6 Natural and Cultural Resources

The Brookhaven National Laboratory Natural Resource Management Program is designed to protect and manage flora and fauna and the ecosystems in which they exist. The Laboratory's management strategy is based on an understanding of the site's resources and on compliance with applicable regulations. The goals of the program include protecting and monitoring the ecosystem, conducting research, and communicating with staff and the public. BNL focuses on protecting New York State Threatened and Endangered species on site, as well as the Laboratory's role within the greater Long Island Central Pine Barrens ecosystem.

Monitoring to determine whether current or historical activities are affecting natural resources is also part of this program. In 2003, deer and fish sampling results were consistent with previous years. Vegetables grown in the BNL garden plot continue to support historical analyses that there are no Laboratory-generated radionuclides in produce.

Completing the third year of managing the Upton Ecological and Research Reserve (Upton Reserve), its technical advisory group approved funding for research on the 530-acre area. Multiple research grants to investigate important local ecological issues were awarded and are discussed in this chapter.

The overriding goal of the Cultural Resource Management Program is to ensure that proper stewardship of BNL and DOE historic resources is established and maintained. Additional goals of the program include maintaining compliance with various historic preservation and archeological laws and regulations, and ensuring the availability of identified resources to on-site personnel and the public for research and interpretation. A BNL Cultural Resource Management Plan is currently being developed to identify, assess, and document BNL's historic and cultural resources. In 2003, compliance procedures and requirements for archaeological surveys were developed.

6.1 NATURAL RESOURCE MANAGEMENT PROGRAM

The purpose of the Natural Resource Management Program at BNL is to promote stewardship of the natural resources found at the Laboratory, as well as to integrate natural resource management and protection with BNL's scientific mission. To meet this purpose, the Laboratory completed and issued the Natural Resource Management Plan (NRMP) (BNL 2003a), which built on the successes of the Wildlife Management Plan (Naidu 1999). The NRMP describes the program strategy, elements, and planned activities for managing the various resources found on site. The plan and related information about natural resources at the Laboratory can be found at http://www.bnl.gov/esd/wildlife/.

6.1.1 Identification and Mapping

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

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

Figure 6-1. Vegetation Map of BNL.

and the crested fringed orchid (*Plantathera cristata*) have been identified on the BNL site in the past. Four New York State threatened species have been positively identified on site and two other species are considered likely to be present. The banded sunfish (*Enneacanthus obesus*), the swamp darter fish (*Etheostoma fusiforme*), and the stiff goldenrod plant (*Solidago rigida*) have been previously reported (BNL 2000). The northern harrier (*Circus cyaneus*) was seen hunting over open fields in November 2003. The frosted elfin butterfly (*Callophrys irus*) has been identified as possibly being at BNL, based on historic documentation and the presence of its preferred habitat and host plant (wild lupine). In addition, stargrass (*Aletris farinose*) has historically been found and is likely to persist. Several other species that either inhabit the BNL site, visit during migration, or have historically been identified at BNL, are listed as rare, species of special concern, or exploitably vulnerable by New York State (Table 6-1).

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

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

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

6.1.2 Habitat Protection and Enhancement

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

6.1.2.1 Tiger Salamander Efforts

To safeguard tiger salamander breeding areas, a map of these locations is reviewed when new projects are proposed. Distribution of the map is limited, to protect the tiger salamander from exploitation by collectors and the pet trade. The map is updated annually as new information concerning tiger salamanders is generated through research and monitoring. Other efforts to protect this state endangered species include determining when adult salamanders are migrat-

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

Water quality testing is conducted as part of the routine monitoring of water basins. In cooperation with the New York State Department of Environmental Conservation (NYSDEC), habitat surveys have been conducted annually since 1999. Biologists conducting egg mass and larval surveys have confirmed that 17 on-site ponds are used by tiger salamanders. Normally, all ponds that had egg masses during the spring surveys are surveyed again in June and July to check for the presence of larval salamanders. Egg mass surveys of 26 ponds plus additional flooded depressions at BNL were conducted in 2003. An intern working through the Summer Undergraduate Laboratory Intern program offered by DOE and BNL's Office of Education Programs, conducted surveys of two known tiger salamander ponds. The results of this study showed large numbers of tiger salamanders emerging from one pond and marbled salamanders from the second pond. The success of this survey resulted in further interest by NYSDEC and researchers at SUNY Binghamton. Additional work on tiger salamanders is planned for spring and summer of 2004, and a doctoral student will use BNL as a study site. Information acquired from this research is entered into a database and portions of the data are linked to a GIS. These data are used to visualize distributions, track reproductive success, and identify areas for focused management or study.

