

**OBTAINING AN AUTHORIZED RELEASE FROM THE DEPARTMENT OF ENERGY
FOR SUBTITLE D DISPOSAL OF THE PECONIC RIVER SEDIMENTS CONTAINING
LOW LEVELS OF RADIONUCLIDES**

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ABSTRACT

Cleanup of the Peconic River at the Brookhaven National Laboratory (BNL) is proceeding under the Comprehensive Environmental Response, Compensation, and Liability Act process. A Proposed Remedial Action Plan (PRAP) and Draft Record of Decision (ROD) have been prepared. Past operations and practices at BNL resulted in wastewater containing chemical and radiological contaminants being processed at the BNL sewage treatment plant. Treated waste from the sewage treatment plant discharged into the Peconic River has been a source of contamination to the Peconic River sediment. This paper describes the procedural steps followed to obtain the Department of Energy (DOE) Authorized Release, including the analysis of characterization data and dose assessment, and close interaction with the New York State Department of Environmental Conservation (NYSDEC) to ensure New York State acceptance.

INTRODUCTION

Brookhaven National Laboratory (BNL), located on 5,265 acres in Upton, New York, is owned by the United States Department of Energy (USDOE) and operated by Brookhaven Science Associates, Inc (BSA). The U.S. Army used the site, formerly known as Camp Upton, during World Wars I and II and as a Civilian Conservation Corps (CCC) Camp between the two wars. In 1947, BNL was established as a multi-discipline, scientific research center, with emphasis on programs that require large-scale research tools, such as nuclear reactors, particle accelerators, and physical, biomedical, and environmental laboratories. Operation of the research facilities and past waste disposal practices have resulted in the introduction of contaminants to the BNL Sewage Treatment Plant and subsequent deposition in sections of the Peconic River.

In 1980, BNL was placed on the New York State Department of Environmental Conservation (NYSDEC) list of Inactive Hazardous Waste Disposal Sites. In 1989, it was included on the U.S. Environmental Protection Agency's (EPA) National Priorities List of Superfund sites. BNL has a total of 30 areas of concern (AOCs) grouped into distinct Operable Units (OUs). This project involves work in an upstream section of the Peconic River.

Past operations and practices at BNL resulted in wastewater containing chemical and trace radiological contaminants being processed at the BNL Sewage Treatment Plant. Treated waste from the sewage treatment plant discharged into the Peconic River has been a source of contamination to the Peconic River sediment. Figure 1 shows the location of the Peconic River on and off BNL site. Over the past several years, DOE and BNL have conducted extensive environmental investigations of the Peconic River sediment, fish, and plants. From the results of these investigations and discussions with the regulatory agencies and community members, it was determined that sediment in the Peconic River will be removed to reduce the potential for both human and ecological health risks. The basis for the cleanup is the presence of mercury and polychlorinated biphenyls (PCBs) detected in fish living in the portions of the river on the Laboratory property, and mercury detected in fish in portions of the Peconic River off of the Laboratory property. However, the PCB and mercury content in the Peconic River sediments is below the Toxic Substance Control Act (TSCA) regulatory levels and the Resource Conservation and Recovery Act (RCRA) hazardous waste designation levels, which will allow disposal at a RCRA Subtitle D, instead of RCRA Subtitle C, landfill.

