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 2005, 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.

In its fifth year, Upton Ecological and Research Reserve (Upton Reserve) was transitioned to the Foundation for Ecological Research in the Northeast (FERN). Final research work under the Upton Reserve was provided to the U.S. Fish & Wildlife Service and utilized by FERN to conduct the first phase of forest health monitoring in the Long Island Central Pine Barrens. This work is discussed in greater detail in this chapter.

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

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 and issued the Natural Resource Management Plan (NRMP) (BNL 2003a). The NRMP 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 the 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 2005, BNL initiated efforts to better understand

the distribution of deer on site. A model of deer density was developed (Figure 6-1) using the mapping and spatial analysis tools. This model will enable resource managers to track changes in deer density over time, detect interactions between components of the ecosystem, and identify locations for management activities.

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. 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 the BNL 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 Bar-

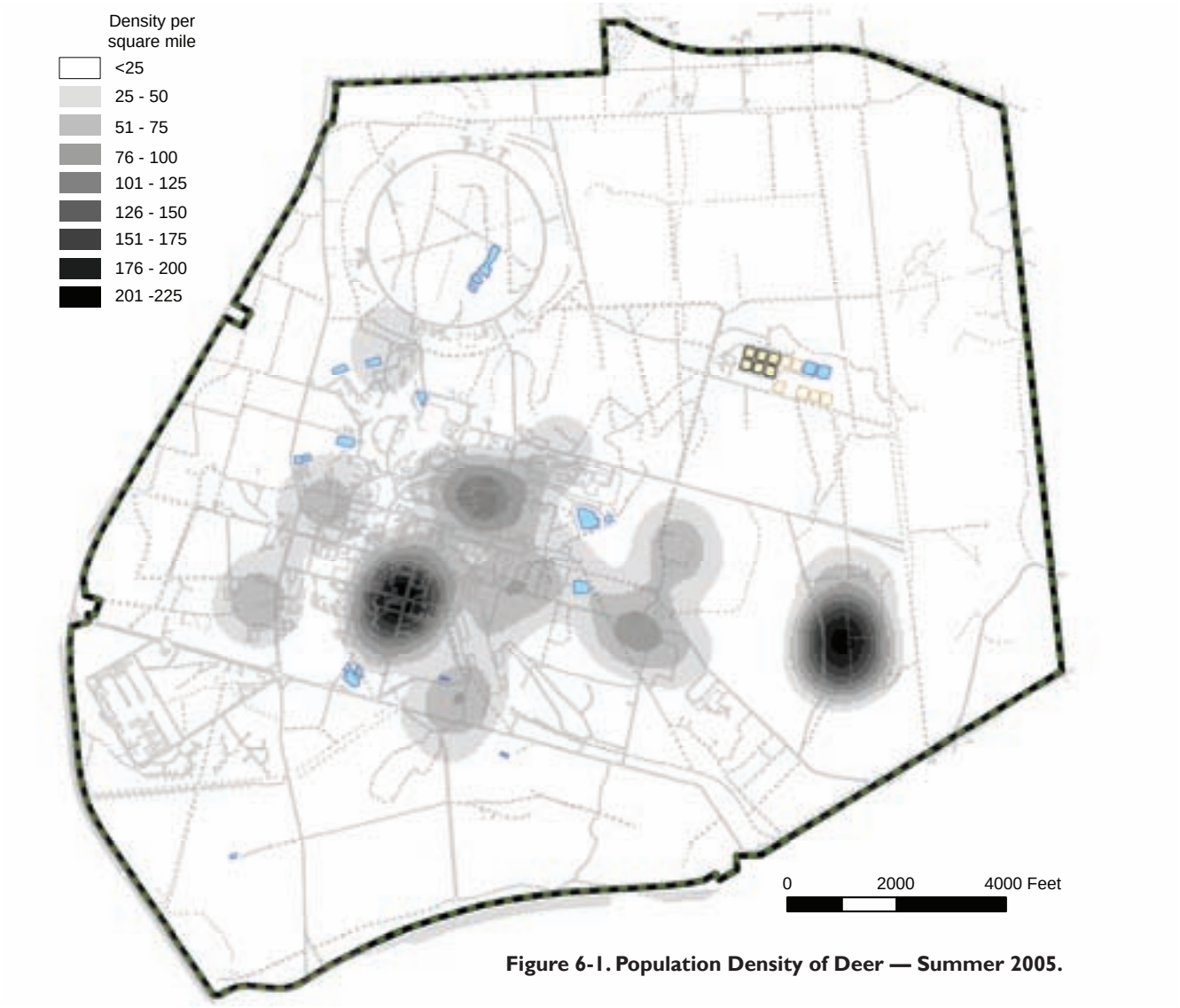


Figure 6-1. Population Density of Deer — Summer 2005.

rens bluet (*Ennalagma recurvatum*) was confirmed at one of the many coastal plain ponds located on the Laboratory 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 farinose*) was reconfirmed to exist at BNL in 2005. Several other species that inhabit the Laboratory site, visit during migration, or have historically been identified, are listed as rare, species of special concern, or exploitably vulnerable by New York State (Table 6-1).

6.1.2 Habitat Protection and Enhancement

The Laboratory has precautions in place to protect on-site habitats and natural resources. Activities to eliminate or minimize negative effects on sensitive or critical species are either incorporated into BNL procedures or into specific program or project plans. Environmental restoration efforts remove pollutant sources that could contaminate habitats. Human access to critical habitats is limited. In some cases, habitats are enhanced to improve survival or increase populations. 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 these 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. 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. BNL environmental protection staff must review any project planned near eastern

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

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

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 conducted annually since 1999. Biologists conducting egg mass and larval surveys have increased the number of confirmed sites from 17 on-site ponds to 26 ponds that are used by eastern tiger salamanders. The study 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. Egg mass surveys of 26 ponds plus additional flooded depressions at the Laboratory were conducted in 2005. A PhD candidate and students working through the intern programs offered by DOE and BNL's Office of Education conducted surveys of tiger salamander ponds, drift fence surveys, and radio telemetry tracking around four ponds. The results of these studies show 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 needs began in 2004, with funding provided to SUNY Binghamton by NYSDEC. Continued research consistently 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.

6.1.2.2 Eastern Hognose Snake

A radio telemetry study of the eastern hognose snake (*Heterodon platyrhinos*) that was initiated in 2003 continued through 2005. This species of special concern was considered to be very rare on Long Island. Reports of the snake were sporadic through 1995, with no reports from Long Island between 1995 and 2001. In 2002, five sightings of this snake occurred at the Laboratory, with photo documentation for two of the sightings. The presence of the snake at BNL and the radio telemetry work conducted have raised interest about this species. Reports from multiple locations on Long Island have been confirmed. While the snake is not highly common, the various reports indicate that it is not as rare on Long Island as was previously thought.

In 2005, eight snakes were tracked, and the potential for snakes to auto-reject implanted transmitters was documented. This may explain some of the earlier retrieval of transmitters without any clear evidence of predation. Tracking of snakes also documented predation by various animals, including red-tailed hawks and small mammals. At the end of the tracking season, only three snakes remained. The snakes were allowed to hibernate and will be recaptured upon re-emergence in 2006. The transmitters will be removed and the snakes released. Results of this 3-year study will be published in the scientific literature.

6.1.2.3 Other Species

As part of the eastern tiger salamander and herpetological surveys, information is being gathered on other species. Including the salamander (see Section 6.1.2.1), sightings of 26 species of reptiles and amphibians have been recorded over the past several years. The species observed 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 punctatus edwardsi*), brown snake (*Storeria d. dekayi*), the northern red-bellied snake (*Storeria occiptiomaculata*), and the eastern wormsnake (*Carphophis amoenus*). This listing 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 river remediation efforts for potential impacts on these habitats. The Peconic River cleanup project was initiated in 2004 and completed in May 2005. Prior to dewatering of both the on- and off-site portions of the river, an effort was made to capture and relocate banded sunfish. A total of 193 fish were relocated to a protected pond, and a study was conducted to determine their breeding success. Approximately 1,200 fish were seined from the pond, measured, and released. The study estimated the number of fish taken per area covered by each seining event. Conservatively, the pond was estimated to contain between 90,000 and 110,000 fish. By October 2005, a severe drought had resulted in the near drying of the pond, and by conservative estimates, 3,000 fish remained. To ensure the continued presence of the banded sunfish in the Peconic River, approximately 250 sunfish were removed from the pond and returned to the river. A population estimate of the pond will again be conducted in 2006 and additional reintroductions of the banded sunfish to the Peconic River will occur, once additional vegetative cover has been re-established.

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 at BNL. In 2005, monthly surveys were conducted, starting at the end of March and extending through the end of September. These surveys identified 67 species, compared to 68 species in 2004 and 79 species during 2003. One new species was identified during the 2005 surveys. A total of 109 species have been identified during surveys in the past 6 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. Trends in the data indicate a slight decline each year in the number of species detected on each transect. Data are stored in an electronic database that is linked to the Laboratory's GIS.

The Laboratory occasionally encounters conflicts with migratory birds. These conflicts are resolved in consultation with NYSDEC, FWS, and the United States Department of Agriculture – Animal Plant Health Inspection Service – Wildlife Services Division (Wildlife Services). In 2005, a pair of Killdeer *(Charadrius vociferous)* nested and laid four eggs in the middle of a contaminated area at the Former Waste Management Facility that was scheduled for cleanup. Due to the high cost of delaying cleanup, Wildlife Services was contacted for consultation. A decision was made to remove the eggs and scan for contamination. Low levels of radiological activity were detected on the surface of the eggs; therefore, they were disposed of along with radiological contaminated soils. Mechanized work in the area and disturbance of the soil in the area of the nest prevented further nesting by the birds.

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 53 nest boxes around open grassland areas on site to enhance their population. In 2005, the boxes were monitored approximate-

ly every 3 weeks during the breeding season to determine use and nesting success. Thirty bluebird nests were observed. Other birds using the houses included house wrens (*Troglodytes aedon*), black-capped chickadees (*Poecile atricapilla*), tufted titmouse (*Baeolophus bicolor*), and tree swallows (*Tachycineta bicolor*). Bluebirds have consistently produced 19 broods or more each year for the past 6 years.

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. Due to the wet spring and drought conditions in 2005, there was a dispersal of many of the birds, resulting in a population estimate of 300 birds.

