459.00	1.04	
		K-40	Mar-99	656.50	687.65	1.05	
			Sep-99	513.00	579.00	1.13	
		Sr-90	Mar-99	736.10	576.41	0.78	
			Sep-99	595.00	586.00	0.98	
		Pu-239	Mar-99	5.20	5.40	1.04	
			Sep-99	4.30	4.48	1.04	
		Am-241	Mar-99	3.52	3.68	1.04	
			Sep-99	2.88	3.13	1.09	
		Cm-244	Mar-99	1.67	2.36	1.41	Warning
			Sep-99	1.61	1.85	1.15	
Water	Bq/L	Alpha	Mar-99	1090.00	1198.52	1.10	
			Sep-99	1580.00	1790.00	1.13	
		Beta	Mar-99	1100.00	1048.57	0.95	
			Sep-99	740.00	969.00	1.31	
		Co-60	Mar-99	51.10	56.30	1.10	
			Sep-99	52.40	54.80	1.05	
		Cs-137	Mar-99	39.38	41.27	1.05	
			Sep-99	76.00	77.60	1.02	

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Table F-3. GEL Quality Assessment Program Test #50 and #51 Results Environmental Measurements Laboratory (EML) *(concluded).*

Matrix	Units	Isotope	Date	EML	GEL	Ratio (a)	Comments (b)
		H-3	Mar-99	121.08	116.39	0.96	
			Sep-99	80.70	84.20	1.04	
		Sr-90	Mar-99	4.10	3.45	0.84	Warning
			Sep-99	1.72	1.77	1.03	
		Fe-55	Mar-99	97.40	89.34	0.92	
			Sep-99	53.00	45.80	0.86	
		U-234	Mar-99	0.27	0.32	1.17	
			Sep-99	0.37	0.39	1.04	
		U-238	Mar-99	0.26	0.31	1.17	
			Sep-99	0.36	0.39	1.08	
		μg U	Mar-99	0.02	23.30	1109.33	Not acceptable
			Sep-99	0.03	0.03	1.07	
		Pu-238	Mar-99	0.77	0.75	0.97	
			Sep-99	0.79	0.86	1.08	
		Pu-239	Mar-99	1.01	0.97	0.97	
			Sep-99	0.87	0.93	1.07	
		Am-241	Mar-99	1.15	1.18	1.03	
			Sep-99	0.85	0.98	1.16	
		Ni-63	Mar-99	114.00	118.88	1.04	
			Sep-99	114.00	115.00	1.01	
Soil	Bq/kg	Ac-228	Mar-99	47.15	49.88	1.06	
			Sep-99	124.00	131.00	1.06	
		Bi-212	Sep-99	140.00	82.90	0.59	
		Bi-214	Mar-99	69.90	74.15	1.06	
			Sep-99	69.50	88.50	1.27	Warning
		Cs-137	Mar-99	659.50	655.83	0.99	
			Sep-99	204.00	217.00	1.06	
		K-40	Mar-99	362.75	357.90	0.99	
			Sep-99	780.00	914.00	1.17	
		Pb-212	Mar-99	47.93	49.54	1.03	
			Sep-99	127.00	142.00	1.12	
		Pb-214	Sep-99	72.00	102.00	1.42	Warning
		Sr-90	Mar-99	32.40	37.79	1.17	
			Sep-99	13.00	9.80	0.75	Warning
		U-234	Mar-99	140.67	135.79	0.97	
			Sep-99	190.00	183.00	0.96	
		U-238	Mar-99	145.00	138.75	0.96	
			Sep-99	202.00	197.00	0.98	
		μg U	Mar-99	11.80	9.77	0.83	
			Sep-99	16.30	15.10	0.93	
		Pu-239	Mar-99	8.11	7.62	0.94	
			Sep-99	3.20	2.75	0.86	Warning
		Am-241	Mar-99	4.89	4.50	0.92	
			Sep-99	1.44	1.69	1.17	
		Th-234	Mar-99	138.00	132.00	0.96	
			Sep-99	198.00	188.00	0.95	

Notes:
(a) The Ratio is the lab result divided by the target value result.
(b) Comment column provides EML evaluation of analytical performance, which is based on control limits established from percentiles of historic data distributions. No comment indicates performance within acceptable limits.

Table F-4. BNL Potable Water Radiochemistry Proficiency Test #207, #208, #217, and #218 Results Environmental Laboratory Approval Program (ELAP).

Analyte	Date	ELAP Reported Value	BNL Reported Value	Ratio (a)	Comment (b)
Alpha (Bq/L)	Apr-99	54.00	50.50	0.94	
	Oct-99	41.00	37.90	0.92	
Beta (Bq/L)	Apr-99	36.00	39.00	1.08	
	Oct-99	24.00	23.00	0.96	

Notes:
(a) The Ratio is the lab result divided by the target value result.
(b) Comment column provides ELAP evaluation of analytical performance, which is based on 95 and 99% confidence intervals about the target value. No comment indicates performance within acceptable limits.

Table F-5. GEL Potable Water Radiochemistry Proficiency Test #207, #208, #217, and #218 Results Environmental Laboratory Approval Program (ELAP).

Analyte	Date	ELAP Reported Value	BNL Reported Value	Ratio (a)	Comment (b)
Alpha (Bq/L)	Apr-99	54.00	50.40	0.93	
	Oct-99	41.00	33.60	0.82	
Beta (Bq/L)	Apr-99	36.00	38.80	1.08	
	Oct-99	24.00	27.20	1.13	
Radium-226 (Bq/L)	Apr-99	43.40	39.50	0.91	
	Oct-99	57.90	58.10	1.00	
Radium-228 (Bq/L)	Apr-99	38.80	35.90	0.93	
	Oct-99	18.30	16.30	0.89	

Notes:
(a) The Ratio is the lab result divided by the target value result.
(b) Comment column provides ELAP evaluation of analytical performance, which is based on 95 and 99% confidence intervals about the target value. No comment indicates performance within acceptable limits.

Table F-6. BNL InterLab RadChem Proficiency Test #813 (Rad-05) and #812 (Rad-10) Results Environmental Resource Associates (ERA).

Analyte	Date	ELAP Reported Value	BNL Reported Value	Ratio (a)	Comment (b)
Alpha (pCi/L)	Apr-99	77.4	89.0	1.15	
Beta (pCi/L)	Apr-99	278	300.0	1.08	
Co-60 (pCi/L)	Apr-99	53.8	57.7	1.07	
Cs-134 (pCi/L)	Apr-99	61.3	56.6	0.92	
Cs-137 (pCi/L)	Apr-99	134	142	1.06	
H-3 (pCi/L)	Aug-99	6130	4640	0.76	Not acceptable

Notes:
(a) The Ratio is the lab result divided by the target value result.
(b) Comment column provides ERA evaluation of analytical performance, which is based on 95 and 99% confidence intervals about the target value. No comment indicates performance within acceptable limits.

Table F-7. BNL Non-Potable Water Chemistry Proficiency Test #203 and #213 Results Environmental Laboratory Approval Program (ELAP)

Analyte	Date	ELAP Reported Value (μg/L)	BNL Reported Value (μg/L)	Ratio (a)	Comment (b)
1,1-Dichloroethane	Jan-99	32.10	32.60	1.02	
	Jul-99	20.70	22.50	1.09	
1,2-Dichloropropane	Jan-99	27.91	27.50	0.99	
	Jul-99	35.70	35.10	0.98	
1,1,2Trichloroethane	Jan-99	24.22	24.60	1.02	
	Jul-99	33.10	32.10	0.97	
1,4-Dichlorobenzene	Jan-99	20.30	21.40	1.05	
	Jul-99	34.70	31.50	0.91	
Tetrachloroethene	Jan-99	31.00	31.50	1.02	
	Jul-99	20.00	21.70	1.09	
Trichloroethene	Jan-99	17.50	18.00	1.03	
	Jul-99	36.00	38.60	1.07	
Benzene	Jan-99	13.90	14.40	1.04	
	Jul-99	26.80	29.10	1.09	
Bromoform	Jan-99	20.53	20.10	0.98	
Carbon tetrachloride	Jan-99	24.93	25.50	1.02	
	Jul-99	42.30	51.30	1.21	
Chlorobenzene	Jan-99	32.09	32.80	1.02	
	Jul-99	39.30	38.50	0.98	
Chloromethane	Jan-99	28.43	28.20	0.99	
	Jul-99	56.00	48.20	0.86	
Ethyl benzene	Jan-99	21.10	21.60	1.02	
	Jul-99	15.40	15.90	1.03	
Methylene chloride	Jan-99	39.08	40.80	1.04	
	Jul-99	15.20	16.20	1.07	
PCB-1016	Jan-99	8.59	9.66	1.13	
	Jul-99	6.11	7.58	1.24	
PCB-1254	Jan-99	5.46	5.45	1.00	
	Jul-99	2.52	3.57	1.42	
Toluene	Jan-99	24.70	25.10	1.02	
	Jul-99	32.90	31.20	0.95	
trans-1,3-Dichloropropene	Jan-99	19.91	20.70	1.04	
	Jul-99	22.60	27.00	1.19	
Vinyl chloride	Jan-99	53.25	53.10	1.00	
	Jul-99	29.80	27.80	0.93	
Total Xylenes	Jan-99	15.80	16.20	1.03	
	Jul-99	20.50	21.40	1.04	
Nitrate (as N)	Jul-99	14.80	14.70	0.99	
Chloride	Jul-99	180.00	169.00	0.94	
Sulfate (as SO4)	Jul-99	25.10	25.60	1.02	
Aluminum	Jul-99	600.00	652.00	1.09	
Antimony	Jul-99	284.00	305.00	1.07	
Arsenic	Jul-99	402.00	313.00	0.78	Unsatisfactory
Barium	Jul-99	2,197.99	2,386.00	1.09	
Copper	Jul-99	602.00	569.00	0.95	
Iron	Jul-99	192.00	193.00	1.01	
Lead	Jul-99	130.00	140.00	1.08	
Manganese	Jul-99	401.00	384.00	0.96	
Mercury	Jul-99	12.50	13.00	1.04	
Molybdenum	Jul-99	188.00	207.00	1.10	Marginal
Nickel	Jul-99	302.00	273.00	0.90	Marginal
Selenium	Jul-99	243.00	185.00	0.76	Unsatisfactory
Silver	Jul-99	100.00	103.00	1.03	
Sodium	Jul-99	35.70	36.40	1.02	
Thallium	Jul-99	197.00	212.00	1.08	
Vanadium	Jul-99	499.00	529.00	1.06	
Zinc	Jul-99	181.00	121.00	0.67	Unsatisfactory

Notes:
(a) The Ratio is the lab result divided by the target value result.
(b) Comment column provides ELAP evaluation of analytical performance, which is based on 95 and 99% confidence intervals about the target value.
No comment indicates performance within acceptable limits.

Table F-8. GEL Non-Potable Water Chemistry Proficiency Test #203 and #213 Results Environmental Laboratory Approval Program (ELAP).

Analyte	Date	ELAP Reported Value (µg/L)	BNL Reported Value (µg/L)	Ratio (a)	Comment (b)
Demand					
Chemical oxygen demand	Jan-99	89.90	94.70	1.05	
	Jul-99	58.80	77.20	1.31	Unsatisfactory
Organic carbon, Total	Jan-99	36.00	37.60	1.04	
	Jul-99	24.10	25.80	1.07	
Residue					
Solids, Total	Jan-99	307.80	301.00	0.98	
	Jul-99	260.00	260.80	1.00	
Solids, Total Disolved	Jan-99	264.00	263.00	1.00	
	Jul-99	240.00	249.00	1.04	
Solids, Total Suspended	Jan-99	39.90	43.00	1.08	
	Jul-99	18.30	19.80	1.08	
Hydrogen ion, (pH)	Jan-99	7.06	7.03	1.00	
	Jul-99	6.00	5.93	0.99	
Kjeldahl nitrogen, Total	Jan-99	4.25	3.90	0.92	
	Jul-99	14.70	13.50	0.92	
Phosphorus, Total	Jan-99	8.16	8.07	0.99	
	Jul-99	1.56	1.51	0.97	
Hardness, Total	Jan-99	159.00	152.00	0.96	
	Jul-99	90.20	81.70	0.91	
Alkalinity	Jan-99	254.00	151.00	0.59	Unsatisfactory
	Jul-99	94.60	98.30	1.04	
Inorganic Nutrients					
Ammonia (as N)	Jan-99	2.90	2.46	0.85	Marginal
	Jul-99	7.98	7.90	0.99	
Nitrate as (as N)	Jan-99	4.44	4.26	0.96	
	Jul-99	14.80	14.20	0.96	
Orthophosphate as P	Jan-99	3.23	3.17	0.98	
	Jul-99	0.91	0.79	0.86	
Waste Water Minerals					
Chloride	Jan-99	259.00	247.00	0.95	
	Jul-99	180.00	170.00	0.94	
Fluoride	Jan-99	3.50	3.27	0.93	Unsatisfactory
	Jul-99	0.75	0.70	0.93	
Sulfate	Jan-99	220.00	209.00	0.95	
	Jul-99	25.10	24.50	0.98	
Phenols	Jan-99	0.18	0.10	0.57	Unsatisfactory
	Jul-99	0.66	0.36	0.54	Unsatisfactory
Oil&Grease Recovery	Jan-99	136.00	144.00	1.06	
	Jul-99	27.40	30.20	1.10	
1,1-Dichloroethane	Jan-99	32.10	32.80	1.02	
	Jul-99	20.70	20.30	0.98	
1,2-Dichloropropane	Jan-99	27.91	26.80	0.96	
	Jul-99	35.70	32.30	0.90	
1,1,2-Trichloroethane	Jan-99	24.22	23.80	0.98	
	Jul-99	33.10	29.50	0.89	
1,4-Dichlorobenzene	Jan-99	20.30	22.70	1.12	
	Jul-99	34.70	32.20	0.93	
Trichloroethene	Jan-99	17.50	18.20	1.04	
	Jul-99	36.00	36.40	1.01	
Benzene	Jul-99	13.90	14.90	1.07	
	Jul-99	26.80	26.20	0.98	
Bromoform	Jan-99	20.50	22.50	1.10	
Carbon tetrachloride	Jan-99	24.93	27.30	1.10	
	Jul-99	42.30	50.60	1.20	

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Table F-8. GEL Non-Potable Water Chemistry Proficiency Test #203 and #213 Results Environmental Laboratory Approval Program (ELAP) ***(continued).***

Analyte	Date	ELAP Reported Value (μg/L)	BNL Reported Value (μg/L)	Ratio (a)	Comment (b)
Chlorobenzene	Jan-99	32.09	34.00	1.06	
	Jul-99	39.30	36.90	0.94	
Chloromethane	Jan-99	28.43	25.70	0.90	
	Jul-99	56.00	52.20	0.93	
Ethyl benzene	Jan-99	21.10	21.90	1.04	
	Jul-99	15.40	14.20	0.92	
Methylene chloride	Jan-99	39.08	41.00	1.05	
	Jul-99	15.20	14.90	0.98	
PCB-1016	Jan-99	8.59	9.50	1.11	
	Jul-99	6.11	4.40	0.72	
PCB-1254	Jan-99	5.46	5.70	1.04	
	Jul-99	2.52	2.50	0.99	
Toluene	Jan-99	24.70	26.00	1.05	
	Jul-99	32.90	31.00	0.94	
trans-1,3-Dichloropropene	Jan-99	19.91	20.20	1.01	
	Jul-99	22.60	23.60	1.04	
Vinyl chloride	Jan-99	53.25	53.90	1.01	
	Jul-99	29.80	30.80	1.03	
Total Xylenes	Jan-99	15.80	16.80	1.06	
	Jul-99	20.50	18.50	0.90	
Waste Water Metals I & II					
Aluminum	Jan-99	217.00	215.00	0.99	
	Jul-99	600.00	535.00	0.89	
Antimony	Jan-99	689.00	463.00	0.67	
	Jul-99	284.00	270.00	0.95	
Aresenic	Jan-99	229.00	210.00	0.92	
	Jul-99	402.00	374.00	0.93	
Barium	Jan-99	1660.00	1620.00	0.98	
	Jul-99	2200.00	2100.00	0.95	
Beryllium	Jan-99	139.00	138.00	0.99	
	Jul-99	108.00	102.00	0.94	
Cadmium	Jan-99	41.20	41.30	1.00	
	Jul-99	169.00	162.00	0.96	
Calcium	Jan-99	25.80	25.20	0.98	
	Jul-99	20.30	18.60	0.92	
Chromium	Jan-99	166.00	165.00	0.99	
	Jul-99	300.00	284.00	0.95	
Cobalt	Jan-99	412.00	419.00	1.02	Marginal
	Jul-99	160.00	152.00	0.95	
Copper	Jan-99	324.00	322.00	0.99	
	Jul-99	602.00	562.00	0.93	
Iron	Jan-99	289.00	290.00	1.00	
	Jul-99	192.00	180.00	0.94	
Manganese	Jan-99	166.00	163.00	0.98	
	Jul-99	401.00	367.00	0.92	
Nickel	Jan-99	157.00	160.00	1.02	
	Jul-99	302.00	288.00	0.95	
Potassium	Jan-99	8.62	8.66	1.00	
	Jul-99	5.03	5.07	1.01	
Selenium	Jan-99	149.00	143.00	0.96	
	Jul-99	243.00	246.00	1.01	
Silver	Jan-99	261.00	259.00	0.99	
	Jul-99	100.00	98.20	0.98	
Sodium	Jan-99	83.90	82.40	0.98	
	Jul-99	35.70	34.60	0.97	

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Table F-8. GEL Non-Potable Water Chemistry Proficiency Test #203 and #213 Results Environmental Laboratory Approval Program (ELAP) *(continued)*.

