Brookhaven Graphite Research Reactor Decommissioning Project

FINAL COMPLETION REPORT FOR REMOVAL OF THE ABOVE-GROUND DUCTS AND PREPARATION OF THE INSTRUMENT HOUSE (708) FOR REMOVAL

April 26, 2002

BROOKHAVEN NATIONAL LABORATORY
BROOKHAVEN SCIENCE ASSOCIATES
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EXECUTIVE SUMMARY

This report documents the status of a removal action Action Memorandum for Above Grade Ducting Removal authorized by the U.S. Department of Energy (DOE) at Brookhaven National Laboratory on February 7, 2000. The removal action, at the Brookhaven Graphite Research Reactor (BGRR), was performed to complete a Time-critical Removal Action of the Above-Ground Ducting and components within the Instrument House (Building 708). The activities covered three major areas of work: removal of the Above-Ground Ducting, removal of components from the Instrument House, and packaging the Above-Ground Ducts for shipment. This removal action was undertaken to prevent low-level radioisotopes being released to surface soil and subsequently migrating into surrounding soils and groundwater.

All contaminated components and secondary waste from the Above-Ground Ducting and Instrument House were removed, packaged, and disposed of at Envirocare of Utah, a licensed waste disposal facility. The major contaminants of concern were Cesium-137 and Americium-241. A layer of concrete was removed from the pedestal that supported the Above-Ground Ducting between the Instrument House (708) and the Fan House (Building 704), which allowed the radiological posting to be removed from the pedestal. The Fan House pedestals were sealed and covered.

This work was performed in accordance with the *Comprehensive Environmental Recovery, Liability, and Compensation Act* of 1980 through the Interagency Agreement between the DOE, the U. S. Environmental Protection Agency, and the New York State Department of Environmental Conservation. This action was consistent with the final remedial actions that will be documented in the BGRR Record of Decision. Work was conducted in accordance with the National Contingency Plan (NCP, 40 CFR 300).

ACRONYMS, ABBREVIATIONS, AND UNITS OF MEASUREMENT

ASTD	Accelerated Site Technology Deployment
BGRR	Brookhaven Graphite Research Reactor
BSA	Brookhaven Science Associates
BNL	Brookhaven National Laboratory
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act*
DOE	Department of Energy
EE/CA	Engineering Evaluation/Cost Analysis
EM	Environmental Management Directorate (formerly ERD)
EPA	Environmental Protection Agency
ERD	Environmental Restoration Division
FY	Fiscal year
IAG	Interagency Agreement
ISOCS	*In-situ* Object Counting System
lb/cf	Pounds per cubic foot
lb/hr	Pounds per hour
N	North
NEPA	*National Environmental Policy Act*
NYSDEC	New York State Department of Environmental Conservation
PCB	polychlorinated biphenyls
pCi/cm^2	Picocuries per square centimeter
PMP	Project Management Plan
PPM	Procurement and Property Management Division
S	South
URS	URS/Dames and Moore
USID/SE	Unreviewed Safety Issue Determination/Safety Evaluation
μCi	microcuries
WBS	Work Breakdown Structure

1.0 INTRODUCTION

1.1 Purpose

This report documents the completion of a removal action authorized by the U.S. Department of Energy (DOE) at Brookhaven National Laboratory (BNL). The specific activity is part of the decommissioning activity at the Brookhaven Graphite Research Reactor (BGRR). Removal activities for the Above-Ground Ducts were defined in the *BGRR Project Management Plan* [1], Work Breakdown Structure (WBS) 1.4, and the BGRR Fiscal Year (FY) 2001 Project Baseline. Completion of these removal activities included:

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- Removal of the Above-Ground Duct from its originally constructed locations
- Size reduction of the duct for transportation
- Transportation and disposal offsite of the Above-Ground Duct
- Isolation of the Above-Ground Ducts from the Below-Ground Ducts
- Soil sampling in areas adjacent to duct sections 1 North and 1 South
- Preparation for removal of the Instrument House by removing hazardous materials (lead, asbestos, and mercury) and removing abandoned instruments, piping and equipment from the Instrument House ("Instrument House Cleanout")

1.2 Removal Authority

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Removal of the Above-Ground Duct was authorized by the following document approvals:

- Brookhaven Graphite Research Reactor Above-Ground Ducting Removal Action, approved February 7, 2000 (Appendix A)
- Unreviewed Safety Issue Determination/Safety Evaluation (USID/SE) for the Above-Ground Duct Removal for BGRR Decommissioning Project, (BGRR-SE-99-04), approved June 8, 2000 (Appendix B)
- USID/SE for the Instrument House (Building 708) Components Removal and Isolation for BGRR Decommissioning Project, (BGRR-SE-00-01), approved March 7, 2000 (Appendix B)

2.0 SITE DESCRIPTION AND HISTORY

2.1 Brookhaven National Laboratory

Located in Upton, Long Island, New York, BNL is near the geographic center of Suffolk County, approximately 60 miles east of New York City (Figure 1). Approximately 1.32 million people
reside in Suffolk County and about 0.41 million people reside in Brookhaven Township, within which the Laboratory is situated.

The BNL facility contains 5,265 acres (8.23 square miles). The terrain is gently rolling with elevations varying between 44 and 120 feet above mean sea level. The land lies on the western rim of the shallow Peconic River watershed, with a principal tributary of the River in the north and west sections of BNL.

Figure 1. The Laboratory Location

The principal facilities at the Laboratory are located, with few exceptions, near the geographic center of the site. The facilities are contained in an area of approximately 900 acres, of which the U.S. Army originally developed about 500 acres for use. The remaining 400 acres are occupied, for the most part, by various large research facilities. Outlying facilities occupy about 550 acres and include apartment areas, biology research fields, a solid waste management area, closed landfills, a sewage treatment plant, and firebreaks. The balance of the site, approximately 75 percent of its total area, is largely wooded. The U.S. Army used the site, formerly known as Camp Upton, during World Wars I and II and by the Civilian Conservation Corps Camp between the wars. In 1947, ownership was transferred to the Atomic Energy Commission for peaceful research on atomic energy and materials. The site was subsequently transferred to the Energy Research and Development Administration in 1975, and finally to the DOE in 1977. These later transfers were the result of agency name changes, not changes in occupancy or function.