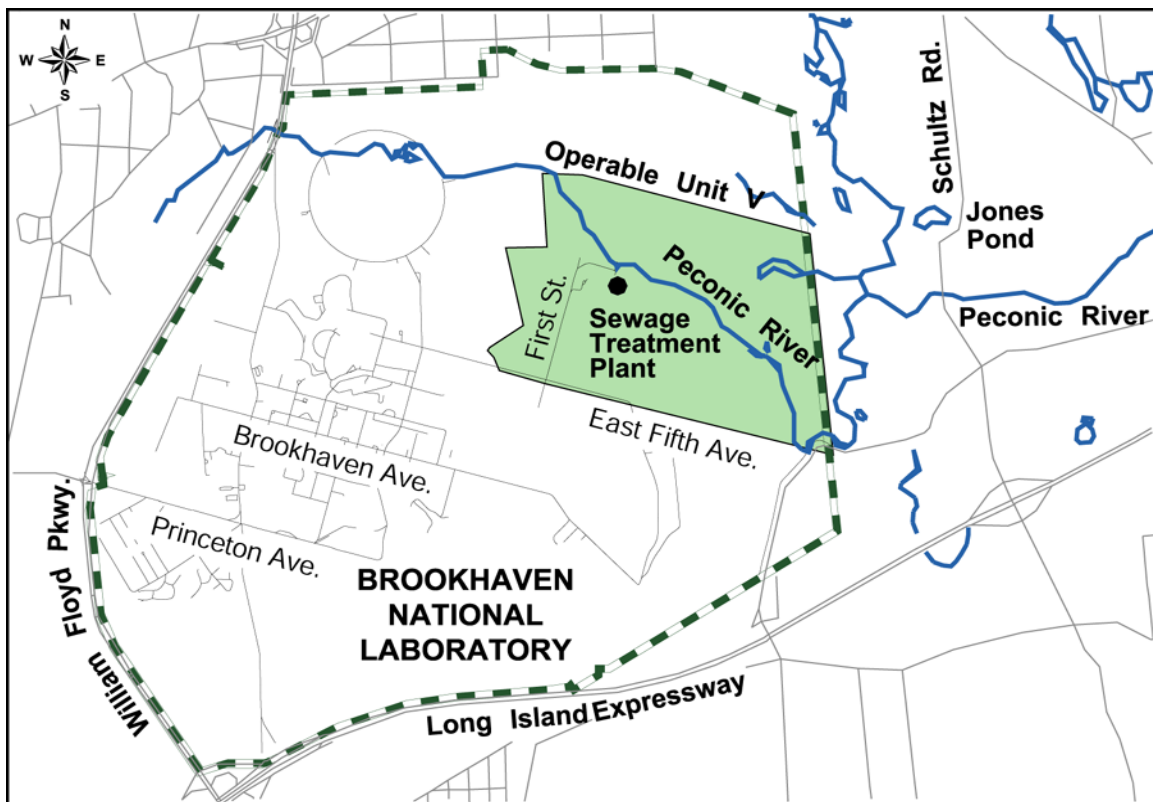


Fig. 1. Peconic River on-site and off-site at BNL.

WASTE DESCRIPTION

The Peconic River soils and sediments require remediation and off-site disposal. The origin of the contamination was from permitted discharges through the BNL Sewage Treatment Plant. The waste stream, once generated, will consist of 95% soils and sediments and 5% vegetative debris. The estimated waste volume is 24,000 cubic yards (cyds), with an upper bound of 29,000 cyds. The waste has been fully characterized for both radiological and hazardous constituents. The sediments to be excavated contain trace amounts of the following radioactive constituents: americium-241 (^{241}Am), cesium-137 (^{137}Cs), cobalt-60 (^{60}Co), plutonium-238 (^{238}Pu), plutonium-239/240 ($^{239/240}\text{Pu}$) and strontium-90 (^{90}Sr).

The results of the radionuclide characterization program for the Peconic River soil and sediment, and the measured range of background activity for Long Island, New York is provided in Table I for all of the radionuclides detected. This table lists the number of samples, the average sample concentrations (in pCi/g), the standard deviation, and the minimum and maximum sample concentrations (pCi/g) obtained from the characterization data (BNL 1997, 2000, 2001, and 2002).