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). BNL has been conducting population surveys of the white-tailed deer since 2000. In February and March 2004, an aerial infrared survey was conducted of three properties, including Wertheim National Wildlife Refuge (south of BNL), Brookhaven National Laboratory, and Rocky Point Wildlife Area (northwest of BNL). The results indicated a population of 412 deer on site and immediately off site. When a correction for survey accuracy was applied, the on-site population was estimated at 446 animals. This value was much lower than a ground-based estimate of 1,302, made at the same time using the existing methodology. Because there was a large discrepancy between methods, a review of the ground-based methodology was conducted and the method of estimating was refined. The new method uses the Laboratory's vegetation map and estimates the deer population based on the habitat in which deer are sighted during surveys. The result of this revised method indicated that the deer population was approximately 497, which is considered to be reasonably comparable to the aerial survey results. The next step taken was to apply the new population model to historic survey data. Most of the data resulted in a much lower estimate, with ranges from approximately 1,000 deer in 2001 to approximately 400 deer in 2005. Note that the revised estimate is still higher than the optimal range of 80 to 250 deer on an area the size of BNL.

Deer overpopulation can affect animal and human health (e.g., animal starvation, Lyme disease from deer ticks, collision injuries—both human and animal), species diversity (songbird species reduction due to selective grazing and destruction of habitat by deer), and property values (auto damage and browsing damage to ornamental plantings). In 2005, there were six deer-related collisions on site, compared to the 25 accidents documented in 2004. This notable decrease in accidents is attributed to a major effort by BNL Safeguards and Security personnel to enforce the 30-mph speed limit on site. Additional emphasis on vehicle–deer safety is also thought to have helped reduce this type of accident. Deer health continues to be affected due to lack of food. Deer damage to vegetation around buildings continues to be a problem, but varies depending on the severity of the winter and the availability of browse in the lawns.

Because the high deer population is a regional problem, BNL is working on the issue with other local jurisdictions. The Laboratory is rep-

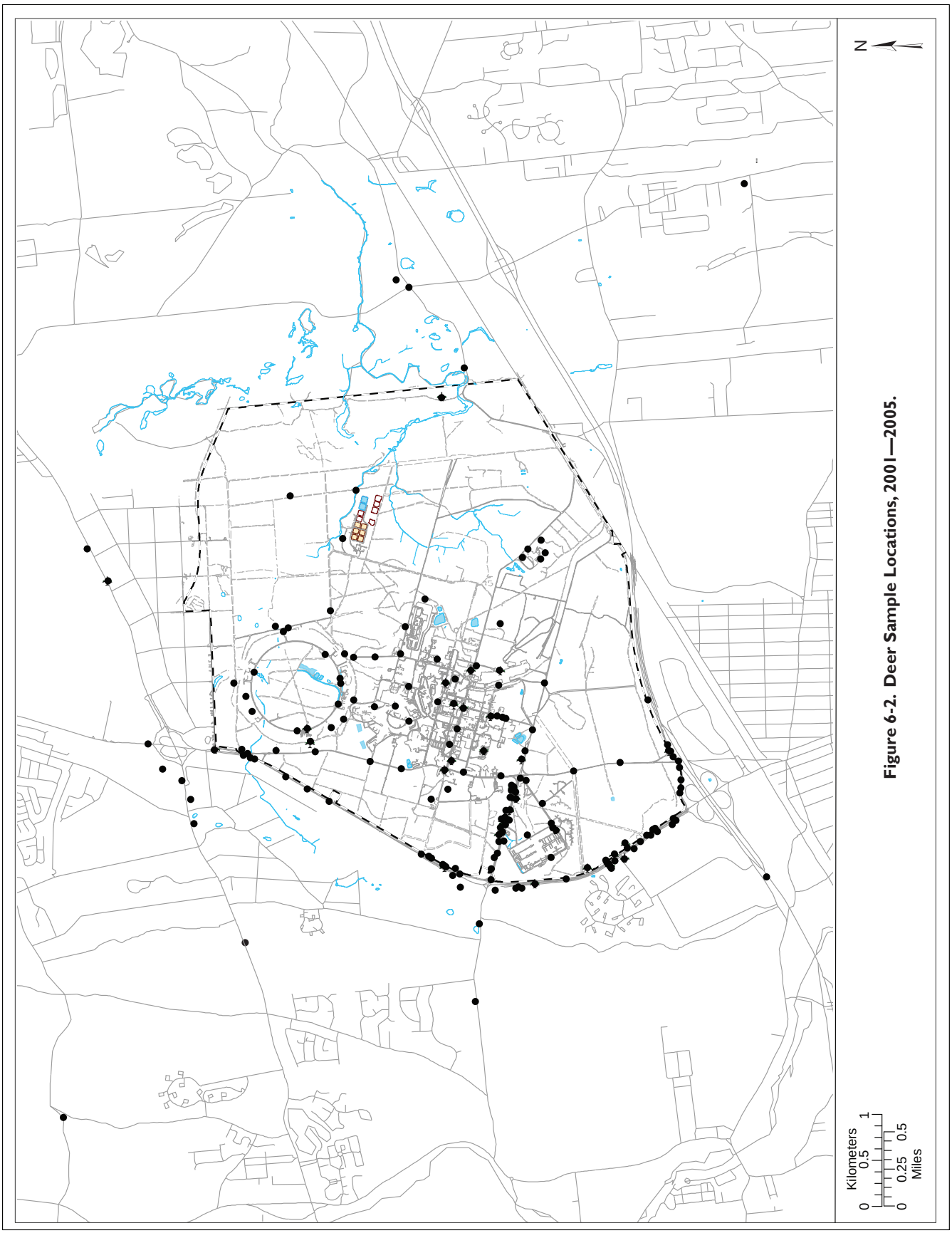


Figure 6-2. Deer Sample Locations, 2001—2005.

resented on a deer advisory panel for the hamlet of Lloyd Harbor. Environmental biologists at BNL would like to see a regional approach to deer management in place before attempting large-scale deer management on site. Options for deer management are limited, and most are controversial. A regional approach would benefit the community, land managers, and the health of the deer population.

6.1.4 Compliance Assurance and Potential Impact Assessment

The National Environmental Policy Act (NEPA) review process at BNL is 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), the Community Advisory Council, and the Brookhaven Roundtable are involved in reviewing major projects that have the potential for significant environmental impacts. Formal NEPA reviews are coordinated with the Stae of New York.

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 Fish & Wildlife Service (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 the 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).

In establishing the Upton Reserve, DOE committed to provide FWS with $1 million to manage the reserve over a 5-year period. 2005 marked the final year of the agreement between DOE and FWS. A planned transition from FWS management of the Upton Reserve to management by BNL and the Foundation for Ecological Research in the Northeast (FERN) occurred, with FERN initiating its first pine barrens-wide monitoring program. The Upton Reserve research efforts concluded with a database of all known pine barrens-related research and forest health monitoring protocols for pine barrens. Both the database and monitoring protocols are available on the FERN website, at www.fern-li.org. The plot-based monitoring protocols were implemented and used by FERN to gather information concerning the health of the Long Island Central Pine Barrens. A total of 50 permanent monitoring plots were established in the summer of 2005; the project will continue in 2006 to fully assess the current health of the forests. Permanent plots will allow the periodic assessment of forest health, to determine whether management actions are having a positive or negative impact.

The Interagency Agreement that established the Upton Reserve specified the formation of a Technical Advisory Group (TAG), which includes the reserve's supervisory FWS biologist and representatives from NYSDEC, Suffolk County Parks Department, Central Pine Barrens Joint Policy and Planning Commission, DOE, BNL's Citizens Advisory Council, Brookhaven Executive Roundtable, Brookhaven Science Associates, and The Nature Conservancy. The TAG's primary responsibility was to develop BNL's comprehensive NRMP. The TAG also developed criteria for soliciting and reviewing proposals and awarding funds for research to be conducted within the Upton Reserve. The multiple research projects over the past few years have greatly improved the understanding of pine barrens

ecology. While most of the TAG's responsibilities have been met, the Laboratory intends to periodically ask for assistance in reviewing annual reports required under the NRMP, and to support the 5-year update of the plan.

Educational programs have been a significant part of the Upton Reserve and were continued in 2005. A project was conducted by Longwood High School to determine the preferential use of artificial shelter ("cover") by reptiles and amphibians. Led by a high school science teacher, students established three transects cutting across multiple habitats. At set intervals, two artificial covers (plywood and geotextile material) were placed on the ground to attract reptiles and amphibians. Transects were checked every other week during fall 2005. Results of the project are still pending.

Research on oak tree defoliators that was initiated by FWS and the Upton Reserve is continuing at the Laboratory. Much of the oak forest on site and immediately east of BNL has been subject to repeated defoliation by gypsy moth and orange-striped oak moth. This double defoliation, if it occurs year after year, can kill large sections of oak forest. In 2003, areas of BNL were experiencing oak death due to repeated defoliation. Cooler temperatures in 2004 appeared to set back the oak moth infestation, but much of the damage had already been incurred; between 15 and 25 percent of the red oaks died. In 2005, a new defoliator, a geometrid moth, appeared on oaks throughout the Long Island Central Pine Barrens, and the orange-striped oak moth was again evident, resulting in additional tree mortality.

FWS management activities for the Upton Reserve in 2005 included mapping vernal pools, conducting educational and outreach activities, coordinating researcher access and training requirements, and radio tracking hognose snakes and spotted turtles, as discussed in Section 6.8.

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

6.3.1 Deer Sampling

White-tailed 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, 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 2005, as in recent years, an off-site deer-sampling program was conducted with the NYSDEC Wildlife Branch and FWS. While most off-site samples are from road-killed deer at and near the Laboratory, NYSDEC provides a few samples that result in data on deer that move beyond BNL boundaries, where they can be legally hunted. The samples provide control data on deer living 1 mile or more from BNL. In addition, FWS informs Laboratory staff of deer that have died in or near the Wertheim National Wildlife Refuge and other FWS properties on Long Island. In all, six deer were obtained on site and 24 were from off-site loca-

tions, ranging from adjacent to BNL along the William Floyd Parkway, to approximately 30 miles away (East Islip, 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 Cs-137 in White-Tailed Deer

White-tailed deer sampled at BNL 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) Program. All major areas of contaminated soil were remediated by September 2005. In addition, all buildings at the former Hazardous Waste Management Facility were removed in 2003, and the cleanup of the remainder of the facility was completed by fall 2005.

