

Natural and Cultural Resources

The Brookhaven National Laboratory (BNL) 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 maintaining compliance with applicable regulations.

The goals of the program include protecting and monitoring the ecosystems, 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 2021, deer, vegetation, and soil sampling results were consistent with previous years' results.

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 for research and interpretation. In 2021, 19 buildings were confirmed by the New York State Historic Preservation Office to be eligible for listing on the National Register of Historic Places. The Cultural Resource program, working with the BNL Graphic Arts team, was able to digitize 1,448 videotapes to digital format for readily available use by the Lab and historians.

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 five years, with the most recent update completed in 2021 (BNL 2021).

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.

Mapping associated with tracking impacts from the operation of the Long Island Solar Farm (LISF) at BNL continues to use GPS and GIS as tools to analyze changes to wildlife populations and vegetation. In 2020, the Lab secured a contract with an aerial imaging service that provides high-definition images that are updated three times each year. This service allows tracking of visually evident changes in vegetation, hydro-period, and infrastructure. The service includes aerial imagery dating back to 2014.

A wide variety of vegetation, birds, reptiles, amphibians, and mammals inhabit the BNL site. Through implementation of the NRMP, endangered and threatened species, as well as

Table 6-1. Federal and New York State Threatened & Endangered Species, Species of Special Concern, & Species of Greatest Conservation Need.

Federal and New York State Threatened & Endangered Species, Species of Special Concern, & Species of Greatest Conservation Need			
Common Name	Scientific Name	State Status	BNL Status
Insects			
Comet damer	<i>Anax longipes</i>	SGCN	Confirmed
Frosted elfin	<i>Callophrys iris</i>	T	Likely
New England bluet	<i>Enallagma laterale</i>	SGCN	Likely
Little bluet	<i>Enallagma minusculum</i>	T	Likely
Scarlet bluet	<i>Enallagma pictum</i>	T	Likely
Pine Barrens bluet	<i>Enallagma recurvatum</i>	T	Confirmed
Mottled duskywing	<i>Erynnis martialis</i>	SC	Likely
Persius duskywing	<i>Erynnis persius persius</i>	E	Likely
Pine barrens zanclognatha	<i>Zanclognatha martha</i>	SGCN	Confirmed
Black-bordered lemon moth	<i>Marimatha nigrofimbria</i>	SGCN	Confirmed
Fish			
Banded sunfish	<i>Enneacanthus obesus</i>	T	Confirmed
Swamp darter	<i>Etheostoma fusiforme</i>	T	Confirmed
Amphibians			
Marbled salamander	<i>Ambystoma opacum</i>	SC	Confirmed
Eastern tiger salamander	<i>Ambystoma tigrinum tigrinum</i>	E	Confirmed
Fowler's toad	<i>Bufo fowleri</i>	SGCN	Confirmed
Four-toed salamander	<i>Hemidactylium scutatum</i>	SGCN	Confirmed
Eastern spadefoot toad	<i>Scaphiopus holbrookii</i>	SC	Confirmed
Reptiles			
Worm snake	<i>Carphophis amoenus</i>	SC	Confirmed
Snapping turtle	<i>Chelydra serpentina</i>	SGCN	Confirmed
Spotted turtle	<i>Clemmys guttata</i>	SC	Confirmed
Northern black racer	<i>Coluber constrictor</i>	SGCN	Confirmed
Eastern hognose snake	<i>Heterodon platyrhinos</i>	SC	Confirmed
Stinkpot turtle	<i>Sternotherus odoratus</i>	SGCN	Confirmed
Eastern box turtle	<i>Terrapene carolina</i>	SC	Confirmed
Eastern ribbon snake	<i>Thamnophis sauritus</i>	SGCN	Confirmed
Birds (nesting, transient, or potentially present)			
Cooper's hawk	<i>Accipiter cooperii</i>	SC	Confirmed
Sharp-shinned hawk	<i>Accipiter striatus</i>	SC	Confirmed
Grasshopper sparrow	<i>Ammodramus savannarum</i>	SC	Confirmed
Great egret	<i>Ardea alba</i>	SGCN	Confirmed
Whip-poor-will	<i>Caprimulgus vociferus</i>	SC	Confirmed
Northern harrier	<i>Circus cyaneus</i>	T	Confirmed
Black-billed cuckoo	<i>Coccyzus erythrophthalmus</i>	SGCN	Confirmed
Northern bobwhite	<i>Colinus virginianus</i>	SGCN	Confirmed
Prairie warbler	<i>Setophaga discolor</i>	SGCN	Confirmed
Horned lark	<i>Eremophila alpestris</i>	SC	Confirmed
Perigrine Falcon	<i>Falco peregrinus</i>	E	Confirmed
Bald Eagle	<i>Haliaeetus leucocephalus</i>	T	Confirmed
Wood thrush	<i>Hylocichla mustelina</i>	SGCN	Confirmed
Red-headed woodpecker	<i>Melanerpes erythrocephalus</i>	SC	Confirmed
Osprey	<i>Pandion haliaetus</i>	SC	Confirmed
Scarlet tanager	<i>Piranga olivacea</i>	SGCN	Confirmed
Glossy ibis	<i>Plegadis falcinellus</i>	SGCN	Confirmed
Brown thrasher	<i>Toxostoma rufum</i>	SGCN	Confirmed
Blue-winged warbler	<i>Vermivora pinus</i>	SGCN	Confirmed

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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). New York State endangered animal species confirmed as currently inhabiting Laboratory property include the eastern tiger salamander (*Ambystoma t. tigrinum*) and the peregrine falcon (*Falco peregrinus*).

Endangered plants that have been confirmed on the BNL site include Engelman spikerush (*Eleocharis engelmannii*), Ipecac spurge (*Euphorbia ipecacuanhae*), dwarf huckleberry (*Gaylussacia bigeloviana*), and whorled loosestrife (*Lysimachia quadrifolia*). Five other New York State endangered species have been identified at BNL in the past or are possibly present including: Persius duskywing (*Erynnis p. persius*), crested fringed orchid (*Plantathera cristata*), prostrate knotweed (*Polygonum aviculare ssp. buxiforme*), bracken fern (*Pteridium aquilinum var. pseudo-caudatum*), and possum haw (*Viburnum nudum var. nudum*).