Analyte	Date	ELAP Reported Value (µg/L)	BNL Reported Value (µg/L)	Ratio (a)	Comment (b)
Thallium	Jan-99	639.00	659.00	1.03	
	Jul-99	197.00	208.00	1.06	
Vanadium	Jan-99	664.00	662.00	1.00	
	Jul-99	499.00	477.00	0.96	
Zinc	Jan-99	1260.00	1270.00	1.01	
	Jul-99	181.00	178.00	0.98	
Mercury	Jan-99	5.27	4.99	0.95	
	Jul-99	2.50	12.20	0.98	
Cyanide	Jan-99	7.77	7.79	1.00	
	Jul-99	0.50	0.46	0.92	
Molybdenum	Jan-99	828.00	829.00	1.00	
	Jul-99	188.00	176.00	0.94	
Tin	Jan-99	2080.00	2070.00	1.00	
	Jul-99	1870.00	1750.00	0.94	
Nitrosamines					
N-Nitrosodimethylamine	Jan-99	30.80	15.80	0.51	
	Jul-99	13.20	7.60	0.58	
N-Nitrosodiphenylamine	Jan-99	32.00	34.10	1.07	
	Jul-99	39.70	34.10	0.86	
N-Nitrosodi-n-propylamine	Jan-99	53.10	55.60	1.05	
	Jul-99	19.00	20.20	1.06	
Benzidines					
Benzidine	Jan-99	67.80	32.40	0.48	
	Jul-99	91.80	128.00	1.39	
3,3-dichloropenzidine	Jan-99	72.70	90.60	1.25	
	Jul-99	48.20	57.90	1.20	
Chlorinated Hydrocarbons					
2-Chloronaphthalene	Jan-99	60.50	60.40	1.00	
	Jul-99	38.80	41.10	1.06	
Hexachlorobenzene	Jan-99	58.00	59.70	1.03	
	Jul-99	52.10	58.20	1.12	
Hexachlorobutadiene	Jan-99	91.10	94.20	1.03	
	Jul-99	103.00	140.00	1.36	
Hexachloroethane	Jan-99	37.20	38.90	1.05	
	Jul-99	49.40	60.30	1.22	
Hexachlorocyclopentadiene	Jan-99	114.00	137.00	1.20	
	Jul-99	110.00	118.00	1.07	
1,2,4-Trichlorbenzene	Jan-99	88.50	87.00	0.98	
	Jul-99	79.30	97.00	1.22	
	Jul-99	83.80	99.30	1.18	
Diethyl phthalate	Jan-99	94.70	98.80	1.04	
	Jul-99	77.00	86.10	1.12	
Dimethyl phthalate	Jan-99	79.00	79.10	1.00	
	Jul-99	70.30	79.70	1.13	
Di-n-butlyl phthalate	Jan-99	96.60	73.10	0.76	
	Jul-99	68.10	63.80	0.94	
Di-n-octyl phthalate	Jan-99	87.80	85.70	0.98	
	Jul-99	63.60	103.00	1.62	Unsatisfactory
Nitroaromatics & Isophorone					
2,4-Dinitrotoluene	Jan-99	45.90	51.90	1.13	
	Jul-99	67.50	78.40	1.16	
2,6-Dinitrotoluene	Jan-99	51.10	50.20	0.98	
	Jul-99	43.10	48.10	1.12	
Isophorone	Jan-99	34.10	31.90	0.94	
	Jul-99	42.50	42.50	1.00	
Nitrobenzene	Jan-99	46.40	43.40	0.94	
	Jul-99	33.30	34.30	1.03	

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Table F-8. GEL Non-Potable Water Chemistry Proficiency Test #203 and #213 Results Environmental Laboratory Approval Program (ELAP) ***(continued).***

Analyte	Date	ELAP Reported Value (μg/L)	BNL Reported Value (μg/L)	Ratio (a)	Comment (b)
Polynuclear Aromatic Hydrocarbons					
Acenaphthylene	Jan-99	34.30	36.30	1.06	
	Jul-99	48.30	51.60	1.07	
Benzo(ghi)perylene	Jan-99	42.20	44.60	1.06	
	Jul-99	23.30	17.40	0.75	
Benzo(k)fluoranthene	Jan-99	48.20	50.60	1.05	
	Jul-99	35.20	39.70	1.13	
Chrysene	Jan-99	38.60	25.60	0.66	Marginal
	Jul-99	31.10	32.50	1.05	
Dibenzo(a,h)anthracene	Jan-99	45.20	50.00	1.11	
	Jul-99	36.20	27.90	0.77	
Fluorene	Jan-99	60.90	61.80	1.01	
	Jul-99	46.90	53.40	1.14	
Naphalene	Jan-99	42.80	44.50	1.04	
	Jul-99	54.00	60.50	1.12	
Phenanthrene	Jan-99	57.90	58.00	1.00	
	Jul-99	45.60	46.30	1.02	
Priority Pollutant Phenols					
4-Chloro-3-methylphenol	Jan-99	93.10	97.00	1.04	
	Jul-99	75.40	89.90	1.19	
2-Chlorophenol	Jan-99	89.80	85.70	0.95	
	Jul-99	83.10	96.30	1.16	
2,4-Dichlorophenol	Jan-99	82.90	88.10	1.06	
	Jul-99	66.40	79.00	1.19	
2,4-Dimethylphenol	Jan-99	78.80	85.10	1.08	
	Jul-99	93.20	116.00	1.24	
2,4-Dinitrophenol	Jan-99	65.60	82.60	1.26	
	Jul-99	86.40	119.00	1.38	
2-Methyl-4,6-dinitrophenol	Jan-99	105.00	110.00	1.05	
	Jul-99	94.60	134.00	1.42	
2-Nitrophenol	Jan-99	86.70	92.00	1.06	
	Jul-99	75.60	102.00	1.35	
4-Nitrophenol	Jan-99	60.00	53.30	0.89	
	Jul-99	53.20	41.50	0.78	
2,4,5-Trichlorophenol	Jan-99	80.00	80.60	1.01	
	Jul-99	75.50	94.40	1.25	
2,4,6-Trichlorophenol	Jan-99	91.70	92.30	1.01	
	Jul-99	66.80	75.70	1.13	
Haloethers					
Bis(2-chloroethyl)ether	Jan-99	81.60	72.60	0.89	
	Jul-99	60.90	69.30	1.14	
Bis(2-chloroisopropyl)ether	Jan-99	86.60	75.50	0.87	
	Jul-99	88.30	83.80	0.95	
Bis(2-chloroethoxy)methane	Jan-99	77.80	77.50	1.00	
	Jul-99	73.90	82.50	1.12	
4-Bromophenyphenyl ether	Jan-99	101.00	92.30	0.91	
	Jul-99	73.80	86.90	1.18	
4-Chlorophenyphenyl ether	Jan-99	73.70	73.20	0.99	
	Jul-99	75.00	89.50	1.19	
Chlordane	Jan-99	51.20	39.00	0.76	
	Jul-99	4.72	4.30	0.91	
Chlorinate Hydrocarbon Pesticides					
alpha-BHC	Jan-99	4.67	4.70	1.01	
	Jul-99	1.31	1.25	0.95	
Lindane	Jan-99	2.83	2.80	0.99	
	Jul-99	1.65	1.57	0.95	

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Table F-8. GEL Non-Potable Water Chemistry Proficiency Test #203 and #213 Results Environmental Laboratory Approval Program (ELAP) *(continued)*.

Analyte	Date	ELAP Reported Value (μg/L)	BNL Reported Value (μg/L)	Ratio (a)	Comment (b)
Dieldrin	Jan-99	3.72	3.61	0.97	
	Jul-99	1.95	1.91	0.98	
4,4'-DDD	Jan-99	4.17	4.65	1.12	
	Jul-99	1.41	1.37	0.97	
Endosulfan I	Jan-99	5.64	6.15	1.09	
	Jul-99	2.65	2.58	0.97	
Endosulfan sulfate	Jan-99	6.22	7.08	1.14	
	Jul-99	2.48	3.44	1.39	
Endin aldehyde	Jan-99	5.07	5.33	1.05	
	Jul-99	3.02	2.99	0.99	
Heptachlor epoxide	Jan-99	1.98	1.75	0.88	
	Jul-99	0.89	0.92	1.03	
Chlorophenox Acid Herbicides					
Dicamba	Jan-99	6.22	5.40	0.87	
	Jul-99	8.27	7.99	0.97	
2,4-D	Jan-99	9.80	9.17	0.94	
	Jul-99	1.95	1.83	0.94	
2,4,5-T	Jan-99	2.50	2.43	0.97	
	Jul-99	3.93	4.02	1.02	
2,4,5-TP (Silvex)	Jan-99	4.16	4.03	0.97	
	Jul-99	5.82	5.60	0.96	
Solid Waste					
Lead in Paint	Jan-99	5.80	6.49	1.12	
	Jul-99	8.35	8.41	1.01	
Solid Waste Metals					
Antimony	Jan-99	95.70	88.20	0.92	
	Jul-99	483.00	402.00	0.83	
Arsenic	Jan-99	180.00	192.00	1.07	
	Jul-99	109.00	112.00	1.03	
Barium	Jan-99	272.00	272.00	1.00	
	Jul-99	361.00	349.00	0.97	
Cadmium	Jan-99	22.00	22.40	1.02	
	Jul-99	57.70	61.90	1.07	
Chromium	Jan-99	104.00	72.80	0.70	
	Jul-99	83.10	65.20	0.78	
Lead	Jan-99	347.00	516.00	1.49	Unsatisfactory
	Jul-99	624.00	611.00	0.98	
Nickel	Jan-99	646.00	693.00	1.07	
	Jul-99	1990.00	2000.00	1.01	
Selenium	Jan-99	40.90	40.80	1.00	
	Jul-99	21.70	22.10	1.02	
Silver	Jan-99	30.80	33.10	1.07	
	Jul-99	51.20	63.40	1.24	
Solid Waste Chlorinated Hydrocarbons					
2-Chloronaphthalen	Jan-99	29.70	25.80	0.87	
	Jul-99	43.80	52.40	1.20	
Hexachlorobenzene	Jan-99	71.40	64.60	0.90	
	Jul-99	52.70	58.00	1.10	
Hexachlorobutadien	Jan-99	70.70	63.00	0.89	
	Jul-99	123.00	166.00	1.35	
Hexachloroethane	Jan-99	32.90	33.60	1.02	
	Jul-99	29.40	40.30	1.37	
Hexacholorocyclopen	Jan-99	15.00	12.60	0.84	
	Jul-99	3.87	2.65	0.68	
1,2,4-Trichlorobenzene	Jan-99	84.30	73.00	0.87	
	Jul-99	132.00	178.00	1.35	

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Table F-8. GEL Non-Potable Water Chemistry Proficiency Test #203 and #213 Results Environmental Laboratory Approval Program (ELAP) ***(continued)*****.**

Analyte	Date	ELAP Reported Value (μg/L)	BNL Reported Value (μg/L)	Ratio (a)	Comment (b)
Solid Waste Phthalate Esters					
Benzyl butyl phthalate	Jan-99	106.00	114.00	1.08	
	Jul-99	142.00	177.00	1.25	
Bis(2-ethyl hexyl)	Jan-99	93.00	94.40	1.02	
	Jul-99	153.00	188.00	1.23	
Diethyl phthalate	Jan-99	78.80	87.00	1.10	
	Jul-99	134.00	166.00	1.24	
Dimethyl phthalate	Jan-99	69.50	78.90	1.14	
	Jul-99	117.00	141.00	1.21	
Di-n-butyl phthalate	Jan-99	78.00	80.40	1.03	
	Jul-99	107.00	126.00	1.18	
Di-n-octyl phthalate	Jan-99	87.40	85.00	0.97	
	Jul-99	124.00	130.00	1.05	
Solid Waste Nitroaromatic & Isophorone					
2,4-Dinitrotoluene	Jan-99	55.20	58.50	1.06	
	Jul-99	57.50	67.90	1.18	
2,6-Dinitrotoluene	Jan-99	37.20	40.10	1.08	
	Jul-99	61.30	72.50	1.18	
Isophorone	Jan-99	62.10	59.40	0.96	
	Jul-99	85.00	99.50	1.17	
Nitrobenzene	Jan-99	50.50	47.60	0.94	
	Jul-99	80.10	93.30	1.16	
Acenaphthene	Jan-99	26.60	24.30	0.91	
	Jul-99	8.12	9.08	1.12	
Anthracene	Jan-99	43.80	45.20	1.03	
	Jul-99	38.90	43.90	1.13	
Benzo(a)anthracene	Jan-99	57.10	60.00	1.05	
	Jul-99	68.00	75.60	1.11	
Benzo(a)pyrene	Jan-99	25.00	28.40	1.14	
	Jul-99	50.10	58.50	1.17	
Benzo(b)fluoranthe	Jan-99	55.20	47.10	0.85	
	Jul-99	52.70	61.20	1.16	
Fluoranthene	Jan-99	64.40	61.90	0.96	
	Jul-99	51.10	57.50	1.13	
Indeno(1,2,3-cd)py	Jan-99	45.20	42.10	0.93	
	Jul-99	39.10	33.30	0.85	
Pyrene	Jan-99	42.80	42.00	0.98	
	Jul-99	64.40	75.80	1.18	
Solid Waste Priority Pollutant Phenols					
4-Chloro-3-methyl phenol	Jan-99	87.20	110.00	1.26	
	Jul-99	107.00	138.00	1.29	
2-Chlorophenol	Jan-99	96.80	88.40	0.91	
	Jul-99	130.00	162.00	1.25	
2,4-Dichlorophenol	Jan-99	69.70	69.30	0.99	
	Jul-99	81.10	102.00	1.26	
2,4-Dimethylphenol	Jan-99	44.30	50.60	1.14	
	Jul-99	63.50	78.80	1.24	
2,4-Dintrophenol	Jan-99	29.90	48.50	1.62	
	Jul-99	44.10	69.20	1.57	
2-Methyl-4,6-dinit	Jan-99	63.90	71.50	1.12	
	Jul-99	86.00	94.10	1.09	
2-Nitrophenol	Jan-99	54.40	51.30	0.94	
	Jul-99	76.00	99.40	1.31	
4-Nitrophenol	Jan-99	54.30	61.30	1.13	
	Jul-99	68.10	102.00	1.50	

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Table F-8. GEL Non-Potable Water Chemistry Proficiency Test #203 and #213 Results Environmental Laboratory Approval Program (ELAP) *(concluded)*.

Analyte	Date	ELAP Reported Value (µg/L)	BNL Reported Value (µg/L)	Ratio (a)	Comment (b)
Pentachlorophenol	Jan-99	85.70	99.40	1.16	
	Jul-99	90.60	112.00	1.24	
Phenol	Jan-99	72.90	62.00	0.85	
	Jul-99	73.70	83.30	1.13	
2,4,6-Trichlorophenol	Jan-99	87.90	103.00	1.17	
	Jul-99	108.00	140.00	1.30	
Solid Waste Haloethers					
Bis(2-chlorisopr	Jan-99	90.40	88.60	0.98	
	Jul-99	88.30	110.00	1.25	
Bis(2-chloroethoxy	Jan-99	91.80	81.90	0.89	
	Jul-99	132.00	166.00	1.26	
Solid Waste Polychlorinate Biphenyls					
PCB-1016	Jan-99	blank	lt. 6.25	1.00	
PCB-1221	Jan-99	blank	lt. 6.25	1.00	
PCB-1232	Jan-99	blank	lt. 6.25	1.00	
PCB-1242	Jan-99	blank	lt. 6.25	1.00	
	Jul-99	84.90	85.30	1.00	
PCB-1248	Jan-99	56.80	66.10	1.16	
PCB-1254	Jan-99	blank	lt. 6.25	1.00	
PCB-1260	Jan-99	blank	lt. 6.25	1.00	
Solid Waste Chlorinate Hydrocarbon Pesticides					
Aldrin	Jan-99	2.72	3.69	1.36	
	Jul-99	0.76	0.80	1.05	
beta-BHC	Jan-99	7.23	9.89	1.37	
	Jul-99	2.47	2.50	1.01	
delta-BHC	Jan-99	2.71	3.79	1.40	
	Jul-99	3.41	3.52	1.03	
4,4'-DDE	Jan-99	4.14	6.57	1.59	
	Jul-99	1.77	1.96	1.11	
4,4'-DDT	Jan-99	2.90	3.94	1.36	
	Jul-99	1.79	2.01	1.12	
Endosulfan II	Jan-99	0.32	0.42	1.31	
	Jul-99	1.39	1.46	1.05	
Endrin	Jan-99	2.22	3.09	1.39	
	Jul-99	1.32	1.36	1.03	
Heptachlor	Jan-99	1.97	2.46	1.25	
	Jul-99	2.44	2.42	0.99	
Solid Waste Chlorophenoxy Acid Pesticides					
Dicamba	Jan-99	5.40	5.42	1.00	
	Jul-99	10.70	15.40	1.44	
2,4-D	Jan-99	9.96	10.90	1.09	
	Jul-99	7.47	11.80	1.58	
2,4,5-T	Jan-99	17.00	18.70	1.10	
	Jul-99	9.04	11.80	1.31	
2,4,5-TP (Silvex)	Jan-99	14.60	14.80	1.01	
	Jul-99	7.26	8.67	1.19	

Notes:
(a) The Ratio is the lab result divided by the target value result
(b) Comment column provides ELAP evaluation of analytical performance, which is based on 95 and 99% confidence intervals about the target value. No comment indicates performance within acceptable limits.

Table F-9. H2M Non-Potable Water Chemistry Proficiency Test #203 and #213 Results Environmental Laboratory Approval Program (ELAP).

