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 personnel and the public on ecological issues. BNL focuses on protecting both Federal and 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 the program. In 2015, deer, fish, and vegetation sampling results were consistent with previous years.

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 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) describes the program strategy, elements, and planned activities for managing the various natural resources found on site. The NRMP is updated every 5 years (BNL 2011), with the next update to be completed in 2016.

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 700 acres off site. Within 2 days of the fire, natural resource personnel began recording the extent of the fire using GPS and established photo points to begin tracking both fire damage and post-fire recovery. Maps of the fire and photo locations were entered into the GIS for future reference and the burned areas are revisited periodically to track recovery. In addition, a deer exclosure area was established to track impacts of the 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 the GIS as a tool to assist analysis of changes to wildlife populations and vegetation. In 2015,

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

(continued on next page)

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 (see Table 6-1). The only New York State endangered species confirmed as currently inhabiting Laboratory property is the eastern tiger salamander *(Ambystoma t. tigrinum)*. Six other New York State endangered species have been identified at BNL in the past or are possibly present including: the Persius duskywing butterfly *(Erynnis p. persius)*, crested fringed orchid *(Plantathera cristata)*, Engelman spikerush *(Eleocharis engelmannii)*, fireweed *(Erectites heiracifolia var. megalocarpa)*, dwarf huckleberry *(Gaylussacia bigeloviana)*, and whorled loosestrife *(Lysimachia quadrifoli)*.

Seven 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 (banded sunfish *[Enneacanthus obesus]* and swamp darter *[Etheostoma fusiforme])* and three plants (stiff-leaved goldenrod *[Oligoneuron rigida]*, stargrass *[Aletris farinose]*, and eastern showy aster *[Eurybia spectabilis])*. The northern harrier *(Circus cyaneus)* is periodically seen in the fall. Insects listed as threatened include

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
Butterfly weed	*Asclepias tuberosa ssp. interior*	V	Confirmed
Cinnamon fern	*Osmunda cinnamomea*	V	Confirmed
Clayton's fern	*Osmunda claytoniana*	V	Confirmed
Crested fringed orchid	*Plantathera cristata*	E	Likely
Dwarf huckleberry	*Gaylussacia bigeloviana*	E	Confirmed
Eastern showy aster	*Eurybia spectabilis*	T	Confirmed
Engelman spikerush	*Eleocharis engelmannii*	E	Confirmed
Fireweed	*Erectites heiracifolia var. megalocarpa*	E	Possible
Flowering dogwood	*Cornus florida*	V	Confirmed
Green fringed orchid	*Platanthera lacera*	V	Confirmed
Ground pine	*Dendrolycopodium obscurum*	V	Confirmed
Long-beaked bald-rush	*Rhynchospora scirpoides*	R	Confirmed
Marginal wood fern	*Dryopteris marginalis*	V	Confirmed
Marsh fern	*Thelypteris palustris var. pubescens*	V	Confirmed
Narrow-leafed bush clover	*Lespedeza augustifolia*	R	Confirmed
New York fern	*Thelypteris novaboracensis*	V	Confirmed
Pink lady's slipper	*Cypripedium acaule*	V	Confirmed
Possum haw	*Viburnum nudum var. nudum*	E	Possible
Prostate knotweed	*Polygonum aviculare ssp. buxiforme*	E	Possible
Round-leaved sundew	*Drosera rotundifolia var. rotundifolia*	V	Confirmed
Royal fern	*Osmunda regalis*	V	Confirmed
Sheep laurel	*Kalmia angustifolia*	V	Confirmed
Small-flowered false foxglove	*Agalinis paupercula*	R	Confirmed
Spotted wintergreen	*Chimaphila maculata*	V	Confirmed
Stargrass	*Aletris farinosa*	T	Confirmed
Stiff-leaved goldenrod	*Oligoneuron rigida*	T	Confirmed
Swamp azalea	*Rhododendron viscosum*	V	Confirmed
Virginia chain-fern	*Woodwardia virginica*	V	Confirmed
Whorled loosestrife	*Lysimachia quadrifolia*	E	Confirmed
Wild lupine	*Lupinus perennis*	R	Confirmed
Winterberry	*Ilex verticillata*	V	Confirmed

Notes:
Table information based on 6 NYCRR Part 182, NYCRR Part 193, and BNL survey data.
* Species added in 2015
E = endangered
F = federally threatened
R = rate
SC = species of special concern
SGCN = species of greatest conservation need
T = threatened
V = exploitably vulnerable

a damselfly, the Pine Barrens bluet *(Enallagma recurvatum)*, 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, as shown 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 (ESA). The comment period was extended two times with a final determination listing the northern long-eared bat as a threatened species was published on April 2, 2015 with an effective date of May 4, 2015. A draft rule under section 4(d) of the ESA was published concurrent to the determination of threatened status and provided guidance on management requirements. The draft 4(d) rule was open for comment with expected finalization in early 2016. 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, and has been added to the Laboratory's list of protected species.

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 buffer areas around tiger salamander habitats 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 postponed 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 that 26 on-site ponds are used by eastern tiger salamanders. In 2015, egg mass surveys confirmed the presence of salamanders in 3 of the 26 ponds. 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. Long Island experienced drought conditions in 2015, with virtually all on-site ponds drying up.

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. During the last population survey in 2011, approximately 6,400 banded sunfish were counted. In 2015, the only known pond with banded sunfish was nearly dry due to drought conditions. A very small depression remained wet throughout the year and may have harbored fish. Surveys to determine the continued presence of the banded sunfish will be conducted in 2016 provided water level conditions in the ponds improve.

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.

In 2015, 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 twice monthly from the end of April through mid-September. These surveys identified 84 songbird species, compared to the 70 species identified in 2014 and 74 species in 2013. A total of 131 bird species have been identified in surveys in the past 15 years; 59 of these species were present in each of the past 15 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 three 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.

There are few known data on the effects of a large, utility-scale solar array 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. The solar farm vegetation and the way it is managed may play a key role as habitat for migratory birds. One species, the indigo bunting *(Passerina cyanea)*, was absent along the Biology Field transect in 2011, but was heard along the Solar Farm transect in 2012, returned to the Biology Field transect in 2013, and was present on both transects in 2014 and 2015. 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 60 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 new boxes were installed around the northern most portions of the LISF in 2012 and are routinely used by bluebirds, house wrens, and tree swallows.

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. Approximately 10 years ago, it was determined that the resident Canada goose population at BNL reached large enough numbers that could result in health and safety issues. Beginning in 2007, under a permit from FWS, the Laboratory began managing the resident goose population by limiting the number of eggs that could hatch. Although 20 nests were treated during 2015, approximately 20 goslings were produced. By the end of 2015, the goose population was estimated at just over 100 birds.

6.1.2.4 Northern Long-eared Bat

As discussed in Section 6.1.1, the northen long-eared bat was added to the list of federally threatened species in 2015. BNL began planning for the eventual listing early on and put in place actions to minimize the likelihood of impacting this species. The two most likely activities that could impact this bat are building demolition and prescribed fires. Inspections for the presence of bats are conducted in multiple ways prior to a building demolition.

During spring, summer, and fall, ultrasonic acoustic monitoring is done around buildings to determine if there is bat activity. Regardless of the outcome of acoustic monitoring, a final internal inspection of the buildings is conducted approximately 24 hours prior to demolition to verify the absence of bats. For growing season prescribed fire, acoustic monitoring is done within the burn unit to determine if there is bat activity. If positive results are acquired, surveys of the entire unit are completed to identify potential roost trees and appropriate protections are put into place to ensure that bats are not impacted by fire. In 2015, four buildings were demolished without impact to bats and no prescribed fires were conducted due to drought conditions.

Mist netting for bats is also conducted, when possible, during summer months to identify and document which bats are present on site. Mist netting in 2015 resulted in captures of eastern red bat *(Lasiurus borealis)* and big brown bats *(Eptesicus fuscus)*, but no northern long-eared bats as had occurred in prior years.

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 2015, the on-site population was approximately 250 birds. In 2009, the wild turkey population across Suffolk County, Long Island, was determined to be of sufficient size to support hunting. Each year, NYSDEC manages a 5-day hunting period for several areas across Long Island, which typically results in over 100 birds taken.

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 routine population surveys of the white-tailed deer since 2000. The fall 2014 survey estimated the population at approximately 830 animals.

Deer overpopulation can affect animal and human health (e.g., animal starvation, Lyme disease from deer ticks, and 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, employee training, and deer management.

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 program. The program eventually resulted in 192 deer taken in just one of the East End towns.

In 2008, BNL began developing a deer management plan which included 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 New York 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 NYSDEC, the Laboratory is required to implement a deer management program. Planning for implementing the deer cull continued through 2014 with a contract to reduce the deer population by 300 animals being in place at year's end and implemented in February 2015. As mentioned above, 300 animals were taken, effectively reducing the population to approximately 530 animals. Furthermore, as many as 100 additional animals did not survive the harsh winter conditions, which resulted in snow cover lasting more than 30 consecutive days. Estimates from fall 2015 surveys indicated that the population had been reduced to approximately 500 animals. Additional population reductions were planned for late 2015, but were precluded due to budgetary constraints.

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 reviews 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. Preparation of an EA for the continued operation of the Alternating Gradient Synchrotron Complex was started at the end of 2015, with completion expected in 2016.

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 2015 included continued microbial work on soils and sediments of the pine barrens and genetic barcoding of Carmans River macroinvertebrates.

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, routine Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)-required monitoring results associated with post-cleanup monitoring of the Peconic River is also conducted. 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 approximately 100 pounds. However, white-tailed deer on Long Island tend to be much smaller, weighing an average of 80 pounds. The meat available for consumption from local deer ranges from 20 to 40 pounds per animal. 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 meat (flesh) to support the necessary calculations. Samples of meat 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.

Since 1996, BNL has routinely collected deer samples from on- and off-site areas. While most off-site samples are the result of car/deer accidents near the Laboratory, samples from deer taken by hunters beyond BNL boundaries or samples from car/deer accidents greater than 1 mile from BNL have also been made available for analysis. In 1998, a statistical analysis suggested that 40 deer from off site and 25 deer from on site are needed to achieve a statistically sound data set. The number obtained each year has not met this preferred level because sample availability depends on accidents

between vehicles and deer and people reporting dead deer.

In 2015, with removal of 300 animals from the deer herd, the Laboratory took the opportunity to obtain 49 representative samples from across the site. Figure 6-1 shows the location of all deer samples taken within a 5-mile radius of the Laboratory since 2011, including the 49 taken during deer management actions. Most of the off-site samples are concentrated along the William Floyd Parkway on the west boundary of BNL, whereas most on-site samples are collected near the Laboratory's main entrance gate and the developed portions of the site. This distribution is 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.