Table I. Peconic River Sediment Sampling and Long Island Background Data^(a)

Radionuclide ^(b)	Number of Samples	Average (pCi/g)	Standard Deviation	Minimum (pCi/g)	Maximum (pCi/g)	Total Activity ^(f) (Ci)	Long Island Soil or Connetquot River Sediment Background Activity Range (pCi/g)
Gross alpha	3	1.2	0.68	0.38	1.6	N/A	N/A ^(c)
Gross beta	3	2.1	1.3	1.0	3.5	N/A	N/A ^(c)
³ H	15	0.11	0.05	ND	0.23	3.9E-03	N/A ^(c)
⁴⁰ K	63	5.0	1.5	2.5	8.6	N/A	1.4 – 12
⁶⁰ Co	67	0.13	0.09	ND	0.49	4.6E-03	N/A ^(c)
⁹⁰ Sr	18	0.60	0.83	ND	3.9	2.2E-02	0.02 - 0.64
¹³⁷ Cs	289	5.8	4.9	ND	33	2.1E-01	0.04 - 1.0
²⁰⁸ Tl	29	0.19	0.03	0.10	0.25	N/A	0.09 - 0.76
²¹⁰ Pb	29	2.8	2.2	ND	3.6	N/A	1.8 ^(d)
²¹² Pb	38	0.60	0.15	0.32	0.93	N/A	0.35 – 2.3
²¹⁴ Pb	34	0.46	0.11	0.23	0.73	N/A	0.08 – 2.0
²¹² Bi	24	0.43	0.13	ND	0.75	N/A	1.0 ^(e)
²¹⁴ Bi	24	0.42	0.09	0.21	0.59	N/A	1.8 ^(d)
²²⁶ Ra	35	0.49	0.27	0.21	1.9	N/A	0.05 – 2.2
²²⁸ Ra	24	0.62	0.13	0.30	0.84	N/A	1.0 ^(e)
²²⁸ Ac	24	0.62	0.13	0.30	0.84	N/A	1.0 ^(e)
²²⁸ Th	3	0.63	0.11	0.54	0.76	N/A	1.8 ^(d)
²³⁰ Th	24	0.42	0.09	0.21	0.59	N/A	1.8 ^(d)
²³⁴ Th	24	1.05	0.36	ND	1.7	N/A	1.8 ^(d)
^{233/234} U	88	0.51	0.28	0.16	1.4	N/A	0.16 – 4.4
²³⁵ U	112	0.07	0.08	ND	0.30	N/A	0.01 – 0.28
²³⁸ U	112	0.52	0.35	ND	1.7	N/A	0.17 – 4.2
²³⁸ Pu	88	0.002	0.001	ND	0.005	6.19E-05	ND - 0.027
^{239/240} Pu	88	0.040	0.036	ND	0.156	1.46E-03	0.001 - 0.07
²⁴¹ Am	172	0.32	0.42	ND	1.9	1.2E-02	0.001 - 0.04
						Total Curies	2.58E-01

(a) Based on information from BNL 1997, 2000, 2001, 2002, and CDM Federal Programs 1996.

(b) Radionuclides considered in this analysis are shown in grey highlights.

(c) N/A = Not Applicable.

(d) For ²³⁸U and decay chain members, the average value for soil in North America from NCRP Report No. 94 (NCRP 1987), Table 4.3, of 66 Bq/kg (1.8 pCi/g) is assumed

(e) For ²³²Th and decay chain members, the average value for soil in North America from NCRP Report No. 94 (NCRP 1987), Table 4.3, of 37 Bq/kg (1.0 pCi/g) is assumed.

(f) Total activity calculated using volume = 29,000 yd³ and density = 1.4 tons/yd³.

DEPARTMENT OF ENERGY AUTHORIZED RELEASE PROCESS

Over the past two years, the BNL cleanup project has been working with DOE staff on a disposal option that would allow this slightly volumetric-contaminated material to be disposed in a “Subtitle D” solid waste landfill. Under the Resource Conservation and Recovery Act (RCRA) regulations, solid waste includes both hazardous waste (Subtitle C) and non-hazardous waste (Subtitle D), e.g. municipal garbage. The levels of mercury contamination and radionuclides in the soil and sediment are sufficiently low to allow disposal in a Subtitle D landfill under RCRA regulations.