Eight threatened species in New York State 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*]); three plants (stiff-leaved goldenrod [*Oligoneuron rigida*], stargrass [*Aletris farinosa*], and eastern showy aster [*Eurybia spectabilis*]); the northern harrier (*Circus cyaneus*) is periodically seen in the fall; and the bald eagle (*Haliaeetus leucocephalus*) is routinely seen visiting the site. Insects listed as threatened include the Pine Barrens bluet (*Enallagma recurvatum*),

Table 6-1. Federal and New York State Threatened & Endangered Species, Species of Special Concern, & Species of Greatest Conservation Need (concluded).

Federal and New York State Threatened & Endangered Species, Species of Special Concern, & Species of Greatest Conservation Need			
Common Name	Scientific Name	State Status	BNL Status
Mammals			
Northern long-eared bat	<i>Myotis septentrionalis</i>	FT	Confirmed
Plants			
Small-flowered false foxglove	<i>Agalinis paupercula</i>	R	Confirmed
Stargrass	<i>Aletris farinosa</i>	T	Confirmed
Butterfly weed	<i>Asclepias tuberosa ssp. interior</i>	V	Confirmed
Spotted wintergreen	<i>Chimaphila maculata</i>	V	Confirmed
Flowering dogwood	<i>Cornus florida</i>	V	Confirmed
Pink lady's slipper	<i>Cypripedium acaule</i>	V	Confirmed
Ground pine	<i>Dendrolycopodium obscurum</i>	V	Confirmed
Round-leaved sundew	<i>Drosera rotundifolia var. rotundifolia</i>	V	Confirmed
Marginal wood fern	<i>Dryopteris marginalis</i>	V	Confirmed
Engelman spikerush	<i>Eleocharis engelmannii</i>	E	Confirmed
Ipecac spurge	<i>Euphorbia ipecacuanhae</i>	E	Confirmed
Eastern showy aster	<i>Eurybia spectabilis</i>	T	Confirmed
Dwarf huckleberry	<i>Gaylussacia bigeloviana</i>	E	Confirmed
Winterberry	<i>Ilex verticillata</i>	V	Confirmed
Sheep laurel	<i>Kalmia angustifolia</i>	V	Confirmed
Narrow-leaved bush clover	<i>Lespedeza angustifolia</i>	R	Confirmed
Wild lupine	<i>Lupinus perennis</i>	R	Confirmed
Whorled loosestrife	<i>Lysimachia quadrifolia</i>	E	Confirmed
Bayberry	<i>Myrica pensylvanica</i>	V	Confirmed
Stiff-leaved goldenrod	<i>Oligoneuron rigida</i>	T	Confirmed
Cinnamon fern	<i>Osmunda cinnamomea</i>	V	Confirmed
Clayton's fern	<i>Osmunda claytoniana</i>	V	Confirmed
Royal fern	<i>Osmunda regalis</i>	V	Confirmed
Crested fringed orchid	<i>Plantathera cristata</i>	E	Likely
Green fringed orchid	<i>Platanthera lacera</i>	V	Confirmed
Prostate knotweed	<i>Polygonum aviculare ssp. buxiforme</i>	E	Possible
Bracken fern	<i>Pteridium alquilinum var. pseudocaudatum</i>	E	Possible
Swamp azalea	<i>Rhododendron viscosum</i>	V	Confirmed
Long-beaked bald-rush	<i>Rhynchospora scirpoides</i>	R	Confirmed
New York fern	<i>Thelypteris novaboracensis</i>	V	Confirmed
Marsh fern	<i>Thelypteris palustris var. pubescens</i>	V	Confirmed
Possum haw	<i>Viburnum nudum var. nudum</i>	E	Possible
Virginia chain-fern	<i>Woodwardia virginica</i>	V	Confirmed
Notes: information based on 6 NYCRR Part 182, 6 NYCRR Part 193, and BNL survey data. E = endangered FE=federally endangered FT = federally threatened R = rare SC = species of special concern SGCN = species of greatest conservation need T = threatened V = exploitably vulnerable			

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. BNL has one federally threatened species, the northern long-eared bat (*Myotis septentrionalis*), that is found within the forests of the Lab.

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 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.

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 2021, a limited number of surveys were completed as COVID-19 restrictions were still in place. A total of six ponds were visited with documentation of 88 egg masses.

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 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. Drought conditions that lasted from 2015 through early 2017 likely resulted in the extirpation of the banded sunfish from the BNL site. The single known habitat held water throughout 2018 and 2019 could likely sustain sunfish. However, a short survey by NYSDEC personnel in 2019 did not find sunfish in the pond. No additional effort has been made regionally with regard to the banded sunfish in 2021.

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 2021, monthly surveys were conducted starting at the end of April and extending through the end of August. These surveys identified 67 bird species, compared to the 65 species identified in 2020 and 73 species in 2019. A total of 135 bird species have been identified in surveys in the past 22 years; 59 of these species were present in each of the past 22 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 on site are by the LISF, the Peconic River, and the eastern edge of the BNL property. The transects passing through the various forest types on site (e.g., white pine, pine-oak forest, and red maple-mesic heath forest) showed a less diverse bird community. Bird survey data are stored in an electronic database for future reference and study. Little data on the effects of a large, utility-scale solar array such as the LISF are present within scientific literature. To assess the effects of the LISF on local bird populations, the collection of migratory bird data in both the Biology Field and Solar Farm transects is important. The LISF vegetation and the way it is managed may play a key role as habitat for migratory birds.

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. The LISF created nearly 200 acres of suitable habitat for the eastern blue bird. Forty boxes were installed around the northern-most portions of the LISF and are routinely used by bluebirds, house wrens, and tree swallows. Bluebirds have also benefited from natural nesting habitat

resulting from the 2012 wildland fire that resulted in significant tree mortality. Bluebirds have been documented annually within the burned area since 2019.

In 2019, a pair of peregrine falcons (*Falco peregrinus*) successfully nested on the stack of the former High Flux Beam Reactor (HFBR). The pair took over a common raven's nest and successfully raised two chicks. While the nesting is a great success, the nesting was discouraged in 2020 to allow the demolition of the stack which is required under the Record of Decision for the Decontamination and Dismantlement of the HFBR. The falcons had been seen in various locations on site in 2020 but nesting was not documented. In 2021, the falcons took over an osprey's nest located on a cellular tower on the western portion of the Lab. The pair successfully raised three chicks.