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 2015, 52 deer were obtained on site, of which three were from car/deer accidents and the remainder from targeted sampling of deer removed during deer management activities, three from off-site locations within 1 mile of the Laboratory, and one from greater than 1 mile from the BNL boundary. The results of deer sampling are shown in Table 6-2. The 300 deer that were removed from the local herd through deer management actions were butchered and the meat donated to a 'hunters for the hungry' program. Prior to donation, batch samples composed of meat samples from five deer/batch were analyzed to ensure Cs-137 content was 1.0 pCi/g, wet weight, or less. (1.0 pCi/g, wet weight, is the 10-year average of deer samples taken from the BNL site and is approximately 15 percent of the New York State Department of Health [NYSDOH] value of 6.9 pCi/g, wet weight, health criterion established in 1999.) Data from batch sampling are presented in Table 6-3.

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. This is most likely because the deer graze on vegetation growing in soil where elevated Cs-137 levels are known to exist. Cesium-137 in soil can be transferred to above-ground plant matter via root uptake, where it then becomes available to browsing/grazing animals or is consumed directly with soil while the animal is grazing. Remediation 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.

In 2015, Cs-137 concentrations in deer meat samples were obtained from 52 deer on site with a range of values from 0.02 pCi/g, wet weight, to 1.92 pCi/g, wet weight, and an arithmetic average of 0.29 pCi/g, wet weight, as shown in Table 6-2. 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 highest on-site sample in 2015 (1.92 pCi/g, wet weight) was about 33 percent higher than the highest on-site sample reported in 2014 (1.46 pCi/g, wet weight) and 6 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 (one sample), as shown in Table 6-2. Concentrations in meat samples taken within 1 mile ranged from 0.01 pCi/g, wet weight, to 0.22 pCi/g, wet weight, with an arithmetic average of 0.10 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 2015, this was 0.28 pCi/g, wet weight. The single deer sampled from greater than 1 mile from BNL had non-detectable levels of Cs-137 present in the meat. Figure 6-2 compares the average values of Cs-137 concentrations in meat samples collected in 2015 from four different location groupings. The first year in which the average Cs-137 content from deer taken within 1 mile of the

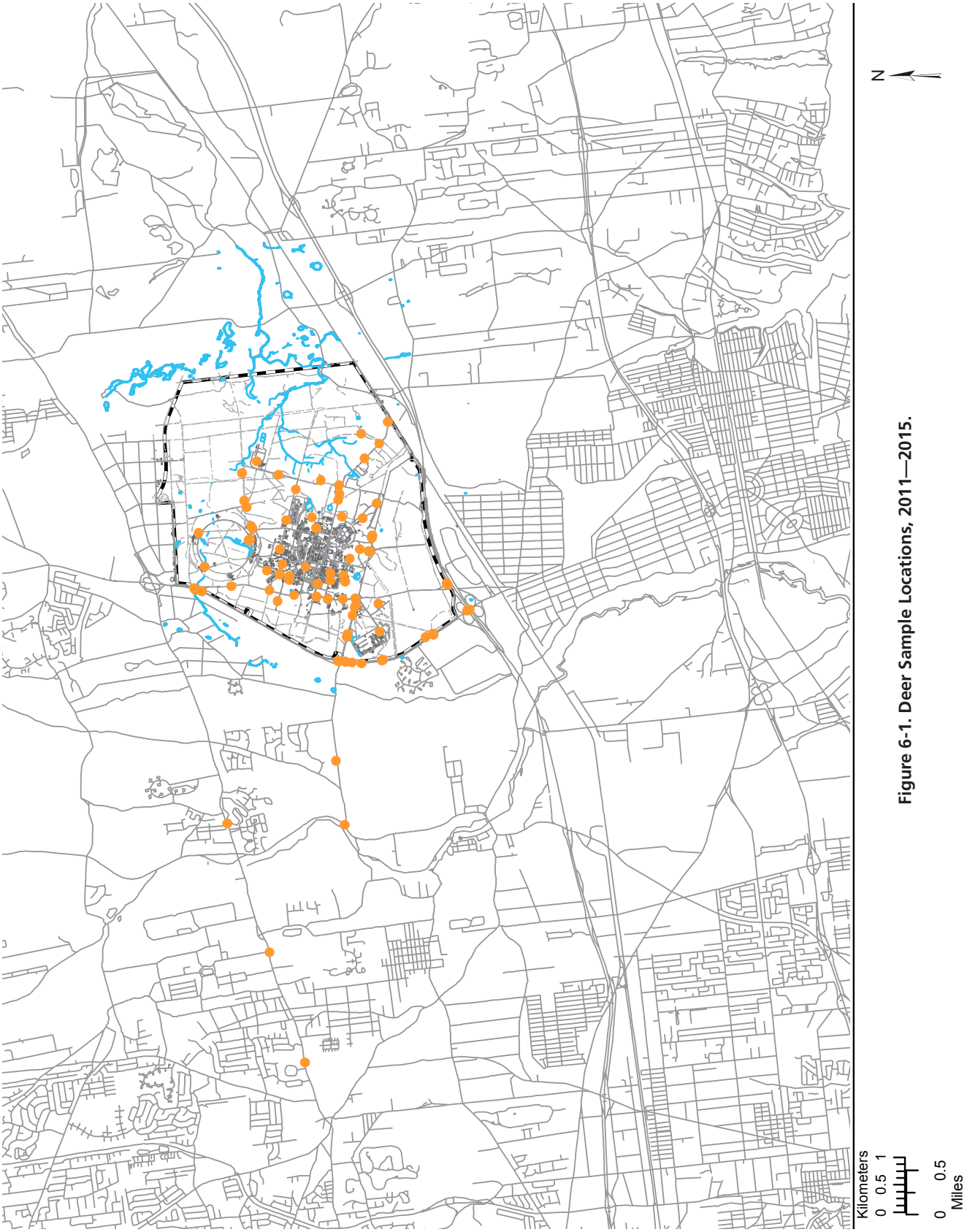

Figure 6-1. Deer Sample Locations, 2011—2015.

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Table 6-2. Radiological Analyses of Deer Tissue. (2015)

Sample Location	Collection Date	Tissue	K-40 pCi/g (Wet Weight)	Cs-137 pCi/g (Wet Weight)
BNL, On Site				
Deer Cull # 112 location 1	02/08/15	Flesh	2.75±0.32	0.61±0.04
		Liver	2.84±0.45	0.11±0.03
Deer Cull # 161 location 2	02/08/15	Flesh	3.62±0.41	0.02±0.02
		Liver	3.25±0.48	ND
Deer Cull # 162 location 2	02/08/15	Flesh	3.00±0.36	0.37±0.03
		Liver	1.88±0.32	0.07±0.02
Deer Cull # 41 location 3	02/07/15	Flesh	3.60±0.36	0.17±0.02
		Liver	1.37±0.35	0.04±0.01
Deer Cull # 48 location 4	02/07/15	Flesh	2.97±0.33	0.24±0.02
		Liver	3.27±0.44	0.06±0.02
Deer Cull # 50 location 4	02/07/15	Flesh	3.15±0.36	0.42±0.03
		Liver	2.73±0.33	0.09±0.02
Deer Cull # 53 location 5	02/07/15	Flesh	2.67±0.38	0.08±0.02
		Liver	3.24±0.35	0.02±0.01
Deer Cull # 57 location 6	02/07/15	Flesh	2.97±0.40	0.07±0.02
		Liver	2.01±0.36	ND
Deer Cull # 58 location 6	02/07/15	Flesh	3.20±0.33	0.05±0.01
		Liver	3.41±0.51	ND
Deer Cull # 83 location 7	02/07/15	Flesh	2.54±0.36	0.16±0.03
		Liver	3.01±0.27	0.04±0.01
Deer Cull # 10 location 8	02/07/15	Flesh	3.10±0.41	0.44±0.04
		Liver	1.84±0.35	0.06±0.02
Deer Cull # 152 location 8	02/08/15	Flesh	3.15±0.36	0.12±0.02
		Liver	2.52±0.31	ND
Deer Cull # 151 location 8	02/08/15	Flesh	2.60±0.31	0.17±0.02
		Liver	1.52±0.24	0.02±0.01
Deer Cull # 9 location 9	02/07/15	Flesh	3.12±0.36	0.06±0.02
		Liver	3.12±0.38	ND
Deer Cull # 5 location 10	02/07/15	Flesh	2.77±0.31	0.21±0.02
		Liver	3.01±0.39	0.05±0.01
Deer Cull # 6 location 10	02/07/15	Flesh	3.11±0.36	0.74±0.04
		Liver	3.09±0.28	0.21±0.02
Deer Cull # 2 location 11	02/07/15	Flesh	2.60±0.35	0.21±0.03
		Liver	2.30±0.31	0.04±0.01
Deer Cull # 3 location 11	02/07/15	Flesh	3.70±0.34	0.16±0.02
		Liver	2.24±0.32	ND
Deer Cull # 1 location 12	02/07/15	Flesh	3.26±0.48	0.10±0.03
		Liver	2.79±0.34	0.02±0.01
Deer Cull # 142 location 15	02/08/15	Flesh	2.65±0.31	0.61±0.04
		Liver	1.82±0.26	0.07±0.02
Deer Cull # 32 location 16	02/07/15	Flesh	2.70±0.33	0.77±0.04
		Liver	2.69±0.32	0.14±0.02
Deer Cull # 29 location 17	02/07/15	Flesh	2.65±0.33	0.24±0.03
		Liver	1.98±0.29	0.08±0.02
Deer Cull # 28 location 17	02/07/15	Flesh	2.80±0.38	1.51±0.06
		Liver	2.27±0.34	0.28±0.03
Deer Cull # 24 location 18	02/07/15	Flesh	3.01±0.47	0.63±0.05
		Liver	1.98±0.34	0.10±0.02
Deer Cull # 25 location 18	02/07/15	Flesh	3.38±0.37	0.65±0.04
		Liver	1.50±0.29	0.08±0.02
Deer Cull # 23 location 20	02/07/15	Flesh	2.87±0.36	0.32±0.03
		Liver	1.57±0.33	0.06±0.02

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Table 6-2. Radiological Analyses of Deer Tissue. (2015)