6.1.2.2 Eastern Hognosed Snake

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

6.1.2.3 Other Species

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

odoratus), spotted turtle (*Clemmys guttata*), eastern box turtle (*Terrapene c. Carolina*), hog-nosed snake (*Heterodon platirhinos*), northern black racer (*Coluber constrictor*), eastern ribbon snake (*Thamnophis s. sauritus*), eastern garter snake (*Thamnophis s. sirtalis*), northern water snake (*Nerodia s. sipedon*), northern ring-necked snake (*Diadophis puctatus edwardsi*), brown snake (*Storeria d. dekayi*), and the northern red-bellied snake (*Storeria occiptiomaculata*). This listing indicates that BNL has one of the most diverse herpetofaunal assemblages on Long Island. One species, the northern red-bellied snake, had not been reported on Long Island for nearly 60 years prior to its discovery in October 2003.

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

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

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

6.1.3 Population Management

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

6.1.3.1 Wild Turkeys

The forested areas of BNL provide good nesting and foraging habitat for wild turkey *(Meleagris gallapavo)*. The on-site population was estimated at 60 to 80 birds in 1999 and had grown to around 250 birds by the end of 2001. Due to drought conditions, the population

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

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

6.1.3.2 White-Tailed Deer

BNL consistently updates information on the resident population of white-tailed deer (*Odocoileus virginianus*). As there are no natural predators on site and hunting is not permitted at BNL, there are no significant pressures on the population to migrate beyond their typical home range of approximately 1 square mile. A 1992 study indicated that the population of deer on site exceeded 700, or approximately 85 per square mile (Thomlinson 1993). Normally, a population density of 10 to 30 per square mile is considered an optimum sustainable level for a given area. This would equate to approximately 80 to 250 deer inhabiting the BNL property, under normal circumstances. This was the approximate density in 1966, when the Laboratory reported an estimate of 267 deer on site (Dwyer 1966). The current estimate, based on surveys conducted late in 2003, is 1,784 deer, or approximately 217 deer per square mile. Significant damage to the ecosystems can occur when there are only 8 deer per square mile.

The deer surveys are conducted at least two times per year: mid-spring before fawns are born and late summer after all fawns have been born. Depending on winter weather conditions, late winter surveys are conducted to determine mortality resulting from weather. These surveys track reproductive success and mortality. In 2003, spring surveys indicated a population of 1,202 deer. Late summer surveys estimated 1,784 deer, for an 11 percent increase in the population over the previous year, and a 48 percent increase over the spring population. The significant increase resulted in higher rates of car–deer accidents in 2003. The spring count of 1,202 deer indicated a winter mortality of approximately 25 percent. The survey methods used require good weather for accurate counts. An infrared aerial survey would be more accurate and less dependent on weather conditions. In 2003, the Upton Reserve committee began discussing plans for conducting an infrared aerial survey of several Long Island properties, including BNL.

Deer overpopulation can affect animal and human health (e.g., animal starvation, Lyme disease from deer ticks, collision injuries—both human and animal), species diversity (songbird species reduction due to selective grazing and destruction of habitat by deer), and property values (auto damage and browsing damage to ornamental plantings). In 2003, there were 24 deer-related collisions on site, compared to the 20 accidents documented in 2002. This increase in the number of on-site collisions is attributed to increasing populations. Deer health appeared to be affected due to drought conditions that reduced the summer and fall food sources. Deer damage to vegetation around buildings was not significant during the winter of 2002–2003, due to mild temperatures, but some damage from deer browse was evident on ornamental vegetation. Although damage to shrubbery is not a threat to human health, it is undesirable because it may result in the need to replace shrubs, at substantial cost.

Because the high deer population is a regional problem, BNL is working on the issue with other entities. BNL is represented on a deer advisory panel for the hamlet of Lloyd Harbor. In addition, BNL environmental biologists would like to see a regional approach to deer management in place before attempting large-scale deer management on site. Options

for deer management are limited, and most are controversial. A regional approach would benefit the community, land managers, and the health of the deer population.

6.1.4 Compliance Assurance and Potential Impact Assessment

The National Environmental Policy Act (NEPA) review process at BNL is one of the keys to ensuring that environmental impacts of a proposed action or activity are adequately evaluated and addressed. BNL will continue to use NEPA (or NEPA-like) processes under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Environmental Restoration Program when identifying potential environmental impacts associated with site activities—especially with physical alterations. As appropriate, stakeholders such as EPA, NYSDEC, Suffolk County Department of Health Services, The Nature Conservancy, the Town of Brookhaven, the Community Advisory Council, and local environmental advocacy groups are involved in reviewing major projects that have the potential for significant environmental impacts.

6.2 UPTON ECOLOGICAL AND RESEARCH RESERVE

On November 9, 2000, then-Secretary of Energy Bill Richardson, and Susan MacMahon, Acting Regional Director of Region 5 FWS, dedicated 530 acres of Laboratory property as an ecological research reserve. The property was designated by DOE as the Upton Ecological and Research Reserve (Upton Reserve) and is managed by FWS under an Interagency Agreement (DOE–FWS 2000). Additional information on the establishment of the Upton Reserve and accomplishments during 2003 can be found at http://www.bnl.gov/esd/reserve/default.htm. The Upton Reserve, near the eastern boundary of BNL (Figure 6-2), is home to a wide variety of flora and fauna. It contains wetlands and is largely within the core preservation area of the Long Island Central Pine Barrens. Based on information from the 1994–1995 biological survey of BNL, experts believe the reserve is home to more than 200 plant species and at least 162 species of mammals, birds, fish, reptiles, and amphibians (LMS 1995).

