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 natural resource management strategy is based on understanding the site's resources and on maintaining compliance with applicable regulations. The goals of the program include protecting and monitoring the ecosystem, conducting research, and communicating with staff and the public on ecological issues. BNL focuses on protecting New York State threatened and endangered species on site, as well as continuing the Laboratory's leadership role within the greater Long Island Central Pine Barrens ecosystem.

Monitoring to determine whether current or historical activities are affecting natural resources is also part of this program. In 2009, 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.

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.

6.1 NATURAL RESOURCE MANAGEMENT PROGRAM

The purpose of the Natural Resource Management Program at BNL is to promote stewardship of the natural resources found at the Laboratory, as well as to integrate natural resource management and protection with BNL's scientific mission. To meet this purpose, the Laboratory prepared a Natural Resource Management Plan (NRMP) (BNL 2003a). This plan describes the program strategy, elements, and planned activities for managing the various resources found on site.

6.1.1 Identification and Mapping

An understanding of an environmental baseline is the foundation of natural resource management planning. BNL uses digital global positioning systems (GPS) and geographic information systems (GIS) to clearly relate various "layers" of geographic information (e.g., vegetation types, soil condition, habitat, forest health, etc.). This is done to gain insight into interrelationships between the biotic systems and physical conditions at the Laboratory.

In 2009, BNL developed an Environmental Assessment (EA) under the National Environmental Policy Act of 1969 for the proposed BP Solar Long Island Solar Farm (LISF) on site. This project will encompass an area of approximately 200 acres. The GIS and natural resource data were utilized in the development of the EA (DOE 2009) and are routinely updated through surveys, observations, and research.

A wide variety of vegetation, birds, reptiles, amphibians, and mammals inhabit the site. Through implementation of the NRMP, additional endangered, threatened, and species of special concern have been identified as having been resident at BNL during the past 30 years.

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

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

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

The only New York State endangered species confirmed as now inhabiting Laboratory property is the eastern tiger salamander (*Ambystoma t. tigrinum*). Additionally, the New York State endangered Persius duskywing butterfly (*Erynnis p. persius*) and the crested fringed orchid (*Plantathera cristata*) have been identified on site in the past. Five New York State threatened species have been positively identified on site and two other species are considered likely to be present. The banded sunfish (*Enneacanthus obesus*), the swamp darter fish (*Etheostoma fusiforme*), and the stiff goldenrod plant (*Solidago rigida*) have been previously reported (BNL 2000). The northern harrier (*Circus cyaneus*) was seen hunting over open fields in November 2003. In 2005, the Pine Barrens bluet (*Enallagma recurvatum*) damselfly was confirmed at one of the many coastal plain ponds located on site. The frosted elfin butterfly (*Callophrys irus*) has been identified as possibly being at BNL, based on historic documentation and the presence of its preferred habitat and host plant (wild lupine). In addition, stargrass (*Aletris farinosa*) was reconfirmed to exist at BNL. A number of other species that are listed as rare, of special concern, or exploitably vulnerable by New York State either currently inhabit the site, visit during migration, or have been identified historically (see Table 6-1).

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 Laboratory procedures or into specific program or project plans. Environmental restoration projects remove pollutant sources that could contaminate habitats. Human access to critical habitats is limited. In some cases, habitats are enhanced to improve survival or increase populations. Even routine activities such as road maintenance are not performed until they have been duly evaluated and determined to be unlikely to affect habitat.

6.1.2.1 Salamander Protection Efforts

To safeguard eastern tiger salamander breeding areas, a map of the locations is reviewed

when new projects are proposed. Distribution of the map is limited, to protect the salamander from exploitation by collectors and the pet trade. The map is routinely updated as new information concerning the salamanders is generated through research and monitoring. The most recent update extends the buffer area around tiger salamander habitat from 800 feet to 1,000 feet. Other efforts to protect this state-endangered species include determining when adult salamanders are migrating toward breeding locations, when metamorphosis has been completed, and when juveniles are migrating after metamorphosis. During these times, construction and maintenance activities near their habitats are postponed or closely monitored. BNL environmental protection staff must review any project planned near eastern tiger salamander habitats, and every effort is made to minimize impacts.

Water quality testing is conducted as part of the routine monitoring of recharge basins, as discussed in Chapter 5. In cooperation with the New York State Department of Environmental Conservation (NYSDEC), habitat surveys have been routinely conducted since 1999. Biologists conducting egg mass and larval surveys have confirmed 26 on-site ponds that are used by eastern tiger salamanders. Egg mass surveys of ponds and additional flooded depressions at the Laboratory were not conducted in 2009. The monitoring procedure calls for all ponds that had egg masses during the spring surveys to be surveyed again in June and July to check for the presence of larval salamanders. A PhD candidate and student interns have conducted surveys of tiger salamander ponds, drift fence surveys, and radio telemetry tracking around four ponds. The results of these studies have shown the extent of egg mass production, the importance of precipitation as a trigger for metamorphic salamanders leaving ponds, and the extent of movements by both adults and metamorphic tiger salamanders. Work toward a comprehensive understanding of eastern tiger salamander movements and habitat requirements began in 2004, with funding provided to SUNY Binghamton by NYSDEC. Continued research adds to the understanding of the needs of this state-endangered species. Information acquired from all research is entered into a database, and portions of the data are linked to a GIS. These data are used to visualize distributions, track reproductive success, and identify areas for focused management or study.

Protection of the eastern tiger salamander was a key component of the EA for the LISF project in 2009. The unique shape of the project, in part, came about due to the need to provide sufficient, viable habitat for the salamander within the area to be developed. Additionally, the LISF agreed to habitat enhancement to improve one of BNL's tiger salamander ponds that was determined to be a population sink area (i.e. breeding occurred in the pond, but has not been successful).

6.1.2.2 Other Species

As part of the eastern tiger salamander and herpetological surveys, information is being gathered on other species found on site. Including the tiger salamander, sightings of 26 species of reptiles and amphibians have been recorded over the past several years. The 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*), 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*), northern red-bellied snake (*Storeria occiptiomaculata*), and eastern wormsnake (*Carphophis amoenus*). This list indicates that BNL has one of the most diverse herpetofaunal assemblages on Long Island.

Banded sunfish protection efforts include observing whether adequate flow in the Peconic River is maintained within areas currently identified as sunfish habitat, ensuring that existing vegetation in their habitat is not disturbed, and evaluating all activities taking place on the river for potential impacts on these habitats. Population estimates are periodically conducted within various waters on site to determine the current health of the banded sunfish. The last estimate was conducted in 2007, with a population of approximately 4,000 fish.

6.1.2.3 Migratory Birds

A total of 216 species of birds have been identified at BNL since 1948; at least 85 species are known to nest on site. Some of these nesting birds have shown declines in their populations nationwide over the past 30 years. The Laboratory conducts routine monitoring of songbirds along six permanent bird survey routes in various habitats on site. In 2009, monthly surveys were conducted starting at the end of March and extending through the end of September. These surveys identified 71 songbird species, compared to 70 species in 2008 and 69 species during 2007. One of the species identified during the 2009 surveys had not been reported previously. A total of 114 songbird species have been identified during surveys in the past 10 years; 45 of these species were present each year. Variations in the number and species identified reflect the time of sampling, variations in weather patterns between years, or actual changes in the environment. The two most diverse transects pass near wetlands by the Biology Fields and the Peconic River. The four transects passing through the various forest types (white pine, moist pine barrens, and dry pine barrens) showed a less diverse bird community. Data are stored in an electronic database that is linked to the Laboratory'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*). BNL's NRMP includes habitat enhancement for the eastern bluebird. Since 2000, the Laboratory has installed more than 56 nest boxes around open grassland areas on site to enhance their population.

Migratory birds occasionally cause safety and health concerns. Birds that typically are of concern include Canada geese (*Branta canadensis*) and several species of migratory birds that occasionally nest on buildings or in construction areas. Over the past several years, the resident Canada goose population began increasing with the potential to reach large numbers that could result in health and safety issues for the Laboratory. In 2007, under a permit from the U.S. Fish & Wildlife Service (FWS), the Laboratory began managing the resident goose population. In the first year, the goose population was estimated at approximately 120 birds and nests were only managed if they posed a health or safety issue; eggs were treated in ten nests, or the nests were removed. At the end of the 2007 nesting season, the goose population reached an estimated 157 birds. Therefore, in 2008, nest management became more aggressive and eggs in 30 nests that were found were oiled to prevent development. Even with a more aggressive approach to nest management, 15 goslings were hatched and survived. However, with attrition and mortality associated with off-site hunting, the resident population was estimated at 148 birds at the end of 2008. In 2009, the goose population was estimated at 120 birds prior to treating 30 nests. By the end of 2009, the local resident goose population was estimated at 105 birds.

In 2009, the Laboratory began construction of the National Synchrotron Light Source II. This involved extensive grading of the site, creating favorable habitat for killdeer (*Charadrius vociferous*), a ground-nesting plover. The area was known to be suitable for this species as determined in the EA for the NSLS-II (BNL 2005). When nests were identified, all work around the nests was halted and the United States Department of Agriculture Animal and Plant Health Inspection Service – Wildlife Services (USDA-WS) division was called to assess and remove nests, as determined necessary. USDA-WS personnel were called on two separate occasions, removing three nests. A fourth nest, away from the construction site, produced four chicks,

which were relocated to the NSLS-II site by the parents. These birds were coaxed away from the construction site by natural resource staff.

6.1.3 Population Management

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

6.1.3.1 Wild Turkey

The forested areas of BNL provide good nesting and foraging habitat for wild turkey *(Meleagris gallapavo)*. The on-site population was estimated at 60 to 80 birds in 1999 and had grown to approximately 500 birds in 2004. Since 2004, the population appears to have stabilized at approximately 300 birds. The population across Suffolk County, Long Island, was determined to be of sufficient size to support hunting in 2009. Biologists from NYSDEC, USDA-WS, and the Wild Turkey Federation attempted to band turkeys on site prior to the hunt, but were unsuccessful. Hunting is not currently allowed at the Laboratory. However, turkeys do not limit their movements to BNL and often move great distances. Banding turkeys taken in the hunt would have provided valuable information on patterns of movement. The first fall hunt (5 days) resulted in over 100 birds taken in Suffolk County, with little or no evidence of effects on the BNL turkey population.

6.1.3.2 White-Tailed Deer

BNL consistently updates information on the resident population of white-tailed deer (*Odocoileus virginianus*). As there are no natural predators on site and hunting is not permitted at the Laboratory, there are no significant pressures on the population to migrate beyond their typical home range of approximately 1 square mile. Normally, a population density of 10 to 30 deer per square mile is considered an optimum sustainable level for a given area. This would equate to approximately 80 to 250 deer inhabiting the BNL property, under normal circumstances. This was the approximate density in 1966, when the Laboratory reported an estimate of 267 deer on site (Dwyer 1966).

The Laboratory has been conducting population surveys of the white-tailed deer since 2000. In 2004, based on results of aerial infrared surveys, BNL adjusted the methods for estimating the deer population. The method utilizes GIS data layers for vegetation to adjust deer counts based on habitat. The deer population increased to an estimate of 800 deer in December 2008. In 2009, the deer population increased to an estimated 893 animals in the spring and began declining in the fall. By December 2009, the population estimate was 731. This decrease is, in part, supported by the increased number of car–deer accidents reported on site during October and November.

To gain additional information on deer populations, an aerial deer survey is being planned during the winter months in early 2010. This survey is very similar to the aerial surveys conducted in February and March 2004. The Spring 2009 estimate of 893 animals is equivalent to 109 deer per square mile and reflects an approximate increase of ten percent over December 2008 numbers.