Sample Location	Collection Date	Tissue	K-40 pCi/g (Wet Weight)	Cs-137 pCi/g (Wet Weight)
Deer Cull # 20 location 21	02/07/15	Flesh	3.18±0.48	0.19±0.04
		Liver	2.01±0.35	0.02±0.01
Deer Cull # 21 lcation 21	02/07/15	Flesh	3.14±0.40	0.10±0.02
		Liver	2.12±0.38	0.04±0.02
Deer Cull # 134 location 23	02/08/15	Flesh	3.11±0.38	0.58±0.04
		Liver	2.45±0.33	0.11±0.02
Deer Cull # 104 location 26	02/07/15	Flesh	2.70±0.40	0.07±0.02
		Liver	2.70±0.26	0.02±0.01
Deer Cull # 102 location 27	02/07/15	Flesh	1.98±0.29	0.02±0.01
		Liver	2.83±0.36	0.06±0.02
Deer Cull # 101 location 27	02/07/15	Flesh	3.00±0.41	0.13±0.02
		Liver	2.77±0.27	0.03±0.01
Deer Cull # 126 location 29	02/08/15	Flesh	2.65±0.33	0.02±0.01
		Liver	2.29±0.28	0.02±0.01
Deer Cull # 92 location 30	02/07/15	Flesh	3.38±0.33	0.10±0.02
		Liver	2.32±0.33	0.04±0.02
Deer Cull # 93 location 30	02/07/15	Flesh	2.90±0.36	0.33±0.03
		Liver	2.41±0.37	0.06±0.03
Deer Cull # 17 location 32	02/07/15	Flesh	3.17±0.36	0.53±0.04
		Liver	2.28±0.31	0.08±0.02
Deer Cull # 107 location 33	02/08/15	Flesh	3.17±0.35	0.03±0.02
		Liver	2.20±0.29	ND
Deer Cull # 154 location 33	02/08/15	Flesh	2.49±0.47	0.16±0.03
		Liver	2.09±0.32	0.03±0.01
Deer Cull # 155 location 33	02/08/15	Flesh	2.71±0.41	0.11±0.02
		Liver	2.14±0.36	ND
Deer Cull # 158 location 33	02/08/15	Flesh	3.53±0.26	0.03±0.01
		Liver	2.8±0.37	ND
Deer Cull # 159 location 33	02/08/15	Flesh	3.08±0.36	0.04±0.02
		Liver	2.23±0.28	ND
Deer Cull # 160 location 33	02/08/15	Flesh	2.96±0.43	0.10±0.02
		Liver	2.54±0.30	0.02±0.01
Deer Cull # 18 location 34	02/07/15	Flesh	3.27±0.37	0.21±0.03
		Liver	1.63±0.24	0.02±0.01
Deer Cull # 95 location 35	02/07/15	Flesh	1.88±0.29	0.03±0.01
		Liver	3.43±0.38	0.16±0.02
Deer Cull # 67 location 36	02/07/15	Flesh	2.55±0.37	0.19±0.03
		Liver	1.95±0.31	0.04±0.01
Deer Cull # 63 location 37	02/07/15	Flesh	2.75±0.33	0.11±0.02
		Liver	2.84±0.46	0.03±0.03
Deer Cull # 69 location 38	02/07/15	Flesh	3.62±0.42	0.30±0.03
		Liver	3.25±0.49	0.06±0.02
Deer Cull # 70 location 38	02/07/15	Flesh	3.00±0.37	0.30±0.03
		Liver	1.88±0.33	0.05±0.02
Deer Cull # 42 location 39	02/07/15	Flesh	3.60±0.37	0.08±0.02
		Liver	1.37±0.36	0.06±0.02
Bldg. 1010	04/18/15	Flesh	2.97±0.34	0.02±0.02
		Liver	3.27±0.45	ND
NWS	03/16/15	Flesh	3.15±0.37	0.12±0.02
		Liver	2.73±0.34	0.10±0.02
East of Stump Dump	12/22/15	Flesh	2.67±0.39	1.92±0.05
		Liver	3.24±0.36	0.43±0.04

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Table 6-2. Radiological Analyses of Deer Tissue. (2015) *(concluded).*

Sample Location	Collection Date	Tissue	K-40 pCi/g (Wet Weight)	Cs-137 pCi/g (Wet Weight)
< 1 Mile from BNL				
William Floyd Parkway, 0.5 miles north of Long Island Expressway	10/05/15	Flesh	3.20±0.34	0.05±0.01
		Liver	3.41±0.52	0.04±0.01
William Floyd Parkway, 0.5 miles north of Long Island Expressway	10/15/15	Flesh	2.54±0.37	0.22±0.01
William Floyd Parkway, 100 yards south of Main Gate	10/16/15	Flesh	3.01±0.28	0.01±0.00
		Liver*	3.10±0.42	0.01±0.00
Longwood High School	03/20/15	Flesh	2.72±0.28	ND
Averages by Tissue				
Flesh Averages				
All Samples (56)			2.96±2.66	0.27±0.21
BNL Average (52)			2.96±2.63	0.29±0.21
< 1 Mile Average (3)			3.00±0.26	0.10±0.01
BNL + < 1 Mile Average (55)			2.96±2.64	0.28±0.21
> 1 Mile Average (1)			2.72±0.28	ND
Liver Averages				
All Samples			2.43±2.51	0.06±0.14
BNL Average			2.41±2.51	0.06±0.14
< 1 Mile Average			2.90±0.17	0.02±0.01
BNL + < 1 Mile Average			2.43±2.51	0.06±0.14

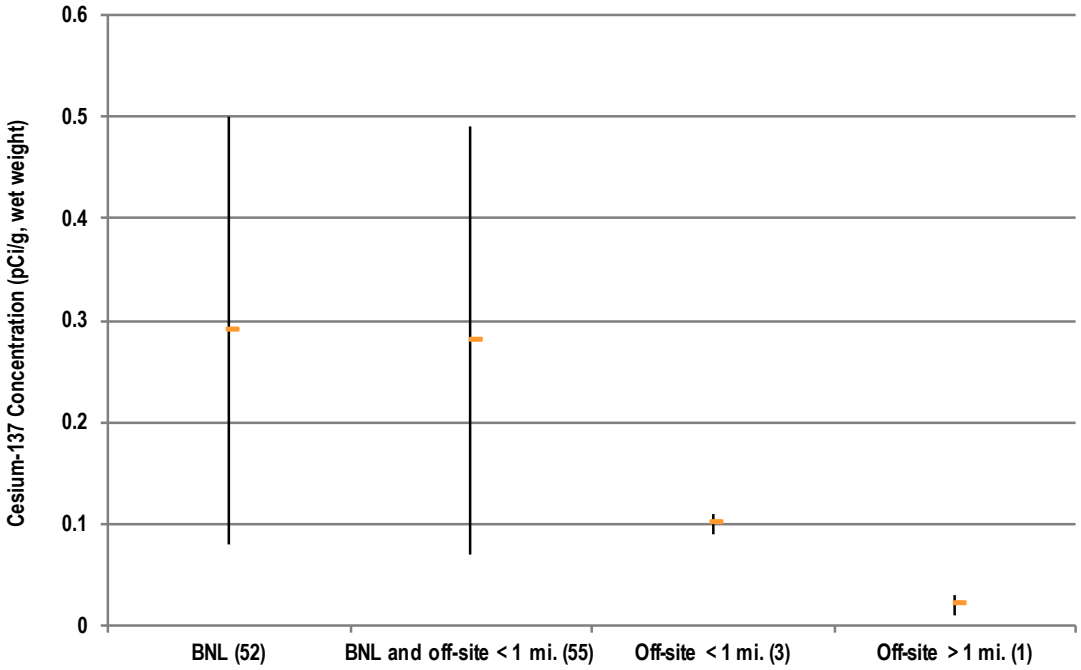
Notes:
* Estimated value for Cs-137 based on laboratory qualifiers.
All values are shown with a 95% confidence interval.
All averages are the arithmetic average with confidence limits using a 2 sigma (95%) propogated error.
K-40 occurs naturally in the environment and is presented as a comparison to Cs-137.
ND = not detected

Laboratory was lower than the on-site average was in 2013, and this result was repeated again in 2014 and 2015. While no definitive explanation can be given to the difference from past results, it could simply be an artifact of low sample numbers and randomness in sample acquisition. Although not shown on Figure 6-2, 96 percent of all 56 meat samples taken both on and off site are below 1 pCi/g, wet weight, and 82 percent were less than 0.50 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 2015 data are comprised of the largest number of samples ever taken, the error around the average is less than 0.5 pCi/g, wet weight, similar to what was seen in 2012 when only nine samples were obtained. The 2015 average is approximately seven times lower than the 2008 average and is 20 percent lower than the 2012 average, which had been 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 downward from 2006 to 2015.

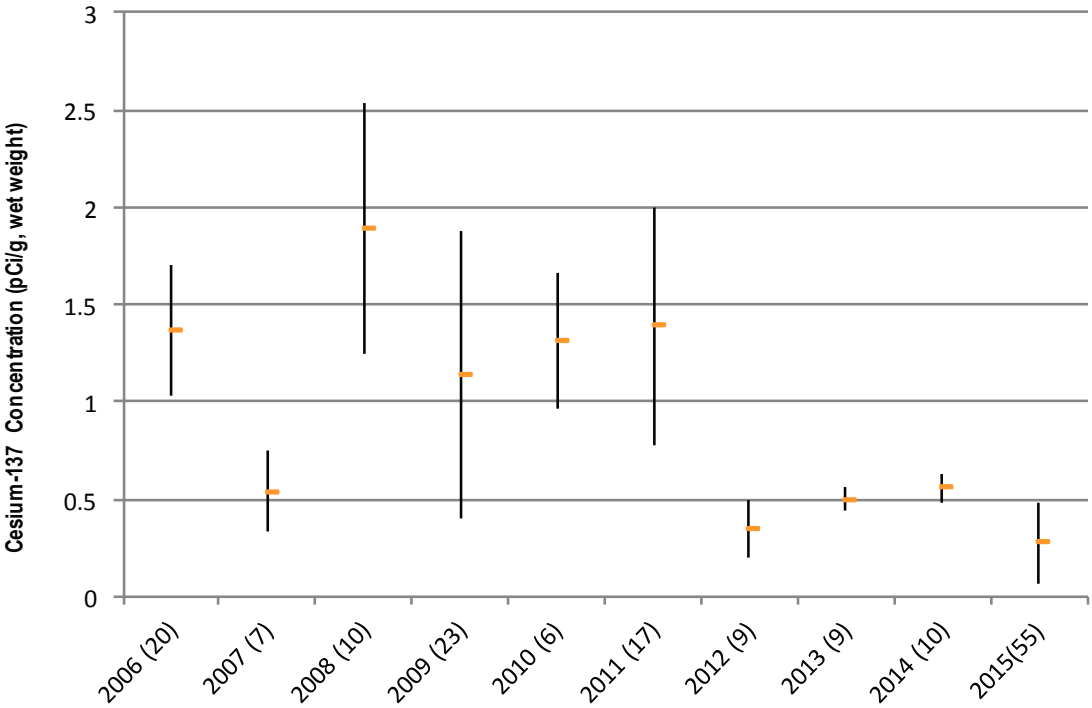
The effectiveness of the BNL soil cleanup program and the reduction of Cs-137 in deer meat was evaluated by Rispoli, et al. (2014). The average Cs-137 content was shown to be statistically lower than before cleanup. Samples taken at distances greater than 1 mile from the BNL site were shown to remain consistent before and after cleanup, while the on-site and near off-site values were shown to decline. In preparing for monitoring associated with the planned reduction of the deer population, the 10-year average for on-site deer samples was calculated to be 1.0 pCi/g, wet weight, and this value was used to establish release criteria for deer meat made available for donation to the 'hunters-for-the-hungry' program.

When possible, liver samples are taken concurrently with meat samples. The liver



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, 2015.



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.

Table 6-3. Radiological Analysis of Batch Samples from Deer Cull Released for Donation (2015).

