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 on-site personnel 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 2013, deer and fish sampling results were consistent with previous years. Vegetables grown in nearby farms continue to support historical analyses that there are no Laboratory-related radionuclides in produce.

The overriding goal of the Cultural Resource Management Program is to ensure that proper stewardship of BNL 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 Natural Resource Management Program at BNL promotes stewardship of the natural resources found at the Laboratory, and integrates natural resource management and protection with BNL's scientific mission. The Natural Resource Management Plan (NRMP) for Brookhaven National Laboratory describes the program strategy, elements, and planned activities for managing the various natural resources found on site. The first iteration of the NRMP was approved by DOE in 2003 and the plan is updated every 5 years (BNL 2011).

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 2012, a forest fire was started on the northern part of BNL property, burning approximately 300 acres on site and an additional 700 acres off site. Within 2 days of the fire, Laboratory personnel began recording the extent of the fire using GPS, established photo points, and began tracking both fire damage and post-fire recovery. Maps of the fire and photo locations were entered into the GIS for future reference and are revisited periodically to track recovery. A deer exclosure area was established to track impacts of BNL's high deer population on the burn area as it continues to recover.

Work associated with tracking impacts from the construction of the Long Island Solar Farm (LISF) at BNL continue to be entered into a GIS as a tool to assist analysis of changes to wildlife populations and vegetation. In 2013, natural resource personnel and interns continued to look at use of the LISF site by wildlife; use of fence openings by wildlife; changes in bird use; and changes in vegetation.

A wide variety of vegetation, birds, reptiles, amphibians, and mammals inhabit the site. Through implementation of the NRMP, endangered, threatened, and species of special concern have been identified as having been resident at BNL during the past 30 years or are expected to be present on site (Table 6-1). The only New York State endangered species confirmed as currently inhabiting Laboratory property is the eastern tiger salamander (*Ambystoma t. tigrinum*). Five other New York State endangered species have been identified at BNL in the past: the Persius duskywing butterfly (*Erynnis p. persius*), the crested fringed orchid (*Plantathera cristata*), Engelman spikerush (*Eleocharis engelmannii*), dwarf huckleberry (*Gaylussacia bigeloviana*), and whorled loosestrife (*Lysimachia quadrifoli*).

Six New York State threatened species have been positively identified on site and three other species are considered likely to be present. Threatened species include two fish, the banded sunfish (*Enneacanthus obesus*) and swamp darter (*Etheostoma fusiforme*); and plants, including the stiff goldenrod (*Solidago rigida*) and stargrass (*Aletris farinose*). The northern harrier (*Circus cyaneus*) is periodically seen in the fall. Insects listed as threatened include the Pine Barrens bluet (*Enallagma recurvatum*), a damselfly, which was confirmed at one of the many coastal plain ponds located on site. Two other damselflies, the little bluet (*Enallagma minisculum*) and the scarlet bluet (*Enallagma pictum*), are likely to be present at one or more of the ponds on site. The frosted elfin (*Callophrys irus*), a butterfly, has been historically present on site due to its preferred habitat and host plant, wild lupine (*Lupinus perennis*).

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 are listed in Table 6-1.

BNL historically has had no federally threatened or endangered species present on site. On October 2, 2013, the U.S. Fish & Wildlife Service (FWS) published a notice in the Federal Register that the northern long-eared bat (*Myotis septentrionalis*) be recommended for listing as an Endangered Species under the Federal Endangered Species Act. The comment period is to be completed by early 2014 and listing to occur in late 2014. The northern long-eared bat is known to be present at BNL having been identified as the first case of white-nosed syndrome found on Long Island in 2011. Work on identifying bats continued in 2013 and is discussed below in Section 6.5.

6.1.2 Habitat Protection and Enhancement

BNL has administrative processes in place to protect on-site habitats and natural resources. Activities to eliminate or minimize negative effects on endangered, threatened, or sensitive species are either incorporated into Laboratory procedures or into specific program or project plans. Human access to critical habitats, when necessary, is limited, and habitats are enhanced to improve survival or increase populations. Routine activities, such as road maintenance, are not performed until the planned activities have been evaluated and determined to be unlikely to affect habitat.

6.1.2.1 Salamander Protection Efforts

Many safeguards are in place to protect eastern tiger salamander breeding areas. BNL staff must review any project planned near eastern tiger salamander habitats, and every effort is made to minimize impacts. A map of the breeding areas is reviewed when new projects are proposed. The map is updated as new information concerning the salamanders is generated through research and monitoring. The current map incorporates a buffer area around tiger salamander habitat of 1,000 feet based on guidance from the New York State Department of Environmental Conservation (NYSDEC).

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 post-poned or closely monitored.

Water quality testing is conducted as part of the routine monitoring of recharge basins, as discussed in Chapter 5. In cooperation with 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. In 2013, egg mass surveys confirmed the presence of salamanders in 8 of the 26 ponds identified at BNL. Whenever possible, ponds with documented egg masses from the spring surveys are revisited in June and July to check for the presence of larval salamanders.

Protection of the eastern tiger salamander was a key component of the Environmental Assessment (EA) conducted for the LISF project. The unique shape of the project construction area is, in part, the result of a need to provide sufficient, viable habitat for the tiger salamander within the area to be developed. In 2010, the LISF project completed habitat enhancements to improve one pond in the area, with the enhancements intended to allow the pond to retain water for longer periods of time to support larval development. The enhanced pond is currently being managed to remove invasive plants that moved into the pond from surrounding areas. Several areas of the LISF have maintained standing water since construction, and these areas have been monitored for use by amphibians.

6.1.2.2 Banded Sunfish

Banded sunfish protection efforts include observing whether adequate water is present within areas currently identified as sunfish habitat, ensuring that existing vegetation in their habitat is not disturbed, and evaluating all activities taking place in ponds and the Peconic River on site for potential impacts on these habitats. Population estimates are periodically conducted within these waters to determine their current health.

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			
Comet darner	*Anax longipes*	SGCN	Confirmed
Frosted elfin	*Callophrys iris*	T	Likely
New England bluet	*Enallagma laterale*	SGCN	Likely
Little bluet	*Enallagma minusculum*	T	Confirmed
Scarlet bluet	*Enallagma pictum*	T	Likely
Pine Barrens bluet	*Enallagma recurvatum*	T	Confirmed
Mottled duskywing	*Erynnis martialis*	SC	Likely
Persius duskywing	*Erynnis persius persius*	E	Likely
Pine barrens zanclognatha	*Zanclognatha martha*	SGCN	Confirmed
Black-bordered lemon moth	*Marimatha nigrofimbria*	SGCN	Confirmed
Fish			
Banded sunfish	*Enniacanthus obesus*	T	Confirmed
Swamp darter	*Etheostoma fusiforme*	T	Confirmed
Amphibians			
Marbled salamander	*Ambystoma opacum*	SC	Confirmed
Eastern tiger salamander	*Ambystoma tigrinum tigrinum*	E	Confirmed
Fowler's toad	*Bufo fowleri*	SGCN	Confirmed
Four-toed salamander	*Hemidactylium scutatum*	SGCN	Confirmed
Eastern spadefoot toad	*Scaphiopus holbrookii*	SC	Confirmed
Reptiles			
Worm snake	*Carphophis amoenus*	SC	Confirmed
Snapping turtle	*Chelydra serpentina*	SGCN	Confirmed
Spotted turtle	*Clemmys guttata*	SC	Confirmed
Northern black racer	*Coluber constrictor*	SGCN	Confirmed
Eastern hognose snake	*Heterodon platyrhinos*	SC	Confirmed
Stinkpot turtle	*Sternotherus odoratus*	SGCN	Confirmed
Eastern box turtle	*Terrapene carolina*	SC	Confirmed
Eastern ribbon snake	*Thamnophis sauritus*	SGCN	Confirmed
Birds (nesting, transient, or potentially present)			
Cooper's hawk	*Accipiter cooperii*	SC	Confirmed
Sharp-shinned hawk	*Accipiter striatus*	SC	Confirmed
Grasshopper sparrow	*Ammodramus savannarum*	SC	Confirmed
Great egret	*Ardea alba*	SGCN	Confirmed
Whip-poor-will	*Caprimulgus vociferus*	SC	Confirmed
Northern harrier	*Circus cyaneus*	T	Confirmed
Black-billed cuckoo	*Coccyzus erythropthalmus*	SGCN	Confirmed
Northern bobwhite	*Colinus virginianus*	SGCN	Confirmed
Prairie warbler	*Dendroica discolor*	SGCN	Confirmed
Horned lark	*Eremophila alpestris*	SC	Confirmed
Wood thrush	*Hylocichla mustelina*	SGCN	Confirmed
Red-headed woodpecker	*Melanerpes erythrocephalus*	SC	Confirmed
Osprey	*Pandion haliaetus*	SC	Confirmed
Scarlet tanager	*Piranga olivacea*	SGCN	Confirmed
Glossy ibis	*Plegadis falcinellus*	SGCN	Confirmed
Brown thrasher	*Toxostoma rufum*	SGCN	Confirmed
Blue-winged warbler	*Vermivora pinus*	SGCN	Confirmed
Plants			
Small-flowered false foxglove**	*Agalinis paupercula*	R	Confirmed
Stargrass	*Aletris farinosa*	T	Confirmed
Butterfly weed	*Asclepias tuberosa ssp. interior*	V	Confirmed

(continued on next page)

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

Common Name	Scientific Name	State Status	BNL Status
Spotted wintergreen	*Chimaphila maculata*	V	Confirmed
Flowering dogwood	*Cornus florida*	V	Confirmed
Pink lady's slipper	*Cypripedium acaule*	V	Confirmed
Ground pine	*Dendrolycopodium obscurum*	V	Confirmed
Round-leaved sundew**	*Drosera rotundifolia var. rotundifolia*	V	Confirmed
Marginal wood fern**	*Dryopteris marginalis*	V	Confirmed
Engelman spikerush**	*Eleocharis engelmannii*	E	Confirmed
Dwarf huckleberry**	*Gaylussacia bigeloviana*	E	Confirmed
Winterberry	*Ilex verticillata*	V	Confirmed
Sheep laurel	*Kalmia angustifolia*	V	Confirmed
Narrow-leafed bush clover	*Lespedeza augustifolia*	R	Confirmed
Wild lupine**	*Lupinus perennis*	R	Confirmed
Whorled loosestrife	*Lysimachia quadrifolia*	E	Confirmed
Bayberry	*Myrica pensylvanica*	V	Confirmed
Stiff-leaved goldenrod	*Oligoneuron rigida*	T	Confirmed
Cinnamon fern	*Osmunda cinnamomea*	V	Confirmed
Clayton's fern	*Osmunda claytoniana*	V	Confirmed
Royal fern	*Osmunda regalis*	V	Confirmed
Crested fringed orchid	*Plantathera cristata*	E	Likely
Green fringed orchis**	*Platanthera lacera*	V	Confirmed
Swamp azalea	*Rhododendron viscosum*	V	Confirmed
Long-beaked bald-rush	*Rhynchospora scirpoides*	R	Confirmed
New York fern	*Thelypteris novaboracensis*	V	Confirmed
Marsh fern	*Thelypteris palustris var. pubescens*	V	Confirmed
Virginia chain-fern	*Woodwardia virginica*	V	Confirmed

Notes:
* Table information based on 6 NYCRR Part 182, NYCRR Part 193, and BNL survey data.
** Species added in 2012
No federally listed threatened or endangered species are known to occur at BNL.