In establishing the Upton Reserve, DOE committed to provide FWS with $1 million over a five-year period, to manage the reserve. In 2001, the first full year of the reserve's existence, FWS hired two biologists, formally established the boundary, and posted the area. During 2002, the staff conducted baseline biological survey work, initiated basic research, and funded educational programs in conjunction with BNL, Suffolk County Community College, and Longwood High School. In 2003, grants were awarded and research was initiated involving the Upton Reserve and Stony Brook University, Dowling College, and Rutgers University.

The Interagency Agreement that established the Upton Reserve specified the formation of a Technical Advisory Group (TAG), which includes the reserve's supervisory FWS biologist and representatives from NYSDEC, Suffolk County Parks Department, Central Pine Barrens Joint Policy and Planning Commission, DOE, BNL's Citizens Advisory Council, Brookhaven Executive Roundtable, Brookhaven Science Associates, and The Nature Conservancy. The TAG's primary responsibility is to help develop the comprehensive Natural Resource Management Plan for both BNL and the Upton Reserve. This plan replaces the Wildlife Management Plan developed in 1999. The TAG also has developed criteria for soliciting and reviewing proposals and awarding funds for research to be conducted within the Upton Reserve. The TAG has approved research proposals that include an assessment of the effects of prescribed fire on the survival of orange-striped oakmoth (*Anisota senatoria*) pupae, and a project to investigate why some vines are more invasive than others. Preliminary results of the oak moth study were presented at the annual Pine Barrens Research Forum held at BNL in October 2003. Several other projects were nearing completion at the end of 2003 and reports and/or publications are expected sometime in 2004.