The Laboratory carries out basic and applied research in the fields of high-energy nuclear and solid-state physics, fundamental material and structure properties and the interactions of matter, nuclear medicine, biomedical, and environmental sciences, and selected energy technologies.

2.2 Brookhaven Graphite Research Reactor

The BGRR at BNL was the first reactor built for the sole purpose of providing neutrons for research. During its years of operation, it was one of the principal research reactors in the United States. Construction was completed in August 1950, and initial criticality of the reactor was achieved the same month. The BGRR operated until June 10, 1968, when operation of the reactor was terminated and deactivation of the facility was initiated. In June of 1972, defueling and shipment of the fuel to the DOE Savannah River site was completed. The BGRR complex was described as being in a safe shutdown condition by the U.S. Atomic Energy Commission and became a surplus facility within the DOE complex. From 1977 until 1997, portions of the facility were used as the BNL Science Museum.

The BGRR was an air-cooled graphite moderated reactor. The primary air-cooling system utilized cooling fans that were located in a building (704) separate from the reactor building (701). Exhaust ducting constructed of reinforced concrete runs in two separate ducts below the ground from the reactor exhaust plenums to the system filters and coolers. Downstream of the coolers, the ducting rises above the ground and combined into one large duct, which was located on, and supported by, the Fan House (704). The individual cooling fans took suction through 48-inch-diameter ducts, which penetrated the building roof and connected at the duct bottom. There was approximately 225 feet of above-grade ducting. During reactor operations, filtered outside cooling air was drawn across the reactor pile through this ductwork by the fans. The air then moved through the ductwork to the Fan House, where it was cooled, filtered, and eventually exited through the 320-foot-tall exhaust stack. Figure 2 shows an aerial picture of the BGRR site.

Figure 2. The BGRR Site Looking North

2.3 Reactor Air-Cooling System

2.3.1 Design

Cooling for the reactor was provided by the primary air-cooling system, which was comprised of the following major components and structures:

- Inlet Air Duct System - Surrounded the pile, directing filtered outside air around and through the pile.
- Inlet Air Filters - Two deep-bed filters located at the east and west exterior walls of Building 701 on elevation 110' used to filter the incoming outside air.
- Primary Cooling Fans - The motive force of the system, a total of five fans were located in the Fan House (Building 704) downstream of the reactor between the Instrument House and the stack. During normal reactor operation, three of the fans were operated to provide 1,113,600 pounds per hour (lb/hr) of filtered cooling air to the pile.

- Secondary Air Cooling Fan (1) - Located the west end of Building 704
- Emergency Cooling Fan (1) - Located in Building 704
- Cooling Ductwork - Consisted of 1) underground ductwork, which are two separate reinforced concrete ducts, one each connected to the north and south pile air plenums, respectively. These ducts carried hot air exiting the pile through the below-grade filters and coolers and rose above ground and connected to the 2) Above-Ground Duct (see Section 2.4), and 3) discharge ductwork, which was below ground and carried the air discharged from the cooling fans to the stack.
- Coolers (2) - The water-cooled fin coolers were located below grade in the Below-Ground Ductwork, one in each of the ducts immediately downstream of the filters. These cooled the air prior to the air reaching the ceiling fans. The cooling water was supplied from the cooling towers and pumps that have been removed from the facility. The Coolers have also been removed.
- Outlet Air Filters (2) - Located below grade in the Below-Ground Ductwork, one bank of filters in each of the ducts. When partially loaded, these woven glass fiber filters were designed to remove more that 95 percent of particles down to three to four microns in size. The original filter elements are still installed, and are planned for removal in FY03.
- Instrument House (Building 708) - The Instrument House contained the instrumentation that was used to monitor the cooling ventilation system for the BGRR. The system included manometers to monitor differential pressure across filters and downstream coolers. The internals of this building contained hazardous substances in the form of mercury, asbestos, and radionuclides. The building and outside adjacent areas around the building are posted as Underground Radioactive Materials Areas.

2.3.2 Operation

During operation, the reactor was cooled by drawing outside air into the reactor inlet duct system through two deep-bed filter banks by the primary cooling fan(s). The cooling air flowed into the narrow adjustable gap in the graphite pile, through the fuel assemblies into plenums at the north and south ends of the pile, and then out of the reactor through two primary underground air ducts. After leaving the reactor, the air passed through filters, coolers, and the cooling fans, and eventually exited through the 100-meter tall stack.

2.4 Above-Ground Duct

The Above-Ground Duct includes all of the ductwork downstream of the first above-grade expansion joint downstream to each of the Fan House (Building 704) roof penetrations. Between the Instrument House and the Fan House, at approximate elevation 114', the two underground ducts rose above grade where they connected to the Above-Ground Duct at the

aforementioned expansion joint. These ducts ran upward and eastward where they combined into one single duct at the west wall line of the Fan House at a duct centerline elevation of 153'5". This single duct was 144'6" long and ran the full length of, and was supported by, the roof of the Fan House. The interior dimension of this duct decreased from 12' x 10' at the west (upstream) end to 8'6" x 6'0" at the centerline of the number 5 fan inlet. The duct had 9"-thick concrete walls with eight penetrations in its bottom (downcomers) which corresponded in size and location to the five primary cooling fan inlets, two for the emergency fan, and the 30" secondary air bypass line.

For identification purposes, the ducts were identified as follows: The five rectangular horizontal sections on the roof of Building 704 were designated (west-to-east) as duct sections 5, 6, 7, 8, and 9. Each of these sections was 26 feet in length with a west-to-east decreasing cross section. In the bottom of each of these sections was a 48-inch (nominal) round downcomer that penetrated the roof of the building and connected to the inlet of each of the five pile fans.

