Hazard Classification and Auditable Safety Analysis for Brookhaven Graphite Research Reactor (BGRR) Decommissioning Project

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ADVISORY

This Hazard Classification and Auditable Safety Analysis document for the BGRR Decommissioning Project was initially developed prior to the availability of formal characterization data. In fact, it was planned from the beginning of the project's authorization to only characterize as necessary to effect remediation as rapidly as possible (instead of postponing the start of any remediation activity until a complete facility characterization could be developed).

To accommodate that decision, it was planned that the ASA would not cover the actual discrete remediation activities needed to be performed, but rather exclude them, requiring the use of an Unreviewed Safety Issue Determination / Safety Evaluation (USID/SE) process for their consideration. The ASA would allow for the gathering of characterization data sufficient for hazard analysis and waste profile development, but the hazard of the remediation would be judged on its own merit via the USID/SE process.

To begin the process however, an estimate needed to be made to develop a conservative basis for classifying the facility even before the remediation (thereby establishing the overall level of risk expected and rigor required).

The determination of the Balance-of-Plant (BOP) radiological inventory estimate was based upon the amount of fuel unaccounted for throughout the reactor's operating life (primarily related to fuel failures and associated releases). While portions of the fission product/fuel inventory unaccounted for were known to have escaped the stack as airborne material, for the sake of conservatism, it was all assumed to be present as BOP inventory. This inventory was considered to be primarily in the form of low-level contamination, widely dispersed throughout the reactor's air-cooling system and adjacent areas (canals, sumps, etc.). Based upon the amount of fuel unaccounted for [14.62 Kg]; the BGRR NU fuel-cycle and burn-up estimates of mixed fission products, actinides, daughter products, and subsequent decay; a gross BOP inventory of 300 to 340% of the Category 3 Threshold was developed. The derivation and data was originally contained in an earlier revision of the ASA in Section 2.3.2 – BGRR Balance-of-Plant (BOP) Inventory. It was subsequently deleted when partial BOP inventory estimates based upon characterization data became available.

No credible accident or phenomenon could be discerned that would cause the release of all of the estimated BOP inventory. This was based upon the distribution of the material as found throughout the Balance-of-Plant, the forms of the material present, and the lack of any intrusive remediation activities included within the scope of work of the ASA to provide the potential energy needed for such a release.

As a result of the completion of the removal of the Below Ground Duct Coolers (as authorized by DOE approval of USID/SE BGRR-SE-01-03 covering the Technical Work Document and Job-Specific Safety Analysis addressing the removal), better access to the Below Ground Duct Filters was effected. An accurate measure of the Filter density was then made (where previously only estimates existed based upon small crushed samples). This resulted in an increase in the estimated radiological inventory of the Below Ground Duct Filters prompting declaration of an Occurrence Report (ORPS No. CH-BH-BNL-BNL-2002-0005, "Determination of Increased Radiological Inventory Leading to Exceeding Radiological Facility Characterization" [69]). In order to resolve

the ORPS report, a USQD/SE was developed (USQD No. BGRR-USQD-02-01, "Challenge to the BGRR-ASA by Increase in Estimated BGD Filter Inventory" [70]). The USQD/SE determined that while the radiological inventory estimated for the Below Ground Duct Filters did increase, it did not rise to the threshold of Nuclear Hazard Category 3 levels for Material-at-Risk in the final analysis. DOE approved this USQD/SE via the issuance of a revised SER for BGRR-DP (dated June 13, 2002) [71] that reconfirmed the Radiological Facility categorization for BGRR-DP. The ORPS was finalized and approved by DOE on 10/31/02 as an Off-normal Occurrence (downgraded from its initial classification of an Unusual Occurrence when it was thought to have become a Nuclear Facility). The updating of the BGRR-ASA to reflect the incorporation of BGRR-USQD-02-01 and the associated DOE-SER is one of the corrective action items associated with the closeout of the approved ORPS report. This revision represents the completion of that corrective action.

The Hazard Analysis contained in Section 3.0 was revised to replace the previous maximum credible BOP inventory with that of the BGD filters, as appropriate, for the accident scenarios examined. The estimated BGD Filter inventory used for the source term of the accidents is maximally estimated at (50% of 129% = 64.5%)[*] of the Category 3 Threshold value and hence a Radiological Facility, not a Nuclear Facility.

This value of 64.5% of the Cat 3 Threshold is conservative, as compared to the consequences calculated for the individual remediation activities covered by the various USID/SEs prepared since 1999, when the ASA and the first USID/SEs were approved.

Similarly, the Pile inventory was initially estimated in the absence of any real characterization data by the determination of activation products and subsequent decay associated with the neutron irradiation of primary anticipated contaminants of the graphite (considering that all the reactor fuel had been removed from the core and fuel channels had been rodded out). The estimate was based on studies originally conducted for British graphite reactor decommissioning planning.

Even though actual Pile characterization data is available (and replaced the estimated inventory data located in ASA Section 2.3.3 – Pile Inventory), the graphite related inventory accidents still rely upon the original and more conservative estimate for their source term, producing a greater dose consequence than recalculation with the characterization data based inventory.

It is important to remember that, although no planned remediation actions are part of the authorized scope of work covered by the ASA, the USID/SEs which are generated to address such out-of-scope activities have to be compared with the ASA. For this reason, the conservatism contained within Section 3.0 – Hazard Analysis of the ASA must be maintained at its original and highest level; to facilitate the approval of USID/SEs by comparison with the previously approved risk accepted under the ASA.

It should be noted that all USID/SEs developed for the performance of remediation activities outside the covered scope of work of the ASA utilize source terms based upon actual characterization data and that data is recaptured back into the ASA from the approved USID/SEs.

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[*] 129% equals entire inventory (Filters and Fines) for the greater of the two ducts (South Duct). 50% equals maximum fraction of inventory present in form that can be released by the impact of the scenario (Material-at-Risk).

EXECUTIVE SUMMARY

The objective of this Hazard Classification and Auditable Safety Analysis (ASA) for the Brookhaven Graphite Research Reactor (BGRR) Decommissioning Project (DP) is to identify the facility's conditions, hazards, authorized activities, safety-management programs, and appropriate safety controls for the BGRR-DP. In keeping with the graded approach, this ASA uses existing documentation and analyses as far as possible, while duplicating only those portions required for a sufficient understanding of the facility and project without needing to directly consult the referenced documents. In conducting the hazards analysis to develop this ASA, the focus was limited to identifying and evaluating bounding scenarios. This limited scope is deemed appropriate based on the use of the graded task-based hazards analysis for the BGRR-DP. This process is discussed in the Hazard Analysis section of this document.

The BGRR-ASA document summarizes the known inventories of radioactive- and hazardous-materials present and at risk within the BGRR, and considers the following operations that will be undertaken: implementation of the Project Management Plan; regular, ongoing stabilization work, surveys/monitoring for the radiological protection of personnel working in or visiting Buildings 701, 702, 704, 708, 709, 709A, and the associated yard area; removal of contaminated water from various BGRR sumps already analyzed by the Department of Energy (DOE) in their reviews of submitted safety evaluations; continuing prevention and elimination of the intrusion of storm water into the contaminated portions of the BGRR facility; and related non-specific activities, to immediately protect the environment from unmonitored releases (actual or potential) originating from within the BGRR.

The BGRR "Deactivation Basis for Interim Operations" (BIO), which was distributed for comment to Brookhaven National Laboratory (BNL), the Department of Energy's Brookhaven Group (formerly DOE-BHG, now the Brookhaven Area Office) and Chicago Operations Office (DOE-CH) on April 15, 1998 by the BGRR Project Manager, classified the facility as Nuclear Hazard Category 2 (which has no upper limit on inventory and so cannot be upgraded to Category 1 based on inventory). The Preliminary Hazard Analysis (PHA) in that document was extremely conservative in the following ways:

1. It included the inventory in Building 701's Nuclear Material Storage Vault that could have been excluded because the material was packaged in Department of Transportation's (DOT) Type B containers, and the vault was considered segmented from the rest of the facility at that time [vault is no longer considered segmented from the rest of the facility].
2. It placed the entire radionuclide inventory at risk for all postulated accidents without considering mitigation represented by the robust structural integrity of building and shielding material.
3. It did not consider the form and distribution of radiological material.
4. It did not address the limited energies available for initiating events based on the tasks to be covered under the BIO (which evolved into the current ASA).

Subsequent reviews and resolution of comments, ultimately resulting in this ASA document, re-evaluated the best conservative estimate of the following parameters:

1. The radiological material at risk of release by postulated accidents
2. The conservatism in DOE-STD-1027-92 Category 3 Threshold values for the type of facility and work planned
3. The form, distribution, and dispersibility of the radioactive materials, and
4. The energy sources available to initiate events, as determined by the accident- and hazards-analysis, demonstrating that there were no credible release mechanisms for operations covered by this ASA.

Based on this reevaluation (in Section 2.3, Inventory of Hazardous Substances and Section 3.0, Hazards Analysis), the BGRR Decommissioning Project is designated **RADIOLOGICAL FACILITY**, as per DOE-EM-STD-5502-94 and DOE-STD-1027-92.

From the scenarios and hazards identified, there are no Technical Safety Requirement (TSR) systems associated with the BGRR facility during operations scheduled under this ASA; however, several administrative work controls are required. These controls will reduce the risk associated with the anticipated work during the implementation of the Project Management Plan. Operations within the scope of this ASA, performed in accordance with appropriate work control and limits, do not pose an unacceptable level of risk to the workers, on-site personnel, the public, or the environment.

Proposed activities not specifically addressed under this ASA will be reviewed against EM-OPM-4.4, *Safety Evaluations for Unreviewed Safety Issue Determinations*[*], to determine if there are any Unreviewed Safety Issues (USIs). If so, USIs (with their associated safety evaluations [SE]) will be submitted to the DOE Manager for the BGRR-DP for review and approval before undertaking the proposed activity in accordance with DOE Order 430.1A, *Life Cycle Asset Management.*

The following USID/SEs have been prepared, approved, and implemented for the BGRR-DP to date:

BGRR-SE-99-01, Removal of Pile Fan #5, approved by DOE 10/26/99
BGRR-SE-99-02, Removal of Pile Fan Sump, approved by DOE 10/15/99
BGRR-SE-99-03, Removal of Residual Pile Fans, approved by DOE 12/08/99
BGRR-SE-99-04, Removal of Aboveground Ducts, approved by DOE 06/08/00
BGRR-SE-00-01, Instrument House Component Removal & Isolation - No DOE approval required
BGRR-SE-00-02, Sealing of Pile Openings, approved by DOE 08/24/00
BGRR-SE-01-01, Above Ground Canal House & Water Treatment House Removal, approved by DOE 03/21/01
BGRR-SE-01-02, Lower Canal and Water Treatment House, Equipment, and Associated Soils Removal, approved by DOE 07/17/01
BGRR-SE-01-03, Below Ground Duct Coolers Removal, approved by DOE 11/19/01

[*] Alternatively, Procedure WMD-ADM-910, "Unreviewed Safety Question Determination (USQD)" will be used for preparing Unreviewed Safety Questions (USQs) where activities include concerns regarding potential nuclear inventory questions.

The following USQD/SEs have been prepared, approved, and implemented for the BGRR-DP to date:

BGRR-USQD-02-01, Challenge to BGRR-ASA by Increased in Estimated BGD Filter Inventory, approved by DOE 07/19/02.