Batch Number (deer number in sample)	K-40 pCi/g (Wet Weight)	Cs-137 pCi/g (Wet Weight)
Day 1 Batch Sampling 02/09/15		
Batch #01 (5,1,2,3,6)	3.43±0.77	0.24±0.05
Batch #02* (4,14,13,9,8)	3.53±0.81	0.11±0.04
Batch #03 (7,11,12,10,15)	3.11±0.67	0.22±0.05
Batch #04* (16,36,31,23,18)	4.05±1.05	0.08±0.07
Batch #05 (22,34,23,20,27)	3.11±1.03	0.20±0.06
Batch #06 (32,37,35,26,25)	3.66±0.76	0.49±0.09
Batch #07 (40,39,30,38,24)	3.06±0.69	0.37±0.06
Batch #08 (28,19,33,17,21)	3.58±0.89	0.89±0.10
Batch #09 (48,50,41,49,47)	4.76±0.91	0.25±0.07
Batch #10 (60,46,44,42,45)	4.00±0.55	0.10±0.05
Batch #11 (57,54,56,51,43)	3.91±0.81	0.36±0.08
Batch #12* (58,59,53,52,55)	3.63±0.68	0.07±0.05
Batch #13* (63,62,68,60,61)	3.11±0.60	0.17±0.04
Batch #14 (67,64,65,69,66)	4.30±0.74	0.37±0.07
Batch #15 (70,80,84,75,71)	3.54±0.57	0.21±0.03
Batch #16 (73,76,81,85,87)	4.04±0.84	0.23±0.07
Batch #17* (86,83,72,77,82)	3.02±0.64	0.14±0.04
Batch #18* (68,78,74,79,88)	3.39±0.58	0.15±0.04
Batch #19 (90,100,96,95,93)	4.31±0.70	0.22±0.04
Batch #20 (98,103,97,94,105)	3.60±0.72	0.20±0.05
Batch #21 (92,91,99,102,104)	3.30±0.62	0.26±0.05
Batch #22 (101,106,112,107,122)	2.73±0.99	0.25±0.06
Batch #23 (110,115,119,120,108)	3.27±0.59	0.30±0.05
Batch #24 (111,118,113,123,124)	4.08±0.95	0.21±0.07
Batch #25 (116,109,117,121,114)	3.19±0.53	0.38±0.05
Batch #26* (130,132,131,127,126)	3.50±0.65	0.18±0.05
Batch #27 (129,128,125,134,142)	3.80±0.65	0.68±0.06
Batch #28 (140,141,135,138,137)	3.47±0.80	0.20±0.06
Batch #29 (139,133,136,145,143)	3.15±0.66	0.42±0.05
Batch #30* (146,147,148,144,150)	2.19±0.96	0.18±0.06
Batch #31* (152,157,156,149,153)	3.79±0.47	0.08±0.03
Batch #32* (160,158,151,155,154)	3.41±0.65	0.12±0.05
Batch #33* (191,162,159,168,164)	3.44±0.54	0.19±0.03
Batch #34 (173,175,170,172,167)	3.53±0.53	0.38±0.04
Batch #35 (163,165,174,171,169)	4.07±0.86	0.43±0.08
Batch #35 (163,165,174,171,169)	4.07±0.86	0.43±0.08
Batch #36* (179,176,178,166,177)	3.49±0.44	0.07±0.02
Batch #37* (182,180,181,187,188)	4.16±0.65	0.17±0.07
Batch #38* (189,185,184,183,161)	3.22±0.52	0.07±0.02
Batch #39* (192,190,186,195,193)	3.35±0.56	0.09±0.03
Batch #40* (194,196,197,201,203)	3.35±0.61	0.19±0.04
Day 2 Batch Sampling 02/10/15		
Batch #41 (219,202,199,200,198)	2.91±0.59	0.34±0.05
Batch #42 (214,207,204,211,220)	2.56±0.57	0.26±0.05
Batch #43* (209,216,217,215,206)	3.69±0.62	0.14±0.03
Batch #44 (227,218,225,205,212)	4.07±0.59	0.35±0.04
Batch #45 (213,223,224,210,221)	3.50±0.54	0.35±0.04
Batch #46 (222,228,226,231,232)	3.72±0.64	0.52±0.06
Batch #47 (236,235,234,233,229)	3.58±0.68	0.34±0.06
Batch #48 (230,239,251,245,240)	3.53±0.67	0.25±0.05
Batch #49* (247,237,242,252,253)	3.69±0.68	0.06±0.04
Batch #50 (254,250,246,238,249)	3.64±0.79	ND
Batch #51* (259,255,241,248,262)	3.57±0.56	0.12±0.03
Batch #52 (244,243,263,266,260)	2.65±0.64	0.21±0.05
Batch #53 (261,257,269,258,264)	3.07±0.77	0.23±0.04
Batch #54* (277,265,271,256,275)	2.89±0.67	0.17±0.04
Batch #55 (270,267,274,272,279)	3.71±0.75	0.22±0.06
Day 3 Batch Sampling 02/11/15		
Batch #56* (276,273,268,288,287)	2.91±0.64	0.10±0.05
Batch #57 (280,283,284,282,298)	4.61±10.2	0.44±0.08
Batch #58* (278,285,286,281,300)	2.87±0.64	0.19±0.04
Batch #59 (299,294,291,295,290)	2.76±0.73	0.59±0.08
Batch #60 (297,296,293,292,289)	3.39±0.91	0.55±0.08
Average Concentration	3.48±5.52	0.26±0.42

Notes:
All values are shown with a 95% confidence interval.
K-40 occurs naturally in the environment and is presented as a comparison to Cs-137.
All averages are the arithmetic average with confidence limits using a 2 sigma (95%) propogated error.
ND = not detected
* Estimated value for Cs-137 based on laboratory qualifiers.

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 2015, Cs-137 concentrations ranged from non-detect to 0.43pCi/g, wet weight, with an average of 0.06 pCi/g, wet weight. The off-site Cs-137 concentration in liver ranged from non-detect to 0.04 pCi/g, wet weight, with an arithmetic average for off-site liver samples within 1 mile of 0.2 pCi/g, wet weight. No liver samples from deer taken greater than one mile from BNL were acquired in 2015.

The potential radiological dose resulting from deer meat consumption is discussed in Chapter 8. The 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). As mentioned above, BNL established an administrative release criteria of 1.0 pCi/g, wet weight, for meat donated from deer removed from the Laboratory. Table 6-3 presents data from the 60 batch samples produced from the 300 deer removed. The average Cs-137 concentration was 0.26 pCi/g, wet weight, with a range from non-detectable levels to 0.89 pCi/g, wet weight. Approximately 7,500 pounds of meat was donated to the 'hunters-for-the-hungry' program.

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 IAEA threshold. 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. No other animals were sampled in 2015.

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 2015 consists of CERCLA post-cleanup monitoring of fish from the Peconic River locations, as well as background monitoring of fish from Lower Lake on the Carmans River.

Samples collected on site were from Area A of the Peconic River just downstream of the former Sewage Treatment Plant (STP) outfall and Area C north of North Street. Various species of fish were also collected off site from 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 from NYSDEC.

6.3.3.1 Radiological Analysis of Fish

The species collected for radiological analysis in 2015 included brown bullhead *(Ictalurus nebulosus)*, chain pickerel *(Esox niger)*, largemouth bass *(Micropterus salmoides)*, black crappie *(Pomoxis nigromaculatus)*, bluegill *(Lepomis macrochirus)*, and pumpkinseed *(Lepomis gibbossu)*. The edible (fillet) contentof each fish was 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

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

Location/Species	K-40	Cs-137
BNL, Area A	------ pCi/g (Wet Weight) -----	
Bluegill*	2.99±0.73	0.13±0.04
Pumpkinseed (composite)*	2.76±0.90	0.13±0.05
Pumpkinseed (composite)*	2.35±0.81	0.12±0.07
Chain Pickerel*	3.79±0.78	0.15±0.05
Largemouth Bass (composite)*	4.46±0.90	0.13±0.05
Brown Bullhead (composite)*	2.45±0.91	0.14±0.06
BNL, Area C		
Bluegill (composite)	3.02±0.75	ND
Bluegill (composite)	2.96±0.82	ND
Black Crappie*	3.24±1.49	0.17±0.16
Largemouth Bass*	3.32±0.80	0.18±0.05
Largemouth Bass	3.28±0.84	0.25±0.06
Largemouth Bass*	3.12±0.74	0.14±0.05
Donahue's Pond		
Black Crappie*	3.49±0.76	0.06±0.05
Chain Pickerel*	4.53±0.76	0.15±0.04
Chain Pickerel*	2.85±0.90	0.08±0.07
Chain Pickerel*	3.71±0.55	0.11±0.03
Largemouth Bass*	2.48±1.01	0.11±0.06
Largemouth Bass*	2.84±0.74	0.10±0.05
Largemouth Bass	3.19±1.10	ND
Brown Bullhead*	4.51±1.01	0.08±0.06
Brown Bullhead*	3.03±0.77	0.08±0.06
Brown Bullhead*	2.57±0.75	0.09±0.05
Brown Bullhead*	3.10±0.92	0.09±0.06
Brown Bullhead*	3.28±0.63	0.07±0.05
Brown Bullhead*	2.90±0.78	0.11±0.06
Brown Bullhead	2.67±1.18	ND
Brown Bullhead*	3.62±0.76	0.08±0.06
Brown Bullhead*	3.82±0.83	0.06±0.04

Location/Species	K-40	Cs-137
Lower Lake, Carmans River	------ pCi/g (Wet Weight) -----	
Bluegill	2.32±1.02	ND
Bluegill	2.39±1.00	ND
Bluegill	3.30±0.50	ND
Bluegill	3.08±0.73	ND
Bluegill	2.22±0.91	ND
Bluegill	3.26±0.75	ND
Bluegill	2.96±1.29	ND
Bluegill	2.70±0.71	ND
Bluegill (composite)	1.92±0.64	ND
Largemouth Bass	3.31±0.78	ND
Largemouth Bass	3.69±0.91	ND
Largemouth Bass	2.79±0.87	ND
Brown Bullhead	2.75±0.64	ND
Brown Bullhead	2.36±0.86	ND
Brown Bullhead	2.44±0.49	ND
Brown Bullhead	2.22±0.89	ND
Brown Bullhead	2.28±0.70	ND
Brown Bullhead	2.44±0.67	ND
Brown Bullhead	2.73±0.82	ND
Brown Bullhead	2.70±0.74	ND

Notes:
All samples analyzed as edible portions (fillets), including composite samples.
* Estimated value for Cs-137 based on lab qualifiers.
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 lab qualifiers

species were composited. Table 6-4 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 levels ranged from non-detected to 0.25 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 an estimated 0.06 pCi/g in brown bullhead taken from Donahue's Pond to 0.25 pCi/g, wet weight, in a largemouth bass taken from Area C on site. For comparison, the highest recent value of Cs-137 was 0.78 pCi/g, wet weight, in a composite sample of bluegill was taken from Forge Pond in 2011.