Deer overpopulation can affect animal and human health (e.g., animal starvation, Lyme disease from deer ticks, collision injuries to both human and animal), species diversity (songbird species reduction due to selective grazing and destruction of habitat by deer), and property values (collision damage to autos and browsing damage to ornamental plantings). In 2009, 13 deer-related collisions occurred on site, compared to 3 accidents in 2007 and 2008. Only in 2006 were there 10 or more deer-related collisions. The increased number of accidents appears to be due to an increase in deer population. While the winter of 2008-2009 was harsh on the BNL deer, many of them survived. This resulted in a significant increase in accidents. While the population was high, winter conditions were such that significant population reduction was likely to occur. Several cold rains occurred in November and December 2009, stressing the population, even though there was significant food available from the 2009 acorn crop.

Because the high deer population is a regional problem, the Laboratory is working on the is-

sue with other local jurisdictions. As part of this regional approach, an issue and decision paper was prepared for BNL management consideration late in 2007. Options for deer management are limited, and most are controversial. While a single regional approach would benefit the community, land managers, and the health of the deer population, multiple land managing organizations like the Laboratory must implement a regional approach. In 2008, the BNL Policy Council approved moving forward with deer management planning. Several meetings were held with employees during the spring months, resulting in the development of an employee survey. The survey was sent out to approximately 2,800 individuals; 829 individuals responded. Most respondents believe that deer management is needed, but the survey was unclear on the method of deer management to be used. In the fall months, several informational sessions were held to further explain the various options available in order to begin moving forward with management. The first step is for BNL to prepare an EA under the requirements of NEPA. The EA process was scheduled to begin sometime in 2009, but was delayed due to the higher priority development of an EA for the LISF.

6.1.4 Compliance Assurance and Potential Impact Assessment

The NEPA review process at BNL is a key to ensuring that environmental impacts of a proposed action or activity are adequately evaluated and addressed. The Laboratory will continue to use NEPA (or NEPA-like) processes under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Environmental Restoration Program when identifying potential environmental impacts associated with site activities—especially with physical alterations. As appropriate, stakeholders such as EPA, NYSDEC, Suffolk County Department of Health Services (SCDHS), BNL's Community Advisory Council, and the BNL Brookhaven Executive Roundtable are involved in reviewing major projects that have the potential for significant environmental impacts. Formal NEPA reviews are coordinated with the State of New York. As discussed previously, in 2009 BNL completed an EA for the proposed LISF. A summary of NEPA reviews is provided in Chapter 3.

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 was managed by FWS under an Interagency Agreement (DOE–FWS 2000). The Upton Reserve, on the eastern boundary of BNL, is home to a wide variety of flora and fauna. It contains wetlands and is largely within the core preservation area of the Long Island Central Pine Barrens. Based on information from a 1994–1995 biological survey of the Laboratory, experts believe the reserve is home to more than 200 plant species and at least 162 species of mammals, birds, fish, reptiles, and amphibians (LMS 1995).

A transition from FWS management of the Upton Reserve to management by BNL and the Foundation for Ecological Research in the Northeast (FERN) occurred in 2005. During that year, FERN initiated its first pine barrens–wide monitoring program to assess the health of the various forest types within the Pine Barrens, followed by a continuation of the effort in 2006. FERN established 91 permanent plots over the 2-year period of the monitoring program. One significant finding from the monitoring is the lack of forest regeneration. In virtually every forest type, there is a lack of survival of trees from seedlings through to saplings. This is likely a result of either deer over-abundance or lack of sunlight penetrating to the understory. Further information on the forest health initiative, as well as other activities of FERN, is available on the FERN website at www.fern-li.org. In 2008, FERN finalized protocols for monitoring wetland health throughout the Pine Barrens. These protocols, when implemented, will provide baseline information on the current health of the wetlands found within the Central Pine Barrens.

Research supported by FERN in 2009 included continued investigation into the microbial world of soils located within a number of the Forest Health Plots and experimental areas at BNL. Microbial research carried out by a scientist at Dowling College in 2007 identified several new species of fungus and bacteria that had not previously been known. In 2008, the work was expanded to develop a microbial community profile of the Pine Barrens. This work has resulted in a small National Science Foundation Grant to further investigate and isolate new bacteria. Research was conducted in conjunction with a Faculty and Student Team from Southern University at New Orleans, who have submitted their results for publication. The work is expected to continue in 2010, with genetic analysis of the microbes to further refine the microbial community structure. Additional work funded by FERN included an aquatic invertebrate survey of the Carmans River and the development of a DVD documenting the various sampling protocols used within the Open Space Stewardship Program (OSSP) sponsored by the Office of Education at BNL. Additional information on these projects is provided in Section 6.5.

6.3 MONITORING FLORA AND FAUNA

The Laboratory routinely monitors flora and fauna to determine the effects of past and present Laboratory activities. Because soil contaminated with a radioactive isotope of cesium (Cs-137) was used in some BNL landscaping projects in the past, traces have now been found in deer and in other animals and plants. At the cellular level, Cs-137 takes the place of potassium (K), an essential nutrient.

Most radionuclide tables in this chapter list data for both Cs-137 and potassium-40 (K-40), a naturally occurring radioisotope of potassium. Because K-40 is naturally in the environment, it is commonly found in flora and fauna. (In general, K-40 values do not receive significant discussion in the scientific literature because K-40 occurs naturally.) Studies indicate that Cs-137 out-competes K and K-40 when potassium salts are limited in the environment, which is typical on Long Island.

The results of the annual sampling conducted under the flora and fauna monitoring program follow.

6.3.1 Deer Sampling

White-tailed deer in New York State typically are large, with males weighing, on average, about 150 pounds; females typically weigh one-third less, approximately 100 pounds. However, white-tailed deer on Long Island tend to be much smaller, weighing an average of 80 pounds. The available meat on local deer ranges from 20 to 40 pounds per deer. This fact has implications for calculating the potential radiation dose to consumers of deer meat containing Cs-137, because smaller deer do not provide sufficient amounts of venison to support the necessary calculations.

In 2009, as in recent years, an off-site deer-sampling program was conducted with the NYSDEC Wildlife Branch. While most off-site samples are from road-killed deer near the Laboratory, NYSDEC provides a few samples from hunters beyond BNL boundaries, yielding control data on deer living 1 mile or more from BNL. In addition, Laboratory employees occasionally inform Laboratory staff of deer that have died in various areas of Long Island. In all, 14 deer were obtained on site and 18 were from off-site locations, ranging from adjacent to BNL along the William Floyd Parkway, to approximately 5 miles away (Baiting Hollow, New York).

BNL sampling technicians collect the samples and process them for analysis. Samples of meat, liver, and bone are taken from each deer, when possible. The meat and liver are analyzed for Cs-137, and the bone is analyzed for strontium-90 (Sr-90).

6.3.1.1 Cesium-137 in White-Tailed Deer

White-tailed deer sampled at the Laboratory contain higher concentrations of Cs-137 than deer from greater than 1 mile off site (BNL 2000), probably because they graze on vegetation growing in soil where elevated Cs-137 levels are known to exist. Cs-137 in soil can be transferred to aboveground plant matter via root uptake, where it then becomes available to browsing animals.

Removal of contaminated soil areas at BNL has occurred under the Laboratory's Environmental Restoration (ER) Project. All major areas of contaminated soil were remediated by September 2005. In addition, all buildings at the former Hazardous Waste Management Facility (HWMF) were removed in 2003, and the cleanup of the remainder of the facility was completed by fall 2005. Subsequent to the completion of cleanup at the former HWMF, additional minor contamination outside that facility was found and characterized, and the majority of the contamination was removed in 2009. Further characterization of the area surrounding the former HWMF was performed in late 2009, with work scheduled to continue into 2010.

The number of deer obtained for sampling steadily increased between 1996 and 2004. However, the numbers of deer obtained from 2005 to 2008 were significantly lower. In 2009, increased number of deer–car collisions resulted in a larger number of samples than in the recent past. 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 obtained each year has varied due to the sampling method, which depends on vehicle and deer accidents and people reporting dead deer. The number of deer hit by vehicles varies widely from year to year, depending on the population of deer present near major roadways and the traffic density. Figure 6-1 shows the location of all deer samples taken within a 5-mile radius of the Laboratory since 2004. Most of the off-site samples are concentrated along the William Floyd Parkway on the west boundary of BNL, whereas the concentration on site is near the front gate area and the constructed portions of the Laboratory. 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 and traffic to and from the front gate are greatest.

In 2009, Cs-137 concentrations in deer muscle ("meat") samples taken at BNL ranged from non-detectable to 2.97 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 2009 on-site concentration (2.97 pCi/g wet weight) was 1.8 times higher than the highest level reported in 2008 (1.67 pCi/g wet weight), but continues to be 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 0.80 pCi/g, wet weight (see Table 6-2), which was comparable to the arithmetic average in 2008, 0.89 pCi/g wet weight.

Cs-137 concentrations in off-site deer meat samples were separated into two groups: samples taken within 1 mile of BNL (nine samples) and samples taken farther away (nine samples) as shown in Table 6-2. Concentrations in meat samples taken within 1 mile ranged from 0.03 to 4.89 pCi/g wet weight, with an arithmetic average of 1.66 pCi/g wet weight; concentrations in meat taken from greater than 1 mile ranged from non-detectable to 1.39 pCi/g wet weight, with an arithmetic average of 0.43 pCi/g wet weight. Because deer on site may routinely travel up to 1 mile off site, the arithmetic average for deer taken on site and within 1 mile of the Laboratory is also calculated; for 2009, this was 1.14 pCi/g wet weight.

Figure 6-2 compares the average values of Cs-137 concentrations in meat samples collected in 2009 from four different location groupings. Although the figure does not show this, 72 percent of all meat samples taken both on and off site are below 1 pCi/g wet weight (Table 6-2).

Figure 6-3 presents the 10-year trend of on-site and near-off-site Cs-137 averages in deer meat. While similar in number to the samples taken in 2001, samples from 2009 indicate a similar range of error and continue to indicate the effectiveness of cleanup actions across the Laboratory; approximately 0.5 pCi lower average than in 2001. In 2003, a seasonal pattern in Cs-137 concentrations in deer meat was noticed. This seasonality was present in data from earlier years and occurred again in 2009 (see Table