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. To control the goose population, the Laboratory manages nesting through egg oiling under an annual permit from the U.S. Fish & Wildlife Service. In 2020, the nest management program was suspended due to restrictions associated with COVID-19. Prior to the start of nesting, the population was estimated at 105 birds; nesting success resulted in a population of approximately 150 birds by August 2020. Nest management in 2021 was overall successful with only a dozen or so goslings produced. The number of resident geese was lowered to approximately 40 birds through the permanent removal of 82 geese from the flock by USDA Wildlife Services.

6.1.2.4 Bald Eagle

The bald eagle (*Haliaeetus leucocephalus*) has been increasing in population locally on Long Island with more than a dozen known nest sites on the island. Bald eagles were sighted numerous times in the area of the Sewage Treatment Plant (STP) throughout 2021. As the eagle population increases on Long Island, the potential for them to nest on the BNL site will increase as well.

6.1.2.5 Northern Long-eared Bat

As discussed in Section 6.1.1, the northern long-eared bat was added to the list of federally threatened species in 2015. BNL began planning for the eventual listing and put in place actions to minimize the likelihood of impacting this species. The two most likely activities that could impact this bat on the BNL site are building demolitions and prescribed fires. Inspections for the presence of bats may be conducted through either acoustic or visual surveys prior to demolition. Regardless of the outcome of acoustic monitoring (when conducted), a final internal inspection of the building(s) is conducted approximately 24 hours prior to demolition to verify the absence of bats.

For growing season prescribed fires, acoustic monitoring may be done within the burn unit to determine if there is bat activity. If positive results occur, surveys of the entire burn 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 2021, two buildings were demolished, and there was no impact to bats. No prescribed fires were conducted in 2021.

To ensure continued understanding of the presence and use of forested habitats by bats, four nights of mist netting were conducted during July and August. No northern long-eared bats were captured. However, acoustic monitoring detected at least one occurrence. Other bats captured included big brown bats (*Eptesicus fuscus*) and eastern red bat (*Lasiurus borealis*). The need to continue bat monitoring will likely increase in the future as the northern long-eared bat is currently under review for being listed as endangered under the Endangered Species Act.

6.1.3 Population Management

In addition to controlling resident Canada goose populations described above, the Laboratory also monitors or 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 ideal nesting and foraging habitat for wild turkey

(*Meleagris gallapavo*). In 2021, the on-site population continued to range between 350 and 500 birds due to successful nesting. Each year, NYSDEC manages a hunting period during the week of Thanksgiving, and a youth-only hunt in May for several areas across Long Island, which typically results in approximately 100 birds taken. The NYSDEC is considering expanding turkey hunting to a month-long season in 2022.

6.1.3.2 White-Tailed Deer

BNL consistently updates information on the resident population of white-tailed deer (*Odocoileus virginianus*). As there are no natural predators on site and hunting is not permitted at the Laboratory, there are no significant pressures on the population to migrate beyond their typical home range of approximately one square mile. Normally, a population density of ten 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.

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 (e.g., songbird species reduction due to selective grazing and destruction of habitat by deer), and property damage (e.g., collision damage to autos and browsing damage to ornamental

plantings). Deer-related collisions on site continued to be low presumably due to deer harvest as well as fewer employees onsite due to the COVID-19 pandemic.

High deer populations are a regional problem, and the Laboratory is just one area on Long Island with such an issue. Multiple east end towns are now managing deer populations either through culls (aka deer harvests), hunting, or sterilization programs. 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. BNL has been implementing deer management since 2015 and conducting herd reductions annually since 2018. The herd was estimated at 425 at the end of 2020 and a harvest was planned for two separate weekends between February and April 2021.

The first herd reduction was conducted in February 2021 with the second round in mid-March, both resulting in a total of 81 animals being taken. Several nights had bad weather and/or icy conditions that prevented safe operations. The removal of 81 deer effectively brought the population to approximately 344 animals which did not meet the reduction goals of getting below 250 deer. With reproduction at approximately 60 percent, the population at the end of 2021 was estimated at approximately 400 deer. Reproductive effort indicated potential population growth to roughly 500 deer but the presence of Epizootic Hemorrhagic Disease (EHD) on Long Island may have resulted in the lower population. EHD is a viral disease transmitted by biting midges and the disease is usually fatal once symptoms emerge. At least a couple of documented deer deaths on the BNL site were likely the result of EHD. Efforts were underway in the fall of 2021 to plan for the next round of population management in 2022 with a later start to avoid weather and help ensure reduction goals can be achieved.

6.1.4 Compliance Assurance and Potential Impact Assessment

The National Environmental Policy Act (NEPA) review process at BNL ensures that environmental impacts of a proposed action or activity



4 poster™ tick management system

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 (CAC), 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.

In January 2020, the Department of Energy (DOE) announced the award for construction of the Electron-Ion Collider at BNL. This resulted in the development of an Environmental Evaluation and Notification Form that was submitted to the Brookhaven Site Office and a determination was issued that an Environmental Assessment (EA) would be necessary. The EA was developed and presented to the CAC in September 2020 and was further developed for submission to New York State by year's end. The EA was finalized and a Finding of No Significant Impact was issued by DOE on March 26, 2021.

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 which also coordinates research projects that occur within the reserve and the larger Pine Barrens. After successfully establishing a Memorandum of Understanding (MOU) with the State

University of New York's School of Environmental Science and Forestry (SUNY-ESF), efforts to revisit the 2005-2006 forest health monitoring program resulted in the completion of monitoring during summer 2020 (see education programs below). The MOU with SUNY-ESF allows for greater levels of research within the Central Pine Barrens and the Upton Reserve. Little research was conducted in 2021 due to continued limitations for on-site internships due to COVID-19.

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 the site. 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 attributable to past practices and worldwide fallout from above-ground nuclear bomb testing can be found in deer and other animals and plants. At the cellular level, Cs-137 takes the place of potassium (K), an essential nutrient. Most tables in this chapter listing Cs-137 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 allows 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 are described in the following sections.

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. 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 one 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 2021, a total of 19 deer were taken both on and off the BNL site. However, the meat sample from one of the onsite deer taken during the deer cull was contaminated during preparation at the analytical laboratory and had to be discarded resulting in 18 meat samples and 19 liver samples.