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FOREWORD TO REVISION 5

Corrective Action No. 1 of ORPS CH-BH-BNL-BNL-2002-0005, "Determination of Increased Radiological Inventory Leading to Exceeding Radiological Facility Categorization," Final Report dated October 31, 2002 states:

> Revise and resubmit BGRR-002, "Hazard Classification and Auditable Safety Analysis for the Brookhaven Graphite Research Reactor (BGRR) Decommissioning Project," to reflect the contents of the DOE-SER issued to approve the USQD/SE. This includes: establishing a separate inventory for the BGD Filters (independent of the Balance-of-Plant Inventory) and revising the Accident Analyses.

This revision is the implementation of that commitment. The revision is limited to the segregation of the Below Ground Duct (BGD) Filter and Fines Inventory from the Balance-of-Plant (BOP) inventory tally, revising the Hazard Analysis section to reflect the use of BGD Filter Material-At-Risk (MAR) in lieu of BOP MAR for the applicable accident scenario and the commitment to use the USQD procedure when preparing the analyses supporting the physical removal of the BGD Filters.

ACRONYMS AND ABBREVIATIONS

ACM	Asbestos Containing Materials
ACT	Actual
AEC	Atomic Energy Commission
AGD	Above Ground Duct
ALARA	As Low As Reasonably Achievable
ASA	Auditable Safety Analysis
BGD	Below Ground Duct
BGRR	Brookhaven Graphite Research Reactor
BGRR-DP	Brookhaven Graphite Research Reactor Decommissioning Project
BIO	Basis for Interim Operation
BNL	Brookhaven National Laboratory
BOP	Balance of Plant
B&W	Babcock & Wilcox
CAM	Continuous Air Monitor(ing)
CEDE	Committed Effective Dose Equivalent
CERCLA	*Comprehensive Environmental Response, Compensation, and Liabilities Act* of 1980
CFR	Code of Federal Regulations
Ci	Curie(s)
Con Ops	Conduct of Operations
CX	Categorical Exclusion
D&D	Decontamination and Decommissioning
DOE	U.S. Department of Energy
DOE-BAO	U.S. Department of Energy, Brookhaven Area Office
DOE-BHG	U.S. Department of Energy, Brookhaven Group
DOE-CH	U.S. Department of Energy, Chicago Operations Office
DOE-EM	U.S. Department of Energy, Environmental Management Office
DOE-SC	U.S. Department of Energy, Office of Science
DOT	U.S. Department of Transportation
EPA	Environmental Protection Agency
ERD	Environmental Restoration Division
ES&H	Environment, Safety, and Health
EU	Enriched Uranium
FASTER	Facility Stabilization and Environmental Restoration
FEMA	Federal Emergency Management Agency
FHA	Fire Hazards Analysis
HASP	Health and Safety Plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
HEPA	High Efficiency Particulate Air
HFBR	High Flux Beam Reactor
HP	Health Physics
HVAC	Heating, Ventilation, and Air Conditioning

ISMS	Integrated Safety Management System
ISOCS	*In-Situ* Object Characterization System
LLW	Low-Level Waste
LO/TOS	Lock-out/Tag-outs
MAR	Material at Risk
MC&A	Material Control & Accountability
MDA	Minimum Detectable Activity
MOA	Memorandum of Agreement
MWt	Megawatts Thermal
ND	Not Detected
NEL	Nuclear Environmental Laboratory
NEPA	*National Environmental Policy Act* of 1986
NFPA	National Fire Protection Association
NU	Natural Uranium
ORPS	Occurrence Reporting and Processing System
OSHA	Occupational Safety and Health Administration
PCB	Polychlorinated Biphenyl
PHA	Preliminary Hazard Analysis
PHC	Preliminary Hazard Classification
PNPS	Pile Negative Pressure System
PPE	Personnel Protective Equipment
QAPP	Quality Assurance Project Plan
RQ	Reportable Quantities
RWP	Radiological Work Permit
SAR	Safety Analysis Report
SBMS	Standards-based Management System
SE	Safety Evaluations
SER	Safety Evaluation Report
SNM	Special Nuclear Material
SOP	Standard Operating Procedure
TLD	Thermoluminescent Dosimeter
TQ	Threshold Quantities
TSR	Technical Safety Requirement
TRU	Transuranics
UCi	micro-curie(s)
USI(D)	Unreviewed Safety Issue (*D*etermination)
USQ(D)	Unreviewed Safety Question (*D*etermination)
WIPP	Waste Isolation Pilot Project
WMF	Waste Management Facility

1.0 INTRODUCTION

1.1 Purpose and Content

The objective of this Hazard Classification and Auditable Safety Analysis (ASA) for the Brookhaven Graphite Research Reactor (BGRR) is to identify the facility's conditions, hazards, authorized project activities, safety management programs, and appropriate safety controls for the BGRR Decommissioning Project (BGRR-DP). In keeping with the graded approach, this ASA uses existing documentation and analyses as far as possible, while duplicating only those portions required for a sufficient understanding of the facility and project without needing to directly consult the referenced documents. In performing the hazards analysis to develop this ASA, the focus was limited to identifying and evaluating bounding scenarios. This limited scope is deemed appropriate based on the use of the graded task-based hazards analysis for the BGRR-DP [1]. This process is discussed in the Hazard Analysis section of this document.

The goal of this document is to determine the appropriate hazard categorization and define the authorization basis for the BGRR. This was done by examining and analyzing the associated hazards and setting up of physical and management systems controls.

This report includes the following items:

- a description of the operations to be performed during the BGRR-DP
- an assessment of the total inventory of radioactive- and hazardous-materials associated with the Project
- an identification of the hazards associated with the tasks of the Project
- an identification of internally and externally initiated accident scenarios with the potential to have significant local consequences during the Project
- a bounding evaluation of the consequences of the potentially significant accident scenarios
- a hazard classification based on evaluating the bounding consequences and material-at-risk (MAR)
- a listing of safety functions and controls, including commitments
- a consideration of controls to protect employee safety, health, and environmental and radiological issues
- a description of the methodology to be used to evaluate proposed work that may not be described in this ASA.

Section 1.2 describes the overall approach used in hazard classification, and Section 1.3 summarizes the findings and commitments to administrative controls.

The following sections are also contained in this document:

Section 2.0 lists the hazardous-material inventories, describes the work to be undertaken during the BGRR-DP and discusses related information, such as demographics and the site features.

Section 3.0 identifies the hazards and the risks associated with the BGRR-DP and contains the hazard classification analysis.

Section 4.0 summarizes the controls and commitments applicable to the Project.

1.2 Overall Approach

Potential initiating events are analyzed by taking into account the form, location, and dispersibility of the radioactive material and its interaction with available energy sources, as allowed by the following: DOE-EM-STD-5502-94 [2], *Hazard Baseline Documentation;* DOE-STD-1027-92 [3], Change 1, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*; DOE-HDBK-3010-94, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities* [4]; and as referenced in BHI-00837, Bechtel Hanford, Inc., *Final Hazard Classification and Auditable Safety Analysis for the 105-C Reactor Interim Safe Storage Project* [5].

The following is the approach taken for classifying the current hazard for the BGRR-DP.

- Not all of the total radioactive inventory is at risk.
- Not all of the radioactive inventory at risk may contribute to the exposure of individuals.
- The collective MAR inventory is below the Category 3 Facility Threshold of DOE-STD-1027-92, Change 1.

By identifying the amount of the radioactive material inventory that credibly contributes to the exposure of individuals, a hazard category can be assigned that reflects the true hazard represented by the BGRR-DP

The specific steps involved in the hazard analysis and initial hazard-classification are summarized below. No active features that could prevent or mitigate the exposure of individuals are considered in the evaluations.

Step 1 The credible hazards associated with the operations to be performed during the BGRR-DP are identified and discussed. Based on this analysis, a set of accident scenarios with potentially significant consequences is identified.

Step 2 The inventory is estimated for each scenario identified using data from radioactive material inventories generated in various analyses conducted and referenced in this report, taking into account their physical location.

Step 3 The physical and chemical form of the radioactive material at risk (e.g., activation, fixed contamination, smearable contamination) for the operations covered by the ASA is integrated with the energy sources introduced by the scenario; from this, the thresholds for Hazard Category 3 are compared to allow for the direct application of Table A.1, Thresholds for Radionuclides, in Appendix 1 of DOE-STD-1027-92, Change 1.

Step 4 Necessary functions or controls (including administrative control commitments) are specified to ensure that the risks associated with the operations during the BGRR-DP and the assumptions and bases of hazard classification remain valid, so that the safety and health of employees are not endangered.

1.3 Hazard-Classification Summary

The BGRR Deactivation Basis for Interim Operations (BIO)[6], distributed for comment to BNL, DOE-BHG, and DOE-CH on April 15, 1998 by the BGRR Project Manager, classified the facility as Nuclear Hazard Category 2 (which has no upper limit on inventory and so cannot be upgraded to Category 1 based on inventory). The Preliminary Hazard Analysis (PHA) contained within that document was extremely conservative in the following ways:

1. It included the inventory in Building 701's Nuclear Material Storage Vault that could have been excluded because the material was packaged in the Department of Transportation's (DOT) Type B containers, and the vault was considered as segmented from the rest of the facility. (The vault is no longer considered segmented from the rest of the facility.)
2. It placed the entire radionuclide inventory at risk for all postulated accidents without considering mitigation represented by the robust structural integrity of building and shielding material.
3. It did not consider the form and distribution of radiological material.
4. It did not address the limited energies available for initiating events based on the tasks to be covered under the BIO (which evolved into the current ASA).

Subsequent reviews and resolution of comments, ultimately resulting in this ASA document, re-evaluated the best conservative estimate of the following parameters:

1. the radiological MAR of release by postulated accidents
2. the extreme conservatism in the DOE-STD-1027-92 Category 3 Threshold values for the type of facility and work planned
3. the form, distribution, and dispersibility of the radioactive materials
4. the energy sources available to initiate events as determined by the accident- and hazards-analysis demonstrating that there were no credible release mechanisms for activities covered by this ASA

Based on this re-evaluation (in Section 2.3, Inventory of Hazardous Substances and Section 3.4, Final Hazards Classification) the BGRR-DP is designated **RADIOLOGICAL** as per DOE-EM-STD-5502-94 and DOE-STD-1027-92.

Brookhaven National Laboratory's (BNL's) radiological and industrial safety procedures are judged adequate to control the work on the BGRR-DP. Appendix A identifies some of these procedures. Five additional administrative controls[1] are established:

Administrative Control #1: Welding/torch cutting on or within 18 inches of the biological shield is prohibited without an approved safety evaluation to demonstrate that the work is safe (margin of safety to prevent igniting graphite or graphite dust).

Administrative Control #2: Electrical penetrations through the biological shield will be isolated from power sources before any other work begins on or near Building 702 Reactor Pile, along with

[1] Administrative controls are those relating to organization and management, record keeping, job reviews, and work practices necessary to ensure safety at the facility. The administrative controls necessary for the BGRR-ASA are those factors already taken credit for in the risk assessment.

other enhanced means of stabilization to minimize all leakage of air into the bioshield. (Completed under BGRR-SE-00-02)

Administrative Control #3: The safety programs identified in Section 4.0, Controls and Commitments, are required for authorization of operations within the BGRR complex. This control requires that the programs be instituted by the Project. Individual and specific deficiencies within a program could constitute a noncompliance with this control (depending upon severity); however, multiple deficiencies within a program may indicate a failed program and identified deficiencies shall be corrected as promptly as possible.