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

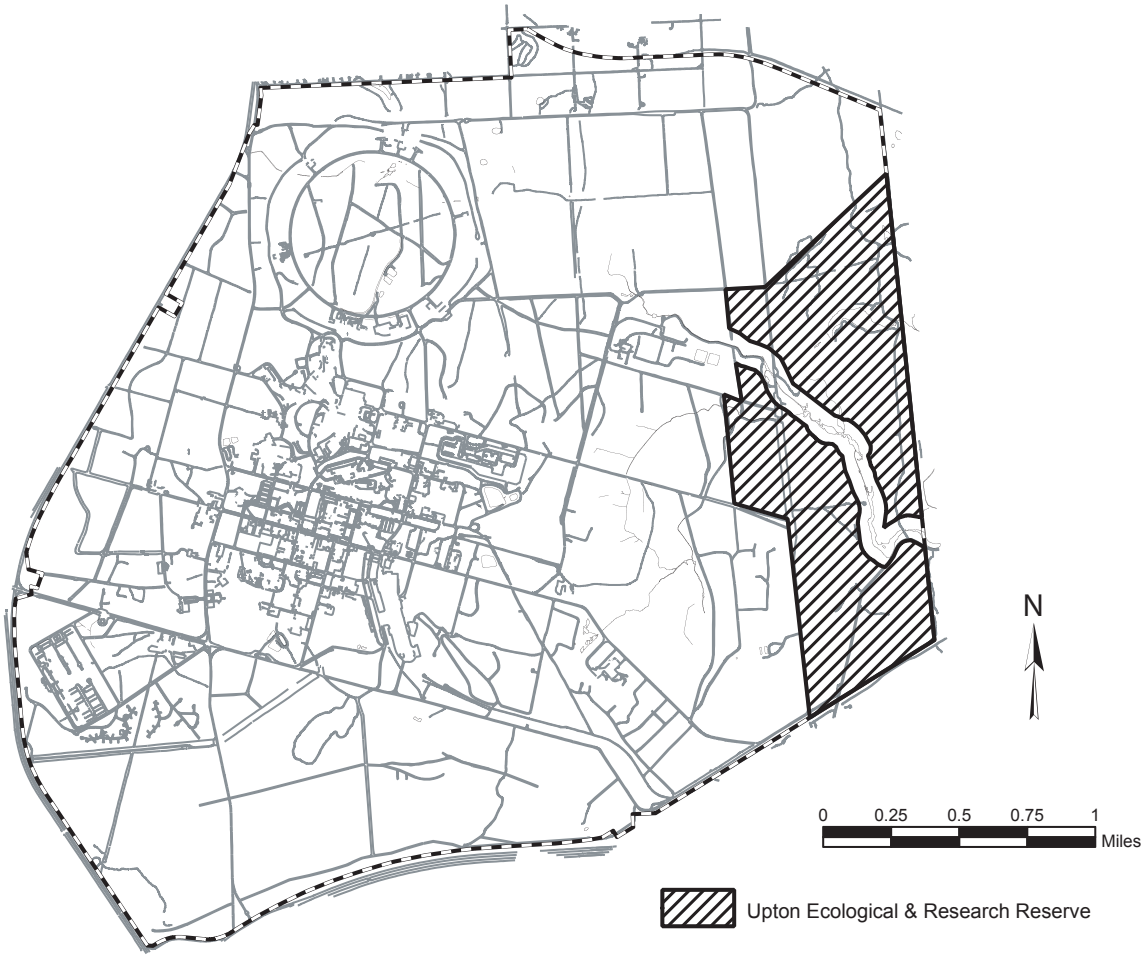

Figure 6-2. BNL Site Map Indicating the Boundary of the Upton Ecological and Research Reserve.

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

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

6.3 MONITORING FLORA AND FAUNA

BNL conducts routine monitoring of flora and fauna to determine the impact of past and present Laboratory activities. Because soils contaminated with cesium-137 (Cs-137), a radioactive isotope of cesium, were used in some BNL landscaping projects in the past, traces have now been found in deer and in other animals and plants. Most radionuclide tables in this chapter list data for both potassium-40 (K-40), a naturally occurring isotope of potassium, and Cs-137. K-40 occurs naturally in the environment and is not uncommon in flora and fauna. It is presented as a comparison to Cs-137, because Cs-137 competes with potassium at a cellular level. General trends indicate that Cs-137 will out-compete potassium when potassium salts are limited in the environment, which is the typical case on Long Island. In general, K-40 values do not receive significant discussion in the scientific literature due to this relationship and the fact that K-40 occurs naturally. The results of the annual sampling conducted under the flora and fauna monitoring program follow.

6.3.1 Deer Sampling

Deer in New York State typically are large, with males weighing, on average, about 150 pounds; females typically weigh one-third less, about 100 pounds. However, deer on Long Island tend to be much smaller, weighing an average of 80 pounds. The available meat on local deer ranges from 20 to 40 pounds per deer. This fact has implications for calculating potential radiation dose to consumers of deer meat containing Cs-137.

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

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

6.3.1.1 Cs-137 in Deer

It has been previously established (BNL 2000) that deer sampled on the BNL site contain higher concentrations of Cs-137 (half-life = 30 years) than deer from greater than 1 mile off site. This is most likely the result of deer consuming contaminated soil and grazing on vegetation growing in soil where elevated Cs-137 levels are known to exist. Cs-137 in soil can be transferred to aboveground plant matter via root uptake, where it then becomes available to browsing animals.

Removal of contaminated soil areas at BNL has occurred under the Laboratory's Environmental Restoration (ER) Program. All major areas of contaminated lawn soils were remediated in 2000. Some soil contamination is still present in areas that are part of Operable Units (OU) I/VI and V (operable units are explained in Chapter 2). The cleanup of areas covered by the Record of Decision for Operable Units I and Radiologically Contaminated Soils (BNL 1999) is scheduled and will be completed as funds are available. Cleanup of one of the two remaining contaminated soil areas under the OU I/VI actions was completed in 2002. A Record of Decision for the Sewage Treatment Plant, a part of OU V, was signed in 2001; cleanup there began in 2002 and was completed in 2003. All buildings at the FWMF were re-

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

The number of deer taken for sampling has steadily increased since 1996. In 1998, a statistical analysis based on existing data suggested that 40 deer from off site and 25 deer from on site were needed to achieve a statistically sound data set. Since that analysis was completed, BNL has attempted to obtain the required number of deer. The number taken each year has varied, due to the sampling method that depends on vehicle/deer accidents and people reporting dead deer. The number of deer hit by cars varies widely from year to year, depending on the population of deer present near major roadways. Figure 6-3 shows the location of all deer samples taken within a 5-mile radius of BNL since 1999. Most of the off-site samples are concentrated along the William Floyd Parkway on the west boundary of BNL, while the concentration on site is near the front gate area and the constructed portions of BNL. This distribution is most likely due to the fact that people on their way to work see and report dead deer. Vehicle collisions with deer on site occur primarily early or late in the day, when deer are more active.

In 2003, Cs-137 concentrations in deer meat samples taken at BNL ranged from 0.07 to 5.57 picocuries per gram (pCi/g) wet weight. The "wet weight" concentration is before a sample is dried for analysis, and is the form most likely to be consumed. Dry weight concentrations are typically higher than wet weight values. The maximum 2003 on-site concentration (5.57 pCi/g wet weight) is slightly higher than the highest level reported in 2002 (4.95 pCi/g wet weight), but much lower than the highest level ever reported (11.74 pCi/g wet weight, in 1996). The arithmetic average concentration in on-site meat samples was 1.06 pCi/g. The average concentration of all off-site meat samples was 1.07 pCi/g wet weight.