Figure 6-1 shows the location of all deer samples taken within a five-mile radius of the Laboratory between 2017 and 2021. Most of the off-site samples are concentrated along the William Floyd Parkway on the west boundary of BNL, whereas historically most on-site samples are collected near the Laboratory's main entrance gate and the developed portions of the site. The distribution of deer samples onsite is becoming more uniform across the site due to obtaining samples during annual deer population reduction efforts. Historically, samples tended to be from near the front gate due to collisions with cars entering or leaving the site.

Based on more than two decades of sampling, deer taken from more than one mile from BNL are used for comparison with populations on and near the Laboratory that could acquire Cs-137 from a BNL source. In 2021, 18 deer were obtained on site, of which 14 were sampled as part of deer reduction efforts, and only one deer was taken from offsite greater than a mile from BNL. As mentioned above, one meat sample from the deer reduction efforts had to be discarded, leaving 17 onsite samples for analysis. The low number of offsite deer was the result of an increased number of employees who normally report deer for sampling continued

to work from home due to COVID-19. The one offsite deer and four of the onsite deer were due to deer/vehicle collisions. The analytical results of deer sampling are shown in Table 6-2. The samples taken as part of deer population reductions serve a dual purpose to provide data for surveillance and to determine the safe release of meat for consumption. Every tenth deer taken was sampled for Cs-137 content in both meat and liver.

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 one 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 and grazing animals or is consumed directly with soil while the animal is grazing.

Remediation of contaminated soil areas on site occurred under the Laboratory's Comprehensive Environmental Response, Compensation & Liability Act (CERCLA) program, with all major areas of contaminated soil being remediated by September 2005.

In 2021, Cs-137 concentrations in deer meat samples were obtained from 17 deer on site with a range of values from 0.07 pCi/g, wet weight, to 1.99 pCi/g, wet weight, and an arithmetic average of 0.41 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 2021 (1.99 pCi/g, wet weight) was roughly eight times the highest on-site sample reported in 2020 (0.24 pCi/g, wet weight) and six times lower than the highest level ever reported in 1996 (11.74 pCi/g, wet weight). Higher values in deer are usually seen during the fall months immediately after plants stop growing and uptake ceases. By January, cesium has usually been excreted.

Cs-137 concentrations in off-site deer meat samples are typically separated into two groups:

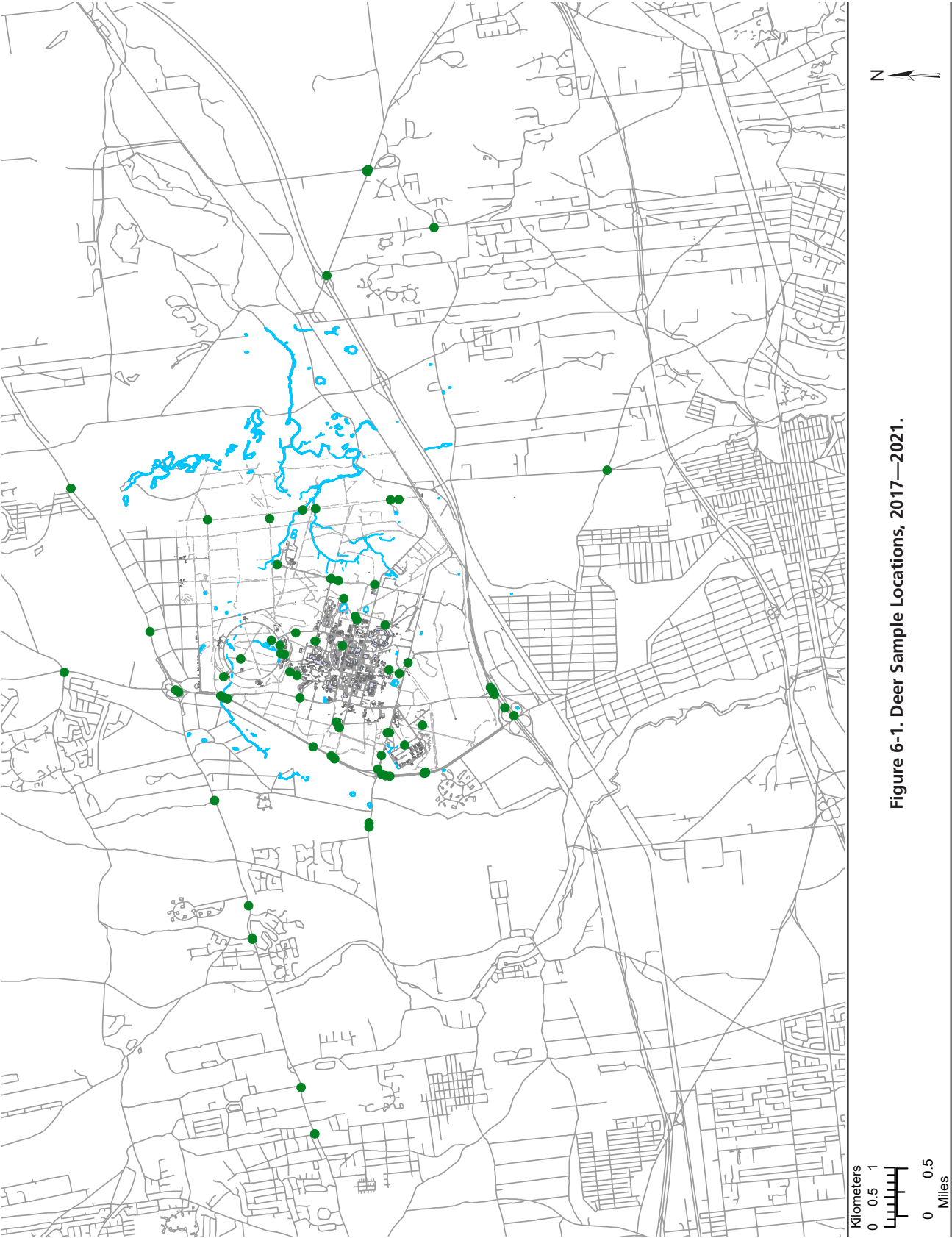


Figure 6-1. Deer Sample Locations, 2017—2021.

CHAPTER 6: NATURAL AND CULTURAL RESOURCES

Table 6-2. Radiological Analyses of Deer Tissue (2021).