Administrative Control #4: Since the current classification of the facility is "Radiological," introducing additional radiological material could change this categorization. Therefore, an administrative control was instituted prohibiting the taking of additional radioactive material into the BGRR facility, excluding the temporary introduction of sealed check sources to calibrate instruments, or sealed sources to image inaccessible areas. The use of Type B shipping containers does not negate the prohibition on introduction of non-BGRR originated radiological material.

Administrative Control #5: Since the facility was determined to be "Low Risk," partly due to the limited combustible material loading and no significant inventory of nonradiological hazardous material, those conditions must be maintained as an administrative control.

DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports* [7], states "Safety Limits are reserved for a small set of extremely significant features that prevent potentially major off-site impact." The Safety Analysis of the BGRR-ASA shows that only localized consequences can be expected as long as the radiological inventory at risk remains below the threshold for Nuclear Hazard Category 3 (adjusted as necessary and appropriate) and the other mitigating factors taken credit for are in place. Also, no credible accident consequence exceeds the classification of "Low Risk" as defined in BNL's Standards-based Management System (SBMS) Subject Area "Hazard Analysis" [8]. Therefore, no safety limits are required for the BGRR facility as part of this BGRR-ASA.

1.4 Scope of Work

The following are the operations planned at the BGRR Complex that are covered by this document:

- routine monitoring of the physical plant for radiological and nonradiological hazards
- characterization sampling for Environmental Safety and Health (ES&H) concerns, waste management, and Unreviewed Safety Issue (USI) [9] analyses for various decommissioning tasks
- undertaking routine facility maintenance and upkeep (including stabilization tasks, e.g., enhancing the isolation of Building 702, as necessary)
- removing any contaminated water from various BGRR sumps
- preventing and eliminating the intrusion of storm water into contaminated portions of the BGRR facility
- undertaking unspecified work to immediately protect the environment from unmonitored releases (actual or potential) originating from within the BGRR Complex.
- packaging and disposal of waste generated by the performance of any of the above listed activities.

The following activities performed at the BGRR Complex are not covered by this document and require evaluation for USI determination:

- decommissioning tasks, such as removing fans from Building 704 and installed equipment from Building 701
- *Comprehensive Environmental Response, Compensation, and Liabilities Act* (CERCLA) Time Critical and Non-Time Critical Removal Actions [10], such as above-grade duct work and removals from Building 708, below-grade duct removal, Canal House and Water Treatment Building removal and
- permanent or long-term disposition tasks related to the Reactor Pile and Bioshield (Building 702)
- packaging and disposal of waste generated by the performance of any of the above listed activities.

Table 1.4-1 provides a matrix of activities and shows whether they are intended to be covered by the BGRR ASA.

Table 1.4-1. ASA Applicability Table

Activities	BGRR ASA covers planned work	USI needed to cover planned work
Surveillance and Maintenance	Yes[1]	No
Characterization sampling for ES&H concerns, waste management and USI analysis of various decommissioning tasks	Yes	No
Work planning and facility "hands-off" inspections	Yes	No
Early *National Environmental Policy Act* [11]-Categorical Exclusion (NEPA-CX) maintenance tasks, such as removing museum material and housekeeping items	Yes[2]	No
NEPA-CX decommissioning tasks, such as removing fans from Building 704 and equipment from Building 701	No	Yes
CERCLA removal actions, such as the above-grade duct and 708 removal, below-grade duct removal, Canal House, and Water Treatment Building removals	No	Yes
Waste packaging and disposal for any of the above actions	Yes[3]	Yes[3]

Notes:
1. Routine Surveillance and Maintenance are covered by ASA; however, if large unanticipated maintenance tasks are needed, a USI would evaluate them.
2. Removal of BNL Science Museum materials already authorized by DOE and completed, independent of the final approval of the ASA.
3. Waste will be dealt with along with the Surveillance and Maintenance, NEPA, or CERCLA work that generates the particular waste stream.

1.5 Unreviewed Safety Issue (USI) Process

The USI Determination process is based on the comparable Unreviewed Safety Question Determination (USQD) applicable to nuclear facilities (DOE Order 5480.21, *Unreviewed Safety Questions* issued, 12/24/91) [12] as superseded by 10CFR 830.203 [68] and DOE G 424.4-1,

"Implementation Guide For Use in Addressing Unreviewed Safety Question Requirements," dated 10/24/01. [64] The BGRR-DP's procedure on USI and associated Safety Evaluations (SE) was modeled after the approved USQD/SE procedure for the BNL Waste Management Facility (HWM-ADM-910, *Safety Evaluations for Unreviewed Safety Question Determinations*, Rev. 0, dated 2/7/97) [13], a nuclear non-reactor Hazard Category 3 facility, using a graded approach.

The process involves analyzing the proposed activity against a series of questions with "yes" or "no" answers. When an answer is "yes," then a USI exists and DOE must review and approve the Unreviewed Safety Issue Determination/Safety Evaluation (USID/SE) before work can begin.

The USI process will be supported by detailed characterizations, detailed engineering and work packages, radiological work procedures, and a Project-Specific Health and Safety Plan prepared in accordance with 29 CFR 1910.120, *Hazardous Waste Operations and Emergency Response* HAZWOPER, dated 9/25/98 [14], and 29 CFR 1926.65, *Safety and Health Regulations for Construction*, updated 9/11/98 [15].

The questions concern the operation's anticipated impact on the following:

- any safety functions or established failure modes of equipment within the facility
- creation of new failure modes
- potential increase in the probability of occurrence of an accident previously evaluated in the authorization basis documentation (ASA and approved USID/SEs)
- potential occurrence of a malfunction of equipment, systems and components that are important to safety
- potential occurrence of an accident of a different type than those previously evaluated in the ASA
- potential equipment, system and component malfunction of a different type than those previously evaluated in the ASA
- potential for change in the margin of safety as defined in the ASA
- change of the facility's configuration as described in the ASA.

Whether the answer to the question asked is "yes" or "no," sufficient supporting data must be provided for an independent review. For questions answered "yes," analytical data should be provided in the responding text that is at least comparable in depth to that in the ASA and of sufficient breadth to warrant DOE's approval with a confident expectation of no significant impact.

If questions arise with respect to radiological inventory, and whether or not a certain inventory involves the Nuclear Hazard Category 3 threshold quantities, then an approved USQ process/procedure must be used if there is any potential for a nuclear facility to exist. Under those circumstances, the approved Waste Management Division procedure (as used for the Category 3 Nonreactor Nuclear Waste Management Facility) HWM-ADM-910 will be used.

2.0 BACKGROUND

2.1 Facility/Systems Description

2.1.1 Operational Overview

The BGRR was a graphite-moderated, graphite-reflected, thermal neutron, air-cooled research reactor facility. The original fuel loading was natural uranium (NU) and its core reached criticality on August 22, 1950. The fuel loading was changed to enriched uranium (EU) fuel elements in April 1958. The reactor was finally shut down in 1969. The nominal power level of the reactor was 28 megawatts thermal (MWt) during the NU fuel loading, and 20 MWt during the EU fuel loading [16].

The graphite moderator was regularly annealed during operation, and was again annealed in 1970 to remove any residual stored energy; while all the remaining fuel was shipped to the DOE's Savannah River site in 1972. The BGRR complex was described as being in a safe shutdown condition by the U.S. Atomic Energy Commission (AEC) and became an "orphaned" facility within the DOE complex. From 1977 until 1997, portions of the facility were used as BNL's Science Museum (see Figure 2.1, BGRR Site Layout Diagram).

2.1.2 History of Operation

The fuel elements were charged and discharged from the south face of the graphite pile through openings in the biological shield's wall, which match the fuel channels in the graphite pile. The spent fuel was lowered directly into a chute or by using an installed cart, which then was emptied into the chute extending from the floor of the south plenum to the bottom of the deep pit. The deep pit was part of the water-filled canal that served to shield, store, and prepare fuel elements and activated sources for shipment. The canal is 64 feet long and 8.5 feet deep, except for the 20-foot deep-pit area near the reactor.

The other five faces of the reactor were penetrated by an assortment of experimental openings. The east and west corners of the south face also had eight penetrations each for control rods. Following permanent shutdown, the control rods were disconnected from the drives and inserted into the graphite pile. The biological-shield penetrations for the control rods were covered with metal plates and tack-welded into place. The experimental openings were closed or plugged.

Radioactive equipment was removed from the experimental area and the underwater canal. The canal water was pumped down to the Building 801 Radioactive Waste Processing Facility. The canal itself was cleaned with soap and water (which was pumped to Building 801 as well). The canal was then covered with concrete slabs for shielding.

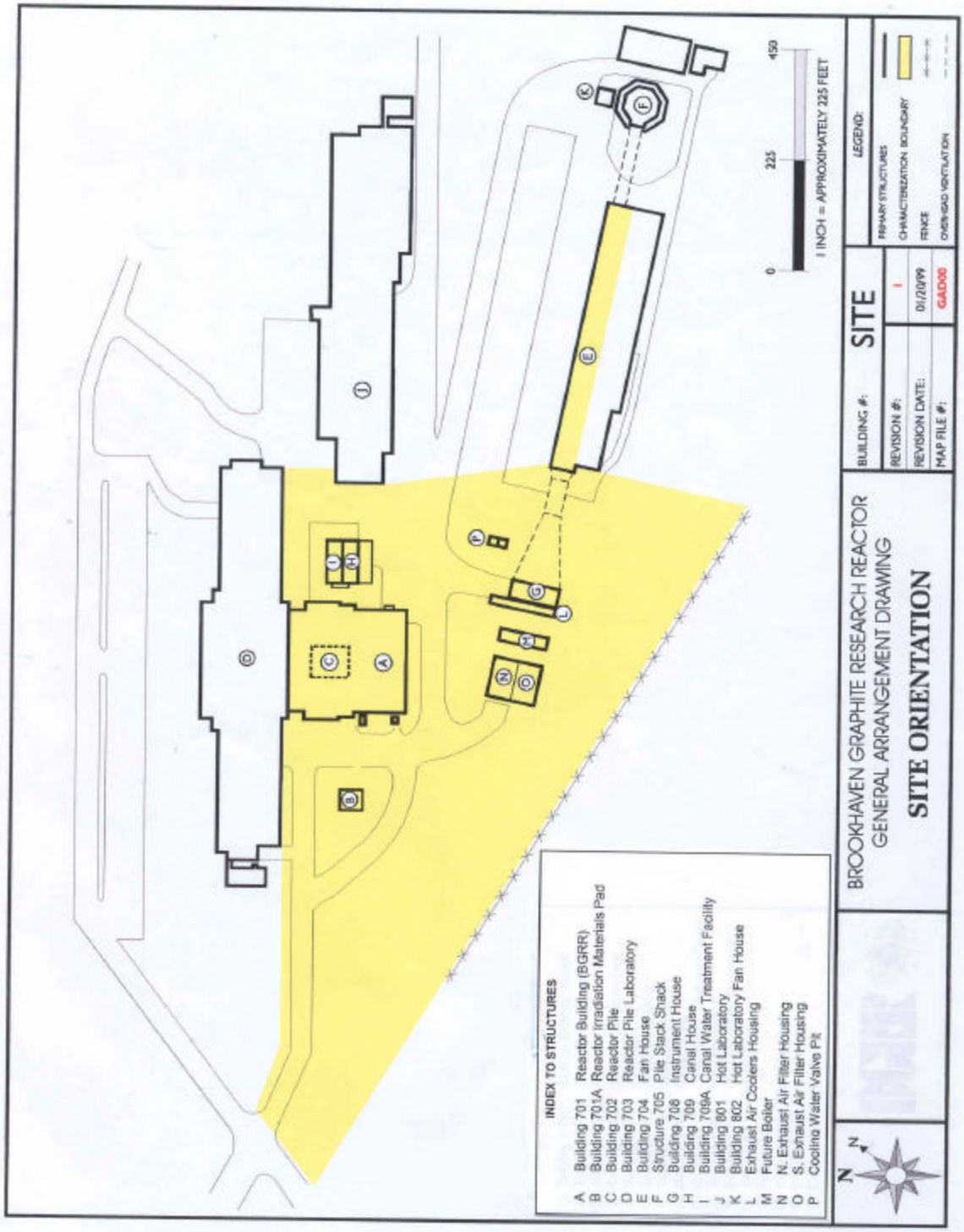

Figure 2.1. BGRR Site Layout Diagram

2.1.3 Current Status of Facility

Since a previous version of this document [BGRR-002, Rev. 3, dated 1/19/01] was prepared, a number of work activities were initiated and/or completed resulting in the following changes to the facility's prior status:

- Above Ground Canal House, Water Treatment House removed.
- Lower Canal, Equipment, and Associated Soils remediated or removed.
- Partial removal/remediation of surface soil/subsoil within the footprint of the BGRR Complex.
- Final cut-up of Above Ground Duct Sections on-site and preparation for shipment offsite.
- Removal of Below Ground Duct Coolers.
- Removal /cut-up of pedestal supports on Building 704 to Above Ground Duct.
- Removal of Walkway Sump, East Yard Sump.

Physical status of the faculty is verified by implementation of EM-OPM-4.2, "Brookhaven Graphite Research Reactor Decommissioning Project (BGRR-DP) Monitoring and Surveillance Procedure" [17], which covers the following types of activities:

- Water Intrusion Level Surveillance Monitoring
- Physical condition Inspection/Surveillance Monitoring

Radiological status of the facility is verified by implementation of FS-BGRR-0001 "Monitoring and Surveillance at the BGRR Decommissioning Project," which covers the following types of activities:

- Exposure rate surveys
- Contamination smear surveys
- Sampling of office vacuum cleaner contents
- Checking of calibration due dates on fixed monitors
- Response checks on fixed monitors
- Inspection of duct covers and isolation seals for physical integrity
- Massline mop head surveys of Alpha, Beta, and Gamma activity

Following the Plant Engineering Maintenance/Testing Program, all fire-alarm panels are tested annually in accordance with National Fire Protection Association (NFPA) recommendations. Furthermore, *BNL's Site-wide Fire Alarm System - System 1000 Operations Manual*, dated March 1994 [18] indicates that the main computer for the site-wide fire-alarm system polls the status of each fire-alarm panel every seven seconds, including the fire-alarm panels associated with the BGRR Complex.

2.2 Project Description

The proposed objectives for the BGRR-DP are detailed in the *BGRR Project Management Plan* [19] and are summarized as follows:

- Determine the type, variability, and extent of radiological- and hazardous-material contamination to aid in assessing the appropriate health physics controls for work planning.
- Develop and implement plans for CERCLA removal actions.
- Estimate the occupational and public health and safety impacts during the Project.
- Determine the inventory of radioactive materials to confirm the final hazard characterization and to establish mitigation methods.
- Stabilize the BGRR wherever it is deemed necessary to protect the public and the environment against any actual or potential unmonitored radiological release.
- Classify wastes to demonstrate that transportation and disposal criteria will be met (waste-acceptance criteria).
- Estimate the types and volumes of waste requiring disposal.
- Undertake maintenance, as allowed for under one or more of the Laboratory's NEPA Categorical Exclusions.
- Estimate costs associated with stabilization, decontamination, and decommissioning.

The data to be generated by implementing the Project plan will have many uses. Therefore, it is important to fully understand the potential uses of these data before their generation. This is the basis upon which the Project plan was developed. The following are the major anticipated uses of the Project data:

- Decommissioning planning and engineering
- Determining the scope of the remedial work to stabilize the BGRR
- Selecting decommissioning and dismantling techniques
- Developing strategies for waste disposal
- Refining decommissioning cost-estimates and schedules
- Benchmarking the accuracy of the analysis of neutron activation
- Updating the BGRR authorization basis and the facility's hazard category, as necessary
- Providing data for developing radiological limits equivalent to regulatory-release criteria via pathways-analysis techniques
- Providing input to formulate or modify procedures for health physics, safety, radioactive waste-handling and environmental monitoring specific to any planned decommissioning programs
- Supplying input to develop the final survey program that will document the facility's status

The scope of the Project includes evaluations of remediation alternatives, where required, as part of planning for CERCLA removal actions.

In addition to the work planned as part of the BGRR-DP, the following operations may take place simultaneously:

- Regular ongoing surveys/monitoring for radiological protection of personnel working in or visiting Buildings 701, 702, 704, 708, 709, 709A, and the associated yard area
- Removal of contaminated water from various BGRR sumps and its transfer to temporary storage at the Waste Management Facility.
- Continuing work to prevent and eliminate the intrusion of storm water into contaminated portions of the BGRR facility
- Unspecified activities, to immediately protect the environment from unmonitored potential or actual releases originating from the BGRR

2.3 Inventory of Hazardous Substances

The total radiological inventory is made up of three sources: Building 701's Nuclear Material Storage Vault Inventory (currently zero), BGRR's Balance-of-Plant (BOP) Material-at-Risk (MAR) Inventory, and Pile MAR Inventory.

Among the non-radiological hazardous materials in the BGRR Complex are the following:

- asbestos and asbestos-containing material
- mercury
- lead shielding and lead-based paint
- polychlorinated biphenyl (PCBs)
- cadmium

2.3.1 Building 701's Nuclear Material Storage Vault Inventory

The Nuclear Material Storage Vault in Building 701 has been emptied and will not be allowed to receive or store any non-BGRR-DP originated radiological or otherwise hazardous material for the duration of the BGRR-DP. It has a gross radiological inventory of 0% of the Hazard Category 3 Threshold and therefore also a Material-at-Risk inventory of 0% of the Category 3 Threshold (for the activities covered under the BGRR-ASA).

2.3.2 BGRR Residual BOP Inventory

Balance-of-Plant radiological inventory removed to date is discussed under Section 2.3.6, Total Inventory Removed. The residual BOP inventory identified so far consists of contamination associated with Below Ground Ducts (BGDs) (not including the filters and fines contained therein),

Canal, Canal House, and Water Treatment House. While some soil in the vicinity of these structures may also contain contamination, that is not considered to be part of the BOP (although any such soil will be remediated as necessary to meet U.S. Environmental Protection Agency (EPA) approved surface and subsurface soils Derived Concentration Guideline Level). Initial analyses of samples recently taken have yielded the following preliminary results.

Table 2.3.2-1, Residual BOP Inventory Based on B&W NEL and *In-Situ* Object Counting System (ISOCS) Results, shows the isotopic inventories of the residual BOP components/areas as determined from the available characterization data (which is captured on Table 2.3.2-2, B&W Nuclear Environmental Laboratory Results of Analyses for Balance-of-Plant and Table 2.3.2-3, ASTD ISOCS Results of Analyses for BOP). Table 2.3.2-1 also shows the Category 3 thresholds for the various isotopes, the respective fraction of each threshold represented by the total inventory of each isotope and the overall fraction of the Category 3 threshold represented by the entire inventory. It has a gross radiological inventory equal to less than 1% of the Hazard Category 3 Threshold and a Material-at-Risk inventory of 0% (for the activities covered under the BGRR-ASA).

Until the completion of the characterization of Building 701 and 702, the inventory values given here in Section 2.3.2, BGRR Residual BOP Inventories, Section 2.3.3, BGD Filter Inventory, and in Section 2.3.4, Pile Inventory, represent only a best estimate.

Table 2.3.2-1. Residual BOP Inventory based on B&W NEL and ISOCS Results[1]

NEL BNL Material Tot. Weight Tot. Weight	ID # ID # Type [lbs] [g]	[2]Combined Canal/ Canal House Concrete 116960 5.31E+07	[3]Combined Water Treatment House Concrete 35200 1.60E+07	Combined Balance of Plant Radiological Inventory Summary [Ci]	Nuclide Specific Category 3 Threshold	Nuclide Specific Category 3 Fraction
H-3	[Ci]	2.19E-04	1.83E-06	2.21E-04	1.60E+04	1.38E-08
C-14	[Ci]	3.76E-05	3.18E-07	3.79E-05	4.20E+02	9.03E-08
Fe-55	[Ci]	3.42E-07	2.09E-07	5.51E-07	5.40E+03	1.02E-10
Co-60	[Ci]	1.35E-04	8.55E-05	2.21E-04	2.80E+02	7.88E-07
Ni-63	[Ci]	5.70E-04	4.81E-06	5.75E-04	5.40E+03	1.06E-07
Sr-90	[Ci]	2.01E-02	1.69E-04	2.03E-02	1.60E+01	1.27E-03
Y-90	[Ci]	2.01E-02	1.69E-04	2.03E-02	1.42E+03	1.43E-05
Tc-99	[Ci]	8.61E-06	7.28E-08	8.68E-06	1.70E+03	5.11E-09
I-129	[Ci]	2.89E-06	2.39E-08	2.91E-06	6.00E-02	4.86E-05
Cs-137	[Ci]	6.92E-02	5.85E-04	6.98E-02	6.00E+01	1.16E-03
Eu-152	[Ci]	9.16E-05	5.77E-05	1.49E-04	2.00E+02	7.47E-07
Eu-154	[Ci]	4.40E-05	2.79E-05	7.19E-05	2.00E+02	3.60E-07
Eu-155	[Ci]	2.86E-06	1.80E-07	3.04E-06	9.40E+02	3.23E-09
Ra-226	[Ci]	7.02E-05	2.90E-05	9.92E-05	1.20E+01	8.27E-06
Th-232	[Ci]	1.28E-06	5.32E-07	1.81E-06	1.00E-01	1.81E-05
U-234	[Ci]	1.95E-05	8.16E-06	2.77E-05	4.20E+00	6.59E-06
U-235	[Ci]	9.11E-07	3.82E-07	1.29E-06	4.20E+00	3.08E-07
U-238	[Ci]	1.72E-05	7.16E-06	2.44E-05	4.20E+00	5.80E-06
Pu-238	[Ci]	3.38E-05	1.41E-05	4.79E-05	6.20E-01	7.73E-05
Pu-239/40	[Ci]	2.05E-03	8.57E-04	2.91E-03	5.20E-01	5.59E-03
Pu-241	[Ci]	2.93E-03	1.23E-03	4.16E-03	3.20E+01	1.30E-04
Am-241	[Ci]	4.94E-04	2.03E-04	6.97E-04	5.20E-01	1.34E-03
					SUM	9.67E-03

[1]Residual BOP Inventory estimate no longer includes BGD Filter and Fines which is separately described in Section 2.3.3, BGD Filter Inventory
[2]Original estimate less the amount of activity removed by USID/SE No. BGRR-SE-01-02.
[3]Original estimate less the amount of activity removed by USID/SE No. BGRR-SE-01-01.