Analyte	Date	ELAP Reported Value (μg/L)	BNL Reported Value (μg/L)	Ratio (a)	Comment (b)
Demand					
Biochem oxygen demand	Jan-99	57.70	48.00	0.83	
	Jul-99	38.10	44.00	1.15	
Chemical oxygen demand	Jan-99	89.90	90.20	1.00	
	Jul-99	58.80	58.40	0.99	
Organic carbon, Total	Jan-99	36.00	33.50	0.93	
	Jul-99	24.10	24.10	1.00	
Residue					
Solids, Total	Jan-99	307.80	288.00	0.94	
	Jul-99	260.00	267.00	1.03	
Solids, Total Disolved	Jan-99	264.00	278.00	1.05	
	Jul-99	240.00	253.00	1.05	
Solids, Total suspended	Jan-99	39.90	36.00	0.90	Marginal
	Jul-99	18.30	19.00	1.04	
Hydrogen ion, (pH)	Jan-99	7.06	7.14	1.01	Marginal
	Jul-99	6.00	6.04	1.01	
Kjeldahl nitrogen, Total	Jan-99	4.25	3.71	0.87	
	Jul-99	14.70	13.69	0.93	
Phosphorus, Total	Jan-99	8.16	7.73	0.95	
	Jul-99	1.56	1.62	1.04	
Hardness, Total	Jan-99	159.00	166.00	1.04	
	Jul-99	90.20	88.80	0.98	
Alkalinity	Jan-99	254.00	258.00	1.02	
	Jul-99	94.60	94.60	1.00	
NW 1,4 Dichlorobenzene	Jan-99	15.66	15.30	0.98	
Inorganic Nutrients					
Ammonia (as N)	Jan-99	2.90	2.85	0.98	
	Jul-99	7.98	7.62	0.95	
Nitrate as (as N)	Jan-99	4.44	4.23	0.95	
	Jul-99	14.80	14.70	0.99	
Orthophosphate as P	Jan-99	3.23	3.01	0.93	
	Jul-99	0.91	0.97	1.06	
Waste Water Minerals					
Chloride	Jan-99	259.00	260.00	1.00	
	Jul-99	180.00	187.00	1.04	
Fluoride	Jan-99	3.50	4.85	1.39	Unsatisfactory
Jul-99	0.75	0.70	0.93		
Sulfate	Jan-99	220.00	258.00	1.17	
	Jul-99	25.10	24.80	0.99	
Phenols	Jan-99	0.18	0.20	1.13	
	Jul-99	0.66	0.44	0.67	
Oil & Grease Recovery	Jan-99	136.00	173.00	1.27	Unsatisfactory
	Jul-99	27.40	30.00	1.09	
1,1-Dichloroethane	Jan-99	32.10	30.00	0.93	
	Jul-99	20.70	20.20	0.98	
1,2-Dichloropropane	Jan-99	27.91	26.20	0.94	
	Jul-99	35.70	35.90	1.01	
1,1,2-Trichloroethane	Jan-99	24.22	22.90	0.95	
	Jul-99	33.10	32.40	0.98	
1,4-Dichlorobenzene	Jan-99	20.30	15.30	0.75	
	Jul-99	34.70	16.50	0.48	Unsatisfactory
	Jul-99	23.75	16.50	0.69	
Tetrachloroethene	Jan-99	31.00	27.70	0.89	
	Jul-99	20.00	19.50	0.98	
Trichloroethene	Jan-99	17.50	16.10	0.92	
	Jul-99	36.00	35.70	0.99	

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Table F-9. H2M Non-Potable Water Chemistry Proficiency Test #203 and #213 Results Environmental Laboratory Approval Program (ELAP) *(continued)*.

Analyte	Date	ELAP Reported Value (μg/L)	BNL Reported Value (μg/L)	Ratio (a)	Comment (b)
Benzene	Jul-99	13.90	13.50	0.97	
	Jul-99	26.80	27.40	1.02	
Bromoform	Jan-99	20.50	16.70	0.81	
Carbon tetrachloride	Jan-99	24.93	22.60	0.91	
	Jul-99	42.30	50.00	1.18	
Chlorobenzene	Jan-99	32.09	31.30	0.98	
	Jul-99	39.30	40.00	1.02	
Chloromethane	Jan-99	28.43	29.80	1.05	
	Jul-99	56.00	60.50	1.08	
Ethyl benzene	Jan-99	21.10	21.40	1.01	
	Jul-99	15.40	15.00	0.97	
Methylene chloride	Jan-99	39.08	37.50	0.96	
	Jul-99	15.20	15.20	1.00	
PCB-1016	Jan-99	8.59	7.22	0.84	
	Jul-99	6.11	5.86	0.96	
PCB-1254	Jan-99	5.46	5.48	1.00	
	Jul-99	2.52	2.42	0.96	
Toluene	Jan-99	24.70	24.30	0.98	
	Jul-99	32.90	34.00	1.03	
trans-1,3-Dichloropropene	Jan-99	19.91	16.10	0.81	
	Jul-99	22.60	25.00	1.11	
Vinyl chloride	Jan-99	53.25	49.80	0.94	
	Jul-99	29.80	28.40	0.95	
Total Xylenes	Jan-99	15.80	15.10	0.96	
	Jul-99	20.50	20.90	1.02	
Waste Water Metals I & II					
Aluminum	Jan-99	217.00	236.00	1.09	
	Jul-99	600.00	603.00	1.01	
Antimony	Jan-99	689.00	908.00	1.32	
	Jul-99	284.00	274.00	0.96	
Aresenic	Jan-99	229.00	230.00	1.00	
	Jul-99	402.00	361.00	0.90	
Barium	Jan-99	1660.00	1580.00	0.95	
	Jul-99	2200.00	2120.00	0.96	
Beryllium	Jan-99	139.00	131.00	0.94	
	Jul-99	108.00	104.00	0.96	
Cadmium	Jan-99	41.20	37.70	0.92	
	Jul-99	169.00	157.00	0.93	
Calcium	Jan-99	25.80	25.00	0.97	
	Jul-99	20.30	18.20	0.90	
Chromium	Jan-99	166.00	153.00	0.92	
	Jul-99	300.00	282.00	0.94	
Cobalt	Jan-99	412.00	376.00	0.91	Marginal
	Jul-99	160.00	149.00	0.93	
Lead	Jan-99	235.00	239.00	1.02	
	Jul-99	130.00	128.00	0.98	
Magnesium	Jan-99	10.40	9.77	0.94	
	Jul-99	13.00	11.00	0.85	Unsatisfactory
Manganese	Jan-99	166.00	154.00	0.93	
	Jul-99	401.00	375.00	0.94	
Nickel	Jan-99	157.00	143.00	0.91	
	Jul-99	302.00	279.00	0.92	
Potassium	Jan-99	8.62	9.54	1.11	
	Jul-99	5.03	4.41	0.88	
Selenium	Jan-99	149.00	142.00	0.95	
	Jul-99	243.00	234.00	0.96	

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Table F-9. H2M Non-Potable Water Chemistry Proficiency Test #203 and #213 Results Environmental Laboratory Approval Program (ELAP) ***(continued).***

Analyte	Date	ELAP Reported Value (μg/L)	H2M Reported Value (μg/L)	Ratio (a)	Comment (b)
Silver	Jan-99	261.00	252.00	0.97	
	Jul-99	100.00	95.30	0.95	
Sodium	Jan-99	83.90	73.90	0.88	
	Jul-99	35.70	30.90	0.87	
Thallium	Jan-99	639.00	621.00	0.97	
	Jul-99	197.00	195.00	0.99	
Vanadium	Jan-99	664.00	612.00	0.92	
	Jul-99	499.00	477.00	0.96	
Zinc	Jan-99	1260.00	1140.00	0.90	
	Jul-99	181.00	179.00	0.99	
Mercury	Jan-99	5.27	5.12	0.97	
	Jul-99	12.50	12.90	1.03	
Cyanide	Jan-99	7.77	10.60	1.36	Unsatisfactory
	Jul-99	0.50	0.51	1.01	
Molybdenum	Jan-99	828.00	864.00	1.04	
	Jul-99	188.00	185.00	0.98	
Tin	Jan-99	2080.00	2120.00	1.02	
	Jul-99	1870.00	1680.00	0.90	
Titanium	Jan-99	552.00	570.00	1.03	
	Jul-99	124.00	127.00	1.02	
Organic Phosphate Pesticides					
Azinphos Methyl	Jan-99	7.28	9.26	1.27	
	Jul-99	6.04	6.31	1.04	
Diazinon	Jan-99	14.80	16.70	1.13	
	Jul-99	8.81	8.49	0.96	
Disulfoton	Jan-99	10.70	10.90	1.02	
	Jul-99	10.00	9.97	1.00	
Malathion	Jan-99	9.38	12.80	1.36	
	Jul-99	5.41	6.10	1.13	
Nitrosamines					
N-Nitrosodimethylamine	Jan-99	30.80	66.90	2.17	Unsatisfactory
	Jul-99	13.20	15.20	1.15	
N-Nitrosodiphenylamine	Jan-99	32.00	53.50	1.67	Unsatisfactory
	Jul-99	39.70	41.30	1.04	
N-Nitrosodi-n-propyl.	Jan-99	53.10	114.00	2.15	Unsatisfactory
	Jul-99	19.00	18.50	0.97	
Benzidines					
Benzidine	Jan-99	67.80	146.00	2.15	Marginal
	Jul-99	91.80	79.10	0.86	
Hexachlorobenzene	Jan-99	58.00	57.00	0.98	
	Jul-99	52.10	51.40	0.99	
Hexachlorobutadiene	Jan-99	91.10	104.00	1.14	
	Jul-99	103.00	115.00	1.12	
Hexachloroethane	Jan-99	37.20	35.00	0.94	
	Jul-99	49.40	52.10	1.05	
Hexachlorocyclopentadiene	Jan-99	114.00	148.00	1.30	
	Jul-99	110.00	127.00	1.15	
1,2,4-Trichlorbenzene	Jan-99	88.50	95.70	1.08	
	Jul-99	79.30	79.00	1.00	
Phthalate Esters					
Benzyl butyl phthalate	Jan-99	76.70	78.70	1.03	
	Jul-99	70.20	74.10	1.06	
Bis(2-ethylhexyl) phthalate	Jan-99	103.00	116.00	1.13	
	Jul-99	83.80	83.10	0.99	

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Table F-9. H2M Non-Potable Water Chemistry Proficiency Test #203 and #213 Results Environmental Laboratory Approval Program (ELAP) *(continued)***.**

Analyte	Date	ELAP Reported Value (μg/L)	BNL Reported Value (μg/L)	Ratio (a)	Comment (b)
Diethyl phthalate	Jan-99	94.70	116.00	1.22	
	Jul-99	77.00	82.70	1.13	
Dimethyl phthalate	Jan-99	79.00	92.50	1.17	
	Jul-99	70.30	82.70	1.18	
Di-n-butlyl phthalate	Jan-99	96.60	121.00	1.25	
	Jul-99	68.10	69.20	1.02	
Di-n-octyl phthalate	Jan-99	87.80	103.00	1.17	
	Jul-99	63.60	60.60	0.95	
Nitroaromatic & Isophorone					
2,4-Dinitrotoluene	Jan-99	45.90	42.70	0.93	
	Jul-99	67.50	67.90	1.01	
2,6-Dinitrotoluene	Jan-99	51.10	49.00	0.96	
	Jul-99	43.10	42.90	1.00	
Isophorone	Jan-99	34.10	33.90	0.99	
	Jul-99	42.50	42.60	1.00	
Nitrobenzene	Jan-99	46.40	45.90	0.99	
	Jul-99	33.30	33.40	1.00	
Polynuclear Aromatic Hydrocarbons					
Acenaphthylene	Jan-99	34.30	33.50	0.98	
	Jul-99	48.30	49.00	1.01	
Benzo(ghi)perylene	Jan-99	42.20	42.60	1.01	
	Jul-99	23.30	24.10	1.03	
Benzo(k)fluoranthene	Jan-99	48.20	44.50	0.92	
	Jul-99	35.20	34.90	0.99	
Chrysene	Jan-99	38.60	37.10	0.96	
	Jul-99	31.10	31.00	1.00	
Dibenzo(a,h)anthracene	Jan-99	45.20	44.70	0.99	
	Jul-99	36.20	36.80	1.02	
Fluorene	Jan-99	60.90	63.50	1.04	
	Jul-99	46.90	47.60	1.01	
Naphalene	Jan-99	42.80	42.90	1.00	
	Jul-99	54.00	53.60	0.99	
Phenanthrene	Jan-99	57.90	58.60	1.01	
	Jul-99	45.60	44.90	0.98	
2,4-Dichlorophenol	Jan-99	82.90	90.00	1.09	
	Jul-99	66.40	67.00	1.01	
2,4-Dimethylphenol	Jan-99	78.80	82.70	1.05	
	Jul-99	93.20	98.60	1.06	
2,4-Dinitrophenol	Jan-99	65.60	77.80	1.19	
	Jul-99	86.40	80.00	0.93	
2-Methyl-4,6-dinitrophenol	Jan-99	105.00	115.00	1.10	
	Jul-99	94.60	83.00	0.88	
2-Nitrophenol	Jan-99	86.70	93.80	1.08	
	Jul-99	75.60	75.00	0.99	
4-Nitrophenol	Jan-99	60.00	79.00	1.32	
	Jul-99	53.20	76.10	1.43	
Pentachlorophenol	Jan-99	71.80	75.50	1.05	
	Jul-99	89.70	82.10	0.92	
Phenol	Jan-99	84.50	130.00	1.54	
	Jul-99	61.80	90.10	1.46	
2,4,5-Trichlorophenol	Jan-99	80.00	90.00	1.13	
	Jul-99	75.50	75.70	1.00	
2,4,6-Trichlorophenol	Jan-99	91.70	111.00	1.21	

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Table F-9. H2M Non-Potable Water Chemistry Proficiency Test #203 and #213 Results Environmental Laboratory Approval Program (ELAP) ***(continued)*****.**

Analyte	Date	ELAP Reported Value (μg/L)	BNL Reported Value (μg/L)	Ratio (a)	Comment (b)
Haloethers					
Bis(2-chloroethyl)ether	Jan-99	81.60	94.10	1.15	
	Jul-99	60.90	59.80	0.98	
Bis(2-chloroisopropyl)ether	Jan-99	86.60	76.10	0.88	
	Jul-99	88.30	90.80	1.03	
Bis(2-chloroethoxy)methane	Jan-99	77.80	88.40	1.14	
	Jul-99	73.90	75.70	1.02	
4-Bromophenyphenyl ether	Jan-99	101.00	117.00	1.16	
	Jul-99	73.80	75.80	1.03	
4-Chlorophenyphenyl ether	Jan-99	73.70	76.80	1.04	
	Jul-99	75.00	77.40	1.03	
Chlordane	Jan-99	51.20	63.60	1.24	
	Jul-99	4.72	4.37	0.93	
Chlorinated Hydorcarbon Pesticides					
alpha-BHC	Jan-99	4.67	5.19	1.11	
	Jul-99	1.31	1.22	0.93	
Lindane	Jan-99	2.83	3.11	1.10	
	Jul-99	1.65	1.51	0.92	
Dieldrin	Jan-99	3.72	4.17	1.12	
	Jul-99	1.95	1.86	0.95	
4,4'-DDD	Jan-99	4.17	4.89	1.17	
	Jul-99	1.41	1.37	0.97	
Endosulfan I	Jan-99	5.64	6.44	1.14	
	Jul-99	2.65	2.50	0.94	
Endosulan sulfate	Jan-99	6.22	7.32	1.18	
	Jul-99	2.48	2.67	1.08	
Endin aldehyde	Jan-99	5.07	5.66	1.12	
	Jul-99	3.02	1.99	0.66	
Heptachlor epoxide	Jan-99	1.98	2.05	1.04	
	Jul-99	0.89	0.88	0.99	
	Jul-99	1.95	2.36	1.21	
2,4,5-T	Jan-99	2.50	3.65	1.46	
	Jul-99	3.93	4.72	1.20	
2,4,5-TP (Silvex)	Jan-99	4.16	5.10	1.23	
	Jul-99	5.82	6.22	1.07	
Solid Waste					
Lead in Paint	Jan-99	5.80	5.06	0.87	
	Jul-99	8.35	7.59	0.91	
Solid Waste Metals					
Antimony	Jan-99	95.70	93.70	0.98	
	Jul-99	483.00	515.00	1.07	
Arsenic	Jan-99	180.00	164.00	0.91	
	Jul-99	109.00	103.00	0.94	
Barium	Jan-99	272.00	236.00	0.87	
	Jul-99	361.00	373.00	1.03	
Cadmium	Jan-99	22.00	19.50	0.89	
	Jul-99	57.70	52.20	0.90	
Chromium	Jan-99	104.00	123.00	1.18	
	Jul-99	83.10	114.00	1.37	
Lead	Jan-99	347.00	318.00	0.92	
	Jul-99	624.00	775.00	1.24	
Nickel	Jan-99	646.00	577.00	0.89	
	Jul-99	1990.00	2050.00	1.03	
Selenium	Jan-99	40.90	37.60	0.92	
	Jul-99	21.70	20.30	0.94	

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Table F-9. H2M Non-Potable Water Chemistry Proficiency Test #203, #213 Results Environmental Laboratory Approval Program ***(continued)*****.**

Analyte	Date	ELAP Reported Value (μg/L)	BNL Reported Value (μg/L)	Ratio (a)	Comment (b)
Silver	Jan-99	30.80	26.00	0.84	
	Jul-99	51.20	45.80	0.89	
Solid Waste Organophosphate Pestides					
Azinophos Methyl	Jan-99	23.20	21.00	0.91	
	Jul-99	19.90	13.40	0.67	
Diazinon	Jan-99	3.50	3.12	0.89	
	Jul-99	2.48	1.84	0.74	
Disulfoton	Jan-99	7.46	6.63	0.89	
	Jul-99	18.90	11.70	0.62	
Malathion	Jan-99	13.60	13.50	0.99	
	Jul-99	15.20	13.00	0.86	
Solid Waste Chlorinated Hydrocarbons					
2-Chloronaphthalen	Jan-99	29.70	25.30	0.85	
	Jul-99	43.80	58.90	1.34	
Hexachlorobenzene	Jan-99	71.40	60.30	0.84	
	Jul-99	52.70	68.30	1.30	
Hexachlorobutadien	Jan-99	70.70	62.90	0.89	
	Jul-99	123.00	168.00	1.37	
Hexachloroethane	Jan-99	32.90	31.10	0.95	
	Jul-99	29.40	41.90	1.43	
Hexacholorocyclopen	Jan-99	15.00	15.60	1.04	
	Jul-99	3.87	4.69	1.21	
1,2,4-Trichloroben	Jan-99	84.30	74.20	0.88	
	Jul-99	132.00	173.00	1.31	
Diethyl phthalate	Jan-99	78.80	72.70	0.92	
	Jul-99	134.00	204.00	1.52	
Dimethyl phthalate	Jan-99	69.50	66.20	0.95	
	Jul-99	117.00	174.00	1.49	
Di-n-butyl phthalate	Jan-99	78.00	65.30	0.84	
	Jul-99	107.00	145.00	1.36	
Di-n-octyl phthalate	Jan-99	87.40	66.20	0.76	
	Jul-99	124.00	159.00	1.28	
Solid Waste Nitroaromatic & Isophorone					
2,4-Dinitrotoluene	Jan-99	55.20	56.20	1.02	
	Jul-99	61.30	86.90	1.42	
2,6-Dinitrotoluene	Jan-99	37.20	35.90	0.97	
	Jul-99	57.50	85.60	1.49	
Isophorone	Jan-99	62.10	56.10	0.90	
	Jul-99	85.00	119.00	1.40	
Nitrobenzene	Jan-99	50.50	46.90	0.93	
	Jul-99	80.10	114.00	1.42	
Solid Waste Polynuclear Aromatic Hydrocarbons					
Acenaphthene	Jan-99	26.60	23.50	0.88	
	Jul-99	8.12	10.90	1.34	
Anthracene	Jan-99	43.80	40.40	0.92	
	Jul-99	38.90	50.80	1.31	
Benzo(a)anthracene	Jan-99	57.10	51.30	0.90	
	Jul-99	68.00	89.00	1.31	
Benzo(a)pyrene	Jan-99	25.00	23.80	0.95	
	Jul-99	50.10	63.80	1.27	
Benzo(b)fluoranthe	Jan-99	55.20	52.80	0.96	
	Jul-99	52.70	69.40	1.32	

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Table F-9. H2M Non-Potable Water Chemistry Proficiency Test #203 and #213 Results Environmental Laboratory Approval Program (ELAP) *(continued)*.

