Chapter 6

Natural and Cultural Resources

The Brookhaven National Laboratory Wildlife Management Program is designed to protect and manage flora and fauna and their habitats. The Laboratory's wildlife 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. Through this program, BNL focuses on protecting New York State threatened and endangered species, as well as on the Laboratory's role within the greater Long Island Central Pine Barrens ecosystem.

Monitoring to determine whether current or historical activities are affecting wildlife is also part of this program. In 2001, deer and fish sampling results were consistent with previous years. Local farm-grown produce, as well as vegetables grown in the BNL garden plot, continue to support historical analyses that there are no Laboratory-generated radionuclides in farm produce.

Completing the first full year of operation of the Upton Ecological and Research Reserve, its advisory group began research and preservation of the 530-acre area. Two research grants to investigate important local ecological issues were awarded.

In 2001, architectural and cultural resource inventories were completed. Work was completed on a survey to determine the potential historic value of BNL's buildings, in accordance with the National Historic Preservation Act. The High Flux Beam Reactor was determined to be eligible for listing on the National Register of Historic Places; the Brookhaven Graphite Research Reactor complex and Camp Upton's training trenches from World War I were previously determined to be eligible.

6.1 WILDLIFE MANAGEMENT PROGRAM

The purpose of the Wildlife Management Program at BNL is to promote stewardship of the natural resources found at the Laboratory, as well as to integrate natural resource protection with BNL's mission. To meet this purpose, the Laboratory has a *Wildlife Management Plan* that describes the program strategy, elements, and planned activities (Naidu 1999). The plan and related information about natural resources at the Laboratory can be found at the Environmental Services Division website, <http://www.bnl.gov/esd/wildlife/>.

6.1.1 Identification and Mapping

An understanding of the environmental baseline is the foundation of wildlife management planning. Prior to 2001, BNL used a natural resource inventory of the site conducted by the Central Pine Barrens Commission, based on data collected from 1970 to 1990. That inventory focused primarily on vegetation at a coarse scale, but was useful in identifying environmentally sensitive areas and significant wildlife communities. In 2001, through funding managed by the U.S. Fish & Wildlife Service (FWS), the entire BNL property was surveyed using the National Vegetation Standard; a new map was produced that clearly identifies the major vegetation complexes and their extents. An additional tool provided with the vegetation map allows the user to predict distributions of key animal species based on the presence of suitable habitat.

As noted in Chapter 1, a wide variety of vegetation, birds, reptiles, amphibians, and mammals reside at BNL. The only New York State endangered species known to inhabit BNL property is the tiger salamander (*Ambystoma t. tigrinum*, Figure 6-1). Three New York State threatened species have been positively identified on site at BNL and a fourth species is considered likely. The banded sunfish (*Enneacanthus obesus*, Figure 6-2), the swamp darter (*Etheostoma fusiformе*, Figure 6-3), and the stiff goldenrod plant (*Solidago rigida*) have been previously reported (BNL 2000). A fourth species, 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, several species that inhabit the BNL site or visit during migration are listed as "rare," "species of special concern," or "exploitably vulnerable" by New York State (Table 6-1).

Figure 6-1. Tiger Salamander ***(Ambystoma t. tigrinum).***

Figure 6-2. Banded Sunfish ***(Enneacanthus obesus).*** This fish was released immediately after the picture was taken.

Figure 6-3. Swamp Darter (*Etheostoma fusiformе***).** This fish was released immediately after the picture was taken.

6.1.2 Habitat Protection and Enhancement

BNL takes many precautions to protect on-site habitat 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

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

Common Name	Scientific Name	State Status
Fish		
Banded sunfish	*Enneacanthus obesus*	T
Swamp darter	*Etheostoma fusiforme*	T
Amphibians		
Eastern tiger salamander	*Ambystoma tigrinum tigrinum*	E
Marbled salamander	*Ambystoma opacum*	SC
Reptiles		
Spotted turtle	*Clemmys guttata*	SC
Eastern box turtle	*Terrapene carolina*	SC
Eastern hognose snake	*Heterodon platyrhinos*	SC
Birds (nesting or common)		
Horned lark	*Eremophila alpestris*	SC
Whip-poor-will	*Caprimulgus vociferus*	SC
Vesper sparrow	*Pooecetes gramineus*	SC
Grasshopper sparrow	*Ammodramus savannarum*	SC
Plants		
Butterfly weed	*Asclepias tuberosa*	V
Spotted wintergreen	*Chimaphila maculata*	V
Flowering dogwood	*Cornus florida*	V
Pink lady's slipper	*Cypripedium acaule*	V
Winterberry	*Ilex verticillata*	V
Sheep laurel	*Kalmia angustifolia*	V
Narrow-leafed bush clover	*Lespedeza augustifolia*	R
Ground pine	*Lycopodium obscurum*	V
Bayberry	*Myrica pensylvanica*	V
Cinnamon fern	*Osmunda cinnamomera*	V
Clayton's fern	*Osmunda claytoniana*	V
Royal fern	*Osmunda regalis*	V
Swamp azalea	*Rhododendron viscosum*	V
Stiff goldenrod	*Solidago rigida*	T
New York fern	*Thelypteris novaboracensis*	V
Marsh fern	*Thelypteris palustris*	V
Virginia chain-fern	*Woodwardia virginica*	V

Notes:
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

remove pollutant sources that could contaminate habitats. Human access to critical habitats is restricted. In some cases, habitats are enhanced to improve survival or increase populations. After due consideration, routine activities that are not expected to affect habitat (such as road maintenance) are allowed to proceed.

6.1.2.1 Tiger Salamander Efforts

To safeguard tiger salamander breeding areas, a map of those 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. Other efforts to protect this state endangered species include determining when adult salamanders are migrating toward breeding locations, when metamorphosis has been completed, and when juveniles are migrating after metamorphosis. During these times, construction and maintenance activities near tiger salamander habitat are postponed. All projects planned near tiger salamander habitat must be reviewed by BNL environmental protection staff, and every effort is made to minimize impacts.

Water quality testing is conducted as part of the routine monitoring of water basins. In cooperation with the New York State Department of Conservation (NYSDEC), limited habitat surveys have been conducted annually since 1999. Biologists taking egg mass surveys have confirmed that 15 on-site ponds are used by tiger salamanders. All ponds that had egg masses during the spring surveys were surveyed again in June and July to check for the presence of larval salamanders; two ponds were surrounded by 4-foot × 4-foot plywood cover boards in order to study the dispersal patterns of metamorphic salamanders. Several hundred larvae were seen, captured, measured, and then released. Seven ponds with spring egg masses were thoroughly surveyed, while other ponds were visited but surveys were not completed due to high water levels. The results of surveys and cover board studies help determine the length of the breeding period and provide information that is needed to determine a window for any activities in and around the breeding areas. The information may also identify activities that could be affecting this

species and changes in site use that may be needed. Information acquired from surveys is entered into a database and will eventually be linked to a geographic information system (GIS). The data will be used to visualize distributions, track reproductive success, and identify areas for focused management or study.

6.1.2.2 Other Species

As part of the tiger salamander surveys, incidental information is recorded on other amphibian species located in and around the tiger salamander habitat. Other species recorded include the northern redback salamander (*Plethodon c. cinereus),* marbled salamander (*Ambystoma opacum*), spring peeper (*Pseudacris crucifer*), wood frog (*Rana sylvatica*), gray tree frog (*Hyla versicolor*), bullfrog (*Rana catesbiana*), green frog (*Rana clamitans*), and Fowler's toad (*Bufo fowleri*). Banded sunfish protection efforts include ensuring that adequate flow of the river is maintained within areas currently identified as sunfish habitat, ensuring that existing vegetation in the sunfish habitat is not disturbed, and evaluating all river remediation efforts for potential impacts on these habitats. River surveys in 2001 indicated the continued presence of two small populations of banded sunfish, including one location that also contains a population of the swamp darter, another species that is threatened in New York.

BNL's *Wildlife 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. In 2001, the Laboratory conducted its second year of routine monitoring of songbirds at five permanent bird survey routes in various habitats on site. Monthly surveys were conducted, starting at the end of March and extending to the end of October. The surveys in 2001 resulted in the identification of 73 species during the year—20 more species than the previous year. Seventeen species were counted only once and are likely to be migrants stopping briefly at BNL. The two most diverse observation transects pass near wetlands by the Biology Fields and the Peconic River. The three 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, and there are plans to link the data 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*). In 2001, BNL installed 10 new bluebird boxes, bringing the total to 36 boxes installed around open grassland areas of the site to enhance the bluebird population. Boxes were monitored approximately every three weeks during the breeding season to determine use and nesting success. Nineteen bluebird nests were observed. House wrens (*Troglodytes aedon*) produced seven nests, of which four were built over bluebird nests after the bluebirds had left. BNL presented bluebird boxes to the winners of BNL Environmental Awards and to winners of the annual *Site Environmental Report* art contest. The gift of nest boxes encourages habitat enhancement within the urban (and suburban) environment.

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 wild turkeys (*Meleagris gallopavo*) on site are doing well. The forested areas of BNL provide good nesting and foraging habitat for this large bird. 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. The large population of turkeys on site generated interest among the news media in 2001, resulting in a feature-length article in *The New York Times* (Nov. 25, 2001). Updated population reports are periodically sent to NYSDEC to assist with their population estimates. The turkey population will continue to be monitored to determine its reproductive success.

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 one 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 2001, is 1,160 deer, or approximately 140 deer per square mile.

There were even more deer in late 2000, when the estimate was 1,942 animals (BNL 2000). The winter of 2000–2001 was wetter than normal, with significant snowfalls in late February through March. Snow covered the ground for significant periods during these two months, making it difficult for deer to forage. A lack of acorn production in 2000 compounded the problem. Between the lack of food and the difficult foraging conditions, the BNL deer population was reduced by approximately 50 percent during the winter of 2000–2001. Reproduction rates were also affected, rebuilding the population to only 60 percent of the 2000 level. The 2002 figures are expected to increase significantly, due to the mild winter.

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 2001, there were only 8 deer-related collisions reported on site, compared to 24 accidents documented in 2000. This dramatic decrease in the number of on-site collisions is attributed to the large population reduction that occurred. Deer attempting to survive the winter of 2001 caused significant damage to ornamental plantings around BNL buildings. Virtually any edible plant was consumed. While damage to shrubbery was not a threat to human health, it may result in the need to replace shrubs at substantial cost.

BNL submitted National Environmental Policy Act (NEPA) documentation for deer management to DOE for review and approval in October 2001. A request for BNL to prepare an environmental assessment for deer management was made by year's end. BNL is developing the options for initiating the environmental assessment process in 2002. BNL continues to work with state regulators to determine the best method for controlling the deer population.

6.1.4 Compliance Assurance and Potential Impact Assessment

The 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) values under the Comprehensive Environmental Response, Compensation and Liability Act (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 potentially 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 U.S. Fish & Wildlife Service, 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 is on the Internet at <http://www.bnl.gov/esd/reserve.htm>. The Upton Reserve, located on the eastern edge of BNL (Figure 6-4), 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 $1,000,000 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. The new staff began baseline biological survey work, initiated basic research, and funded educational programs in conjunction with BNL and Suffolk County Community College.