E = endangered
R = rare
T = threatened
SC = species of special concern
SGCN = species of greatest conservation need
V = exploitably vulnerable

During the last population survey in 2011, approximately 6,400 banded sunfish were counted.

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 seven permanent bird survey routes in various habitats on site. A new route was established in 2010 in the vicinity of the LISF.

In 2013, monthly surveys were conducted starting at the end of April and extending through the end of August. Two routes associated with the LISF were monitored bi-weekly from mid-May through mid-September. These surveys identified 73 songbird species, compared to the 69 species identified in 2012 and 62 species in 2011. A total of 129 bird species have been identified in surveys in the past 14 years; 59 of these species were present in each of the past 14 years. Variations in the number and species identified during each survey may reflect the time of observation, variations in weather patterns between years, and possible changes in the environment. The two most diverse transects pass near on-site wetlands near the LISF and the Peconic River. The four transects passing through the various forest types on site (white pine, moist pine barrens, and dry pine barrens) showed a less diverse bird community. Bird survey data are stored in an electronic database for future reference and study. In 2013, BNL worked with a statistician to analyze 13 years of collected data to determine any trends. This effort found that 20 percent of the bird species detected accounted for 80 percent of the number of birds detected on bird surveys. This is known as the Pareto Principle, or the 80-20 rule: approximately 80 percent of the effects come from 20 percent of the causes (Rispoli, et al. 2014).

No known data on the effects of a large, utility-scale solar arrays such as the LISF are known within scientific literature. To assess the effects of the solar farm on local bird populations, the collection of migratory bird data in both the Biology Field transect and the solar farm transect is important. It is currently predicted that the LISF will improve habitat for some migratory birds over time, as understory vegetation grows below the arrays and deer are kept out of the area. One species, indigo bunting (*Passerina cyanea*), was absent along the Biology Field transect in 2011, but was heard along the solar farm transect in 2012 and returned to the Biology Field transect in 2013. This temporary absence is thought to be due to disturbance from construction activities while building the solar farm.

The eastern bluebird (*Sialia sialis*) has been identified as a declining species of migratory

birds in North America. This is due to loss of habitat and 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. Although many of these boxes were removed from service in 2010 in preparation for the construction of the LISF, the LISF created nearly 200 acres of suitable habitat for the eastern blue bird. Forty additional boxes were installed around the northernmost portions of the LISF in 2012, and an additional 40 boxes are planned for installation or replacement in 2014.

Migratory birds occasionally cause safety and health concerns, particularly Canada geese (*Branta canadensis*) and several species of migratory birds that occasionally nest on buildings or in construction areas on site. Over the past several years, the resident Canada goose population at BNL began increasing, with the potential to reach large enough numbers that could result in health and safety issues. In 2007, under a permit from FWS, the Laboratory began managing the resident goose population. In 2013, 20 nests were treated, but many nests were missed and approximately 45 goslings were produced, resulting in a population increase to more than 130 individuals. In order to educate BNL facility managers and other environmental and safety personnel about migratory birds, a training program on the Migratory Bird Treaty Act and other bird regulations was prepared. It is anticipated that this training will result in improved employee awareness of the Canada goose problems, and allow for a more timely response for nest management.

6.1.3 Population Management

In addition to controlling resident Canada goose populations described above, 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*). In 2013, the on-site population appears to have stabilized at approximately 300 birds. In 2009, the wild turkey population across Suffolk County, Long Island, was determined to be of sufficient size to support hunting. Each year, the NYSDEC manages a five-day hunting period for several areas across Long Island, which typically results in over 100 birds taken each year.

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 currently 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 optimal circumstances. This was the approximate density in 1966, when BNL reported an estimate of 267 deer on site (Dwyer 1966). The Laboratory has been conducting population surveys of the white-tailed deer since 2000. Spring surveys in 2013 estimated the population at more than 600 animals.

Deer overpopulation can affect animal and human health (e.g., animal starvation, Lyme disease from deer ticks, collision injuries to both humans and animals), species diversity (songbird species reduction due to selective grazing and destruction of habitat by deer), and property damage (collision damage to autos and browsing damage to ornamental plantings). Deer related collisions on site are less common than in the past, presumably due to improved vehicular speed controls and employee training.

High deer populations are a regional problem, and the Laboratory is just one area on Long Island with such an issue. In 2012, several governmental entities on eastern Long Island began working to manage deer populations and the

USDA-Wildlife Services, in cooperation with NYSDEC and the Suffolk County Farm Bureau, planned a limited culling operation. Culling was to start in several of Long Island's east end towns in late 2013, but was delayed to early 2014 due to public concerns about the culling program.

In 2008, BNL began developing a deer management plan which includes an option to reduce the population through culling. The planning effort has included engagement of Laboratory employees and guests in discussions concerning the need and methods for deer management. In 2012, an Environmental Assessment (EA) under the National Environmental Policy Act (NEPA) was completed and sent to NY State for comment. The Final EA was completed in the spring of 2013. Additionally, under BNL's permit for deployment of the 4-Poster tick management system issued by the NYSDEC, the Lab is required to implement a deer management program. Planning for implementing the deer cull is ongoing.

6.1.4 Compliance Assurance and Potential Impact Assessment

The NEPA review process at BNL ensures that environmental impacts of a proposed action or activity are adequately evaluated and addressed. The Laboratory uses NEPA when identifying potential environmental impacts associated with site activities, especially projects that may result in physical alterations to the landscape and structures. As appropriate, stakeholders such as EPA, NYSDEC, Suffolk County Department of Health Services (SCDHS), BNL's Community Advisory Council, and the 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 2012, BNL started an EA for the proposed management of white-tailed deer on the BNL site. The EA was completed in the spring of 2013 with a Finding of No Significant Impact (FONSI). A summary of NEPA reviews is provided in Chapter 3.

6.2 UPTON ECOLOGICAL AND RESEARCH RESERVE

The Upton Ecological and Research Reserve (Upton Reserve) consists of 530 acres located on the eastern boundary of the BNL site. The Reserve has been designated as an area for the protection of sensitive habitats and a place where researchers can study local ecosystems. The Upton Reserve 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).

The Upton Reserve is managed by BNL and the Foundation for Ecological Research in the Northeast (FERN). Funding is coordinated for research projects that occur within the reserve and the larger pine barrens area of Long Island. Research supported by FERN in 2013 included continued investigation into bat populations on Long Island that were impacted by white-nosed syndrome, and the funding of a leopard frog identification guide to help differentiate a newly discovered species of leopard frog in the northeast. Information on these projects and others is provided in Section 6.5.

6.3 MONITORING FLORA AND FAUNA

The Laboratory routinely conducts surveillance monitoring of flora and fauna to determine the effects of past and present activities on site. In addition to surveillance monitoring, CERCLA-required monitoring results associated with post-cleanup monitoring of the Peconic River are now addressed in the annual Site Environmental Report. Because soil contaminated with a radioactive isotope of cesium (Cs-137) was used in some BNL landscaping projects in the past, traces of Cs-137 can be 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 also list analytical results for potassium-40 (K-40), a naturally occurring radioisotope of potassium that is commonly found

in flora and fauna. Studies indicate that Cs-137 out-competes potassium when potassium salts are limited in the environment, which is typical on Long Island. Including K-40 in tables allow for a comparison with Cs-137 levels and is used, in part, to determine the accuracy of analytical results. 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 are typically large, with males weighing, on average, approximately 150 pounds; females typically weigh 1/3 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 2013, as in recent years, an on- and off-site deer-sampling program was conducted. While most off-site samples are the result of car/deer accidents near the Laboratory, in most years, samples from deer taken by hunters beyond BNL boundaries or samples from car/deer accidents greater than 1 mile from BNL are used. Based on more than a decade of sampling, deer taken from more than 1 mile from BNL are used for comparison with populations on and near the Laboratory that could acquire Cs-137 from a BNL source. In 2013, six deer were obtained on site, three from off-site locations within 1 mile of the Laboratory, and two from areas greater than 1 mile from the BNL boundary. The results of deer sampling are shown in Table 6-2.

BNL sampling technicians collect the samples and send them for analysis. Samples of meat (flesh) and liver are taken from each deer, when possible, and are analyzed for Cs-137. Data are reported on a wet-weight basis, as that is the form most likely used for consumption.

6.3.1.1 Cesium-137 in White-Tailed Deer

Based on historic and current data, white-tailed deer sampled at or near the Laboratory contain higher concentrations of Cs-137 than deer from greater than 1 mile off site (BNL 2000), most likely 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 or is consumed directly while the animal is grazing.