The Department currently does not have free release criteria (clearance level) for volume-contaminated material. However, DOE Order 5400.5, *Radiation Protection of the Public and the Environment* [1], allows for such material to be released if criteria and survey techniques are approved by the Assistant Secretary for Environment, Safety, and Health (EH-1). In a memorandum issued by the Director of the Office of Environmental Policy and Assistance (EH-41) in November 1995, interim guidance was provided to clarify issues relating to Order DOE 5400.5. This guidance allows for authorized limits and measurement protocols for release to be derived and approved by DOE field office managers without EH-1 written approval if:

Applicable criteria for onsite or offsite landfills as appropriate are addressed, such as applying of As-Low-As-Reasonably-Achievable criteria to optimize the balance between risks and benefits, ensuring ground water protection consistent with applicable State regulations and guidelines, ensuring that no future remediation will be required as a result of DOE disposal, and coordinating with landfill operators and State regulators to ensure landfill acceptance criteria and specific radiological protection requirements are met;

- Based on a realistic, but reasonably conservative assessment of potential doses, releases from the material are demonstrated to not exceed of 1 mrem per year (maximum exposed individual) or a collective dose of more than 10 person rem;
- A procedure is in place to maintain records of releases consistent with DOE Order 5400.5, and survey or measurements results are reported consistent with DOE reporting guidelines; and
- A copy of the authorized limits, measurement/survey protocols and procedures, and supporting documentation are archived, along with documentation on coordination with State regulators, and provided to the Office of Environment (EH-4) at least 40 days prior to the authorized limits becoming effective.

EH-4 staff is required to acknowledge receipt and notify the field office within 20 days of receipt if the authorized limits or supporting material are not acceptable; otherwise the authorized limits are considered approved without EH-1 approval.

The 1-mrem limit allows for fairly high radionuclide concentrations; however, it was BNL's experience that the authorized limit had to be set much lower, closer to background levels. Although the site recognized that there were tradeoffs of potentially having to dispose of some of the waste as low-level waste, the lower limit facilitated State approval. The Pine Avenue Landfill in Niagara Falls, New York, has rail access and is the planned disposal site for this waste. Several alternative disposal facilities/States were identified early on in the process to

serve as backup. For example, BNL originally planned to send the waste to the Lee County Landfill in South Carolina, but the State was not prepared to approve the disposal request. Other possible disposal sites considered included the EQ Detroit Inc. Landfill in the state of Michigan and Waste Control Specialists in Texas. Other landfills in Tennessee and Pennsylvania were considered and rejected because of a lack of rail access, even though they probably would have accepted the waste.

AUTHORIZED LIMITS TECHNICAL BASIS

The strategy used in developing the technical basis included conducting a radiation exposure scenario analysis for identified individuals who could be exposed during offsite shipment and disposal, with the determination of Authorized Limits that assure that individual radiation doses to members of the public will be less than 1 mrem/y, with a total collective dose less than 10 person-rem/y. Potential long-term remediation issues associated with disposal of the waste at a RCRA Subtitle D facility were evaluated by consideration of a post-closure human intrusion scenario and a long-term groundwater protection scenario. The TSD-Dose (Pfungston et al. 1998) and RESRAD (Yu, et al. 2001) computer programs were used.

The goal of this effort was to provide reasonable assurance that potential radiation doses to members of the public from the residual radioactive material in the Peconic River soils and sediments disposed of at a RCRA Subtitle D facility will be less than the DOE dose constraint for release under an Authorized Limit (less than 1 mrem/y to the maximum individual in the public and a collective dose less than 10 person-rem/y). The Authorized Limits are provided in units of pCi/g for the radionuclides identified for Peconic River soils and sediments. The Authorized Limits also considered administrative and practicality issues.

Dose calculations to the maximally exposed individuals who may receive radiation doses after release from BNL were performed using TSD-Dose for the average concentration of each radionuclide considered. Waste operations at the landfill, which included receipt inspection, transfer from the rail cars to trucks for landfill emplacement and covering the waste, were also evaluated using TSD-Dose. These calculations established that the doses were all less than 1 mrem/y. From these TSD-Dose calculations, through an administrative review process, the Authorized Limits were established. As a final check, the TSD-Dose calculations were performed at the assigned Authorized Limits to assure that the maximumally exposed individual would receive less than 1 mrem/y.