Analyte	Date	ELAP Reported Value (μg/L)	BNL Reported Value (μg/L)	Ratio (a)	Comment (b)
Fluoranthene	Jan-99	64.40	59.70	0.93	
	Jul-99	51.10	64.50	1.26	
Indeno(1,2,3-cd)py	Jan-99	45.20	41.10	0.91	
	Jul-99	39.10	50.50	1.29	
Pyrene	Jan-99	42.80	39.00	0.91	
	Jul-99	64.40	86.90	1.35	
Solid Waste Priority Pollutant Phenols					
4-Chloro-3-methyl phenol	Jan-99	87.20	93.10	1.07	
	Jul-99	107.00	178.00	1.66	
2-Chlorophenol	Jan-99	96.80	101.00	1.04	
	Jul-99	130.00	217.00	1.67	
2,4-Dichlorophenol	Jan-99	69.70	74.60	1.07	
	Jul-99	81.10	132.00	1.63	
2,4-Dimethylphenol	Jan-99	44.30	45.10	1.02	
	Jul-99	63.50	99.80	1.57	
2,4-Dintrophenol	Jan-99	29.90	67.70	2.26	
	Jul-99	44.10	101.00	2.29	
2-Methyl-4,6-dinit	Jan-99	63.90	131.00	2.05	Marginal
	Jul-99	86.00	185.00	2.15	
2-Nitrophenol	Jan-99	54.40	61.00	1.12	
	Jul-99	76.00	126.00	1.66	
4-Nitrophenol	Jan-99	54.30	77.90	1.43	
	Jul-99	68.10	157.00	2.31	
Pentachlorophenol	Jan-99	85.70	114.00	1.33	
	Jul-99	90.60	160.00	1.77	
Phenol	Jan-99	72.90	66.20	0.91	
	Jul-99	73.70	118.00	1.60	
2,4,6-Trichlorophenol	Jan-99	87.90	104.00	1.18	
	Jul-99	108.00	183.00	1.69	
Solid Waste Haloethers					
Bis(2-chlorisopr	Jan-99	90.40	65.30	0.72	
	Jul-99	88.30	103.00	1.17	
Bis(2—chloroethoxy	Jan-99	91.80	87.90	0.96	
	Jul-99	132.00	206.00	1.56	
Solid Waste Polychlorinated Biphenyls					
PBC-1016	Jan-99	blank	0.03	1.00	
PBC-1221	Jan-99	blank	0.06	1.00	
PBC-1232	Jan-99	blank	0.03	1.00	
PBC-1242	Jan-99	blank	0.03	1.00	
	Jul-99	84.90	91.50	1.08	
PBC-1248	Jan-99	56.80	51.80	0.91	
PBC-1254	Jan-99	blank	0.03	1.00	
PBC-1260	Jan-99	blank	0.00	1.00	
Solid Waste Chlorinated Hydrocarbon Pesticides					
Aldrin	Jan-99	2.72	2.41	0.89	
	Jul-99	0.76	1.03	1.36	
beta-BHC	Jan-99	7.23	7.06	0.98	
	Jul-99	2.47	3.71	1.50	
delta-BHC	Jan-99	2.71	2.76	1.02	
	Jul-99	3.41	4.94	1.45	
4,4'-DDE	Jan-99	4.14	3.85	0.93	
	Jul-99	1.77	2.56	1.45	

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Table F-9. H2M Non-Potable Water Chemistry Proficiency Test #203 and #213 Results Environmental Laboratory Approval Program (ELAP) *(concluded)*.

Analyte	Date	ELAP Reported Value (µg/L)	BNL Reported Value (µg/L)	Ratio (a)	Comment (b)
4,4'-DDT	Jan-99	2.90	2.93	1.01	
	Jul-99	1.79	2.60	1.45	
Endosulfan II	Jan-99	0.32	0.31	0.96	
	Jul-99	1.39	1.87	1.35	
Endrin	Jan-99	2.22	1.97	0.89	
	Jul-99	1.32	1.95	1.48	
Heptachlor	Jan-99	1.97	1.93	0.98	
	Jul-99	2.44	3.44	1.41	
Solid Waste Chlorophenoxy Acid Pesticides					
Dicamba	Jan-99	5.40	6.15	1.14	
	Jul-99	10.70	16.70	1.56	
2,4-D	Jan-99	9.96	12.60	1.27	
	Jul-99	7.47	13.80	1.85	
2,4,5-T	Jan-99	17.00	24.10	1.42	
	Jul-99	9.04	15.50	1.71	
2,4,5-TP (Silvex)	Jan-99	14.60	15.80	1.08	
	Jul-99	7.26	13.60	1.87	

Notes:
(a) The Ratio is the lab result divided by the target value result.
(b) Comment column provides ELAP evaluation of analytical performance, which is based on 95 and 99% confidence intervals about the target value. No comment indicates performance within acceptable limits.

Table F-10. Severn Trent Non-Potable Water Chemistry Proficiency Test #203 and #213 Results Environmental Laboratory Approval Program (ELAP).

Analyte	Date	ELAP Reported Value (µg/L)	BNL Reported Value (µg/L)	Ratio (a)	Comment (b)
Demand					
Biochm oxygen demand	Jan-99	57.70	63.40	1.10	
	Jul-99	38.10	28.50	0.75	
Chemical oxygen demand	Jan-99	89.90	81.60	0.91	
	Jul-99	58.80	51.90	0.88	
Organic carbon, Total	Jan-99	36.00	35.30	0.98	
	Jul-99	24.10	25.10	1.04	
Residue					
Solids, Total	Jan-99	307.80	320.00	1.04	
	Jul-99	260.00	244.00	0.94	
Solids, Total Disolved	Jan-99	264.00	250.00	0.95	
	Jul-99	240.00	219.00	0.91	
Solids,Total suspended	Jan-99	39.90	30.00	0.75	Not Acceptable
	Jul-99	18.30	19.70	1.08	
Hydrogen ion, (pH)	Jan-99	7.06	6.99	0.99	
	Jul-99	6.00	5.92	0.99	
Kjeldahl nitrogen, Total	Jan-99	4.25	4.33	1.02	
	Jul-99	14.70	14.80	1.01	
Phosphorus, Total	Jan-99	8.16	7.65	0.94	
	Jul-99	1.56	1.69	1.08	
Hardness, Total	Jan-99	159.00	155.00	0.97	
	Jul-99	90.20	88.20	0.98	
Alkalinity	Jan-99	254.00	260.00	1.02	
	Jul-99	94.60	94.80	1.00	
NW 1,4 Dichlorobenzene	Jan-99	15.66	16.60	1.06	
Inorganic Nutrients					
Ammonia (as N)	Jan-99	2.90	2.96	1.02	
	Jul-99	7.98	8.46	1.06	
Nitrate as (as N)	Jan-99	4.44	4.40	0.99	
	Jul-99	14.80	14.10	0.95	
Orthophosphate as P	Jan-99	3.23	3.17	0.98	
	Jul-99	0.91	0.92	1.01	
Waste Water Minerals					
Chloride	Jan-99	259.00	263.00	1.02	
	Jul-99	180.00	181.00	1.01	
Fluoride	Jan-99	3.50	3.10	0.89	
	Jul-99	0.75	0.85	1.13	
Sulfate	Jan-99	220.00	242.00	1.10	
	Jul-99	25.10	21.50	0.86	
Phenols	Jan-99	0.18	0.17	0.99	
	Jul-99	0.66	0.69	1.04	
Oil & Grease Recovery	Jan-99	136.00	141.00	1.04	
	Jul-99	27.40	28.30	1.03	
1,1-Dichloroethane	Jan-99	32.10	32.80	1.02	
	Jul-99	20.70	22.40	1.08	
1,2-Dichloropropane	Jan-99	27.91	27.10	0.97	
	Jul-99	35.70	39.40	1.10	
1,1,2-Trichloroethane	Jan-99	24.22	25.10	1.04	
	Jul-99	33.10	35.90	1.08	
1,4-Dichlorobenzene	Jan-99	20.30	16.60	0.82	
	Jul-99	34.70	25.00	0.72	
	Jul-99	23.75	25.00	1.05	
Tetrachloroethene	Jan-99	31.00	29.50	0.95	
	Jul-99	20.00	19.10	0.96	
Trichloroethene	Jan-99	17.50	17.80	1.02	
	Jul-99	36.00	38.10	1.06	
Benzene	Jul-99	13.90	13.40	0.96	
	Jul-99	26.80	29.30	1.09	
Bromoform	Jan-99	20.50	21.70	1.06	
Carbon tetrachloride	Jan-99	24.93	25.40	1.02	
	Jul-99	42.30	56.60	1.34	
Chlorobenzene	Jan-99	32.09	31.40	0.98	
	Jul-99	39.30	39.70	1.01	

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Table F-10. Severn Trent Non-Potable Water Chemistry Proficiency Test #203 and #213 Results Environmental Laboratory Approval Program (ELAP) ***(continued)*****.**

Analyte	Date	ELAP Reported Value (μg/L)	BNL Reported Value (μg/L)	Ratio (a)	Comment (b)
Chloromethane	Jan-99	28.43	24.10	0.85	
	Jul-99	56.00	56.10	1.00	
Ethyl benzene	Jan-99	21.10	20.10	0.95	
	Jul-99	15.40	16.60	1.08	
Methylene chloride	Jan-99	39.08	36.40	0.93	
	Jul-99	15.20	15.80	1.04	
PCB-1016	Jan-99	8.59	0.00	0.00	Not Acceptable
	Jul-99	6.11	4.90	0.80	
PCB-1254	Jan-99	5.46	4.90	0.90	
	Jul-99	2.52	2.30	0.91	
Toluene	Jan-99	24.70	24.90	1.01	
	Jul-99	32.90	33.10	1.01	
trans-1,3-Dichloropropene	Jan-99	19.91	20.40	1.02	
	Jul-99	22.60	30.50	1.35	
Vinyl chloride	Jan-99	53.25	43.70	0.82	
	Jul-99	29.80	30.20	1.01	
Total Xylenes	Jan-99	15.80	15.20	0.96	
	Jul-99	20.50	21.40	1.04	
Waste Water Metals I & II					
Aluminum	Jan-99	217.00	216.00	1.00	
	Jul-99	600.00	579.00	0.97	
Antimony	Jan-99	689.00	964.00	1.40	
	Jul-99	284.00	285.00	1.00	
Aresenic	Jan-99	229.00	243.00	1.06	
	Jul-99	402.00	382.00	0.95	
Barium	Jan-99	1660.00	1640.00	0.99	
	Jul-99	2200.00	2190.00	1.00	
Beryllium	Jan-99	139.00	138.00	0.99	
	Jul-99	108.00	107.00	0.99	
Cadmium	Jan-99	41.20	41.10	1.00	
	Jul-99	169.00	174.00	1.03	
Calcium	Jan-99	25.80	26.20	1.02	
	Jul-99	20.30	20.00	0.99	
Chromium	Jan-99	166.00	165.00	0.99	
	Jul-99	300.00	290.00	0.97	
Cobalt	Jan-99	412.00	418.00	1.01	
	Jul-99	160.00	153.00	0.96	
Copper	Jan-99	324.00	333.00	1.03	
	Jul-99	602.00	592.00	0.98	
Iron	Jan-99	289.00	270.00	0.93	
	Jul-99	192.00	170.00	0.89	
Lead	Jan-99	235.00	259.00	1.10	
	Jul-99	130.00	132.00	1.02	
Magnesium	Jan-99	10.40	10.30	0.99	
	Jul-99	13.00	12.70	0.98	
Manganese	Jan-99	166.00	166.00	1.00	
	Jul-99	401.00	392.00	0.98	
Nickel	Jan-99	157.00	157.00	1.00	
	Jul-99	302.00	295.00	0.98	
Potassium	Jan-99	8.62	9.55	1.11	
	Jul-99	5.03	4.91	0.98	
Selenium	Jan-99	149.00	147.00	0.99	
	Jul-99	243.00	250.00	1.03	
Silver	Jan-99	261.00	259.00	0.99	
	Jul-99	100.00	100.00	1.00	
Sodium	Jan-99	83.90	70.60	0.84	Not Acceptable
	Jul-99	35.70	33.90	0.95	
Thallium	Jan-99	639.00	690.00	1.08	
	Jul-99	197.00	198.00	1.01	
Vanadium	Jan-99	664.00	661.00	1.00	
	Jul-99	499.00	500.00	1.00	
Zinc	Jan-99	1260.00	1239.00	0.98	
	Jul-99	181.00	185.00	1.02	

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Table F-10. Severn Trent Non-Potable Water Chemistry Proficiency Test #203 and #213 Results Environmental Laboratory Approval Program (ELAP) ***(continued)*****.**

Analyte	Date	ELAP Reported Value (µg/L)	BNL Reported Value (µg/L)	Ratio (a)	Comment (b)
Mercury	Jan-99	5.27	5.10	0.97	
	Jul-99	12.50	11.70	0.94	
Cyanide	Jan-99	7.77	7.47	0.96	
	Jul-99	0.50	0.47	0.94	
Molybdenum	Jan-99	828.00	822.00	0.99	
	Jul-99	188.00	188.00	1.00	
Tin	Jan-99	2080.00	2040.00	0.98	
	Jul-99	1870.00	1870.00	1.00	
Titanium	Jan-99	552.00	543.00	0.98	
	Jul-99	124.00	127.00	1.02	
Organic Phosphate Pesticides					
Azinphos Methyl	Jan-99	7.28	7.00	0.96	
	Jul-99	6.04	5.83	0.97	
Diazinon	Jan-99	14.80	13.50	0.91	
	Jul-99	8.81	8.45	0.96	
Disulfoton	Jan-99	10.70	12.10	1.13	
	Jul-99	10.00	11.50	1.15	
Malathion	Jan-99	9.38	7.48	0.80	
	Jul-99	5.41	5.68	1.05	
Nitrosamines					
N-Nitrosodimethylamine	Jan-99	30.80	29.30	0.95	
	Jul-99	13.20	13.90	1.05	
N-Nitrosodiphenylamine	Jan-99	32.00	36.60	1.14	
	Jul-99	39.70	51.90	1.31	
N-Nitrosodi-n-propyl.	Jan-99	53.10	51.80	0.98	
	Jul-99	19.00	22.40	1.18	
Benzidines					
Benzidine	Jan-99	67.80	40.80	0.60	
	Jul-99	91.80	39.60	0.43	
3,3-dichloropenzidine	Jan-99	72.70	68.60	0.94	
	Jul-99	48.20	40.10	0.83	
Chlorinated Hydrocarbons					
2-Chloronaphthalene	Jan-99	60.50	61.90	1.02	
	Jul-99	38.80	40.90	1.05	
Hexachlorobenzene	Jan-99	58.00	57.20	0.99	
	Jul-99	52.10	51.60	0.99	
Hexachlorobutadiene	Jan-99	91.10	95.50	1.05	
	Jul-99	103.00	110.00	1.07	
Hexachloroethane	Jan-99	37.20	40.90	1.10	
	Jul-99	49.40	52.70	1.07	
Hexachlorocyclopentadiene	Jan-99	114.00	104.00	0.91	
	Jul-99	110.00	78.90	0.72	
1,2,4-Trichlorbenzene	Jan-99	88.50	80.90	0.91	
	Jul-99	79.30	77.70	0.98	
Phthalate Esters					
Benzyl butyl phthalate	Jan-99	76.70	77.40	1.01	
	Jul-99	70.20	68.10	0.97	
Bis(2-ethylhexyl) phthalate	Jan-99	103.00	91.70	0.89	
	Jul-99	83.80	72.90	0.87	
Diethyl phthalate	Jan-99	94.70	80.90	0.85	
	Jul-99	77.00	66.50	0.86	
Dimethyl phthalate	Jan-99	79.00	71.10	0.90	
	Jul-99	70.30	64.00	0.91	
Di-n-butlyl phthalate	Jan-99	96.60	86.40	0.89	
	Jul-99	68.10	64.50	0.95	
Di-n-octyl phthalate	Jan-99	87.80	72.40	0.82	
	Jul-99	63.60	50.20	0.79	
Nitroaromatic & Isophorone					
2,4-Dinitrotoluene	Jan-99	45.90	44.00	0.96	
	Jul-99	67.50	65.60	0.97	
2,6-Dinitrotoluene	Jan-99	51.10	46.20	0.90	
	Jul-99	43.10	38.20	0.89	