To account for the different feeding habits and weight of various species, it is important to compare Cs-137 concentrations and other contaminants in species with similar feeding habits (i.e., bottom feeders such as brown

bullhead should be compared to other bottom feeders). Cesium-137 concentrations in brown bullhead collected at all locations along the Peconic River had values less than 0.14 pCi/g, wet weight. Largemouth bass, the top predator from the Peconic River, showed Cs-137 levels of 0.25 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 by natural radioactive decay. Cesium-137 has a half-life of 30 years. Discharge monitoring has demonstrated that no Cs-137 was released from the STP to the Peconic River during 2003 through 2014. Discharges from the STP to the Peconic River were discontinued in October 2014. Additionally, the cleanup of both on- and off-site portions of the Peconic River 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 size 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 2015, even with low water levels in the on-site portion of the Peconic River, indicated that populations have maintained themselves. However, the combination of no further STP discharges to the Peconic River and drought conditions have resulted in the on-site portions of the Peconic River to be totally dry and no longer able to support fish. For fish populations to survive and flourish, water levels must be substantial enough to allow migration of fish and to maintain their presence for an extended period of time to replenish populations. New criteria for the collection of fish samples have been developed. These criteria will guide the environmental monitoring approach for fish.

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. Results for 2015 post cleanup monitoring of the Peconic River and a comparison to data from Lower Lake on the Carmans River are shown in Table 6-5. All samples were obtained between April and mid-June. Mercury ranged from 0.40 mg/kg in brown bullhead to 1.16 mg/kg in a chain pickerel taken from Area A; less than the method detection level (MDL) in brown bullhead to 3.26 mg/kg in a largemouth bass from Area C; from 0.14 mg/kg to 0.26 mg/kg in bluegill from Area D; and from 0.06 mg/kg in a brown bullhead to 0.61 mg/kg in a largemouth bass at Donahue's Pond. Mercury in control fish taken from Lower Lake on the Carmans River ranged from 0.04 mg/kg in brown bullhead to 0.19 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 6-6 and utilizes the data regardless of whether or not it fell below MDLs in order 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 Area A during 2015 are similar those seen in 2014 but higher than those seen in 2011 and 2012. This increase is most likely due to low water flow conditions in the river since late summer 2011, with limited open water areas and little or no flow off site. Consequently, fish have been isolated to the BNL site and any methylated mercury was not diluted by flow. Mercury content in fish between on-and off-site locations indicate that concentrations decrease significantly once off site, and values at Donahue's Pond are similar to those from Lower Lake on the Carmans River.

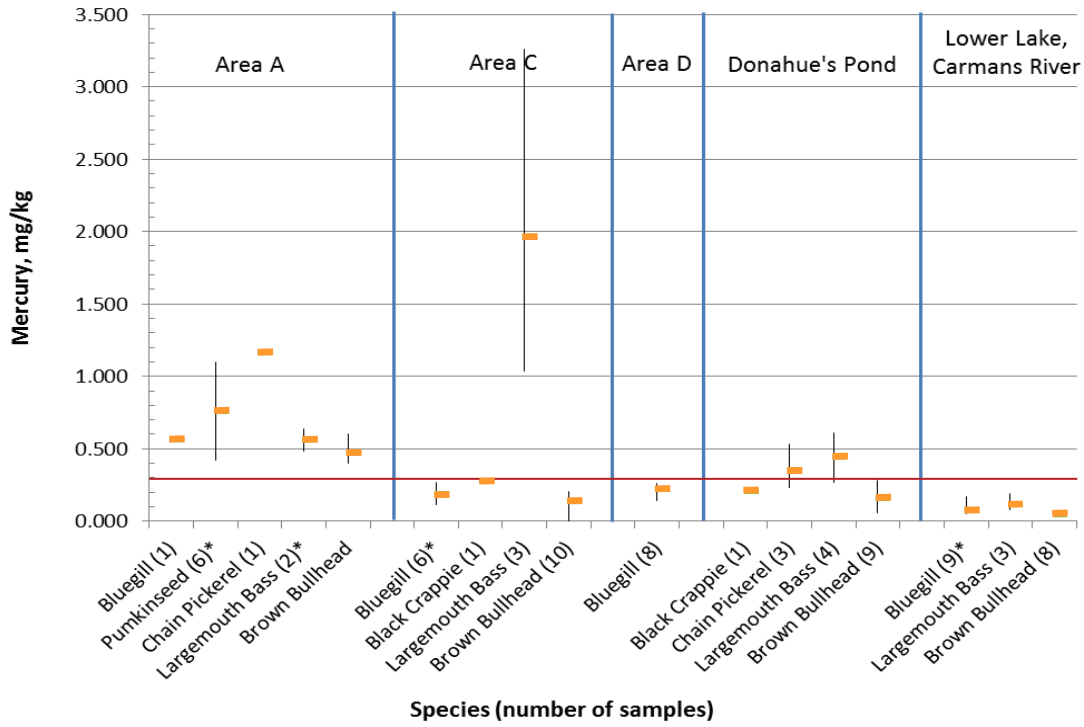
On-site fish are monitored for PCBs due to

Table 6-5. Metals Analysis of Fish from the Peconic River System and Carmans River, Lower Lake (2015).

Location/Species (number of samples)	Mercury ------ mg/kg ------
BNL, Area A	
Bluegill	0.558
Brown Bullhead (composite)	0.603
Brown Bullhead	0.406
Brown Bullhead	0.402
Chain Pickerel	1.160
Largemouth Bass	0.638
Largemouth Bass (composite)	0.486
Pumpkinseed (composite)	0.700
Pumpkinseed (composite)	0.742
Pumpkinseed	0.871
Pumpkinseed	0.721
Pumpkinseed	0.420
Pumpkinseed	1.100
BNL, Area C	
Black Crappie	0.275
Bluegill (composite)	0.123
Bluegill (composite)	0.200
Bluegill	0.115
Bluegill	0.271
Bluegill	0.201
Bluegill	0.197
Brown Bullhead	< MDL
Brown Bullhead	0.121
Brown Bullhead	0.161
Brown Bullhead	0.202
Brown Bullhead	0.069
Brown Bullhead	< MDL
Brown Bullhead	< MDL
Brown Bullhead	0.076
Brown Bullhead	0.191
Brown Bullhead	0.103
Largemouth Bass	3.260
Largemouth Bass	1.570
Largemouth Bass	1.040
BNL, Area D	
Bluegill	0.207
Bluegill	0.141
Bluegill	0.261
Bluegill	0.205
Bluegill	0.200
Bluegill	0.230
Bluegill	0.254
Bluegill	0.243

Location/Species (number of samples)	Mercury ------ mg/kg ------
Donahue's Pond	
Black Crappie	0.204
Brown Bullhead	0.124
Brown Bullhead	0.211
Brown Bullhead	0.119
Brown Bullhead	0.109
Brown Bullhead	0.226
Brown Bullhead	0.282
Brown Bullhead	0.059
Brown Bullhead	0.173
Brown Bullhead	0.075
Chain Pickerel	0.530
Chain Pickerel	0.235
Chain Pickerel	0.279
Largemouth Bass	0.607
Largemouth Bass	0.604
Largemouth Bass	0.303
Largemouth Bass	0.267
Lower Lake, Carmans River	
Bluegill	0.172
Bluegill	0.057
Bluegill	0.069
Bluegill	0.074
Bluegill	0.061
Bluegill	0.056
Bluegill	0.048
Bluegill	0.083
Bluegill (composite)	0.052
Brown Bullhead	0.049
Brown Bullhead	0.048
Brown Bullhead	0.053
Brown Bullhead	0.053
Brown Bullhead	0.037
Brown Bullhead	0.037
Brown Bullhead	0.035
Brown Bullhead	0.063
Largemouth Bass	0.194
Largemouth Bass	0.080
Largemouth Bass	0.077

Notes:
See Figure 5-4 for sampling locations.
All samples were analyzed as edible portions (fillets), including composite samples.
Area letter designations refer to Peconic River cleanup areas.
MDL = method detection level



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).

their historical use at the Laboratory. Table 6-7 shows the results for PCBs from fish taken from Areas A and C on site. Fillets are analyzed for PCBs after metals and radionuclides. Due to lack of sufficient sample volume, some samples had no PCB analysis. Only two PCB congeners were detected, Aroclor-1254 and Aroclor-1260, and most values were below the MDL. Aroclor-1254 was detected in pumpkinseed, brown bullhead, and largemouth bass above the MDL. Aroclor-1260 was detected above MDL in pumpkinseed and largemouth bass. The highest concentration of Aroclor-1254 was 50.1 µg/kg in a composite sample of pumpkinseed. The highest concentration of Aroclor-1260 was 20.7 µg/kg found in the same sample. These levels are compared to the Food and Drug Administration tolerance levels of 2000 µg/kg in edible portions of fish in the commercial food supply.

6.3.4 Peconic River Post-Cleanup Monitoring

Approximately 20 acres of the Peconic River were remediated in 2004 and 2005 to remove sediments containing mercury and associated contaminants. To ensure that the cleanup provided adequate protection of human health and the environment, BNL conducted 5 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 and

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

Location/Species	Mercury ----------µg/kg----------		
BNL, Area A	**Min.**	**Max.**	**Avg.**
Bluegill (1)	0.558	0.558	0.558
Brown Bullhead	0.402	0.603	0.470
Chain Pickerel (1)	1.160	1.160	1.160
Largemouth Bass (2)*	0.486	0.638	0.562
Pumkinseed (6)*	0.420	1.100	0.759
BNL, Area C			
Black Crappie (1)	0.275	0.275	0.275
Bluegill (6)*	0.115	0.271	0.185
Brown Bullhead (10)	0.000	0.202	0.132
Largemouth Bass (3)	1.040	3.260	1.957
BNL, Area D			
Bluegill (8)	0.141	0.261	0.218
Donahue's Pond			
Black Crappie (1)	0.204	0.204	0.204
Brown Bullhead (9)	0.059	0.282	0.153
Chain Pickerel (3)	0.235	0.530	0.348
Largemouth Bass (4)	0.267	0.607	0.445
Lower Lake, Carmans River			
Bluegill (9)*	0.048	0.172	0.075
Brown Bullhead (8)	0.035	0.063	0.047
Largemouth Bass (3)	0.077	0.194	0.117

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 6-7. PCB Analysis of Fish from BNL Portions of the Peconic River System.

Location/Species	Aroclor-1254	Aroclor-1260
	----------µg/kg----------	
BNL, Area A		
Brown Bullhead (composite)	25.1	< MDL
Pumpkinseed (composite)	50.1	20.7
Pumpkinseed (composite)	13.2*	< MDL
BNL, Area C		
Largemouth Bass	< MDL	< MDL
Largemouth Bass	30.2	15.2*
Largemouth Bass	< MDL	< MDL

Notes:
All samples were analyzed as edible portions (fillets),including composite samples.
* estimated value for reported analyte based on lab qualifiers
MDL = minimum detection limit

reviewed (BNL 2011). The Five-Year Review recommended that reduced monitoring should take place beginning in 2012. The reductions included decreasing sediment sampling to just the three areas associated with the supplemental cleanup; water monitoring was reduced from 30 locations to the current 14, and fish monitoring was to alternate years with the surveillance monitoring. The 2015 sediment and surface water results are described below.