The number of deer taken for sampling has steadily increased since 1996, with the exception of 2005. In 1998, a statistical analysis based on existing data suggested that 40 deer from off site and 25 deer from on site were needed to achieve a statistically sound data set. Since that analysis was completed, BNL has attempted to obtain the required number of deer. The number taken each year has varied due to the sampling method, 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 6-2 shows the location of all deer samples taken within a 5-mile radius of the Laboratory since 2001. 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 BNL. This distribution is most likely due to the fact that people on their way to work see and report dead deer. Vehicle collisions with deer on site occur primarily early or late in the day, when deer are more active.

In 2005, Cs-137 concentrations in deer meat samples taken at BNL ranged from 0.08 to 0.52 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 2005 on-site concentration (0.52 pCi/g wet weight) was much lower than the highest level reported in 2004 (2.93 pCi/g wet weight), and is significantly 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 0.20 pCi/g. The average concentration of all off-site meat samples was 0.40 pCi/g wet weight. In 2004, averages for Cs-137 both on and off site were below 1.0 pCi/g wet weight for the first time since the cleanup of landscape soils was completed in 2000 (see Table 6-2).

Cs-137 concentrations in off-site deer meat samples were separated into two groups: samples taken within 1 mile of BNL and samples taken farther away (see Table 6-2). Concentrations in meat samples taken within 1 mile ranged from 0.03 to 2.75 pCi/g wet weight, with an average of 0.26 pCi/g wet weight; concentrations in meat taken from greater than 1 mile ranged from nondetectable to 0.64 pCi/g wet weight, with an average of 0.13 pCi/g wet weight.

Figure 6-3 compares the average values of Cs-137 concentrations in meat samples collected in 2005 from four different location groupings. Although the figure does not show this, more than 90 percent of all samples taken both on and off site are below 1 pCi/g wet weight (see Table 6-2).

Figure 6-4 presents the 5-year trend of on-site and near off-site Cs-137 averages in deer meat. Although there is no statistical difference between the values across the five years, there is a statistical difference between values in 2001 (before landscape soils were cleaned up) and values in 2002, 2004, and 2005.

In 2003, a seasonal pattern in Cs-137 concentrations in deer meat was noticed. This seasonality was present in earlier years and

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

Sample Location	Collection Date	Tissue Type	K-40 Wet Weight pCi/g	Cs-137 Wet Weight pCi/g	Sr-90 Dry Weight pCi/g
BNL, On Site					
1,000 ft east of main entrance	01/20/05	Flesh	3.83 ± 0.32	0.26 ± 0.02	
		Liver*	2.33 ± 0.25	0.08 ± 0.01	
		Bone			0.67 ± 0.16
Princeton Ave. at Motor Pool Bldg.	02/09/05	Flesh	3.87 ± 0.43	0.52 ± 0.04	
		Liver*	2.07 ± 0.23	0.09 ± 0.01	
Bldg. 912	08/08/05	Flesh*	4.10 ± 0.39	0.02 ± 0.01	
		Liver	2.53 ± 0.43	ND	
		Bone**			0.68 ± 0.25
West side of Bldg. 912	10/31/05	Flesh*	3.60 ± 0.30	0.08 ± 0.01	
		Liver*	2.78 ± 0.25	0.05 ± 0.01	
		Bone**			0.65 ± 0.29
Northeast of Bldg. 463	11/28/05	Flesh*	2.39 ± 0.42	0.09 ± 0.02	
		Bone			1.44 ± 0.37
Back of Bldg. 925 in AGS Ring access road	12/20/05	Flesh	4.03 ± 0.58	0.21 ± 0.04	
		Liver*	2.21 ± 0.53	0.06 ± 0.03	
		Bone			ND
< 1 Mile from BNL					
Outside South Gate	02/07/05	Flesh	4.14 ± 0.37	0.99 ± 0.09	
		Liver*	1.94 ± 0.22	0.13 ± 0.02	
		Bone			3.66 ± 0.61
William Floyd Pkwy., North Gate	02/09/05	Flesh	4.19 ± 0.33	0.34 ± 0.04	
		Liver*	2.89 ± 0.29	0.06 ± 0.01	
		Bone			2.10 ± 0.39
South Gate	03/25/05	Flesh	3.57 ± 0.35	0.12 ± 0.02	
		Liver	2.67 ± 0.28	0.06 ± 0.02	
		Bone			2.51 ± 0.54
Longwood Estate	06/01/05	Flesh	3.44 ± 0.40	0.13 ± 0.02	
		Liver*	3.09 ± 0.48	0.05 ± 0.02	
		Bone			2.32 ± 0.61
William Floyd Pkwy., Main Gate	09/28/05	Flesh	3.70 ± 0.25	0.42 ± 0.03	
		Liver*	2.93 ± 0.25	0.12 ± 0.01	
		Bone			3.55 ± 0.61
William Floyd Pkwy., 1 mile north of Main Gate	10/13/05	Flesh*	4.07 ± 0.29	0.03 ± 0.01	
		Liver	3.13 ± 0.15	ND	
		Bone			1.41 ± 0.41
Longwood Rd., 1/2 mile west of William Floyd Pkwy.	10/27/05	Flesh	4.03 ± 0.30	0.39 ± 0.03	
		Liver	2.63 ± 0.20	0.30 ± 0.03	
Longwood Rd., 1/2 mile west of William Floyd Pkwy.	10/27/05	Bone			1.95 ± 0.40
William Floyd Pkwy., North Gate (deer No. 1)	11/14/05	Flesh	3.54 ± 0.28	0.74 ± 0.05	
		Bone			1.82 ± 0.41

(continued on next page)

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

Sample Location	Collection Date	Tissue Type	K-40 Wet Weight pCi/g	Cs-137 Wet Weight pCi/g	Sr-90 Dry Weight pCi/g
William Floyd Pkwy., North Gate (deer No. 2)	11/14/05	Flesh	4.57 ± 0.32	1.69 ± 0.14	
		Bone			1.19 ± 0.34
Rte. 25 Ridge, east of William Floyd Pkwy.	11/30/05	Flesh	3.45 ± 0.40	2.75 ± 0.22	
		Liver	3.21 ± 0.38	1.32 ± 0.12	
		Bone			1.41 ± 0.37
> 1 Mile from BNL					
Swan Pond Rd. at Grumman main gate	02/09/05	Flesh	3.04 ± 0.28	0.58 ± 0.04	
		Liver*	2.41 ± 0.25	0.09 ± 0.01	
		Bone			1.26 ± 0.40
Calverton, 1 mile north of Rte. 25 on Fresh Pond Rd.	06/27/05	Flesh*	3.61 ± 0.46	0.04 ± 0.01	
		Bone			1.79 ± 0.53
Kaplan Farm in Northville	08/31/05	Flesh*	4.07 ± 0.34	0.01 ± 0.01	
		Liver	3.35 ± 0.36	ND	
		Bone			1.34 ± 0.35
Rte., 25 west of Wading River Hollow Rd.	10/31/05	Flesh	3.68 ± 0.28	0.27 ± 0.02	
		Bone			1.21 ± 0.32
Sunrise Hwy., just west of William Floyd Pkwy.	12/08/05	Flesh	3.38 ± 0.63	0.64 ± 0.03	
		Liver	3.21 ± 0.26	0.22 ± 0.02	
		Bone			ND
Seatuck deer cull (deer No. 1)	12/12/05	Liver	3.03 ± 0.27	ND	
		Bone**			0.52 ± 0.19
Seatuck deer cull (deer No. 2)	12/12/05	Flesh	3.66 ± 0.41	ND	
		Liver	3.11 ± 0.27	ND	
		Bone			ND
Seatuck deer cull (deer No. 3)	12/12/05	Flesh	3.95 ± 0.40	ND	
		Liver	3.42 ± 0.37	ND	
		Bone**			0.97 ± 0.26
Seatuck deer cull (deer No. 4)	12/12/05	Flesh	4.32 ± 0.24	ND	
		Liver	3.22 ± 0.31	ND	
		Bone**			0.46 ± 0.21
Seatuck deer cull (deer No. 5)	12/12/05	Flesh*	4.17 ± 0.41	0.02 ± 0.01	
		Liver	2.62 ± 0.28	ND	
		Bone			ND
Old Stump Road, outside Werthereim	12/13/05	Flesh	3.07 ± 0.30	0.06 ± 0.01	
		Liver*	2.75 ± 0.24	0.01 ± 0.01	
		Bone			1.15 ± 0.34
Seatuck deer cull (deer No. 6)	12/20/05	Flesh*	3.46 ± 0.25	0.01 ± 0.01	
		Liver	2.45 ± 0.14	ND	
		Bone			ND
Seatuck deer cull (deer No. 7)	12/20/05	Flesh*	3.14 ± 2.32	0.02 ± 0.01	
		Liver	3.77 ± 0.34	ND	
		Bone			ND

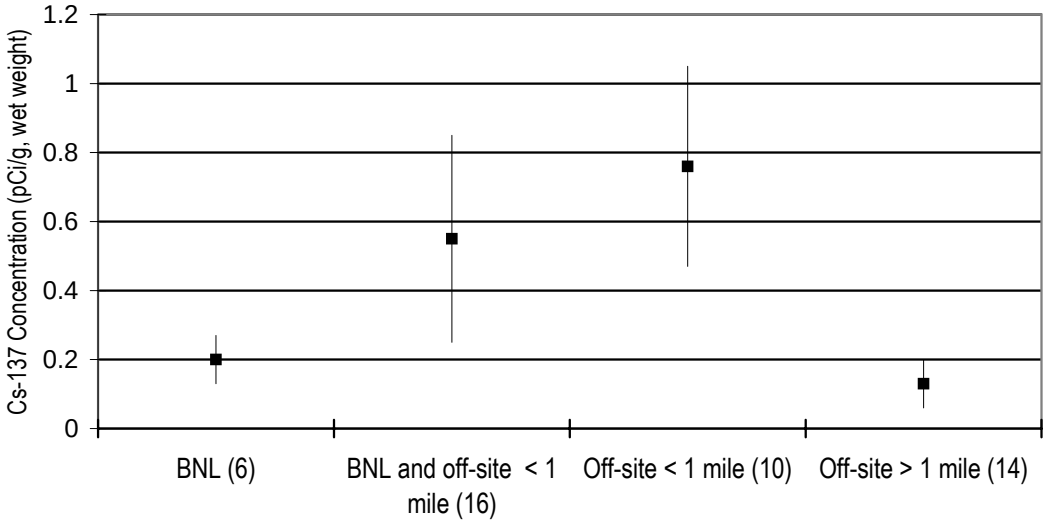
(continued on next page)