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, Citizens Advisory Council, Brookhaven Executive Roundtable, Brookhaven Science Associates, and The Nature Conservancy. The TAG's primary responsibility is to provide technical

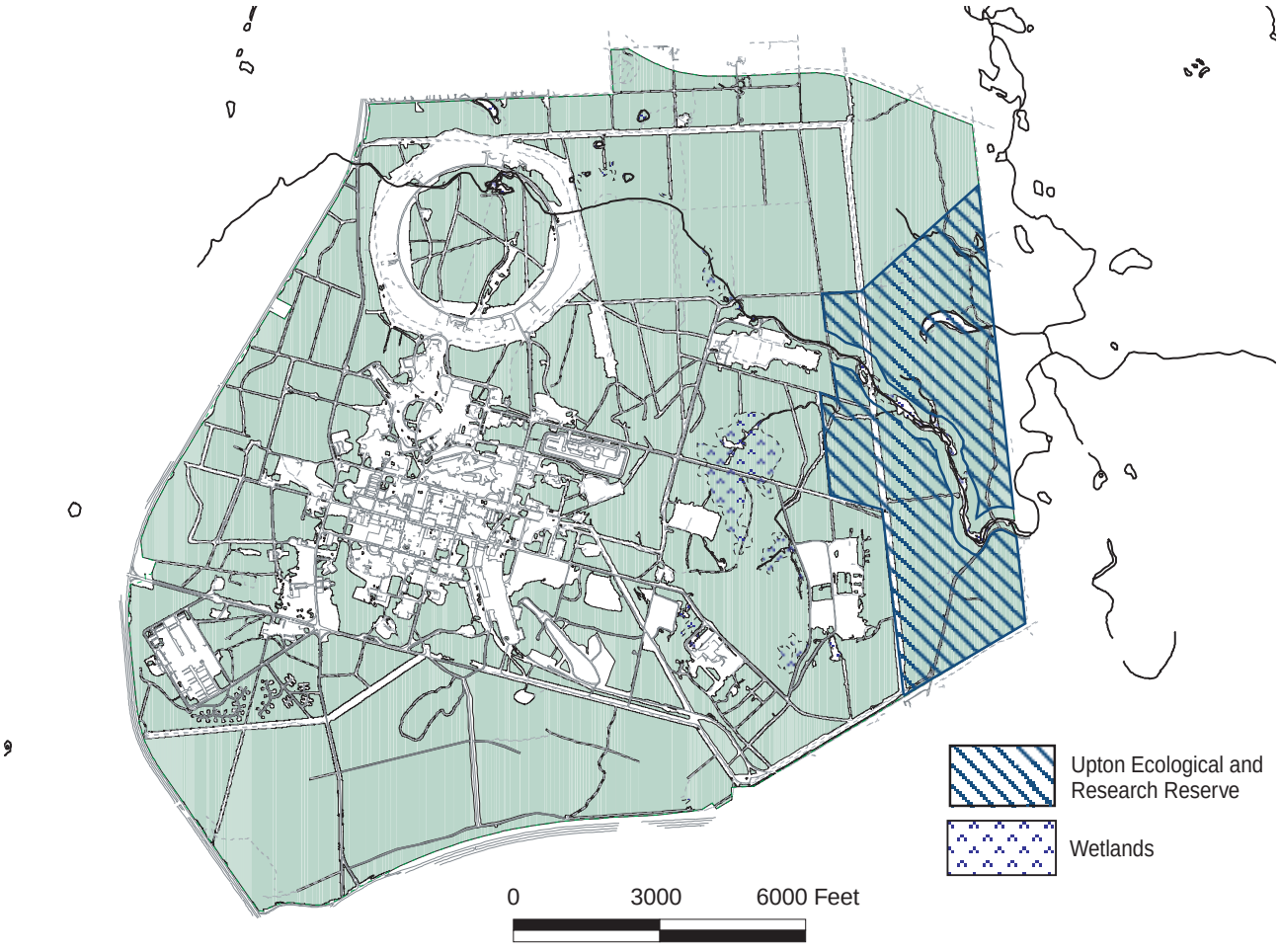

Figure 6-4. BNL Site Map Indicating the Boundary of the Upton Ecological and Research Reserve.

input into the development of a comprehensive natural resource management plan for both BNL and the Upton Reserve. This plan will eventually replace the existing *Wildlife Management Plan*. The TAG also has developed criteria for soliciting and reviewing proposals and awarding funds for research to be conducted within the Upton Reserve. By the end of 2001, the TAG had approved two research proposals: one to investigate the physiological responses of oak trees to fall defoliation caused by the orange-striped oakmoth caterpillar (*Anisota senatoria*), and the second to investigate why some plants are more invasive than others.

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 were used in some BNL landscaping projects at some point in the past, traces of contamination are found in deer and possibly in other animals and plants. Most tables of Laboratory radionuclide data list both potassium-40 and cesium-137 data. Potassium-40 occurs naturally in the environment and is not uncommon in flora and fauna. It is presented as a comparison to cesium-137, because cesium-137 competes with potassium at a cellular level. General trends indicate that cesium-137 will out-compete potassium when potassium salts are limited in the environment, which is the typical case on Long Island. In general, potassium-40 values do not receive significant discussion in the scientific literature due to this relationship and the fact that potassium-40 occurs naturally. The paragraphs below describe the results of the annual sampling conducted under the flora and fauna monitoring program.

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, with an average weight around 80 pounds. The available meat on local deer ranges from 20 to 40 pounds per deer. This fact has implications for calculations of possible human dose from eating BNL deer.

In 2001, as in recent years, an off-site deer sampling program was conducted with the NYSDEC Wildlife Branch and FWS. NYSDEC samples provide data on deer moving beyond BNL boundaries, where they can be legally hunted. NYSDEC also provides control data on deer living far from BNL. Also, FWS informed BNL staff of deer killed in or near the Wertheim National Wildlife Refuge and other FWS properties on Long Island. BNL sampling technicians then collected the samples and processed them for analysis. Samples were also obtained from road kill on and near BNL, and from BNL employees who hunt. The total number of samples obtained near the BNL site increased from past years, due to a large number of deer–vehicle accidents that occurred off site; hunter donations remained the same as in past years. In all, 8 deer samples were obtained on site and 36 were gathered from off-site locations, ranging from adjacent to BNL along the William Floyd Parkway, to as far away as Kingsfield, Maine.

6.3.1.1 Cesium-137 in Deer Meat and Liver

It has been previously established (BNL 1999) that deer taken on the BNL site contain higher concentrations of cesium-137 (half-life = 30 years) than deer taken off site. This is most likely the result of deer consuming contaminated soil and grazing on vegetation growing in soils where elevated cesium-137 levels are known to exist. Cesium-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 site Environmental Restoration Program. All major areas of contamination in 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. 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. A Record of Decision for the Sewage Treatment Plant (STP), a part of OU V, was signed in 2001; cleanup there is scheduled to begin in 2002.

In 2001, cesium-137 concentrations in deer meat samples taken at BNL ranged from nondetectable to 4.31 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 2001 on-site concentration (4.31 pCi/g wet weight) is significantly lower than the highest level reported in 2000 (7.31 pCi/g wet weight) and much lower than the highest level ever reported (11.74 pCi/g wet weight, in 1996). In 2001, the maximum off-site concentration of cesium-137 in deer meat samples was 6.19 pCi/g wet weight. The arithmetic average concentration in on-site meat samples was 1.44 pCi/g. The average concentration in off-site meat samples was 1.23 pCi/g wet weight.

Cesium-137 concentrations in off-site deer meat samples were separated into two groups: samples taken within one mile of BNL and samples taken farther away (see Table 6-2). Concentrations in meat samples nearby range from 0.11 to 6.19 pCi/g; concentrations in meat taken from farther away ranged from being nondetectable to 5.34 pCi/g.

Figure 6-5 compares the ranges of cesium-137 concentrations in meat samples from on-site and off-site deer collected since 1996. The majority of all samples taken both on and off site are at or below 1 pCi/g wet weight.

In liver samples collected on site, the maximum cesium-137 concentration was 2.62 pCi/g and the average was 0.50 pCi/g. Concentrations in off-site deer liver samples ranged from nondetectable to 1.47 pCi/g wet weight, with the average for all off-site liver samples being 0.45 pCi/g.

Figure 6-6 presents the five-year trend in arithmetic averages of both on- and off-site cesium-137 concentrations in deer meat. The on-site trend was essentially level compared to 2000, from 1.48 to 1.44 pCi/g wet weight. The level was maintained even with a lower number of samples, compared to 2000. The trend for off-site samples indicates a decline from 1999 and 2000, where values had appeared to be leveling off. The off-site average declined from approximately 2.07 to 1.23 pCi/g wet weight.

The arithmetic average of cesium-137 in the 43 samples taken since 1996 from locations more than one mile from BNL is 0.78 pCi/g. The on-site average concentration of 1.44 pCi/g is therefore 1.85 times greater than the average off-site concentration. This ratio is lower than that reported in 2000, which was 2.14.

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 cesium-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 cesium-137 at the highest levels observed to date (11.74 pCi/g wet weight reported in 1996) would carry a total body burden 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 established by IAEA. The deer observed and sampled on site appear to have no health effects from the level of cesium-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 bone (when available) for strontium-90 (Sr-90) content in 2000 and continued this analysis in 2001. Strontium-90 content ranged from 0.44 to 3.95 pCi/g dry weight in on-site samples, 0.92 to 5.88 pCi/g dry weight in samples taken within one mile of BNL, and 0.46 to 6.34 pCi/g dry weight in samples taken from locations greater than a mile from BNL. This overlap in values between all samples suggests that strontium-90 is present in the environment at background levels; it is likely a

Table 6-2. Radiological Analysis Results of Deer Tissue.

Sampling Location	Collection Date	Tissue	K-40 pCi/g, Wet Wt.	Cs-137 pCi/g, Wet Wt.	Sr-90 pCi/g, Dry Wt.
BNL					
Building 51	01/23/01	Flesh	2.52 ± 0.44	0.09 ± 0.02	
150 ft. west of Main Gate	02/23/01	Flesh	4.45 ± 0.91	0.26 ± 0.06	
	02/23/01	Flesh*	2.39 ± 0.40	0.17 ± 0.03	
	02/23/01	Liver	1.97 ± 0.36	0.05 ± 0.02	
	02/23/01	Bone			2.59 ± 0.30
Building 460	03/13/01	Flesh	2.69 ± 0.45	0.05 ± 0.01	
	03/13/01	Liver	4.31 ± 1.85	ND	
	03/13/01	Bone			2.52 ± 0.39
Gamma Forest, East RHIC	04/01/01	Liver	1.89 ± 0.38	0.11 ± 0.03	
	04/01/01	Bone			3.95 ± 0.59
Building 901	04/05/01	Flesh	5.40 ± 1.16	ND	
	04/05/01	Liver	1.95 ± 0.37	ND	
	04/05/01	Bone			3.42 ± 0.65
Princeton Ave. at Vehicle Monitoring Station	07/28/01	Flesh	2.47 ± 0.41	0.69 ± 0.12	
	07/28/01	Liver	1.81 ± 0.34	0.29 ± 0.05	
	07/28/01	Bone			1.61 ± 0.46
Upton Rd. .25 miles north of RHIC Access Rd	08/21/01	Flesh	2.93 ± 0.48	4.31 ± 0.72	
	08/21/01	Flesh**	2.59 ± 0.44	4.01 ± 0.67	
	08/21/01	Liver	ND	ND	
	08/21/01	Liver**	4.58 ± 1.27	2.62 ± 0.61	
	08/21/01	Bone			3.40 ± 0.48
Bell and Upton Rd.	11/28/01	Flesh	2.26 ± 0.40	3.4 ± 0.57	
	11/28/01	Liver	2.03 ± 0.47	0.96 ± 0.22	
	11/28/01	Bone			0.44 ± 0.21
Off site < 1 mile					
William Floyd Prkwy	12/26/00	Flesh	2.07 ± 0.35	1.08 ± 0.18	
	12/26/00	Liver	1.51 ± 0.27	0.19 ± 0.03	
	12/26/00	Bone			5.88 ± 0.85
	12/26/00	Bone*			4.15 ± 0.61
William Floyd Prkwy	01/17/01	Flesh	2.37 ± 0.40	1.91 ± 0.32	
	01/17/01	Liver	3.12 ± 0.74	1.47 ± 0.26	
	01/17/01	Bone			4.27 ± 0.49
211 North Street (doe)	04/18/01	Flesh	2.29 ± 0.41	0.25 ± 0.05	
	04/18/01	Bone			5.51 ± 0.67
	04/18/01	Flesh	3.74 ± 0.91	0.38 ± 0.09	
	04/18/01	Flesh*	2.79 ± 0.62	0.30 ± 0.07	
North of Longwood Rd.	05/12/01	Flesh	2.22 ± 0.39	0.09 ± 0.02	
	05/12/01	Bone			4.72 ± 0.61
211 North Street	06/27/01	Flesh	5.73 ± 1.30	1.20 ± 0.26	
	06/27/01	Bone			3.55 ± 0.55
William Floyd Prkwy .5 miles north of Main Gate	08/31/01	Flesh	2.76 ± 0.65	0.72 ± 0.14	
	08/31/01	Liver	2.38 ± 0.43	0.75 ± 0.13	
	08/31/01	Bone			2.72 ± 0.40
William Floyd Prkwy	09/28/01	Flesh	2.38 ± 0.40	5.27 ± 0.88	
	09/28/01	Liver	1.99 ± 0.34	1.41 ± 0.24	
	09/28/01	Bone			2.77 ± 0.53

(continued on next page)

Table 6-2. Radiological Analysis Results of Deer Tissue *(continued)*.