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Table 2.3.2-2. B&W Nuclear Environmental Laboratory Results of Analyses for Balance-of-Plant

NEL BNL Material Sample Wt.	ID# ID# Type [g]	0008076-06 AD-6 So. Cooler Coils/Mtl 2090.0	0008076-07 AD-9 No. Cooler Coils/Mtl 115.0	0006055-04 AGD-30 N. Filter Mesh 74.5	0006055-01 AGD-31 S. Dust/Fines Floor 430.1	0006055-02 AGD-32 S. Filter Media 104.5	0006055-03 AGD-33 S. Filter Mesh 106.7
H-3	[pCi/g]	5.30E+00	5.01E+00	1.93E+04	1.61E+03	1.78E+03	1.00E+03
C-14	[pCi/g]	5.37 E+00	4.48E+00	3.27E+03	3.13E+02	3.26E+02	1.98E+02
Co-60	[pCi/g]	2.61 E+01	2.68E+01	3.27E+03	2.04E+03	3.34E+02	3.24E+02
Ni-63	[pCi/g]	1.11E+02	3.63E+02	4.29E+04	1.49E+04	1.93E+03	3.81E+03
Sr-90	[pCi/g]	7.34E+03	1.73E+03	5.95E+04	5.97E+04	1.40E+06	8.57E+04
Y-90	[p/Ci/g]	7.34E+03	1.73E+03	5.95E+04	5.97E+04	1.40E+06	8.57E+04
Tc-99	[pCi/g]	3.46E+01	3.15E+01	3.67E+02	3.64E+01	2.55E+02	1.56E+02
I-129	[pCi/g]	9.87E+00	6.26E+00	1.57E+02	1.80E+01	8.82E+01	5.66E+00
Cs-137	[pCi/g]	4.75E+03	5.85E+03	2.06E+06	2.49E+05	3.62E+06	1.89E+05
Eu-152	[pCi/g]	9.73E+00	1.98E+01	2.58E+03	2.98E+02	7.45E+02	1.26E+02
Eu-154	[pCi/g]	5.78E+00	6.29E+00	1.28E+03	2.48E+01	4.17E+02	6.30E+01
Eu-155	[pCi/g]	8.39E+00	1.23E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ra-226	[pCi/g]	8.92E+00	1.16E+01	6.40E+02	1.49E+02	1.22E+03	1.60E+02
Th-232	[pCi/g]	1.50E+00	1.16E+00	1.74E+01	3.15E+00	1.70E+01	3.31E+00
U-234	[pCi/g]	1.84E+01	8.64E+01	3.09E+02	2.28E+02	7.52E+01	6.98E+01
U-235	[pCi/g]	3.62E+00	8.33E+00	1.16E+01	8.12E+00	3.90E+00	3.58E+00
U-238	[pCi/g]	1.44E+00	5.23E+00	2.90E+02	2.40E+02	5.75E+01	6.86E+01
Pu-238	[pCi/g]	6.15E+00	1.94E+00	4.88E+02	2.64E+02	3.65E+02	4.62E+01
Pu-239/40	[pCi/g]	4.19E+02	2.76E+01	3.70E+04	1.58E+04	1.76E+04	2.80E+03
Pu-241	[pCi/g]	2.67E+02	3.73E+02	Not Measured	Not Measured	Not Measured	Not Measured
Am-241	[pCi/g]	7.13E+01	2.35E+01	8.02E+03	2.07E+03	5.90E+03	4.70E+02
G. Alpha	[pCi/g]	4.63E+02	4.18E+01	6.31E+04	1.91E+04	6.47E+04	3.23E+03
G. Beta	[pCi/g]	1.62E+04	7.61E+03	3.12E+06	3.51E+05	6.13E+06	3.64E+05
		ACT vs MDA	ACT vs MDA	ACT vs MDA	ACT vs MDA	ACT vs MDA	ACT vs MDA

Table 2.3.2-3. ISOCS Results of Analyses for Balance-of-Plant			
Average Results ISOCS Analysis		**Water Treatment House Concrete**	**Canal and Canal House Concrete**
Co-60	[pCi/gm]	5.48E+00	9.86E+00
Cs-137	[pCi/gm]	3.84E+01	5.07E+03
Am-241	[pCi/gm]	1.30E+01	3.53E+01

2.3.3 Below-Ground Ducts Filter Inventory

While the BGD Filters were previously treated as part of the BOP inventory, a determination of increased inventory prompted an Occurrence Reporting and Processing System (ORPS) report and the commitment to consider it separate and distinct from BOP inventory, which was considered diffuse and without highly localized concentration. The previous estimate of the BGD Filters has been deleted from Table 2.3.2-1, Residual BOP Inventory based on B&W NEL and ISOCS Results. Instead, the current inventory is presented in Table 2.3.3-1, BGD Filter Inventory based on B&W NEL and ISOCS Results.

Table 2.3.3-1. BGD Filter Inventory based on B&W NEL and ISOCS Results

NEL BNL Material Tot. Weight Tot. Weight	ID # ID # Type [lbs] [g]	North Duct Filter Material 9312 4.22E+06	North Duct Fines Material 9312 4.22E+06	South Duct Filter Material 9312 4.22E+06	South Duct Fines Material 322 1.46E+05	Combined BGD Filter and Fines Radiolog. Inventory Summary [Ci]	Nuclide Specific Category 3 Threshold	Nuclide Specific Category 3 Fraction
H-3	[Ci]	5.46E-02	4.06E-05	2.33E-02	1.06E-04	7.80E-02	1.60E+04	4.88E-06
C-14	[Ci]	1.00E-02	7.94E-06	3.29E-03	2.07E-05	1.33E-02	4.20E+02	3.17E-05
Fe-55	[Ci]	8.09E-03	8.33E-05	6.49E-03	2.17E-04	1.49E-02	5.40E+03	2.76E-06
Co-60	[Ci]	9.35E-03	6.29E-05	3.35E-03	1.64E-04	1.29E-02	2.80E+02	4.62E-05
Ni-63	[Ci]	1.08E-01	5.08E-04	3.41E-02	1.33E-03	1.44E-01	5.40E+03	2.67E-05
Sr-90	[Ci]	1.54E+00	1.17E-02	7.09E+00	3.04E-02	8.67E+00	1.60E+01	5.42E-01
Y-90	[Ci]	1.54E+00	1.17E-02	7.09E+00	3.04E-02	8.67E+00	1.42E+03	6.11E-03
Tc-99	[Ci]	6.26E-04	2.33E-06	8.37E-04	6.08E-06	1.47E-03	1.70E+03	8.66E-07
I-129	[Ci]	2.48E-04	1.01E-06	7.05E-05	2.64E-06	3.22E-04	6.00E-02	5.37E-03
Cs-137	[Ci]	6.91E+00	6.25E-02	1.62E+01	1.63E-01	2.33E+01	6.00E+01	3.89E-01
Eu-152	[Ci]	7.53E-03	9.87E-06	6.11E-03	2.58E-05	1.37E-02	2.00E+02	6.84E-05
Eu-154	[Ci]	3.34E-03	2.47E-06	3.18E-03	6.44E-06	6.53E-03	2.00E+02	3.26E-05
Eu-155	[Ci]	2.18E-03	2.91E-05	4.80E-03	7.60E-05	7.09E-03	9.40E+02	7.54E-06
Ra-226	[Ci]	2.70E-03	8.33E-06	2.20E-03	2.17E-05	4.93E-03	1.20E+01	4.11E-04
Th-232	[Ci]	2.71E-05	1.02E-07	1.34E-05	2.66E-07	4.09E-05	1.00E-01	4.09E-04
U-234	[Ci]	9.88E-04	7.49E-06	1.31E-03	1.96E-05	2.33E-03	4.20E+00	5.54E-04
U-235	[Ci]	5.31E-05	3.42E-07	8.71E-05	8.94E-07	1.41E-04	4.20E+00	3.37E-05
U-238	[Ci]	9.61E-04	6.32E-06	1.36E-03	1.65E-05	2.34E-03	4.20E+00	5.58E-04
Pu-238	[Ci]	1.73E-03	6.24E-06	3.32E-03	1.63E-05	5.07E-03	6.20E-01	8.18E-03
Pu-239	[Ci]	5.70E-02	1.86E-04	1.24E-01	4.87E-04	1.82E-01	5.20E-01	3.49E-01
Pu-240	[Ci]	5.70E-02	1.86E-04	1.24E-01	4.87E-04	1.82E-01	5.20E-01	3.49E-01
Pu-241	[Ci]	5.09E-02	3.36E-06	1.39E-01	8.76E-06	1.90E-01	3.20E+01	5.93E-03
Am-241	[Ci]	2.12E-02	4.89E-05	3.79E-02	1.28E-04	5.93E-02	5.20E-01	1.14E-01
							SUM	1.77E+00

Note: Maximal MAR has been shown to be equal to 50% of the Duct with the larger Filter Inventory = 64.5% of the Category 3 Threshold (based on South Duct) as per BGRR-USQD-02-01, approved by DOE on July 24, 2002.

Upon removal of the BGD Coolers (as authorized by DOE approval of USID/SE No. BGRR-SE-01-03), increased access allowed for additional sampling and more extensive characterization of BGD Filters (including a direct physical measurement of the Filter media and mesh density from a large section of Filter Element which was retrieved intact). This resulted in a significant revision in the Filters' inventory estimate (due to an increase in its calculated mass).

As a result of the increased estimated inventory, an ORPS was issued (CH-BH-BNL-BNL-2002-0005) and made final on 10/31/2002, and a USQD developed to address the concerns raised regarding the adequacy of the previous classification of BGRR-DP as a Radiological Facility. The USQD/SE No. BGRR-USQD-02-01, "Challenge to BGRR-ASA by Increase in Estimated BGD Filter Inventory," was developed to assess the impact of the increased filter inventory on the classification of the BGRR-DP. Based upon the scope of work covered under the BGRR-ASA, and the final determine of MAR as approved by DOE, the BGRR-DP was, and continues to be, a Radiological Facility.

Any work contemplated on the BGD Filters (outside the scope of the activities authorized under the BGRR-ASA) will require a USQD analysis, in lieu of the normally prepared USID (due to the potential unmitigated inventories involved).

Though the combined gross radiological inventory s estimated at 177% of the Hazard Category 3 threshold; the maximum MAR, as determined by the USQD/SE and confirmed by the DOE-SER, equals 64.5% of the Nuclear Hazard Category 3 Threshold for the activities covered under the BGRR-ASA authorized scope.

2.3.4 Pile Inventory

Based upon the results of the analysis of the individual samples of the five types of graphite used in the construction of the BGRR Pile, the pile graphite inventory of Table 2.3.4-2 was developed.

The MAR inventory of the BGRR Pile has always been zero (based on the strength of the Bio-shield surrounding it and the lack of Pile-intrusive work included in the covered scope of the BGRR-ASA). The refinement of the previously estimated pile inventory by incorporation of actual characterization data in no way changed the definition of or amount of Pile MAR. With the completion of the sealing of the Pile, its stability was further enhanced.

Additional sampling and analysis may result in a refinement of the inventory with respect to the sixteen (16) control rods (boron steel) which extend 25' 6" into the graphite pile fully inserted. Based on the peak activity measurements made by the ISOCS equipment (a portable gamma ray spectrometer/multi-channel analyzer/computer/software which can identify concentrations of nuclides by their characteristic gamma ray emissions even in the presence of shielding), the control rod inventory shown in Table 2.3.4-1 was developed.