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

Sample Location	Collection Date	Tissue Type	K-40 Wet Weight pCi/g	Cs-137 Wet Weight pCi/g	Sr-90 Dry Weight pCi/g
Seatuck deer cull (deer No. 8)	12/20/05	Flesh*	3.47 ± 0.21	0.01 ± 0.01	
		Liver	3.06 ± 0.19	ND	
		Bone			ND
Averages by Tissue					
Flesh					
Average for all samples			3.71 ± 3.03	0.36 ± 0.31	
BNL on-site average			3.64 ± 1.02	0.20 ± 0.07	
BNL on- and off-site < 1 mile average			3.78 ± 1.47	0.55 ± 0.30	
Off-site average			3.73 ± 2.85	0.40 ± 0.30	
Off-site < 1 mile average			3.87 ± 1.06	0.76 ± 0.29	
Off-site > 1 mile average			3.62 ± 2.65	0.13 ± 0.07	
Liver					
Average for all samples			2.83 ± 1.51	0.11 ± 0.14	
BNL on-site average			2.38 ± 0.80	0.06 ± 0.04	
BNL on- and off-site < 1 mile average			2.67 ± 1.14	0.19 ± 0.14	
Off-site average			2.94 ± 1.29	0.12 ± 0.14	
Off-site < 1 mile average			2.81 ± 0.85	0.26 ± 0.13	
Off-site > 1 mile average			3.03 ± 0.97	0.03 ± 0.04	
Bone					
Average for all samples					1.25 ± 2.01
BNL on-site average					0.72 ± 0.59
BNL on- and off-site < 1 mile average					1.70 ± 1.63
Off-site average					1.36 ± 1.92
Off-site < 1 mile average					2.19 ± 1.52
Off-site > 1 mile average					0.75 ± 1.18

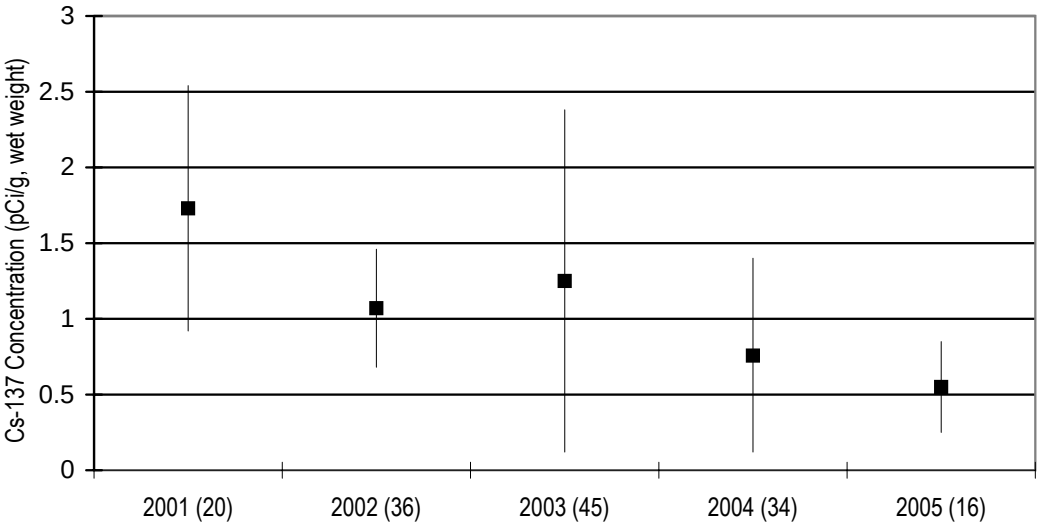
Notes:
All values are shown with a 95% confidence interval.
Potassium-40 (K-40) occurs naturally in the environment and is presented as a comparison to cesium-137 (Cs-137).
All averages are the arithmetic average and utilize estimated values for ND. Confidence limits are 2σ sigma (95%) propogated error.
ND = Not Detected
* = estimated value for Cs-137
** = estimated value for strontium-90 (Sr-90)

occurred again in 2005 (see Table 6-2). During the summer of 2004, a student in the Community College Intern Program reviewed all data from 2000–2003, analyzed it 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 the 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 containing Cs-137, are more likely to obtain a continuous supply, which is incorporated into their tissues. 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.



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

Figure 6-3. Comparison of Cs-137 Average Concentrations in Deer, 2005.



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.

Figure 6-4. Five-Year Cs-137 Concentration Trends in Deer Meat at BNL and Within 1 Mile of BNL, 2001 to 2005.

When possible, liver samples are taken concurrently with meat samples. Liver generally accumulates Cs-137 at a lower rate than muscle tissue (meat). The lower values in liver allow the results to be used 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 2005, Cs-137 concentrations ranged from nondetectable to 0.09 pCi/g wet weight, with an average of 0.06 pCi/g wet weight. The off-site Cs-137 concentration in

liver ranged from nondetectable to 1.32 pCi/g wet weight, with an average for all off-site liver samples of 0.12 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 about 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 the IAEA. The deer observed and sampled on site appear to have no health effects from the level of Cs-137 found in their tissues.

6.3.1.2 Strontium-90 in Deer Bone

BNL began testing deer bones for Sr-90 content in 2000, and continued this analysis in 2005. Sr-90 content ranged from nondetectable to 1.44 pCi/g dry weight in on-site samples. Sr-90 in off-site samples ranged from 1.19 to 3.66 pCi/g dry weight in samples taken within 1 mile of BNL, and nondetectable to 1.79 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. BNL will continue to test for Sr-90 in bone to develop baseline information on this radionuclide and its presence in white-tailed deer.

6.3.2 Small Mammal Sampling

BNL continued small mammal sampling in 2005. The original goal of this sampling was to determine the suitability of small mammals, primarily squirrels, as a surrogate for deer sampling. Squirrels are readily trapped and tend to eat similar food as deer, but have a much more restricted range and therefore can indicate areas where low levels of contamination may be present. Squirrels were sent to an off-site contract

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

Location	Collection Date	Species	K-40	Cs-137	Sr-90
			pCi/g, Dry Weight		
BNL					
Trailer 96	03/10/05	Squirrel	13.4 ± 1.5	2.68 ± 0.17	0.25 ± 0.06
Cornell Ave. and Rutherford St.	03/18/05	Squirrel	11 ± 1.6	0.13 ± 0.08	0.78 ± 0.10
Trailer 533	03/31/05	Squirrel	9.14 ± 1.6	0.54 ± 0.09	0.50 ± 0.10
Off Site					
Flanders	04/30/05	Squirrel*	12.9 ± 2.1	0.20 ± 0.08	0.19 ± 0.08
Flanders	05/01/05	Squirrel*	12 ± 1.5	0.26 ± 0.06	0.41 ± 0.10
Flanders	05/02/05	Squirrel*	12 ± 2.1	0.40 ± 0.15	0.32 ± 0.09

Notes:
All values are presented with a 95% confidence interval.
* The strontium-90 (Sr-90) concentration was reported as an estimated value by the contract analytical laboratory.

analytical laboratory for dissection and analysis. Meat was separated from the bone and tested for gamma-emitting radionuclides, and the bone was tested for Sr-90. Results of the analyses are presented in Table 6-3. Cs-137 in off-site samples ranged from 0.20 to 0.40 pCi/g dry weight. On-site samples contained Cs-137 ranging from 0.13 to 2.68 pCi/g dry weight. Sr-90 values ranged from 0.19 to 0.41 pCi/g dry weight in off-site squirrels. On-site squirrels had Sr-90 values ranging from 0.25 to 0.78 pCi/g dry weight. Small mammals will continue to be sampled to obtain additional information about their usefulness for environmental surveillance.

6.3.3 Other Animals Sampled

Occasionally, other animals of interest are found dead along the roads of the Laboratory and the immediate vicinity. Generally, BNL tests wild turkey or Canada geese if they are found dead due to road mortality. In 2005, no other animals were tested.

6.3.4 Fish Sampling

In collaboration with the NYSDEC Fisheries Division, the Laboratory maintains an ongoing program for collecting and analyzing fish from the Peconic River and surrounding freshwater bodies. Annual on-site sampling has depleted the number of large fish. To obtain a sample large enough to complete all analyses desired, multiple small fish would be needed. BNL suspended most on-site sampling beginning in 2001, and population surveys indicate that population levels on site are still insufficient to conduct full-scale annual sampling and analysis. On-site fish were sampled in 2004 when the river was de-watered for the Peconic River cleanup project. Flow was returned to the river in the spring of 2005, then the area experienced drought conditions toward the end of summer. Natural flow to the river resumed after heavy rains in October 2005. No fish samples were taken in 2005 directly on-site, but a single sample was taken downstream of gauging station HQ, adjacent to North Street, and is reported as an on-site sample. The on-site population of fish will be assessed in 2006 and samples will be taken if the fish populations have sufficiently recovered.

Off-site fish sampling continued as in the past. All samples were analyzed for edible (fillet) portion content of each of the analytes reported. In 2005, various species of fish were collected off site from Swan Pond, Donahue's Pond, Forge Pond, and Lower Lake on the Carmans River (see Figure 5-8 for sampling stations). Swan Pond is a semi-control location on the Peconic River system (a tributary 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 Cold Spring Harbor Fish Hatchery and Museum. Twenty-seven samples were taken, representing eight species of fish.

6.3.4.1 Radiological Analysis of Fish

The species collected for radiological analysis in 2005 by the Laboratory and through contract labor included brown bullhead (*Ictalurus nebulosus*), chain pickerel (*Esox niger*), largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), pumpkinseed (*Lepomis gibbosus*), golden shiner (*Notemigonus crysoleucas*), yellow perch (*Perca flavescens*), and black crappie (*Pomoxis nigromaculatus*). Gamma spectroscopy analysis was performed on all samples. Table 6-4 presents specific information on the sampling location, species collected, and analytical results. All sample results are presented as wet weight concentrations. Because Sr-90 is deposited only in bone, and fillets (not bone) were tested, no Sr-90 data is presented. Information on the natural radioisotope K-40 is included as a comparison.