Sampling Location	Collection Date	Tissue	K-40 pCi/g, Wet Wt.	Cs-137 pCi/g, Wet Wt.	Sr-90 pCi/g, Dry Wt.
North Street and Wading River Rd.	10/03/01	Flesh	2.55 ± 0.43	0.99 ± 0.17	
	10/03/01	Liver	2.23 ± 0.40	0.20 ± 0.04	
	10/03/01	Bone			2.48 ± 0.45
William Floyd Prkwy	10/03/01	Flesh	2.29 ± 0.39	2.17 ± 0.37	
	10/03/01	Liver	4.02 ± 0.91	1.21 ± 0.25	
	10/03/01	Bone			2.00 ± 0.35
William Floyd Prkwy North of Rt. 25	10/10/01	Flesh	2.17 ± 0.38	1.56 ± 0.26	
	10/10/01	Bone			2.21 ± 0.45
William Floyd Prkwy .25 miles north of Main Gate	10/30/01	Flesh	2.92 ± 0.76	2.79 ± 0.52	
	10/30/01	Bone			0.92 ± 0.29
William Floyd Prkwy .125 miles north of Main Gate	11/02/01	Flesh	1.91 ± 0.35	2.62 ± 0.45	
	11/02/01	Bone			ND
William Floyd Prkwy	12/05/01	Flesh	2.45 ± 0.42	6.19 ± 1.04	
	12/05/01	Bone			1.43 ± 0.34
William Floyd Prkwy	12/06/01	Flesh	2.20 ± 0.38	0.21 ± 0.04	
	12/06/01	Flesh*	1.86 ± 0.32	0.11 ± 0.02	
	12/06/01	Liver	2.85 ± 0.48	0.27 ± 0.05	
	12/06/01	Bone			1.26 ± 0.38
Off site > 1 mile					
Manorville, deer 5	12/03/00	Heart	4.23 ± 1.57	1.67 ± 0.39	
	12/03/00	Liver	2.65 ± 0.71	0.52 ± 0.11	
Manorville, deer 4	12/07/00	Flesh	1.95 ± 0.35	0.60 ± 0.10	
	12/07/00	Flesh*	1.84 ± 0.33	0.52 ± 0.09	
	12/07/00	Bone			3.77 ± 0.52
	12/07/00	Bone*			3.31 ± 0.59
Manorville, deer 6	12/07/00	Flesh	3.59 ± 0.64	1.24 ± 0.21	
	12/07/00	Bone			1.99 ± 0.48
	12/07/00	Bone			6.34 ± 0.82
Manorville, deer 2	12/29/00	Liver	1.48 ± 0.30	0.07 ± 0.02	
Smith Rd. N. of RR Tracks	01/02/01	Flesh	5.57 ± 0.58	1.87 ± 0.19	
	01/02/01	Bone			2.74 ± 0.41
Seatuck Wildlife Preserve	01/12/01	Flesh	2.18 ± 0.20	0.02 ± 0.00	
	01/12/01	Bone			3.38 ± 0.40
Seatuck Wildlife Preserve	01/17/01	Flesh	2.80 ± 0.35	ND	
	01/17/01	Liver	1.69 ± 0.16	0.01 ± 0.00	
	01/17/01	Liver*	2.15 ± 0.19	ND	
	01/17/01	Bone			3.14 ± 0.46
Seatuck Wildlife Preserve deer 1	02/06/01	Flesh	2.74 ± 0.73	ND	
	02/06/01	Bone			2.24 ± 0.32
Seatuck Wildlife Preserve deer 2	02/06/01	Flesh	2.24 ± 0.38	0.01 ± 0.01	
	02/06/01	Bone			1.32 ± 0.26
	02/06/01	Bone*			0.87 ± 0.17
Seatuck Wildlife Preserve deer 3	02/06/01	Flesh	1.84 ± 0.33	0.04 ± 0.01	
	02/06/01	Bone			1.99 ± 0.31
Montauk Hwy .25 miles west of Carmens River	02/09/01	Flesh	2.34 ± 0.41	0.05 ± 0.01	
Montauk Hwy and Smith Rd	03/09/01	Flesh	2.42 ± 0.43	0.01 ± 0.01	
	03/09/01	Bone			2.43 ± 0.39

(continued on next page)

Table 6-2. Radiological Analysis Results of Deer Tissue *(concluded)*.

Sampling Location	Collection Date	Tissue	K-40 pCi/g, Wet Wt.	Cs-137 pCi/g, Wet Wt.	Sr-90 pCi/g, Dry Wt.
Montauk Hwy .5 miles west of Carmens River	05/03/01	Flesh	5.67 ± 1.21	ND	
	05/03/01	Liver	2.27 ± 0.64	ND	
	05/03/01	Bone			2.16 ± 0.50
NYSDEC Area 42	10/04/01	Flesh	2.60 ± 0.44	1.31 ± 0.22	
	10/04/01	Bone			1.87 ± 0.41
Shoreham	10/10/01	Flesh	3.51 ± 0.82	0.34 ± 0.08	
	10/10/01	Flesh*	1.54 ± 0.28	0.18 ± 0.03	
	10/10/01	Bone			0.58 ± 0.25
	10/10/01	Bone*			1.62 ± 0.44
William Floyd Prkwy .25 miles south of NAT Center	11/02/01	Flesh	2.49 ± 0.42	2.92 ± 0.49	
	11/02/01	Bone			2.09 ± 0.41
Frowien Rd. East Moriches	11/13/01	Flesh	5.65 ± 1.39	5.34 ± 1.07	
	11/13/01	Bone			0.90 ± 0.25
Kingsfield, Maine	11/19/01	Flesh	3.97 ± 1.18	1.51 ± 0.29	
Route 26, Rome, NY	11/24/01	Bone			0.46 ± 0.24
Maridale, NY	11/25/01	Liver	1.99 ± 0.36	0.01 ± 0.01	
	11/25/01	Bone			1.61 ± 0.30
Beaver Dam Rd.	12/11/01	Flesh	5.49 ± 1.18	ND	
	12/11/01	Bone			2.13 ± 0.46
Merrick Rd.	12/11/01	Flesh	3.46 ± 0.75	1.7 ± 0.32	
	12/11/01	Liver	1.49 ± 0.27	0.25 ± 0.04	
	12/11/01	Bone			1.03 ± 0.31
Averages by Tissue	**No. of samples**				
Flesh					
Average for all samples	46		2.96 ± 0.57	1.27 ± 0.22	
BNL On-site Avg.	9		3.08 ± 0.57	1.44 ± 0.24	
BNL On-site and Off-site < 1 mile Avg.	26		2.78 ± 0.54	1.57 ± 0.27	
Off-site Avg.	37		2.93 ± 0.57	1.23 ± 0.22	
Off-site Avg. < 1 mile	17		2.63 ± 0.52	1.64 ± 0.29	
Off-site Avg. > 1 mile	20		3.19 ± 0.62	0.88 ± 0.16	
Liver					
Average for all samples	22		2.65 ± 0.71	0.52 ± 0.11	
BNL On-site Avg.	8		2.32 ± 0.63	0.50 ± 0.12	
BNL On-site and Off-site < 1 mile Avg.	15		2.44 ± 0.57	0.64 ± 0.13	
Off-site Avg.	14		2.27 ± 0.44	0.45 ± 0.08	
Off-site Avg. < 1 mile	7		2.59 ± 0.51	0.79 ± 0.14	
Off-site Avg. > 1 mile	7		1.96 ± 0.38	0.12 ± 0.03	
Bone					
Average for all samples	43				2.54 ± 0.43
BNL On-site Avg.	7				2.56 ± 0.44
BNL On-site and Off-site < 1 mile Avg.	22				2.81 ± 0.46
Off-site Avg.	37				2.51 ± 0.43
Off-site Avg. < 1 mile	15				2.92 ± 0.46
Off-site Avg. > 1 mile	22				2.67 ± 0.44

Notes:
All values 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 non detections as 0.
ND = Not Detected
* Duplicate sample
** Re-analysis of sample

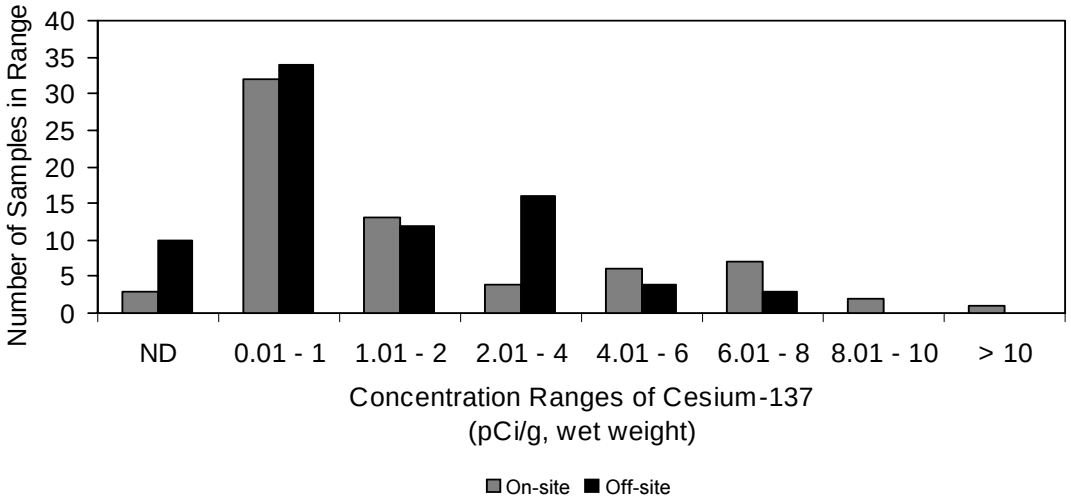

Figure 6-5. Distribution of Samples across Concentration Ranges of CS-137 in Deer Meat Samples Taken (1996—2001).

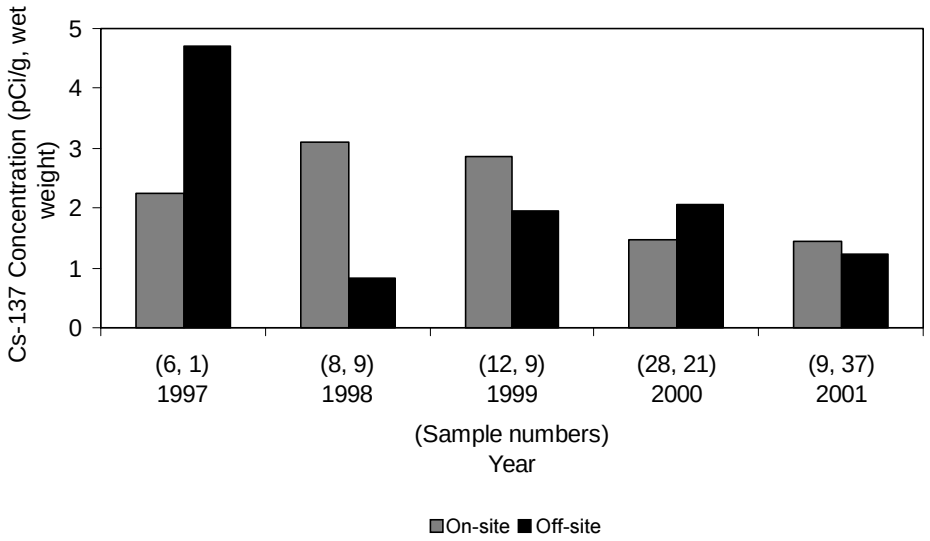

Figure 6-6. Five Year Trend of Cesium-137 Average Concentrations in Meat Taken from On-Site and Off-Site Deer (1997—2001).

result of worldwide fallout from nuclear weapons testing. Strontium-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 strontium-90 in bone to develop baseline information on this radionuclide and its presence in deer.