From the first above-ground joint upward and eastward the pair of north and south ducts were designated as sections 1N, 1S, 2N, 2S, 3N, and 3S. At the point where the two ducts changed from the 23 degree incline to horizontal and combined into one was given the designation of Section 4. This piece weighed nearly 300,000 pounds. Figure 3 shows the duct numbering scheme.

2.5 Source, Nature, and Extent of Contamination

To identify the hazardous substances in the Above-Ground Duct and the Fan House, several sources of information were used including historical operations records, process knowledge, knowledge of construction material, and limited facility characterization. The primary hazardous substances of concern were determined to be radioactive materials, asbestos, polychlorinated biphenyls (PCBs), and mercury.

From 1950 until 1958, the BGRR was fueled with natural uranium. During this period, there were twenty-eight known ruptured fuel cartridges. In 1958, the natural uranium fuel was replaced with enriched uranium, and there were two occurrences of enriched uranium fuel cladding failures between 1960 and 1962. These events contributed to the majority of the contamination in the cooling system ductwork and components.

In September 1999, radiological surveys and samples were taken on the duct interior near the first above-grade joint at the north and south duct access doors. The survey data taken from these locations provide a representation of the nature and extent of the contamination existing in the Above-Ground Duct. These survey sample results are provided in Table 1.

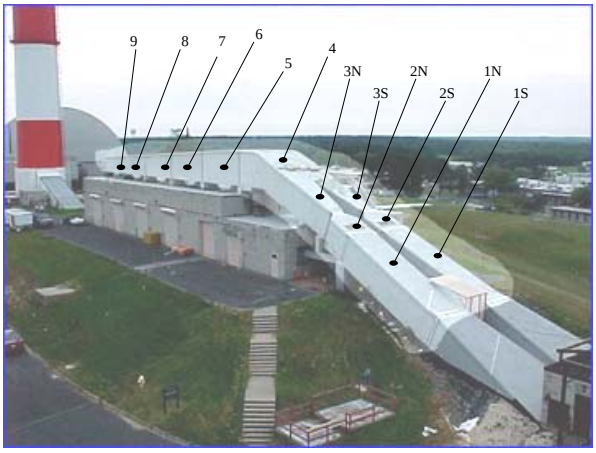

Figure 3. Above-Ground Ducts Numbering Scheme

Table 1. Radiological Sample Results

Sample ID	Nuclide Name	Activity µCi/gram	1-Sigma % Error
99091713-01	Cobalt-60	4.09E-06	6.17
	Cesium-137	4.94E-04	8.30
	Europium-152	2.50E-06	9.71
	Europium-154	1.25E-06	10.69
	Americium-241	5.39E-06	30.48
99091713-02	Potassium-40	9.54E-07	28.71
	Cobalt-60	6.05E-06	5.95
	Cesium-137	1.48E-03	8.25
	Europium-152	3.98E-06	7.16
	Europium-154	1.68E-06	19.09
	Americium-241	1.00E-05	18.11

Notes: Sample No. 99091713-01 was taken from north duct access door
Sample No. 99091713-02 was taken from south duct access door

On August 11, 1999, the Accelerated Site Technology Deployment (ASTD) *In-situ* Object Counting System (ISOCS) technical team performed gamma spectrum analysis of a cement core plug that was taken from the duct sidewall. On September 2 and September 9, 1999, the ISOCS team performed *in-situ* analyses of the duct interior at three locations, one on the duct section on the roof of Building 704, and the other two at the access doors near the first above-grade expansion joint. This survey data is provided in Table 2.

Table 2. Preliminary ISOCS Analysis taken 9/2/99 and 9/9/99. Surface Activity Concentration on Inner Surface of Above-Ground Ducts

Radionuclide	Plug Surface μCi/gram	North Duct μCi/gram	South Duct μCi/gram	Rooftop Duct μCi/gram
Americium-241	3.7E+1	1.3E+1	2.1E+1	1.5E+1
Cesium-137	8.5E+3	1.04E+4	2.41E+4	1.37E+4
Cobalt-60	ND	ND	3.4E+1	2.6E+1
Sodium-22	ND	2.3	2.7	ND

ND = Not detected

2.6 Stakeholder Participation

Stakeholders, including the public, regulators, legislators, and Laboratory employees, have been informed and involved in the Above-Ground Duct removal action through several planned media releases and scheduled events. Initially, the BGRR Decommissioning Project informed the stakeholders what the planning case was for the decommissioning of the BGRR and solicited "community values" from the stakeholders that could be evaluated with the values set forth in the *National Environmental Policy Act* (NEPA) and *Comprehensive Environmental Response, Compensation, and Liability Act* of 1980 (CERCLA) regulations to determine a path forward for the decommissioning. In parallel with these efforts, the *Removal Action Alternative Study* [2] was being prepared by an independent contractor.

The hazardous and radiological material characterization of the Above-Ground Ducts began in September of 1999. Later that year, the *Action Memorandum: Brookhaven Graphite Research Reactor Above Grade Ducting Removal Action* (see Appendix A) was prepared and submitted to the DOE, U.S. Environmental Protection Agency (EPA), and New York State Department of Environmental Conservation (NYSDEC) for review and comment. Following the incorporation of comments from the regulatory agencies, the Action Memorandum was distributed by the

DOE. There was no public comment period for the Action Memorandum. Notices of Availability were prepared and published in *Newsday* on February 14, 2000, and in *Suffolk Life* on February 16, 2000. Presentations about the status of the Above-Ground Duct removal project were given to the Community Advisory Council in November 1999, March 2000, and September 2000, and to the Brookhaven Executive Roundtable in November 2000.

Additionally, the BGRR Working Group was formed in June 2000. The BGRR Working Group is comprised of community members and local regulators. This group meets monthly with members of the BGRR Project team. The agenda usually includes a status of ongoing work and planned activities. The BGRR Working Group provides valuable feed back to the Project team during the planning and implementation phases of proposed work activities. Work on the Above-Ground Duct project was discussed at four meetings in 2000, June 22, July 18, August 15 and September 19, and six in 2001, January 16, February 20, June 20, July 17, October 16, and November 12. Members of the BGRR Working Group also observed the different duct-lifting activities.