Removal of contaminated soil areas on site has occurred under the Laboratory's cleanup program, with all major areas of contaminated soil being remediated by September 2005. The number of deer obtained for sampling steadily increased between 1996 and 2004. However, the number of deer obtained from 2005 to 2013 was significantly lower. In 1998, a statistical analysis based on existing data suggested that 40 deer from off site and 25 deer from on site are needed to achieve a statistically sound data set. Since that analysis was completed, BNL has attempted to obtain the required number of deer, but the number obtained each year has varied due to the sampling method, which depends on accidents between vehicles and deer and people reporting dead deer. The number of deer hit by vehicles also 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 2009. 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 is greatest.

In 2013, Cs-137 concentrations in deer meat (muscle) samples were obtained from six deer on site with a range of values from non-detect to 0.85 pCi/g, wet weight, and an arithmetic average of 0.51 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.

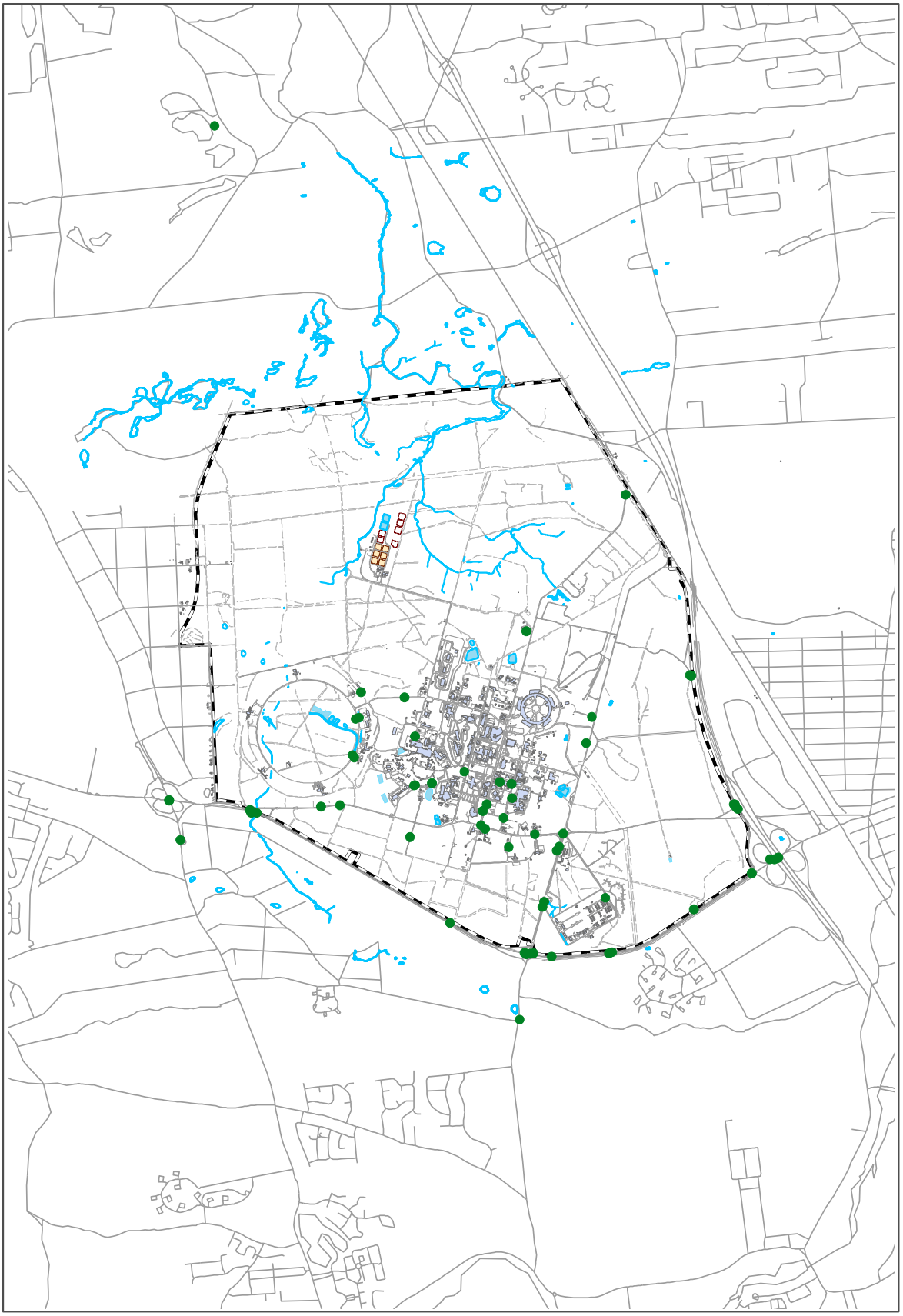


Figure 6-1. Deer Sample Locations, 2009—2013.

Dry weight concentrations are typically higher than wet weight values. The highest on-site sample in 2013 (0.85pCi/g, wet weight) was 3 times higher than the highest on-site sample reported in 2012 (0.27 pCi/g, wet weight) and 14 times lower than the highest level ever reported in 1996 (11.74 pCi/g, wet weight).

Cs-137 concentrations in off-site deer meat samples are typically separated into two groups: samples taken within 1 mile of BNL (three samples) and samples taken farther away (two samples), as shown in Table 6-2. Concentrations in meat samples taken within 1 mile ranged from 0.14 to 1.08 pCi/g, wet weight, with an arithmetic average of 0.46 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 2013, this was 0.50 pCi/g, wet weight. Deer samples from greater than 1 mile from BNL ranged from 0.05 pCi/g, wet weight, to 1.39 pCi/g, wet weight, with the arithmetic average being 0.72 pCi/g, wet weight.

Figure 6-2 compares the average values of Cs-137 concentrations in meat samples collected in 2013 from four different location groupings; 2013 is the first year in which the average Cs-137 content from deer taken within 1 mile of the Laboratory is lower than the on-site average. While no definitive explanation can be given to the difference from past results, it could simply be due to the low sample numbers and randomness in sample acquisition. Although not shown on the figure, 89 percent of all meat samples taken both on and off site are below 1 pCi/g, wet weight.

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 2007, samples from 2013 indicate a similar range of error. The average is approximately 10 percent lower than the 2007 average and is 30 percent higher than the 2012 average, which was the lowest average seen since trending began in 2000. These sample results continue to indicate the effectiveness of cleanup actions across the Laboratory, with the trend being slightly downward from 2003 to 2013.

When possible, liver samples are taken concurrently with meat samples. The 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 2013, Cs-137 concentrations ranged from non-detect to 0.24 pCi/g, wet weight, with an average of 0.10 pCi/g, wet weight. The off-site Cs-137 concentration in liver ranged from 0.02 to 0.25 pCi/g, wet weight, with an arithmetic average for all off-site liver samples of 0.17 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.

6.3.2 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. In 2013, a single turkey was found dead from unknown trauma. A sample of the breast meat was sent

Table 6-2. Radiological Analyses of Deer Tissue.

Sample Location	Collection Date	Tissue	K-40 pCi/g (Wet Weight)	Cs-137 pCi/g (Wet Weight)
BNL, On Site				
Bldg. 490	01/29/13	Flesh	3.09±0.10	0.40±0.01
		Liver	2.14±0.08	0.07±0.00
NW Corner, Center and Cornell Streets	02/14/13	Flesh	2.43±0.13	ND
		Liver	1.74±0.17	ND
AGS Well 102	11/08/13	Flesh	3.03±0.20	0.85±0.03
North Gate	11/08/13	Flesh	3.56±0.18	0.65±0.02
		Liver	3.04±0.18	0.24±0.01
South Gate	11/15/13	Flesh	3.22±0.26	0.85±0.03
North Gate Rd.	11/20/13	Flesh	2.78±0.29	0.32±0.02
< 1 Mile from BNL				
William Floyd Parkway and North Gate	01/03/13	Flesh	3.25±0.10	1.08±0.01
		Liver	2.48±0.15	0.23±0.01
William Floyd Parkway, 1 mile S of Main Gate	03/20/13	Flesh	3.03±0.17	0.16±0.01
William Floyd Parkway and Long Island Expressway	12/19/13	Flesh	2.63±0.13	0.14±0.01
> 1 Mile from BNL				
Middle Island Rd. and Sunrise Highway	11/05/13	Flesh	3.18±0.12	1.39±0.02
		Liver	2.76±0.16	0.25±0.01
East Merideth, NY	11/16/13	Flesh	3.08±0.27	0.05±0.01
		Liver	2.52±0.26	0.02±0.01
Averages by Tissue				
Flesh Averages				
All Samples (11)			3.03±0.63	0.54±0.06
BNL Average (6)			3.02±0.50	0.51±0.06
< 1 Mile Average (3)			2.97±0.24	0.46±0.02
BNL + < 1 mile (9)			3.00±0.55	0.50±0.06
> 1 Mile Average (2)			3.13±0.30	0.72±0.02
Liver Averages				
All Samples (7)			2.34±0.44	0.12±0.03
BNL Average (3)			2.31±0.26	0.10±0.02
< 1 Mile Average (2)			2.11±0.18	0.14±0.01
BNL + < 1 mile (5)			2.23±0.32	0.12±0.02
> 1 Mile Average (2)			2.64±0.30	0.13±0.02

Notes:
All values are shown with a 95% confidence interval.
All averages are the arithmetic average with confidence limits with a 2 sigma (95%) propogated error
K-40 occurs naturally in the environment and is presented as a comparison to Cs-137.
AGS = Alternate Gradient Synchrotron
Cs-137 = cesium-137
K-40 = potassium-40
ND = not detected

for radiological analysis, and Cs-137 level was determined to be 0.12 pCi/g, wet weight.

6.3.3 Fish Sampling

BNL maintains an ongoing program for collecting and analyzing fish from the Peconic River and surrounding freshwater bodies. Monitoring of the river is conducted under the environmental surveillance program and the CERCLA post-cleanup program. Surveillance monitoring occurs during even-numbered years and post-cleanup monitoring occurs in odd-numbered years. Therefore, data presented for 2013 is for compliance with post-cleanup monitoring requirements. Data for 2014 will consist of surveillance monitoring of fish from the Peconic River locations, as well as background monitoring of fish from Lower Lake on the Carmans River.