Sample Location	Collection Date	Tissue	K-40 pCi/g (Wet Weight)	Cs-137 pCi/g (Wet Weight)
BNL				
Cull Sample 1 East Firebreak at HM-s	2/20/21	flesh	3.21±0.62	0.63±0.07
		liver	2.39±0.19	0.12±0.01
Cull Sample 2 HT-e Area	2/20/21	flesh	3.24±0.57	0.20±0.04
		liver	2.00±0.17	0.04±0.01
Cull Sample 3 former Bldg 51 Area	2/20/21	flesh	2.83±0.65	0.26±0.05
		liver	2.03±0.19	0.05±0.01
Cull Sample 4 First St. South of East Fifth Ave.	2/21/21	flesh	1.38±0.82	0.36±0.07
		liver	2.13±0.19	0.09±0.01
Cull Sample 5 East Firebreak at HM-n	2/21/21	flesh	3.16±0.73	0.07±0.04
		liver	2.31±0.18	0.01±0.01
Cull Sample 6 East of Bldg. 924*	2/22/21	liver	2.20±0.16	0.06±0.01
Cull Sample 7 West Meteorology Field	3/12/21	flesh	3.14±0.56	0.13±0.03
		liver	2.19±0.16	0.03±0.01
Cull Sample 8 RHIC Center	3/13/21	flesh	3.17±0.48	0.23±0.04
		liver	2.00±0.14	0.05±0.01
Cull Sample 9 East Firebreak North of South Boundary 1	3/13/21	flesh	3.26±0.47	0.33±0.04
		liver	2.30±0.31	0.07±0.02
Cull Sample 10 Stump Dump	3/13/21	flesh	2.43±0.45	0.17±0.03
		liver	2.10±0.21	0.05±0.01
Cull Sample 11 Front Gate Area	3/13/21	flesh	2.91±0.67	0.20±0.05
		liver	1.93±0.15	0.05±0.01
Cull Sample 12 East Princeton and Fawn Path	3/13/21	flesh	2.81±0.48	0.13±0.03
		liver	2.14±0.15	0.04±0.01
Cull Sample 14 East Firebreak North of South Boundary 2	3/14/21	flesh	3.03±0.88	0.44±0.07
		liver	2.02±0.26	0.10±0.02
Cull Sample 13 east of Basin HO	3/14/21	flesh	2.83±0.53	0.26±0.04
		liver	2.18±0.17	0.06±0.01
Rochester St. East of Bldg. 479	10/5/21	flesh	2.92±0.24	1.23±0.04
		liver	2.52±0.19	0.36±0.02
East Firebreak northeast corner	11/18/21	flesh	3.03±0.14	1.99±0.03
		liver	2.73±0.17	0.51±0.02
Princeton Ave. east of main gate deer 1	12/15/21	flesh	2.31±0.39	0.16±0.03
		liver	3.42±0.52	0.50±0.05
Princeton Ave. east of main gate deer 2	12/17/21	flesh	3.13±0.39	0.19±0.03
		liver	2.19±0.30	0.03±0.01
> 1 Mile from BNL				
Route 25, 1 mile east of East Bartlett Rd	3/4/21	flesh	2.91±0.16	0.06±0.01
		liver	2.82±0.22	0.01±0.01
Flesh Averages				
All Samples (18)			2.87±0.55	0.39±0.04
BNL Average (17)			2.87±0.56	0.41±0.04
> 1 Mile Average (1)			2.91±0.16	0.06±0.01
Cull Average (13)			1.88±0.62	0.26±0.05
Liver Averages				
All Samples (19)			2.29±0.23	0.12±0.02
BNL Average (18)			2.27±0.23	0.12±0.02
> 1 Mile Average (1)			2.82±0.22	0.01±0.01
Cull Average (14)			2.14±0.19	0.06±0.01

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%) propagated error.

* Cull Sample 6 flesh sample was damaged during lab preparation and could not be analyzed.

samples taken within one mile of BNL (no samples in 2021) and samples taken farther away (one sample in 2021), as shown in Table 6-2. Concentrations in meat samples taken within one mile were not available due to the lack of samples. Because deer on site may routinely travel up to one mile off site, the arithmetic average for deer taken on site and within one mile of the Laboratory is also calculated; for 2021, this could not be calculated due to the lack of near offsite deer samples. The single deer sampled from greater than one mile from BNL had a Cs-137 concentration of 0.06 pCi/g, wet weight. Figure 6-2 compares the average values of Cs-137 concentrations in meat samples collected in 2021 from onsite, greater than one mile, and deer taken from culling.

Figure 6-3 presents the ten-year trend of on-site and near off-site Cs-137 averages in deer meat. The 2021 average is approximately seven times the 2020 value of 0.06 pCi/g, wet weight but is lower than the ten-year average. The higher averages shown are reflective of a significant number of samples taken in the fall when Cs-137 levels are typically higher. However, these sample results continue to indicate the effectiveness of cleanup actions across the Laboratory, with the trend being downward from 2012 to 2021 and the ten-year average being 0.49 pCi/g.

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 one 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 2017, while preparing for monitoring associated with the reduction of the deer population, the ten-year average for on-site deer samples was calculated to be 1.0 pCi/g, wet weight, and this value was used to establish an administrative release criterion for deer meat made available for donation. 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 2021, Cs-137 concentrations ranged from 0.01 pCi/g to 0.51 pCi/g, wet weight, with an average of 0.12 pCi/g, wet weight. The single liver sample from deer taken greater than one mile from BNL had a Cs-137 concentration of 0.01 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 risks 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 has established an administrative release criterion of 1.0 pCi/g, wet weight, for meat from deer removed from the Laboratory and donated for consumption. A total of 81 deer were taken during population reductions in 2021. Meat samples were obtained from every tenth deer during the first weekend and every fifth deer during the second weekend. Samples were sent for analysis and are included in Table 6-2. The results ranged from 0.07 pCi/g, wet weight, to 0.44 pCi/g, wet weight, with the arithmetic average being 0.26 pCi/g, wet weight. Since all samples were well below the 1.0 pCi/g, wet weight administrative limit, all 2,204 pounds of meat were donated to Island Harvest Food Pantry.