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Table F-10. Severn Trent Non-Potable Water Chemistry Proficiency Test #203 and #213 Results Environmental Laboratory Approval Program (ELAP) ***(continued)*****.**

Analyte	Date	ELAP Reported Value (μg/L)	BNL Reported Value (μg/L)	Ratio (a)	Comment (b)
Isophorone	Jan-99	34.10	34.60	1.01	
	Jul-99	42.50	43.40	1.02	
Nitrobenzene	Jan-99	46.40	44.80	0.97	
	Jul-99	33.30	34.30	1.03	
Polynuclear Aromatic Hydrocarbons					
Acenaphthylene	Jan-99	34.30	33.20	0.97	
	Jul-99	48.30	44.20	0.92	
Benzo(ghi)perylene	Jan-99	42.20	28.10	0.67	
	Jul-99	23.30	20.00	0.86	
Benzo(k)fluoranthene	Jan-99	48.20	55.30	1.15	
	Jul-99	35.20	35.60	1.01	
Chrysene	Jan-99	38.60	40.20	1.04	
	Jul-99	31.10	31.20	1.00	
Dibenzo(a,h)anthracene	Jan-99	45.20	45.70	1.01	
	Jul-99	36.20	32.50	0.90	
Fluorene	Jan-99	60.90	55.80	0.92	
	Jul-99	46.90	41.40	0.88	
Naphalene	Jan-99	42.80	42.50	0.99	
	Jul-99	54.00	54.50	1.01	
Phenanthrene	Jan-99	57.90	57.20	0.99	
	Jul-99	45.60	45.70	1.00	
Priority Pollutant Phenols					
4-Chloro-3-methylphenol	Jan-99	93.10	81.10	0.87	
	Jul-99	75.40	72.80	0.97	
2-Chlorophenol	Jan-99	89.80	82.60	0.92	
	Jul-99	83.10	68.60	0.83	
2,4-Dichlorophenol	Jan-99	82.90	74.70	0.90	
	Jul-99	66.40	63.90	0.96	
2,4-Dimethylphenol	Jan-99	78.80	66.90	0.85	
	Jul-99	93.20	78.50	0.84	
2,4-Dinitrophenol	Jan-99	65.60	56.00	0.85	
	Jul-99	86.40	87.60	1.01	
2-Methyl-4,6-dinitrophenol	Jan-99	105.00	106.00	1.01	
	Jul-99	94.60	99.60	1.05	
2-Nitrophenol	Jan-99	86.70	78.40	0.90	
	Jul-99	75.60	73.80	0.98	
4-Nitrophenol	Jan-99	60.00	76.90	1.28	
	Jul-99	53.20	66.40	1.25	
Pentachlorophenol	Jan-99	71.80	68.20	0.95	
	Jul-99	89.70	86.90	0.97	
Phenol	Jan-99	84.50	106.00	1.25	
	Jul-99	61.80	74.60	1.21	
2,4,5-Trichlorophenol	Jan-99	80.00	68.50	0.86	
	Jul-99	75.50	65.50	0.87	
2,4,6-Trichlorophenol	Jan-99	91.70	80.60	0.88	
	Jul-99	66.80	57.30	0.86	
Haloethers					
Bis(2-chloroethyl)ether	Jan-99	81.60	71.90	0.88	
	Jul-99	60.90	55.60	0.91	
Bis(2-chloroisopropyl)ether	Jan-99	86.60	77.70	0.90	
	Jul-99	88.30	85.80	0.97	
Bis(2-chloroethoxy)methan	Jan-99	77.80	72.70	0.93	
	Jul-99	73.90	74.10	1.00	
4-Bromophenyphenyl ether	Jan-99	101.00	92.60	0.92	
	Jul-99	73.80	69.50	0.94	
4-Chlorophenyphenyl ether	Jan-99	73.70	66.40	0.90	
	Jul-99	75.00	64.70	0.86	
Chlordane	Jan-99	51.20	51.30	1.00	
	Jul-99	4.72	5.10	1.08	
Chlorinated Hydrocarbon Pesticides					
alpha-BHC	Jan-99	4.67	2.60	0.56	
	Jul-99	1.31	1.35	1.03	

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Table F-10. Severn Trent Non-Potable Water Chemistry Proficiency Test #203 and #213 Results Environmental Laboratory Approval Program (ELAP) ***(continued).***

Analyte	Date	ELAP Reported Value (μg/L)	BNL Reported Value (μg/L)	Ratio (a)	Comment (b)
Lindane	Jan-99	2.83	1.59	0.56	
	Jul-99	1.65	1.65	1.00	
Dieldrin	Jan-99	3.72	2.18	0.59	Not Acceptable
	Jul-99	1.95	1.95	1.00	
4,4'-DDD	Jan-99	4.17	2.17	0.52	Not Acceptable
	Jul-99	1.41	1.29	0.91	
Endosulfan I	Jan-99	5.64	3.65	0.65	Marginal
	Jul-99	2.65	2.74	1.03	
Endosulfan sulfate	Jan-99	6.22	4.44	0.71	
	Jul-99	2.48	2.49	1.00	
Endin aldehyde	Jan-99	5.07	3.36	0.66	
	Jul-99	3.02	2.70	0.89	
Heptachlor epoxide	Jan-99	1.98	1.57	0.79	
	Jul-99	0.89	0.97	1.09	
Chlorophen Acid Herbicides					
Dicamba	Jan-99	6.22	6.98	1.12	
	Jul-99	8.27	5.92	0.72	
2,4-D	Jan-99	9.80	15.50	1.58	
	Jul-99	1.95	1.44	0.74	
2,4,5-T	Jan-99	2.50	2.86	1.14	
	Jul-99	3.93	2.66	0.68	
2,4,5-TP (Silvex)	Jan-99	4.16	4.40	1.06	
	Jul-99	5.82	3.90	0.67	
Solid Waste Metals					
Antimony	Jan-99	95.70	40.40	0.42	
	Jul-99	483.00	497.00	1.03	
Arsenic	Jan-99	180.00	176.00	0.98	
	Jul-99	109.00	111.00	1.02	
Barium	Jan-99	272.00	265.00	0.97	
	Jul-99	361.00	392.00	1.09	
Cadmium	Jan-99	22.00	21.20	0.96	
	Jul-99	57.70	68.50	1.19	
Chromium	Jan-99	104.00	131.00	1.26	
	Jul-99	83.10	102.00	1.23	
Lead	Jan-99	347.00	376.00	1.08	
	Jul-99	624.00	601.00	0.96	
Nickel	Jan-99	646.00	652.00	1.01	
	Jul-99	1990.00	2180.00	1.10	
Selenium	Jan-99	40.90	41.70	1.02	
	Jul-99	21.70	14.30	0.66	
Silver	Jan-99	30.80	31.60	1.03	
	Jul-99	51.20	69.50	1.36	
Solid Waste Organophosphate Pestides					
Azinophos Methyl	Jan-99	23.20	16.80	0.72	
	Jul-99	19.90	20.40	1.03	
Diazinon	Jan-99	3.50	2.32	0.66	
	Jul-99	2.48	1.99	0.80	
Disulfoton	Jan-99	7.46	6.99	0.94	
	Jul-99	18.90	23.80	1.26	
Malathion	Jan-99	13.60	8.41	0.62	
	Jul-99	15.20	17.90	1.18	
Solid Waste Chlorinated Hydrocarbons					
2-Chloronaphthalen	Jan-99	29.70	27.10	0.91	
	Jul-99	43.80	58.70	1.34	
Hexachlorobenzene	Jan-99	71.40	58.50	0.82	
	Jul-99	52.70	62.00	1.18	
Hexachlorobutadien	Jan-99	70.70	64.40	0.91	
	Jul-99	123.00	148.00	1.20	
Hexachloroethane	Jan-99	32.90	34.00	1.03	
	Jul-99	29.40	45.30	1.54	
Hexacholorocyclopen	Jan-99	15.00	12.60	0.84	
	Jul-99	3.87	4.57	1.18	

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Table F-10. Severn Trent Non-Potable Water Chemistry Proficiency Test #203 and #213 Results Environmental Laboratory Approval Program (ELAP) ***(continued).***

Analyte	Date	ELAP Reported Value (μg/L)	BNL Reported Value (μg/L)	Ratio (a)	Comment (b)
1,2,4-Trichloroben	Jan-99	84.30	73.50	0.87	
	Jul-99	132.00	151.00	1.14	
SW Phthalate Esters					
Benzyl butyl phthalate	Jan-99	106.00	84.70	0.80	
	Jul-99	142.00	156.00	1.10	
Bis(2-ethyl hexyl)	Jan-99	93.00	76.60	0.82	
	Jul-99	153.00	164.00	1.07	
Diethyl phthalate	Jan-99	78.80	58.50	0.74	
	Jul-99	134.00	139.00	1.04	
Dimethyl phthalate	Jan-99	69.50	55.80	0.80	
	Jul-99	117.00	127.00	1.09	
Di-n-butyl phthalate	Jan-99	78.00	61.70	0.79	
	Jul-99	107.00	117.00	1.09	
Di-n-octyl phthalate	Jan-99	87.40	64.20	0.73	
	Jul-99	124.00	119.00	0.96	
SW Nitroaromatic & Isophorone					
2,4-Dinitrotoluene	Jan-99	55.20	45.90	0.83	
	Jul-99	57.50	74.20	1.29	
2,6-Dinitrotoluene	Jan-99	37.20	30.70	0.83	
	Jul-99	61.30	69.10	1.13	
Isophorone	Jan-99	62.10	53.90	0.87	
	Jul-99	85.00	107.00	1.26	
Nitrobenzene	Jan-99	50.50	48.20	0.95	
	Jul-99	80.10	116.00	1.45	
SW Polynuclear Aromatic Hydocarbons					
Acenaphthene	Jan-99	26.60	22.80	0.86	
	Jul-99	8.12	10.20	1.26	
Anthracene	Jan-99	43.80	41.10	0.94	
	Jul-99	38.90	48.80	1.25	
Benzo(a)anthracene	Jan-99	57.10	51.10	0.89	
	Jul-99	68.00	74.50	1.10	
Benzo(a)pyrene	Jan-99	25.00	23.40	0.94	
	Jul-99	50.10	54.00	1.08	
Benzo(b)fluoranthe	Jan-99	55.20	45.70	0.83	
	Jul-99	52.70	57.20	1.09	
Fluoranthene	Jan-99	64.40	58.20	0.90	
	Jul-99	51.10	62.40	1.22	
Indeno(1,2,3-cd)py	Jan-99	45.20	39.40	0.87	
	Jul-99	39.10	43.00	1.10	
Pyrene	Jan-99	42.80	40.00	0.93	
	Jul-99	64.40	76.50	1.19	
SW Priority Pollutant Phenols					
4-Chloro-3-methyl phenol	Jan-99	87.20	74.30	0.85	
	Jul-99	107.00	141.00	1.32	
2-Chlorophenol	Jan-99	96.80	83.40	0.86	
	Jul-99	130.00	171.00	1.32	
2,4-Dichlorophenol	Jan-99	69.70	64.00	0.92	
	Jul-99	81.10	114.00	1.41	
2,4-Dimethylphenol	Jan-99	44.30	36.20	0.82	
	Jul-99	63.50	72.20	1.14	
2,4-Dintrophenol	Jan-99	29.90	41.60	1.39	
	Jul-99	44.10	92.90	2.11	
2-Methyl-4,6-dinit	Jan-99	63.90	92.80	1.45	
	Jul-99	86.00	187.00	2.17	
2-Nitrophenol	Jan-99	54.40	53.00	0.97	
	Jul-99	76.00	113.00	1.49	
4-Nitrophenol	Jan-99	54.30	62.90	1.16	
	Jul-99	68.10	122.00	1.79	
Pentachlorophenol	Jan-99	85.70	89.90	1.05	
	Jul-99	90.60	142.00	1.57	
Phenol	Jan-99	72.90	64.00	0.88	
	Jul-99	73.70	114.00	1.55	
2,4,6-Trichlorophenol	Jan-99	87.90	78.40	0.89	
	Jul-99	108.00	136.00	1.26	

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Table F-10. Severn Trent Non-Potable Water Chemistry Proficiency Test #203 and #213 Results Environmental Laboratory Approval Program (ELAP) ***(concluded)*****.**

Analyte	Date	ELAP Reported Value (μg/L)	BNL Reported Value (μg/L)	Ratio (a)	Comment (b)
Solid Waste Haloethers					
Bis(2-chlorisopr	Jan-99	90.40	70.30	0.78	
	Jul-99	88.30	123.00	1.39	
Bis(2-chloroethoxy	Jan-99	91.80	78.00	0.85	
	Jul-99	132.00	172.00	1.30	
Solid Waste Polychlorinated Biphenyls					
PBC-1016	Jan-99	blank	blank	1.00	
PBC-1221	Jan-99	blank	blank	1.00	
PBC-1232	Jan-99	blank	blank	1.00	
PBC-1242	Jan-99	blank	blank	1.00	
	Jul-99	84.90	110.00	1.30	
PBC-1248	Jan-99	56.80	43.00	0.76	
PBC-1254	Jan-99	blank	blank	1.00	
PBC-1260	Jan-99	blank	blank	1.00	
Solid Waste Chlorinated Hydcarbon Pesticides					
Aldrin	Jan-99	2.72	3.07	1.13	
	Jul-99	0.76	0.79	1.04	
beta-BHC	Jan-99	7.23	6.94	0.96	
	Jul-99	2.47	1.99	0.81	
delta-BHC	Jan-99	2.71	2.08	0.77	
	Jul-99	3.41	3.44	1.01	
4,4'-DDE	Jan-99	4.14	4.68	1.13	
	Jul-99	1.77	1.50	0.85	
4,4'-DDT	Jan-99	2.90	2.17	0.75	
	Jul-99	1.79	1.36	0.76	
Endosulfan II	Jan-99	0.32	0.00	0.00	Not Acceptable
	Jul-99	1.39	1.31	0.94	
Endrin	Jan-99	2.22	1.78	0.80	
	Jul-99	1.32	1.14	0.86	
Heptachlor	Jan-99	1.97	2.08	1.06	
	Jul-99	2.44	1.99	0.82	
Solid Waste Chlorophenoxy Acid Pesticides					
Dicamba	Jan-99	5.40	3.82	0.71	
	Jul-99	10.70	7.84	0.73	
2,4-D	Jan-99	9.96	7.87	0.79	
	Jul-99	7.47	5.54	0.74	
2,4,5-T	Jan-99	17.00	11.60	0.68	
	Jul-99	9.04	6.88	0.76	
2,4,5-TP (Silvex)	Jan-99	14.60	9.60	0.66	
	Jul-99	7.26	4.61	0.63	

Notes:
(a) The Ratio is the lab result divided by the target value result.
(b) Comment column provides ELAP evaluation of analytical performance, which is based on 95 and 99% confidence intervals about the target value. No comment indicates performance within acceptable limits.

Table F-11. BNL Potable Water Chemistry Proficiency Test #207, 208, #217, and 218 Results Environmental Laboratory Approval Program (ELAP).