Due to the deepening of several areas of the river during restoration activities, large areas of open water on site were created that provide sufficient habitat to support larger fish. During 2013, sampling activities, numerous schools of bass and sunfish fry have been 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 2013 to take advantage of periods of high oxygen.

Samples collected on site were from Area A of the Peconic River just downstream of the Sewage Treatment Plant (STP) outfall and Area D near the east boundary of the Laboratory. Various species of fish were also collected off site from Shultz Road, Donahue's Pond, and Lower Lake on the Carmans River (see Figure 5-4 for sampling stations). Lower Lake on the Carmans River is the non-Peconic control site. Sampling is carried out under a permit with NYSDEC.

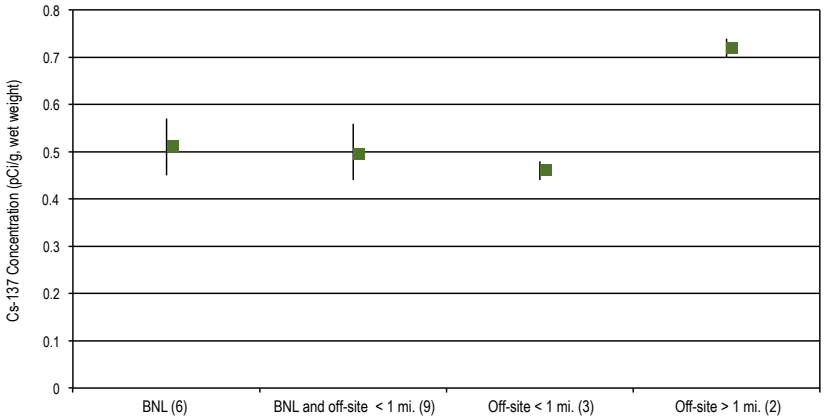
6.3.3.1 Radiological Analysis of Fish

The species collected for radiological analysis in 2013 included brown bullhead (*Ictalurus nebulosus*), chain pickerel (*Esox niger*), largemouth bass (*Micropterus salmoides*), black crappie (*Pomoxis nigromaculatus*), and pumpkinseed (*Lepomis gibbossu*). The edible (fillet) content of each fish were collected for analysis. Gamma spectroscopy analysis was performed on all samples. When fish samples were not of sufficient volume to conduct all non-radiological and radiological analyses, samples of the same species were composited. Table 6-3 presents specific information on the sampling location, species collected, and analytical results. All sample results are presented as wet weight concentrations, and information on the naturally occurring radioisotope K-40 is included as a comparison.

Cs-137 was measured at levels ranging from non-detected to 0.47 pCi/g, wet weight, from the Peconic River system, and all samples from the Carmans River had non-detectable levels. Detectable Cs-137 levels in fish ranged from and estimated 0.06 pCi/g, wet weight, in a brown bullhead taken from Donahue's Pond to an estimated 0.47 pCi/g, wet weight, in a chain pickerel taken from Area D. For comparison, the highest recent value of Cs-137 was 0.78 pCi/g, wet weight, in a composite sample of bluegill (*Lepomis macrochirus*) taken from Forge Pond in 2011.

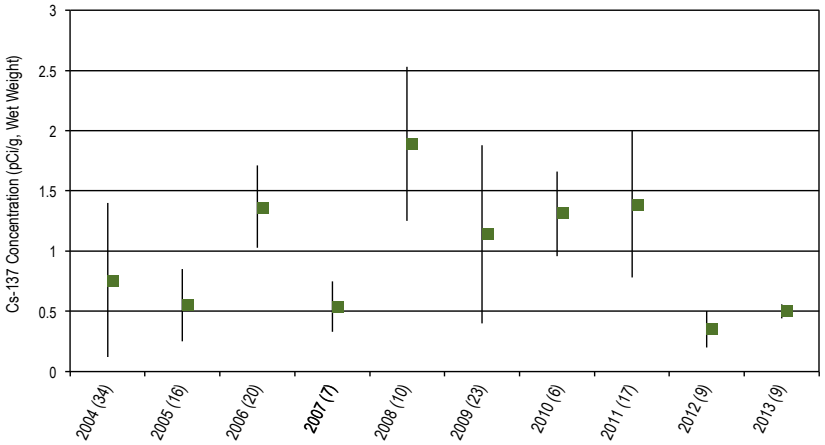
To account for the different feeding habits and weights of various species, it is important to compare species with similar feeding habits (i.e., bottom feeders such as brown bullhead should be compared to other bottom feeders). This comparison within different feeding guilds extends to other potential contaminants and is not limited to comparisons for radionuclides. Cs-137 concentrations in brown bullhead collected at all locations along the Peconic River had values less than 0.23 pCi/g, wet weight. Largemouth bass, the top predator from the Peconic River, showed Cs-137 levels of 0.34 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



Notes: Averages are shown for samples collected at BNL, on site and off site within 1 mile, off site within 1 mile of BNL, and off site greater than 1 mile from BNL.
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 Meat, 2013.



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.

by natural radioactive decay. Cs-137 has a half-life of 30 years. Discharge monitoring has demonstrated that no Cs-137 was released from the BNL Sewage Treatment Plant (STP) to the Peconic River during 2003 through 2013. Additionally, the cleanup of both on- and off-site portions of the Peconic River in 2004 and 2005 is estimated to have removed approximately 88 percent of the identified Cs-137 in the sediment that was co-located with mercury. Removal of this contamination is expected to result in continued decreases in Cs-137 levels in fish.

6.3.3.2 Fish Population Assessment

The relative sizes of fish caught during annual sampling events are tracked and modifications to future sampling events are made, as necessary, to ensure long-term health of the on-site fish populations. Successful sampling of sufficiently large fish for analysis from 2008 through 2013, even with low water levels in the on-site portion of the Peconic River, indicated that populations are maintaining themselves and can continue to support annual sampling efforts.

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

Location/Species	K-40 (pCi/g Wet Weight)	Cs-137 (pCi/g Wet Weight)
On Site		
Area A		
Largemouth Bass*	3.16±0.68	0.23±0.05
Largemouth Bass*	3.94±0.90	0.18±0.08
Largemouth Bass (composite)*	3.20±1.08	0.22±0.07
Largemouth Bass (composite)*	3.03±0.79	0.15±0.07
Chain Pickerel (composite)*	3.22±0.67	0.32±0.05
Pumpkinseed (composite)*	3.21±0.86	0.22±0.07
Brown Bullhead (composite)*	3.61±0.83	0.23±0.04
Brown Bullhead (composite)*	2.61±0.71	0.18±0.05
Area D		
Largemouth Bass*	3.65±0.67	0.34±0.06
Largemouth Bass*	3.82±0.61	0.30±0.05
Chain Pickerel*	3.31±0.64	0.35±0.05
Chain Pickerel*	3.53±0.79	0.47±0.08
Black Crappie (composite)*	2.70±0.84	0.20±0.06
Brown Bullhead (composite)	3.37±0.83	0.23±0.08
Brown Bullhead (composite)*	3.12±0.65	0.19±0.05
Brown Bullhead (composite)	1.78±0.89	ND
Largemouth Bass*	2.51±0.28	0.21±0.02
Largemouth Bass*	2.72±0.35	0.23±0.03
Chain Pickerel*	2.77±0.38	0.24±0.03
Brown Bullhead (composite)*	3.88±0.78	0.19±0.07
Off Site		
Schultz Road		
Largemouth Bass*	3.46±0.90	0.15±0.07
Largemouth Bass*	3.46±0.65	0.16±0.05
Largemouth Bass*	3.68±0.72	0.10±0.01
Largemouth Bass*	2.90±0.84	0.22±0.07
Largemouth Bass*	2.97±0.71	0.11±0.36
Largemouth Bass*	3.80±0.75	0.15±0.06
Donahue's Pond		
Largemouth Bass	2.94±1.33	ND
Largemouth Bass*	2.31±0.89	0.10±0.05
Largemouth Bass*	3.90±0.72	0.10±0.04
Largemouth Bass*	4.09±0.87	0.07±0.06
Black Crappie*	3.77±0.77	0.09±0.04
Brown Bullhead*	3.30±1.16	0.13±0.07
Brown Bullhead*	2.31±0.80	0.11±0.06
Brown Bullhead*	3.25±0.96	0.08±0.06
Brown Bullhead*	2.86±1.11	0.06±0.05
Brown Bullhead*	2.75±0.78	0.08±0.08
Lower Lake, Carmans River		
Largemouth Bass	4.04±1.05	ND
Brown Bullhead	4.13±1.06	ND
Brown Bullhead	3.37±0.91	ND
Brown Bullhead	2.96±0.96	ND
Brown Bullhead	3.31±0.81	ND
Largemouth Bass	3.37±0.89	ND
Largemouth Bass	3.24±1.02	ND
Largemouth Bass	2.80±0.87	ND
Largemouth Bass	2.64±1.00	ND
Brown Bullhead	2.77±0.88	ND

Notes:
All samples were analyzed as edible portions (fillets), including composite samples.
K-40 occurs naturally in the environment and is presented as a comparison to Cs-137
Cs-137 = cesium-137
K-40 = potassium 40
ND = not detected, based on analytical lab qualifiers
* = cesium-137 values are estimated based on analytical laboratory qualifiers.

6.3.3.3 Non-Radiological Analysis of Fish

Beginning in 2005, all fish of sufficient size have been analyzed as edible portions (fillets). Due to its known health effects, mercury is the metal of highest concern. Monitoring results for 2013 from post cleanup monitoring of the Peconic River and comparison to Lower Lake on the Carmans River is shown in Table 6-4. All samples are obtained between April and mid-June. During 2013, mercury ranged from 0.09 mg/kg in a composite of brown bullhead to 1.49 mg/kg in a composite sample of chain pickerel in Area A; 0.05 mg/kg in a composite of brown bullhead to 4.08 mg/kg in a chain pickerel in

Area D; 0.07 mg/kg to 0.68 mg/kg in a largemouth bass taken from the Peconic River at Shultz Rd; and 0.06mg/kg in a brown bullhead to 0.48 mg/kg in a largemouth bass at Donahue's Pond. Mercury in control fish taken from Lower Lake on the Carmans River ranged from less than the method detection level (MDL) in both brown bullhead and largemouth bass to 0.42 mg/kg in a largemouth bass.