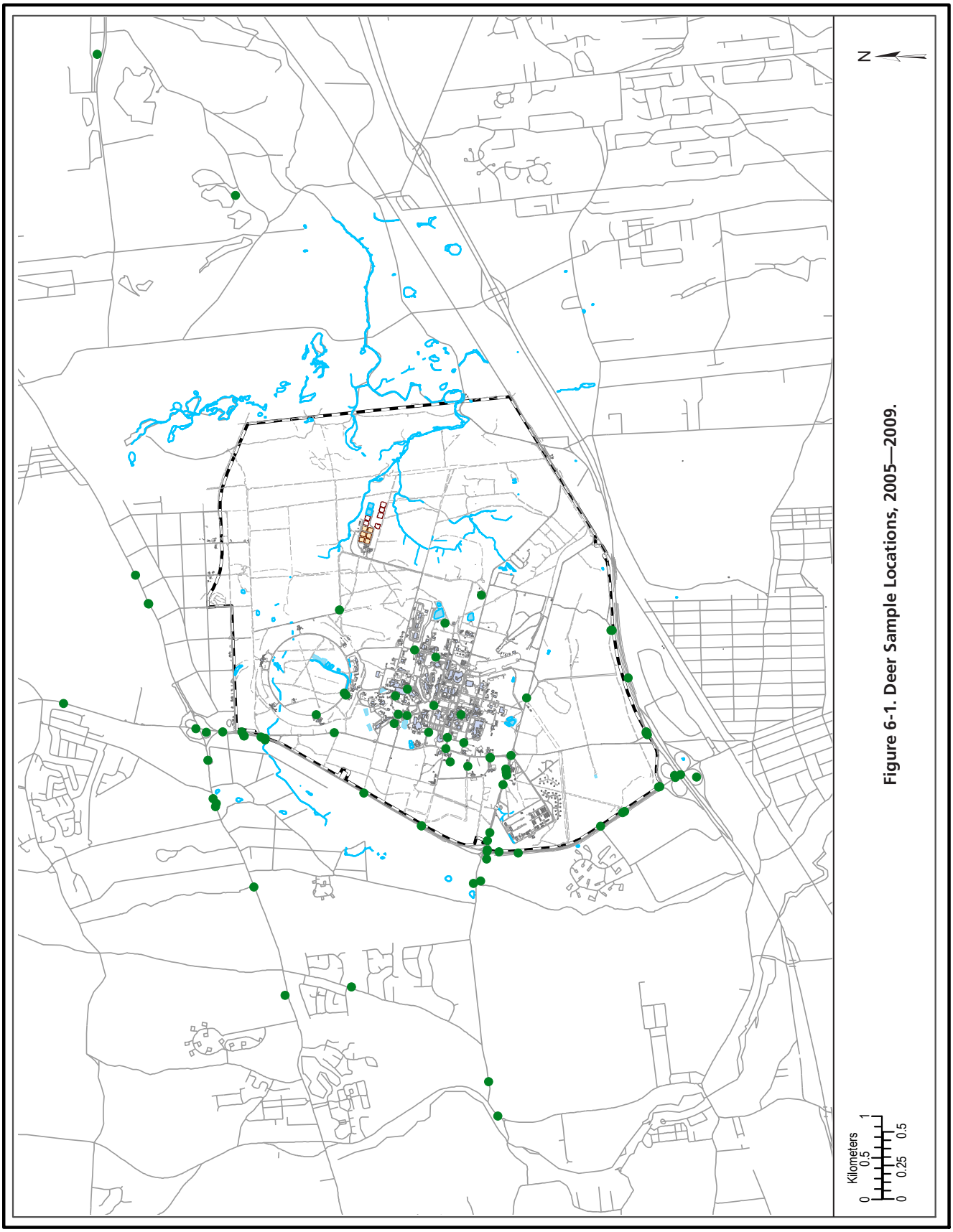


Figure 6-1. Deer Sample Locations, 2005—2009.

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

Sample Location	Collection Date	Tissue Type	K-40 pCi/g (Wet Weight)	Cs-137 pCi/g (Wet Weight)	Sr-90 pCi/g (Dry Weight)
BNL, On Site					
Bldg 1070	01/06/09	Hind	3.19 ± 0.35	0.41 ± 0.04	
		Bone			0.23 ± 0.55
Between Bldgs. 460 and 461	02/09/09	Hind*	2.89 ± 0.33	0.04 ± 0.01	
		Liver*	2.21 ± 0.47	0.06 ± 0.02	
		Bone			0.63 ± 0.50
National Weather Service	03/09/09	Hind	2.87 ± 0.36	0.03 ± 0.01	
		Bone**			0.96 ± 0.59
Bldg. 488	04/04/09	Hind*	3.26 ± 0.38	0.02 ± 0.01	
		Liver	2.42 ± 0.32	0.01 ± 0.01	
		Bone			0.70 ± 0.45
Bldg 258	04/20/09	Hind	2.10 ± 0.46	ND	
		Liver	2.96 ± 0.76	ND	
		Bone**			0.83 ± 0.52
Near P-2 area	06/22/09	Hind*	3.19 ± 0.37	0.02 ± 0.01	
		Liver*	1.84 ± 0.26	0.01 ± 0.01	
		Bone			ND
P-2 area, Bldg. 488	09/04/09	Hind*	3.62 ± 0.41	0.08 ± 0.01	
		Liver*	2.33 ± 0.41	0.03 ± 0.02	
		Bone			1.60 ± 0.52
Fence between Bldgs. 908 and 941	11/17/09	Hind	3.75 ± 0.54	0.73 ± 0.07	
		Liver	2.93 ± 0.31	0.29 ± 0.03	
		Bone			1.13 ± 0.35
Intersection, Bell Ave. and Columbia St.	11/20/09	Hind	3.11 ± 0.36	0.76 ± 0.05	
		Bone			1.49 ± 0.39
Intersection, Upton Rd. and Princeton Ave.	11/20/09	Hind	3.36 ± 0.38	2.97 ± 0.30	
		Bone			ND
Corner, Upton Rd. and Bell Ave.	12/11/09	Hind	2.61 ± 0.38	0.66 ± 0.07	
		Liver*	2.21 ± 0.31	0.12 ± 0.02	
		Bone			ND
Princeton Ave., across from Motorpool	12/11/09	Hind	3.41 ± 0.40	2.81 ± 0.28	
		Bone			2.75 ± 0.45
North Gate Rd.	12/11/09	Hind	3.40 ± 0.39	1.00 ± 0.09	
		Liver*	2.26 ± 0.55	0.13 ± 0.04	
		Bone			ND
Inner RHIC Rd., across from Bldg. 1007	12/19/09	Hind	3.28 ± 0.35	1.71 ± 0.11	
		Liver	2.22 ± 0.29	0.42 ± 0.04	
		Bone			4.66 ± 0.57
Offsite < 1 mile					
LIE and WFP NE cloverleaf	05/20/2009	Hind	3.02 ± 0.34	0.24 ± 0.03	
		Liver*	1.66 ± 0.37	0.12 ± 0.03	
		Bone			1.00 ± 0.59
LIE and WFP	07/17/2009	Hind	3.25 ± 0.34	0.60 ± 0.05	
		Bone			1.96 ± 0.58

(continued on next page)

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

Sample Location	Collection Date	Tissue Type	K-40 pCi/g (Wet Weight)	Cs-137 pCi/g (Wet Weight)	Sr-90 pCi/g (Dry Weight)
Red Deer from Sandy Pond	10/02/2009	Hind*	2.66 ± 0.34	0.03 ± 0.01	
		Bone			1.53 ± 0.57
WFP and Main Gate	10/02/2009	Hind	3.14 ± 0.37	1.79 ± 0.10	
		Bone			1.31 ± 0.58
WFP, 0.5 miles S of Main Gate	10/31/2009	Hind	3.10 ± 0.37	1.70 ± 0.09	
		Bone			ND
WFP at North Gate	11/05/2009	Hind	3.17 ± 0.38	0.52 ± 0.05	
		Bone			ND
WFP	11/20/2009	Hind	3.49 ± 0.40	4.07 ± 0.36	
		Bone			1.91 ± 0.47
LIE, Exit 68 at South Gate	11/23/2009	Hind	3.15 ± 0.36	4.89 ± 0.42	
		Bone			7.82 ± 0.73
LIE, Exit 68 at South Gate	11/23/2009	Hind	3.04 ± 0.34	1.13 ± 0.09	
		Bone			ND
Offsite > 1 mile					
WFP, 1 mile N of Rte 25	01/06/2009	Hind	2.65 ± 0.30	1.39 ± 0.09	
		Bone			2.76 ± 0.76
Rt. 25, 0.25 mile W of WFP	01/06/2009	Hind	3.06 ± 0.33	0.40 ± 0.04	
		Liver*	2.06 ± 0.28	0.09 ± 0.02	
		Bone			1.58 ± 0.62
3186 Sound Ave., Riverhead	10/02/2009	Hind	2.79 ± 0.32	0.02 ± 0.01	
		Liver	2.85 ± 0.32	ND	
		Bone			ND
3186a Sound Ave., Riverhead	10/02/2009	Hind*	3.11 ± 0.34	0.01 ± 0.01	
		Liver*	3.05 ± 0.35	0.02 ± 0.01	
		Bone			ND
3186b Sound Ave., Riverhead	10/03/2009	Hind	3.02 ± 0.33	0.66 ± 0.05	
		Liver	2.48 ± 0.31	0.38 ± 0.03	
		Bone			1.44 ± 0.55
3186c Sound Ave., Riverhead	10/04/2009	Hind*	2.66 ± 0.33	0.02 ± 0.01	
		Liver*	2.69 ± 0.32	0.01 ± 0.01	
		Bone			ND
3186d Sound Ave., Riverhead	10/05/2009	Hind	2.77 ± 0.34	0.87 ± 0.08	
		Liver	2.80 ± 0.35	0.37 ± 0.04	
		Bone			ND
4603 Rt. 25, Calverton	11/04/2009	Hind	3.00 ± 0.44	0.52 ± 0.05	
		Liver	3.64 ± 0.39	0.98 ± 0.08	
		Bone			1.42 ± 0.40
Tanner Neck Rd., Westhampton	12/10/2009	Hind	3.50 ± 0.43	ND	
		Liver	3.36 ± 0.49	ND	
		Bone			ND

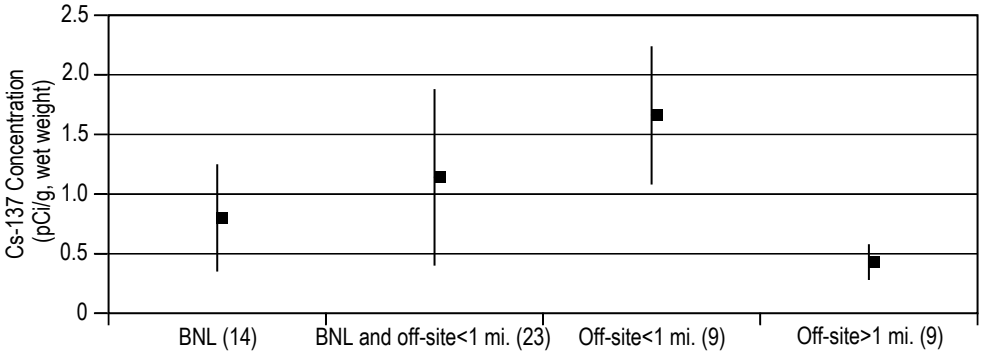
(continued on next page)

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

Sample Location	Collection Date	Tissue Type	K-40 pCi/g (Wet Weight)	Cs-137 pCi/g (Wet Weight)	Sr-90 pCi/g (Dry Weight)
Averages by Tissue					
Flesh					
Average for all Samples (32 samples)			3.08 ± 2.11	0.94 ± 0.75	
BNL on-site average (14 samples)			3.15 ± 1.47	0.80 ± 0.45	
BNL on- and off-site < 1 mile avg. (23 samples)			3.13 ± 1.82	1.14 ± 0.74	
Off-site average (18 samples)			3.03 ± 1.52	1.05 ± 0.60	
Off-site < 1 mile average (9 samples)			3.11 ± 1.08	1.66 ± 0.58	
Off-site > 1 mile average (9 samples)			2.95 ± 1.07	0.43 ± 0.15	
Liver					
Average for all samples (18 samples)			2.55 ± 1.69	0.17 ± 0.13	
BNL on-site average (9 samples)			2.38 ± 1.30	0.12 ± 0.08	
BNL on- and off-site < 1 mile avg. (10 samples)			2.30 ± 1.35	0.12 ± 0.08	
Off-site average (9 samples)			2.73 ± 1.07	0.22 ± 0.10	
Off-site < 1 mile average (1 sample)*			1.66 ± 0.37	0.12 ± 0.03	
Off-site > 1 mile average (8 samples)			2.87 ± 1.01	0.23 ± 0.10	
Bone					
Average for all samples (32 samples)					1.39 ± 3.29
BNL on-site average (14 samples)					1.25 ± 1.98
BNL on- and off-site < 1 mile avg. (23 samples)					1.55 ± 2.79
Off-site average (18 samples)					1.51 ± 2.62
Off-site < 1 mile average (9 samples)					2.01 ± 1.96
Off-site > 1 mile average (9 samples)					1.00 ± 1.74