Analyte	Date	ELAP Reported Value (μg/L)	BNL Reported Value (μg/L)	Ratio (a)	Comment (b)
Drinking Water Metals					
Antimony	Apr-99	50.00	49.40	0.99	
	Oct-99	25.00	25.40	1.02	
Arsenic	Apr-99	65.22	69.30	1.06	
	Oct-99	87.20	89.00	1.02	
Barium	Apr-99	1170.00	1173.00	1.00	
	Oct-99	943.00	941.00	1.00	
Beryllium	Apr-99	10.00	10.20	1.02	
	Oct-99	5.00	5.05	1.01	
Cadmium	Apr-99	33.30	33.40	1.00	
	Oct-99	18.80	19.70	1.05	
Chromium	Apr-99	150.00	144.00	0.96	
	Oct-99	75.00	75.70	1.01	
Copper	Apr-99	217.00	213.00	0.98	
	Oct-99	375.00	371.00	0.99	
Iron	Apr-99	250.00	237.00	0.95	
	Oct-99	161.00	163.00	1.01	
Lead	Apr-99	66.70	63.70	0.96	
	Oct-99	37.50	38.10	1.02	
Manganese	Apr-99	498.00	484.00	0.97	
	Oct-99	620.00	615.00	0.99	
Mercury	Apr-99	8.33	8.84	1.06	
	Oct-99	7.00	6.86	0.98	
Nickel	Apr-99	300.00	291.00	0.97	
	Oct-99	438.00	425.00	0.97	
Selenium	Apr-99	66.70	70.30	1.05	
	Oct-99	75.00	78.50	1.05	
Silver	Apr-99	17.00	16.70	0.98	
	Oct-99	312.00	308.00	0.99	
Sodium	Apr-99	19.50	19.20	0.98	
	Oct-99	16.00	15.70	0.98	
Thallium	Apr-99	6.00	6.01	1.00	
	Oct-99	10.00	10.00	1.00	
Zinc	Apr-99	839.00	808.00	0.96	
	Oct-99	1250.00	1235.00	0.99	
Drinking Water Minerals					
Chloride	Apr-99	54.30	56.10	1.03	
	Oct-99	89.70	133.00	1.48	Unsatisfactory
Nitrate (as N)	Apr-99	8.49	8.41	0.99	
	Oct-99	4.50	4.68	1.04	
Sulfate (as SO4)	Apr-99	248.00	249.00	1.00	
	Oct-99	310.00	320.00	1.03	
Volatile Aromatics					
Benzene	Apr-99	17.60	18.80	1.07	
	Oct-99	6.55	6.50	0.99	
Bromobenzene	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
n-Butylbenzene	Apr-99	4.96	5.76	1.16	
	Oct-99	15.20	15.30	1.01	
sec-Butylbenzene	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
tert-Butylbezene	Apr-99	22.00	24.60	1.12	
	Oct-99	5.19	4.43	0.85	
Chlorobenzene	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
2-Chlorotoluene	Apr-99	4.90	4.99	1.02	
	Oct-99	6.73	5.79	0.86	
4-Chlorotoluene	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
1,2-Dichlorobenzene	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
Ethyl benzene	Apr-99	26.40	28.70	1.09	
	Oct-99	15.20	15.80	1.04	

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Table F-11. BNL Potable Water Chemistry Proficiency Test #207, 208, #217, and 218 Results Environmental Laboratory Approval Program (ELAP) ***(continued)*****.**

Analyte	Date	ELAP Reported Value (μg/L)	BNL Reported Value (μg/L)	Ratio (a)	Comment (b)
Hexachlorobutadiene	Apr-99	7.44	7.33	0.99	
	Oct-99	16.50	15.40	0.93	
Isopropylbenzene	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
p-Isopropyltolune	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
n-propylbenzene	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
Styrene	Apr-99	23.00	16.70	0.73	
	Oct-99	5.54	3.51	0.63	
Toluene	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
1,2,3-Trichlorobenzene	Apr-99	4.19	3.26	0.78	
	Oct-99	8.92	7.51	0.84	
1,2,4-Trichlorobenzene	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
1,2,4-Trimethylbenzene	Apr-99	17.20	19.60	1.14	
	Oct-99	13.90	13.70	0.99	
1,3,5-Trimythlbenzene	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
m-Xylene	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
o-Xylene	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
p-Xylene	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
Volatile Halocarbons					
Bromochloromethane	Apr-99	21.50	22.00	1.02	
	Oct-99	14.20	17.20	1.21	Unsatisfactory
Bromomethane	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
Carbon tetrachloride	Apr-99	17.90	20.20	1.13	
	Oct-99	7.73	7.72	1.00	
Chloroethane	Apr-99	blank	< .500	1.00	
	Oct-99	29.30	36.40	1.24	Unsatisfactory
Chloromethane	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
Dibromomethane	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
Dichlorodifluoromethane	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
1,1-Dichlorethane	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
1,2-Dichlorethane	Apr-99	9.93	10.10	1.02	
	Oct-99	8.76	8.99	1.03	
1,2-Dichlorethene	Apr-99	19.00	23.50	1.24	Unsatisfactory
	Oct-99	7.25	8.16	1.13	
cis-1,2-Dichlorothene	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
trans-1,2-Dichlorothene	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
1,2-Dichloropropane	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
1,3-Dichloropropane	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
2,2-Dichloropropane	Apr-99	blank	< .500	1.00	
	Oct-09	blank	< .500	1.00	
1,1-Dichloropropene	Apr-99	9.12	11.20	1.23	
	Oct-99	5.53	5.96	1.08	
cis1,3-Dichloropropene	Apr-99	15.50	13.20	0.85	
	Oct-99	9.50	8.40	0.88	
trans1,3-Dichloropropene	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
Methylene chloride	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	

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Table F-11. BNL Potable Water Chemistry Proficiency Test #207, 208, #217, and 218 Results Environmental Laboratory Approval Program (ELAP) ***(concluded)*****.**

Analyte	Date	ELAP Reported Value (μg/L)	BNL Reported Value (μg/L)	Ratio (a)	Comment (b)
1,1,1,2-Tetrachloroethane	Apr-99	23.80	23.70	1.00	
	Oct-99	4.69	4.06	0.87	
1,1,2,2-Tetrachloroethane	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
Tetrachloroethene	Apr-99	5.10	4.52	0.89	
	Oct-99	17.00	16.90	0.99	
1,1,1-Trichloroethane	Apr-99	10.00	11.60	1.16	
	Oct-99	15.90	16.50	1.04	
1,1,2-Trichloroethane	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
Trichloroethene	Apr-99	30.20	32.90	1.09	
	Oct-99	15.40	15.60	1.01	
Trichlorofluoromethane	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
1,2,3-Trichloropropane	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
Vinyl Chloride	Apr-99	31.70	34.60	1.09	
	Oct-99	58.70	59.30	1.01	

Notes:
(a) The Ratio is the lab result divided by the target value result.
(b) Comment column provides ELAP evaluation of analytical performance, which is based on 95 and 99% confidence intervals about the target value. No comment indicates performance within acceptable limits.

Table F-12. GEL Potable Water Chemistry Proficiency Test #207, #208, #217, and #218 Results Environmental Laboratory Approval Program (ELAP).

Analyte	Date	ELAP Reported Value (μg/L)	BNL Reported Value (μg/L)	Ratio (a)	Comment (b)
Drinking Water Metals					
Antimony	Apr-99	50.00	49.10	0.98	
	Oct-99	25.00	25.20	1.01	
Arsenic	Apr-99	65.22	63.30	0.97	
	Oct-99	87.20	90.00	1.03	
Barium	Apr-99	1170.00	1140.00	0.97	
	Oct-99	943.00	964.00	1.02	
Beryllium	Apr-99	10.00	9.70	0.97	
	Oct-99	5.00	5.03	1.01	
Cadmium	Apr-99	33.30	33.90	1.02	
	Oct-99	18.80	18.90	1.01	
Chromium	Apr-99	150.00	150.00	1.00	
	Oct-99	75.00	75.50	1.01	
Copper	Apr-99	217.00	210.00	0.97	
	Oct-99	375.00	368.00	0.98	
Iron	Apr-99	250.00	254.00	1.02	
	Oct-99	161.00	159.00	0.99	
Lead	Apr-99	66.70	64.60	0.97	
	Oct-99	37.50	41.70	1.11	
Manganese	Apr-99	498.00	497.00	1.00	
	Oct-99	620.00	639.00	1.03	
Mercury	Apr-99	8.33	6.18	0.74	
	Oct-99	7.00	6.21	0.89	
Nickel	Apr-99	300.00	310.00	1.03	
	Oct-99	438.00	454.00	1.04	
Selenium	Apr-99	66.70	66.40	1.00	
	Oct-99	75.00	79.50	1.06	
Silver	Apr-99	17.00	14.00	0.82	Unsatisfactory
	Oct-99	312.00	320.00	1.03	
Sodium	Apr-99	19.50	20.10	1.03	
	Oct-99	16.00	16.30	1.02	
Thallium	Apr-99	6.00	5.82	0.97	
	Oct-99	10.00	11.40	1.14	
Zinc	Apr-99	839.00	826.00	0.98	
	Oct-99	1250.00	1290.00	1.03	
Drinking Water Minerals					
Chloride	Apr-99	54.30	52.50	0.97	
	Oct-99	89.70	84.90	0.95	
Fluoride	Apr-99	6.01	5.65	0.94	
	Oct-99	4.20	4.18	1.00	
Nitrate (as N)	Apr-99	8.49	8.33	0.98	
	Oct-99	4.50	4.56	1.01	
Sulfate (as SO4)	Apr-99	248.00	238.00	0.96	
	Oct-99	310.00	300.00	0.97	
Total disolved solids	Apr-99	533.00	532.00	1.00	
	Oct-99	642.00	652.00	1.02	
Miscellaneous					
Alkalinity	Apr-99	41.00	38.70	0.94	
	Oct-99	34.60	31.70	0.92	
Calcium hardness	Apr-99	115.00	114.00	0.99	
	Oct-99	141.00	143.00		
Hydrogen Ion (pH)	Apr-99	6.84	6.80	0.99	
	Oct-99	8.00	7.76	0.97	
Cyanide	Apr-99	0.21	0.19	0.92	
	Oct-99	0.14	0.13	0.91	
Volatile Aromatics					
Benzene	Apr-99	17.60	17.70	1.01	
	Oct-99	6.65	7.48	1.12	
Bromobenzene	Apr-99	blank	<0.50	1.00	
	Oct-99	blank	<0.50	1.00	
n-Butylbenzene	Apr-99	4.96	4.23	0.85	
	Oct-99	15.20	16.80	1.11	

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Table F-12. GEL Potable Water Chemistry Proficiency Test #207, #208, #217, and #218 Results Environmental Laboratory Approval Program (ELAP) ***(continued)*****.**

Analyte	Date	ELAP Reported Value (μg/L)	BNL Reported Value (μg/L)	Ratio (a)	Comment (b)
sec-Butylbenzene	Apr-99	blank	<0.50	1.00	
	Oct-99	blank	<0.50	1.00	
tert-Butylbezene	Apr-99	22.00	20.60	0.94	
	Oct-99	5.19	6.64	1.28	
Chlorobenzene	Apr-99	blank	<0.50	1.00	
	Oct-99	blank	<0.50	1.00	
2-Chlorotoluene	Apr-99	4.90	4.46	0.91	
	Oct-99	6.73	6.42	0.95	
4-Chlorotoluene	Apr-99	blank	<0.50	1.00	
	Oct-99	blank	<0.50	1.00	
1,2-Dichlorobenzene	Apr-99	blank	<0.50	1.00	
	Oct-99	blank	<0.50	1.00	
1,3-Dichlorobenzene	Apr-99	4.03	3.57	0.89	
	Oct-99	18.10	18.90	1.04	
1,4-Dichlorobenzene	Apr-99	blank	<0.50	1.00	
	Oct-99	blank	<0.50	1.00	
Ethyl benzene	Apr-99	26.40	24.50	0.93	
	Oct-99	15.20	15.80	1.04	
Hexachlorobutadiene	Apr-99	7.44	5.98	0.80	
	Oct-99	16.50	16.40	0.99	
Isopropylbenzene	Apr-99	blank	<0.50	1.00	
	Oct-99	blank	<0.50	1.00	
p-Isopropyltolune	Apr-99	blank	<0.50	1.00	
	Oct-99	blank	<0.50	1.00	
n-propylbenzene	Apr-99	blank	<0.50	1.00	
	Oct-99	blank	<0.50	1.00	
Styrene	Apr-99	23.00	21.00	0.91	
	Oct-99	5.54	5.85	1.06	
Toluene	Apr-99	blank	<0.50	1.00	
	Oct-99	blank	<0.50	1.00	
1,2,3Trichlorobenzene	Apr-99	4.19	3.39	0.81	
	Oct-99	8.92	9.05	1.01	
1,2,4Trichlorobenzene	Apr-99	blank	<0.50	1.00	
	Oct-99	blank	<0.50	1.00	
1,2,4-Trimythlbenzene	Apr-99	17.20	15.80	0.92	
	Oct-99	13.90	14.90	1.07	
1,3,5-Trimythlbenzene	Apr-99	blank	<0.50	1.00	
	Oct-99	blank	<0.50	1.00	
m-Xylene	Apr-99	blank	<0.50	1.00	
	Oct-99	blank	<0.50	1.00	
o-Xylene	Apr-99	blank	<0.50	1.00	
	Oct-99	blank	<0.50	1.00	
p-Xylene	Apr-99	blank	<0.50	1.00	
	Oct-99	blank	<0.50	1.00	
Volatile Halocarbons					
Brochloromethane	Apr-99	21.50	21.70	1.01	
	Oct-99	14.20	15.80	1.11	
Bromomethane	Apr-99	blank	<0.50	1.00	
	Oct-99	blank	<0.50	1.00	
Carbon tetrachloride	Apr-99	17.90	16.60	0.93	
	Oct-99	7.73	7.06	0.91	
Chloroethane	Apr-99	blank	<0.50	1.00	
	Oct-99	29.30	32.50	1.11	
Chloromethane	Apr-99	blank	<0.50	1.00	
	Oct-99	blank	<0.50	1.00	
Dibromomethane	Apr-99	blank	<0.50	1.00	
	Oct-99	blank	<0.50	1.00	
Dichlorodifluoromethane	Apr-99	blank	<0.50	1.00	
	Oct-99	blank	<0.50	1.00	
1,1-Dichlorethane	Apr-99	blank	<0.50	1.00	
	Oct-99	blank	<0.50	1.00	
1,2-Dichlorethane	Apr-99	9.93	9.29	0.94	
	Oct-99	8.76	8.32	0.95	
1,2-Dichlorethene	Apr-99	19.00	20.60	1.08	
	Oct-99	7.25	8.36	1.15	

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Table F-12. GEL Potable Water Chemistry Proficiency Test #207, #208, #217, and #218 Results Environmental Laboratory Approval Program (ELAP) ***(continued)*****.**

Analyte	Date	ELAP Reported Value (µg/L)	BNL Reported Value (µg/L)	Ratio (a)	Comment (b)
cis-1,2-Dichlorothene	Apr-99	blank	<0.50	1.00	
	Oct-99	blank	<0.50	1.00	
trans-1,2-Dichlorothene	Apr-99	blank	<0.50	1.00	
	Oct-99	blank	<0.50	1.00	
1,2-Dichloropropane	Apr-99	blank	<0.50	1.00	
	Oct-99	blank	<0.50	1.00	
1,3-Dichloropropane	Apr-99	blank	<0.50	1.00	
	Oct-99	blank	<0.50	1.00	
2,2-Dichloropropane	Apr-99	blank	<0.50	1.00	
	Oct-99	blank	<0.50	1.00	
1,1-Dichloropropene	Apr-99	9.12	9.18	1.01	
	Oct-99	5.53	5.76	1.04	
cis-1,3-Dichloropropene	Apr-99	15.50	14.10	0.91	
	Oct-99	9.50	9.30	0.98	
trans-1,3-Dichloropropene	Apr-99	blank	<0.50	1.00	
	Oct-99	blank	<0.50	1.00	
Methylene chloride	Apr-99	blank	<0.50	1.00	
	Oct-99	blank	<0.50	1.00	
1,1,1,2-Tetrachloroethane	Apr-99	23.80	24.60	1.03	
	Oct-99	4.69	4.76	1.01	
1,1,2,2-Tetrachloroethane	Apr-99	blank	<0.50	1.00	
	Oct-99	blank	<0.50	1.00	
Tetrachloroethene	Apr-99	5.10	4.28	0.84	
	Oct-99	17.00	16.60	0.98	
1,1,1-Trichloroethane	Apr-99	10.00	10.20	1.02	
	Oct-99	15.90	15.80	0.99	
1,1,2-Trichloroethane	Apr-99	blank	<0.50	1.00	
	Oct-99	blank	<0.50	1.00	
Trichloroethene	Apr-99	30.20	30.60	1.01	
	Oct-99	15.40	15.20	0.99	
Trichlorofluoromethane	Apr-99	blank	<0.50	1.00	
	Oct-99	blank	<0.50	1.00	
1,2,3-Trichloropropane	Apr-99	blank	<0.50	1.00	
	Oct-99	blank	<0.50	1.00	
Vinyl Chloride	Apr-99	31.70	33.00	1.04	
	Oct-99	58.70	62.80	1.07	
Trihalomethanes					
Bromodichloromethane	Apr-99	24.50	22.20	0.91	
	Oct-99	15.10	14.40	0.95	
Bromoform	Apr-99	30.10	28.90	0.96	
	Oct-99	36.20	35.30	0.98	
Chloroform	Apr-99	19.10	17.50	0.92	
	Oct-99	9.37	9.42	1.01	
Dibromochloromethane	Apr-99	37.40	34.80	0.93	
	Oct-99	18.20	17.80	0.98	
Methylcarbamate Pesticides					
Microextractables					
1,2-Dibromoethane	Apr-99	1.65	1.46	0.88	
	Oct-99	0.88	0.78	0.89	
1,2-Dibromo-3-chlorop	Apr-99	1.22	1.15	0.94	
	Oct-99	0.87	0.75	0.87	

Notes:
(a) The Ratio is thelab result divided by the target value result.
(b) Comment column provides ELAP evaluation of analytical performance, which is based on 95-99% confidence interval about the target value.
No comment indicates performance within acceptable limits.

Table F-13. H2M Potable Water Chemistry Proficiency Test #207, # 208, # 217, and # 218 Results Environmental Laboratory Approval Program (ELAP).