6.3.2 Small Mammal Sampling

BNL continued small mammal sampling in 2001 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. Squirrels were sent to an off-site lab for dissection and analysis. The meat was tested for gamma-emitting radionuclides and the bone was tested for strontium-90. Results of the analyses are presented in Table 6-3. Cesium-137 in off-site samples ranged from 0.05 to 1.53 pCi/g wet weight. On-site samples contained cesium-137 ranging from 0.07 to 16.60 pCi/g wet weight. Strontium-90 was found in the bone samples of four squirrels, two on site and two off site.

Cesium-137 levels in one squirrel were high, 16.60 pCi/g wet weight, compared to all other

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

Location	Date	K-40 (pCi/g, wet weight)	Cs-137 (pCi/g, wet weight)	Sr-90 (pCi/g, dry weight)
BNL				
Trailer 533	01/17/01	7.12 ± 0.90	0.09 ± 0.02	ND
Bldg. 50	02/15/01	12.50 ± 1.83	0.32 ± 0.06	ND
Firehouse	03/14/01	9.43 ± 1.21	0.39 ± 0.05	0.39 ± 0.16
Firehouse	03/15/01	10.50 ± 1.11	1.06 ± 0.08	0.48 ± 0.16
BNL Rochester and Rowland	04/20/01	8.23 ± 1.59	0.07 ± 0.07	ND
E.Fifth/ MH 192	08/23/01	12.40 ± 0.37	16.60 ± 1.77	ND
Bldg. 729 and Railroad Street	08/30/01	16.40 ± 2.46	4.63 ± 0.51	ND
Railroad Street	10/05/01	17.60 ± 3.39	5.42 ± 0.64	ND
T533	10/10/01	17.60 ± 4.91	0.99 ± 0.49	ND
Bldg. 120	10/11/01	15.40 ± 2.41	2.55 ± 0.40	ND
Off site				
Moriches	01/27/01	10.20 ± 1.03	0.10 ± 0.04	0.28 ± 0.14
	03/15/01	10.90 ± 1.48	0.15 ± 0.04	0.66 ± 0.19
	04/20/01	12.20 ± 1.82	0.05 ± 0.04	ND
	07/29/01	12.20 ± 2.12	0.72 ± 0.13	ND
	10/17/01	15.6 ± 3.11	1.53 ± 0.25	ND

Notes:
All values shown with a 95% confidence interval.
ND = Not Detected
K-40 occurs naturally in the environment and is presented as a comparison to Cs-137.

samples, including deer. The area in which this squirrel was taken is near old sewer lines that contain cesium-137 contamination. Contaminated sewer lines in the area have been isolated from the sewer system. Cleanup of these lines or abandonment in place has been addressed in the Record of Decision for the STP portion of Operable Unit V. Small mammals will continue to be sampled to obtain added information about their usefulness in environmental surveillance and to better define where they may be acquiring cesium-137.

6.3.3 Goose Fecal Material

BNL has a resident population of Canada geese (*Branta canadensis*) that fluctuates between 80 and 120 birds. Canada geese tend to feed on green grasses and weedy plants and may ingest soil as they pull young plants out of the ground. In 2000, BNL initiated the sampling of goose fecal material and lawn grasses to determine if there is potential for the Canada goose population to pick up cesium-137 contamination from some of the landscape soils. Concurrent soil sampling was added to determine if cesium-137 was present in the areas where grass and goose fecal matter were collected. Table 6-4 displays the data from the radiological analysis of the goose fecal material, as well as grass and soil taken from the same areas. With the exception of one recharge basin, soil samples from all of the on-site locations showed very low levels of cesium-137 (soil range: nondetect to 0.62 pCi/g dry weight). None of the grass samples indicated the presence of cesium-137. However, goose fecal material collected near Buildings 438 and 490 and near the Sewage Treatment Plant showed levels of cesium-137 ranging from 0.02 to 0.14 pCi/g wet weight, with the highest value taken near the STP. There is known cesium-137 contamination at the treatment plant, which is scheduled for cleanup in 2002. It also was known that there had been cesium-137 contamination near Building 490; this was remediated in 2000 when contaminated landscape soils were removed sitewide. The levels of cesium-137 in goose fecal material indicate that geese do have the potential to acquire it. However, comparing the range of levels observed between years indicates that cesium-137 levels may be declining

Table 6-4. Radiological Analysis of Goose Fecal Material, Associated Grass Clippings, and Soil.

Location	Material	K-40 (pCi/g, wet weight)	Cs-137 (pCi/g, wet weight)
BNL			
HFBR Lawn	Goose droppings	3.28 ± 0.58	ND
	Grass	10.94 ± 4.29	ND
	Soil*	6.59 ± 1.82	0.23 ± 0.13
Ballfield 6	Goose droppings	8.19 ± 1.52	ND
	Grass	10.25 ± 3.84	ND
	Soil*	6.96 ± 1.77	0.40 ± 0.13
RA5 Recharge Basin	Goose droppings	3.51 ± 0.74	ND
	Grass	5.09 ± 1.19	ND
	Soil*	2.81 ± 0.55	ND
STP Hold-up Pond	Goose droppings	4.13 ± 0.89	0.14 ± 0.04
	Grass	3.30 ± 0.96	ND
	Soil*	6.25 ± 1.07	0.62 ± 0.11
Bldg. 490 North Side	Goose droppings	1.78 ± 0.42	0.03 ± 0.02
Bldg. 438 Parking Lot	Goose droppings	2.65 ± 0.45	0.02 ± 0.01
Off site			
Spring Lake, Middle Island	Goose droppings	ND	ND
	Grass	12.36 ± 10.72	ND

Notes:
All values shown with a 95% confidence interval.
ND = Not Detected
K-40 occurs naturally in the environment and is presented as a comparison to Cs-137.
* = Soil data reported on a dry weight basis.

(just 0.14 pCi/g wet weight in 2001, compared to a maximum of 0.64 in 2000). At present, there are no data about cesium-137 in the geese. If sampling of geese were warranted, BNL would acquire the necessary licenses before obtaining samples.

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 sample sufficiently large 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. (The only on-site sampling in 2001 was performed by New York State in the stretch of river immediately east of the last gauging station on BNL property to Schultz Road, and in Ice Pond just off the Peconic River east of BNL.)

Off-site 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 2001, various species of fish were collected off site from Swan Pond, Donahue's Pond, and Forge Pond (see Chapter 5, Figure 5-9 for locations). Swan Pond is a control location on the Peconic system, and Lower Lake on the Carmans River is the non-Peconic control site. Sampling is carried out through a contract with Cold Springs Harbor Fish Hatchery and Museum.

6.3.4.1 Radiological Analysis of Fish

The species collected in 2001 by BNL and NYSDEC for radiological analysis included Brown bullhead (*Ictalurus nebulosus*), chain pickerel (*Esox niger*), red-finned pickerel (*Esox americanus*), largemouth bass (*Micropterus*

salmoides), black crappie (*Pomoxis nigromaculatus*), bluegill (*Lepomis macrochirus*), pumpkinseed *(Lepomis gibbosus*), yellow perch *(Perca flavescens),* sunfish (*Lepomis spp*.), and golden shiner (*Notemigonus crysoleucas).* Gamma spectroscopy analysis was performed on all samples. Table 6-5 presents specific information on the sampling point, species collected, and analytical results. All sample results are presented as wet weight concentrations. NYSDEC results are based on analysis of fillets, whereas BNL results are based on whole-body analysis.

Cesium-137 was identified at low levels in all samples from the Peconic River system, ranging from 0.06 pCi/g wet weight in pumpkinseed fillets from Swan Pond, to 0.62 pCi/g wet weight in a whole-body analysis of a largemouth bass from Donahue's Pond. It is interesting to note that the highest value the previous year for the Peconic River system was also in a largemouth bass from Donahue's Pond (0.66 pCi/g wet weight). In 2001, fish taken from Lower Lake on the Carmans River (the non-Peconic control location) were either below the minimum detection limit for the analysis or had no detection of cesium-137, except for brown bullhead fillets, which had a level of 0.23 pCi/g wet weight.

In 2001, BNL continued the testing for strontium-90 that was initiated in 2000. Strontium-90 is readily deposited in bone. Values ranged from nondetect to 5.00 pCi/g dry weight in the same largemouth bass taken from Donahue's Pond that had the highest cesium-137 level. Because fish were analyzed for either whole-body content or as fillets, values for strontium-90 may vary widely, 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. The low levels detected in BNL on-site samples may also reflect the small size of the fish used to generate a composite sample. Younger fish have less bone mass than older fish. BNL will continue to test for strontium-90 in off-site samples in order to build baseline values for future comparisons.

Concentrations of naturally occurring potassium-40 were observed to be very consistent in fish from the Peconic River and Carmans River, for both whole body and fillets, validating the comparability of the data. However, differences exist between sample types— whole-body versus fillets. Differences are likely due to laboratory preparation methods (wet analysis or dry analysis), methods for sample counting, and method detection limits. Data with low values are from the NYSDOH laboratory that typically runs wet analysis and long count times, whereas BNL-reported data comes from dry analysis with conversion to wet weight values and shorter count times. Data from BNL's contract laboratory are consistent from year to year.

Some cesium-137 is detectable in the environment worldwide as a result of global fallout from past aboveground nuclear weapons testing. This is evident when examining the analytical results of fish from the control locations. To account for the different feeding habits and weights of various species, it is important to compare species with similar feeding habits (*i.e*., bottom feeders such as brown bullhead should be compared to other bottom feeders—in this case, other brown bullhead). Cesium-137 concentrations in bullhead collected at all locations along the Peconic River had values less than 0.49 pCi/g wet weight, whereas values for bullhead at the control locations of Swan Pond and Lower Lake on the Carmans River had 0.33 and 0.23 pCi/g wet weight, respectively. Largemouth bass had levels below 0.62 pCi/g wet weight at all locations; a comparison between bass at Swan Pond and Lower Lake on the Carmans River shows respective values of 0.54 pCi/g wet weight and nondetect. Using data provided by NYSDEC for fish fillets of the various species (Table 6-5), the levels of cesium-137 decrease with increasing distance from the BNL boundary. Cesium-137 values in fish from both Donahue's Pond and Forge Pond are roughly equivalent to those seen at Swan Pond.

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 (cesium-137 has a half-life of 30 years).

Table 6-5. Radiological Analysis of Fish from the Peconic River System and Control Location.

Location and Fish/Sample Type	K-40 (pCi/g, wet weight)	Cs-137 (pCi/g, wet weight)	Sr-90 (pCi/g, dry weight)
BNL HQ - Schultz Rd.			
Largemouth Bass (fillet)*	3.01 ± 0.16	0.28 ± 0.01	0.18 ± 0.01
Largemouth Bass (fillet)*	2.94 ± 0.13	0.30 ± 0.01	0.09 ± 0.01
Pumpkinseed (fillet)*	2.80 ± 0.30	0.26 ± 0.03	0.19 ± 0.02
Ice Pond			
Chain Pickerel (fillet)*	2.96 ± 0.13	0.32 ± 0.01	0.05 ± 0.01
Swan Pond			
Largemouth Bass (whole body)	11.40 ± 1.57	0.54 ± 0.07	<MDL
Bluegill (whole body)	9.20 ± 1.29	0.29 ± 0.05	<MDL
Brown Bullhead (whole body)	12.70 ± 1.69	0.33 ± 0.06	<MDL
Largemouth Bass (fillet)*	2.72 ± 0.18	0.18 ± 0.01	0.04 ± 0.01
Pumpkinseed (fillet)*	2.76 ± 0.19	0.06 ± 0.01	0.06 ± 0.01
Brown Bullhead (fillet)*	2.89 ± 0.17	0.07 ± 0.01	<MDL
Donahue's Pond			
Bluegill	9.07 ± 1.31	0.41 ± 0.07	1.56 ± 0.46
Brown Bullhead	14.10 ± 2.16	0.49 ± 0.09	1.32 ± 0.37
Largemouth Bass	10.10 ± 2.23	0.62 ± 0.17	5.00 ± 0.75
Sunfish (fillet)*	2.68 ± 0.19	0.19 ± 0.01	0.01 ± 0.00
Chain Pickerel (fillet)*	2.90 ± 0.16	0.28 ± 0.02	0.03 ± 0.00
Forge Pond			
Bluegill (whole body)	8.80 ± 0.86	0.33 ± 0.06	0.90 ± 0.36
Largemouth Bass (whole body)	10.10 ± 1.48	0.56 ± 0.11	0.84 ± 0.37
Brown Bullhead (whole body)	10.20 ± 1.46	0.43 ± 0.07	<MDL
Brown Bullhead (fillet)*	2.66 ± 0.18	0.11 ± 0.01	0.00 ± 0.00
Pumpkinseed (fillet)*	2.70 ± 0.20	0.11 ± 0.01	0.03 ± 0.01
Chain Pickerel (fillet)*	2.88 ± 0.19	0.15 ± 0.01	0.03 ± 0.01
Lower Lake, Carmans River			
Bluegill	10.20 ± 1.28	<MDL	ND
Bluegill	9.33 ± 1.77	ND	ND
Pumpkinseed	9.31 ± 1.45	<MDL	ND
Pumpkinseed (fillet)*	2.50 ± 0.30	< MDL	0.03 ± 0.01
Black Crappie	10.90 ± 1.80	<MDL	ND
Bass	11.90 ± 2.62	ND	ND
Golden Shiner	8.94 ± 1.82	ND	ND
Golden Shiner	11.20 ± 2.12	<MDL	ND
Black Crappie	13.80 ± 3.50	ND	ND
Yellow Perch	12.20 ± 2.91	<MDL	ND
Red-finned Pickerel	19.00 ± 4.67	ND	ND
Brown Bullhead	15.80 ± 2.92	0.23 ± 0.15	ND

Notes:
* = Data provided by NYSDEC.
MDL = Minimum Detection Limit
ND = Not Detected
K-40 occurs naturally in the environment and is presented as a comparison to Cs-137.