Appendix C, Community Relations, captures some of the media used to present information regarding the progress of the BGRR Decommissioning Project and the removal of the Above-Ground Ducts. It demonstrates the commitment the Project has to informing and involving stakeholders in all facets of the decommissioning.

3.0 REMOVAL ACTIVITY

3.1 Objectives

The objectives were to successfully complete the decommissioning work activities for removal of the Above-Ground Ducts and preparation for removing the Instrument House (Building 708) as defined by the WBS 1.4 in the *BGRR Project Management Plan* and the BGRR FY 01 Project Baseline. Specifically, these objectives were:

- Remove all of the above-ground primary air-cooling ductwork from the first joint above the ground eastward over the top of Building 704.

- Prepare for removal the above-ground Instrument House Building 708 that is constructed over portions of the underground ductwork.

- Reduce the Above-Ground Duct in size and ship for disposal.

3.2 Activities

3.2.1 Determination of Action

3.2.1.1 Preparation for Removing the Instrument House (Building 708)

The work activities required to prepare the Instrument House for removal were determined to be under the NEPA Categorical Exclusion for the BGRR, approved September 16, 1999 (Appendix D).

3.2.1.2 Removal of the Above-Ground Duct

On September 30, 2000, a draft Engineering Evaluation and Cost Analysis (EE/CA) to evaluate the alternatives for removal of the Above-Ground Duct was submitted by the BGRR staff to the management of the Environmental Restoration Division (ERD, now Environmental Management Directorate [EM]). Upon review of this draft analysis and data, which described the deteriorating condition of the ducts, the decision was made to remove the ducts as a CERCLA "Time-Critical Removal Action," in accordance with Interagency Agreement (IAG) between the DOE, the EPA, and NYSDEC [3]. On February 7, 2000, the Action Memorandum to remove the Above-Ground Duct was approved by DOE (see Appendix A).

3.2.2 Selection of Contractors

3.2.2.1 Preparation for Removing the Instrument (House Building 708)

The BGRR staff determined that the scope and complexity of the Instrument House cleanout was within the capabilities of the Laboratory's Plant Engineering craft personnel and the BGRR decommissioning field workforce.

3.2.2.2 Removal of the Above-Ground Duct

On February 1, 2000, the Laboratory solicited bids for a fixed-price, lump-sum construction contract for the following:

- Remove the Above-Ground Duct
- Seal Building 704 roof openings left after removal of the ducts
- Install a weather-tight cover on the open-ended sections of the Below-Grade Ducts after removal of the Above-Ground Duct

On February 14, 2000, the sealed bids were opened and forwarded to the BGRR Decommissioning Project staff for technical evaluation. After completion of the technical

evaluation, recommendations were forwarded to the Laboratory's Procurement and Property Management (PPM) Division, and a fixed-price, lump-sum contract for the amount of $1,599,586 was awarded to URS/Dames & Moore (URS) of Orchard Park, New York.

The URS proposal provided for an 85 percent reduction in volume of contaminated concrete to be disposed. The proposed method was to remove approximately ½" of contaminated surface and release the remaining material as nonradioactive waste. This was a major factor in determining that the URS bid was technically advantageous to the other bids received.

3.2.3 Conduct of Removal Activities

3.2.3.1 Preparation for Removing the Instrument House (Building 708)

The Laboratory's Plant Engineering personnel were used to remove the asbestos pipe insulation. The cooling-water lines that penetrated the Below-Ground Ducts were cut and capped, and the remainder of the piping, instruments, and miscellaneous equipment was removed by Plant Engineering personnel and BGRR decommissioning field workers under the direct supervision of the Project's engineers.

During the final cleanup of the building, a mercury spill occurred when one of the instruments that had been removed leaked mercury into a roll-off container and onto the asphalt pavement adjacent to Building 708. The instrument was one of three identified as potentially containing mercury, and were set aside for disposition and disposal. Work procedures were strictly followed, but when sampled with a mercury detector, the presence of mercury was not detected in this instrument. The BNL Emergency Services Division responded and a cleanup was performed with no further consequences.

The BGRR fieldwork procedure ERD-OPM-4.5, "Implementation, Control, and Configuration Management for BGRR Decommissioning Work Activities," was revised to require a separate hazardous materials evaluation before starting any decommissioning fieldwork. A new procedure, ERD-OPM-4.6, "Hazard Materials Assessment, Analysis, and Mitigation for BGRR Decommissioning Activities," was developed and issued to implement this evaluation.

Post-work radiological and hazardous substance surveys were performed, and the building was free-released in accordance with BNL radiological control procedures.

3.2.3.2 Removal of the Above-Ground Duct

The Laboratory's ERD management approved the interim URS Health and Safety Plan, which allowed URS to mobilize and commence site preparation such as saw-cutting containment construction and equipment setup. URS mobilized at the BGRR during the first week in June 2000 and commenced setup of the work site, and continued preparation of their work documents

that would govern the actual duct-removal activities.
The URS plan for the duct-removal project was comprised of two phases. Phase 1 would be the removal and segmentation of the five horizontal duct sections on the roof of Building 704 (sections 5 through 9). After the Phase 1 work was completed, the Phase 2 work would commence which was the removal and segmentation of the remaining seven inclined duct sections (sections 1N, 1S, 2N, 2S, 3N, 3S, and 4).

3.2.3.3 Phase 1 - Duct Removal Work

On July 25, 2000, the first section of duct (section 5) was lifted from the roof of Building 704 by Bay Crane, a URS subcontractor. At that time, it was determined from the crane's load cell readings that the duct weighed more than the URS calculation. The lifts of the remaining four horizontal duct sections on the roof of Building 704 further substantiated that the concrete density URS had used in the weight calculations was incorrect. A calculation of the weight-to-volume of the ducts was done by URS and revealed that the reinforced concrete used in the construction of these duct sections actually weighed over 163 pounds per cubic foot (lb/cf); URS had used the industry standard of 150 lb/cf for their calculations. For all subsequent weight calculations, a conservative value of 165 lb/cf was used. Based on recent core-bore weights, the value of 165 lb/cf used by URS was sufficiently conservative.