Cs-137 was detected at low levels in all samples from the Peconic River system, ranging from 0.03 pCi/g wet weight in golden shiners from Swan Pond, to 0.22 pCi/g wet weight in chain pickerel from Donahue's Pond. In 2005, all fish taken from Lower Lake on the Carmans River (the non-Peconic control location) had estimated levels of Cs-137 below the minimum detection limit (MDL) and are shown in Table 6-4 as ND (nondetectable).

To account for the different feeding habits and weights of various species, it is important to compare species with similar feeding habits

Table 6-4. Radiological Analyses of Fish from the Peconic River System and Carmans River, Lower Lake.

Species	K-40	Cs-137
	pCi/g Wet Weight	
BNL, On Site (HQ area)		
Brown bullhead	3.09 ± 0.32	0.17 ± 0.02*
Donahue's Pond		
Largemouth bass	3.61 ± 0.47	0.15 ± 0.03*
Brown bullhead	3.04 ± 0.38	0.12 ± 0.02*
Golden shiner	2.85 ± 0.54	0.19 ± 0.03*
Bluegill	2.93 ± 0.50	0.13 ± 0.04*
Chain pickerel	2.86 ± 0.41	0.22 ± 0.03
Pumpkinseed	2.81 ± 0.16	0.08 ± 0.03*
Forge Pond		
Pumpkinseed	3.48 ± 0.39	0.04 ± 0.02*
Largemouth bass	3.30 ± 0.31	0.10 ± 0.02*
Yellow perch	3.20 ± 0.28	0.09 ± 0.01*
Black crappie	3.12 ± 0.49	0.10 ± 0.03
Bluegill	2.58 ± 0.70	0.04 ± 0.04*
Brown bullhead	2.97 ± 0.27	0.09 ± 0.01
Golden shiner	3.01 ± 0.30	0.05 ± 0.01
Chain pickerel	2.42 ± 0.25	0.09 ± 0.02
Swan Pond		
Pumpkinseed	2.34 ± 0.37	0.06 ± 0.02
Largemouth bass	3.83 ± 0.38	0.15 ± 0.02
Yellow perch	3.48 ± 0.44	0.15 ± 0.02
Black crappie	3.25 ± 0.41	0.12 ± 0.02
Bluegill	2.27 ± 0.32	0.07 ± 0.02
Brown bullhead	3.14 ± 0.39	0.06 ± 0.03
Golden shiner	3.10 ± 0.35	0.03 ± 0.02
Chain pickerel	3.46 ± 0.41	0.13 ± 0.03
Lower Lake, Carmans River (control location)		
Bluegill	2.19 ± 0.43	ND
Pumpkinseed	2.24 ± 0.48	ND
Brown bullhead	4.56 ± 0.75	ND
Largemouth bass	2.03 ± 0.41	ND

Notes:
All values are presented with a 95% confidence interval.
Potassium-40 (K-40) occurs naturally in the environment and is presented as a comparison to cesium-137 (Cs-137).
All samples analyzed as edible portions (fillets) except golden shiners, which were analyzed as whole body composite samples.
See Figure 5-8 for sampling locations.
ND = Not Detected
* = estimated value based on analytical laboratory qualifiers

(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 0.17 pCi/g wet weight; values for brown bullhead at the control location had nondetectable levels of Cs-137. On-site pumpkinseed showed Cs-137 levels of 0.08 pCi/g wet weight; it was nondetetable in pumpkinseed from the control location. Levels of Cs-137 in all fish species appear to be declining, compared with historic values.

Though it is clear from discharge records and sediment sampling that past BNL operations have contributed to anthropogenic (human-caused) radionuclide levels in the Peconic River system, most of these radionuclides 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 Sewage Treatment Plant (STP) to the Peconic River in 2003, 2004, or 2005 (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 should 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. The cleanup of the Peconic River was completed in May 2005. Flows from the STP were directed back into the on-site portion of the river in early spring 2005. This resulted in on-site flows in the river being present for only a few months prior to the summer drought. The short time frame, drought, and the presence of the sediment trap at the east boundary of the Laboratory did not allow sufficient opportunity for fish to migrate into the on-site portions of river. Therefore, a population assessment was not performed. Heavy rains in October 2005 resulted in significant flows that would allow fish to migrate

upstream. Population assessments will resume in 2006.

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. Since 2002, analysis has been limited to off-site fish. The timing of sampling has varied from year to year, as well as the sample preparation (whole-body, tissue separation, composite sampling). In 1997, sampling was performed during April through May; in 1999, sampling was performed during September through December. Since 2000, sampling has been performed from

Table 6-5. Metals Analyses of Fish from the Peconic River System and Carmans River, Lower Lake.

Location/Species	Barium	Chromium	Copper	Iron	Manganese	Mercury	Selenium	Zinc
	mg/kg							
BNL, On Site								
Brown bullhead	0.11	0.16	0.44	19.2	<MDL	0.26	<MDL	6.93
Donahue's Pond								
Largemouth bass	0.29	0.21	0.30	7.96	0.26	0.58	0.813	9.39
Brown bullhead	0.19	0.19	0.33	7.54	0.31	0.22	<MDL	5.47
Golden shiner	0.18	0.39	<MDL	13.5	2.6	0.19	<MDL	4.56
Bluegill	2.5	0.72	0.33	15	12.2	0.12	0.708	25.1
Chain pickerel	<MDL	0.35	<MDL	11.9	0.587	0.20	0.629	11
Pumpkinseed	<MDL	0.23	<MDL	9.12	<MDL	0.06	<MDL	9.38
Forge Pond								
Pumpkinseed	<MDL	0.21	<MDL	6.4	<MDL	0.06	<MDL	10.5
Largemouth bass	<MDL	5.01	<MDL	18.1	0.43	<MDL	<MDL	7.91
Yellow perch	0.14	0.17	<MDL	13.9	0.68	0.06	<MDL	7.16
Black crappie	1.75	0.29	<MDL	10.2	3.92	0.27	<MDL	9.31
Bluegill	0.56	0.23	<MDL	4.87	1.54	0.17	<MDL	9.21
Brown bullhead	0.13	0.15	0.53	13.9	0.24	0.09	<MDL	6.52
Golden shiner	2.18	0.27	<MDL	14.7	3.38	0.08	<MDL	16.6
Chain pickerel	0.13	0.23	0.417	7.68	0.87	0.30	<MDL	16.7
Swan Pond								
Pumpkinseed	<MDL	0.20	<MDL	2.81	0.38	0.03	<MDL	11.1
Largemouth bass	<MDL	0.36	<MDL	4.11	0.36	0.24	0.616	8.3
Yellow perch	<MDL	0.18	0.47	6.44	0.64	0.05	<MDL	8.1
Black crappie	0.38	0.20	<MDL	2.27	2.04	0.03	0.632	6.3
Bluegill	1.37	0.16	0.35	3.55	10.3	0.04	<MDL	9.15
Brown bullhead	0.13	0.22	0.30	6.24	0.39	0.03	<MDL	6.27
Golden shiner	0.35	0.12	<MDL	3.66	1.07	0.02	<MDL	8.68
Chain pickerel	<MDL	0.19	0.49	8.27	2.87	0.06	0.732	31.5
Lower Lake, Carmans River (control location)								
Bluegill	2.11	0.56	0.39	8.08	5.46	0.08	0.85	16.5
Pumpkinseed	0.84	0.33	<MDL	4.56	2.78	0.02	<MDL	17.5
Brown bullhead	0.11	0.18	<MDL	6.74	0.95	0.02	<MDL	5.34
Largemouth bass	<MDL	0.17	<MDL	1.95	<MDL	0.07	<MDL	5.18

Notes:
All fish were analyzed as edible portions (fillets) except golden shiners, which were analyzed as whole body composite samples.
See Figure 5-8 for sampling locations.
MDL = Minimum Detection Limit

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 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.

Table 6-5 shows the 2005 concentration of metals in fish. According to NYSDEC, none of the metal concentrations were considered capable of affecting the health of the consumers of such fish. Due to the fact that values for arsenic, beryllium, cadmium, cobalt, silver, thallium, and vanadium were less than the MDL for the analytical procedure, they were not included in Table 6-5. Other metals tested but not included in the table include aluminum, antimony, lead, nickel, and silver, as most values reported for these metals were less than the MDL. Values that were above the MDL are discussed below.

Mercury is the metal of highest concern, due to its known health effects. It was found (0.26 mg/kg) in the single brown bullhead taken just east of the BNL boundary. Mercury in off-site Peconic River samples ranged from less than MDL to 0.58 mg/kg in a largemouth bass from Donahue's Pond. The highest mercury value in the control location on the Carmans River was 0.08 mg/kg. All mercury values were less than the 1.0 mg/kg consumption standard set by the U.S. Food and Drug Administration.

Values for metals not shown in Table 6-5 because they were at or near MDL were as follows. Antimony was found in a largemouth bass (0.41 mg/kg) and black crappie (0.43 mg/kg) taken from Forge Pond. Lead was found in a largemouth bass (0.27 mg/kg) from the control location on the Carmans River. Nickel was recorded three times: in the brown bullhead (0.11 mg/kg) from east of BNL, in golden shiners (0.25 mg/kg) from Donahues' Pond, and in a largemouth bass (0.66 mg/kg) from Forge Pond. These reported values and those presented in Table 6-5 are not considered to pose any health

Table 6-6. Pesticide and PCB Analyses of Fish from the Peconic River System and Carmans River, Lower Lake.