6.3.4.2 Fish Population Assessment

As was mentioned earlier, in 2001 BNL suspended fish sampling on site because years of 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 STP to just beyond the east firebreak (Figure 6-7). The results of that survey are summarized in Table 6-6. A total of 106 fish and six species were found in this section of river. The average length of fish ranged from 2.81 inches to 7.06 inches. The largest fish was a 13-inch chain pickerel. The total number of fish is indicative of poor population numbers. One bright point to the surveys was the presence of the banded sunfish, a NYS threatened species, in shallow waters near the east firebreak. This small population appeared to be healthy. Brown bullhead and chain pickerel were the most abundant fish species; the largemouth bass was documented with a single individual. BNL will continue to monitor the population to determine when routine sampling may resume.

6.3.4.3 Nonradiological Analysis of Fish and Shellfish

In 1997, under the Operable Unit V remediation project, the BNL Environmental Restoration 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 in 1999 and 2000; analysis 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. In 2000 and 2001, sampling occurred during July through August. Additionally, there were wide variations in fish size and samples had to be composite whole-body and fillet to obtain significant mass for analysis. These variables make the comparisons difficult, as there can be significant seasonal variations in feeding, energy consumption, and incorporation of nutrients in tissues.

Table 6-6. BNL Peconic River (STP to HMn) Population Survey Results.

	No. Caught	Avg. Size (in.)
Banded Sunfish	18	2.8
Brown Bullhead	43	5.1
Chain Pickerel	20	7.1
Golden Shiner	9	4.4
Largemouth Bass	1	4.4
Pumpkinseed	15	3.9
Total No. of Fish	106	

Table 6-7 shows the concentration levels of metals in fish and shellfish (clams and mussels) for 2001. (Note: NYS only analyzed for mercury.) None of the metal concentrations were considered to be capable of affecting the health of the consumers of such fish or clams. Mercury was found in all fish at levels less than 1.0 mg/kg, which is the consumption standard set by the U.S. Food and Drug Administration. The highest levels of mercury detected were in pumpkinseed (a pan fish), taken from an area east of BNL known as the Ice Pond, at 0.925 mg/kg. The area closest to the Laboratory (BNL-HQ Area) had a peak value for mercury of 0.66 mg/kg, in brown bullhead. There is no fishing allowed on site at BNL, and, in general, fish on site are below legal size limits for retaining.

Figure 6-7. Electroshocking in the Peconic River.

Table 6-7. Metals Analysis of Fish and Shellfish from the Peconic River System and Control Locations.

		Arsenic	Barium	Cadmium	Chromium	Copper	Iron	Lead	Manganese	Mercury	Nickel	Selenium	Silver	Sodium	Zinc
		mg/kg (ppm)													
BNL HQ Area	Brown Bullhead**	-	-	-	-	-	-	-	-	0.24	-	-	-	-	-
	Brown Bullhead**	-	-	-	-	-	-	-	-	0.33	-	-	-	-	-
	Brown Bullhead**	-	-	-	-	-	-	-	-	0.66	-	-	-	-	-
	Pumpkinseed**	-	-	-	-	-	-	-	-	0.20	-	-	-	-	-
	Pumpkinseed**	-	-	-	-	-	-	-	-	0.51	-	-	-	-	-
	Pumpkinseed**	-	-	-	-	-	-	-	-	0.47	-	-	-	-	-
	Pumpkinseed**	-	-	-	-	-	-	-	-	0.40	-	-	-	-	-
Ice Pond	Pumpkinseed**	-	-	-	-	-	-	-	-	0.93	-	-	-	-	-
	Pumpkinseed**	-	-	-	-	-	-	-	-	0.54	-	-	-	-	-
	Pumpkinseed**	-	-	-	-	-	-	-	-	0.79	-	-	-	-	-
	Pumpkinseed**	-	-	-	-	-	-	-	-	0.54	-	-	-	-	-
	Pumpkinseed**	-	-	-	-	-	-	-	-	0.82	-	-	-	-	-
	Pumpkinseed**	-	-	-	-	-	-	-	-	0.39	-	-	-	-	-
	Pumpkinseed**	-	-	-	-	-	-	-	-	0.78	-	-	-	-	-
	Pumpkinseed**	-	-	-	-	-	-	-	-	0.87	-	-	-	-	-
	Chain Pickerel**	-	-	-	-	-	-	-	-	0.51	-	-	-	-	-
	Chain Pickerel**	-	-	-	-	-	-	-	-	0.60	-	-	-	-	-
	Chain Pickerel**	-	-	-	-	-	-	-	-	0.72	-	-	-	-	-
	Chain Pickerel**	-	-	-	-	-	-	-	-	0.59	-	-	-	-	-
	Brown Bullhead**	-	-	-	-	-	-	-	-	0.43	-	-	-	-	-
	Brown Bullhead**	-	-	-	-	-	-	-	-	0.51	-	-	-	-	-
	Brown Bullhead**	-	-	-	-	-	-	-	-	0.43	-	-	-	-	-
Schultz Road Area	Pumpkinseed**	-	-	-	-	-	-	-	-	0.80	-	-	-	-	-
	Pumpkinseed**	-	-	-	-	-	-	-	-	0.69	-	-	-	-	-
	Pumpkinseed**	-	-	-	-	-	-	-	-	0.91	-	-	-	-	-
	Pumpkinseed**	-	-	-	-	-	-	-	-	0.86	-	-	-	-	-
	Pumpkinseed**	-	-	-	-	-	-	-	-	0.34	-	-	-	-	-
	Pumpkinseed**	-	-	-	-	-	-	-	-	0.49	-	-	-	-	-
	Pumpkinseed**	-	-	-	-	-	-	-	-	0.32	-	-	-	-	-
	Pumpkinseed**	-	-	-	-	-	-	-	-	0.38	-	-	-	-	-
	Pumpkinseed**	-	-	-	-	-	-	-	-	0.70	-	-	-	-	-
	Pumpkinseed**	-	-	-	-	-	-	-	-	0.38	-	-	-	-	-
	Chain Pickerel**	-	-	-	-	-	-	-	-	0.54	-	-	-	-	-
	Chain Pickerel**	-	-	-	-	-	-	-	-	0.76	-	-	-	-	-
	Chain Pickerel**	-	-	-	-	-	-	-	-	0.79	-	-	-	-	-
	Chain Pickerel**	-	-	-	-	-	-	-	-	0.77	-	-	-	-	-
	Chain Pickerel**	-	-	-	-	-	-	-	-	0.78	-	-	-	-	-
	Chain Pickerel**	-	-	-	-	-	-	-	-	0.75	-	-	-	-	-

(continued on next page)

Table 6-7. Metals Analysis of Fish and Shellfish from the Peconic River System and Control Locations *(concluded)*.

		Arsenic	Barium	Cadmium	Chromium	Copper	Iron	Lead	Manganese	Mercury	Nickel	Selenium	Silver	Sodium	Zinc
		mg/kg (ppm)													
	Brown Bullhead**	-	-	-	-	-	-	-	-	1.33	-	-	-	-	-
	Brown Bullhead**	-	-	-	-	-	-	-	-	1.29	-	-	-	-	-
	Brown Bullhead**	-	-	-	-	-	-	-	-	0.33	-	-	-	-	-
	Brown Bullhead**	-	-	-	-	-	-	-	-	0.5	-	-	-	-	-
Donahue's Pond	Bluegill	0.36	2.6	ND	0.25	0.56	27.6*	0.27	7.97*	0.08*	0.12	1.36	ND	1200	19.7*
	Brown Bullhead	ND	2.42	ND	0.27	2.34	173*	0.68	4.99*	0.013*	0.16	0.36	ND	1180	16.2*
	Bass	0.26	0.41	ND	0.11	0.31	4.70*	0.21	0.32*	0.20*	ND	ND	ND	1010	5.86*
Lower Lake,	Bluegill	0.26	3.27	ND	0.27	0.35	21.6*	ND	6.46	0.31*	0.13	0.88*	ND	1110	18.6
Carmans River	Bluegill	0.34	6.04	ND	0.65	0.77	130*	1.44	14.5	0.02	0.18	0.89*	ND	2100	28
	Pumpkinseed	ND	2.2	ND	0.29	0.58	11.3*	0.39	5.79	0.08*	ND	0.77*	ND	1460	25.4
	Black Crappie	ND	3.53	ND	0.32	0.18	8.53*	0.25	7.63	0.06*	ND	0.67*	ND	1190	22.3
	Bass	2.18	8.6*	ND	0.84	1.85*	56.4*	1.5	77.9*	0.04*	ND	5.16	ND	4770*	82.5*
	Golden Shiner	ND	6.55*	ND	0.66	0.79*	34.4*	ND	7.19*	0.09*	ND	2.22	ND	2310*	62.1*
	Golden Shiner	ND	28.1*	ND	1.22	3.42*	422*	1.6	132*	0.03*	ND	2.46	ND	4300*	152*
	Black Crappie	ND	18.7*	ND	1.26	1.12*	35.6*	ND	22.6*	0.05*	ND	2.01	ND	4360*	111*
	Yellow Perch	ND	3.19*	ND	0.97	1.71*	77.6*	ND	66.0*	ND	ND	ND	ND	3730*	36.4*
	Red-finned Pickerel	ND	9.91*	ND	0.67	1.35*	33.3*	ND	89.8*	0.07*	ND	1.85	ND	5060*	213*
	Brown Bullhead	ND	9.90*	ND	0.5	3.34*	246*	1.97	22.7*	0.02*	ND	2.91	ND	6850*	57.1*
Connecticut Ave.	Mussels	0.91	280	0.38	0.26	1.69	3250*	1.44*	506	0.06	0.31	1.6	6.5	327	25.1
	Mussels	0.44	4.14	0.13	0.17	0.37	67.0*	0.33*	26.4	0.06	0.09	0.28	0.33	281	7.97*
Forge Pond	Mussels	0.73	156	0.11	ND	0.99	437*	ND	1790	0.02	0.15	0.73	0.19	244	48.0*
	Mussels	1.14	109	0.08	ND	0.88	331*	ND	1300	0.02	0.08	0.34	0.09	268	46.9*
Peconic Bay	Clams	9.92	0.71	0.34	0.61	4.68*	67.6	ND	13.4	ND	3.15*	1.26	1.56	32600*	54.9*
	Clams	6.48	0.62	0.37	0.58	3.57*	52.9*	ND	17.0*	ND	2.50*	ND	1.68	30900*	40.5*
Flanders Bay	Clams	20.1	1.04	0.74	1.00	5.37*	90.6*	ND	6.61*	ND	5.89*	1.98	2.06	28300*	36.2*
Indian Island	Mussels	11.5	5.10*	0.97	2.2	9.45	734*	1.85	91.5*	ND	ND	2.63	0.83	32900*	50.0*
Moriches Bay	Clams	1.49	0.29	0.12	0.45	2.4	27.9*	0.4	1.67	0.04	0.46	ND	0.11	8330	17.0*

Notes:
See Figure 5-9 for sampling locations.
ND = Not Detected
* = Estimated value based on lab qualifiers.
** = Data provided by New York State.
- = Data not provided
All values in mg/kg

Table 6-8. Pesticide and PCB Analysis in Fish and Shellfish from the Peconic River System and Control Locations.