6.3.4.1 Sediment Sampling

Sediment was sampled in June 2015 at three Peconic River locations associated with the supplemental cleanup areas remediated during 2010 and 2011. Radiological analysis (not included in the table) of sediments at all three locations indicate that low levels of Cs-137 are present, ranging from 0.67 pCi/g to 3.71 pCi/g, which are consistent with previous analyses of the river sediments. Analysis of sediment for mercury identified values ranging from 0.02 mg/kg to 0.77 mg/kg taken at the 2010/2011 cleanup sites. In 2014, the highest value (7.40 mg/kg) was from a sample taken at the PR-WC-06 area and was above the 2.0 mg/kg cleanup goal for post cleanup confirmatory sampling. This result, along with the fact that concentrations above 2.0 mg/kg were seen at this location in the past, resulted in an effort to determine the extent of mercury in sediment around this point. Additional samples were collected in late 2014, and samples for the delineation of contamination within an area of approximately 200 feet x 35 feet were collected through October 2015. These data are presented in Table 6-8. The area of contamination with sediment concentrations above 2.0 mg/kg is shown in Figure 6-5. Sampling results ranged from 0.10 to 23.0 mg/kg. The area of contamination above 2.0 mg/kg covers approximately 2,560 square feet. By the end of 2015, BNL had begun development of

Table 6-8. Peconic River Post-Cleanup Annual and Extent of Contamination Sampling for Mercury.

Location	Sample Date	Mercury
Annual Sampling		**mg/kg**
ST1-80-U20	06/09/15	0.02
PR-WC-06-D1-L50		0.77
PR-SS-15-U1-L65-0		0.20
Extent of Contamination Sampling		
PR-WC-06-D1-L50-05	01/20/15	5.50
PR-WC-06-D1-L50-06		4.20
PR-WC-06-D1-L50-07		3.70
PR-WC-06-D1-L50-08		0.42
PR-WC-06-D1-L50-09		0.42
PR-WC-06-D1-L50-10		1.10
PR-WC-06-D1-L50-11	03/30/15	18.00
PR-WC-06-D1-L50-12		0.50
PR-WC-06-D1-L50-13		0.56
PR-WC-06-D1-L50-14		0.35
PR-WC-06-D1-L50-15		0.12
PR-WC-06-D1-L50-16		0.21
PR-WC-06-D1-L50-17		0.25
PR-WC-06-D1-L50-18		16.00
PR-WC-06-D1-L50-25	05/19/15	0.79
PR-WC-06-D1-L50-26		0.55
PR-WC-06-D1-L50-27		0.21
PR-WC-06-D1-L50-28		7.60
PR-WC-06-D1-L50-29		6.20
PR-WC-06-D1-L50-30		6.20
PR-WC-06-D1-L50-31		5.50
PR-WC-06-D1-L50-32		6.60
PR-WC-06-D1-L50-33		0.21
PR-WC-06-D1-L50-34		0.10
PR-WC-06-D1-L50-35	06/24/15	16.00
PR-WC-06-D1-L50-36		18.00
PR-WC-06-D1-L50-37		0.91
PR-WC-06-D1-L50-38		13.00
PR-WC-06-D1-L50-39		0.16
PR-WC-06-D1-L50-40		2.00
PR-WC-06-D1-L50-41		0.47
PR-WC-06-D1-L50-42		3.50
PR-WC-06-D1-L50-43		1.10
PR-WC-06-D1-L50-44		2.80
PR-WC-06-D1-L50-45		1.30
PR-WC-06-D1-L50-46		1.30
PR-WC-06-D1-L50-47		0.51
PR-WC-06-D1-L50-48		0.27
PR-WC-06-D1-L50-49		9.20
PR-WC-06-D1-L50-50		1.80
PR-WC-06-D1-L50-51		0.66
PR-WC-06-D1-L50-52		1.60

Location	Sample Date	Mercury
Extent of Contamination Sampling (continued)		**mg/kg**
PR-WC-06-D1-L50-53		0.21
PR-WC-06-D1-L50-54		0.74
PR-WC-06-D1-L50-55		1.40
PR-WC-06-D1-L50-56		0.55
PR-WC-06-D1-L50-57	07/16/15	0.30
PR-WC-06-D1-L50-58		10.00
PR-WC-06-D1-L50-59		3.00
PR-WC-06-D1-L50-60		4.20
PR-WC-06-D1-L50-61		4.50
PR-WC-06-D1-L50-62		3.60
PR-WC-06-D1-L50-63		0.43
PR-WC-06-D1-L50-64		3.30
PR-WC-06-D1-L50-65		4.70
PR-WC-06-D1-L50-66	08/19/15	1.20
PR-WC-06-D1-L50-67		0.86
PR-WC-06-D1-L50-68		1.70
PR-WC-06-D1-L50-69		3.60
PR-WC-06-D1-L50-70		2.90
PR-WC-06-D1-L50-71		0.49
PR-WC-06-D1-L50-72		1.70
PR-WC-06-D1-L50-73		6.50
PR-WC-06-D1-L50-74		1.90
PR-WC-06-D1-L50-75		0.32
PR-WC-06-D1-L50-76		0.24
PR-WC-06-D1-L50-77		0.37
PR-WC-06-D1-L50-78		1.40
PR-WC-06-D1-L50-79		1.30
PR-WC-06-D1-L50-80		3.50
PR-WC-06-D1-L50-81		3.10
PR-WC-06-D1-L50-82		0.39
PR-WC-06-D1-L50-83		0.94
PR-WC-06-D1-L50-84		1.30
PR-WC-06-D1-L50-85		1.20
PR-WC-06-D1-L50-86		3.40
PR-WC-06-D1-L50-87		4.30
PR-WC-06-D1-L50-88		0.54
PR-WC-06-D1-L50-89		0.29
PR-WC-06-D1-L50-90		1.40
PR-WC-06-D1-L50-91		3.20
PR-WC-06-D1-L50-92		2.00
PR-WC-06-D1-L50-93		1.80
PR-WC-06-D1-L50-94		1.60
PR-WC-06-D1-L50-95		5.10
PR-WC-06-D1-L50-96		1.70
PR-WC-06-D1-L50-97		0.60
PR-WC-06-D1-L50-98	09/09/15	0.60

(continued on next page)

Table 6-8. Peconic River Post-Cleanup Annual and Extent of Contamination Sampling for Mercury. *(concluded)*

Location	Sample Date	Mercury
Extent of Contamination Sampling (continued)		**mg/kg**
PR-WC-06-D1-L50-99		0.47
PR-WC-06-D1-L50-100		2.50
PR-WC-06-D1-L50-101		23.00
PR-WC-06-D1-L50-102		0.22
PR-WC-06-D1-L50-103	10/08/15	4.00
PR-WC-06-D1-L50-104		0.87
PR-WC-06-D1-L50-105		2.40
PR-WC-06-D1-L50-106		3.70
PR-WC-06-D1-L50-107		2.10
PR-WC-06-D1-L50-108		2.40
PR-WC-06-D1-L50-109		0.19
PR-WC-06-D1-L50-110		2.60
PR-WC-06-D1-L50-111		2.30
PR-WC-06-D1-L50-112		1.80
PR-WC-06-D1-L50-113		2.70
PR-WC-06-D1-L50-114		0.94
PR-WC-06-D1-L50-115		3.50
PR-WC-06-D1-L50-116		1.00
PR-WC-06-D1-L50-117		3.40
PR-WC-06-D1-L50-118		1.40
PR-WC-06-D1-L50-119		0.18
PR-WC-06-D1-L50-120		0.21
PR-WC-06-D1-L50-121		1.10
PR-WC-06-D1-L50-122		0.77
PR-WC-06-D1-L50-123		2.60
PR-WC-06-D1-L50-124		2.30
PR-WC-06-D1-L50-125		0.55
PR-WC-06-D1-L50-126		0.28
PR-WC-06-D1-L50-127		3.30
PR-WC-06-D1-L50-128		4.50
PR-WC-06-D1-L50-129		0.21
PR-WC-06-D1-L50-130	**Location**	0.30
PR-WC-06-D1-L50-131		1.00
PR-WC-06-D1-L50-132		0.40
PR-WC-06-D1-L50-133		3.10
PR-WC-06-D1-L50-134		0.44
PR-WC-06-D1-L50-135		2.40
PR-WC-06-D1-L50-136		0.19
PR-WC-06-D1-L50-137		2.40
PR-WC-06-D1-L50-138		0.17
PR-WC-06-D1-L50-139		2.10
PR-WC-06-D1-L50-140		1.10
PR-WC-06-D1-L50-141		4.60
PR-WC-06-D1-L50-142		1.40
PR-WC-06-D1-L50-143		2.30
PR-WC-06-D1-L50-144		2.00
PR-WC-06-D1-L50-145		2.40
PR-WC-06-D1-L50-146		1.40

Note: See Figure 6-5 for extent of contamination associated with sampling effort.

plans for removal of the contaminated material and continued to communicate with stakeholders and regulators.

6.3.4.2 Water Column Sampling

Surface water was analyzed in June and July 2015 for total mercury and methyl mercury at three of the 14 Peconic River sampling stations each month. Water column sampling locations are shown on Figure 6-6. Eleven stations could not be sampled in both June and July due to being too shallow or dry and the former STP outfall being removed due to the transfer of discharge to groundwater recharge basins in October 2014. Total Suspended Solids (TSS) are reported in Table 6-9 because 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 total mercury concentrations above the former STP outfall were lower than the two samples taken further downstream in both June and July. The typical pattern of declining mercury and methyl mercury concentrations downstream of the former outfall is not apparent in these data, due in part to the lack of sufficient samples collected during the year resulting from the river being mostly dry.