On August 18, 2000, URS began the segmentation of the larger duct sections into smaller sections. Each of the five 26-foot-long duct sections was cut into smaller pieces, yielding twenty-six smaller duct segments. On September 22, 2000, the first duct sections were shipped to US Ecology's Oak Ridge facility for processing. A total of eleven duct segments from duct sections 6, 7, 8, and 9 were shipped to Oak Ridge; fifteen segments remained in the west laydown area of the BGRR.

On August 28, 2000, URS requested an extension to the required contract completion date, citing delays caused by weather and the additional duct weight. A Contract Change Order was issued to extend the required completion date to November 30, 2000.

3.2.3.4 Phase 2 - Duct Removal Work

On November 7, 2000, URS requested a second contract extension, citing crane availability and transportation sequence as the reason. With this request, URS submitted a revised project schedule that committed to having all site work completed by February 13, 2001. After a review of the current work progress and the submitted schedule, Change Order No. 3 to the URS contract was issued on November 21, 2000, changing the required completion date to March 31, 2001.

On December 16, 2000, Bay Crane again mobilized to commence the lifting of duct section 4. Section 4 was the largest of the duct sections, calculated by URS to weigh approximately

265,000 lbs. With the rigging weight of approximately 11,000 lbs, the total calculated gross weight of the load was approximately 276,000 lbs. On December 18, the lift of section 4 was attempted, but halted when the crane's load cell indicated a gross load of 317,000 lbs. Although the 500-ton Leibherr crane had the capacity to lift the load, it did not have sufficient capacity to deliver the load to the Goldhofer transport trailer once the crane boom was extended. Furthermore, the safety margin of some of the below-hook rigging was inadequate. URS demobilized Bay Crane and the remainder of their site crew for the holidays. During the holiday break, URS located a crane contractor, Marino Crane of Middletown, Connecticut, with a crane with sufficient capacity to lift duct section 4.

On January 18, 2001, Marino Crane mobilized their 450-ton Demag crawler crane, and on January 29, 2001 the lift of duct section 4 was again attempted. The crane lifted the duct section without problems, with the indicated gross load being 317,000 lbs. The duct was lifted from the support pedestals, and was rotated northward to align axially with the Goldhofer trailer. Once aligned with the trailer, the duct was slowly lowered as planned until one end of the duct touched down. The duct was held in this position for a short period while it was verified to be stabilized and aligned. As the person in charge of the lift directed the duct to be further lowered, the duct rolled almost instantaneously and uncontrolled in the rigging, coming to rest on the hydraulic power pack on the Goldhofer trailer.

A Stop Work order was issued to URS, which prohibited any further lifting until URS provided the following:

- A causal analysis of the load shifting in the rigging
- A recovery plan to re-lift section 4
- A review of all Critical Lift Review Forms

BNL/Brookhaven Science Associates (BSA) management commenced an investigation of the accident. The accident investigation committee was comprised of BNL subject-matter experts, along with a senior rigging engineer from Bechtel Equipment Operations. The following was taken from the BNL Internal Committee Review of the Critical Lift Failure [4] dated March 28, 2001:

Root Cause:

- *The contractor failed to provide adequate planning required to make the critical lift, including placement of the duct on transporter. Of particular importance were the development, analysis, and understanding of the mechanics of such a lift.*

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On February 15, 2001, URS presented the causal analysis to BNL/BSA and the DOE management and staff. URS had contracted a third-party expert to perform this analysis, which concluded that the below-hook-lifting configuration that used a roller-block created an unstable condition with the load, which allowed uncontrolled rotation.

On February 23, 2001, URS issued their recovery plan and the Stop Work order was rescinded.

Marino Crane mobilized again, and during the week of February 26 to March 3, 2001 all remaining duct sections were successfully lifted without incident. The ducts were placed onto cribbing for the required size-reduction for transportation and disposal to complete the decommissioning removal activities identified as the IAG milestone for submission of this report.

During this period of resumed lifting activities, internal discussions between the BGRR and PPM were held regarding URS's ability to complete the Above-Ground Duct project. It was determined that, given URS's past inability to complete the project in a timely manner, consideration should be given to either terminate the URS contract for cause, or de-scope the contract and allow the Laboratory's personnel to complete the project.

On February 15, 2001, a meeting was held between the management of the Laboratory's PPM Division, BGRR, and URS. The aforementioned concerns were brought to URS's attention, and their representative stated that URS was losing "thousands of dollars each day" and would like to end the work at BNL as quickly as possible. At the conclusion of this meeting, it was the unanimous conclusion of all parties that it would be in the best interest of BNL if URS could terminate their work activities as soon as all ducts were lifted and placed on the ground. URS agreed to submit to BNL a proposal to de-scope the URS contract once all of the remaining duct sections were lifted and placed on the ground. URS would demobilize and BNL would assume responsibility for the segmentation, transportation, and disposal of the ducts remaining at BNL. BNL also assumed responsibility for transportation and disposal of the 11 duct segments that had already been shipped to US Ecology's Oak Ridge facility.

BNL received URS's proposal to de-scope the Above-Ground Duct contract on March 11, 2001. On March 23, 2001 a Contract Change Order was issued to reduce the total amount of the URS contract from $1,599,586.00 to $1,195,933.00. URS commenced demobilization on March 26, 2001.

3.2.4 Isolation of the Below-Ground Duct

On March 15, 2001, the sealing of the open-ended Below-Ground Ducts was completed. This was accomplished by installation of weather-tight covers, constructed of galvanized steel, on the open end of each of the two ducts and application of cold-set construction sealant.