The gross radiological inventory of the pile is estimated at 350% of the Hazard Category 3 threshold, while the Material-at-Risk inverts is estimated at 0% for the activities covered by the BGRR-ASA.

Table 2.3.4-1. Control Rod Inventory			
Nuclide	**Activity [Ci]**	**Cat 3 Thresh [Ci]**	**Cat 3 Fraction**
Co-60	3.32E-01	280	1.18E-03
Cs-137	1.75E-03	60	2.92E-05
Eu-152	8.57E-04	200	4.28E-06
Eu-154	1.80E-03	200	8.98E-06
Eu-155	1.14E-02	940	1.22E-05
Am-241	2.53E-02	0.52	4.86E-02
	3.73E-01	Sum	4.99E-02

Additional ISOCS measurements and/or alternate sampling and analysis technique (e.g., Beta-Scint) may result in a refinement of the inventory.

Finally, there may be some as-yet unattributed inventory present as interior bioshield wall surface activation due to neutron leakage as well as activation of structural steel components in contact with the graphite pile.

Table 2.3.4-2. Pile Graphite Inventory Based On B&W NEL Results

NEL ID#	0008076-01	0008076-02	0008076-03	0008076-04	0008076-05	COMBINED SUM	[Ci] CATEGORY 3 THRESHOLD	CATEGORY 3 FRACTION
BNL ID#	W-12-AA-1	W-32-B-2	W-32-C-3	W-32-D-4	W-35-A			
Graphite Type	**AA**	**B**	**C**	**D**	**A**	**ALL**		
Tot. Weight [lbs.]	13060	170390	147105	953175	179820	1463550		
Tot. Weight [g]	5.92E+06	7.73E+07	6.67E+07	4.32E+08	8.16E+07	6.64E+08		
H-3 [Ci]	7.23E+00	4.36E+02	3.43E+02	2.00E+03	6.13E+02	3.40E+03	1.60E+04	2.13E-01
C-14 [Ci]	9.83E-01	1.45E+02	1.04E+02	4.97E+02	3.02E+02	1.05E+03	4.20E+02	2.50E+00
*Fe-55 [Ci]	1.03E-05	4.56E-03	1.70E-03	2.42E-02	9.66E-04	3.14E-02	5.40E+03	5.82E-06
Co-60 [Ci]	4.09E-03	1.81E+00	6.74E-01	9.60E+00	3.83E-01	1.25E+01	2.80E+02	4.45E-02
Ni-63 [Ci]	6.99E-03	3.72E+00	1.37E+00	9.04E+01	1.86E+00	9.73E+01	5.40E+03	1.80E-02
Sr-90 [Ci]	1.43E-04	3.49E-01	5.22E-03	6.05E-02	6.05E-03	4.21E-01	1.60E+01	2.63E-02
Y-90 [Ci]	1.43E-04	3.49E-01	5.22E-03	6.05E-02	6.05E-03	4.21E-01	1.42E+03	2.97E-04
Tc-99 [Ci]	4.06E-05	5.06E-04	4.52E-04	3.42E-03	5.45E-04	4.96E-03	1.70E+03	2.92E-06
I-129 [Ci]	9.72E-05	7.88E-04	6.49E-04	2.95E-03	6.44E-04	5.13E-03	6.00E-02	8.54E-02
Cs-137 [Ci]	5.15E-04	1.19E+00	3.90E-04	3.74E-03	6.93E-02	1.26E+00	6.00E+01	2.11E-02
Eu-152 [Ci]	2.92E-02	1.30E-03	9.41E-04	7.13E-03	9.54E-04	3.95E-02	2.00E+02	1.98E-04
Eu-154 [Ci]	1.24E-03	4.88E-01	5.81E-01	3.91E+00	6.72E-01	5.66E+00	2.00E+02	2.83E-02
Eu-155 [Ci]	1.28E-03	4.31E-02	5.40E-02	2.08E-01	4.82E-02	3.55E-01	9.40E+02	3.78E-04
Ra-226 [Ci]	7.58E-04	9.51E-04	5.16E-04	4.13E-03	5.30E-04	6.88E-03	1.20E+01	5.74E-04
Th-232 [Ci]	1.48E-05	3.14E-04	2.19E-04	1.23E-03	2.92E-04	2.07E-03	1.00E-01	2.07E-02
U-234 [Ci]	3.10E-04	1.61E-03	6.87E-04	3.73E-03	8.24E-04	7.16E-03	4.20E+00	1.70E-03
U-235 [Ci]	1.44E-05	1.01E-04	1.07E-04	3.53E-04	1.17E-04	6.93E-04	4.20E+00	1.65E-04
U-238 [Ci]	4.19E-06	6.41E-05	6.81E-05	3.53E-04	1.17E-04	6.07E-04	4.20E+00	1.44E-04
Pu-238 [Ci]	4.11E-05	3.86E-02	3.68E-04	7.83E-03	1.22E-03	4.81E-02	6.20E-01	7.76E-02
Pu-239/40 [Ci]	2.06E-05	5.73E-02	1.19E-03	1.57E-02	1.87E-03	7.61E-02	5.20E-01	1.46E-01
**Pu-241 [Ci]	2.95E-05	8.21E-02	1.71E-03	2.26E-02	2.68E-03	1.09E-01	3.20E+01	3.41E-03
Am-241 [Ci]	4.14E-05	1.25E-01	1.59E-03	3.52E-02	3.99E-03	1.66E-01	5.20E-01	3.19E-01
G.Alpha [Ci]	1.75E-05	2.84E-01	3.55E-03	5.62E-02	7.89E-03		SUM	3.50E+00
G. Beta [Ci]	1.97E-02	4.10E+00	1.20E+00	1.32E+01	1.22E+00			

*Fe-55 results based on a single composite sample analysis from all graphite samples by B&W yielding below MDA (4.73E+01 pCi/gm)
**Pu-241 attributed by scaling off of results on analyses of BGD HX samples and actual Pu-239/40 measurements.

2.3.5 Total Residual Inventory

The following fractions are determined for the BGRR Complex.

		Fraction of Nuclear Category 3 Threshold, %
Building 701's Nuclear Material Storage Vault Inventory @		0.00
BGRR BOP Material-at-Risk @		0.00
BGRR BGD Filter Material-at-Risk @		64.50
BGRR Pile Material-at-Risk Inventory @		0.00
	SUM ≈	64.50%

The BGD Filter Material-at-Risk Inventory estimate of 64.5% of Category 3 threshold is based on characterization of BGD Filters and Fines. Remediation of the BGD Filters and Fines inventory is not within the current scope of work covered by this ASA and hence not truly at risk here. (See Section 3.0 Hazard Analysis for a complete discussion of bounding accidents and consequences, as well as final classification of the facility for the activities covered by the BGRR-ASA.)

2.3.6 Total Inventory Removed

As the work scope covered by this document does not include decommissioning actions nor disposal of materials removed by decommissioning actions, except for material removed for characterization purposes, all non-trivial radiological inventory removed from the BGRR Complex had to be removed under USID process, USQD process, or external approved Standard Operating Procedures (SOP) (removal of items from Building 701 Accountable Nuclear Material Storage Vault by Isotopes and Special Materials Group of Safeguards and Security Division).

Under WMF-SE-97-03, “Temporary Storage of BGRR Air Cooling Duct Water at the WMF” [22], 56,800 gallons of contaminated water were removed from the below ground ducts and assorted sumps and ultimately disposed of off-site. Among the contaminants were: H-3 @ 1.075E-02 Ci, Sr-90 @ 2.088E-01 Ci, Y-90 @2.088E-01Ci, Cs-137 @ 1.163E-01 Ci, Ra-226 @ 4.762E-06Ci; U-233/34 @ 1.074E-01 Ci, U-235 @ 1.905E-08 Ci, U-238 @ 1.385E-07 Ci, Np-237 @ 1.039E-08 Ci, Pu-239/40 @ 5.369E-08 Ci, Pu-241 @ 7.69E-08Ci, Am-241 @ 6.234E-08 Ci, and Cm-244 @ 6.927E-09 Ci. (Pu-241 attributed after the fact by scaling from Pu-239/40).

Under BNL *Material Control and Accountability (MC&A) Manual*, Section 4, "Intra-site Transfer of Accountable Nuclear Material" [23], all of the material previously listed in Table 2.1, Building 701's Nuclear Material Storage Vault Inventory, was removed and either relocated to an alternate storage location or disposed of as waste material. These materials included: 3 Kg of solid enriched Lithium, Ra-226 @ 5.90E-01 Ci, Th-232 @ 5.56E-03 Ci, U-238 @ 2.75E+00 Ci, Np-237 @ 1.00E-04 Ci, Am-241 @ 2.06E-02 Ci, and Cf-252 @ 1.93E-02 Ci.

Under BGRR-SE-99-01, “Removal of Pile Fan No. 5” [24], the contaminated Primary Cooling Fan #5 was removed and disposed of offsite. Among the contaminants were: Co-60 @ 2.53E-07 Ci, Sr-90 @ 1.19E-04 Ci, Y-90 @ 1.19E-04 Ci, Cs-137 @ 1.34E-03 Ci, U-233 @ 1.70E-05 Ci, U-234 @ 1.70E-05 Ci, U-235 @ 2.96E-06 Ci, U-238 @ 3.65E-05 Ci, Pu-238 @ 2.84E-05 Ci, Pu-239 @ 1.00E-03 Ci, Pu-240 @

1.00E-03 Ci, Pu-241 @ 4.97E-06 Ci, and Am-241 @ 3.60E-04 Ci. (Pu-241 attributed after the fact by scaling from Pu-239/40).

Under BGRR-SE-99-02, "Removal of Pile Fan Sump" [25], the contaminated Pile Fan Sump, piping and soil was removed and disposed of offsite. Among the contaminants were: H-3 @ 6.74E-05 Ci, Co-60 @ 5.77E-06 Ci, Sr-90 @ 3.21E-04 Ci, Y-90 @ 3.21E-04 Ci, Cs-137 @ 4.62E-04 Ci, Eu-155 @ 1.78E-05 Ci, U-235 @ 2.59E-06 Ci, U-238 @ 3.88E-05 Ci, Pu-238 @ 9.84E-06 Ci, Pu-239 @ 3.80E-05 Ci, Pu-240 @ 3.80E-05 Ci, Pu-241 @ 1.89E-07 Ci and Am-241 @ 1.17E-05 Ci. (Pu-241 attributed after the fact by scaling from Pu-239/40).

Under BGRR-SE-99-03, "Removal of Residual Pile Fans" [26], all the remaining contaminated primary/auxiliary/emergency cooling fans and components were removed and disposed of off-site. Among the contaminants were: Co-60 @ 2.93E-05 Ci, Sr-90 @ 1.20E-03 Ci, Y-90 @ 1.20E-03 Ci, Cs-137 @ 3.35E-03 Ci, Eu-152 @ 4.11E-05 Ci, Eu-154 @ 2.80E-05Ci, U233 @ 1.27E-04 Ci,U-234 @ 1.27E-04 Ci, U-235 @ 3.67E-07 Ci, U-238 @ 4.03E-06 Ci, Pu-238 @ 2.64E-06 Ci, Pu-239 @ 5.86E-04 Ci, Pu-240 @ 5.86E-04 Ci, Pu-241 @ 2.91E–06 Ci, Am-241 @ 4.38E-04 Ci.