Methyl mercury is the form of mercury that is bio-available to aquatic organisms. Methyl mercury was measured at three monitoring stations in both June and July. In June, methyl mercury ranged from 2.7 ng/L at the station immediately upstream of the former STP outfall to 1.3 ng/L

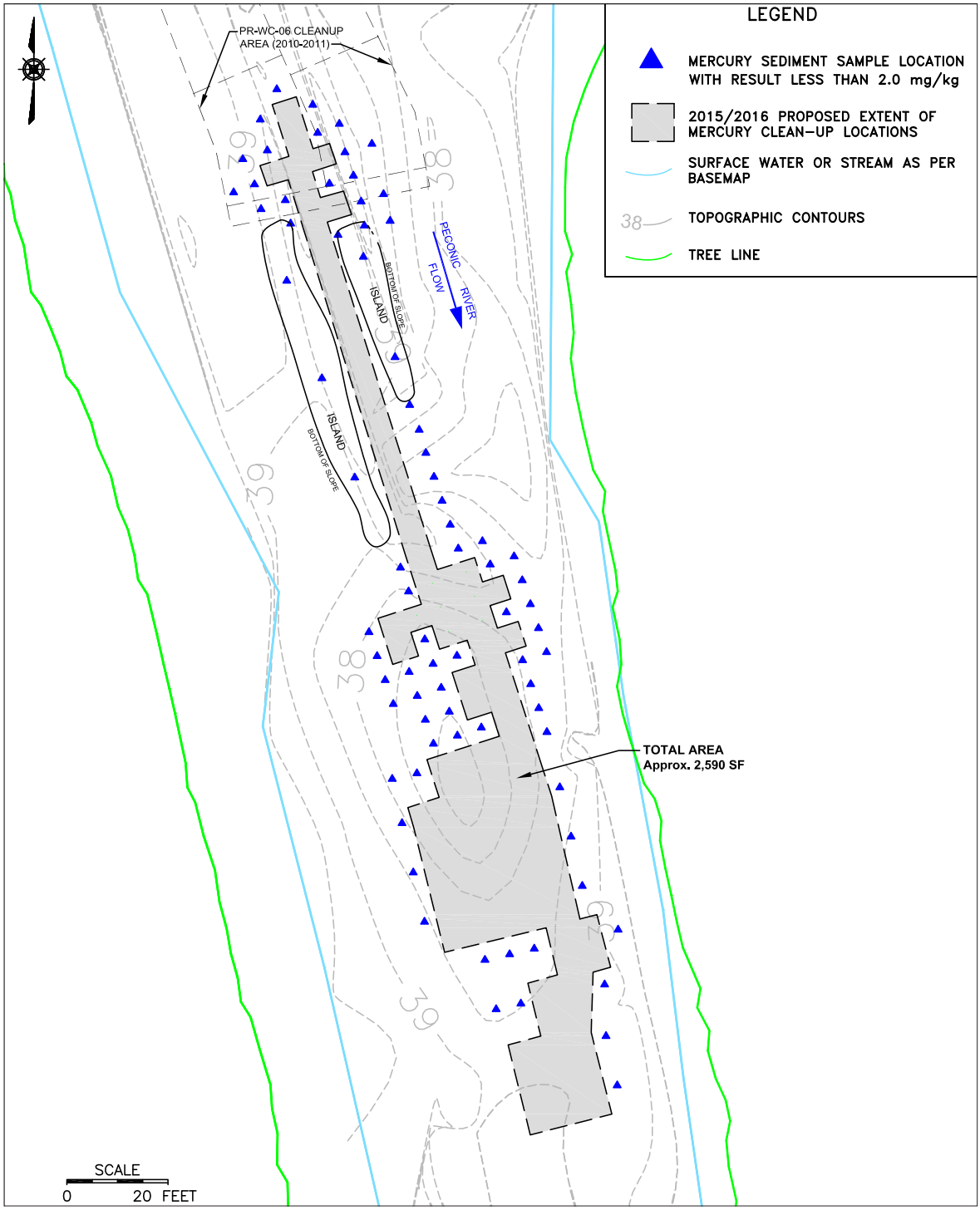


Figure 6-5. Peconic River Mercury Contamination.

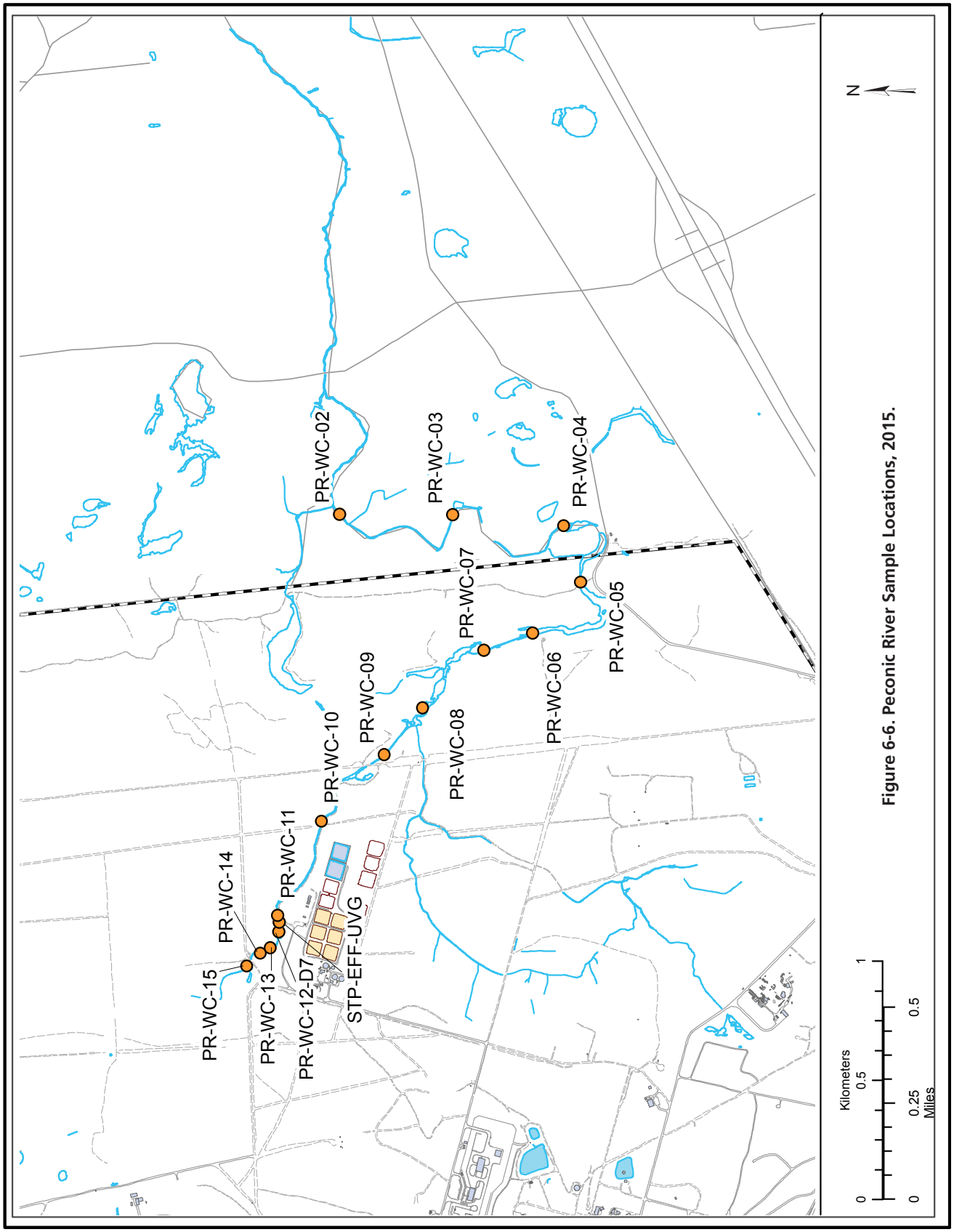


Figure 6-6. Peconic River Sample Locations, 2015.

Table 6-9. Post Cleanup Peconic River Water Column Monitoring (2015).

Location	Station Description	Dist from STP (miles)	June 2015			July 2015		
			Mercury	Methyl Mercury	TSS	Mercury	Methyl Mercury	TSS
			-------- ng/L --------		mg/L	-------- ng/L --------		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	10	2.7	< MDL	3.4	1.4	< MDL
STP-EFF-UVG	Grab Sample	0	No Discharge in 2015					
PR-WC-11DS	"50"" downstream of outfall"	0.01	SW	SW	SW	SW	SW	SW
PR-WC-10	West of HMN	0.3	SW	SW	SW	SW	SW	SW
PR-WC-09	Downstream of HMN	0.56	SW	SW	SW	SW	SW	SW
PR-WC-08	South of Area B	0.78	21	1.6	< MDL	SW	SW	SW
PR-WC-07	South of Area C	0.96	SW	SW	SW	SW	SW	SW
PR-WC-06	South of Area D	1.1	SW	SW	SW	4.7	0.48	8
PR-WC-05	Downstream of HQ	1.46	SW	SW	SW	SW	SW	SW
PR-WC-04	2nd downstream of HQ	1.7	SW	SW	SW	SW	SW	SW
PR-WC-03	3rd west of Schultz Rd.	2.1	20	1.3	4	26	1.2	7
PR-WC-02	2nd west of Schultz Rd.	2.52	SW	SW	SW	SW	SW	SW

Notes:
See Figure 6-5 for Peconic River water sampling locations.
MDL= Method Detection Level
SW = water too shallow to sample or location was dry

at the station approximately 2.1 miles below the former STP outfall. In July, methyl mercury values ranged from 1.4 ng/L above the former STP outfall down to 0.48 ng/L approximately 1.1 miles below the former STP outfall.

Continued monitoring of the river for mercury and methyl mercury will be addressed in 2016 during the Five-Year Review process. With the removal of STP discharges to the river, water level conditions in the river are dependent on seasonal precipitation rates and groundwater conditions. The on-site portion of the Peconic River has been mostly dry since June 2015.

6.3.5 Vegetation Sampling

6.3.5.1 Grassy Plants and Soil

During 2015, grassy vegetation samples were collected from 12 locations around the Laboratory (Figure 6-7). All samples were analyzed for Cs-137 (see Table 6-10). Cs-137 content in vegetation ranged from non-detectable to 0.43 pCi/g, wet weight. Five of the 12 samples had detectable levels of Cs-137. All values are consistent with historic monitoring. 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 12 locations where the grassy vegetation was collected and analyzed for Cs-137 (Table 6-10). Cs-137 concentrations in soils ranged from 0.05 pCi/g, dry weight, to 2.84 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 that receive water discharges that are permitted under the Laboratory's State Pollutant Discharge Elimination System (SPDES) permit (see Figure 5-5 for outfall locations). Basin sediments were last sampled in 2012 and results were