Cesium-137 concentrations in off-site deer meat samples were separated into two groups: samples taken within 1 mile of BNL and samples taken farther away (see Table 6-2). Concentrations in meat samples nearby range from 0.07 to 4.23 pCi/g wet weight, with an average of 1.51 pCi/g wet weight; concentrations in meat taken from farther away ranged from nondetectable to 0.32 pCi/g wet weight, with an average of 0.11 pCi/g wet weight.

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

Figure 6-5 presents the five-year trend of on-site and near off-site Cs-137 averages in deer meat. Although there is no statistical difference between the values across the 5 years, there is a statistical difference between values in 2000 (when landscape soils were cleaned up) and values in 2002. The slightly higher value in 2003 compared to 2002 is statistically the same.

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

When possible, liver samples are taken concurrently with meat samples. Liver generally accumulates Cs-137 at a lower rate than muscle tissue (meat). The lower values in liver allow the results to be used somewhat as a validity check for meat values (i.e., if liver values are higher than meat values, results can be considered questionable and should be confirmed). In liver samples collected on site in 2003, the range of Cs-137 concentrations was 0.05 to 1.43 pCi/g wet weight, with an average of 0.33

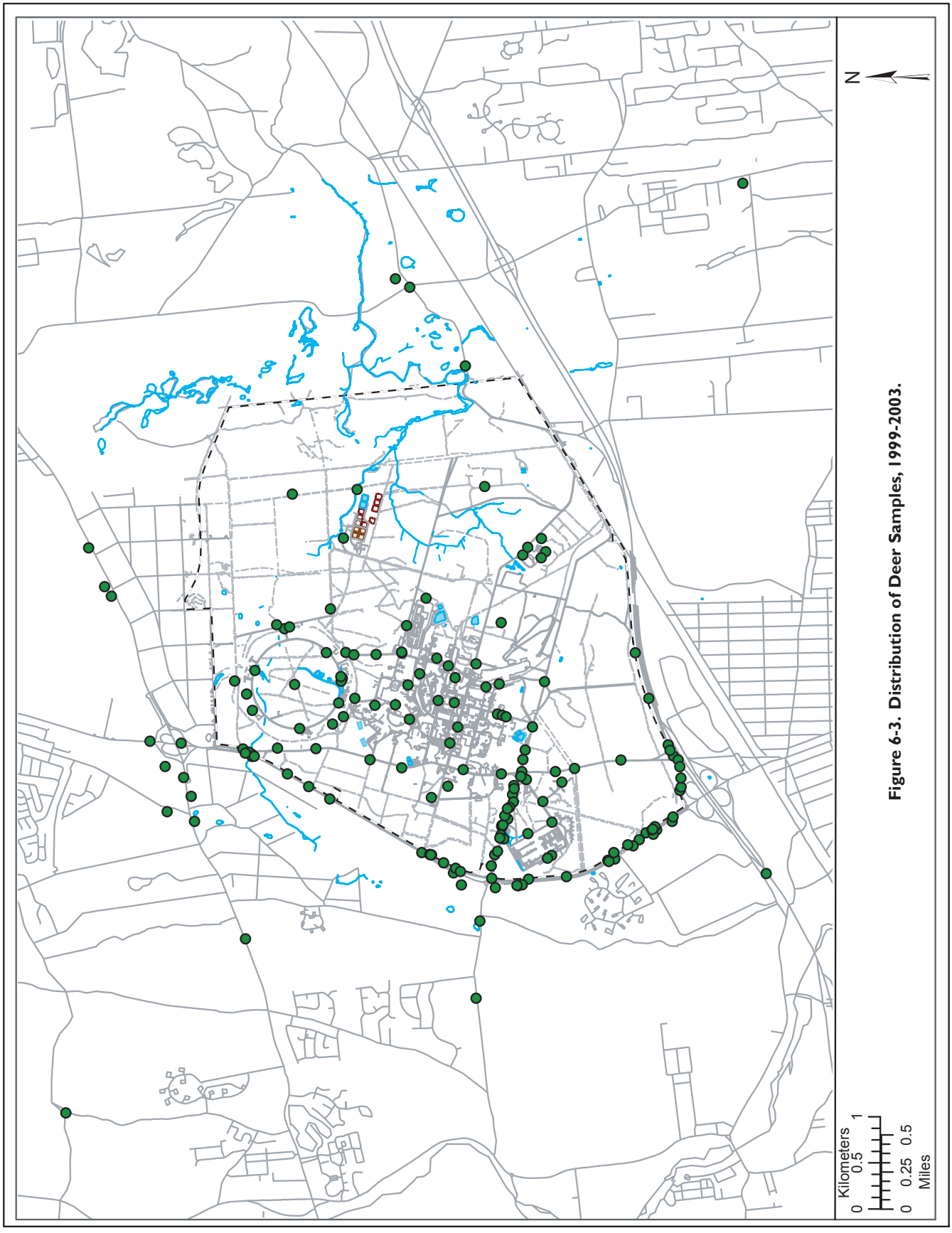

Figure 6-3. Distribution of Deer Samples, 1999-2003.