Analyte	Date	ELAP Reported Value (μg/L)	BNL Reported Value (μg/L)	Ratio (a)	Comment (b)
Drinking Water Metals					
Antimony	Apr-99	50.00	48.40	0.97	
	Oct-99	25.00	25.40	1.02	
Arsenic	Apr-99	65.22	65.80	1.01	
	Oct-99	87.20	87.00	1.00	
Barium	Apr-99	1170.00	1230.00	1.05	
	Oct-99	943.00	964.00	1.02	
Beryllium	Apr-99	10.00	10.40	1.04	
	Oct-99	5.00	5.03	1.01	
Cadmium	Apr-99	33.30	34.90	1.05	
	Oct-99	18.80	18.70	0.99	
Chromium	Apr-99	150.00	156.00	1.04	
	Oct-99	75.00	76.10	1.01	
Copper	Apr-99	217.00	226.00	1.04	
	Oct-99	375.00	375.00	1.00	
Iron	Apr-99	250.00	265.00	1.06	
	Oct-99	161.00	163.00	1.01	
Lead	Apr-99	66.70	61.00	0.91	
	Oct-99	37.50	33.60	0.90	
Manganese	Apr-99	498.00	520.00	1.04	
	Oct-99	620.00	627.00	1.01	
Mercury	Apr-99	8.33	7.50	0.90	
	Oct-99	7.00	6.40	0.91	
Nickel	Apr-99	300.00	313.00	1.04	
	Oct-99	438.00	437.00	1.00	
Selenium	Apr-99	66.70	61.40	0.92	
	Oct-99	75.00	72.50	0.97	
Silver	Apr-99	17.00	17.20	1.01	
	Oct-99	312.00	304.00	0.97	
Sodium	Apr-99	19.50	19.20	0.98	
	Oct-99	16.00	15.10	0.94	
Thallium	Apr-99	6.00	6.30	1.05	
	Oct-99	10.00	10.10	1.01	
Zinc	Apr-99	839.00	881.00	1.05	
	Oct-99	1250.00	1270.00	1.02	
Drinking Water Minerals					
Chloride	Apr-99	54.30	55.70	1.03	
	Oct-99	89.70	97.00	1.08	
Fluoride	Apr-99	6.01	5.60	0.93	
	Oct-99	4.20	4.10	0.98	
Nitrate (as N)	Apr-99	8.49	8.56	1.01	
	Oct-99	4.50	4.29	0.95	
Sulfate (as SO4)	Apr-99	248.00	250.00	1.01	
	Oct-99	310.00	280.00	0.90	Unsatisfactory
Total disolved solids	Apr-99	533.00	539.00	1.01	
	Oct-99	642.00	718.00	1.12	
Miscellaneous					
Alkalinity	Apr-99	41.00	42.60	1.04	
	Oct-99	34.60	34.10	0.99	
Calcium hardness	Apr-99	115.00	113.00	0.98	
	Oct-99	141.00	133.00	0.94	
Hydrogen Ion (pH)	Apr-99	6.84	6.96	1.02	Unsatisfactory
	Oct-99	8.00	7.86	0.98	
Cyanide	Apr-99	0.21	0.18	0.85	
	Oct-99	0.14	0.13	0.95	

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Table F-13. H2M Potable Water Chemistry Proficiency Test #207, # 208, # 217, and # 218 Results Environmental Laboratory Approval Program (ELAP) ***(continued)*****.**

Analyte	Date	ELAP Reported Value (µg/L)	BNL Reported Value (µg/L)	Ratio (a)	Comment (b)
Volatile Aromatics					
Benzene	Apr-99	17.60	20.40	1.16	
	Oct-99	6.65	6.70	1.01	
Bromobenzene	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
n-Butylbenzene	Apr-99	4.96	5.63	1.14	
	Oct-99	15.20	15.10	0.99	
Chlorobenzene	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
2-Chlorotoluene	Apr-99	4.90	5.33	1.09	
	Oct-99	6.73	6.30	0.94	
4-Chlorotoluene	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
1,2-Dichlorobenzene	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
1,3-Dichlorobenzene	Apr-99	4.03	3.56	0.88	
	Oct-99	18.10	18.70	1.03	
1,4-Dichlorobenzene	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
Ethyl benzene	Apr-99	26.40	26.90	1.02	
	Oct-99	15.20	15.20	1.00	
Hexachlorobutadiene	Apr-99	7.44	7.75	1.04	
	Oct-99	16.50	16.00	0.97	
Isopropylbenzene	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
p-Isopropyltolune	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
n-propylbenzene	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
Styrene	Apr-99	23.00	21.50	0.93	
	Oct-99	5.54	5.30	0.96	
Toluene	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
1,2,3-Trichlorobenzene	Apr-99	4.19	3.26	0.78	
	Oct-99	8.92	8.46	0.95	
1,2,4-Trichlorobenzene	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
1,2,4-Trimythlbenzene	Apr-99	17.20	19.10	1.11	
	Oct-99	13.90	13.90	1.00	
1,3,5-Trimythlbenzene	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
m-Xylene	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
o-Xylene	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
p-Xylene	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
Volatile Halocarbons					
Brochloromethane	Apr-99	21.50	18.30	0.85	
	Oct-99	14.20	13.60	0.96	
Bromomethane	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
Carbon tetrachloride	Apr-99	17.90	19.90	1.11	
	Oct-99	7.73	7.90	1.02	
Chloroethane	Apr-99	blank	< .500	1.00	
	Oct-99	29.30	37.80	1.29	Unsatisfactory

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Table F-13. H2M Potable Water Chemistry Proficiency Test #207, # 208, # 217, and # 218 Results Environmental Laboratory Approval Program (ELAP) ***(continued)*****.**

Analyte	Date	ELAP Reported Value (μg/L)	BNL Reported Value (μg/L)	Ratio (a)	Comment (b)
Chloromethane	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
Dibromomethane	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
Dichlorodifluoromethane	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
1,1-Dichlorethane	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
1,2-Dichlorethane	Apr-99	9.93	10.80	1.09	
	Oct-99	8.76	9.64	1.10	
1,2-Dichlorethene	Apr-99	19.00	22.30	1.17	
	Oct-99	7.25	7.90	1.09	
cis-1,2-Dichlorothene	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
trans-1,2-Dichlorothene	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
1,2-Dichloropropane	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
1,3-Dichloropropane	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
2,2-Dichloropropane	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
1,1-Dichloropropene	Apr-99	9.12	9.40	1.03	
	Oct-99	5.53	5.60	1.01	
cis1,3-Dichloropropene	Apr-99	15.50	14.40	0.93	
	Oct-99	9.50	8.80	0.93	
trs1,3-Dichloropropene	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
Methylene chloride	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
1,1,1,2-Tetrachloroethane	Apr-99	23.80	24.90	1.05	
	Oct-99	4.69	4.50	0.96	
1,1,2,2-Tetrachloroethane	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
Tetrachloroethene	Apr-99	5.10	4.50	0.88	
	Oct-99	17.00	17.10	1.01	
1,1,1-Trichloroethane	Apr-99	10.00	11.30	1.13	
	Oct-99	15.90	15.90	1.00	
1,1,2-Trichloroethane	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
Trichloroethene	Apr-99	30.20	30.60	1.01	
	Oct-99	15.40	14.50	0.94	
Trichlorofluoromethane	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
1,2,3-Trichloropropane	Apr-99	blank	< .500	1.00	
	Oct-99	blank	< .500	1.00	
Vinyl Chloride	Apr-99	31.70	34.60	1.09	
	Oct-99	58.70	85.50	1.46	Unsatisfactory
Mixed pesticides I					
Aldrin	Apr-99	11.10	10.10	0.91	
	Oct-99	0.88	0.68	0.77	
Dieldrin	Apr-99	16.90	14.40	0.85	
	Oct-99	1.93	1.48	0.77	
Endrin	Apr-99	7.03	6.21	0.88	
	Oct-99	4.92	4.49	0.91	

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Table F-13. H2M Potable Water Chemistry Proficiency Test #207, # 208, # 217, and # 218 Results Environmental Laboratory Approval Program (ELAP) *(continued)*.

Analyte	Date	ELAP Reported Value (μg/L)	BNL Reported Value (μg/L)	Ratio (a)	Comment (b)
Heptachlor	Apr-99	1.94	1.79	0.92	
	Oct-99	2.98	2.34	0.79	
Heptachlor epoxide	Apr-99	1.52	1.19	0.78	
	Oct-99	4.00	3.24	0.81	
Hexachlorobenzene	Apr-99	2.39	2.23	0.93	
	Oct-99	2.99	3.53	1.18	
Hexachlorocylopentadiene	Apr-99	73.10	78.20	1.07	
	Oct-99	2.76	3.94	1.43	
Lindane	Apr-99	2.02	1.90	0.94	
	Oct-99	2.93	2.49	0.85	
Methoxychlor	Apr-99	4.93	5.62	1.14	
	Oct-99	15.70	12.50	0.80	
Propachlor	Apr-99	90.80	93.40	1.03	
	Oct-99	2.46	2.72	1.11	
Mixed pesticides II					
Alachor	Apr-99	2.38	2.66	1.12	
	Oct-99	11.40	12.50	1.10	
Atrazine	Apr-99	3.68	4.38	1.19	
	Oct-99	14.90	16.80	1.13	
Metribuzin	Apr-99	33.40	11.30	0.34	
	Oct-99	15.60	6.41	0.41	
Metolachlor	Apr-99	44.30	49.10	1.11	
	Oct-99	19.00	25.30	1.33	
	Oct-99	19.30	20.10	1.04	
Benzo(a)pyrene	Apr-99	3.37	4.98	1.48	
	Oct-99	5.34	7.39	1.38	
Diquat	Apr-99	25.80	29.90	1.16	
	Oct-99	13.10	7.09	0.54	
Glyphosate	Apr-99	214.00	1930.00	9.02	Unsatisfactory
	Oct-99	449.00	493.00	1.10	
Trihalomethanes					
Bromodichloromethane	Apr-99	24.50	26.00	1.06	
	Oct-99	15.10	14.10	0.93	
Bromoform	Apr-99	30.10	37.60	1.25	
	Oct-99	36.20	36.20	1.00	
Chloroform	Apr-99	19.10	17.00	0.89	
	Oct-99	9.37	8.60	0.92	
Dibromochloromethane	Apr-99	37.40	37.50	1.00	
	Oct-99	18.20	17.50	0.96	
Chlordane	Apr-99	3.04	3.54	1.16	
	Oct-99	8.22	10.30	1.25	
Methylcarbamate Pesticides					
Aldicarb	Apr-99	18.70	18.70	1.00	
	Oct-99	41.50	76.60	1.85	Unsatisfactory
Aldicarb Sulfone	Apr-99	16.20	15.40	0.95	
	Oct-99	32.70	33.00	1.01	
Aldicarb Sulfoxide	Apr-99	15.80	16.60	1.05	
	Oct-99	44.50	51.10	1.15	
Carbaryl	Apr-99	67.20	64.90	0.97	
	Oct-99	43.20	44.00	1.02	
Carbofuran	Apr-99	18.90	17.50	0.93	
	Oct-99	77.40	69.70	0.90	
3-Hydroxy Carbofuran	Apr-99	60.50	70.10	1.16	
	Oct-99	34.60	34.00	0.98	
Methomyl	Apr-99	55.10	53.10	0.96	
	Oct-99	63.20	70.00	1.11	
Oxamyl	Apr-99	42.20	48.10	1.14	
	Oct-99	57.40	50.00	0.87	

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Table F-13. H2M Potable Water Chemistry Proficiency Test #207, # 208, # 217, and # 218 Results Environmental Laboratory Approval Program (ELAP) ***(concluded)*****.**

Analyte	Date	ELAP Reported Value (µg/L)	BNL Reported Value (µg/L)	Ratio (a)	Comment (b)
Toxaphene	Apr-99	3.24	3.98	1.23	
	Oct-99	11.00	10.30	0.94	
Mixed Herbicides					
2,4-D	Apr-99	35.80	39.70	1.11	
	Oct-99	60.70	56.30	0.93	
Dalapon	Apr-99	49.50	59.90	1.21	
	Oct-99	61.50	66.00	1.07	
Dicamba	Apr-99	46.40	44.68	0.96	
	Oct-99	34.30	33.20	0.97	
Dinoseb	Apr-99	3.38	2.99	0.88	
	Oct-99	16.20	16.80	1.04	
Pentachlorophenol	Apr-99	6.02	1.66	0.28	Unsatisfactory
	Oct-99	51.30	48.10	0.94	
Pichloram	Apr-99	34.90	30.80	0.88	
	Oct-99	39.80	49.20	1.24	
2,4,5-TP (Silvex)	Apr-99	19.40	22.30	1.15	
	Oct-99	78.10	72.80	0.93	
Microextractables					
1,2-Dibromoethane	Apr-99	1.65	1.55	0.94	
	Oct-99	0.88	1.03	1.18	
1,2-Dibromo-3-chlorop	Apr-99	1.22	1.12	0.92	
	Oct-99	0.87	1.11	1.28	

Notes:
(a) The Ratio is the lab result divided by the target value result.
(b) Comment column provides ELAP evaluation of analytical performance, which is based on 95 and 99% confidence intervals about the target value. No comment indicates performance within acceptable limits.

Table F-14. Severn Trent Potable Water Chemistry Proficiency Test #207, #208, #217, and #218 Results Environmental Laboratory Approval Program (ELAP).

Analyte	Date	ELAP Reported Value (µg/L)	BNL Reported Value (µg/L)	Ratio (a)	Comment (b)
Drinking Water Metals					
Arsenic	Apr-99	65.22	66.90	1.03	
	Oct-99	87.20	84.20	0.97	
Barium	Apr-99	1170.00	1173.00	1.00	
	Oct-99	943.00	924.00	0.98	
Cadmium	Apr-99	33.30	35.80	1.08	
	Oct-99	18.80	19.20	1.02	
Chromium	Apr-99	150.00	153.00	1.02	
	Oct-99	75.00	74.90	1.00	
Copper	Apr-99	217.00	219.00	1.01	
	Oct-99	375.00	386.00	1.03	
Iron	Apr-99	250.00	289.00	1.16	Not Acceptable
	Oct-99	161.00	186.00	1.16	Not Acceptable
Lead	Apr-99	66.70	69.80	1.05	
	Oct-99	37.50	38.00	1.01	
Manganese	Apr-99	498.00	506.00	1.02	
	Oct-99	620.00	619.00	1.00	
Mercury	Apr-99	8.33	8.00	0.96	
	Oct-99	7.00	7.20	1.03	
Selenium	Apr-99	66.70	67.30	1.01	
	Oct-99	75.00	70.60	0.94	
Silver	Apr-99	17.00	17.40	1.02	
	Oct-99	312.00	306.00	0.98	
Sodium	Apr-99	19.50	17.20	0.88	Marginal
	Oct-99	16.00	13.30	0.83	Not Acceptable
Zinc	Apr-99	839.00	832.00	0.99	
	Oct-99	1250.00	1250.00	1.00	
Drinking Water Minerals					
Chloride	Apr-99	54.30	54.90	1.01	
	Oct-99	89.70	92.30	1.03	
Fluoride	Apr-99	6.01	6.04	1.00	
	Oct-99	4.20	4.31	1.03	
Nitrate (as N)	Apr-99	8.49	8.57	1.01	
	Oct-99	4.50	4.66	1.04	
Sulfate (as SO4)	Apr-99	248.00	233.00	0.94	
	Oct-99	310.00	336.00	1.08	
Total dissolved solids	Apr-99	533.00	545.00	1.02	
	Oct-99	642.00	657.00	1.02	
Miscellaneous					
Alkalinity	Apr-99	41.00	43.00	1.05	
	Oct-99	34.60	32.80	0.95	
Calcium hardness	Apr-99	115.00	121.00	1.05	
	Oct-99	141.00	132.60		
Hydrogen Ion (pH)	Apr-99	6.84	6.89	1.01	
	Oct-99	8.00	7.95	0.99	
Volatile Aromatics					
Benzene	Apr-99	17.60	19.00	1.08	
	Oct-99	6.65	6.90	1.04	
Bromobenzene	Apr-99	blank	blank	1.00	
	Oct-99	blank	blank	1.00	
n-Butylbenzene	Apr-99	4.96	5.18	1.04	
	Oct-99	15.20	12.60	0.83	
sec-Butylbenzene	Apr-99	blank	blank	1.00	
	Oct-99	blank	blank	1.00	
tert-Butylbezene	Apr-99	22.00	19.10	0.87	
	Oct-99	5.19	4.60	0.89	
Chlorobenzene	Apr-99	blank	blank		
	Oct-99	blank	blank		

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Table F-14. Severn Trent Potable Water Chemistry Proficiency Test #207, #208, #217, and #218 Results Environmental Laboratory Approval Program (ELAP) *(continued)*.

Analyte	Date	ELAP Reported Value (µg/L)	BNL Reported Value (µg/L)	Ratio (a)	Comment (b)
2-Chlorotoluene	Apr-99	4.90	5.40	1.10	
	Oct-99	6.73	6.70	1.00	
4-Chlorotoluene	Apr-99	blank	blank	1.00	
	Oct-99	blank	blank	1.00	
1,2-Dichlorobenzene	Apr-99	blank	blank	1.00	
	Oct-99	blank	blank	1.00	
1,3-Dichlorobenzene	Apr-99	4.03	4.41	1.09	
	Oct-99	18.10	17.40	0.96	
1,4-Dichlorobenzene	Apr-99	blank	blank		
	Oct-99	blank	blank		
Ethyl benzene	Apr-99	26.40	25.50	0.97	
	Oct-99	15.20	14.00	0.92	
Hexachlorobutadiene	Apr-99	7.44	7.68	1.03	
	Oct-99	16.50	15.00	0.91	
Isopropylbenzene	Apr-99	blank	blank	1.00	
	Oct-99	blank	blank	1.00	
p-Isopropyltolune	Apr-99	blank	blank	1.00	
	Oct-99	blank	blank	1.00	
n-propylbenzene	Apr-99	blank	blank	1.00	
	Oct-99	blank	blank	1.00	
Styrene	Apr-99	23.00	22.00	0.96	
	Oct-99	5.54	5.34	0.96	
Toluene	Apr-99	blank	blank	1.00	
	Oct-99	blank	blank	1.00	
1,2,3-Trichlorobenzene	Apr-99	4.19	4.28	1.02	
	Oct-99	8.92	9.43	1.06	
1,2,4-Trichlorobenzene	Apr-99	blank	3.48		Not Acceptable
	Oct-99	blank	blank	1.00	
1,2,4-Trimethylbenzene	Apr-99	17.20	16.30	0.95	
	Oct-99	13.90	12.40	0.89	
1,3,5-Trimythlbenzene	Apr-99	blank	blank	1.00	
	Oct-99	blank	blank	1.00	
m-Xylene	Apr-99	blank	blank	1.00	
	Oct-99	blank	blank	1.00	
o-Xylene	Apr-99	blank	blank	1.00	
	Oct-99	blank	blank	1.00	
p-Xylene	Apr-99	blank	blank	1.00	
	Oct-99	blank	blank	1.00	
Volatile Halocarbons					
Brochloromethane	Apr-99	21.50	21.50	1.00	
	Oct-99	14.20	16.80	1.18	
Bromomethane	Apr-99	blank	blank	1.00	
	Oct-99	blank	blank	1.00	
Carbon tetrachloride	Apr-99	17.90	17.30	0.97	
	Oct-99	7.73	6.27	0.81	
Chloroethane	Apr-99	blank	blank	1.00	
	Oct-99	29.30	28.20	0.96	
Chloromethane	Apr-99	blank	blank	1.00	
	Oct-99	blank	blank	1.00	
Dibromomethane	Apr-99	blank	blank	1.00	
	Oct-99	blank	blank	1.00	
Dichlorodifluoromethane	Apr-99	blank	blank	1.00	
	Oct-99	blank	blank	1.00	
1,1-Dichlorethane	Apr-99	blank	blank	1.00	
	Oct-99	blank	blank	1.00	
1,2-Dichlorethane	Apr-99	9.93	11.80	1.19	
	Oct-99	8.76	9.46	1.08	

continued on next page

Table F-14. Severn Trent Potable Water Chemistry Proficiency Test #207, #208, #217, and #218 Results Environmental Laboratory Approval Program (ELAP) ***(concluded)*****.**