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 μ Ci. That animal would receive an absorbed dose of approximately 3 millirad per day, which is only three percent of the IAEA threshold. The deer observed and sampled on

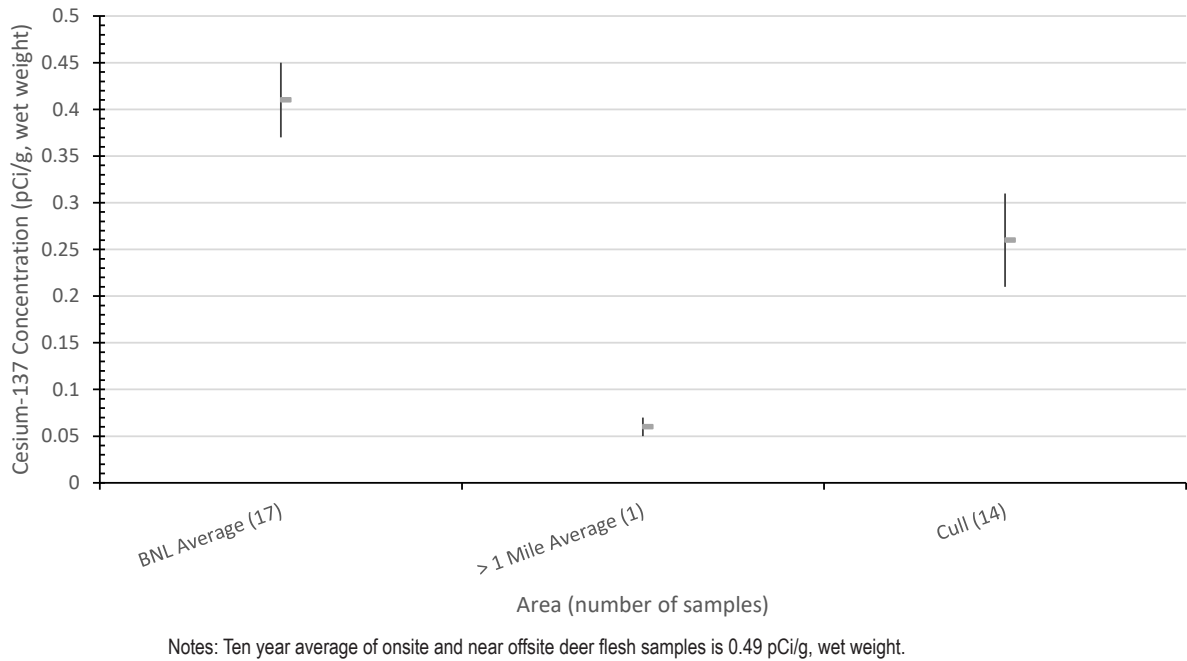


Figure 6-2. Comparison of Cs-137 values in deer flesh for onsite, offsite within 1 mile, onsite and near offsite, and offsite greater than 1 mile from the Laboratory.

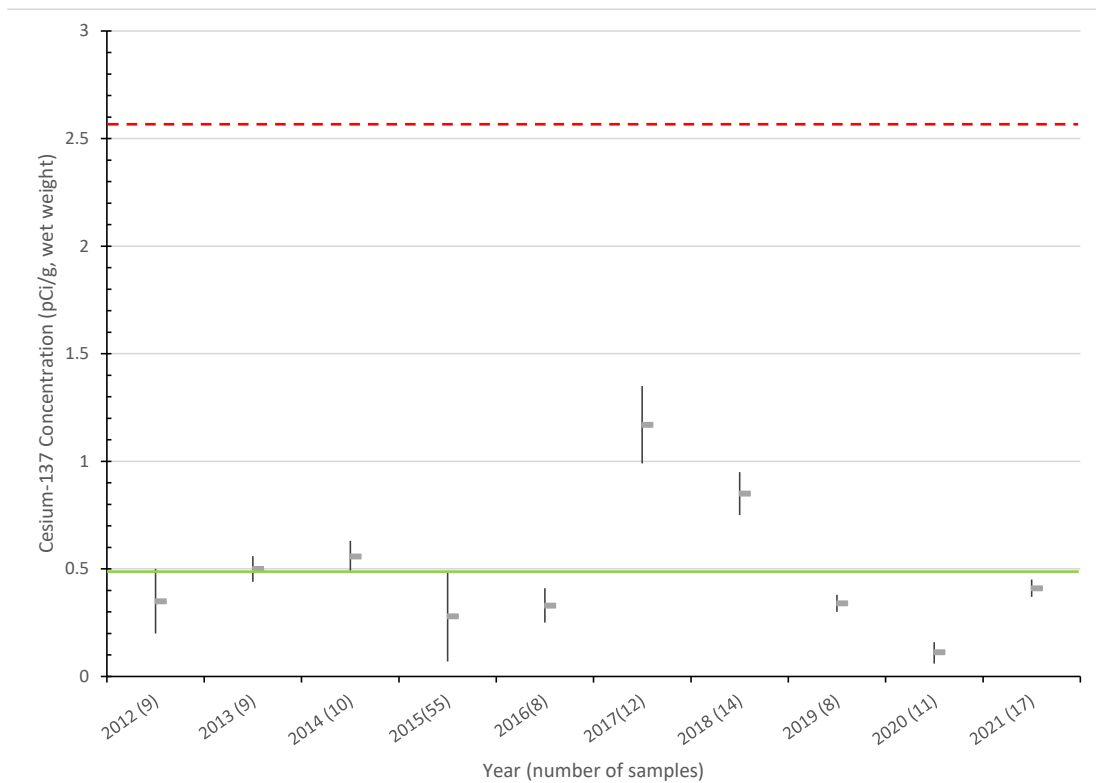


Figure 6-3. Ten year trend in Cs-137 in deer flesh for samples taken at BNL and within 1 mile of the Laboratory. Ten-year average is 0.49 pCi/g (solid line). The average before environmental cleanup was 2.57 pCi/g (dashed line).

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. A single Canada goose was hit by a car in 2021 and a sample was sent for analysis with an estimated result of 0.01 pCi/g, wet weight reported by the Laboratory.

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 has been conducted under the environmental surveillance program and the CERCLA post-cleanup program. Surveillance monitoring had occurred during even-numbered years and post-cleanup monitoring occurred in odd-numbered years. However, with the discontinuance of discharges from the STP to the Peconic River in September 2014 and current lack of flow off site, the objectives for the fish monitoring program have changed to reflect the current intermittent presence of water in the on-site portions of the river. Fish are now only sampled under the surveillance program when there is enough water to support a sufficient population of fish that can be sampled without harm to their population and that are of sufficient size for analysis.