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

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

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

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

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

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

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

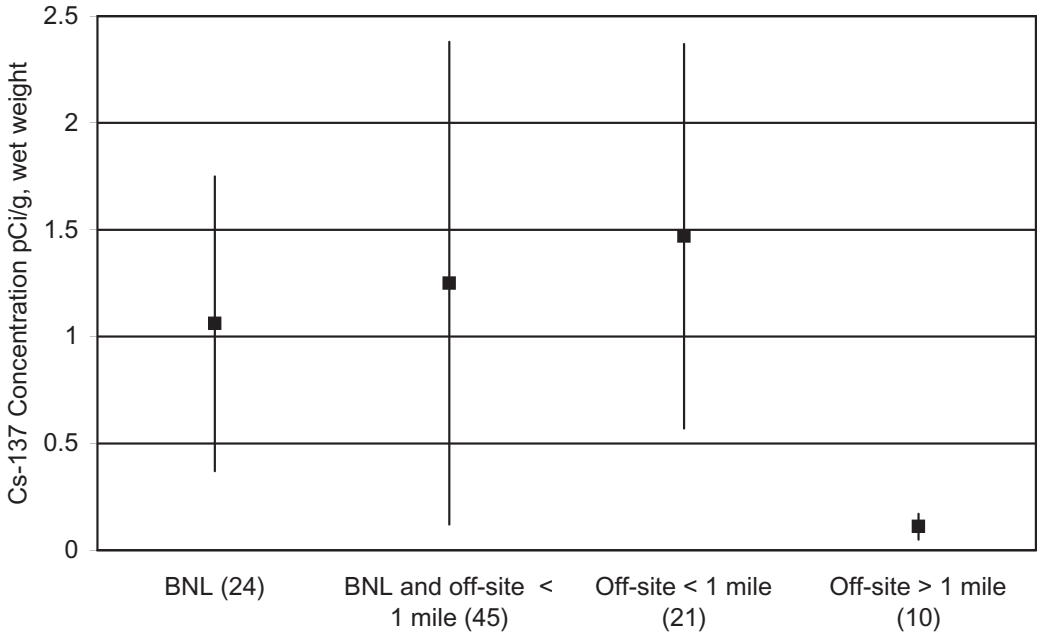
Sample Location	Collection Date	Tissue/ Organ/ Bone	K-40 pCi/g Wet Weight	Cs-137 pCi/g Wet Weight	Sr-90 pCi/g Dry Weight
Smith Rd. south of Wertheim	12/29/03	Flesh	2.84 ± 0.32	0.29 ± 0.03	
		Liver	2.33 ± 0.31	0.01 ± 0.00	
		Bone*			1.09 ± 0.40
Averages by Tissue	**No. of Samples**				
Flesh					
Avg.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

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

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

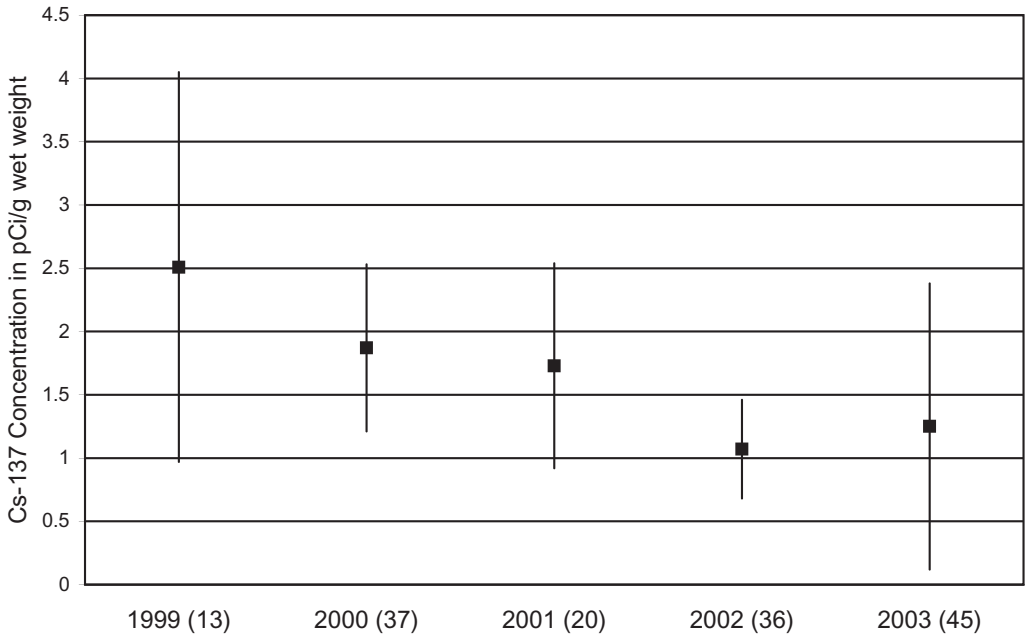
The potential radiological dose resulting from deer meat consumption is discussed in Chapter 8. The New York State Department of Health (NYSDOH) has formally considered the potential public health risk associated with elevated Cs-137 levels in on-site deer and determined that neither hunting restrictions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