Since DOE contract workers would be loading the gondola rail cars, and since the BNL Radiological Protection Program (RPP) covers these operations, they are not considered to be members of the public for this analysis. Four major activities with potential exposures to define the maximally exposed individual members of the public were identified for the offsite shipment and disposal of BNL soils and sediments. These were consistent with those analyzed in the TSD-Dose computer program, modified to model the geometry of a gondola rail car, and included: 1) exposure to rail workers who may inspect the gondola rail cars, 2) receiving/inspecting/sampling the waste at the landfill, 3) unloading the rail car and truck transport to the landfill, and 4) disposal and covering the waste in the landfill. Each scenario involves different workers and no individual worker is exposed to all or multiple scenarios.

The Authorized Limits for BNL Peconic River soils and sediments, and the average waste concentration of each identified radionuclide are summarized for comparison in Table II. Authorized Limits are shown separately for both ^{239}Pu and ^{240}Pu , however analytical results for the two radionuclides are reported together as one result. An upper limit of about 22,200 m³ (29,000 yd³) of waste is assumed for this analysis. This volume would require about 427 gondola rail cars of waste, with each rail car containing about 52 m³ (68 yd³).

As part of the implementation of the Authorized Limits, BNL is keeping records of the radionuclide characterization and quantity of waste disposed, and calculating compliance with the Authorized Limits and curies sent for disposal.

Table II. Average Waste Concentrations and Authorized Limits for BNL Peconic River Soils And Sediments

Radionuclide	Average Waste Concentration (pCi/g)	Authorized Limit (pCi/g)
^3H	0.11	1
^{60}Co	0.13	2
^{90}Sr	0.60	5
^{137}Cs	5.8	10
^{238}Pu	0.002	1
^{239}Pu	0.04	1
^{240}Pu	0.04	1
^{241}Am	0.32	3

Table III summarizes the estimated TSD-Dose maximum individual radiation doses if the entire volume of soil and sediments were at the average concentrations for each radionuclide. For comparison, Table IV summarizes the estimated TSD-Dose maximum individual radiation doses if the entire volume of soil and sediments were at the Authorized Limits. The maximum individual dose results are shown to be less than 1 mrem/y for both the average concentrations and the Authorized Limit concentrations.

The evaluation also concluded that there would be no long-term groundwater impacts associated with disposal of the waste at a regulated RCRA Subtitle D landfill, even if no credit is taken for the clay liner system. The results concluded that drinking water doses out to 10,000 years are within the U.S. Environmental Protection Agency criterion of 4 mrem/y for the average waste concentrations. Groundwater protection is further assured by regulation and facility design.

Consistent with the DOE guidance, a conservative analysis of potential long-term remediation issues using a human intrusion scenario modeled after those used by the U.S. Nuclear Regulatory Commission (NRC) for low-level radioactive waste concluded that the potential dose to future intruders at the closed RCRA Subtitle D facility would be a fraction of the 100 mrem/y limit - a few mrem/y at most; thus, there would be no long-term remediation issues. The potential doses from the human intrusion scenario for the average waste concentrations were 5 mrem/y and 15

mrem/y for the Authorized Limits concentrations, immediately after disposal (i.e., no radioactive decay). The estimated dose to an intruder at 60 years post-disposal (accounting for 30 years of landfill operation after receipt of the BNL waste and 30 years of post closure monitoring and institutional control under RCRA) is 1.2 mrem/y at the average waste concentrations, and 2.3 mrem/y at the Authorized Limit concentrations.