Analyte	Date	ELAP Reported Value (μg/L)	BNL Reported Value (μg/L)	Ratio (a)	Comment (b)
1,2-Dichlorethene	Apr-99	19.00	21.00	1.11	
	Oct-99	7.25	6.44	0.89	
cis-1,2-Dichlorothene	Apr-99	blank	blank	1.00	
	Oct-99	blank	blank	1.00	
trans-1,2-Dichlorothene	Apr-99	blank	blank	1.00	
	Oct-99	blank	blank	1.00	
1,2-Dichloropropane	Apr-99	blank	blank	1.00	
	Oct-99	blank	blank	1.00	
1,3-Dichloropropane	Apr-99	blank	blank	1.00	
	Oct-99	blank	blank	1.00	
2,2-Dichloropropane	Apr-99	blank	blank	1.00	
	Oct-99	blank	blank	1.00	
1,1-Dichloropropene	Apr-99	9.12	9.59	1.05	
	Oct-99	5.53	4.48		
cis1,3Dichloropropene	Apr-99	15.50	15.50	1.00	
	Oct-99	9.50	9.07	0.95	
trs1,3Dichloropropene	Apr-99	blank	blank	1.00	
	Oct-99	blank	blank	1.00	
Methylene chloride	Apr-99	blank	blank	1.00	
	Oct-99	blank	1.91		Not Acceptable
1,1,1,2Tetrachloroethane	Apr-99	23.80	26.20	1.10	
	Oct-99	4.69	4.26	0.91	
1,1,2,2Tetrachloroethane	Apr-99	blank	blank	1.00	
	Oct-99	blank	blank	1.00	
Tetrachloroethene	Apr-99	5.10	4.31	0.85	
	Oct-99	17.00	12.80	0.75	Not Acceptable
1,1,1-Trichloroethane	Apr-99	10.00	10.70	1.07	
	Oct-99	15.90	12.80	0.81	
1,1,2-Trichloroethane	Apr-99	blank	blank	1.00	
	Oct-99	blank	blank	1.00	
	Oct-99	58.70	55.10	0.94	
Trihalomethanes					
Bromodichloromethane	Apr-99	24.50	23.90	0.98	
	Oct-99	15.10	15.00	0.99	
Bromoform	Apr-99	30.10	29.50	0.98	
	Oct-99	36.20	37.30	1.03	
Chloroform	Apr-99	19.10	18.60	0.97	
	Oct-99	9.37	9.51	1.01	
Dibromochloromethane	Apr-99	37.40	36.30	0.97	
	Oct-99	18.20	18.60	1.02	

Notes:
(a) The Ratio is the lab result divided by the target value result.
(b) Comment column provides ELAP evaluation of analytical performance, which is based on 95 and 99% confidence intervals about the target value. No comment indicates performance within acceptable limits.

Table F-15. BNL Water Pollution Performance Evaluation Studies WP-52, WP-54, and WP-58 Results Environmental Resources Associates (ERA)

Analyte	Units	Date	BNL Reported Value	ERA Reported Value	Ratio (a)	Comment (b)
Volatiles						
Acetone	µg/L	Nov-99	<10.00	<5.00	1.00	
Benzene	µg/L	May-99	27.60	29.90	0.92	
		Nov-99	56.50	58.00	0.97	
Bromodichloromethane	µg/L	May-99	30.20	31.80	0.95	
		Nov-99	53.70	53.00	1.01	
Bromoform	µg/L	May-99	40.40	44.70	0.90	
		Nov-99	15.30	16.80	0.91	
Bromomethane	µg/L	Nov-99	<1.00	<5.00	1.00	
2- Butanone (MEK)	µg/L	Nov-99	<1.00	<5.00	1.00	
Carbon tetrachloride	µg/L	May-99	35.00	33.30	1.05	
		Nov-99	53.80	59.70	0.90	
Chlorobenzene	µg/L	May-99	36.30	37.80	0.96	
		Nov-99	22.60	26.20	0.86	
Chlorodibromomethane	µg/L	May-99	32.30	36.20	0.89	
		Nov-99	10.80	11.90	0.91	
Chloroform	µg/L	May-99	18.60	18.70	0.99	
		Nov-99	57.20	59.20	0.97	
Cloroethane	µg/L	Nov-99	<1.00	<5.00	1.00	
Chloromethane	µg/L	Nov-99	<1.00	<5.00	1.00	
1,2-Dichlorobenzene	µg/L	May-99	27.40	30.90	0.89	
		Nov-99	31.30	44.20	0.71	Check for error
1,3-Dichlorobenzene	µg/L	May-99	18.80	24.10	0.78	Check for error
		Nov-99	35.30	56.00	0.63	Not acceptable
1,4-Dichlorobenzene	µg/L	May-99	42.60	47.60	0.89	
		Nov-99	10.60	15.70	0.68	Check for error
1,1-Dichloroethane	µg/L	May-99	49.90	49.00	1.02	
		Nov-99	<1.00	<5.00	1.00	
1,2-Dichloroethane	µg/L	May-99	49.20	52.90	0.93	
		Nov-99	69.00	69.80	0.99	
1,1-Dichloroethylene	µg/L	Nov-99	<1.00	<5.00	1.00	
trans1,2-Dichlorethylene	µg/L	Nov-99	<1.00	<5.00	1.00	
1,2-Dichloropropane	µg/L	May-99	17.70	19.20	0.92	
		Nov-99	<1.00	<5.00	1.00	
cis1,3-Dichloropropylene	µg/L	Nov-99	<1.00	<5.00	1.00	
trans1,3-Dichloropropylene	µg/L	Nov-99	<1.00	<5.00	1.00	
Ethylbenzene	µg/L	May-99	44.20	46.40	0.95	
		Nov-99	40.60	56.10	0.72	Check for error
2-Hexanone	µg/L	Nov-99	<1.00	<5.00	1.00	
Methyl Chloride	µg/L	May-99	27.10	31.30	0.87	
		Nov-99	31.60	30.80	1.03	
MIBK	µg/L	Nov-99	42.40	39.90	1.06	
4-Methyl-2-pentanone	µg/L	May-99	42.10	56.10	0.75	
1,1,1,2-Tetrachloroethane	µg/L	Nov-99	<1.00	<5.00	1.00	
1,1,2,2-Tetrachloroethane	µg/L	May-99	54.30	72.60	0.75	
		Nov-99	<1.00	<5.00	1.00	
Tetrachloroethylene	µg/L	May-99	32.10	37.60	0.85	
		Nov-99	49.30	62.50	0.79	
Toluene	µg/L	May-99	27.90	30.40	0.92	
		Nov-99	17.80	20.40	0.87	
1,1,1-Trichloroethane	µg/L	May-99	50.50	50.50	1.00	
		Nov-99	29.20	33.20	0.88	
1,1,2-Trichloroethane	µg/L	Nov-99	<1.00	<5.00	1.00	
Trichlorethylene	µg/L	May-99	9.24	9.60	0.96	
		Nov-99	40.70	43.00	0.95	
Trichlorofluormethane	µg/L	Nov-99	<1.00	<5.00	1.00	
Vinyl chloride	µg/L	Nov-99	<1.00	<5.00	1.00	
Xylenes	µg/L	Nov-99	252.00	299.00	0.84	
Trace Metals						
Aluminum	µg/L	May-99	2410.00	2390.00	1.01	
		Nov-99	768.00	797.00	0.96	
Antimony	µg/L	May-99	638.00	609.00	1.05	
		Nov-99	252.00	254.00	0.99	

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Table F-15. BNL Water Pollution Performance Evaluation Studies - WP-52, WP-54, and WP-58 Results Environmental Resources Associates (ERA) ***(concluded)*****.**

Analyte	Units	Date	BNL Reported Value	ERA Reported Value	Ratio (a)	Comment (b)
Arsenic	µg/L	May-99	582.00	526.00	1.11	
		Nov-99	440.00	388.00	1.13	Check for error
Barium	µg/L	May-99	292.00	282.00	1.04	
		Nov-99	776.00	791.00	0.98	
Beryllium	µg/L	May-99	829.00	772.00	1.07	
		Nov-99	428.00	456.00	0.94	
Cadmium	µg/L	May-99	387.00	372.00	1.04	
		Nov-99	157.00	167.00	0.94	
Chromium	µg/L	May-99	855.00	838.00	1.02	
		Nov-99	476.00	493.00	0.97	
Cobalt	µg/L	May-99	188.00	192.00	0.98	
		Nov-99	958.00	954.00	1.00	
Copper	µg/L	May-99	701.00	716.00	0.98	
		Nov-99	84.90	86.60	0.98	
Iron	µg/L	May-99	2650.00	2630.00	1.01	
		Nov-99	1250.00	1240.00	1.01	
Lead	µg/L	May-99	360.00	314.00	1.15	Not acceptable
		Nov-99	574.00	605.00	0.95	
Manganese	µg/L	May-99	1800.00	1800.00	1.00	
		Nov-99	532.00	571.00	0.93	
Mercury	µg/L	Oct-99	16.20	16.20	1.00	
		Nov-99	5.31	10.80	0.49	Not acceptable
Molybdenum	µg/L	Nov-99	535.00	548.00	0.98	
Nickel	µg/L	May-99	151.00	150.00	1.01	
		Nov-99	2450.00	2490.00	0.98	
Selenium	µg/L	May-99	882.00	829.00	1.06	
		Nov-99	1480.00	1480.00	1.00	
Silver	µg/L	May-99	50.80	55.40	0.92	
		Nov-99	531.00	513.00	1.04	
Thallium	µg/L	May-99	175.00	157.00	1.11	
		Nov-99	296.00	321.00	0.92	
Vanadium	µg/L	May-99	2490.00	2467.00	1.01	
		Nov-99	207.00	228.00	0.91	Check for error
Zinc	µg/L	May-99	995.00	972.00	1.02	
		Nov-99	1300.00	1340.00	0.97	
Minerals						
Chloride	mg/L	May-99	54.40	54.80	0.99	
		Nov-99	75.40	73.00	1.03	
Sulfate	mg/L	May-99	29.30	30.40	0.96	
		Nov-99	19.70	19.60	1.01	
Sodium	mg/L	May-99	71.80	71.20	1.01	
		Nov-99	19.70	19.60	1.01	
PCBs in Oil						
Aroclor 1254	mg/kg	May-99	26.30	41.30	0.64	
Aroclor 1260	mg/kg	Oct-99	19.10	27.10	0.70	
Aroclor 1232	mg/kg	Oct-99	27.90	NR		Not acceptable
Aroclor 1016/1242	mg/kg	Nov-99	18.10	29.00	0.62	
PCB Aroclor Identity	µg/L	Nov-99	1242.00	1242.00	1.00	
Aroclor 1254	mg/kg	Nov-99	7.61	17.20	0.44	
PCB Aroclor Identity	µg/L	Nov-99	1254.00	1254.00	1.00	

Notes:
(a) The Ratio is the lab result divided by the target value result.
(b) Comment column provides ERA evaluation of analytical performance, which is based on 95 and 99% confidence intervals about the target value. No comment indicates performance within acceptable limits.

Table F-16. BNL Water Supply Performance Evaluation Studies WS-36 Results Environmental Resources Associates (ERA).

Analyte	Units	Date	BNL Reported Value	ERA Reported Value	Ratio (a)	Comment (b)
Volatiles						
Benzene	µg/L	Jul-99	4.11	3.95	1.04	
Bromodichloromethane	µg/L	Jul-99	28.30	26.20	1.08	
Bromoform	µg/L	Jul-99	18.90	20.20	0.94	
Carbon tetrachloride	µg/L	Jul-99	12.40	12.00	1.03	
Chlorobenzene	µg/L	Jul-99	3.73	3.56	1.05	
Chlorodibromomethane	µg/L	Jul-99	22.80	22.50	1.01	
Chloroform	µg/L	Jul-99	7.45	6.86	1.09	
1,2-Dichlorobenzene	µg/L	Jul-99	7.58	8.58	0.88	
1,4-Dichlorobenzene	µg/L	Jul-99	3.09	3.74	0.83	
1,2-Dichloroethane	µg/L	Jul-99	6.11	5.98	1.02	
1,1-Dichloroethylene	µg/L	Jul-99	5.73	5.20	1.10	
trans1,2-Dichloroethylene	µg/L	Jul-99	5.48	7.11	0.77	
cis-1,2-Dichloroethylene	µg/L	Jul-99	6.85	6.87	1.00	
cis-1,2-Dichloropropane	µg/L	Jul-99	14.70	15.10	0.97	
Ethylbenzene	µg/L	Jul-99	8.12	8.15	1.00	
Methyl Chloride	µg/L	Jul-99	12.80	12.70	1.01	
Styrene	µg/L	Jul-99	3.59	3.46	1.04	
Total Trihalomethanes	µg/L	Jul-99	77.50	75.80	1.02	
Tetrachloroethylene	µg/L	Jul-99	4.02	4.20	0.96	
Toluene	µg/L	Jul-99	11.30	11.20	1.01	
1,2,4-Trichlorobenzene	µg/L	Jul-99	2.03	2.61	0.78	
1,1,1-Trichloroethane	µg/L	Jul-99	9.80	9.82	1.00	
1,1,2-Trichloroethane	µg/L	Jul-99	7.83	8.50	0.92	
Trichlorethylene	µg/L	Jul-99	9.71	10.10	0.96	
Vinyl chloride	µg/L	Jul-99	13.50	11.70	1.15	
Xylenes,total	µg/L	Jul-99	42.20	41.20	1.02	
Trace Metals						
Aluminum	µg/L	Jul-99	221.00	243.00	0.91	
Antimony	µg/L	Jul-99	18.10	18.40	0.98	
Arsenic	µg/L	Jul-99	53.40	55.30	0.97	
Barium	µg/L	Jul-99	634.00	648.00	0.98	
Beryllium	µg/L	Jul-99	5.79	7.00	0.83	Not acceptable
Cadmium	µg/L	Jul-99	35.80	37.40	0.96	
Chromium	µg/L	Jul-99	32.70	37.50	0.87	
Copper	µg/L	Jul-99	187.00	205.00	0.91	
Iron	µg/L	Jul-99	406.00	347.00	1.17	
Lead	µg/L	Jul-99	26.40	27.10	0.97	
Manganese	µg/L	Jul-99	87.80	92.50	0.95	
Molybdenum	µg/L	Jul-99	65.20	65.80	0.99	
Nickel	µg/L	Jul-99	87.10	94.50	0.92	
Selenium	µg/L	Jul-99	50.30	51.80	0.97	
Silver	µg/L	Jul-99	114.00	120.00	0.95	
Thallium	µg/L	Jul-99	6.00	6.25	0.96	
Zinc	µg/L	Jul-99	656.00	710.00	0.92	
Mercury	µg/L	Jul-99	3.92	3.80	1.03	
Inorganics						
Chloride	mg/L	Jul-99	7.66	6.88	1.11	
Nitrate as N	mg/L	Jul-99	8.43	8.75	0.96	
Sulfate	mg/L	Jul-99	25.50	26.40	0.97	

Notes:
(a) The Ratio is the lab result divided by the target value result.
(b) Comment column provides ERA evaluation of analytical performance, which is based on 95 and 99% confidence intervals about the target value. No comment indicates performance within acceptable limits.

Helpful Information on Units of Measure and Conversions

UNITS OF RADIATION MEASUREMENT AND CONVERSION

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)	1.04	quarts (qt.)	quart	0.95	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	hectares
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 MEASUREMENT

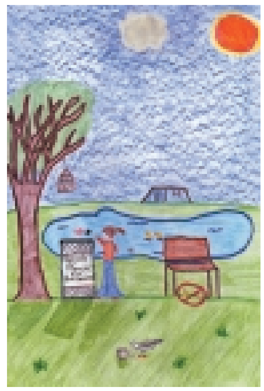
Multiple	Decimal Equivalent	Notation	Prefix	Symbol
1×10^{3}	1000	E+03	kilo-	k
1×10^{-2}	0.01	E-02	centi-	c
1×10^{-3}	0.001	E-03	milli-	m
1×10^{-6}	0.000001	E-06	micro-	µ
1×10^{-9}	0.000000001	E-09	nano-	n
1×10^{-12}	0.000000000001	E-12	pico-	p

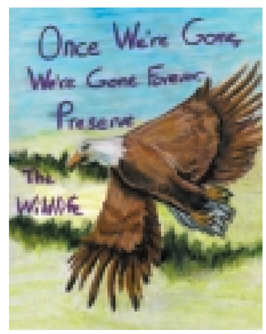
CONCENTRATION CONVERSION

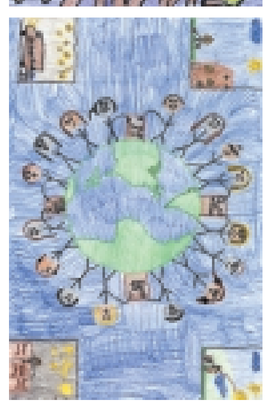
1 ppm	=	1000 ppb		
1 ppb	=	0.001 ppm	=	1µg/L*
1 ppm	=	1 mg/L	=	1000 µg/L*

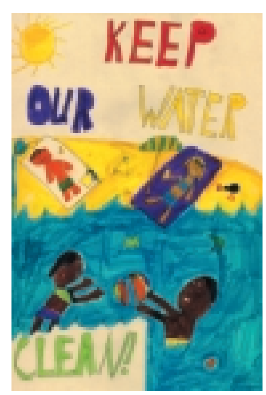
* For aqueous fractions only.

EXPLORING EARTH'S MYSTERIES
...PROTECTING ITS FUTURE









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