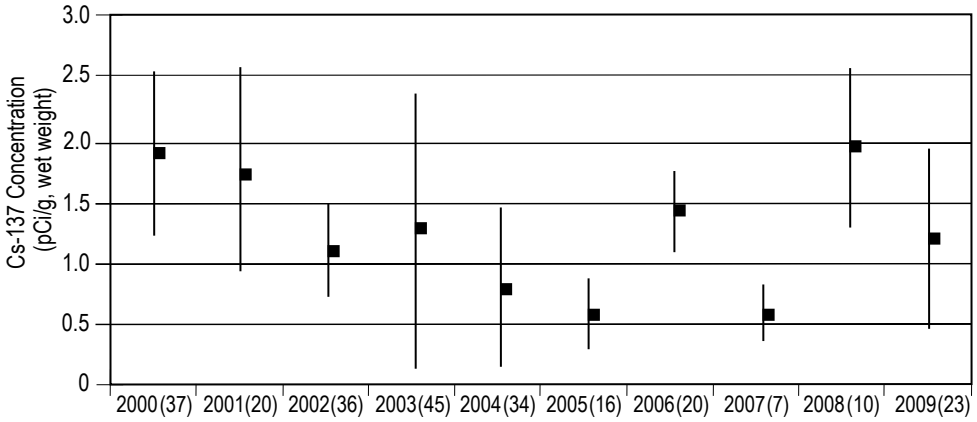
Notes:
All values are shown with a 95% confidence interval.
K-40 occurs naturally in the environment and is presented as a comparison to Cs-137.
All averages are the arithmetic average.
Confidence limits are 2σ signma (95%) propogated error.
Cs-137 = cesium-137
K-40 = potassium-40
LIE = Long Island Expressway
Sr-90 = strontium-90
WPF = William Floyd Parkway
* = estimated value for Cs-137
** = estimated value for Sr-90

6-2); deer sampled from October to December typically have higher Cs-137 values than those obtained in the spring. During the summer of 2004, a student in the Community College Intern Program reviewed all data from 2000–2003, analyzed the data statistically, and determined that there was a statistical seasonal variation in values for deer both on site as well as far off site (Florendo 2004). This seasonality is likely due to diet and the biological processing of Cs-137. From January through May, deer have a limited food supply—mostly dry vegetation from the previous year's growth (with a fixed concentration of Cs-137 because plants are dormant). In the summer and fall, deer eat more and the vegetation is constantly growing, taking up nutrients and contaminants from the soil. In summer and fall, deer feeding on vegetation growing in soil



Notes: Averages are shown for samples collected at BNL, on site and off site within 1 mile, off site but within 1 mile of the boundary, and off site greater than 1 mile from the boundary.
Numbers in parentheses indicate the number of samples in that data set.
All values are presented with a 95% confidence interval.
Cs-137 = cesium-137

Figure 6-2. Comparison of Cs-137 Average Concentrations in Deer, 2009.



Notes: Averages are shown for samples collected at BNL, and within 1 mile.
Numbers in parentheses indicate the number of samples in that data set.
All values are presented with a 95% confidence interval.
Cs-137 = cesium-137

Figure 6-3. Ten-Year Trend of Cs-137 Concentrations in Deer Meat at BNL and Within 1 Mile of BNL.

containing Cs-137 are more likely to obtain a continuous supply, which is incorporated into their tissues. This increased concentration of Cs-137 in tissues is evidenced by the three highest values seen in deer in 2009 (2.81, 4.07, and 4.89 pCi/g wet weight) from samples taken in October through December. By January or February, the Cs-137 in their tissues has been eliminated through biological processes. The levels of Cs-137 in deer tissue during June through early August are not well known, as there are few vehicle–deer accidents at this time of year.

When possible, liver samples are taken concurrently with meat samples. Liver generally accumulates Cs-137 at a lower rate than muscle tissue. The typically lower values in liver allow the results to be used as a validity check for meat values (i.e., if liver values are higher than meat values, results can be considered questionable and should be confirmed). In liver samples collected on site in 2009, Cs-137 concentrations ranged from non-detectable to 0.42 pCi/g wet weight, with an arithmetic average of 0.12 pCi/g wet weight. The off-site Cs-137 concentration in liver ranged from non-detectable to 0.98 pCi/g wet weight, with an arithmetic average for all off-site liver samples of 0.22 pCi/g wet weight.

The potential radiological dose resulting from deer meat consumption is discussed in Chapter 8. The New York State Department of Health (NYSDOH) has formally considered the potential public health risk associated with elevated Cs-137 levels in on-site deer and determined that neither hunting restrictions nor formal health advisories are warranted (NYSDOH 1999).

With respect to the health of on-site deer based on their exposure to radionuclides, the International Atomic Energy Agency (IAEA) has concluded that chronic dose rates of 100 millirad per day to even the most radiosensitive species in terrestrial ecosystems are unlikely to cause detrimental effects in animal populations (IAEA 1992). A deer containing a uniform distribution of Cs-137 within muscle tissue at the highest levels observed to date (11.74 pCi/g wet weight, reported in 1996) would carry a total amount of approximately 0.2 µCi. That animal would receive an absorbed dose of approximately 3 millirad per day, which is only 3 percent of the threshold evaluated by IAEA. The deer observed and sampled on site appear to have no health effects from the level of Cs-137 found in their tissues.

6.3.1.2 Strontium-90 in Deer Bone

BNL began testing deer bones for Sr-90 content in 2000. In 2009, Sr-90 content ranged from non-detectable to 4.66 pCi/g dry weight in on-site samples. Sr-90 in off-site samples ranged from non-detectable to 7.82 pCi/g dry weight in samples taken within 1 mile of BNL, and non-detectable to 2.76 pCi/g dry weight in samples taken more than a mile from BNL. This overlap in values between all samples suggests that Sr-90 is present in the environment at background levels, probably as a result of worldwide fallout from nuclear weapons testing. Sr-90 is present at very low levels in the environment, is readily incorporated into bone tissue, and may concentrate over time. The Laboratory will continue to test for Sr-90 in bone to maintain baseline information on this radionuclide and its presence in local white-tailed deer.

6.3.2 Other Animals Sampled

When other animals, such as wild turkey or Canada geese, are found dead along the roads of BNL and the immediate vicinity due to road mortality, they are tested for Cs-137 and Sr-90 content. In 2009 as in 2008, there were no samples taken from geese or turkeys. Data taken over the past several years indicate that both species do not readily uptake radionuclides from their diet.

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. Routine annual on-site sampling of fish resumed in 2007. Large areas of open water on site resulting from the cleanup of the Peconic River have resulted in sufficient habitat to support larger fish. During sampling activities in 2007, numerous schools of fry of bass and sunfish were noticed. While low dissolved oxygen levels continue to be a problem for fish, the deeper pools provide areas of cooler, more highly oxygenated water for long-term survival. Fish were sampled early in 2009 to take advantage of periods when dissolved oxygen levels are higher, supporting the presence of fish.

As in the past, off-site fish sampling continued in 2009. All samples were analyzed for edible (fillet) content of each of the analytes reported. In 2009, various species of fish were collected off site from Swan Pond, Donahue's Pond, Forge Pond, Manor Road, Schultz Road, and Lower Lake on the Carmans River (see Figure 5-8 for sampling stations). Swan Pond is a semi-control location on the Peconic River system (a tributary of the Peconic not connected to the BNL branch), and Lower Lake on the Carmans River is the non-Peconic control site. Sampling is carried out in cooperation with NYSDEC and through a contract with the Cold Spring Harbor Fish Hatchery and Museum. Sampling is also separated into samples taken as part of the routine surveillance monitoring program, and those taken as part of the post cleanup monitoring for the Peconic River Cleanup project (primarily for mercury analysis).

6.3.4.1 Radiological Analysis of Fish

The species collected for radiological analysis in 2009 by the Laboratory, NYSDEC, and through contract labor included brown bullhead (*Ictalurus nebulosus*), chain pickerel (*Esox niger*), largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), pumpkinseed (*Lepomis gibbosus*), brown trout (*Salmo trutta*), and yellow perch (*Perca flavescens*). Gamma spectroscopy analysis was performed on all samples. When fish were not of sufficient mass to conduct all non-radiological and radiological analyses, samples of the same species were composited to gain sufficient volume for radiological analysis. Table 6-3 presents specific information on the sampling location, species collected, and analytical results. All sample results are presented as wet weight concentrations. Information on the natural radioisotope K-40 is included as a comparison.

Cs-137 was detected at low levels in all but two samples from the Peconic River system, ranging from non-detectable for a largemouth bass and brown bullhead from Forge Pond and Swan Pond, respectively, to 0.51 pCi/g wet weight in a composite sample of largemouth bass taken from Area C on site. In 2009, fish taken from Lower Lake on the Carmans River (the non-Peconic control location) had no measurable values of Cs-137.

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). Cs-137 concentrations in brown bullhead collected at all locations along the Peconic River had values less than 0.30 pCi/g wet weight. Largemouth bass from the Peconic River showed Cs-137 levels of 0.51 pCi/g wet weight or less. Levels of Cs-137 in all fish species appear to be declining, compared to historic values.

Though it is clear from discharge records and sediment sampling that past BNL operations have contributed to anthropogenic (human-caused) radionuclide levels in the Peconic River system, most of these radionuclides were released between the late 1950s and early 1970s. Concentrations continue to decline over time through natural decay. Cs-137 has a half-life of 30 years. No Cs-137 was released from the BNL Sewage Treatment Plant (STP) to the Peconic River between 2003 and 2009 (see Figure 5-4 for a trend of Cs-137 discharges). Additionally, the cleanup of both on- and off-site portions of the Peconic River in 2004 and 2005 removed approximately 88 percent of Cs-137 in the sediment that was co-located with mercury. Removal of this contamination is expected to result in further decreases in Cs-137 levels in fish.

6.3.4.2 Fish Population Assessment

BNL suspended fish sampling on site in 2001 because prior fish sampling had depleted the population and limited the remaining fish to smaller sizes. Sampling resumed in 2007 when multiple schools of small fish were observed throughout the on-site portions of the river. The relative sizes of fish caught during annual sampling events will be tracked, and modifications to future sampling events will be made, as necessary, to ensure long-term health of the on-site fish populations. Successful sampling of sufficiently large fish for analysis in 2008 and 2009 indicated that populations are maintaining themselves and can support annual sampling.

6.3.4.3 Nonradiological Analysis of Fish

In 1997, under BNL's Environmental Restoration Program Operable Unit (OU) V Remediation Project, fish from the Peconic River on site were analyzed for metals, pesticides, and PCBs. From 2002 through 2006, analysis 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. From 2000 through 2006, sampling was performed from July through August. Additionally, there has been a wide variation in fish size; therefore, samples have had to be composite whole-body to obtain significant mass for analysis. These variables make the comparisons from year to year difficult, as there can be significant seasonal variations in

Table 6-3. Radiological Analysis of Fish from the Peconic River System and Carmens River, Lower Lake.