Table III. TSD-Dose Results for Transport and Disposal of the Average Concentrations of BNL Peconic River Soils and Sediments at a RCRA Subtitle D Waste Disposal Facility

Radionuclide	TSD Dose Enroute Inspector (mrem)	TSD Dose for Receipt Inspection and Sampling (mrem)	TSD Dose for Truck Transfer from Railcar (mrem)	TSD Dose for Landfill Disposal (mrem/y)
³ H	0.0E+00	7.6E-11	0.0E+00	1.4E-10
⁶⁰ Co	4.5E-03	5.3E-03	3.2E-02	8.9E-03
⁹⁰ Sr	0.0E+00	3.9E-05	2.4E-04	7.1E-05
¹³⁷ Cs	4.1E-02	4.4E-02	2.7E-01	7.4E-02
²³⁸ Pu	2.9E-15	8.3E-06	1.1E-17	1.5E-05
²³⁹ Pu	1.5E-08	1.8E-04	7.0E-08	3.2E-04
²⁴⁰ Pu	6.6E-14	1.8E-04	2.9E-16	3.2E-04
²⁴¹ Am	6.7E-09	1.5E-03	1.4E-10	2.7E-03
Total:	4.5E-02	5.1E-02	3.0E-01	8.6E-02

Table IV. TSD-Dose Results for Transport and Disposal of the Authorized Limit Concentrations of BNL Peconic River Soils and Sediments at a RCRA Subtitle D Waste Disposal Facility

Radionuclide	TSD Dose Enroute Inspector (mrem)	TSD Dose for Receipt Inspection and Sampling (mrem)	TSD Dose for Truck Transfer from Railcar (mrem)	TSD Dose for Landfill Disposal (mrem/y)
³ H	0.0E+00	6.9E-10	0.0E+00	1.2E-09
⁶⁰ Co	6.9E-02	8.2E-02	5.0E-01	1.4E-01
⁹⁰ Sr	0.0E+00	3.3E-04	1.9E-03	5.9E-04
¹³⁷ Cs	7.0E-02	7.5E-02	4.6E-01	1.3E-01
²³⁸ Pu	1.1E-12	4.2E-03	5.9E-15	7.6E-03
²³⁹ Pu	4.0E-07	4.6E-03	1.8E-06	8.3E-03
²⁴⁰ Pu	1.7E-12	4.6E-03	7.4E-15	8.3E-03
²⁴¹ Am	6.1E-08	1.4E-02	1.2E-09	2.5E-02
Total:	1.4E-01	1.6E-01	9.6E-01	3.1E-01

Prior to shipping any wastes, BNL must verify that local, state, and other regulatory requirements are met for shipment to the proposed RCRA Subtitle D facility.

Finally, in conducting the analysis of Authorized Limits for BNL Peconic River soils and sediments, attempts were made to identify realistic, yet conservative, exposure scenarios. Some of the more important assumptions contributing to the conservative nature of the results include:

- Deriving Authorized Limits based on the limiting scenarios and radionuclides, and assuming, as a worst case, that the same individuals would be exposed for all gondola rail cars. This conservative analysis would further assure that it would be unlikely that any real individual could receive doses in excess of 1 mrem/y during transportation and disposal.
- Assuming conservative, yet reasonable, transportation distances that would bound the potential doses.

The dose assessment and authorized release limits are detailed in the *Technical Basis for the Derivation of Authorized Limits for Peconic River Soils and Sediments from Brookhaven National Laboratory* [2].

STATE ACCEPTANCE

As previously stated, the DOE Authorized Release must optimize the balance between risks and benefits, ensure ground water protection is consistent with applicable State regulations and guidelines, ensure that no future remediation will be required as a result of DOE disposal, and coordination with landfill operators and State regulators to ensure landfill acceptance criteria and specific radiological protection requirements are met.

Extensive discussions were held with the New York State Department of Environmental Conservation (NYSDEC) regarding the disposal of the Peconic River Sediment at the Pine Avenue Landfill. Based on the characterization data presented in Table I, the State requested a demonstration that the concentrations of the radionuclides in the sediment were in the range of background.

To address the NYSDEC request, the BNL and DOE team performed a detailed analysis of the characterization data. The analysis included the evaluation of sample locations, sample depths, sample density, and the remediation plans so an estimate of radionuclide concentration in the waste could be predicted.