Monitoring data for mercury analysis in fish is presented as a range of results by species and location in Table 6-5 to facilitate comparisons. The data are presented graphically in Figure 6-4. Data are typically compared to the EPA mercury water criterion of 0.3 mg/kg. Mercury values in on-site fish taken from Areas A and D during 2013 are much higher than those seen in 2011 and 2012. The increase was most likely due to water flow conditions in the river since late summer 2011. Since that time, the river was running low and open water areas were limited, with little or no flow off site. Consequently, fish were isolated to the BNL site and any methylated mercury was not diluted by flow. A total of 27 samples were taken from the three cleanup locations, with an average mercury concentration of 0.86 mg/kg. When sample results from the entire main stream of the Peconic River were combined (inclusion of Donahue's Pond samples), the average was 0.69 mg/kg. As a comparison to the main portion of the river, mercury averages for Shultz Road (six samples) was 0.37 mg/kg and Donahue's Pond (ten samples) was 0.23 mg/kg, and Lower Lake on the Carmans River (ten samples) was 0.12 mg/kg.

When comparing data from location to location along the Peconic River from year to year, a wide range of values are seen between locations and both within and between species. This lack of a clear pattern is likely attributable to fish age, size, time spent in areas of high methylation of mercury, and foods consumed. The data presented in Table 6-4 are from larger fish, which allow for the analysis of all metals of interest, as well as radiological analysis for Cs-137 and K-40. Data are also presented graphically in Figure 6-4 to facilitate year-to-year comparisons of the data.

The cleanup of the Peconic River that was conducted in 2005 and 2011 removed most of the PCBs present within the sediments. Although BNL has discontinued most pesticide and PCB monitoring, tests for PCBs in fish taken on site continue to be conducted to track the presence or absence of these long lived contaminants. Table 6-6 presents PCB data for fish taken from Area A and D. Only two PCB congeners were detected (Aroclor-1254 and Aroclor-1260). Most values were below the MDL. Aroclor-1260 was detected above the MDL in a composite sample of largemouth bass at a concentration of 32.1 µg/kg. The highest concentration of Aroclor-1254 was also detected in this composite sample at 64.1 µg/kg.

6.3.4 Aquatic Sampling

6.3.4.1 Radiological Analysis

Annual sampling of sediment and vegetation in the Peconic River and a control location on the Carmans River was conducted in 2013. (See Chapter 5 for a discussion on water quality and monitoring and Figure 5-4 for the locations of sampling stations.) During 2013, Cs-137 was detected in a single aquatic vegetation sample at an estimated concentration of 0.09 pCi/g, wet weight (Table 6-7).

6.3.5 Peconic River Post-Cleanup Monitoring

Approximately 20 acres of the Peconic River were remediated in 2004 and 2005 to remove sediments contaminated with mercury and associated contaminants. To ensure that the cleanup provided adequate protection of human health and the environment, BNL conducted five years (2006-2010) of post-cleanup monitoring of the sediment, surface water, and fish. This monitoring effort identified approximately 0.39 acres in three small areas (PR-WC-06, PR-SS-15, and sediment trap areas) with mercury concentrations greater than the cleanup goal of 2.0 mg/kg. The three areas were remediated between November 2010 and February 2011 (see Section 6.3.5.1).

During the required CERCLA Five-Year review process in 2011, all data and accomplishments related to the Peconic River cleanup and subsequent monitoring were summarized

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

Location/Species	Mercury (mg/kg)
On Site	
Area A	
Largemouth Bass	1.27
Largemouth Bass	1.07
Largemouth Bass (composite)	1.13
Largemouth Bass (composite)	0.55
Chain Pickerel (composite)	1.49
Chain Pickerel	0.82
Pumpkinseed (composite)	0.80
Brown Bullhead (composite)	0.28
Brown Bullhead (composite)	0.09
Area D	
Largemouth Bass	2.47
Largemouth Bass	0.77
Largemouth Bass	1.12
Largemouth Bass	1.16
Chain Pickerel	1.63
Chain Pickerel	4.08
Chain Pickerel	1.30
Black Crappie (composite)	0.55
Brown Bullhead (composite)	0.11
Brown Bullhead (composite)	0.17
Brown Bullhead (composite)	0.05
Brown Bullhead (composite)	0.16
Off Site	
Shultz Road	
Largemouth Bass	0.68
Largemouth Bass	0.53
Largemouth Bass	0.08
Largemouth Bass	0.56
Largemouth Bass	0.27
Largemouth Bass	0.07
Donahue's Pond	
Largemouth Bass	0.41
Largemouth Bass	0.31
Largemouth Bass	0.48
Largemouth Bass	0.26
Black Crappie	0.14
Brown Bullhead	0.06
Brown Bullhead	0.10

(continued on the right)

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

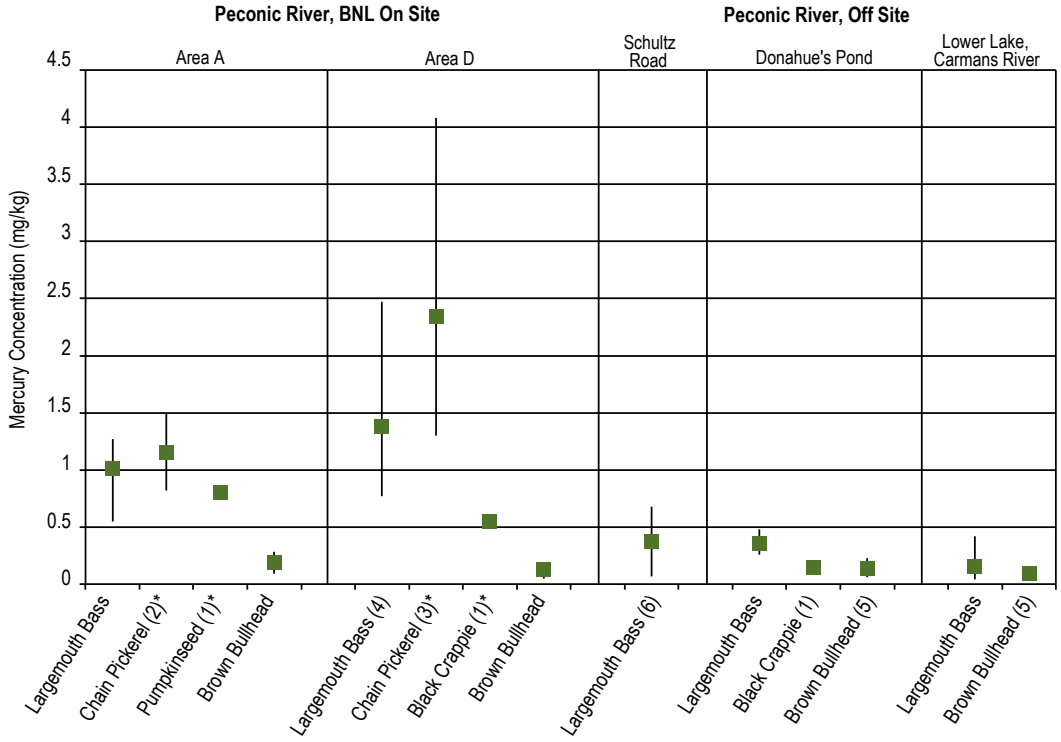
Location/Species	Mercury (mg/kg)
Brown Bullhead	0.23
Brown Bullhead	0.14
Brown Bullhead	0.17
Lower Lake, Carmans River	
Largemouth Bass	<MDL
Brown Bullhead	0.09
Brown Bullhead	<MDL
Brown Bullhead	<MDL
Brown Bullhead	<MDL
Largemouth Bass	0.42
Largemouth Bass	0.08
Largemouth Bass	0.19
Largemouth Bass	0.04
Brown Bullhead	0.12

Notes:
See Figure 5-4 for sampling locations.
All samples were analyzed as edible portions (fillets), including composite samples.
Area letter designation refers to Peconic River cleanup areas on site.
MDL = minimum detection limit

and reviewed. The Five-Year Review recommended that reduced monitoring should take place beginning in 2012, and all future reporting of post-cleanup monitoring results would be documented in the annual Site Environmental Report. The 2013 sediment and surface water results follow.

6.3.5.1 Sediment Sampling

Sediment was sampled in June 2013 at three Peconic River locations associated with the supplemental cleanup areas (Table 6-7). Radiological analysis of sediments at all three locations indicate that low levels of Cs-137 are present, ranging from 0.19 pCi/g to 0.51 pCi/g, which are consistent with previous analyses of the river sediments. Analysis of sediment for mercury identified values ranging from 0.06 mg/kg to 1.50 mg/kg, with all values being below the cleanup goal of 2.0 mg/kg. Sediment from the three locations was also analyzed for presence of PCBs in order to track presence/absence of these long lived contaminants. Aroclor-1254 was the only congener detected at estimated concentrations between 15 and 36 µg/kg.



Notes: Number in parentheses indicate the number of samples included.
* = some samples were composite

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

6.3.5.2 Water Column Sampling

Surface water was analyzed in June and July 2013 for total mercury and methyl mercury at 9 of the 14 Peconic River sampling stations (Table 6-8). Water column sampling locations are shown on Figure 6-6. A sample of the treated STP effluent was also collected during each round of sampling. Six stations could not be sampled in June and nine in July due to either being too shallow or dry. Total Suspended Solids (TSS) are reported in Table 6-8 as a point of comparison for total mercury and methyl-mercury. TSS values can provide an indication of the quality of the sample collection effort. Low TSS indicates a sample was taken without disturbing bottom sediments, whereas samples with high TSS values might explain, in part, unusually high mercury values due to increased particles that may contain mercury. The maximum total mercury concentration in the June (48 ng/L) and July (58 ng/L) STP effluent samples were typical of what has been seen since efforts at mercury minimization have been implemented. The total mercury concentrations generally trended downwards, with minor fluctuations at increasing distance downstream from the STP until reaching concentrations of 22 ng/L (June 2013) and 21 ng/L (July 2013) at sampling stations near Shultz Road, approximately 2.52 miles and 2.1 miles downstream of the STP outfall, respectively.