For characterization purposes in preparation for the development of BGRR-SE-99-04, "Removal of Above Ground Ducts" [27], sludge was removed from the expansion joints within the Above Ground Ducts and ultimately disposed of offsite. Among the containments were: H-3 @ 1.13E-04 Ci, C-14 @ 4.38E-05 Ci, Co-60 @ 1.89E-03 Ci, Ni-63 @ 2.13 E-04 Ci, Sr-90 @ 4.49E-03 Ci, Y-90 @ 4.49E-03 Ci, Tc-99@ 7.49E-06 Ci, Cs-137 @ 1.06E-02 Ci, Eu-152 @ 1.22 E-05 Ci, E-154 @ 5.11 E-06 Ci, U-234 @ 2.51 E-06 Ci, U-235 @ 1.73 E-07 Ci, U-238 @ 2.42 E-06 Ci, Pu-238 @ 4.40 E-06 Ci, Pu-239 @ 1.52 E-04 Ci, Pu-240 @ 1.52 E-04 Ci, Pu-241 @ 7.55E-07 Ci and Am-241 @ 4.69 E-05 Ci. (Pu-241 attributed after the fact by scaling from Pu-239/40).

Under BGRR-SE-99-04, "Removal of Above Ground Ducts," all the above ground portion of the contaminated primary cooling duct(s) were removed and disposed of (will be disposed of) off-site. Among the contaminants were: Co-60 @ 6.67E-04 Ci, Sr-90 @ 1.37E-01 Ci, Y-90 @ 1.37E-01 Ci, Cs-137 @ 4.66E-01 Ci, Eu-152 @ 1.10E-04 Ci, Eu-154 @ 5.98 E-05 Ci, U-233 @ 2.35E-04 Ci, U-234 @ 2.35E-04 Ci, U-235 @ 5.04E-07 Ci, U-238 @ 5.54E-06 Ci, Pu-238 @ 4.28E-06 Ci, Pu-239 @ 2.09E-03 Ci, Pu-240 @ 2.09E-03 Ci, Pu-241 @ 1.04E-05 and Am-241 @ 1.62E-03 Ci. (Pu-241 attributed after the fact by scaling from Pu-239/40).

Under BGRR-SE-01-01, "Above Ground Canal House and Water Treatment House Removal", [65] the two structures and contents were removed to grade elevation and disposed of offsite. Among the contaminates were: H-3 @ 9.18 E-08 Ci, C-14 @ 1.60E-08 Ci, Fe-55 @ 5.44E-09 Ci, Co-60 @ 2.17E-06 Ci, Ni-63 @ 2.42E-07 Ci, Sr-90 @ 8.47E-06 Ci, Y-90 @ 8.47E-06 Ci, Tc-99 @ 3.65E-09 Ci, I-129 @ 1.20E-09 Ci, Cs-137 @ 2.93E-05 Ci, Eu-152 @ 1.47E-06 Ci, Eu-154 @ 7.08E-07 Ci, Eu-155 @ 5.14E-09 Ci, Ra-226 @ 7.42E-07 Ci, Th-232 @ 1.36E-08 Ci, U-233 @ 1.04E-07 Ci, U-234 @ 1.04E-07 Ci, U-235 @ 9.77E-09 Ci, U-238 @ 1.83E-07 Ci, Pu-238 @ 3.59E-07 Ci, Pu-239 @ 1.09E-05 Ci, Pu-240 @ 1.09E-05 Ci, Pu-241 @ 3.14E-05 Ci, and Am-241 @ 5.18E-06.

Under BGRR-SE-01-02, "Lower Canal and Water Treatment House, Equipment and Associated Soil-Removal Action;" [66] the following activities: (1) Remediation and/or removal of the outdoor working pad area that surrounds the Canal and Water Treatment House on the north, east, and south sides; (2) Remediation and/or removal of the Lower Canal Piping Systems trench; (3) Remediation and/or removal of the East Yard Sump; (4) Remediation and/or removal of the associated surface soils; (5) Rerouting of storm drain lines; (6); Installation of 3 monitoring wells; (7) Remediation of Canal and covering to

prevent water intrusion, were performed with waste material removed and disposed of offsite. Among the contaminates were: H-3 @ 6.25E-04 Ci, C-14 @ 1.09E-04 Ci, Fe-55 @ 9.78E-07 Ci, Co-60 @ 3.89E-04 Ci, Ni-63 @1.65E-03 Ci, Sr-90 @5.74E-02 Ci, Y-90 @ 5.74E-02 Ci, Tc-99 @ 2.49E-05 Ci, I-129 @ 8.15E-06 Ci, Cs-137 @ 2.00E-01 Ci, Eu-152 @ 2.62E-04 Ci, Eu-154 @ 1.27E-04, Eu-155 @ 8.29E-06 Ci, Ra-226 @ 1.98E-04 Ci, Th-232 @ 3.63E-06 Ci, U-234 @5.59E-05 Ci, U-235 @ 2.62E-06 Ci, U-238 @ 4.92E-05 Ci, Pu-238 @ 9.63E-05 Ci, Pu-239/40 @ 5.86E-03 Ci, Pu-241 @ 8.37E-03 Ci, and Am-241 @ 1.38E-03 Ci.

Under BGRR-SE-01-03 "Below Ground Duct Coolers Removal", [67] the coolers were removed and packaged for disposal off-site. Among the contaminates were: H-3 @ 1.44E-05 Ci, C-14 @ 1.38E-05 Ci, Fe-55 @ 1.85E-07 Ci, Co-60 @ 7.41E-05 Ci, Ni-63 @ 6.63E-04 Ci, Sr-90 @ 1.27E-02 Ci, Y-90 @ 1.27E-02 Ci, Tc-99 @ 9.26E-05 Ci, I-129 @ 2.26E-05 Ci, Cs-137 @ 1.48E-02 Ci, Eu-152 @ 4.13E-05 Ci, Eu-154 @ 1.69E-05 Ci, Eu-155 @ 2.90E-05 Ci, Ra-226 @ 2.88E-05 Ci, Th-232 @ 3.72E-06 Ci, U-234 @ 1.47E-04 Ci, U-235 @ 1.67E-05 Ci, U-238 @ 9.34E-06 Ci, Pu-238 @ 1.13E-05 Ci, Pu-239 @ 3.13E-04 Ci, Pu-240 @ 3.13E-04 Ci, Pu-241 @ 8.97E-04 Ci, Am-241 @ 1.33E-04 Ci.

The combined sum [9.07 E-01 times Category 3 Threshold], though never accumulated in one place at one time, is reflected in Table 2.3.6-1, Tally of BGRR Decommissioning Project's Inventory Removed, which follows.

Table 2.3.6-1. Tally of BGRR Decommissioning Project's Inventory Removed

Radionuclide	Half-Life [Yr]	Total Activity [Ci]	Haz. Cat. 3 Threshold [Ci]	Haz. Cat. 3 Fraction
H-3	1.23E+01	1.16E-02	1.60E+04	7.23E-07
C-14	5.72E+03	1.67E-04	4.20E+02	3.97E-07
Fe-55	2.70E+00	1.17E-06	5.40E+03	2.17E-10
Co-60	5.27E+00	3.06E-03	2.80E+02	1.09E-05
Ni-63	1.00E+02	2.53E-03	5.40E+03	4.68E-07
Sr-90	2.88E+01	4.22E-01	1.60E+01	2.64E-02
Y-90	7.31E-03	4.22E-01	1.42E+03	2.97E-04
Tc-99	2.14E+05	1.25E-04	1.70E+03	7.35E-08
I-129	1.57E+07	3.08E-05	6.00E-02	5.13E-04
Cs-137	3.02E+01	8.13E-01	6.00E+01	1.35E-02
Eu-152	1.30E+01	4.68E-04	2.00E+02	2.34E-06
Eu-154	8.50E+00	2.38E-04	2.00E+02	1.19E-06
Eu-155	4.90E+00	5.51E-05	9.40E+02	5.86E-08
Ra-226	1.60E+03	5.90E-01	1.20E+01	4.92E-02
Th-232	1.41E+10	5.57E-03	1.00E-01	5.57E-02
U-233	1.59E+05	1.08E-01	4.20E+00	2.57E-02
U-234	2.45E+05	5.85E-04	4.20E+00	1.39E-04
U-235	7.04E+08	2.59E-05	4.20E+00	6.18E-06
U-238	4.47E+09	2.75E+00	4.20E+00	6.55E-01
Np-237	2.14E+06	1.00E-04	4.20E-01	2.38E-04
Pu-238	8.77E+01	1.58E-04	6.20E-01	2.54E-04
Pu-239	2.44E+04	7.12E-03	5.20E-01	1.37E-02
Pu-240	6.57E+03	7.12E-03	5.20E-01	1.37E-02
Pu-241	1.44E+01	9.32E-03	3.20E+01	2.91E-04
Am-241	4.33E+02	2.41E-02	5.20E-01	4.64E-02
Cm-244	1.81E+01	6.93E-09	1.04E+00	6.66E-09
Cf-252	2.64E+00	1.93E-02	3.20E+00	6.03E-03
			Sum	9.07 E-01

Includes: WMF-SE-97-03 [Below Ground Duct Water], BGRR-SE-99-01 [Pile Fan #5], BGRR-SE-99-02 [Pile Fan Sump and contiguous piping and soil], BGRR-SE-99-03 [Residual Pile Fans], Characterization of sludge for preparation of USID/SE, BGRR-SE-99-04 [Above Ground Ducts], 701 Vault Cleanout, BGRR-SE-01-01 [Aboveground Canal, and Water Treatment House], BGRR-SE-01-02 [Lower Canal, Water Treatment House, Equipment, and Soils], BGRR-SE-01-03 [Below Ground Duct Coolers].

2.4 Demographics

The size and distribution of populations are important criteria for assessing the magnitude of risk to the public from radiological releases. However, the inventories at risk, for both chemical and radiological releases, are sufficiently low such that credible release scenarios would produce only localized effects. This is consistent with the designation of "Radiological Facility," as defined in DOE-EM-STD-5502-94, *Hazard Baseline Documentation*.

2.5 Site Features

The information contained in this section was derived from various BNL annual environmental reports from the last ten years.

2.5.1 Meteorology and Climate

Brookhaven National Laboratory has a Meteorology Group that has kept data on the site since 1948. In addition, in 1993, a NEXRAD meteorology facility began operation at BNL, expanding the capability of gathering meteorological information for the BNL area.

The general region experiences a combination of maritime- and continental-exposure, maritime along the coast, gradually changing to continental inland. On a broad scale, the weather is greatly influenced by the Atlantic Ocean, Long Island Sound, and various bays. The presence of these water bodies and associated land units moderates both summer and winter temperatures, and strongly influences wind and humidity patterns. These factors also greatly reduce the snowfall in the BNL area from that expected further inland from the more continental environment. BNL can be characterized, like many eastern seaboard areas, as well ventilated by winds from all directions with rapid, fairly consistent alternations among various types of atmospheric stability.

2.5.2 Temperature

The annual average temperature is approximately 50 ºF, which is higher than most places of the same latitude within the United States, except along the Pacific Coast. Winter temperatures are milder because of the surrounding warmer water. During the summer, afternoon temperatures are moderated by local sea breezes blowing on-shore from the cool water-surfaces. However, temperatures onsite have been recorded as high as 100 ºF in July to as low as –23 ºF in January. Figure 2.2 shows the monthly average temperatures in 2000 and also the 51-year monthly average. Rapid extremes in winter temperatures that melt snow and ice would not flood the BGRR facility due to its elevation and the grading around the facility [28].