		Heptachlor epoxide	Dieldrin	4,4'-DDE	4,4'-DDD	4,4'-DDT	gamma-Chlordane	alpha-Chlordane	Aroclor-1254	Aroclor-1260
						µg/kg				
BNL HQ Area	Brown Bullhead**	ND	ND	10	6	ND	ND	ND	ND	ND
	Brown Bullhead**	ND	ND	2	ND	ND	ND	ND	ND	ND
	Largemouth Bass**	ND	ND	3	ND	ND	ND	ND	ND	ND
	Pumpkinseed**	ND	ND	21	4	3	ND	ND	33	75
	Pumpkinseed**	ND	ND	5	ND	ND	ND	ND	ND	ND
	Pumpkinseed**	ND	ND	12	4	ND	ND	ND	ND	21
	Pumpkinseed**	ND	ND	21	5	5	ND	ND	33	164
Ice Pond	Pumpkinseed**	ND	ND	8	2	ND	ND	ND	ND	24
	Pumpkinseed**	ND	ND	17	4	ND	ND	ND	ND	21
	Pumpkinseed**	ND	ND	13	3	2	ND	ND	ND	21
	Pumpkinseed**	ND	ND	12	2	ND	ND	ND	ND	21
	Pumpkinseed**	ND	ND	13	3	ND	ND	ND	20	22
	Pumpkinseed**	ND	ND	25	5	ND	ND	ND	ND	36
	Pumpkinseed**	ND	ND	10	2	ND	ND	ND	ND	20
	Pumpkinseed**	ND	ND	17	2	ND	ND	ND	ND	37
	Chain Pickerel**	ND	ND	3	ND	ND	ND	ND	ND	ND
	Chain Pickerel**	ND	ND	6	3	ND	ND	ND	ND	ND
	Chain Pickerel**	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Chain Pickerel**	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Brown Bullhead**	ND	ND	16	4	2	ND	ND	23	49
	Brown Bullhead**	ND	ND	14	2	ND	ND	ND	ND	ND
	Brown Bullhead**	ND	ND	20	7	2	ND	ND	30	79
Schultz Road Area	Pumpkinseed**	ND	ND	14	5	ND	ND	ND	ND	20
	Pumpkinseed**	ND	13	17	2	ND	ND	ND	ND	22
	Pumpkinseed**	ND	ND	13	4	ND	ND	ND	ND	ND
	Pumpkinseed**	ND	ND	35	25	3	ND	ND	ND	20
	Pumpkinseed**	ND	ND	13	7	ND	ND	ND	21	ND
	Pumpkinseed**	ND	ND	19	6	ND	ND	ND	ND	ND
	Pumpkinseed**	ND	ND	15	5	ND	ND	ND	ND	ND
	Pumpkinseed**	ND	ND	21	10	2	ND	ND	ND	22
	Pumpkinseed**	ND	ND	8	2	ND	ND	ND	ND	ND
	Chain Pickerel**	ND	ND	2	ND	ND	ND	ND	ND	ND
	Chain Pickerel**	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Chain Pickerel**	ND	ND	2	ND	ND	ND	ND	ND	ND
	Chain Pickerel**	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Chain Pickerel**	ND	ND	2	ND	ND	ND	ND	ND	ND
	Brown Bullhead**	ND	ND	3	ND	ND	ND	ND	ND	ND
	Brown Bullhead**	ND	ND	13	6	ND	ND	ND	ND	ND
	Brown Bullhead**	ND	ND	18	6	ND	ND	ND	ND	20
Donahue's Pond	Bluegill	ND	ND	40	23	5*	ND	ND	ND	ND
	Brown Bullhead	ND	ND	13	4	ND	ND	ND	ND	ND
	Bass	ND	ND	21	9	ND	ND	ND	ND	ND

(continued on next page)

Table 6-8. Pesticides Analysis in Fish and Shellfish from the Peconic River System and Control Locations *(concluded)*.

		Heptachlor epoxide	Dieldrin	4,4'-DDE	4,4'-DDD	4,4'-DDT	gamma-Chlordane	alpha-Chlordane	Aroclor-1254	Aroclor-1260
		μg/kg								
Lower Lake,	Bluegill	ND	1*	31	10*	4*	1*	2*	ND	ND
Carmans River	Bluegill	0.79*	2*	68	19*	7*	3*	1*	ND	ND
	Pumpkinseed	ND	1*	47	11*	7*	1*	1*	ND	ND
	Black Crappie	ND	1*	98	24*	11*	5*	10*	ND	ND
	Bass	ND	ND	101	21	ND	ND	ND	ND	ND
	Golden Shiner	ND	ND	119	36	ND	ND	ND	ND	ND
	Golden Shiner	ND	5*	152	47	ND	10*	16*	ND	ND
	Black Crappie	ND	7*	441	118	45	62*	18	ND	ND
	Yellow Perch	ND	15*	305	68*	ND	ND	ND	ND	ND
	Red-finned Pickerel	ND	ND	101	20	ND	6*	8*	ND	ND
	Brown Bullhead	ND	ND	77	24*	ND	7*	12*	ND	ND
Moriches Bay	Clams	ND	ND	17	2*	41*	ND	ND	ND	ND

Notes:
* = Estimated value based on lab qualifiers.
** = Data provided by New York State.
ND = Not Detected

Metals in shellfish are also presented in Table 6-7. In most samples, metals appear to be consistent with or slightly above previous years' sampling efforts. One exception is the presence of manganese at high levels in freshwater mussels taken from Connecticut Avenue and Forge Pond. Also, arsenic in clams and mussels from Indian Island, Flanders Bay, and Peconic Bay appears higher compared to values reported in last year's report. Arsenic has historically been used in agricultural practices on Long Island. Run-off from farms is a likely source of this metal in the Peconic River.

Table 6-8 shows the concentrations of pesticides and PCBs in fish and shellfish for 2001. The table reflects only samples with detectable levels of pesticide in the tissues. Clams from Moriches Bay were the only shellfish to show measurable levels of pesticides. The levels detected in fish and shellfish do not exceed any standards that constitute health impacts on the consumers of such fish and are not considered harmful. No pesticides were detected in on-site samples. The pesticides DDT, DDD, and DDE were detected at low levels at several off-site locations. DDD and DDE pesticides are breakdown products of DDT, a pesticide commonly used before 1970. Chlordane and Dieldrin were also commonly used across Long Island and show up at off-site locations in low levels.

Barely detectable levels of PCBs (Aroclor-1242 and Aroclor-1260) were found in fish taken from the Peconic River at the east boundary, as well as just off site at Ice Pond. All levels are below the FDA standard of 2 ppm and should not pose a health hazard. Historically, Aroclor-1260 was used in electrical equipment. The levels of PCBs detected were similar to levels seen in the past. The variation in the results may be due to differences in laboratory procedures, sample types (whole-body, composites, or tissues), and fish sizes.

6.3.5 Marine/Estuarine Sampling

Annual sampling for clams, sediment, and seawater in Peconic Bay, Flanders Bay, Indian Island, and Moriches Bay (control location) was conducted in 2001. (See Chapter 5, Figure 5-9, for locations.) Stakeholder concern that BNL's discharges and ongoing work with Operable Unit V may affect the clamming industry is the basis for continuing this sampling program. As in past years, the NYSDEC Marine Fisheries Branch assisted BNL in coordinating the sampling with local baymen. Table 6-9 summarizes the radiological data. Researchers tested estuarine vegeta-

Table 6-9. Radiological Analysis Results for Shellfish, Aquatic Vegetation, Water, and Sediment.

Location/ sample type	K-40 (pCi/g, wet weight)	Cs-137 (pCi/g, wet weight)
BNL (EA-HMn)		
Duckweed	1.48 ± 0.3	0.04 ± 0.01
Duckweed	1.81 ± 0.5	0.87 ± 0.1
Grass	2.15 ± 1.1	ND
Grass	2.74 ± 1.8	ND
Algae	0.83 ± 0.3	0.71 ± 0.1
BNL (HQ-downstream)		
vegetation	17.8 ± 8.3	0.49 ± 0.4
soil	5.66 ± 1.3	11.4 ± 1.4
water pCi/L	ND	ND
Donahue's Pond		
Lily Pad	15.5 ± 2.5	0.69 ± 0.2
water pCi/L	NT	ND
sediment	2.59 ± 0.5	ND
Connecticut Ave		
Mussels	2.00 ± 0.9	<MDL
Mussels	2.33 ± 0.9	<MDL
Forge Pond		
Mussels	1.64 ± 1.4	<MDL
Mussels	1.88 ± 0.8	<MDL
water pCi/L	NT	ND
sediment	5.74 ± 1.0	1.51 ± 0.2
Lily Pad	13.20 ± 2.6	<MDL
Swan Pond		
water pCi/L	NT	ND
Lily Pad	20.4 ± 3.4	<MDL
sediment	0.82 ± 0.6	ND
Lower Lake, Carmans River		
vegetation	13.7 ± 3.5	ND
sediment	3.45 ± 0.7	0.60 ± 0.1
water pCi/L	NT	ND
Indian Island		
Mussels	11.10 ± 1.7	ND
vegetation	57.5 ± 7.1	ND
sediment	3.16 ± 0.4	<MDL
water pCi/L	NT	ND
Peconic Bay		
Clams	14.10 ± 1.8	<MDL
Clams	14.70 ± 1.9	ND
vegetation	30.3 ± 4.3	ND
sediment	9.61 ± 1.3	<MDL
water pCi/L	270 ± 65.6	ND
Flanders Bay		
Clams	12.1 ± 1.6	ND
sediment	20.9 ± 4.7	ND
water pCi/L	174 ± 53.6	ND
Moriches Bay		
Clams	13.50 ± 2.3	ND
water pCi/L	NT	ND
Eel Grass	16.8 ± 2.9	ND
sediment	3.06 ± 0.7	ND

Notes:
All values shown with a 95% confidence interval.
ND = Not Detected
NT = Not Tested
<MDL = Less than Minimum Detection Limit
Sediment values are for dry weights.

tion from Indian Island, Peconic Bay, and Moriches Bay. In addition, sediment and/or water samples from all four locations were tested. Naturally occurring potassium-40 was the only radionuclide observed in any of the samples. No BNL-generated radionuclides have ever been detected in marine samples since 1992, when sampling began.

6.3.6 Metals and Pesticides in Aquatic Samples

Samples of freshwater mussels, vegetation, sediments, and water were taken at several locations within the Peconic River, bays, and estuaries, including on site at BNL and the Carmans River. Cesium-137 was detected at low levels in vegetation from on-site locations and Donahue's Pond. Sediments from BNL, Forge Pond, and Lower Lake on the Carmans River also showed low levels of cesium-137. None was detected in mussel samples. These levels were similar to past observations.

Metals analysis (Table 6-10) was conducted on aquatic vegetation, water, and sediments from the Peconic River, bays, and estuaries. 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. Water sample results are compared to New York State Drinking Water Standards (see Chapter 3). Vegetation results are compared to both standards, because metals in vegetation may accumulate via uptake from sediment or water. Arsenic was found in vegetation taken from Peconic Bay and Indian Island at levels above cleanup objectives but below drinking water standards. Elevated levels of chromium, copper, mercury, nickel, and silver were found in vegetation taken on the BNL site from the Peconic River near the east firebreak. This area is scheduled to be included in a pilot study of cleanup options being considered for use in the Operable Unit V remediation activities. Chromium, copper, mercury, and silver were also seen in river sediments and water taken at the east boundary of the Laboratory. This area is also scheduled to be included in pilot studies. Off site, mercury was detected at levels just above Suffolk County cleanup objectives in sediments

Table 6-10. Metals Analysis in Aquatic Vegetation, Water, and Sediments from the Peconic River System, Bays, and Control Locations.