Based upon the 2016 CERCLA Five-Year Review of the effectiveness of the environmental cleanup and the final supplemental cleanup of a small area within the river during 2017, the Laboratory has discontinued fish monitoring under the CERCLA program. However, when conditions allow, fish sampling will be conducted under the surveillance program for radionuclide, mercury, and PCB content. Analysis for radionuclides supports calculation for a dose to biota and dose to the maximally exposed off site individual. Due to lack of water and fish within the on-site portions of the Peconic River, no fish were sampled in 2021.

6.3.3.1 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 2015, even with low water levels in the on-site portion of the Peconic River, indicated that fish populations could maintain themselves. However, the combination of discontinuing STP discharges to the Peconic River results in high variability in the presence of water and flow sufficient enough to reach offsite portions of the river. In 2019, water levels began to recede, resulting in water being retained only in deeper open water areas and levels continued to recede through 2021. There was no documented offsite flow in 2021.

For fish populations to survive and flourish, water levels must be substantial enough to allow migration of fish and maintain their presence for an extended period to replenish populations. As mentioned above, new criteria for the collection of fish samples have been developed. These criteria will guide the environmental monitoring approach for fish in the future. To determine if enough fish are present to support sampling, population assessments are conducted. In 2021, a population assessment was conducted at the end of May and resulted in the capture of nine chain pickerel. The largest fish caught had a length of 80 mm, or a little over three inches. The average length of fish was 58 mm. Since there were no fish of significant size, no samples were taken.

6.3.4 Vegetation Sampling

6.3.4.1 Grassy Plants and Soil

During 2021, grassy vegetation samples were collected from 11 locations around the Laboratory (Figure 6-4) and a control location at the NYSDEC hunter check station in Ridge, New York. All samples were analyzed for Cs-137 (see Table 6-3). All vegetation samples were non-detect for Cs-137. Soil samples had Cs-137 levels ranging from non-detect to 0.27 pCi/g, dry weight. All values were consistent with historic monitoring and knowledge of cleanup areas.

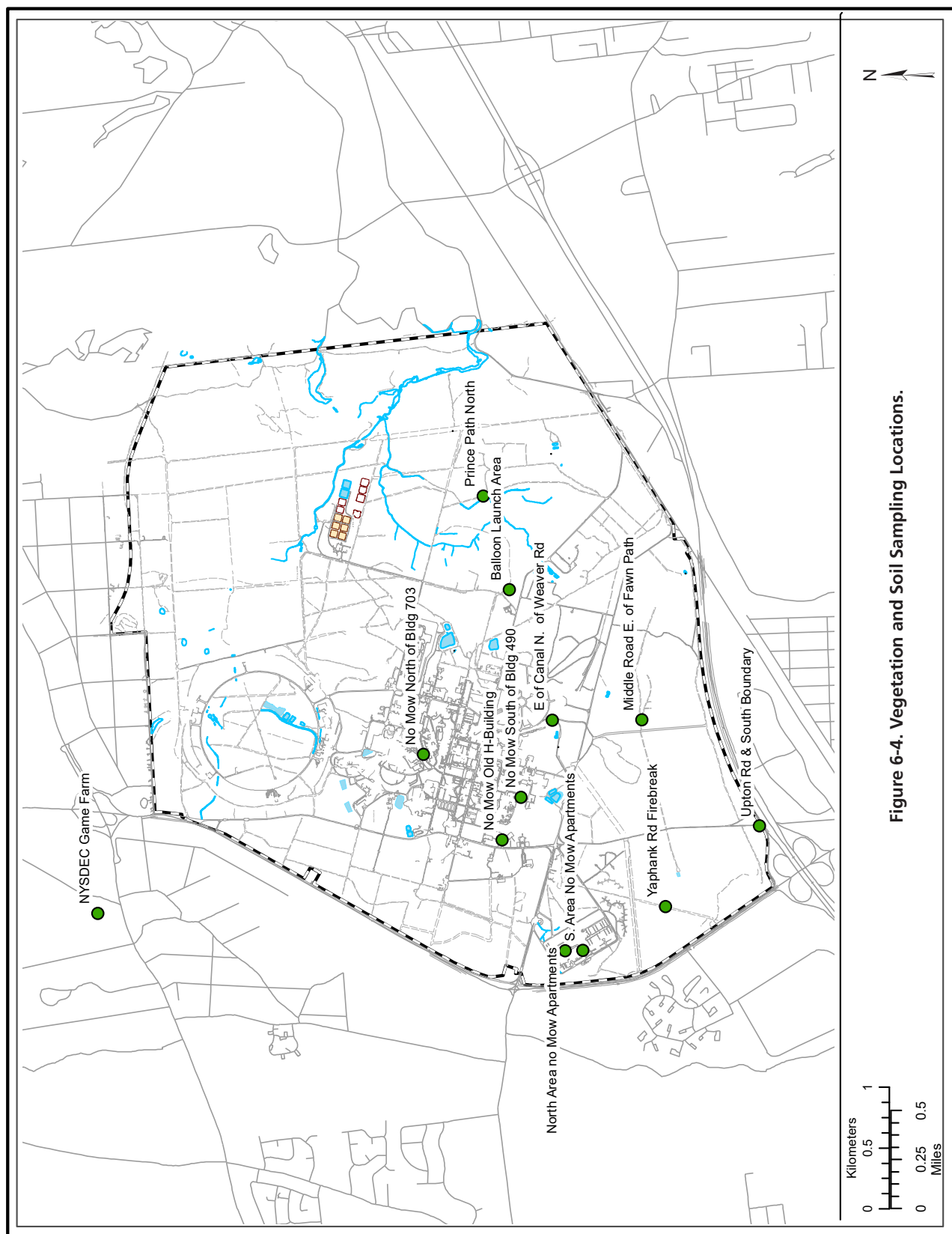


Figure 6-4. Vegetation and Soil Sampling Locations.

Table 6-3. Radiological analysis of grassy vegetation and associated soils.