Location/Species	4,4'-DDE	4,4'-DDD	Aroclor-1254	Aroclor-1260
	µg/kg			
BNL, On Site				
Brown bullhead	28.7	15.6	<MDL	<MDL
Donahue's Pond				
Largemouth bass	1.24*	<MDL	<MDL	<MDL
Brown bullhead	<MDL	<MDL	<MDL	<MDL
Golden shiner	3.80*	<MDL	<MDL	<MDL
Bluegill	2.43*	<MDL	<MDL	<MDL
Chain pickerel	<MDL	<MDL	<MDL	<MDL
Pumpkinseed	<MDL	<MDL	<MDL	<MDL
Forge Pond				
Pumpkinseed	2.08*	1.50*	<MDL	<MDL
Largemouth bass	1.69*	<MDL	<MDL	<MDL
Yellow perch	2.22*	<MDL	<MDL	<MDL
Black crappie	<MDL	<MDL	<MDL	<MDL
Bluegill	<MDL	<MDL	<MDL	<MDL
Brown bullhead	14	7.02	<MDL	<MDL
Golden shiner	2.96*	2.40*	<MDL	<MDL
Chain pickerel	5.38	1.67*	<MDL	<MDL
Swan Pond				
Pumpkinseed	2.04*	<MDL	<MDL	<MDL
Largemouth bass	2.12*	<MDL	<MDL	<MDL
Yellow perch	8.77	2.47*	45.9(<MDL)	34.8(31.8)
Black crappie	3.79	<MDL	<MDL	<MDL
Bluegill	2.08*	<MDL	<MDL	<MDL
Brown bullhead	2.03*	<MDL	<MDL	<MDL
Golden shiner	3.57*	1.56*	<MDL	<MDL
Chain pickerel	22.8	8.8	<MDL	5.9*(<MDL)
Lower Lake, Carmans River (control location)				
Bluegill	7.79	2.36*	<MDL	<MDL
Pumpkinseed	12	2.98*	<MDL	<MDL
Brown bullhead	39.4	11.5	<MDL	<MDL
Largemouth bass	18.9	4.88	<MDL	<MDL

Notes:
All fish analyzed as edible portions (fillets) except golden shiners, which were analyzed as whole-body composite samples.
* The reported concentration was estimated by the contract analytical laboratory.
See Figure 5-8 for sampling locations.
MDL = Minimum Detection Limit
PCB = Polychlorinated biphenyls

Table 6-7. Radiological Analyses of Aquatic Vegetation and Sediment from the Peconic River System and Carmans River, Lower Lake.

Sample type	K-40	Cs-137
	pCi/g Dry Sediment	
BNL		
Sediment	1.90 ± 0.61	0.07 ± 0.03**
Vegetation	35.9 ± 7.55*	ND
Sediment	2.91 ± 0.55	ND
Vegetation	9.01 ± 1.56	0.14 ± 0.01**
Sediment	4.19 ± 0.78	0.70 ± 0.09
Vegetation	21.4 ± 4.94	ND
Sediment	5.40 ± 0.87	1.86 ± 0.19
Vegetation	30.5 ± 6.08*	ND
Donahue's Pond		
Vegetation	12.2 ± 4.08	ND
Sediment	1.52 ± 0.27	.03 ± 0.01**
Forge Pond		
Lily pad	NR	0.20 ± 0.09**
Sediment	NR	0.17 ± 0.03**
Swan Pond		
Lily pad	17.6 ± 3.19*	ND
Sediment	2.82 ± 2.99	0.44 ± 0.20
Lower Lake, Carmans River (control location)		
Sediment	3.41 ± 1.77	ND
Lily pad	24.3 ± 5.52*	ND

Notes:
All values are presented with a 95% confidence interval.
See Figure 5-8 for sampling locations.
ND = Not detected
NR = Not reported
* The potassium-40 (K-40) concentration was reported as an estimated value by the contract analytical laboratory.
** The cesium-137 (Cs-137) concentration was reported as an estimated value by the contract analytical laboratory.

risks to humans or other animals that might consume fish.

Table 6-6 shows the concentrations of DDE and DDD, breakdown products of the pesticide DDT, that were found in low levels in both on- and off-site fish sampled in 2005. The brown bullhead taken east of BNL had Endrin (2.40 µg/kg, estimated) and Chlordane (36.9 µg/kg). Lindane (0.74 µg/kg) was found in a brown bullhead from Forge Pond. Heptachlor epoxide (2.88 µg/kg, estimated) was found in a brown bullhead from Lower Lake on the Carmans River. The levels of pesticides detected in fish do not exceed any standards that may constitute a health impact to the consumers of such fish and thus are not considered harmful. DDT was commonly used on Long Island before 1970. Chlordane was also commonly used across Long Island and is found occasionally in fish samples. Endrin, Lindane, and Heptachlor (which breaks down to Heptachlor epoxide) were used to treat soil insects in crops (termites in potatoes).

PCBs were found at levels above the MDL in two samples taken from Swan Pond. Aroclor-1254 was found in a yellow perch (45.9 µg/kg), but a re-analysis of this sample indicated the level to be below the MDL. The same yellow perch had an initial Aroclor-1260 concentration of 34.8 µg/kg, with the re-analysis indicating a concentration of 31.8 µg/kg. Additionally, a chain pickerel taken at Swan Pond had an Aroclor-1260 concentration estimated at 5.9 µg/kg; the re-analysis of the sample indicated a concentration less than the MDL. 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.

6.3.5 Aquatic Sampling

6.3.5.1 Radiological Analysis

Annual sampling of sediment, vegetation, and freshwater in the Peconic River and a control location on the Carmans River was conducted in 2005. See Chapter 5 for a discussion on water quality and monitoring, and Figure 5-8 for sampling stations. Table 6-7 summarizes the radiological data. Low levels of Cs-137 were documented in sediments at all locations, except Lower Lake on the Carmans River. A single on-site sample taken west of the east firebreak at BNL had a Cs-137 concentration of 1.86 pCi/g dry weight. This sample also had elevated metals and PCBs, indicating that it is an isolated area of contamination, as all other sediment samples on site were well below 1.0 pCi/g dry weight. The Laboratory has established a long-term sampling program for sediments in the Peconic River to document the effectiveness

Table 6-8. Metals Analyses of Aquatic Vegetation and Sediment from the Peconic River System and Carmans River, Lower Lake Control Location.

Location/ Sample Type	Aluminum	Barium	Cadmium	Chromium	Copper	Iron	Lead	Manganese	Mercury	Nickel	Silver	Vanadium	Zinc
	mg/kg												
BNL													
Sediment	1530	8.37	<MDL	1.83	6.34	1010	1.86	7.47	0.04	0.12	0.62	2.59	8.01
Vegetation	51.7	9.87	0.37	0.77	7.75	407	2.04	7.16	0.07	2.15	0.54	0.42	44.8
Sediment	1580	4.66	<MDL	2.09	2.35	612	1.6	9.44	0.05	0.99	0.52	1.83	4.3
Vegetation	60.6	3.2	0.14	0.34	5.94	71.4	0.391	4.71	0.21	1.74	0.32	0.17	33.2
Sediment	748	7.08	220	2.6	15.1	382	2.42	5.97	0.59	1.11	2.96	1.42	9.73
Vegetation	10.8	2.97	<MDL	0.23	3.4	16.3	<MDL	15	0.03	1.69	<MDL	0.15	20.5
Sediment	3130	35.3	0.74	10.8	31.3	1590	7.43	28.8	2.26	3.8	18.2	3.7	61.4
Vegetation	14.3	2.87	<MDL	0.25	2.16	24.8	<MDL	25.1	<MDL	1.39	<MDL	<MDL	9.34
Donahue's Pond													
Vegetation	11.4	14.8	<MDL	0.14	<MDL	108	<MDL	108	<MDL	0.43	0.16	<MDL	11.7
Sediment	341	2.2	<MDL	0.79	1.11	377	1.31	7.29	<MDL	0.47	0.16	0.97	3.64
Forge Pond													
Lily pad	7.6	44.9	<MDL	0.17	0.98	45.9	<MDL	28	<MDL	<MDL	<MDL	<MDL	5.6
Sediment	958	18.6	<MDL	1.7	3.1	1400	5.2	30.2	<MDL	1.2	<MDL	3.1	25.3
Swan Pond													
Lilly pad	10.3	18.6	<MDL	0.19	<MDL	27.8	0.25	106	<MDL	0.16	<MDL	<MDL	81
Sediment	5230	84.5	<MDL	20.5	9.9	2570	10.3	1580	<MDL	6.99	<MDL	26.5	52
Lower Lake, Carmans River													
Sediment	8740	111	0.97	42.5	17.1	13800	87.5	630	0.14	10.7	<MDL	29.3	156
Lily pad	<MDL	52.8	<MDL	0.12	<MDL	31.8	<MDL	27.1	<MDL	<MDL	<MDL	<MDL	4.29

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

Table 6-9. Pesticide and PCB Analyses of Aquatic Vegetation, Water, and Sediment from the Peconic River System and Carmans River, Lower Lake.

Location*/ Sample Type	4,4'-DDD	Aroclor-1254	Aroclor-260
	µg/kg		
BNL			
Sediment	< MDL	14.5	4.2**
Vegetation	< MDL	32.4	24.4
Sediment	< MDL	7.0	< MDL
Vegetation	< MDL	< MDL	< MDL
Sediment	8.19**	25.6	5.5
Vegetation	< MDL	< MDL	< MDL
Sediment	7.28**	122	16.7**
Vegetation	< MDL	< MDL	< MDL

Notes:
See Figure 5-8 for sampling locations.
*Samples also were taken at Donahue's Pond, Forge Pond, Swan Pond, and Carmans River (the control location), but were all less than the MDL (Minimum Detection Limit).
**The concentration was reported as an estimated value by the contract analytical laboratory.

of the cleanup operations. Aquatic vegetation taken from on-site locations had levels of Cs-137 ranging from nondetectable to an estimated value of 0.14 pCi/g dry weight. Lily pads from Forge Pond had an estimated Cs-137 concentration of 0.20 pCi/g dry weight.

6.3.5.2 Metals in Aquatic Samples

Metals analyses (Table 6-8) were conducted on aquatic vegetation and sediments from the Peconic River and Carmans River. Most of the data indicate metals at background levels. The standard used for comparison of sediments is the soil cleanup objectives for heavy metals supported by SCDHS. Vegetation results are compared to soil cleanup standards, because metals in vegetation may accumulate via uptake from sediment. In general, metals are seen in vegetation at levels lower than in associated sediment.

Off site, levels of arsenic and chromium were higher than the SCDHS cleanup objectives in sediment at Lower Lake. Chromium was higher than the cleanup objectives at Swan Pond and at one on-site sampling location on the Peconic River. The same BNL sampling location also had elevated mercury (2.26 mg/kg) and silver (18.2 mg/kg). These metals were co-located in the sample containing Cs-137, mentioned above, and appear to represent an isolated area of contamination.

6.3.5.3 Pesticides and PCBs in Aquatic Samples

Pesticides and PCBs are reported in Table 6-9 for only those samples with detectable limits. Samples were taken at Donahue's Pond, Forge Pond, and Swan Pond on the Peconic River, and at Lower Lake on the Carmans River. Sediments from the on-site portions of the Peconic River contained trace levels of DDD, a breakdown product of the pesticide DDT. Both sediments and vegetation from BNL had detectable levels of the PCBs Aroclor-1254 and -1260. Aroclor-1254 ranged in value from 7.0 to 122 µg/kg in sediment, and was present in a single sample of vegetation at 32.4 µg/kg. Aroclor-1260 ranged from an estimated value of 4.2 µg/kg in sediment, to 24.4 µg/kg in vegetation. DDT was one of the pesticides used widely in the 1950s and 1960s, and residual amounts of its breakdown products are still detected. Both PCBs reported were historically used on site.