Location/Species	K-40 (pCi/g, wet weight)	Cs-137 (pCi/g, wet weight)
BNL, On Site		
Area A		
Brown Bullhead (composite)	NR	0.23 ± 0.03
Brown Bullhead (composite)	NR	0.22 ± 0.03
Brown Bullhead (composite)	NR	0.30 ± 0.04
Brown Bullhead (composite)	NR	0.23 ± 0.03
Brown Bullhead (composite)	NR	0.20 ± 0.03
Brown Bullhead (composite)	NR	0.26 ± 0.03
Brown Bullhead (composite)	NR	0.21 ± 0.03
Brown Bullhead (composite)	NR	0.25 ± 0.03
Brown Bullhead (composite)	NR	0.20 ± 0.04
Largemouth Bass	NR	0.19 ± 0.02
Pumpkinseed (composite)	NR	0.26 ± 0.04
Pumpkinseed (composite)	NR	0.20 ± 0.02
Pumpkinseed (composite)	NR	0.26 ± 0.03
Area C		
Bluegill (composite)	NR	0.19 ± 0.04
Bluegill (composite)	NR	0.18 ± 0.04
Brown Bullhead (composite)	NR	0.21 ± 0.03
Largemouth Bass (composite)	NR	0.51 ± 0.06
Pumpkinseed (composite)	NR	0.28 ± 0.08
Pumpkinseed (composite)	NR	0.22 ± 0.04
Pumpkinseed (composite)	NR	0.21 ± 0.04
Area D		
Brown Bullhead	NR	0.24 ± 0.03

(continued)

Table 6-3. Radiological Analysis of Fish from the Peconic River System and Carmens River, Lower Lake *(continued).*

Location/Species	K-40 (pCi/g, wet weight)	Cs-137 (pCi/g, wet weight)
Brown Bullhead (composite)	4.12 ± 0.52	0.30 ± 0.05
Brown Bullhead (composite)	3.10 ± 0.36	0.23 ± 0.03
Brown Bullhead (composite)	3.92 ± 0.42	0.22 ± 0.03
Brown Bullhead (composite)	NR	0.22 ± 0.03
Brown Bullhead (composite)	NR	0.24 ± 0.03
Brown Bullhead (composite)	3.04 ± 0.50	0.09 ± 0.03
Brown Bullhead (composite)	3.54 ± 0.48	0.15 ± 0.03
Largemouth Bass	3.39 ± 0.45	0.43 ± 0.04
Pumpkinseed	NR	0.24 ± 0.04
Pumpkinseed (composite)	2.94 ± 0.47	0.14 ± 0.03
Schultz Road		
Chain Pickerel	3.19 ± 0.44	0.14 ± 0.03
Largemouth Bass	2.74 ± 0.43	0.08 ± 0.02
Manor Road		
Brown Bullhead	3.43 ± 0.51	0.12 ± 0.03
Brown Bullhead	2.90 ± 0.42	0.19 ± 0.02
Brown Bullhead	3.17 ± 0.47	0.24 ± 0.03
Brown Bullhead	3.13 ± 0.44	0.12 ± 0.02
Brown Bullhead (composite)	2.10 ± 0.36	0.09 ± 0.02
Brown Bullhead (composite)	2.90 ± 0.40	0.19 ± 0.02
Brown Bullhead (composite)	2.95 ± 0.40	0.08 ± 0.03
Brown Bullhead (composite)	3.49 ± 0.54	0.14 ± 0.03
Chain Pickerel	3.61 ± 0.43	0.11 ± 0.02
Largemouth Bass	2.66 ± 0.45	0.07 ± 0.02
Largemouth Bass	3.43 ± 0.42	0.09 ± 0.02
Swan Pond (Peconic River control location)		
Brown Bullhead	2.34 ± 0.50	ND
Brown Bullhead*	4.09 ± 0.70	0.07 ± 0.03

(continued)

Table 6-3. Radiological Analysis of Fish from the Peconic River System and Carmens River, Lower Lake *(continued).*

Location/Species	K-40 (pCi/g, wet weight)	Cs-137 (pCi/g, wet weight)
Brown Bullhead*	3.33 ± 0.72	0.08 ± 0.04
Brown Bullhead*	2.85 ± 0.67	0.05 ± 0.03
Chain Pickerel*	3.76 ± 0.88	0.12 ± 0.06
Largemouth Bass*	3.90 ± 0.63	0.08 ± 0.03
Largemouth Bass*	4.63 ± 0.66	0.11 ± 0.03
Largemouth Bass*	2.45 ± 0.67	0.09 ± 0.03
Largemouth Bass*	3.69 ± 0.57	0.11 ± 0.04
Yellow Perch*	2.36 ± 0.70	0.10 ± 0.04
Yellow Perch*	3.60 ± 0.79	0.06 ± 0.05
Yellow Perch*	2.91 ± 0.65	0.09 ± 0.04
Yellow Perch*	3.29 ± 0.80	0.07 ± 0.05
Yellow Perch*	3.29 ± 0.93	0.09 ± 0.07
Yellow Perch*	2.20 ± 0.66	0.05 ± 0.04
Yellow Perch*	2.89 ± 0.78	0.08 ± 0.05
Donahue's Pond		
Bluegill (composite)	2.63 ± 0.51	0.05 ± 0.03
Bluegill (composite)	2.00 ± 0.47	0.05 ± 0.03
Bluegill (composite)	1.78 ± 0.38	0.05 ± 0.02
Bluegill (composite)	2.43 ± 0.41	0.09 ± 0.02
Bluegill (composite)	1.63 ± 0.58	0.07 ± 0.03
Bluegill (composite)	2.09 ± 0.42	0.07 ± 0.03
Brown Bullhead	2.87 ± 0.45	0.07 ± 0.02
Brown Bullhead	3.33 ± 0.49	0.07 ± 0.02
Brown Bullhead	3.06 ± 0.52	0.09 ± 0.02
Brown Bullhead	2.59 ± 0.52	0.10 ± 0.02
Brown Bullhead	3.03 ± 0.45	0.05 ± 0.02
Brown Bullhead (composite)	2.65 ± 0.52	0.06 ± 0.02
Chain Pickerel	3.05 ± 0.41	0.15 ± 0.02
Chain Pickerel	2.35 ± 0.37	0.26 ± 0.03
Chain Pickerel	3.35 ± 0.43	0.13 ± 0.02
Chain Pickerel	2.52 ± 0.37	0.10 ± 0.02
Pumpkinseed (composite)	2.02 ± 0.36	0.02 ± 0.02
Forge Pond		
Brown Bullhead*	3.27 ± 0.50	0.04 ± 0.02
Chain Pickerel*	2.84 ± 0.83	0.10 ± 0.05

(continued)

Table 6-3. Radiological Analysis of Fish from the Peconic River System and Carmens River, Lower Lake *(concluded).*

Location/Species	K-40 (pCi/g, wet weight)	Cs-137 (pCi/g, wet weight)
Chain Pickerel*	3.33 ± 0.76	0.19 ± 0.05
Chain Pickerel*	2.95 ± 0.58	0.08 ± 0.03
Chain Pickerel*	3.27 ± 0.70	0.09 ± 0.04
Largemouth Bass*	3.32 ± 0.84	0.08 ± 0.05
Largemouth Bass*	2.86 ± 0.90	0.12 ± 0.06
Largemouth Bass	4.91 ± 1.13	ND
Largemouth Bass*	4.65 ± 0.94	0.11 ± 0.06
Largemouth Bass*	2.88 ± 0.92	0.11 ± 0.06
Largemouth Bass*	3.82 ± 0.91	0.08 ± 0.05
Yellow Perch*	3.39 ± 0.68	0.07 ± 0.03
Yellow Perch*	2.83 ± 0.68	0.11 ± 0.04
Yellow Perch*	3.42 ± 0.62	0.08 ± 0.03
Yellow Perch*	4.09 ± 0.74	0.07 ± 0.03
Yellow Perch*	3.96 ± 0.86	0.09 ± 0.05
Yellow Perch*	2.79 ± 0.71	0.11 ± 0.03
Lower Lake, Carmans River		
Brown Bullhead	NR	ND
Brown Bullhead	NR	ND
Brown Bullhead	NR	ND
Brown Trout	NR	ND
Brown Trout	NR	ND
Brown Trout (composite)	NR	ND
Brown Trout (composite)	NR	ND
Largemouth Bass	NR	ND
Largemouth Bass	NR	ND
Largemouth Bass	NR	ND
Largemouth Bass	NR	ND
Largemouth Bass	NR	ND
Largemouth Bass	NR	ND

Notes:
All samples analyzed as edible portions (fillets).
K-40 occurs naturally in the environment and is presented as a comparison to Cs-137.
Cs-137 = cesium-137
K-40 = potassium-40
* = estimated value for Cs-137 based on analytical laboratory qualifiers.
ND = not detected, based on analytical laboratory qualifiiers.
NR = data not reported by analytical laboratory.

feeding, energy consumption, and incorporation of nutrients into various tissues. Beginning in 2005, all fish of sufficient size were analyzed as edible portions (fillets). Smaller fish, such as golden shiners, were composited for whole-body analysis. In 2007, fish sampling was moved to the spring months to lessen the effect of low oxygen levels on fish distributions. Nearly all samples were obtained between April and mid-June.

Table 6-4 shows the 2009 concentration of metals in fish taken for surveillance monitoring within the Peconic River and Lower Lake on the Carmans River. Due to the fact that values for arsenic, beryllium, cadmium, cobalt, silver, thallium, selenium, and vanadium were near or less than the minimum detection level (MDL) for the analytical procedure, they were not included in Table 6-4. Other metals tested but not included in the table include aluminum, antimony, and nickel, as most values reported for these metals were less than the MDL. Values that were above the MDL are discussed below. Fish taken on site are important to the post cleanup monitoring program; they are analyzed for mercury and the data are presented in Table 6-5.

Values for metals not shown in Table 6-4 because they were at or near MDL were as follows: aluminum was found in a composite sample of brown trout from the Carmans River at a level of 32.7 mg/kg; antimony was found in a single yellow perch from Swan Pond at a level of 0.383 mg/kg; arsenic was detected in several brown trout samples from Lower Lake on the Carmans River and ranged from 0.27 to 0.34 mg/kg, and was present in a single yellow perch from Forge Pond at a level of 0.28 mg/kg; cadmium, nickel, and selenium were not detected in any samples taken; and silver was found in two fish taken from the Peconic River, a yellow perch taken at Forge Pond and a large-mouth bass from Swan Pond. Both fish had a value of 0.10 mg/kg. These reported values and those presented in Table 6-4 are not considered to pose any health risks to humans or other animals that may consume fish.

Due to its known health effects, mercury is the metal of highest concern. Peconic River samples taken for surveillance were inadvertently not analyzed for mercury content in 2009. This error in analytical testing does not include fish taken for post cleanup monitoring related to the Peconic River Cleanup.

Table 6-4. Surveillance Monitoring Metals Analysis of Fish from the Peconic River System and Carmans River, Lower Lake.