With respect to the health of the on-site deer based on their exposure to radionuclides, the International Atomic Energy Agency (IAEA) has concluded that chronic dose rates of 100 millirad per day to even the most radiosensitive species in terrestrial ecosystems are unlikely to cause detrimental effects in animal populations (IAEA 1992). A deer containing a uniform distribution of Cs-137 within muscle tissue at the highest levels observed to date (11.74 pCi/g



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

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



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

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

wet weight, reported in 1996) would carry a total body burden (total amount in body) of about 0.2 μCi. Under these conditions, an animal would receive an absorbed dose of approximately 3 millirad per day, which is only 3 percent of the threshold evaluated by the IAEA. The deer observed and sampled on site appear to have no health effects from the level of Cs-137 found in their tissues, although the general health of the herd is not optimal because of overpopulation.

6.3.1.2 Strontium-90 in Deer Bone

BNL began testing deer bones (when available) for Sr-90 content in 2000, and continued this analysis in 2003. Sr-90 content ranged from nondetectable to 7.65 pCi/g dry weight in on-site samples, with higher values seen in bone taken during special sampling at the FWMF. Sr-90 in off-site samples ranged from nondetectable to 5.75 pCi/g dry weight in samples taken within 1 mile of BNL, and 1.09 to 2.61 pCi/g dry weight in samples taken from locations greater than a mile from BNL. This overlap in values between all samples suggests that Sr-90 is present in the environment at background levels; this is likely a result of worldwide fallout from nuclear weapons testing. Sr-90 is present at very low levels in the environment, is readily incorporated into bone tissue, and may concentrate over time. BNL will continue to test for Sr-90 in bone to develop baseline information on this radionuclide and its presence in deer.

6.3.1.3 Special Sampling of Deer in FWMF

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

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

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

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

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

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

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

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

6.3.2 Small Mammal Sampling

BNL continued small mammal sampling in 2003. The original idea for this sampling was to determine the suitability of using small mammals, primarily squirrels, as a surrogate for deer sampling. Squirrels are readily trapped and tend to eat similar food as deer, but have a much more restricted range and therefore can indicate areas where low levels of contamination may be present. Squirrels were sent to an off-site laboratory for dissection and analysis. The meat was separated from the bone and tested for gamma-emitting radionuclides and the bone was tested for Sr-90. Results of the analyses are presented in Table 6-4. Cs-137 in off-site samples ranged from 0.06 to 0.30 pCi/g dry weight. On-site samples contained Cs-137 ranging from 0.31 to 3.27 pCi/g dry weight. Sr-90 was not detected in any of the bone samples of eight squirrels, four on site and four off site.

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

6.3.3 Other Animals Sampled

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

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

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

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

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

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

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

6.3.4 Fish Sampling

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

Off-site fish sampling continued as in the past. All samples were analyzed for whole-body content of each of the analytes reported; in most instances, the samples were a composite of several fish to ensure adequate sample size for analysis. In 2003, various species of fish were collected off site from Swan Pond, Donahue's Pond, Forge Pond, and Lower Lake on the Carmans River (see Figure 5-8 for sampling stations). Swan Pond is a semi-control location on the Peconic River system (a tributary not connected to the BNL tributary) and Lower Lake on the Carmans River is the non-Peconic control site. Sampling is carried out in cooperation with NYSDEC and through a contract with Cold Spring Harbor Fish Hatchery and Museum. Fifteen samples were taken, representing seven species of fish.

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

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

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

6.3.4.1 Radiological Analysis of Fish

The species collected for radiological analysis in 2003 by BNL, NYSDEC, and through contract labor included brown bullhead (*Ictalurus nebulosus*), chain pickerel (*Esox niger*), largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), pumpkinseed (*Lepomis gibbosus*), golden shiner (*Notemigonus crysoleucas*), and brown trout (*Salmo trutta*). Gamma spectroscopy analysis was performed on all samples. Table 6-5 presents specific information on the sampling location, species collected, and analytical results. All sample results are presented as dry weight concentrations.

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

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

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

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

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

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

species with similar feeding habits (i.e., bottom feeders such as brown bullhead should be compared to other bottom feeders—in this case, other brown bullhead). Cs-137 concentrations in bullhead collected at all locations along the Peconic River had values less than 0.36 pCi/g dry weight, whereas values for bullhead at Lower Lake on the Carmans River had 0.05 pCi/g dry weight. Levels of Cs-137 in all fish species appear to be declining, compared with historic values.