6.3.6 Peconic River Post Clean-up Monitoring

The Peconic River cleanup began in April 2004 and was completed in May 2005. Prior to the cleanup, extensive sampling occurred to determine the extent of contamination in sediments. A study was also conducted in 2003 and 2004 to identify sections of the Peconic River that were preferentially converting inorganic mercury into methylmercury in the sediment and water column (QEA 2004a; QEA 2004b). Methylmercury monitoring is important because it is the form of mercury that is bio-available to biota and can accumulate in fish tissues. Long-term post remediation monitoring will include annual sediment sampling in June and annual water column sampling in June and August. In 2005, only water column sampling was conducted, as the cleanup had recently been completed and significant numbers of confirmatory sediment samples had been taken as part of the cleanup process. Therefore, only water column sampling results are presented for 2005 (Table 6-10, discussed below).

6.3.6.1 Water Column Sampling

Water column sampling in support of the post clean-up monitoring of the Peconic River occurred in June and August 2005. A water column sample was taken at the center of the river and at one-half the depth of the river at each of 20 locations (see Figure 6-5 for sampling locations and Table 6-10 for results), plus a comparison site in the Connetquot River. Each sample was analyzed for mercury, methylmercury, and total suspended solids (TSS). Additionally, water velocity, water depth, temperature, and water quality parameters were taken at each site. The results of these samples have been fully analyzed in a formal report (QEA 2006). During the August sampling period, several sampling locations were either dry or had water levels that were too shallow to allow of a suitable sample free of suspended sediment. The protocols for obtaining a representative sample require water depths sufficiently deep to totally immerse sample bottles in the water without disturbing sediments.

Mercury samples taken in June ranged from 6.61 ng/L (parts per trillion) at the furthest downstream, off-site sampling point (Figure 6-5), to 229 ng/L at the PR-WC-02 off-site location. Methylmercury values ranged from 1.22 ng/L at PR-WC-11 (downstream of the STP outfall), to 25.2 ng/L (east of the eastern boundary of the Laboratory). Associated TSS samples ranged from 0.58 mg/L downstream of the STP outfall, to 997 mg/L above the outfall. A number of the samples taken in June 2005 were higher in either mercury or methylmercury, or both, compared to values taken at the same location prior to cleanup. The QEA report suggests that this may be due to a number of factors: with recent completion of the cleanup project in May, disturbed sediments may not have had sufficient time to settle and consolidate, and vegetation had not had time to reestablish. In addition, sediment disturbance may have occurred during sampling.

Samples taken in August had mercury values ranging from 1.69 ng/L at locations far off site to 105 ng/L below the STP outfall. Methylmercury values ranged from an estimated low value of 0.028 ng/L below the STP outfall, to 4.79 ng/L at station PR-WC-03, off site. Associated TSS samples ranged from less than the MDL downstream of the STP outfall, to 52.2 mg/L at PR-WC-08 east of the eastern on-site firebreak. In general, values for both mercury

Table 6-10. Analysis Results of Peconic River Water Samples for Mercury, Methylmercury, and Total Suspended Solids (TSS)

	Jun-05			Aug-05		
	Mercury	Methyl-mercury	TSS	Mercury	Methyl-mercury	TSS
Location	ng/L	ng/L	mg/L	ng/L	ng/L	mg/L
Off-Site Control						
Connetquot River	0.68	0.107	2.2	3.88	0.431	< MDL
BNL						
PR-WC-14	58.9	22.2	997	NS	NS	NS
PR-WC-13	NS	NS	NS	dry	dry	dry
PR-WC-12	29.3	19	160	dry	dry	dry
PR-WC-11	79.4	1.22	0.58	105	.028*	1.900*
PR-WC-10	93.1	2.43	1.09	81	0.535	< MDL
PR-WC-09	769	3.44	9.1	81.3	0.69	1.900*
PR-WC-08	190	7.98	61.9	161	1.33	52.2
PR-WC-07	70.9	9.48	6.8	dry	dry	dry
PR-WC-06	200	9.93	58.1	dry	dry	dry
PR-WC-05	60.2	8.32	7	dry	dry	dry
PR-WC-04	160	25.2	34.7	dry	dry	dry
PR-WC-03	83.7	20.3	87	196	4.79	11.7
PR-WC-02	229	9.59	5.6	dry	dry	dry
PR-WC-01	46.4	6.05	7.7	11.4	1.58	6.3
Off Site						
PR-WCS-01	22.2	4.76	10.8	dry	dry	dry
PR-WCS-02	17.9	3.97	9.4	dry	dry	dry
PR-WCS-03	14	4.02	14	dry	dry	dry
PR-WCS-04	40	5.12	52.5	dry	dry	dry
PR-WCS-05	10.5	4.74	12.8	5.28	0.783	9
PR-WCS-06	8.15	4.03	4.1	1.69	0.743	6.5
PR-WCS-07	6.61	2.34	1.4	2.54	0.429	< MDL

Notes:
* Estimated value based on contract analytical laboratory qualifiers.
"Dry" refers to location being dry or water levels too low to sample.
NS = area not sampled
MDL = Minimum Detection Limit

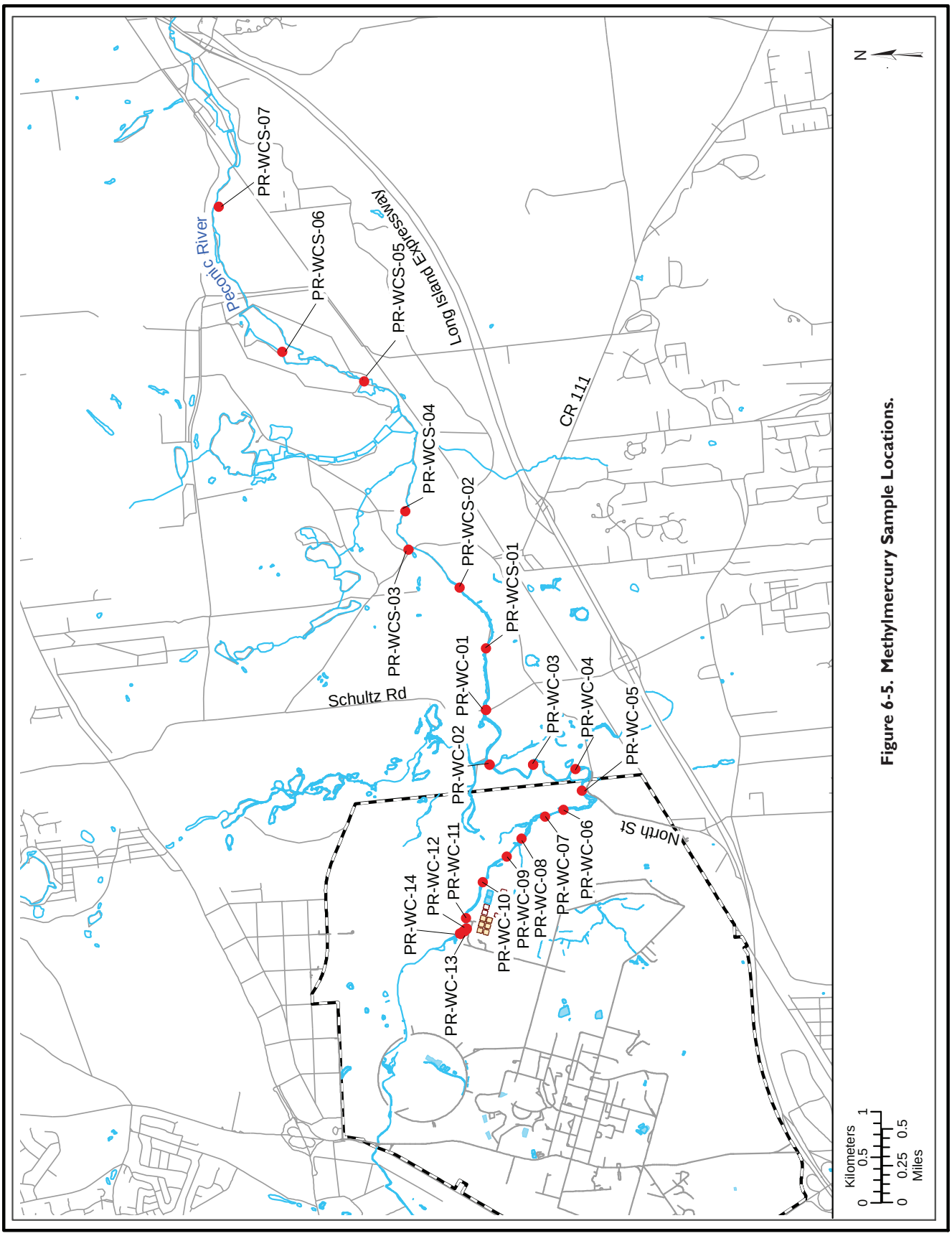


Figure 6-5. Methylmercury Sample Locations.

and methylmercury were lower than values seen before the Peconic River cleanup.

6.3.7 Vegetation Sampling

6.3.7.1 Garden Vegetables

On-site sampling of garden vegetables continued in 2005. Samples of zucchini, cucumber, tomato, pepper, and eggplant were analyzed for Cs-137 content. The radionuclide was not detected in any vegetable sample, nor in associated soil samples. Sampling of off-site farm vegetation was discontinued in 2003 because historical data have consistently indicated the absence of BNL-related radionuclides in off-site vegetation. Periodic confirmatory sampling (approximately every 5 years) will be conducted off site to obtain data on farm vegetables.

6.3.7.2 Grassy Plants

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

6.4 OTHER MONITORING

6.4.1 Soil Sampling

Soil sampling uses the same graded approach as that used for grassy vegetation sampling and was taken out of the basic monitoring protocols in 2003. Confirmatory soil sampling will be conducted every 5 years.

6.4.2 Basin Sediments

A new 5-year testing cycle for basin sediment samples was established in 2003. There are 14 basins associated with outfalls that receive discharges permitted under the State Pollutant Discharge Elimination System (SPDES) permit (see Figure 5-6 for outfall locations). The next round of basin sampling will occur in 2008.