Location/Species	Barium	Chromium	Copper	Iron	Lead	Manganese	Mercury	Zinc
	mg/kg							
Forge Pond								
Chain Pickerel	< MDL	< MDL	< MDL	< MDL	< MDL	0.472	NT	4.450
Chain Pickerel	< MDL	< MDL	< MDL	< MDL	< MDL	0.873	NT	6.310
Chain Pickerel	< MDL	< MDL	< MDL	< MDL	< MDL	0.206	NT	3.530
Chain Pickerel	< MDL	< MDL	< MDL	< MDL	< MDL	0.226	NT	3.120
Brown Bullhead	0.154	< MDL	< MDL	< MDL	< MDL	0.258	NT	2.480
Yellow Perch	< MDL	< MDL	< MDL	< MDL	< MDL	0.442	NT	3.660
Yellow Perch	< MDL	< MDL	< MDL	< MDL	< MDL	0.584	NT	5.850
Yellow Perch	0.343	< MDL	< MDL	< MDL	< MDL	2.020	NT	10.900
Yellow Perch	< MDL	< MDL	< MDL	< MDL	< MDL	0.575	NT	4.330
Yellow Perch	< MDL	< MDL	< MDL	< MDL	< MDL	0.396	NT	4.000
Yellow Perch	< MDL	< MDL	< MDL	< MDL	< MDL	0.620	NT	4.610
Yellow Perch	0.101	< MDL	< MDL	< MDL	0.121	0.199	NT	4.610
Yellow Perch	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	NT	5.510

(continued on next page)

Table 6-4. Surveillance Monitoring Metals Analysis of Fish from the Peconic River System and Carmans River, Lower Lake *(concluded).*

Location/Species	Barium	Chromium	Copper	Iron	Lead	Manganese	Mercury	Zinc
	mg/kg							
Yellow Perch	0.156	1.910	< MDL	14.000	< MDL	0.453	NT	7.780
Yellow Perch	0.184	< MDL	< MDL	< MDL	< MDL	0.240	NT	5.670
Yellow Perch	< MDL	< MDL	< MDL	< MDL	< MDL	0.274	NT	5.820
Yellow Perch	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	NT	5.440
Swan Pond (Peconic River control location)								
Largemouth Bass	0.170	0.157	< MDL	< MDL	< MDL	0.437	NT	5.580
Largemouth Bass	< MDL	< MDL	< MDL	< MDL	< MDL	0.211	NT	7.220
Largemouth Bass	0.110	< MDL	< MDL	< MDL	< MDL	0.281	NT	5.070
Largemouth Bass	0.142	< MDL	< MDL	< MDL	< MDL	0.271	NT	5.460
Chain Pickerel	< MDL	< MDL	< MDL	< MDL	< MDL	0.260	NT	6.220
Yellow Perch	0.218	< MDL	< MDL	< MDL	< MDL	2.660	NT	6.090
Yellow Perch	< MDL	< MDL	< MDL	< MDL	< MDL	0.318	NT	5.230
Yellow Perch	0.159	0.407	< MDL	< MDL	< MDL	0.406	NT	6.870
Yellow Perch	0.152	< MDL	< MDL	< MDL	< MDL	1.790	NT	4.530
Yellow Perch	< MDL	< MDL	< MDL	< MDL	< MDL	0.250	NT	4.210
Yellow Perch	0.112	< MDL	< MDL	< MDL	< MDL	0.317	NT	6.250
Yellow Perch	0.418	< MDL	< MDL	< MDL	< MDL	2.070	NT	8.160
Brown Bullhead	0.291	< MDL	< MDL	< MDL	< MDL	0.322	NT	4.910
Brown Bullhead	0.395	< MDL	< MDL	< MDL	< MDL	0.348	NT	4.590
Brown Bullhead	0.212	< MDL	< MDL	< MDL	< MDL	0.830	NT	4.400
Brown Bullhead	0.291	< MDL	< MDL	< MDL	< MDL	0.290	NT	4.100
Lower Lake, Carmans River (control location)								
Brown Bullhead	0.328	0.125	< MDL	5.190	< MDL	0.449	0.035	5.440
Brown Bullhead	0.222	0.124	< MDL	6.340	< MDL	0.305	0.018	4.760
Brown Bullhead	0.191	0.101	< MDL	2.800	< MDL	< MDL	0.029	3.290
Largemouth Bass	< MDL	0.128	< MDL	< MDL	< MDL	< MDL	0.055	4.670
Largemouth Bass	0.338	0.126	< MDL	< MDL	< MDL	0.690	0.047	4.480
Largemouth Bass	< MDL	0.122	< MDL	< MDL	< MDL	0.271	0.066	6.470
Largemouth Bass	0.172	0.153	< MDL	< MDL	< MDL	0.332	0.055	5.850
Largemouth Bass	0.124	0.114	< MDL	< MDL	< MDL	< MDL	0.051	5.410
Largemouth Bass	< MDL	0.102	< MDL	< MDL	< MDL	0.223	0.395	7.150
Brown Trout composite(3)	< MDL	0.119	< MDL	3.510	< MDL	0.213	0.004	3.950
Brown Trout composite(4)	0.411	0.152	< MDL	< MDL	< MDL	0.322	0.004	4.010
Brown Trout	0.131	0.150	< MDL	< MDL	< MDL	0.387	0.004	5.260
Brown Trout	< MDL	0.126	< MDL	< MDL	< MDL	0.204	0.004	3.760

Notes:
See Figure 5-8 for sampling locations.
All fish were analyzed as edible portions (fillets).
NT = No Test
MDL = Minimum Detection Limit

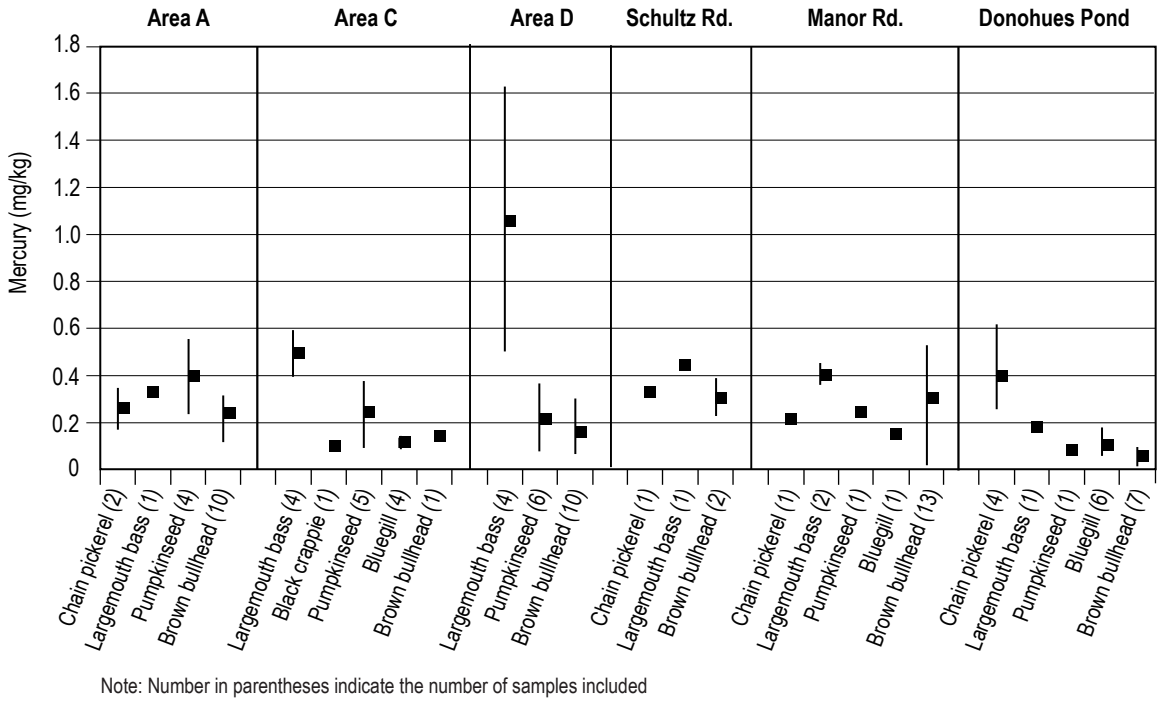
Table 6-5. Mercury Analysis of Fish from the Peconic River System Post Cleanup Monitoring.

Location/Species	Mercury mg/kg Min	Max	Avg
BNL, On Site			
Area A			
Chain pickerel (2)	0.167	0.349	0.258
Largemouth bass (1)	0.328	0.328	0.328
Pumpkinseed (4)	0.236	0.557	0.396
Brown bullhead (10 with composites)	0.116	0.319	0.241
Area C			
Largemouth bass (4 with composites)	0.393	0.593	0.496
Black Crappie (1)	0.100	0.100	0.100
Pumpkinseed (5 with composites)	0.088	0.383	0.248
Bluegill (4 with composites)	0.093	0.135	0.121
Brown bullhead (1 with composites)	0.145	0.145	0.145
Area D			
Largemouth bass (4)	0.507	1.630	1.056
Pumpkinseed (6 with composites)	0.081	0.367	0.211
Brown bullhead (10 with composites)	0.066	0.304	0.161
Schultz Road			
Chain pickerel (1)	0.329	0.329	0.329
Largemouth bass(1)	0.445	0.445	0.445
Brown bullhead (2)	0.228	0.386	0.307
Manor Road			
Chain pickerel (1)	0.214	0.214	0.214
Largemouth bass (2)	0.356	0.451	0.404
Pumpkinseed (1)	0.245	0.245	0.245
Bluegill (1)	0.152	0.152	0.152
Brown bullhead (13 with composites)	0.022	0.534	0.304
Donahue's Pond			
Chain pickerel (4)	0.262	0.624	0.399
Largemouth bass (1)	0.186	0.186	0.186
Pumpkinseed (1)	0.085	0.085	0.085
Bluegill (6 with composites)	0.065	0.177	0.106
Brown bullhead (7 with composites)	0.025	0.091	0.057

Notes:
Area letter designation refers to Peconic River cleanup areas on site.
All samples were analyzed as edible portions (fillets), including composite samples.
Full data sets are available in 2009 Peconic River Monitoring Report.

The post cleanup monitoring data for mercury analysis in fish is presented in Table 6-5 and is shown as a range of results by species and area sampled, to reduce the size of the table. The data is presented graphically in Figure 6-4. Mercury values in Area A of the Peconic River (area nearest the Sewage Treatment Plant [STP] outfall) ranged from 0.116 mg/kg in brown bullheads to 0.0.557 mk/kg in a pumpkinseed. At Area C, mercury ranged from 0.088 mg/kg in pumpkinseed to 0.593 mg/kg in largemouth bass. Fish taken from Area D near the boundary of the Laboratory had mercury content ranging from 0.066 mg/kg in brown bullhead to 1.630 mg/kg in largemouth bass. At Schultz Road, mercury ranged from 0.228 mg/kg in brown bullhead to 0.445 mg/kg in largemouth bass. At Manor Road, mercury content ranged from 0.022 mg/kg to 0.534 mg/kg in brown bullhead. The last location sampled as a part of the Peconic River Cleanup monitoring was Donahue's Pond, where mercury content in fish ranged from 0.025 mg/kg in brown bullhead to 0.624 mg/kg in chain pickerel. In general, from the rough data presented, a trend of decreasing mercury content going downstream from BNL's STP is evident. A more detailed review of the data is covered in the Annual Report on Peconic River Sampling for 2009 (BNL 2010).

Pesticide analyses in fish were discontinued in 2008, since several years of sampling detected pesticides in only a few fish far off site. PCB analyses in fish was also discontinued from surveillance monitoring, but continued to be completed on fish collected on site. Two fish samples taken from within Area A tested positive for Aroclor 1254: a 4-year-old brown bullhead containing 18.9 µg/kg and a composite sample of pumpkinseed containing 13.7 µg/kg. Historically, PCBs have been found in both fish and sediment at BNL and periodically at other locations in the Peconic River. The cleanup of the Peconic River that was completed in 2005 removed most PCBs within the sediments. Although BNL has discontinued most pesticide and PCB monitoring, the Laboratory may periodically test for PCBs and pesticides in fish to verify the presence/absence in fish tissue.



Note: Number in parentheses indicate the number of samples included

Figure 6-4. Peconic River Post Cleanup Mercury Distribution in Fish Species (Minimum, Maximum, and Average Values).

6.3.5 Aquatic Sampling

6.3.5.1 Radiological Analysis

Annual sampling of sediment and vegetation in the Peconic River and a control location on the Carmans River was conducted in 2009. (See Chapter 5 for a discussion on water quality and monitoring, and Figure 5-8 for the locations of sampling stations. Additionally, refer to Section 6.3.6 for a discussion of sediment and water analysis related to monitoring post-cleanup of the Peconic River.) Because significant numbers of samples are now taken under this monitoring program, fewer samples are being taken through routine surveillance monitoring, to reduce duplication of effort and lessen the impact on the fish populations.