BNL		Arsenic mg/kg	Barium mg/kg	Cadmium mg/kg	Chromium mg/kg	Copper mg/kg	Iron mg/kg	Lead mg/kg	Manganese mg/kg	Mercury mg/kg	Nickel mg/kg	Selenium mg/kg	Silver mg/kg	Sodium mg/kg	Zinc mg/kg
EA-HMn	Duckweed	ND	39.7	4.43	5.38	177	1440*	6.6	361	0.68	13.2	ND	10.6	7720	425
	Duckweed	ND	60.5	5.9	40.8	502	2670*	40.9	371	5.88	34.6	ND	60.8	4250	401
	Grass	ND	34.7	ND	2.31	7.75	481*	ND	77.2	ND	3.2	ND	1.2	5920	29.4
	Grass	ND	25.2	0.7	2.07	22.8	866*	1.61	256	1.84	2.66	ND	3.07	6650	134
	Algae	ND	69.2	1.54	11.2	134	3210*	13.1	767	1.67	8.09	ND	18.7	897	286
HQ-downstream	Vegetation	ND	6.63	0.07	0.42	2.01	144*	0.59	52.9*	0.03*	0.34	ND	0.35	481*	4.66*
	water µg/L	ND	40.8	0.67	12.3	36.2	3200	6.86	121	ND	6.6	3.62	8.97	26200	45
	sediment	1.27	26.4	1.37	17.1	116	1530*	21	17.9*	2.80*	4.74	0.79	26.2	55*	61.7*
Donahue's Pond	Lily Pad	0.35	7.93	0.04	0.12	0.28	50.7*	0.36*	52	0.01	0.09	ND	ND	313	17.2*
	water µg/L	3.75	13.2	ND	ND	0.94	1090	3.35	163	ND	1.06	4.5	ND	5430	7.04
	sediment	0.66	3.56	0.03	0.72	0.9	368*	2.02*	6.69	0.01	0.48	ND	ND	8.05	6.27*
Forge Pond	Lily Pad	0.29	22.3	ND	0.1	0.22	82.3*	0.24*	109	109	109	109	109	109	109
	water µg/L	3.34	17.8	ND	ND	0.78	1290	4.4	60.6	0.31	1.02	2.93	0.87	8480	5.12
	sediment	1.9	14.8	0.21	2.51	6.03	2490*	10.3*	54.1	0.04	1.64	0.86	ND	20.3	39.1*
Swan Pond	Lily Pad	0.29	8.94	ND	ND	0.16	16.4*	ND	332	ND	ND	ND	ND	353	2.38*
	water µg/L	ND	19.3	ND	ND	1.2	339	ND	873	0.28	ND	ND	ND	5900	4.45
	sediment	0.61	2.54	0.04	0.67	0.29	94.0*	1.49*	38.4	0.01	0.26	ND	ND	8.88	1.47*
Lower Lake,	vegetation	3.6	238*	ND	0.96	1.36	201*	ND	163*	ND	ND	ND	ND	2810*	22.4*
Carmans River	water µg/L	ND	25.1	ND	0.68	ND	148	ND	14.7	ND	ND	ND	ND	10600	1.27
	sediment	2.72	14.8	0.24	5.04	3.69	1400	26.3	47.4*	0.04	1.19	0.57	ND	28.1	35.3*
Peconic Bay	vegetation	8.93	14.6	ND	1.49	4.65	5250	3.33	5860	0.01	3.38	4.14	0.43	5820	16.8
	water µg/L	ND	17	ND	ND	4.72	284	ND	192	ND	ND	ND	ND	2830000*	ND
	sediment	5.66	10	0.06	9.67	11	12100	11.1	166	0.04	6.5	0.5	0.55	4790	36.4
Flanders Bay	water µg/L	ND	14.5	ND	ND	2.29	41.4	ND	102	ND	ND	ND	ND	9440000*	ND
	sediment	5.79	10.8	ND	9.95	15.3	14900	18.7	132	0.03	6.47	0.37	1.02	6690	41.9
Indian Island	vegetation	19.5	20.9*	0.47	0.56	3.94	102*	ND	298*	ND	2.97	ND	0.38	32100*	51.6*
	water µg/L	ND	17.3	ND	1.63	5.51	1250	ND	134	ND	ND	ND	ND	8330000	ND
	sediment	1.69	3.18	ND	2.56	1.89	2450	3.31	37.1*	0.004	0.72	ND	ND	1580	3.10*
Moriches Bay	Eel Grass	0.49	0.54	0.07	0.09	0.64	100*	0.4	441*	0.03	0.2	ND	ND	7160	4.58*
	water µg/L	6.44	10.2	ND	ND	24	128	ND	16	ND	ND	ND	ND	9540000*	ND
	sediment	0.26	1.66	ND	1.17	0.45	546*	2.8	6.2*	ND	0.32	ND	ND	1710	1.89*

Notes:
Water values are in µg/L.
* = Estimated value based on lab qualifiers.
ND = Not Detected

from Forge Pond and Swan Pond.

Pesticides and PCBs are reported in Table 6-11 for only those samples with detectable limits. Aroclor-1248 was the only PCB detected. A very low level of this PCB was detected in a water sample from Lower Lake on the Carmans River. DDT and its breakdown products, DDD and DDE, were detected in the Peconic River and Peconic Bay system, as well as in eel grass taken from Moriches Bay. All detections of DDT, DDD, and DDE were below the minimum detection limit. Chlordane was detected in duckweed taken on site. Both DDT and Chlordane were used historically across Long Island, including at BNL.

6.3.7 Vegetation Sampling

A variety of farm and garden vegetables were sampled in 2001. Samples were collected from farms near BNL as well as from an on-site garden (Figure 6-8). Samples were submitted for radiological analysis and the results are presented in Table 6-12. As in the past, no radionuclides attributable to BNL operations were observed in farm produce. Cesium-137 was absent from all on-site garden vegetables and apples. Potassium-40, which occurs naturally, was the only radionuclide detected in all of the produce sampled. BNL sampled grassy vegetation (Table 6-13) near air monitoring stations to support the surveillance monitoring associated with these points. Grassy vegetation was also sampled in lawn areas where geese tend to graze, for comparison with goose fecal sampling (see Section 6.3.3). Vegetation sampling is carried out to determine if depositional material is accumulating on plant surfaces and soils and whether there is uptake by the vegetation. In 2001, the only anthropogenic radionuclide found in grassy vegetation was cesium-137. A single sample from air station S-5 at the STP indicated a very low cesium-137 level (0.06 pCi/g wet weight). Cesium-137 was also detected at very low levels in grassy vegetation sampled from the NYSDEC Game Farm located in the nearby village of Ridge.

6.4 BASIN SEDIMENT SAMPLING

BNL samples basin sediments on a two-year cycle. The next sampling is scheduled for 2002. However, in 2000, BNL reported levels of lead above Suffolk County cleanup action levels at the outfall for the Central Steam Facility and planned follow-up sampling to determine the extent of contamination. Details of this investigation are presented in Chapter 5.

Table 6-11. Pesticide and PCB Analysis of Aquatic Vegetation, Water, and Sediments from the Peconic River System, Bays, and Control Locations.

		delta-BHC	Dieldrin	4,4'-DDE	4,4'-DDD	Endosulfan sulfate	4,4'-DDT	gamma-Chlordane	alpha-Chlordane	Aroclor-1248
		μg/kg								
BNL										
EA-HMn	Duckweed	<MDL	ND	<MDL	ND	<MDL	ND	<MDL	<MDL	ND
	Duckweed	ND	<MDL	<MDL	<MDL	ND	ND	<MDL	45.4	ND
HQ-downstream	sediment	ND	ND	<MDL	ND	ND	<MDL	ND	ND	ND
Forge Pond	water μg/L	ND	ND	ND	ND	ND	<MDL	ND	ND	ND
Swan Pond	water μg/L	ND	ND	ND	ND	ND	<MDL	ND	ND	ND
Peconic Bay	sediment	ND	ND	<MDL	<MDL	ND	ND	ND	ND	ND
Indian Island	water μg/L	ND	ND	ND	ND	ND	<MDL	ND	ND	ND
Moriches Bay	Eel Grass	ND	ND	<MDL	ND	ND	<MDL	ND	ND	ND
Lower Lake, Carmans River	water μg/L	ND	ND	ND	ND	ND	ND	ND	ND	0.89

Notes:
Water values are in μg/L.
<MDL = Less than Minimum Detection Limit
ND = Not Detected

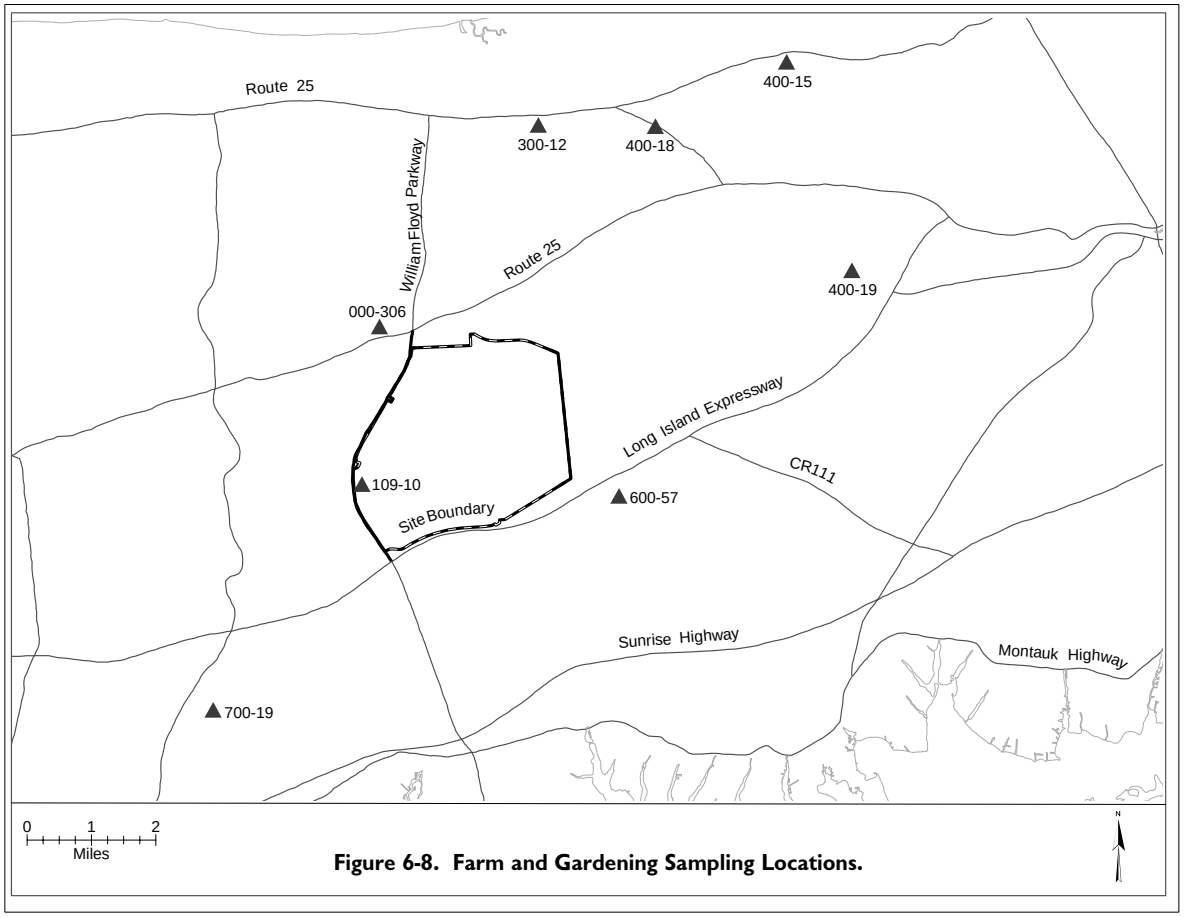

Figure 6-8. Farm and Gardening Sampling Locations.