3.2.5 Verification of Soil in the Above-Ground Duct Area

After removal of duct sections 1N and 1S, sixteen soil samples were taken in the area immediately below and adjacent to the location of these ducts. All samples were verified to be less than the residential criteria of 23 picoCuries per gram (pCi/gm) for Cesium-137 and 15 pCi/gm for Strontium-90 as per BNL's Final Feasability Study Report, Operable Unit 1 and Radiologically Contaminated Soils (3/31/1999). Sample results are provided in Appendix E.

3.2.6 Completion of Activities

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Subsequent to the URS demobilization, the BGRR Decommissioning Project staff and field workers, with support from the Laboratory's Plant Engineering and a specialty subcontractor (Bluegrass), completed the size-reduction, packaging, and transportation of the Above-Ground Duct to Envirocare of Utah for disposal.

3.3 Final Conditions

3.3.1 Above-Ground Duct

- All of the Above-Ground Duct has been removed from its original operation configuration.
- Isolation of the Above-Ground Duct from the Below-Ground Ducts was accomplished by installation of weatherproof covers
- Initial surveys of the Above-Ground Duct supports at the west end of 704 had identified multiple areas of fixed contamination (500-800 corrected counts per minute) on the supports. A work package was developed (BGRR-WP-191), a tent constructed, and decontamination work commenced on March 26, 2002. The pedestals were decontaminated using hand-held scabblers. The pedestal was turned over to the Laboratory's Radiological Controls staff to survey on March 28. A direct frisk survey was completed on April 4, 2002, with results left at less than 100 corrected counts above background (established a background reading prior to performing a direct frisk of pedestal).
- Soil samples in the areas adjacent to duct sections 1N and 1S were collected, sampled and verified to meet residential release criteria. Soil sample locations and sample results are given in Appendix E.
- The Building 704 roof duct pedestals were either decontaminated or had contamination fixed in place, and were enclosed using a weather-tight aluminum-plate covering. The remaining contamination will be addressed during the Building 704 cleanup.

3.3.2 Instrument House (Building 708)

The Instrument House Building was free-released with all hazardous materials, abandoned instruments, equipment, and components removed, and the piping penetrations to the Below-Ground Duct sealed.

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3.4 Personnel Safety

Worker, public, and environmental safety were paramount in the planning and implementation of the removal work. During the performance of the removal activities, there were no instances of personnel radioactive contaminations, overexposures, internal radioactive material uptakes, or lost-time accidents.

3.5 Activity Cost

The total estimated cost of the activity was approximately $2,139,984, which includes the fixed-cost contract to URS for the removal. It is anticipated that additional costs will be incurred due to the higher density of the concrete. The total cost includes planning, execution, waste disposal, and closure of the activity.

Table 3. Activity Costs associated with the Above-Ground Ducts

Description	Project to Date	To Go (dollars remaining to be spent)	Estimate at Completion	Baseline (initial cost estimate)	Cost Variance
BNL Labor Total	91,893		91,893	141,618	49,725
Subcontracts Total	2,430,911	886,419	3,317,330	1,526,933	(1,790,397)
Materials Total	230,204		230,204	65,160	(165,044)
Plant Engineering Support Total	536,015	51,232	587,247	112,435	(474,812)
Other Distributed Costs Total	341,937		341,937	82,445	(259,492)
Facilities Site Services Support Total	243,022	53,315	296,337	211,393	(84,944)

Subtotal	3,873,982	990,966	4,864,948	2,139,984	(2,724,964)

3.6 Pictorial Summary

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Pictures of the Above-Ground Duct and the Instrument House removal work activities are included in this report (see Appendices F and G).

4.0 WASTE MANAGEMENT

On December 7, 2000, URS received notification from US Ecology that they were experiencing difficulties in decontaminating the duct segments that were at their Oak Ridge facility. Specifically, in attempts to decontaminate four of the eleven segments, the contamination levels in the ducts was were found to be higher than the levels provided in radiological survey data provided by BNL with the original solicitation for bids. Furthermore, the contamination was deeper (3 to 6 inches) into the concrete than US Ecology had assumed in their Waste Minimization Plan (one-half inch). Therefore, no cost savings were realized by utilizing US Ecology's Bulk Survey for Release Program.

Due to the inability of URS decontaminate the duct sections, special pricing was developed between BNL and Envirocare of Utah. Cost for large components and oversized debris exceeded $30 per cubic foot; special pricing was established at $20 per cubic foot. Between August 31, 2001, through September 27, 2001, US Ecology transported and disposed of the first eleven duct sections, which had been stored at their Oak Ridge site, at Envirocare in Utah. The remaining forty duct sections were shipped directly to Envirocare from BNL from November 1, 2001 through February 21, 2002.

There were two moratoriums placed on shipping the Above-Ground Ducts:

1. A DOE-imposed moratorium, which concerned problems encountered while the ducts were in transit, as well as a condition identified while inspecting the Above-Ground Ducts prior to transport:

   - Overweight shipment
   - Breach of strong-tight package
   - Water inside a stored duct

   The BGRR and Waste Management Division's Pre-shipment Plan (BGRR-AGD-001) was developed with the corrective actions identified to preclude further incidents. A check-off sheet was used to ensure compliance with all applicable regulations.

2. A self-imposed moratorium, which concerned the packaging technique used to establish a strong-tight container for the ducts. Subsequently, custom-sized super sacks were used to

package the ducts to ensure that they met Department of Transportation regulations.

5.0 LESSONS LEARNED

1. A thorough evaluation of the contractor's proposals for complex work is essential. Pre-award interviews must be conducted to ensure the prospective contractors fully understand the scope of work, expected outcome, and have successfully completed projects of a similar nature.

2. When the contractor plans to use subcontractors, the contractor should be required to submit a subcontracting plan delineating the scope of work to be assigned to each lower-tier subcontractor. Qualifications of the lower-tier contractors should be reviewed using the same scrutiny as for the prime contractor.

3. A complete radiological characterization must be performed which should include, but not be limited to, core-bore samples and complete visual inspection.

4. Hazardous materials assessment, remediation, and abatement should be accomplished before starting decommissioning removal activities. This will limit the oversight of potential hazards by “schedule-driven” field personnel.