Table 6-6 summarizes the radiological data. Cs-137 was not detected in any aquatic vegetation samples in 2009. Low levels of Cs-137 were detected in sediments at Swan Pond, Forge Pond, and Lower Lake on the Carmans River.

6.3.5.2 Metals in Aquatic Samples

Metals analyses (Table 6-7) were conducted on aquatic vegetation and sediments from the Peconic River and Lower Lake on the Carmans River. Most of the data indicate metals at background levels. The standard used for comparison of sediments is the SCDHS soil cleanup objectives for heavy metals. 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.

Other metals analyzed for, but not listed in Table 6-7, include antimony, arsenic, beryllium, cadmium, magnesium, potassium, selenium, sodium, and thalium. In general, levels of these metals are either below detection limits, below action levels or cleanup objectives, or, like sodium, are common in the environment. In the past, both arsenic and cadmium were detected in either Donahue's Pond and Lower Lake or in both. Neither of these metals were detected in sediments taken in 2009. Arsenic was detected above SCDHS cleanup objectives of 7.5 mg/kg in sediments at Donahue's Pond and Lower Lake (11 and 8.7 mg/kg, respectively). Cadmium was found in sediments at Lower Lake at a concentration of 1.16 mg/kg, which is above cleanup objectives but well below SCDHS ac-

Table 6-6. Radiological Analysis of Aquatic Vegetaion and Sediment from the Peconic River System and Carmans River, Lower Lake.

Location/Sample Type	K-40 (pCi/g)	Cs-137 (pCi/g)
BNL, On Site		
Aquatic vegetation	4.53 ± 0.51	ND
Aquatic vegetation	3.27 ± 0.48	ND
Aquatic vegetation	2.99 ± 0.45	ND
Aquatic vegetation	3.35 ± 0.39	ND
Donahue's Pond		
Aquatic vegetation	0.76 ± 0.27	ND
Sediment	1.48 ± 0.52	ND
Forge Pond		
Lilypads	1.7 ± 0.32	ND
Sediment	2.74 ± 0.33	0.07 ± 0.01
Swan Pond (Peconic River control location)		
Lilypads	2.6 ± 0.43	ND
Sediment	3.27 ± 0.63	1.06 ± 0.12
Lower Lake, Carmans River (control location)		
Lilypads	2.54 ± 0.43	ND
Sediment	3.99 ± 0.74	0.48 ± 0.09

Notes:
Cs-137 = cesium-137
K-40 = potassium-40
ND = not detected
Aquatic vegetation values are reported as wet weight.
Sediment values are reported as dry weight.

tion levels. Chromium was found above cleanup objectives of 10 mg/kg in sediment at Swan Pond and Lower Lake. Mercury and nickel were just above SCDHS cleanup objectives of 0.1 and 13 mg/kg, respectively, at Lower Lake.

6.3.5.3 Pesticides and PCBs in Aquatic Samples

Pesticides and PCBs analyses of aquatic samples were discontinued in 2008, corresponding to the discontinuance of this sampling in fish. DDT and its breakdown products have been the primary pesticide observed in sediments due to its long persistence in the environment. BNL will periodically analyze aquatic sediments to track the continued degradation of this pesticide in the environment.

6.3.6 Peconic River Post-Cleanup Monitoring

Sediment from the Peconic River was remediated in 2004 and 2005 to remove mercury and associated contaminants from the river. BNL/DOE must ensure that the cleanup provides adequate protection of human health and the environment by monitoring the sediment, surface water, and fish in the river for five years (2006–2010). A summary of the 2009 sediment, surface water, and fish sampling results for 2009 is described below. Detailed information on 2009 sampling results can be found in the Final 2009 Peconic River Monitoring Report (BNL, 2010).

6.3.6.1 Sediment Sampling

Sediment was sampled in August 2009 at 15 Peconic River routine sampling stations on site and 15 routine sampling stations off site. All of the 30 annual sediment samples collected in 2009 met the mercury cleanup goal of 2.0 mg/kg. Five supplemental samples were collected in the 80–100 square-foot area surrounding one on-site 2008 sediment sample location with a mercury concentration slightly greater than 2.0 mg/kg. The mercury concentrations for these five samples ranged between 0.35 mg/kg and 3.1 mg/kg, respectively, with an average of 1.37 mg/kg and only one sample exceeding 2.0 mg/kg. No further action is required in this area.

Supplemental sediment sampling was also conducted to evaluate elevated water column mercury concentrations at station PR-WC-06. The supplemental 2009 and January 2010 sediment samples identified a small on-site section of the river which will receive supplemental cleanup in the fall of 2010.

6.3.6.2 Water Column Sampling

In 2009, surface water was analyzed in June and July for total mercury and methylmercury at 20 and 17 of 22 Peconic River sampling stations, respectively. Samples at the STP and one reference station on the Connetquot River were also collected. Not all stations could be sampled due to low water tables in June and July. The concentrations of total mercury in the June (120 ng/L maximum) and July (115 ng/L maximum) water samples generally trended down-

Table 6-7. Metals Analysis of Aquatic Vegetation and Sediment from the Peconic River System and Carmens River, Lower Lake.

Location/ Sample Type	Aluminum	Barium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Manganese	Mercury	Nickel	Silver	Vanadium	Zinc
	mg/kg													
BNL, On Site														
Aquatic vegetation	10.2	3.05	1020	< MDL	< MDL	1.73	38.6	0.1	28.7	< MDL	0.204	0.127	0.155	4.83
Aquatic vegetation	54.3	17.6	782	0.309	< MDL	2.27	156	0.38	27	0.018	0.629	1.21	0.292	7.53
Aquatic vegetation	13.6	3.74	1450	< MDL	0.16	1.83	61.5	0.1	67.8	< MDL	0.365	< MDL	0.183	5.84
Aquatic vegetation	9.4	6.27	1750	< MDL	< MDL	1.08	42.1	0.117	46.7	< MDL	0.584	< MDL	0.187	7.1
Donahue's Pond														
Aquatic vegetation	10.2	44.4	4140	< MDL	0.232	< MDL	127	0.22	151	< MDL	< MDL	< MDL	< MDL	5.62
Sediment	78.6	1.67	44.9	0.267	< MDL	< MDL	163	2.03	6.18	< MDL	< MDL	< MDL	0.294	0.968
Forge Pond														
Aquatic vegetation	< MDL	33.2	1830	< MDL	< MDL	0.311	57	0.21	85.5	< MDL	< MDL	< MDL	< MDL	4.6
Sediment	4070	11.9	775	4.15	1.33	2.22	3940	3.39	17.7	< MDL	2.53	< MDL	5.5	23.9
Swan Pond (Peconic River control location)														
Aquatic vegetation	10.7	10.9	1200	< MDL	< MDL	< MDL	10.3	0.22	234	< MDL	< MDL	< MDL	< MDL	3.89
Sediment	3630	58.2	4350	14	2.45	10.7	2850	149	1180	< MDL	6.87	< MDL	27.8	45.3
Carmans River, Lower Lake (control location)														
Aquatic vegetation	7.38	44.9	2390	0.247	< MDL	0.531	71.1	0.2	232	< MDL	0.19	< MDL	0.195	5.95
Sediment	9670	161	5510	41.6	9.48	27.2	16700	131	883	0.235	15	< MDL	39.4	201
SCDHS Action Levels	N/A	N/A	N/A	100	N/A	500	N/A	400	N/A	2	1000	100	N/A	N/A
Cleanup Objectives	N/A	N/A	N/A	10	N/A	25	N/A	100	N/A	0.1	13	5	N/A	N/A

Notes:
MDL = method detection level
N/A = not applicable
SCDHS = Suffolk County Department of Health Services

wards with fluctuations and with increasing distance downstream from the STP until reaching concentrations of 3.17 ng/L to 3.84 ng/L at sample stations east of the cranberry bogs.

Peconic River methylmercury concentrations increased slightly from the STP outfall to the BNL site border. The methylmercury concentrations then decreased gradually with increasing distance downstream of the site border. The June methylmercury concentrations (3.97 ng/L maximum) in Peconic River samples were slightly less than the July samples (8.08 ng/L maximum), and decreased with increasing distance downstream of the site border until reaching the historic range of concentrations for the Connetquot River reference station. The decreasing methylmercury concentrations are associated with flow in downstream sections of the river with lower mercury concentrations in the sediment, and with dilution by flow into the river from ground water and tributaries.

6.3.6.3 Fish Sampling

In 2009, fish were collected from the Peconic River at Area A downstream of the STP, Area C, Area D near North Street, the Schultz Road and Manor Road areas, and Donahue's Pond. The average mercury concentration for all 93 fish samples was 0.27 mg/kg, which is significantly lower than the average pre-cleanup (1996 and 2001) fish mercury concentration (0.58 mg/kg). The EPA criterion for methylmercury concentration in fish tissue is 0.3 mg/kg. For PCBs, 52 fish samples were analyzed for 7 PCB isomers, for a total of 364 PCB analyses. Two (of 364) PCB analyses had concentrations greater than the detection limit (Aroclor 1254 at 13.7 and 18.9 ug/kg). The remaining 362 analyses had PCB concentrations less than the detection limit. The 2009 Cs-137 activity for the 61 fish samples analyzed was between non-detect and 0.51 pCi/g, and had an average of 0.17 pCi/g.

6.3.6.4 Remedial Actions

BNL/DOE recommended to EPA, DEC, and SCDHS that a sediment trap be removed from the river as required by the ROD, and that small sections of the river in the PR-WC-06 and PR-SS-15 areas with elevated sediment mercury concentrations be remediated. The work is planned for the fall of 2010.

6.3.7 Vegetation Sampling

6.3.7.1 Farm and Garden Vegetables

On-site sampling of garden vegetables was completed in 2009. The data on garden vegetables are presented in Table 6-8. Samples of zucchini, cucumber, tomato, pepper, and corn were analyzed for Cs-137 content. This radionuclide was not detected in any vegetables sampled from the on-site garden, but was detected in soils at a very low level (0.23 pCi/g). This value for Cs-137 in soil is consistent with background levels resulting from worldwide fallout from historic above-ground nuclear testing.

6.3.7.2 Grassy Plants

Grassy vegetation sampling around the Laboratory was conducted in 2009. Vegetation was sampled from ten locations around the Laboratory, including on the top and sides of the berms at the BNL Alternating Gradient Synchrotron and the Relativistic Heavy Ion Collider. Samples were also taken along the south and north boundaries of the Lab. All samples were analyzed for Cs-137 content. Data are presented in Table 6-8. None of the grassy vegetation samples had detectable levels of Cs-137, which is consistent with past sampling efforts. Grassy vegetation sampling is utilized for the annual dose to biota analysis reported in Chapter 8.

6.4 OTHER MONITORING

6.4.1 Soil Sampling

Soil sampling was conducted at the same ten locations where grassy vegetation was sampled in 2009. Soil samples were analyzed for Cs-137 and the data are presented in Table 6-8. Cs-137 content in soils ranged from non-detectable to 0.27 pCi/g. These values are consistent with past soil analysis and are indicative of background levels resulting from worldwide fallout from historic above-ground nuclear testing.

6.4.2 Basin Sediments

A 5-year testing cycle for basin sediment samples was established in 2003. Basin sediments were sampled in 2007 and results were

Table 6-8. Radiological Analysis of Farm and Garden Vegetables and Associated Soils.