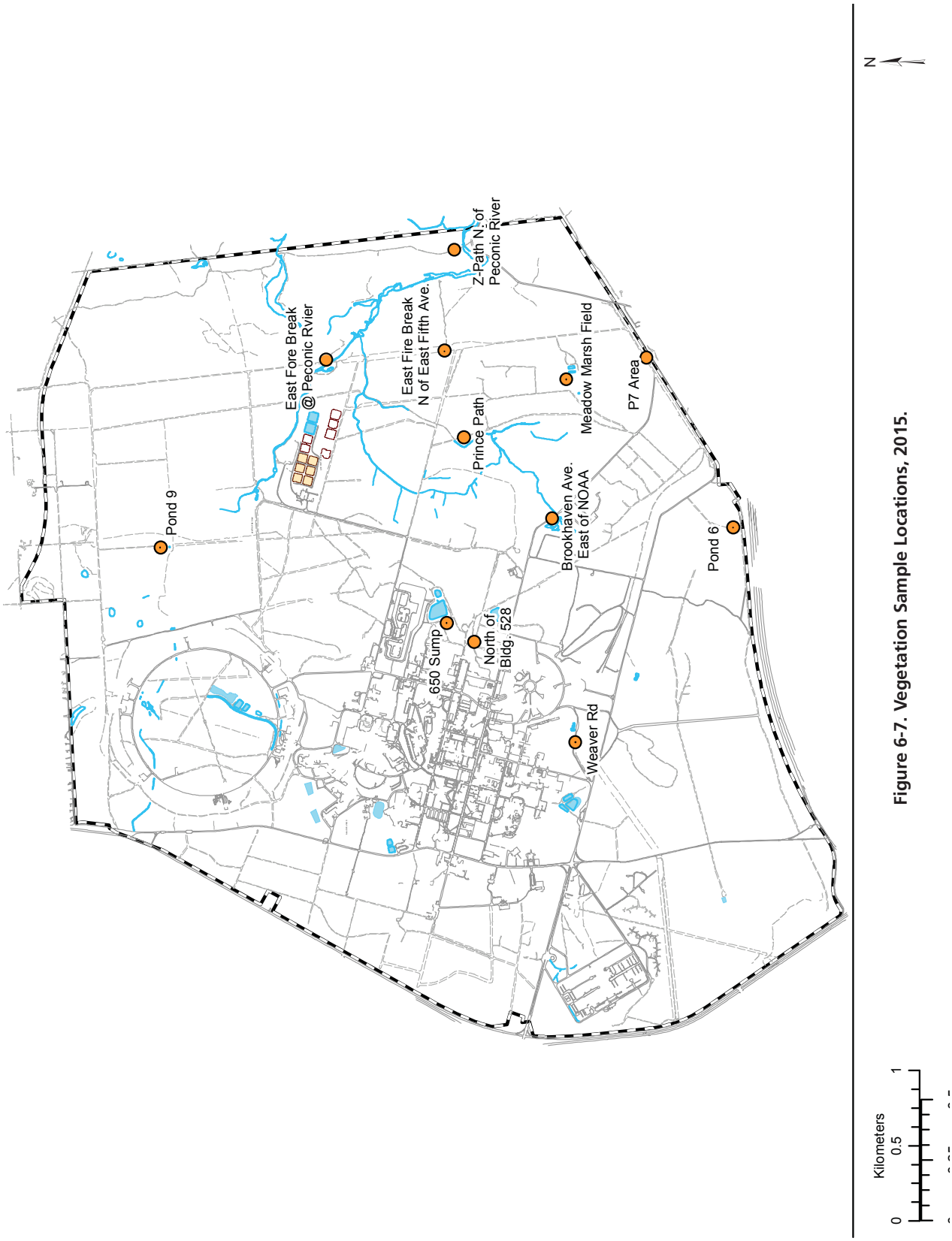


Figure 6-7. Vegetation Sample Locations, 2015.

summarized in the 2012 Site Environmental Report (BNL, 2013b). The next round of routine basin sampling will be conducted in 2017.

6.4.2 Radiological and Mercury Monitoring of Precipitation

During 2015, precipitation samples were collected quarterly at air monitoring Stations P4 and S5 (see Figure 4-2 for station locations). The samples were analyzed for radiological content and total mercury (see Table 6-11). Gross beta activity was measured in samples collected during all four quarters at monitoring stations P4 and S5. Location P4 had a maximum gross beta activity level of 4.61 pCi/L in the third quarter of 2015. Location S5 had a maximum gross beta activity level of 5.72 pCi/L, also in the third quarter. Gross beta, gamma, and strontium-90 (Sr-90) (no detection) activity values were within the range of historically observed values at these two locations.

Mercury concentrations in precipitation have been measured at BNL since 2007. 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 1.97 ng/L at station S5 in October to 18.2 ng/L at station P4 in July. This range is one twelfth to three fourths of the highest value measured in precipitation, 24.6 ng/L, recorded in 2013.

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, foster an interest in science, and to provide a meaningful experience for interns in preparation for further studies or a career. 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 2015, BNL hosted 22 student interns and one faculty member. Two of the interns worked with a faculty member from Dowling College as part of the BNL Visiting Faculty Program (VFP) and 20 interns participated in research associated with various projects including several related to the LISF. The Natural Resource program typically supports two interns in the spring, three in the fall, and the remainder participate in the summer internship program.

The VFP team continued ongoing work on statistical analysis of migratory bird data and meteorological data to determine the potential for placing one or more wind turbines on site.

Work associated with the LISF involved tracking 24 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 42 turtles; as a result, BNL is building a very good understanding of their habits. Turtles are also permanently marked to facilitate identification of individual turtles as part of a mark recapture effort. As more turtles are marked, more recaptures are occurring, providing good long-term movement data.

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 summer and fall and paired small mammal trapping grids looked at variations in small mammal populations both inside and outside of the LISF 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). 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.

To facilitate the analysis of the wildlife surveillance data and to develop plans for the placement of transects, trapping grids and

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

Location/Matrix	K-40 pCi/g (Wet Weight)	Cs-137 pCi/g (Wet Weight)
North of Bldg. 528		
Vegetation	3.84±0.50	ND
Soil*	7.26±0.90	0.16±0.06
Meadow Marsh Field		
Vegetation	4.74±0.39	ND
Soil	6.43±0.80	0.21±0.05
East Fire Break N of East Fifth Ave.		
Vegetation	3.67±0.47	ND
Soil*	6.03±0.70	0.05±0.04
Pond 9		
Vegetation	3.53±0.43	0.43±0.03
Soil	11.10±1.45	2.84±0.19
Pond 6		
Vegetation	2.41±0.46	0.42±0.04
Soil	12.00±1.20	0.34±0.06
650 Sump		
Vegetation*	5.26±0.44	0.05±0.04
Soil	6.66±0.80	0.28±0.04
Weaver Rd		
Vegetation*	4.14±0.33	0.02±0.01
Soil	5.28±0.68	0.23±0.05
Prince Path		
Vegetation	4.57±0.37	ND
Soil	3.33±0.43	0.33±0.04
P9 Area		
Vegetation	3.72±0.39	ND
Soil*	8.50±1.06	0.10±0.06
Brookhaven Ave. East of NOAA		
Vegetation*	3.08±0.26	0.05±0.01
Soil	5.92±0.53	0.89±0.06
Z-Path N. of Peconic River		
Vegetation	3.84±0.42	ND
Soil	4.19±0.58	0.25±0.05
East Fire Break @ Peconic River		
Vegetation	3.53±0.35	ND
Soil*	9.16±0.75	0.13±0.04

Notes:
All values are shown with a 95% confidence interval.
Radiological values for soils are on a 'dry weight' basis.
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
* Estimated value for Cs-137 based on lab qualifiers

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

Location/ Period	Gross Alpha	Gross Beta	Mercury
	---------- pCi/L ----------		ng/L
P4			
01/07/15	-	-	6.01
01/30/15	2.01±1.00	1.87±0.72	-
04/10/15	-	-	14.1
04/30/15	ND	1.87±0.69	-
07/10/15	-	-	18.2
07/30/15	1.82±1.05	4.61±1.04	
10/06/15	-	-	10.1
10/30/15	ND	1.61±0.74	-
S5			
01/07/15	-	-	7.27
01/30/15	ND	1.90±0.72	-
04/10/15	-	-	13.5
04/30/15	ND	1.21±0.66	-
07/10/15	-	-	11.7
07/31/15	2.66±1.06	5.72±1.17	-
10/06/15	-	-	1.97
10/30/15	ND	2.07±0.79	-

Notes:
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

placement of cameras are used. 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. The bat was the first recorded incidence of white-nose syndrome on Long Island. As a result, BNL and NYSDEC established permanent acoustical survey routes on Long Island for monitoring. The northern long-eared bat was listed as a threatened species under the Endangered Species Act on April 2, 2015. During summer 2015, a bat specialist captured bats on site using mist-netting. These results were compared to 2012-2014 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, 1 in 2013, 2 'young of the year' in 2014, and none in 2015. Reports of northern long-eared bats on Shelter Island were occurring in December 2015, suggesting that there is potential for the population to survive and over-winter on Long Island even if at low population densities.

In 2015, BNL continued to participate in several events in support of ecological education programs including: providing on-site ecology tours; hosting the Twentieth Annual Pine Barrens Research Forum for ecosystems researchers to share and discuss their results; participation in the Sixth Annual Pine Barrens Discovery Day held at the Wertheim National Wildlife Refuge; and assisting the Central Pine Barrens Commission on "A Day in the Life of the Rivers," which allowed students from multiple school districts to acquire environmental and biological data about the Carmans, Peconic, and Nissequogue Rivers. On four separate days, over 30 partner organizations and agencies, 29 school districts, and over 1,500 students collected scientific information for analysis to be used to portray the status of the rivers and estuary systems. These events provide students hands-on experience with field techniques in catching fish, invertebrate sampling, biodiversity inventory, and water chemistry. In addition, BNL is in the 12th year of the Open Space Stewardship Program (OSSP) and worked with 30 schools and over 3,000 students in 2015. The OSSP enables students to engage in activities to solve problems within their local community through scientific discovery, conservation, and stewardship. The effort integrates outdoor research with school curricula in language arts, civics, community service, and media arts. Participation in OSSP creates an opportunity for many students to enhance their educational experiences as well as to promote the realization that a career in science and technology is accessible with the proper academic coursework and interaction with teachers and field experts who have a passion for discovery and mentorship.

The Laboratory also hosts 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. A growing season prescribed fire was planned to take place in June 2015; however, extended drought conditions prevented implementation.

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. BNL's cultural resources include buildings and structures, World War I (WWI) earthwork features, the Camp Upton Historical Collection, scien-tific 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 2014, BNL submitted a Section 106 review concerning the planned demolition of four structures on site to the New York State Historic Preservation Office (NYSHPO) for review as

required under the National Historic Preservation Act. Although the four buildings were auxiliary support structures associated with the early history of BNL, they were determined not to have played a significant contribution. The NYSHPO requested additional analysis in order to provide concurrence with the finding. Discussions with the NYSHPO concluded on the topic in 2015 with a NYSHPO concurrence with the Section 106 findings.

In 2014, the Laboratory loaned the Long Island History Museum materials from the Camp Upton Collection covering both World War I and WW II for their display on "Long Island at War." The materials were returned to BNL early in 2015. A small display on Camp Upton is continually maintained at the Laboratory's cafeteria and conference center in Berkner Hall. The display is reviewed each year for changes before the Summer Sundays program starts in July. During Summer Sundays 2015, a 'History of the BNL Site' and the "Construction of Camp Upton" talks were presented to visitors. The Laboratory also made arrangements for the loan of materials associated with "Tennis for Two," which is considered to be the first video game. Materials were loaned to the New York Historical Society Museum and Library in New York City, and the Stron Museum, National Museum of Play in Rochester, New York.

The Laboratory undergoes an annual external assessment as part of its ISO 14001 certification, which is discussed in Chapter 2, and in 2014, the Cultural Resource Management program was evaluated. The Cultural Resource Management Plan contains a Standard Operating Procedure (SOP) for the tagging of cultural resource items. This SOP had not been implemented due to staffing issues. The assessment listed the finding as a non-conformance and corrective actions were required to ensure that the tagging program was implemented. An intern project was posted at C.W. Post Library Sciences department and an intern was selected and scheduled to start on the project by year's end. The tagging of historically significant items was implemented in 2015 with new items being tagged as they are identified.

REFERENCES AND BIBLIOGRAPHY

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

BNL, 2011. Five-Year Review Report for Brookhaven National Laboratory Superfund Site, March 2011.

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.

Rispoli, Fred J., Green Timothy, Fasano, Thomas A., Shah, Vishal, 2014. The effect of environmental remediation on the cesium-137 levels in white-tailed deer. Environmental Science and Pollution Research Oct. 2014, 21(19): 11598-11602.