6.4.3 Chronic Toxicity Tests

Under the SPDES discharge permit, BNL conducted chronic toxicity testing of the STP effluents. Results of this testing are discussed in Chapter 3, Section 3.6.1.1. Testing will continue in 2006.

6.4.4 Radiological 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. Four samples were taken from each of these two stations in 2005. There were no gross alpha activity measurements above the MDL at either sampling location.

Gross beta activity was measured in samples in the first three quarters from Station P4 and all quarters from Station S5. 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 4.5 pCi/L, with an average of 3.6 pCi/L. Location S5 had a maximum gross beta activity level of 3.6 pCi/L, with an average of 3.1 pCi/L. Gross beta activity values were within the range of values historically observed at these two locations. No radionuclide-specific analyses indicated values above MDL.

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 2005, the Environmental and Waste Management Services Division (EWMSD) and FERN hosted a total of 18 interns and one faculty member in the Natural Resource Program, as well as two high school interns, seven undergraduate interns, and three high school teachers during the summer. FERN also hosted six undergraduate interns for their Forest Health

Monitoring Program. Two of the undergraduate interns worked with a faculty member from North Carolina Agricultural and Technical University in the Faculty and Student Teams Program. Interns worked on a variety of projects: surveying dragonflies and damselflies, radio tracking turtles and snakes, analyzing the water chemistry of coastal plain ponds, investigating banded sunfish population dynamics, and studying various ecological aspects of forest health. A limited discussion concerning each project is presented below.

An intern in the Community College Internship (CCI) program continued work on the identification and distribution of dragonflies and damselflies (Order *Odonata*) that was started in 2003. These aquatic insects are common around the ponds and Peconic River on site. The distribution of aquatic invertebrates may be useful for monitoring the health of aquatic systems. In addition, results from the Odonate surveys will supplement the New York State Odonate Atlas. The intern increased the number of species identified from 46 to 55. One new species identified on site was the threatened Pine Barrens bluet (*Enallagma recurvatum*). A second species, the double-ringed pennant (*Celithemis verna*), was the first documented record of this dragonfly in New York. The state atlas project will continue for 2 more years, as will the Laboratory's surveys for Odonates.

Two interns in the CCI program from Rhode Island continued radio telemetry work on the Eastern hognose snake and spotted turtle. Both projects have resulted in interesting information concerning these two species, their habits, and habitat needs. The study on the hognose snake has resulted in the documentation of auto-expulsion of radio transmitters from the body and predation of the snake by small mammals and red-tailed hawks. The study on the spotted turtle resulted in better definition of the home range of this small, cryptic ("shy") species, and provided better understanding on the survival of "head-started" turtles (raised in captivity, then released).

An intern in the Science Undergraduate Laboratory Intern (SULI) program from Wesleyan College attempted to use the computer software DISTANCE with survey transects to estimate the hognose snake population at BNL. After criss-crossing the Laboratory with transects to document the snake, it was determined that the powerful DISTANCE software was not useful for this research, as small populations of cryptic species do not provide sufficient data for the program to analyze because the number of sightings is low. Therefore, the Laboratory's reliance on random sightings of this snake and reports by BNL personnel are more useful for determining population levels.

A population analysis of the NY State threatened banded sunfish, conducted by a SULI student from Lafayette College in Pennsylvania, is described in Section 6.1.2.3. A population study in 2006 will again estimate the population in the pond.

A Faculty and Student Team (FaST) conducted tests of four on-site ponds to look at chemical and water quality differences between ponds that are known to be used by tiger salamanders and those that are not used by tiger salamanders. Although no conclusive evidence was found for the differences in the two types of ponds, students gained experience, documented the presence of lead in one pond (a likely source is hunters' spent ammunition), and developed ideas for future work. This study will continue in 2006 and will include the testing of additional ponds, to gain a better understanding of factors that may affect tiger salamander distributions.

Associated with this study was a continuing effort by three teachers in the Lab Science Teacher Professional Development (LSTPD) Program. This project involves obtaining water quality data from all ponds on site. In 2005, the teachers in this program joined the FaST group to use GPS and GIS to enhance their data. They also evaluated and purchased field measurement equipment suitable for use in the classroom, and developed curricula for monitoring freshwaters. The curricula, equipment, and procedures that were developed will be utilized in the Laboratory's newly formed Open Space Stewardship Program called "Gaining Research Experience in the ENvironment [GREEN] Institute," operated out of BNL's Office of Education

Programs. The teachers will utilize their experience and training to run teacher workshops in 2006.

Two high school students completed separate projects in 2005. The first student, from the Stony Brook School, used GPS and GIS to survey invasive species in developed portions of the Laboratory. Such areas were deliberately excluded from the original invasive species surveys in 2003, but the need to better understand the potential source of invasives on site resulted in this project. The second student, from the Earl L. Vandermeulen High School, worked with a doctoral candidate to track tiger salamanders fitted with radio transmitters.

FERN hosted six summer students who conducted the first Forest Health Monitoring Program in the Long Island Central Pine Barrens. The students were able to establish 50 permanent monitoring plots throughout the pine barrens, gather data, analyze it, and produce six separate projects. Their scientific posters, forest health monitoring protocols, and the associated database are available on the FERN website at www.fern-li.org. The various projects dealt with different aspects of forest health or the ability to gather accurate information. Students evaluated differences in leaf litter among forest types, differences in understory composition and age class structure of the various forest types, differences between canopy estimates using human observers versus instruments, differences in snag (dead limb) density among forest types, and effects of overstory canopy on understory density. This project will continue in 2006, to finish establishing a sufficient number of plots to ensure an accurate assessment of forest health and to detect changes in forest health over time.

Members of EWMSD and other BNL departments volunteered as speakers for schools and civic groups and provided on-site ecology tours. EWMSD also hosted events in association with Earth Day. In October, BNL hosted the Tenth Annual Pine Barrens Research Forum, providing a venue for researchers who are conducting work on pine barrens ecosystems to share and discuss their results. BNL also hosted the annual Wildland Fire Academy, offered by NYSDEC and the Central Pine Barrens Commission. This academy trains fire fighters in the methods of wildland fire suppression, prescribed fire, and fire analysis, using the Incident Command System of wildfire management.

BNL has developed and is implementing a Wildland Fire Management Plan. In October 2004, the first prescribed fire at BNL was conducted. This fire treated approximately 7 acres to improve germination and recruitment of oak seedlings. It also reduced fine-textured forest fuels that tend to increase the severity of wildfires. Pre-fire monitoring was conducted before the fire was started, and post-fire monitoring indicated the fire was conducted properly for its intended purpose. Additional post-fire monitoring in 2005 indicated that the prescribed fire had improved conditions that support the germination of oak seedlings. BNL's second prescribed fire was planned for 2005, but heavy rainfall precluded conducting the activity in the timeframe allotted. The Laboratory intends to continue the use of prescribed fire for fuel and forest management in the future.

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), which will guide the management of all of BNL's historical resources, was approved by DOE in March 2005. 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 complex, the High Flux Beam Reactor 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 2005, the cultural resource program focused primarily on outreach activities. A drive-by tour of historic Laboratory structures was developed, along with an accompanying narrative CD and pamphlet. Talking points and visuals were also developed for tours of select WWI trench areas.

A portion of one BNL Summer Sunday Open House in August was devoted to BNL history. This event, which was open to the general public and promoted through radio and newspaper ads, featured displays related to the Laboratory and Camp Upton history, talks by scientific staff, as well as a bus tour and walking tour of the WWI trenches. More than 1,000 people visited the Laboratory on this day, with approximately 500 participating in the tours. Additional tours of the WW I trenches were provided to local organizations throughout the year.

REFERENCES AND BIBLIOGRAPHY

BNL. 1999. *Record of Decision: Operable Unit I and Radiologically Contaminated Soils*. BNL/OUI/12.1/1-57 05-OCT-99. Brookhaven National Laboratory, Upton, NY.

BNL. 2000. *1999 Site Environmental Report.* BNL-52553. Brookhaven National Laboratory, Upton, NY.

BNL. 2003a. *Natural Resource Management Plan for Brookhaven National Laboratory.* BNL-71870-2003. Brookhaven National Laboratory, Upton, NY.

BNL. 2003b. *Wildland Fire Management Plan for Brookhaven National Laboratory.* BNL-71629-2003. Brookhaven National Laboratory, Upton, NY.

BNL. 2005. *Cultural Resource Management Plan for Brookhaven National Laboratory.* BNL-73839-2005. Brookhaven National Laboratory, Upton, NY. March 2005.

DOE-FWS. 2000. *Interagency Agreement Number AI02-01CH1107 Between the U.S. Department of Interior, U.S. Fish & Wildlife Service, Long Island National Wildlife Refuge Complex, and the U.S. Department of Energy Chicago Operations Office Brookhaven Group.*

Dwyer, Norval. 1966. *Brookhaven National Laboratory. Long Island Forum* (reprint), West Islip, NY.

Florendo, Esperanza. 2004. "Seasonal food intake affecting Cs-137 levels in white-tailed deer at Brookhaven National Laboratory." CCI Paper. Brookhaven National Laboratory.

IAEA. 1992. *Effects of Ionizing Radiation on Plants and Animals at Levels Implied by Current Radiation Protection Standards*. Technical Report Series No. 332. International Atomic Energy Agency, Vienna.

LMS. 1995. *Phase II Sitewide Biological Inventory Report, Final.* Lawler, Matusky & Skelly Engineers. Pearl River, NY.

NYSDOH. 1996. *Radioactive Contamination in the Peconic River.* Bureau of Environmental Radiation Protection, New York State Department of Health, Albany, NY.

NYSDOH. 1999. *Deer Meat Contaminated with Cesium-137 at Brookhaven National Laboratory.* Bureau of Environmental Radiation Protection, New York State Department of Health, Albany, NY.

QEA. 2004a. *PECONIC RIVER 2003 DATA SUMMARY REPORT.* Quantitative Environmental Analysis, LLC. Montvale, New Jersey.

QEA. 2004b. *2004 Methylmercury Sampling Program Results: Addendum to the Peconic River 2003 Data Summary Report.* Quantitative Environmental Analysis, LLC. Montvale, New Jersey.

QEA. 2006. *2005 Peconic River Water Column Sampling Data Summary Report.* Quantitative Environmental Analysis, LLC. Montvale, New Jersey.