Methyl mercury is the form of mercury that is bio-available to aquatic organisms. Methyl mercury was detected in STP effluent samples in June at a concentration of 0.06 ng/L and was detected at an estimated 0.04 ng/L in a July sample. Between the station immediately downstream of the STP effluent outfall and the BNL east boundary, the June methyl mercury concentrations fluctuated between 0.6 ng/L and 1.9 ng/L, and the July concentrations fluctuated between 0.46 ng/L and 2.5 ng/L. The methyl mercury values from downstream of the BNL boundary to the second station west of Shultz

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

Location/Species (number of samples)	Mercury mg/kg Min.	Max.	Avg.
On Site			
Area A			
Largemouth Bass (4)*	0.55	1.27	1.00
Chain Pickerel (2)*	0.82	1.49	1.15
Pumpkinseed (1)*	0.80	0.80	0.80
Brown Bullhead (2)*	0.09	0.28	0.19
Area D			
Largemouth Bass (4)	0.77	2.47	1.38
Chain Pickerel (3)	1.30	4.08	2.34
Black Crappie (1)*	0.55	0.55	0.55
Brown Bullhead (4)*	0.05	0.17	0.12
Off Site			
Schultz Road			
Largemouth Bass (6)	0.07	0.68	0.37
Donahue's Pond			
Largemouth Bass (4)	0.26	0.48	0.36
Black Crappie (1)	0.14	0.14	0.14
Brown Bullhead (5)	0.06	0.23	0.14
Lower Lake, Carmans River			
Largemouth Bass (5)	0.04	0.42	0.16
Brown Bullhead (5)	0.07	0.12	0.09
Peconic River, BNL On Site			
Largemouth Bass (8)*	0.55	2.47	1.19
Chain Pickerel (5)*	0.82	4.08	1.86
Pumpkinseed (1)*	0.80	0.80	0.80
Black Crappie (1)*	0.55	0.55	0.55
Brown Bullhead (6)*	0.05	0.28	0.14
Peconic River, Off Site			
Largemouth Bass (10)	0.07	0.56	0.36
Black Crappie (1)	0.14	0.14	0.14
Brown Bullhead (5)	0.06	0.23	0.14

Notes:
See Figure 5-4 for sampling locations.
All samples were analyzed as edible portions (fillets), including composite samples.
Area letter designation refers to Peconic River cleanup areas on site.
* = one or more samples in the average were composite samples.

Table 6-6. PCB Analysis of Fish from BNL Portions of the Peconic River System.

Location/Species	Aroclor-1254 μg/kg	Aroclor-1260 μg/kg
On Site		
Area A		
Largemouth Bass	<MDL	<MDL
Largemouth Bass	60.8	<MDL
Largemouth Bass (composite)	50.2	<MDL
Largemouth Bass (composite)	64.1	32.1
Chain Pickerel (composite)	< MDL	< MDL
Chain Pickerel	No Data	No Data
Pumpkinseed (composite)	No Data	No Data
Brown Bullhead (composite)	<MDL	<MDL
Brown Bullhead (composite)	45.6	31.9
Area D		
Largemouth Bass	<MDL	<MDL
Largemouth Bass	<MDL	<MDL
Chain Pickerel	<MDL	<MDL
Chain Pickerel	<MDL	<MDL
Black Crappie (composite)	No Data	No Data
Brown Bullhead (composite)	<MDL	<MDL
Brown Bullhead (composite)	<MDL	<MDL
Brown Bullhead (composite)	No Data	No Data
Largemouth Bass	<MDL	<MDL
Largemouth Bass*	11.5	<MDL
Chain Pickerel	<MDL	<MDL
Brown Bullhead (composite)	<MDL	<MDL

Notes:
See Figure 5-4 for sampling locations.
All samples were analyzed as edible portions (fillets), including composite samples.
Area letter designation refers to Peconic River cleanup areas on site.
MDL = minimum detection limit
No Data = insufficient sample size to complete analysis
* = estimated value for reported analyte based on lab qualifiers

Road (PR-WC-02) fluctuated between 1.4 ng/L and 2.5 ng/L in June (which is consistent with previous measurements) and a single value of 0.8 ng/L was obtained at station PR-WC-03 in July due to low water levels. Alternating wet/dry periods often facilitate the methylation of mercury, and could explain the elevated levels in isolated pools of the river.

6.3.6 Vegetation Sampling

6.3.6.1 Farm Vegetables

Farm vegetables and a representative soil sample were taken from four local farms as

Table 6-7. Survellience and Post Cleanup Montioring Data for Aquatic Vegetation and Sediment from the Peconic River.

Location	Matrix	K-40 pCi/g (Wet Weight)	Cs-137 pCi/g (Wet Weight)	Aroclor 1254 µg/kg	Mercury mg/kg
Surveillance Samples					
BNL	Vegetation	4.21±0.60	ND	NT	NT
BNL	Vegetation	3.75±0.61	ND	NT	NT
BNL	Vegetation	4.37±0.72	0.09±0.04 *	NT	NT
BNL	Vegetation	3.51±0.54	ND	NT	NT
Post-Cleanup Samples[t]					
PR-SS-15-U1-L65-O	Sediment	NT	0.19±0.05	ND	0.06
ST1-80-U20	Sediment	NT	0.51±0.11	15**	0.50
PR-WC-06-D1-L50	Sediment	NT	0.47±0.10	36**	1.50

Notes:
All radiological analysis values are shown with a 95% confidence interval.
K-40 Occurs naturally in the environment and is presented as a comparison to Cs-137
Cs-137 = cesium-137
K-40 = potassium-40
ND = not detected
NT = not tested
* = values for Cs-137 are estimated based on analytical lab qualifiers
** = values for Aroclor 1254 are estimated based on analytical lab qualifiers
t = Sediment values reported as dry weight

part of the surveillance monitoring program. The data from farm vegetables and soil are shown in Table 6-9. None of the vegetables sampled had detectable levels of Cs-137. Soil samples had concentrations of Cs-137 ranging from 0.07 pCi/g to 0.10 pCi/g, dry weight. Because BNL no longer has operating nuclear reactors, surveillance monitoring of farm vegetables is no longer needed, and will be discontinued after 2013.

6.3.6.2 Grassy Plants and Soil

Grassy vegetation sampling around the Laboratory was conducted in 2013. Vegetation was sampled from 10 random locations around the Laboratory as shown in Figure 6-6. All samples were analyzed for Cs-137 (Table 6-10). The grassy vegetation samples had levels of Cs-137 ranging from non-detectable to 0.08 pCi/g, wet weight, which is consistent with past sampling efforts. Monitoring results for grassy vegetation is utilized for the annual dose to biota analysis reported in Chapter 8.

Soil sampling was conducted at the same 10 locations where the grassy vegetation was collected. Soil samples were analyzed for Cs-137 (Table 6-10). Cs-137 concentrations in soils ranged from non-detect to 0.26 pCi/g, dry weight. These values were consistent with past soil monitoring results.

6.4 OTHER MONITORING

6.4.1 Basin Sediments

A 5-year cycle for the collection of recharge basin sediment samples was established in 2003. There are 11 recharge basins receive water discharges that are permitted under the Laboratory's State Pollutant Discharge Elimination System (SPDES) permit (see Figure 5-2 for outfall locations). Basin sediments were last sampled in 2012 and results were summarized in the 2012 Site Environmental Report (BNL, 2013b). The next round of routine basin sampling will be conducted in 2017.

In 2012, sampling at Basin HT-W identified four semi-volatile organic compounds (SVOC) that were above SCDHS action levels. All four compounds consisted of polycyclic aromatic hydrocarbons (PAHs), which are petroleum breakdown products, and are most likely attributable to road runoff and the combustion of fossil fuels. Work planning to further characterize Basin HT-W was initiated at the end of 2012 and additional samples were collected in March 2013.

Table 6-8. Post Cleanup Peconic River Water Column Monitoring.

Location	Station Description	Dist from STP (miles)	June 2013 Mercury (ng/L)	June 2013 Methyl Mercury (ng/L)	June 2013 TSS (mg/L)	July 2013 Mercury (ng/L)	July 2013 Methyl Mercury (ng/L)	July 2013 TSS (mg/L)
PR-WC-15	Upstream of Forest Path	-0.17	SW	SW	SW	SW	SW	SW
PR-WC-14	Upstream of STP	-0.13	SW	SW	SW	SW	SW	SW
PR-WC-13	Upstream of STP	-0.07	SW	SW	SW	SW	SW	SW
PR-WC-12-D7	Downstream of Sump	-0.04	11	1.7	ND	10	0.5	4
STP-EFF-UVG	Grab Sample	0	48	0.06	ND	58	0.04*	ND
PR-WC-11DS	50" Downstream of Outfall	0.01	32	0.6	ND	SW	SW	SW
PR-WC-10	West of Station HMN	0.3	49	1.6	4	51	0.46	ND
PR-WC-09	Downstream of Station HMN	0.56	SW	SW	SW	SW	SW	SW
PR-WC-08	South of Area B	0.78	30	1.9	ND	17	1.2	2
PR-WC-07	South of Area C	0.96	SW	SW	SW	SW	SW	SW
PR-WC-06	South of Area D	1.1	32	1.9	ND	17	2.5	6
PR-WC-05	Downstream of Station HQ	1.46	28	1.7	ND	SW	SW	SW
PR-WC-04	2nd Downstream of Station HQ	1.7	SW	SW	SW	SW	SW	SW
PR-WC-03	3rd West of Schultz Road	2.1	25	2.5	ND	21	0.8	7
PR-WC-02	2nd West of Schultz Road	2.52	22	1.4	ND	SW	SW	SW

Notes:
See Figure 6-5 for Peconic River sampling locations.
ND = not detected based on lab qualifiers
STP = Sewage Treatment Plant
SW = water too shallow to sample
* = estimated value based on lab qualifiers

The scope of this sampling effort included the collection of five additional surface samples downstream of the outfall for SVOC analysis. In addition, a field blank and blind duplicate sample was collected for quality assurance and quality control purposes. Review of these data showed that, with the exception of one sample location, SVOC results were all below SCDHS action levels. One sample collected furthest downstream of the outfall contained three PAHs that were just above SCDHS action levels. However, a blind duplicate sample collected at the same location did not show any PAHs above action levels. Prior to making any final decisions on whether remediation is necessary at this outfall, and based on the discrepancy in the 2013 analytical results, a decision was made to coordinate further characterization efforts with SCDHS, which will include the collection and analysis of split samples. The results of this coordinated characterization effort and any final decisions made between SCDHS and BNL on whether remediation is necessary will be reported in a future Site Environmental Report.