Though it is clear from discharge records and sediment sampling that past BNL operations have contributed to anthropogenic (human-caused) radionuclide levels in the Peconic River system, most of these radionuclides—with the exception of tritium—were released between the late 1950s and early 1970s, and concentrations continue to decline over time through natural decay. Cs-137 has a half-life of 30 years. No Cs-137 was released from the STP to the Peconic River in 2003. See Figure 5-5 for a trend of Cs-137 discharges.

6.3.4.2 Fish Population Assessment

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

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

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

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

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

6.3.4.3 Nonradiological Analysis of Fish

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

Table 6-7 shows the concentration levels of metals in fish for 2003. None of the metal concentrations were considered capable of affecting the health of the consumers of such fish. Due to the fact that values for cadmium, beryllium, nickel, silver, thallium, and vanadium were all less than the MDL for the analytical procedure, they were not included in Table 6-7. Other metals tested but not included in the table include antimony, arsenic, and cobalt. Pumpkinseed and bullhead taken from Swan Pond had a content of 0.36 mg/kg of antimony, while pumpkinseed from Forge Pond had a content of 0.44 mg/kg. Arsenic was present in golden shiners and bluegill taken from Lower Lake on the Carmans River at levels of 0.24 and 0.43 mg/kg,

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

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

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

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

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

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

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

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

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

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

6.3.5 Aquatic Sampling

6.3.5.1 Radiological Analysis

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

6.3.5.2 Metals in Aquatic Samples

Metals analyses (Table 6-10) were conducted on aquatic vegetation and sediments from the Peconic River and Carmans River. Most of the data indicate metals at background levels. The standard used for comparison of sediments is the soil cleanup objectives for heavy metals supported by the Suffolk County Department of Health Services (SCDHS). Vegetation results are compared to soil cleanup standards because metals in vegetation may accumulate via uptake from sediment. In general, metals are seen in vegetation at levels lower than in associated sediment.

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

6.3.5.3 Pesticides and PCBs in Aquatic Samples

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

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

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

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

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

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

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

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

6.3.6 Vegetation Sampling

6.3.6.1 Garden Vegetables

On-site sampling of garden vegetables continued in 2003. Samples of zucchini, cucumber, tomato, pepper, eggplant, and sweet corn were analyzed for Cs-137 content. None of the samples analyzed contained Cs-137. Sampling of off-site farm vegetation was discontinued in 2003 because historic data indicated the absence of BNL-related radionuclides in off-site vegetation. Periodic confirmatory sampling (approximately every 5 years) will be conducted off site to obtain data on farm vegetables.

6.3.6.2 Grassy Plants

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

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

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

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

6.4 SOIL SAMPLING

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

6.5 BASIN SEDIMENTS

A new 5-year testing cycle for basin sediment samples was established in 2003. There are 14 basins associated with outfalls that receive discharges permitted under the State Pollutant Discharge Elimination System (SPDES) permit (see Figure 5-6 for basin locations). A new basin, HN-NS, was added to the group of recharge basins in the southern end of the area near the Relativistic Heavy Ion Collider (RHIC), to manage stormwater runoff from the Alternating Gradient Synchrotron (AGS) complex. Soil samples are taken to a depth of 6 inches and split into 2-inch increments. Samples under HN-NS headings in the associated tables were taken in February 2003 in different areas of the basin; samples under HN-NS-1 were taken during May 2003. No PCBs or pesticides were detected in any of the samples taken at basin HN-NS.

6.5.1 Chemical Analysis

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

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

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

Notes:
MDL = Minimum Detection Limit

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

6.5.2 Metals

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

6.5.3 Radiological Analysis

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

6.6 CHRONIC TOXICITY TESTS, SEWAGE TREATMENT PLANT

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

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

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

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

6.7 PRECIPITATION MONITORING

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

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

6.8 WILDLIFE PROGRAMS

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

In 2003, the Environmental and Waste Management Services Division (EWMSD) hosted four student interns and a high school volunteer during the summer. Two interns from the Community College of Rhode Island and University of Rhode Island worked on identification and distribution of dragonflies and damselflies (Order Odonata). These aquatic insects are common around the ponds and Peconic River on site. The distribution of aquatic invertebrates may be useful for monitoring the health of aquatic systems. In addition, results from the Odonate surveys are expected to supplement

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

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

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

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

In addition to hosting interns, members of EWMSD and other BNL departments volunteered as speakers for schools and civic groups and provided on-site ecology tours. EWMSD also hosted events in association with Earth Day and provided activities to educate Laboratory employees and the general public on the environment and conservation during a Summer Sunday event in July. In October, BNL hosted the Eighth Annual Pine Barrens Research Forum, providing a venue for researchers who are conducting work on pine barrens ecosystems to share and discuss their results. BNL also hosted the annual Wildland Fire Academy, offered by NYSDEC and the Central Pine Barrens Commission. This academy trains fire fighters in the methods of wildland fire suppression, prescribed fire, and fire analysis, using the Incident Command System of wildfire management.

6.9 CULTURAL RESOURCE ACTIVITIES

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

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

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

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

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

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

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

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

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

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

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

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

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

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