5. When complex and hazardous operations such as a critical lift are made, the Project should take advantage of the availability of subject-matter experts whose opinions should be considered before allowing a contractor to perform such operations. This is particularly important if a contractor intends to use new technology or work practices and procedures with which BNL has not had experience, such as the roller-block lifting device.

6. Require incorporation of vendor piping and instrumentation drawings in all work packages and procedures prior to performing hazardous substance assessments. Ensure that all mercury reservoirs are identified before starting work, with the appropriate hold-point signoffs.

7. Concrete cutting on the scale of the Above-Ground Ducts required extensive coordination and support. Health and safety issues were a constant concern. The issues of silica, lead, PCBs and asbestos were of initial concern. Samples taken and analyzed during the project resulted in additional administrative and engineering controls. These samples should have been collected and analyzed prior to work start.

8. A single contact, i.e., Project Manager, should be assigned responsibility for an activity of this complexity. High turnover of key personnel and contractors also contributes to poor communications and inadequate documentation of events.

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9. Waste specialists should be utilized to determine the optimum methods for packaging and shipping the waste generated from the project.

10. Packaging and transporting of the large and irregularly shaped concrete sections presented many challenges that resulted in schedule delays and cost overruns. Waste packaging was an issue throughout the project. Water was found in one of the duct sections prior to shipment. It was determined that the cover over the opening of the duct had a seam that allowed water into the duct. Provisions must be made to cover waste in such a way as to preclude liquid from getting into the package. If stored for an extended period of time, inspection procedures should be developed that will identify this type of issue.

6.0 REFERENCES

1. Brookhaven National Laboratory, “Brookhaven Graphite Research Reactor Project Management Plan,” BGRR-001, Rev. 1, March 2, 2000.

2. Brookhaven National Laboratory, "Brookhaven Graphite Research Reactor Decommissioning Project Removal Action Alternatives Study," BGRR-015, Rev. 0, April 13, 2000.

3. Federal Facility Agreement under CERCLA Section 120, Administrative Docket Number II-CERCLA-FFA-00201, United States Environmental Protection Agency, Region II, United States Department of Energy, and the New York State Department of Environmental Conservation. In the matter of the U.S. Department of Energy's Brookhaven National Laboratory, 1992.

4. Brookhaven National Laboratory, "BNL Internal Committee Review of Critical Lift Failure, Report on the January 29, 2001 Property Damage Incident During the Removal of the Above Ground Ductwork at the BGRR Decommissioning Project,” March 28, 2001.

APPENDIX A

ACTION MEMORANDUM

APPENDIX B

APPROVAL OF USID/SE FOR ABOVE-GROUND DUCT REMOVAL and APPROVAL OF USID/SE FOR PREPARING THE INSTRUMENT HOUSE BUILDING 708 FOR REMOVAL

APPENDIX C

COMMUNITY RELATIONS

In addition to the required public notices, the BGRR Decommissioning Project has involved its neighbors and stakeholders in the removal of the Above-Ground Ducts. This appendix captures some of the media used to present information regarding the progress of the removal project.

APPENDIX D

NEPA CATEGORICAL EXCLUSION BNL-361

APPENDIX E

SOIL SAMPLE RESULTS FROM THE AREA AROUND DUCT SECTIONS 1N AND 1S

APPENDIX F

DUCT REMOVAL PICTORIAL

View of Above-Ground Duct prior to removal.

URS workers setting diamond-wire-cutting enclosure on roof of Building 704.

500-ton crane in place to begin lifting duct section 5.

Commencement of duct section 5 lift (7/25/00).

Duct section 5 on the cribbing (7/25/00).

Duct sections 5 through 9 on cribbing after being lifted from roof of Building 704.

First segmented section of duct ready for shipment.

Segmented section of duct being loaded for shipment.

Setting up the diamond-wire-cutting equipment to make the section 4/3 separation cut.

View of duct section 5 being segmented into smaller pieces. The yellow containment for the section 4/3 separation cut is visible.

Installation of the diamond-wire-cutting equipment to cut duct section 1N/S support pedestal.

Setting up the 500-ton mobile crane for first lift attempt of duct section 4.

Rigging in place to lift duct section 4 (12/18/00).

East end of duct section 4 lifted (12/18/00)

Note: Lifting was suspended shortly after this photo was taken due to the duct weight indicated on the crane's load cell being higher than the crane's capacity.

Second lifting of duct section 4 (1/29/01)

Duct section 4 moments before it rotated (counter-clockwise as viewed) in the rigging (1/29/01).

Duct section 4 after it came to rest after shifting in the rigging (1/29/01).

Re-lifting duct section 4 with revised rigging configuration (2/26/01).

Setting duct section 4 on the repaired Goldhofer trailer (2/27/01).

Moving duct section 4 to the laydown area on the Goldhofer trailer (2/27/01).

Lifting duct section 3N (2/28/01).

Lifting duct section 4 from the Goldhofer trailer in the laydown area (3/1/01).