6.4.2 Chronic Toxicity Tests

Under BNL's SPDES discharge permit, the Laboratory conducted chronic toxicity testing of the STP effluent. The results of the chronic toxicity tests are discussed in Chapter 3, Section 3.6.1.1.

6.4.3 Radiological and Mercury Monitoring of Precipitation

During 2013, precipitation samples were collected quarterly at air monitoring Stations P4 and S5 (see Figure 4-3 for station locations). The samples were analyzed for radiological content and total mercury. A total of four samples were taken from each of these two stations

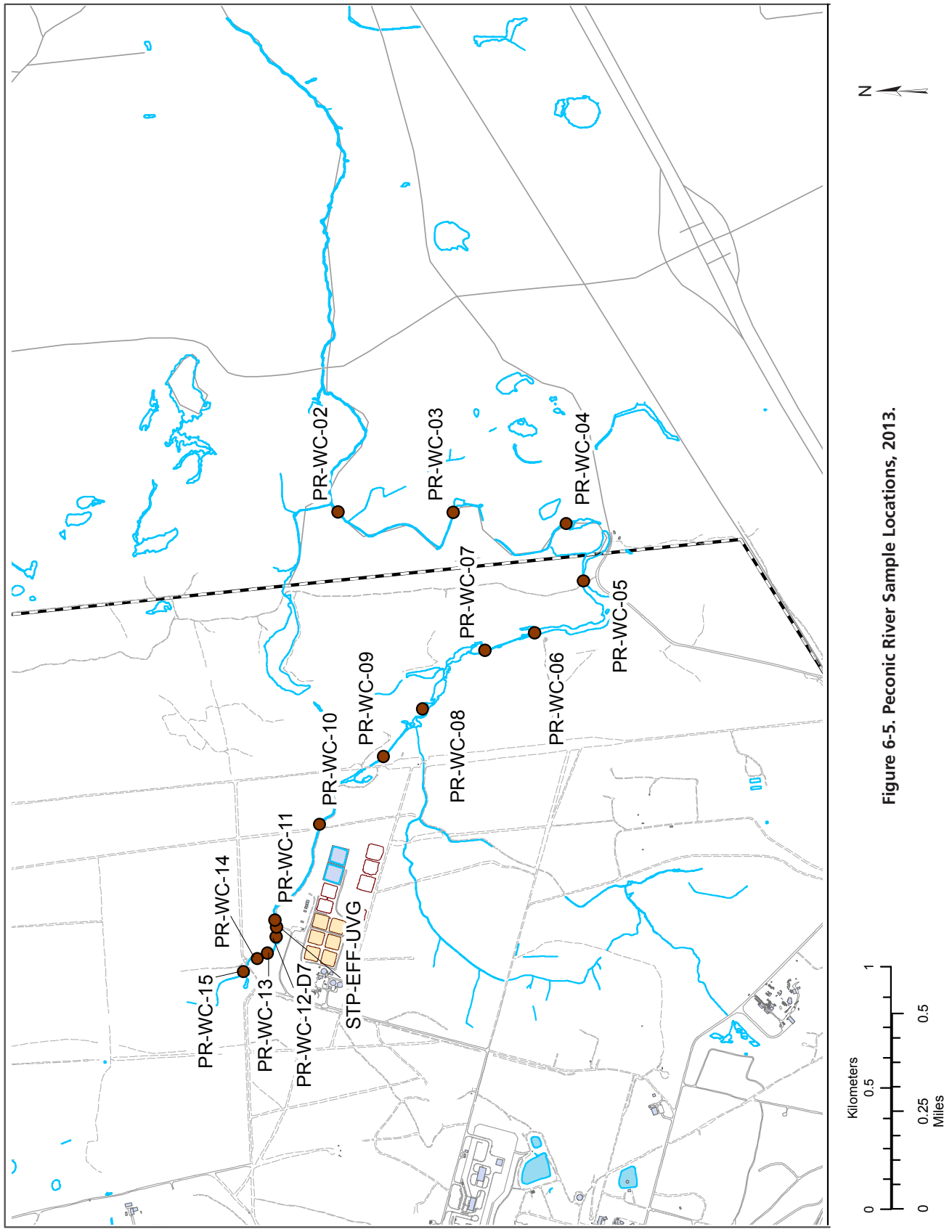


Figure 6-5. Peconic River Sample Locations, 2013.

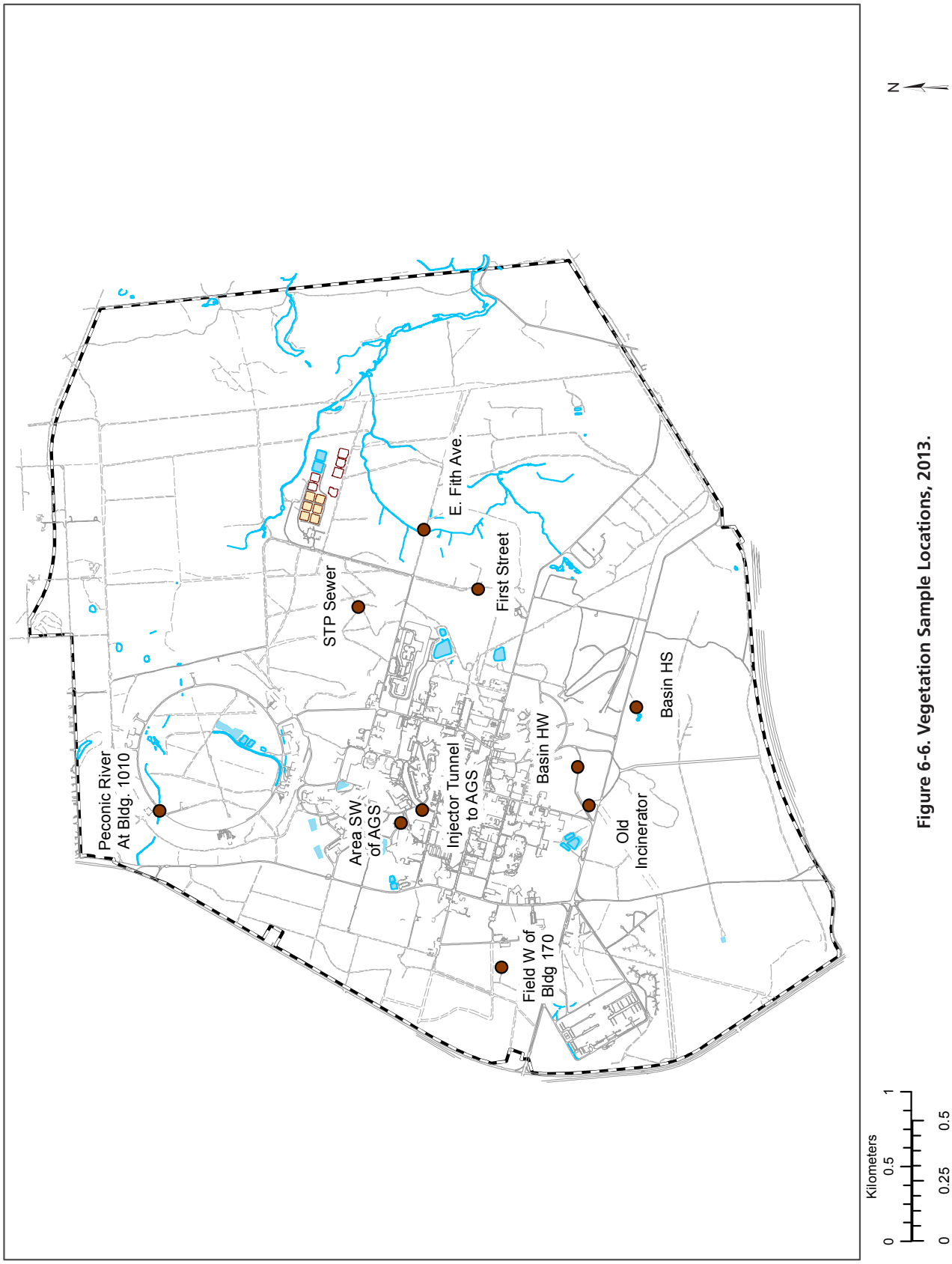


Figure 6-6. Vegetation Sample Locations, 2013.

Table 6-9. Radiological Analysis of Farm Vegetables and Associated Soils.

Location/Vegetable	K-40	Cs-137
	pCi/g (Wet Weight)	
May's Farm		
Cantalope	1.67±0.09	ND
Corn	2.62±0.21	ND
Zucchini	2.01±0.05	ND
Tomato	2.09±0.09	ND
Eggplant	1.89±0.11	ND
Soil (dry weight)	7.71±0.71	0.07±0.03
Lewin's Farm		
Potato	3.03±0.16	ND
Corn	2.32±0.19	ND
Eggplant	1.59±0.09	ND
Squash	4.55±0.18	ND
Zucchini	1.85±0.08	ND
Soil (dry weight)	6.69±0.66	0.09±0.04
Cornell Farm		
Pumpkin	2.67±0.14	ND
Corn	1.62±0.11	ND
Soil (dry weight)	7.83±0.66	0.10±0.04
Bruno Farm		
Corn	2.84±0.17	ND
String Beans	2.32±0.18	ND
Tomato	2.13±0.12	ND
Eggplant	2.02±0.18	ND
Soil (dry weight)	7.59±0.70	0.09±0.04

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

Table 6-10. Radiological Analysis of Grassy Vegetation and Associated Soils.