6.5 SOIL SAMPLING

Soil sampling was conducted to correspond with vegetation sampling near air stations, goose fecal matter collection points, the on-site garden, and local farms. Soil sampling is conducted as part of the surveillance program and is used to determine uptake in plants, as well as to determine long-term deposition or lack thereof. Soil samples were analyzed for gamma-emitting radionuclides. Table 6-14 shows the sampling results of the radiological analysis of soils. All radionuclides detected, with the exception of cesium-137, are found naturally in Long Island soils. Higher levels of some of the radionuclides, such as lead-212, lead-214, bismuth-214, and potassium-40 in some of the farm locations, are likely due to the addition of fertilizers to soils for growing crops. The maximum cesium-137 concentration was 0.62 pCi/g dry weight, except at station S-5 located at the Sewage Treatment Plant. The lower values are considered to be consistent with background levels resulting from worldwide fallout from historic aboveground nuclear weapons testing. The high elevation seen near the STP is likely due to known historic contamination in the area.

6.6 TOXICITY TESTING, SEWAGE TREATMENT PLANT

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

6.7 PRECIPITATION MONITORING

As part of the Environmental Monitoring Program, precipitation samples were collected approximately quarterly at air monitoring Stations

Table 6-12. Radiological Analysis of Farm and Garden Produce.

Location		K-40 (pCi/g, wet weight)	Cs-137 (pCi/g, wet weight)
BNL Garden	Lettuce	1.94 ± 0.43	ND
	String Bean	ND	ND
	Tomato	1.50 ± 0.24	ND
	Tomato	1.59 ± 0.26	ND
	Cucumber	1.55 ± 0.33	ND
	Eggplant	0.10 ± 0.02	ND
	Peppers	1.27 ± 0.21	ND
	Corn	2.05 ± 0.36	ND
BNL Vegetation			
Bldg. 555	Apple	0.86 ± 0.16	ND
Mays Farm	Tomato	4.26 ± 0.79	ND
	Corn	2.16 ± 0.52	ND
	Corn*	1.77 ± 0.30	ND
	String Bean	1.91 ± 0.31	ND
	Cucumber	1.28 ± 0.21	ND
	Pumpkin	3.19 ± 0.60	ND
	Cauliflower	3.16 ± 0.60	ND
	Eggplant	1.85 ± 0.30	ND
Lewins Farm	Cucumber	0.98 ± 0.21	ND
	Yellow Squash	1.50 ± 0.24	ND
	Zuchini	1.89 ± 0.39	ND
	Potato	1.66 ± 0.35	ND
	Potato*	1.42 ± 0.23	ND
	Corn	2.42 ± 0.44	ND
	Apple	1.02 ± 0.17	ND
	Peaches	ND	ND
	Pumpkin	1.89 ± 0.31	ND
	Apple	7.76 ± 1.33	ND
Cornell Farm	Corn	1.73 ± 0.31	ND
Bruno Farm	Cucumber	3.48 ± 0.68	ND
	Zuchini	2.12 ± 0.41	ND
	String Bean	1.35 ± 0.22	ND
	Tomato	1.92 ± 0.30	ND
Rt. 25 Farm	Strawberry	1.25 ± 0.21	ND
River Road	Strawberry	1.01 ± 0.17	ND
	Snap Peas	1.63 ± 0.40	ND

Notes:
See Figure 6-9 for sampling locations.
All values 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
* = Duplicate sample

Table 6-13. Radiological Analysis of Grassy Vegetation.

Location	K-40 (pCi/g, wet weight)	Cs-137 (pCi/g, wet weight)
BNL		
S-5	4.13 ± 0.76	0.06 ± 0.02
P-7	3.88 ± 0.73	ND
S-6	3.70 ± 0.66	ND
P-2	2.72 ± 1.29	ND
P-9	2.24 ± 0.55	ND
P-4	3.91 ± 0.68	ND
HFBR Lawn	10.94 ± 4.29	ND
NSLS Lawn	5.86 ± 1.38	ND
Ballfield 6	10.25 ± 3.84	ND
RA5 Recharge Basin	5.09 ± 1.19	ND
STP Hold-up Pond	3.30 ± 0.96	ND
Offsite		
NYSDEC Game Farm	0.33 ± 0.10	0.01 ± 0.00
Spring Lake, Middle Island	12.36 ± 10.72	ND

Notes:
All values shown with a 95% confidence interval.
Table contains information also reported in Table 6-4.
K-40 occurs naturally in the environment and is presented as a comparison to Cs-137.
ND = Not Detected

P4 and S5 (see Chapter 4, Figure 4-4 for station locations) and analyzed for radiological content. Four samples were taken from each of these two stations in 2001. Gross alpha activity measurements above the minimum detection limit were found in samples taken in July and October. The samples from the P4 location showed a maximum of 4.86 pCi/L activity, whereas the samples from the S5 location had a maximum activity level of 19.40 pCi/L. Both of these values are within the range of historic values reported for gross alpha activity. Gross beta activity was measured in four samples at each of the sampling locations. In general, radioactivity in precipitation comes from naturally occurring radionuclides in dust and activation products resulting from solar radiation. Location P4 had a maximum activity level of 11.50 pCi/L, with an average of 5.55 pCi/L. Location S5 had a maximum of 17.20 pCi/L, with the average activity of 6.88 pCi/L. Gross beta activity values were within the range of values historically observed at these two locations. Tritium was not detected in any of the

Table 6-14. Radiological Analysis of Soils On Site and from Local Farms.

Location	K-40	Cs-137	Tl-208	Pb-212	Bi-214	Pb-214	Ac-228	Th-232
	pCi/g (dry weight)							
BNL								
S-5	5.81 ± 1.04	2.28 ± 0.40	0.21 ± 0.05	0.67 ± 0.10	0.51 ± 0.07	0.43 ± 0.08	0.67 ± 0.10	0.77 ± 0.27
P-7	6.85 ± 1.17	0.08 ± 0.03	0.21 ± 0.04	0.62 ± 0.09	ND	0.50 ± 0.08	0.66 ± 0.10	0.61 ± 0.27
S-6	3.78 ± 0.75	ND	0.17 ± 0.05	0.46 ± 0.10	ND	0.35 ± 0.07	ND	ND
P-2	4.86 ± 1.77	ND	ND	0.38 ± 0.22	ND	ND	ND	ND
P-9	4.53 ± 0.86	0.03 ± 0.02	0.22 ± 0.05	0.62 ± 0.10	0.47 ± 0.08	0.46 ± 0.13	0.58 ± 0.11	0.70 ± 0.29
P-4	4.01 ± 0.74	0.27 ± 0.05	0.18 ± 0.04	0.48 ± 0.08	0.48 ± 0.07	0.44 ± 0.07	0.56 ± 0.09	0.48 ± 0.19
HFBR Lawn	6.59 ± 1.82	0.23 ± 0.13	0.32 ± 0.10	0.75 ± 0.18	ND	0.66 ± 0.30	ND	ND
NSLS Lawn	5.39 ± 1.03	0.32 ± 0.08	0.26 ± 0.06	0.72 ± 0.13	0.54 ± 0.10	0.52 ± 0.10	0.61 ± 0.13	ND
Ballfield 6	6.96 ± 1.77	0.40 ± 0.13	0.37 ± 0.12	0.92 ± 0.20	ND	0.49 ± 0.28	ND	ND
RA V Recharge Basin	2.81 ± 0.55	ND	0.11 ± 0.03	0.26 ± 0.05	0.21 ± 0.05	0.21 ± 0.05	0.33 ± 0.07	0.37 ± 0.15
Sewage Treatment Plant	6.25 ± 1.07	0.62 ± 0.11	0.23 ± 0.05	0.74 ± 0.11	0.59 ± 0.08	0.55 ± 0.14	0.67 ± 0.10	0.64 ± 0.24
Off site								
NYSDEC Game Farm	4.49 ± 1.72	ND	ND	0.89 ± 0.34	ND	0.59 ± 0.25	ND	ND
May's Farm	6.57 ± 1.67	ND	0.35 ± 0.12	0.99 ± 0.21	ND	0.79 ± 0.37	ND	ND
Lewin Farm	7.19 ± 1.28	0.14 ± 0.04	0.28 ± 0.06	0.85 ± 0.13	0.73 ± 0.11	0.81 ± 0.12	0.89 ± 0.15	ND
Cornell Farm	7.29 ± 1.27	0.15 ± 0.04	0.37 ± 0.07	1.02 ± 0.15	0.78 ± 0.11	0.81 ± 0.11	0.96 ± 0.14	0.94 ± 0.39
Bruno Farm	5.65 ± 0.98	0.09 ± 0.03	0.25 ± 0.05	0.81 ± 0.12	0.54 ± 0.08	0.56 ± 0.08	0.76 ± 0.10	0.88 ± 0.26

Note:
ND = Not Detected

samples from either location. Gamma analysis of samples taken in February, April, and July showed the presence of beryllium-7 at a maximum of 67.5 pCi/L at Station P4 in April and 60.9 pCi/L in April at Station S5. Beryllium-7 is a naturally occurring radionuclide resulting from solar flare activity.

6.8 WILDLIFE OUTREACH

BNL sponsors a variety of educational and outreach activities on 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 resources inventory, gain a better understanding of the ecosystem, and guide management planning.

In 2001, the Environmental Services Division (ESD) hosted two student fellowships during the summer. One student was from the University of Puerto Rico and worked with Suffolk County Community College and the U.S. Fish & Wildlife Service on plant distributions, fire ecology, and ecological education programs. The second student was from the University of Georgia and conducted research on the tiger salamander (Figure 6-9). The data gained from their studies have furthered BNL's understanding of pine barrens and tiger salamander ecology on BNL property.

In addition to hosting student fellowships, members of ESD and other departments volunteer as speakers and give guest lectures at schools, civic groups, and provide on-site ecology tours. ESD also hosted activities in association with Earth Day 2001 and provided activities to educate Laboratory employees and the general public on the environment and conservation. BNL hosted the Sixth Annual Pine Barrens Research Forum in October, providing a venue for researchers who are conducting work on pine barrens ecosystems to share and discuss their results. BNL also hosted the annual

Figure 6-9. Summer Intern Working on Tiger Salamander Ecology.

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, all using the Incident Command System of wildfire management.

6.9 CULTURAL RESOURCE ACTIVITIES

The cultural resource management program is being developed to ensure that the Laboratory fully complies with the numerous cultural resource requirements. In October 2001, BNL submitted to the Department of Energy an accelerated schedule for developing the BNL Cultural Resources Management Plan, with a target completion date of December 2003. Development of a formal plan will guide the management of all of BNL's cultural resources. These resources include World War I trenches, Civilian Conservation Corps features such as the white pine groves, World War II buildings, and historic structures associated with high-energy physics and other science conducted at the Laboratory.

Section 110 of the National Historic Preservation Act requires that government agencies conduct surveys of their properties to identify buildings, structures, and features that may be eligible for inclusion in the National Register of Historic Places. In February 2001, BNL accepted receipt of *The Architectural Inventory of the Brookhaven National Laboratory* (Bernstein 2001a). The Institute for Long Island Archaeology, located at the State University of New York at Stony Brook, developed this document by conducting a building-by-building survey of all 440 buildings located at BNL.

In October 2001, BNL accepted receipt of the *Cultural Resources Inventory of the Brookhaven National Laboratory* (Bernstein 2001b), also prepared by the Institute for Long Island Archaeology. This document includes historic period contexts and an archeological sensitivity assessment of the BNL site. Information provided in this document will be used in developing the BNL Cultural Resource Management Plan.

With the permanent shutdown of the High Flux Beam Reactor in November 1999, BNL began placing the reactor into a safe and secure shutdown configuration. As part of this process, discussions began about the HFBR's significant contributions to science, its unique design, and its place in the BNL landscape. In October 2001, the New York State Historic Preservation Officer concurred with BNL's determination that the HFBR complex was eligible for listing on the National Register of Historic Places. The Laboratory has two additional structures or sites that have been determined to be eligible for listing: the World War I training trenches associated with Camp Upton and the BGRR complex.

BNL continued developing the mitigation packages associated with the *Memorandum of Agreement (MOA) for the Mitigation of the Decommissioning of the Brookhaven Graphite Research Reactor (BGRR)* (Desmarais 2000). Production of a BGRR history video documentary was in progress throughout 2001. The contract, which used the services of a professional archivist to inventory and appraise BGRR-related records and develop a researcher's guide, was completed in December 2001. Records relating to the design, construction, operations, and maintenance of the BGRR were evaluated as part of this effort. The *BGRR Researcher's Guide* includes an Excel database of all records, along with key-word descriptors and lists of all records and photographs.

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