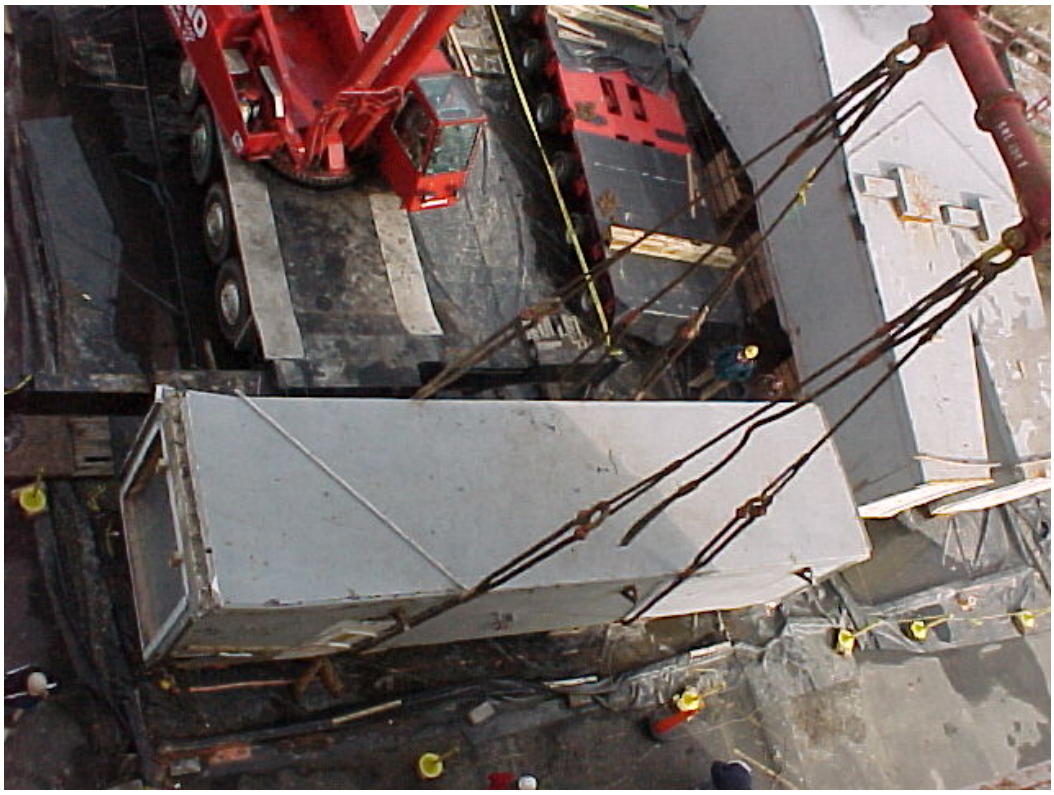
Duct section on the cribbing in the laydown area (3/1/01).

Lifting duct section 2N (3/2/01).

Lifting duct section 1N (3/3/01).

Duct section 1N over Building 704 (3/2/01).

Bringing duct section 1N to the laydown area on the Goldhofer trailer (3/3/01).



Duct section 1N being lowered onto cribbing (3/3/01).

Offloading duct section 1S onto cribbing (3/3/01).

De-mobilization and cleanup activities (3/15/01).

Sheet metal seal covers installed on Below-Ground Duct openings (3/15/01).

Maintenance and covering of ducts in west side laydown area (4/12/01).

Maintenance and covering of ducts in east side laydown area (4/25/01).

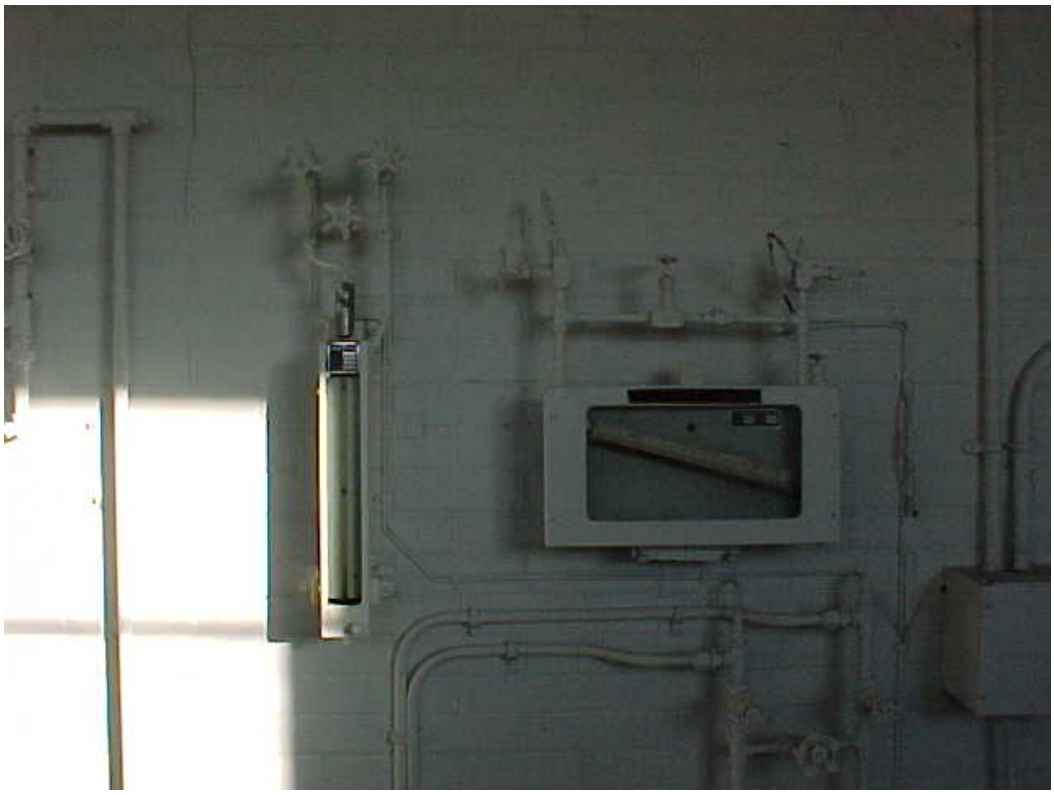
APPENDIX G

INSTRUMENT HOUSE WORK ACTIVITIES PICTORIAL

North cooling water manifold.

South cooling water manifold.

Cooling water penetrations into Below-Ground Duct.



Abandoned instruments

Abandoned flow transmitter

Work in progress - removing cooling water manifolds.

Abandoned valves and piping ready for disposal.

Cooling water penetrations into Below-Ground Duct after being sealed.

View of West Instrument House wall after removal of the cooling water manifolds. The main supply and return headers are visible at the grating opening.

Interior view of the Instrument House after removal of all abandoned equipment.

APPENDIX H

DUCT SHIPMENT PICTORIAL

Internal inspection of duct section 1S-3 before shipment.

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Shipment 9011-02-027 (duct section 1S-3).

Internal inspection of Duct 2S.

Duct 2S placed in Super Sack.

Shipment 9011-02-025 (duct section 2S).