Location/ Matrix	K-40	Cs-137
	pCi/g (Wet Weight)	
Basin HS		
Vegetation	4.89±0.19	ND
Soil (dry weight)	4.37±0.46	ND
Old Incinerator		
Vegetation	3.07±0.47	ND
Soil (dry weight)	6.39±0.63	0.26±0.04
Basin HW		
Vegetation	2.55±0.48	0.03±0.03 *
Soil (dry weight)	4.60±0.56	0.10±0.03
Field W of Bldg. 170		
Vegetation	2.55±0.44	ND
Soil (dry weight)	6.73±0.79	0.22±0.05
Injector Tunnel to AGS		
Vegetation	2.61±0.52	ND
Soil (dry weight)	5.41±0.60	0.07±0.04 *
Area SW of AGS		
Vegetation	4.18±0.48	ND
Soil (dry weight)	4.86±0.60	0.25±0.05
First St. near Ecology Field		
Vegetation	3.87±0.74	ND
Soil (dry weight)	5.20±0.52	0.16±0.04
E. Fifth Ave., East of First St.		
Vegetation	4.68±0.59	0.06±0.04 *
Soil (dry weight)	4.61±0.63	0.12±0.05
STP Sewer, Main Firebreak		
Vegetation	2.75±0.40	0.08±0.02
Soil (dry weight)	6.42±0.68	0.10±0.03
Peconic River at Bldg. 1010		
Vegetation	3.04±0.45	ND
Soil (dry weight)	5.10±0.52	ND

Notes:
All values are shown with a 95% confidence interval.
K-40 occurs naturally in the environment and is presented as a comparison to Cs-137.
AGS = Alternate Gradient Synchrotron
Cs-137 = cesium-137
K-40 = potassium-40
ND = not detected
* = value for Cs-137 is estimated

in 2013 and tested for radiological parameters. Gross alpha activity measurements were above the MDL at P4 in the second and fourth quarters and in the first two quarters at S5 (Table 6-11).

Gross beta activity was measured in samples collected during all four quarters, at both P4 and S5. Location P4 had a maximum gross beta activity level of 4.44 pCi/L in the first quarter of 2013. Location S5 had a maximum gross beta activity level of 4.35 pCi/L in the second quarter. Gross beta activity values were within the range of historically observed values at these two locations. Beryllium-7 (Be-7) derived from sun spot activity was not detected at either P4 or S5 in 2013. In general, radioactivity in precipitation comes from naturally occurring radionuclides in dust and from activation products that result from solar radiation.

Precipitation was also analyzed for Sr-90. Analyses indicated non-detectable levels at both

Table 6-11. Precipitation Monitoring (Radiological and Mercury).

Location/Period	Gross Alpha	Gross Beta	Sr-90	Mercury
	pCi/L			ng/L
P4				
01/16/13	—	—	—	6.01
01/31/13	ND	4.44±0.98	ND	—
04/05/13	—	—	—	6.69
04/30/13	0.69±0.47	1.64±0.75	ND	—
07/15/13	—	—	—	9.35
07/31/13	ND	1.55±0.63	ND	—
10/08/13	—	—	—	24.6
11/27/13	2.12±1.12	2.54±0.84	ND	—
S5				
01/16/13	—	—	—	5.24
01/31/13	1.18±0.64	3.48±0.89	ND	—
04/05/13	—	—	—	8.98
04/30/13	1.30±0.59	4.35±0.94	ND	—
07/15/13	—	—	—	7.21
07/31/13	ND	1.17±0.62	0.21±0.11	—
10/08/13	—	—	—	10.4
11/27/13	ND	1.75±0.70	ND	—

Notes:
See Figure 4-2 for P4 and P5 locations.
Method detection limit for mercury is 0.2 ng/L.
— = parameter not tested on date
ND = not dected
P4 = precipitation sampler near BNL Apartment area
S5 = precipitation sampler near BNL Sewage Treatment Plant
Sr-90 - strontium-90

locations in all but a single positive detection of 0.21 pCi/L at station S5 in the third quarter of 2013. However, the associated analytical error (or measurement uncertainty) was more than 50 percent of the value, making the result questionable.

Analysis of mercury in precipitation is conducted to document mercury deposition that is attributable to off-site sources. This information is compared to Peconic River monitoring data and aids in understanding the sources of mercury within the Peconic River watershed. Mercury was detected in all of the precipitation samples collected at both sampling stations. Mercury ranged from 5.24 ng/L at station S5 in January to 24.6 ng/L at station P4 in October. The 24.6 ng/L concentration is the highest value measured in precipitation since mercury monitoring began in 2007.

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 an interest in science. Wildlife programs are conducted at the Laboratory 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 2013, BNL hosted 15 student interns and two faculty members. Three of the interns worked with a faculty member from Dowling College as part of the BNL Visiting Faculty Program (VFP). An additional 3 interns worked on various research projects associated with the LISF.

The VFP teams continued ongoing work on soil microbial studies of Pine Barrens soils, statistical analysis of migratory bird data, and data associated with Cs-137 in deer. Analysis of bird data resulted in a published paper (Rispoli, et al., 2014), and a second paper is being prepared for the Cs-137 in deer studies.

Work associated with the LISF involved tracking 26 eastern box turtles outfitted with transmitters to determine home range sizes. Many of the turtles were captured in or near the LISF in order to determine if they utilize habitats found in the facility. Since 2011, student interns have followed a total of 38 different turtles, and as a result BNL is building a very good understanding of their habits.

Interns also conducted surveys in and around the LISF to study the relationship and impacts of this facility on the local ecosystems. Vegetation data were gathered on paired transects during the spring and fall, and paired small mammal trapping grids and moveable cameras were used to look at how animals used the fence openings. Paired transects for vegetation allow comparison of vegetation growth and establishment inside and outside of the LISF. In addition, interior transects were established based on the vegetative assemblage that existed prior to construction. Paired trapping grids were established to compare small mammal population in the core of the facility to core habitats outside of the facility, and to compare recruitment of small mammals from the forest to the immediate interior of the solar farm (one grid on either side of the LISF fence). Wildlife cameras were placed for 2-week periods on individual openings along the fence line to document wildlife use of the fence openings. The camera surveillance data verified that all species that were expected to use the openings are doing so (e.g., raccoons, skunks, foxes, etc.).

To facilitate the analysis of the wildlife surveillance data, and to develop plans for the placement of transects, trapping grids, and placement of cameras, all surveillance data are entered into databases, and a GIS is used to visualize the data.

In March 2011, a northern long-eared bat was found on the ground outside a building on site. The bat appeared to have discoloration on the fur around its muzzle and was reported to NYSDEC as a possible incidence of white-nose syndrome. White-nose syndrome is a recently identified fungal infection impacting bats throughout the Northeast and Midwest. The bat was the first recorded incidence of white-nose syndrome on Long Island. As a result, BNL and the NYSDEC established permanent acoustical survey routes on Long Island for monitoring. In 2013, a bat specialist captured bats on site using mist-netting. These results were compared to 2012 efforts, and confirmed that white-nosed syndrome has had a major impact on certain bat species, particularly the northern long-eared bat which showed a dramatic reduction in population at BNL based upon 15 captures in 2012 to only one capture in 2013.

In 2013, BNL participated in several events in support of ecological education programs including: providing on site ecology tours; hosting the Eighteenth Annual Pine Barrens Research Forum for ecosystems researchers to share and discuss their results; participated in the Fourth Annual Pine Barrens Discovery Day held in association with the Tri-Hamlet Celebration at the Wertheim National Wildlife Refuge; assisting the Central Pine Barrens Commission on 'A Day in the Life of the Carmans River' which allowed students from multiple school districts to acquire environmental and biological data about the river, an successful effort that will be expanded to the Peconic and Nissequogue Rivers in 2014; and BNL and the Long Island Nature Organization hosted the second annual Long Island Natural History conference.

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 firefighters in the methods of wildland fire suppression, prescribed fire, and fire analysis. BNL has developed and is implementing a Wildland Fire Management Plan. The Laboratory continues the use of prescribed fire for fuel and forest management and is working with NYSDEC to conduct growing season fires in northern and eastern sections of the BNL property.

6.6 CULTURAL RESOURCE ACTIVITIES

The BNL Cultural Resource Management (CRM) Program ensures that the Laboratory fully complies with numerous cultural resource regulations. The Cultural Resource Management Plan for Brookhaven National Laboratory (BNL 2013a) guides the management of all of the Laboratory'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 on site. BNL's cultural resources include 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 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 trenches are examples of the few surviving WWI earthworks in the United States.

In 2013, BNL submitted a revised Cultural Resource Management Plan to the New York State Historic Preservation Office for review and received no comments. Small displays on Camp Upton are maintained in Berkner Hall for the interest of the visiting public. In 2013, the Long Island Museum again requested loan of historic materials from BNL for a planned display on 'Long Island at War' for the summer of 2014.

REFERENCES AND BIBLIOGRAPHY

BNL. 2000. *1999 Site Environmental Report*. BNL-52553. Brookhaven National Laboratory, Upton, NY. October 2010.

BNL. 2011. *Natural Resource Management Plan for Brookhaven National Laboratory*. BNL-96320-2011. Brookhaven National Laboratory, Upton, NY.

BNL. 2013a. *Cultural Resource Management Plan for Brookhaven National Laboratory*. BNL-100708-2013. Brookhaven National Laboratory, Upton, NY. May 2013.

BNL. 2013b. *2012 Site Environmental Report*. BNL-101643-2013. Brookhaven National Laboratory, Upton, NY. October 2013

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

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.

Rispoli, F. J., Zeng, S., Green, T., Higbie, J. "Even birds follow pareto's 80-20 rule." *Significance Statistics Making Sense* Feb. 2014.

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.

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