Because the majority of samples obtained were for mercury characterization, the radiological data has been obtained from sample locations biased toward higher concentrations in depositional areas. Supporting this conclusion, the *Operable Unit V Remedial Investigation Report* [3] states “ Factors influencing the selection of sample sites were the presence or absence of surface water and the presence of depositional zones which might serve to concentrate contaminant loadings in particular areas”. Also, the *Operable Unit V Contamination*

Characterization and Radiological Dose and Risk Assessment Report [4] states, “All sediment sample locations have been chosen to represent areas where deposition is likely to occur based on hydrology and which represent assorted potential exposure routes”.

The Radiological Dose and Risk Assessment Report went on to state, “ In general, higher activities of these radionuclides were found in the surface sediments (0 to 2 inches)”. That is an important conclusion. The cleanup of the Peconic River involves the removal of the entire sediment layer, down to 9 inches on average, thus lowering the average concentration of radionuclides significantly.

The extent of the remediation area also will significantly impact the average concentration of radionuclides. Initially, BNL proposed only remediation of the depositional areas where the mercury and collocated contaminants were concentrated. Based on the Record of Decision negotiations with the regulatory agencies, the proposed cleanup area has doubled in size and now includes channel and non-depositional areas that have low levels of mercury. Based on the low levels of mercury, it is anticipated that near background levels of radionuclides will be present. For example, thirteen biased samples were obtained from the 2.5-acre section of river recently added to the cleanup. The average concentration of those thirteen samples is 2.5 pCi/g of ¹³⁷Cs. The one hundred percent increase in remediation area to include non-depositional areas is expected to lower the average radionuclide concentrations. The current average concentration of ¹³⁷Cs is 5.8 pCi/g but BNL expects this to be 2 to 3 pCi/g when the confirmatory sample results are obtained.

To verify that BNL does not exceed any of the Authorized Release Limits, an extensive waste confirmation sampling procedure was developed. The key components of the waste verification procedure include the following:

- Grab samples for TCLP, gamma spectroscopy, and Am-241, Pu-238 and Pu-239/240 analyses will be collected at the rate of one sample per 300 cubic yards.
- Grab samples for Sr-90 Beta-Scintillation analysis will be collected at the rate of one sample per 300 cubic yards.
- Grab samples for gamma spectroscopy utilizing BNL's ISOCS will be collected at the rate of one sample per 70 cubic yards.
- Any material exceeding an Authorized Release Limit or Hazardous Waste classification will be segregated from the waste going to the Subtitle D Landfill. The segregated waste will be further sampled to determine the proper disposal facility.

Based on the dose assessment, data analysis, and waste confirmation procedures, BNL was able to obtain NYSDEC approval for accepting Peconic River Sediment at the Pine Avenue Landfill.

CONCLUSION

The Office of Science is the Program Secretarial Office for the Brookhaven National Laboratory. The Brookhaven Site Office Manager has approved the authorized limits and transmitted the documentation to EH-4, which has made no comments, allowing the authorization to go into effect.

The waste profile form has been submitted to the NYSDEC regional office and approval has been granted. Now that release limits are established and are acceptable to regulators in the New York State Department of Environmental Conservation (NYSDEC), the BNL project is currently disposing of the sediment at the Pine Avenue Landfill. As of November 2004, BNL has disposed of approximately 13,000 cubic yards of sediment at the landfill and anticipate the transportation and disposal of another 12,000 cubic yards in FY2005. BNL has complied with all of the sampling requirements and none of the material analyzed has exceeded the Authorized Release Limits. For example, the Cs-137 average concentration over the 13,000 cubic yards was 2.37 pCi/g, well within the range estimated and presented to the NYSDEC.

This was the first time Brookhaven has applied the process for authorization for release of waste, although other DOE sites have successfully used this process. The process was extremely long and difficult and required a dedicated effort. The team of BNL, DOE, and subject matter experts worked through numerous procedural requirements, regulatory statutes, and NYSDEC acceptance to achieve the desired outcome. The bottom line is the disposal of the waste in a Subtitle D facility is projected to save \$4.2 million as compared to the cost of disposal at a radiological disposal facility.

REFERENCES

1. U.S. Department of Energy (DOE). 1993. *Radiation Protection of the Public and Environment*. DOE Order 5400.5/Change 2. Washington, D.C.
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