Location/Matrix	K-40 pCi/g±95% C.I.	Cs-137 pCi/g±95% C.I.
North Area No Mow Apartments		
Vegetation	5.17±0.68	ND
Soil	6.31±1.11	0.27±0.07
South Area No Mow Apartments		
Vegetation	5.02±0.98	ND
Soil	6.00±0.90	0.20±0.05
No Mow South of Bldg. 490		
Vegetation	6.74±0.99	ND
Soil	5.77±0.81	0.22±0.06
E. of Canal N. of Weaver Rd.		
Vegetation	5.68±0.85	ND
Soil*	5.46±1.01	0.14±0.06
No Mow North of Bldg. 703		
Vegetation	4.08±0.71	ND
Soil*	4.54±0.81	0.17±0.06
Upton Rd. & South Boundary		
Vegetation	4.74±0.85	ND
Soil	6.83±1.11	0.20±0.08
Yaphank Rd. Firebreak		
Vegetation	6.29±1.00	ND
Soil*	7.06±0.90	0.08±0.05
Prince Path North		
Vegetation	4.25±0.86	ND
Soil*	5.19±0.85	0.08±0.06
Balloon Launch Area		
Vegetation	6.04±0.93	ND
Soil*	5.53±0.83	0.07±0.04
No Mow Old H-Building		
Vegetation	5.17±0.90	ND
Soil	5.62±0.81	0.20±0.06
Middle Road E. of Fawn Path		
Vegetation	5.22±1.10	ND
Soil	5.75±0.77	ND
NYSDEC Game Farm (Control)		
Vegetation	4.27±0.83	ND
Soil	5.14±0.87	0.27±0.07

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 laboratory qualifiers.

Monitoring results for grassy vegetation and soils were utilized for the annual dose to biota analysis reported in Chapter 8.

6.4 PRECIPITATION MONITORING**6.4.1 Mercury Monitoring of Precipitation**

During 2021, precipitation samples were collected quarterly at air monitoring Stations P4 and S5 (Figure 4-2 for station locations). The samples were analyzed for total mercury (Table 6-4) using low-level mercury analysis.

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 has been used as a comparison to Peconic River monitoring data and aids in understanding the distribution of mercury within the Peconic River watershed.

Mercury was detected in all the precipitation samples collected at both sampling stations. Mercury ranged from 2.52 ng/L at station P4 in January 2021 to 15.3 ng/L at station S5 in July 2021. The 15.3 ng/L concentration is three times lower than the highest value of 45.1 ng/L, recorded in 2017.

Table 6-4. Precipitation Monitoring (Mercury).

Location/Period	Mercury ng/L
P4	
1/19/21	2.52
4/12/21	5.79
7/7/21	10.6
10/18/21	7.92
S5	
1/19/21	2.81
4/12/21	6.92
7/7/21	15.3
10/18/21	7.41

Notes:

Method detection limit for mercury is 0.2 ng/L.
 P4 = precipitation sampler near BNL Apartment area.
 S5 = precipitation sampler near BNL Sewage Treatment Plant.

6.5 EDUCATIONAL 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 provide a meaningful experience for interns in preparation for further studies or a career. Wildlife programs are conducted at the Laboratory in collaboration with the DOE, local agencies, colleges, and high schools. Ecological research is also conducted on site to routinely update the natural resource inventory records, gain a better understanding of the ecosystem, and guide management planning.

In 2021, due to COVID-19 restrictions, all internships were required to be conducted virtually. Due to the nature of the natural resources program, the Environmental Protection Division hosted one intern during the summer of 2021 who worked on statistical analysis of data associated with the 4-Poster™ project for tick management.

In a normal year, BNL participates in, coordinates, or hosts activities that support ecological education on Long Island. In 2021, due to restrictions associated with COVID-19, the following programs were cancelled:

- Long Island Natural History Conference
- Participation in the Pine Barrens Discovery Day
- Open Space Stewardship Program (which involves 2,500 students from 30 schools)
- NY Wildfire & Incident Management Academy

However, the Day in the Life of a River program did run from September 24 to November 5, 2021. The Day in the Life of a River Program is a place-based educational experience where students and teachers collaborate with environmental professionals to collect scientific information capturing a snapshot of the health of the Long Island rivers and creeks. The Day in the Life of a River is a collaboration between the Central Pine Barrens Commission, the NYSDEC, and BNL.

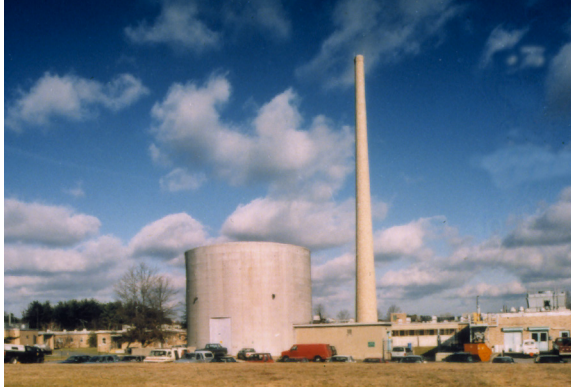
Due to the ongoing COVID-19 pandemic, the number of participants was not at pre-pandemic levels. For 2021, 1,392 students and 54 teachers from 30 Long Island schools participated in the program. The Day in the Life program was

supported by 69 experts from the US Geological Survey, Town of Brookhaven, Trout Unlimited, New York State Parks, Cornell Cooperative Extension, and Seatuck Environmental Association, among others.

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 2013) guides the management for all the Laboratory's historical resources. 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 local and national history and culture are documented and available for interpretation.

In 2019, the Laboratory contracted with Hartgen Archeological Associates to conduct historical architectural reviews of buildings that had recently reached 50 years of age. The contract continued into early 2020 with three reports covering the Alternating Gradient Synchrotron (AGS) complex, Medical Complex, and several other buildings. The reports provided determinations of eligibility for the Medical Complex (Buildings 490 and 491), Buildings 820, 820A, 820B, 830, 902, and the WWII water tower, and several buildings combined within the AGS complex, including Buildings 901, 901A, 911, 912, 913, 913A through E, and 930. Several buildings were determined to not meet criteria for consideration. The Lab submitted reports to the New York State Historic Preservation Office (NYSHPO) in 2021 and received concurrence of its findings. With COVID-19 restrictions lessened, the NYSHPO visited the Lab in October 2021 to gain a better understanding of the Lab's historic resources, see two resources that are scheduled for demolition, and discuss the potential for a Programmatic Agreement that would streamline the Section 106 process. In 2021, the Cultural



Brookhaven Medical Research Reactor.



World War II water tower

Resource program worked with Graphic Arts to establish a project to catalog and evaluate all of the video tapes held by Graphic Arts. The videos were evaluated, prioritized, and contract established with Puddle Drop Media to digitize those videos of highest historic value. The contract resulted in a total of 1,448 videos being digitized. The digitized videos are now more accessible for use in video production and historic study.

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