Location/Sample	K-40 (pCi/g)	Cs-137 (pCi/g)
BNL Garden		
Green Pepper	1.95 ± 0.20	ND
Cucumber	1.77 ± 0.13	ND
Tomato	2.63 ± 0.24	ND
Corn	2.79 ± 0.23	ND
Zuchini	1.70 ± 0.15	ND
Soil	6.24 ± 0.61	0.23 ± 0.03
BNL grassy vegetation		
RHIC Ring, 10 o'clock beam stop		
Vegetation	3.02 ± 0.74	ND
Soil	6.5 ± 1.05	0.27 ± 0.06
RHIC Ring, 10 o'clock berm side		
Vegetation	2.52 ± 0.56	ND
Soil	3.66 ± 0.65	ND
RHIC Ring, 2 o'clock beam stop		
Vegetation	2.57 ± 0.49	ND
Soil*	4.61 ±0.75	0.09 ± 0.03
RHIC Ring, 2 o'clock berm side		
Vegetation	5.11 ± 0.76	ND
Soil*	4.57 ± 0.68	0.11 ± 0.03
AGS Berm		
Vegetation	4.84 ± 0.68	ND
Soil*	4.81 ± 0.83	0.16 ± 0.05
Tunnel Berm, S of Bldg. 925		
Vegetation	4.12 ± 0.50	ND
Soil*	5.75 ± 0.88	0.08 ± 0.06
South Boundary Rd., SW Corner		
Vegetation	4.16 ± 0.64	ND
Soil*	9.55 ± 1.27	0.12 ± 0.06
Biology Fields, E of Astronomy Way		
Vegetation	6.30 ± 0.70	ND
Soil*	7.27 ± 1.04	0.17 ± 0.07
W of Air Station P7		
Vegetation	6.21 ± 0.77	ND
Soil*	7.81 ± 0.99	0.06 ± 0.04
N of Wooded Wetland		
Vegetation	4.47 ± 0.59	ND
Soil	5.92 ± 0.93	0.24 ± 0.05

Notes:
Vegetables are reported as wet weight values.
Soils are reported as dry weight values.
* = estimated values for Cs-137
K-40 = Potassium-40
Cs-137 = Cesium-137

presented in the 2007 Site Environmental Report. In 2007, at basins HO and HT-E, initial results of sampling identified several compounds above SCDHS action levels. Suffolk County was notified and a co-sampling event was conducted with BNL and Suffolk County's participation. Both sets of results indicated that no issue existed, suggesting an error in the original sample results. Under the 5-year cycle for basin sediments, the next sampling will occur in 2012.

6.4.3 Chronic Toxicity Tests

Under BNL's SPDES discharge permit, the Laboratory conducted chronic toxicity testing of STP effluents. The results of this testing are discussed in Chapter 3, Section 3.6.1.1. Testing will continue in 2010.

6.4.4 Radiological and Mercury Monitoring of Precipitation

As part of the BNL Environmental Monitoring Program, precipitation samples were collected quarterly at air monitoring Stations P4 and S5 (see Figure 4-3 for station locations), and were analyzed for radiological content and total mercury (Table 6-9). Four samples were taken from each of these two stations in 2009. Gross alpha activity measurements were above the MDL at P4 in the first and third quarters of 2009. Values were 7.8 pCi/L in the first quarter and estimated at 1.67 pCi/L in the third quarter.

Gross beta activity was measured in samples for three of the four quarters at both stations in 2009. 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 10.7 pCi/L, with an average of 3.47 pCi/L. Location S5 had a maximum gross beta activity level of 5.6 pCi/L, with an average of 3.36 pCi/L. Gross beta activity values were within the range of values historically observed at these two locations. Beryllium-7 (Be-7) was not detected in any of the quarterly samples at either station. Be-7 is produced in the atmosphere by cosmic radiation and is periodically found in precipitation.

Analysis of mercury in precipitation is completed to document the range of mercury depo-

Table 6-9. Precipitation Monitoring (Radiological and Mercury).

Location/ Period	Be-7	Gross Alpha	Gross Beta	Mercury
	pCi/L			ng/L
P4				
1st Quarter	ND	7.8 ± 1.6	10.7 ± 1.6	10.4
2nd Quarter	ND	ND	2.10 ± 0.74*	5.47
3rd Quarter	ND	1.67 ± 0.84	1.06 ± 0.67*	6.79
4th Quarter	ND	ND	ND	7.57
S5				
1st Quarter	ND	ND	5.6 ± 1.3	10.6
2nd Quarter	ND	ND	2.94 ± 0.93*	5.54
3rd Quarter	ND	ND	ND	7.36
4th Quarter	ND	ND	1.54 ± 0.71*	9.46

Notes:
Method detection limit for mercury is 0.2 ng/L.
* = estimated values based on laboratory qualifiers.
P4 = precipitaion sampler near BNL Apartments area.
S5 = precipitation sampler near BNL Sewage Treatment Plant.

sition that occurs on site. This information is compared to Peconic River monitoring data and aids in understanding the sources of mercury within the Peconic River. Mercury was detected in precipitation samples in each quarter and at both sampling stations. Mercury ranged from 5.54 ng/L at station S5 in the second quarter to 10.6 ng/L at station S5 during the first quarter of 2009.

6.5 WILDLIFE PROGRAMS

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

In 2009, the Environmental Protection Division (EPD) and FERN hosted 19 interns and one faculty member. Interns consisted of one high school intern, eleven undergraduate interns, and six school teachers during the summer. Two of the undergraduate interns worked with a faculty member from Southern University at New Orleans, as part of the Faculty and Student Teams (FaST) Program. Interns worked on a variety of projects. The FaST team worked on soil microbial studies of Pine Barrens soils and oak gall maker surveys (galls are unusual plant growths caused by insects). Undergraduate interns worked on invertebrate distribution surveys of the Carmans River, small mammal and flying squirrel surveys, and the quantification of soil nitrogen using the NSLS. The high school student worked on tree selection by flying squirrels. Teachers in the ACTS program worked on bathymetry of a small lake, inventory of Odonate species, mtDNA analysis of Odonates, GIS work, and a survey of night active birds. Teachers also participated in a week-long workshop on environmental monitoring under the OSSP. In addition to intern projects, FERN continued work on video-based instruction for protocols used within OSSP. A limited discussion concerning each project is presented below, and associated papers and posters are available at www.bnl.gov/esd/wildlife/research.asp.

Work on Odonate species continued in 2009 with teachers conducting research including: a comparative study between Odonate diversity and water quality and vegetation of man-made and man-modified ponds and genetic variations of Odonates between ponds at BNL; determining the effects of lunar cycles on night active birds, such as whippoorwill and other nightjars; work to develop and conduct a bathymetric study of Lake Arrowhead on the Baiting Hollow Boy Scout Camp; and a GIS study of BNL's contours and sanitary systems. These studies are designed to help teachers develop out-of-class room experience for their students that meet state curriculum requirements.

Students from the Southern University at New Orleans (SUNO) worked on a variety of projects including: quantification of soil nitrogen within Pine Barrens soils using the NSLS; genetic and nutrient use by microbial flora and fauna to form an analysis of the microbial community within the Gamma Forest soils compared to microbial distributions elsewhere in the Pine Barrens; and a study of the natural history

of scrub oak gall makers, which included the imaging of galls using the NSLS.

Other students worked on a variety of projects associated with the Carmans River, including the effects of water quality parameters on the distribution of aquatic invertebrates and the effects of substrate variations on invertebrate distributions using artificial substrates. These studies may become useful for assisting with management decision associated with efforts to protect the Carmans River watershed, a combined project being undertaken by the Town of Brookhaven, Suffolk County, and the Central Pine Barrens Commission.

Work being conducted on small mammals and flying squirrels was completed within the area proposed for the Long Island Solar Farm. These studies utilized live traps to determine population and diversity of small mammals (mice, shrews, etc.) and flying squirrels. This information is important for assessing the long-term changes and use by small mammals after the facility is constructed. Specific tree species used by flying squirrels were also studied. The flying squirrel studies were particularly successful and raised multiple questions, which warrant further study in 2010. The 2010 study will focus on squirrel movements using radio telemetry.

Members of EPD and other BNL departments volunteered as speakers for schools and civic groups and provided on-site ecology tours. EPD also hosted several environmental events in association with Earth Day and participated in Family Day during BNL's Summer Sunday program. In October, the Laboratory hosted the Fourteenth Annual Pine Barrens Research Forum for ecosystems researchers to share and discuss their results. In addition, BNL and FERN participated in the first Annual Pine Barrens Discovery Day held on the Suffolk County Community College Campus in Riverhead, New York.

The Laboratory also hosted the annual New York Wildfire & Incident Management Academy, offered by NYSDEC and the Central Pine Barrens Commission. Using the Incident Command System of wildfire management, this academy trains fire fighters in the methods of wildland fire suppression, prescribed fire, and fire analysis. BNL has developed and is implementing a Wildland Fire Management Plan. While plans were prepared for conducting a prescribed fire during the Academy, the conditions did not meet the requirements of the prescription. Post-fire monitoring on previous fires, conducted in 2007, indicated that prescribed fires have been somewhat effective at opening up the understory to allow forest regeneration. BNL intends to continue the use of prescribed fire for fuel and forest management in the future, and is working with NYSDEC to prepare additional prescriptions for a larger portion of the northern and eastern sections of the Laboratory property.

6.6 CULTURAL RESOURCE ACTIVITIES

The BNL Cultural Resource Management (CRM) Program ensures that the Laboratory fully complies with the numerous cultural resource regulations. The Cultural Resource Management Plan for Brookhaven National Laboratory (BNL, 2005) guides the management of all of BNL's historical 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 range of the Laboratory's cultural resources includes buildings and structures, World War I (WWI) earthwork features, the Camp Upton Historical Collection, scientific equipment, photo/audio/video archives, and institutional records. As various cultural resources are identified, plans for their long-term stewardship are being developed and implemented. Achieving these goals will ensure that the contributions BNL and the site have made to our history and culture are documented and available for interpretation. The Laboratory has three structures or sites that have been determined to be eligible for listing on the National Register of Historic Places: the Brookhaven Graphite Research Reactor (BGRR) complex, the High Flux Beam Reactor (HFBR) complex, and the WWI training trenches associated with Camp Upton. The BNL trenches are examples of the few surviving WWI earthworks in the United States.

In 2009, two field studies were conducted to evaluate the proposed Long Island Solar Farm project site; Section 106 project reports were subsequently submitted to the New York State

Historic Preservation (SHPO) Officer. An archaeological survey was performed on 33 acres formerly occupied by the World War I Camp Upton Remount Facility (Bernstein, 2009a) in order to assess the overall potential of the area for the presence of cultural resources, including both a surface inspection and subsurface testing. The surface inspection entailed a walkover of the entire project area. Subsurface testing involved the excavation of small-shovel test pits on a closely spaced grid system, in accordance with NY State guidelines.

An architectural and archeological data recovery/assessment of a standing Civilian Conservation Corps (CCC) era privy was conducted on a half-acre site (Bernstein, 2009b). The architectural documentation was designed to meet the standards of the Historic American Buildings Survey (HABS). The survey included excavation of the outhouse pit to document the potential presence of artifacts and required removal of the privy structure from its rotted sill. Once SHPO comments were addressed, SHPO concluded that the project would have no adverse effect upon cultural resources in or eligible for inclusion in the National Registers of Historic Places.

Additional cultural resource management activities primarily focused on identifying and relocating artifacts from the BGRR and HFBR, including items such as scale models, graphite block, operating status board, mock fuel elements, and spare control rods. Outreach activities consisted of providing presentations on Laboratory cultural resources and tours of the WWI trenches to several small groups.

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