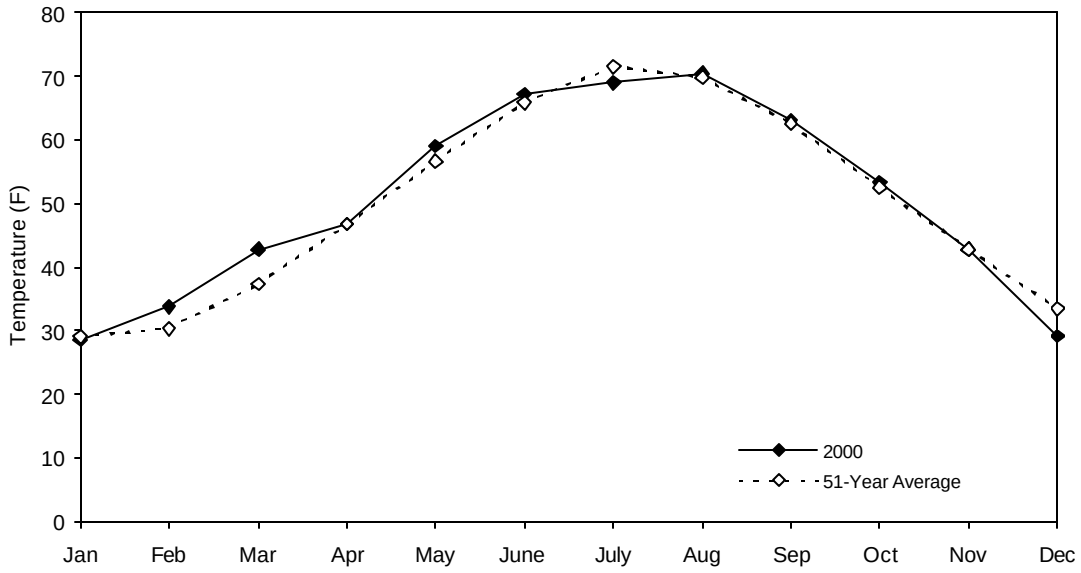


Figure 2.2. 2000 Monthly Mean Temperature Versus 51-Year Monthly Average

2.5.3 Precipitation

The average annual precipitation is approximately 48.5 inches, with little variation in the monthly averages. Warm season precipitation is primarily convective, whereas most late fall and winter precipitation results from storms moving northeastward along or near the east coast. An hourly rainfall rate of more than 2 inches and a 24-hour rainfall rate of 8 inches are exceptional but not unknown. Thundershowers have occurred during every month, but are most prevalent during the summer. Because of the proximity to the ocean, storms are generated over inland areas around midday and are carried to eastern Long Island by upper-level wind flow. Average relatively humidity is 74% annually, with a high of 82% during August and September, and a low of 66% in March.

Snow falls between October and April. The seasonal amount averages 29.6 inches, but varies greatly from year to year, e.g., 4.5 inches were recorded during 1997-98, and 90.8 inches during 1995-96. The mean annual number of days with freezing rain or freezing drizzle is six. Heavy ice storms are infrequent and generally occur in January. The total precipitation for 1997 was 40.04 inches, which is about 8 inches below the 40-year annual average. Figures 2.3 and 2.4, respectively, show the 2000 monthly and historic precipitation data. On average, about half of the annual precipitation is lost to the atmosphere through evapotranspiration, and the other half percolates through the soil to recharge groundwater.

The roof structure of the BGRR facility is designed for a snow loading of 40 pounds per square foot. A worst-case snowstorm would not damage the structure.

Grading around the BGRR is such that runoff will be away from the facility to protect against internal flooding of the facility precipitation and melting snow.

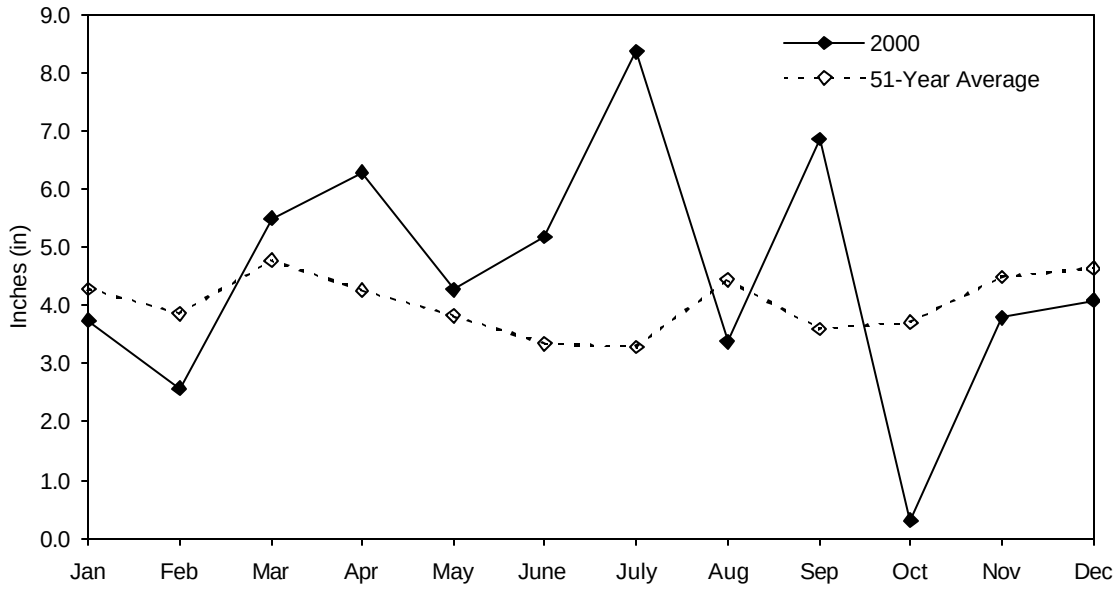


Figure 2.3. 2000 Monthly Precipitation Versus 51-Year Monthly Average

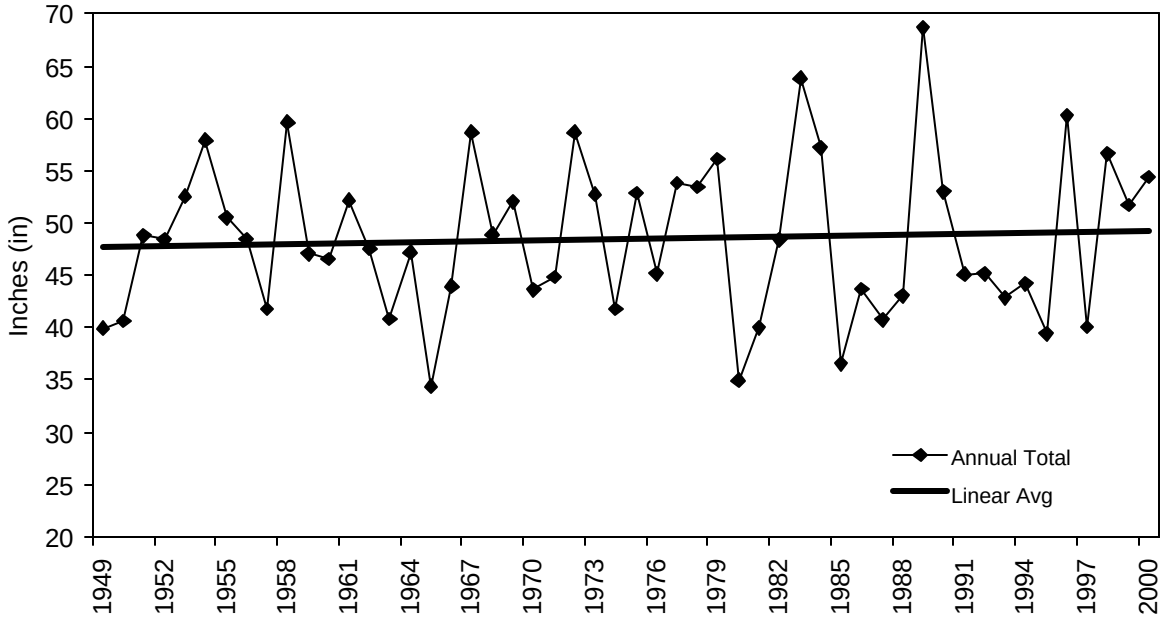


Figure 2.4. Fifty-One Year Annual Precipitation Trend (1949-2000)

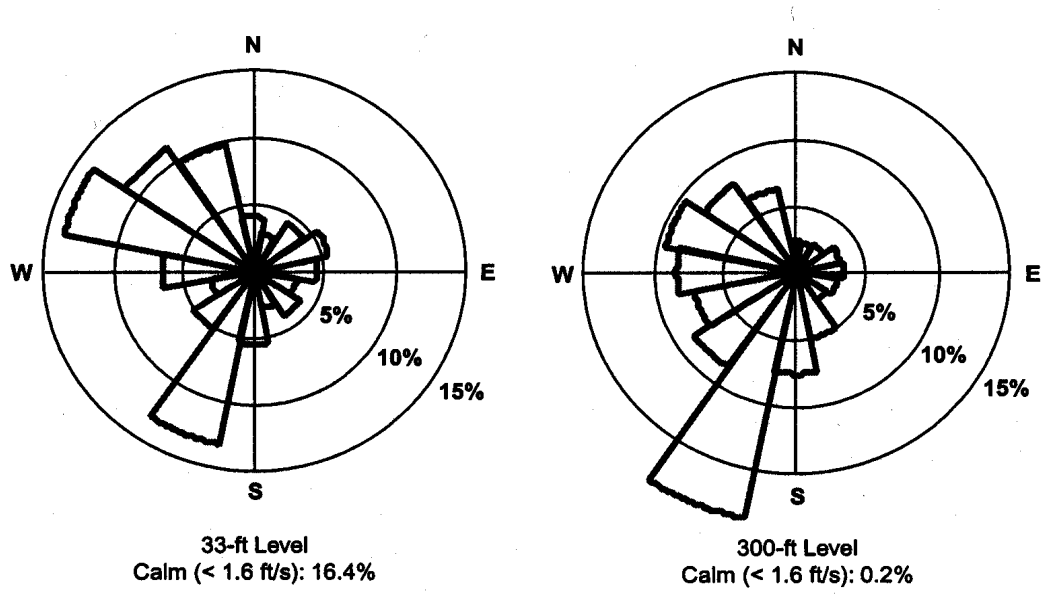
2.5.4 Prevailing Winds

The prevailing ground-level winds are from the southwest during the summer, from the northwest during the winter, and about equally from these two directions during the spring and fall. Figure 2.5 shows the annual wind rose for calendar year 2000 at both 33-foot level and the 300-foot level.

"Nor'easters" can occur from December through March, bringing wind gusts of 80 to 90 mph. The probability during September for at least one tropical cyclone somewhere in the North Atlantic is 92%, with a 42% chance of three or more storms occurring. In recent decades, hurricanes have moved inland or passed close enough offshore to result in storms of hurricane winds, heavy rainfall, or high storm tides. Tornadoes occur, on average, at least once per year.

The highest wind speeds at BNL have occurred with hurricanes that occur from June to October, and a few weak or declining storms in May and November. In September, the chances are 92% for at least one tropical cyclone somewhere in the North Atlantic and 42% for three or more. The northeastern states experienced hurricanes of moderate intensity only rarely between 1901 and 1931. Sections of the coast have been severely affected since 1932, with several hurricanes moving inland or passing close enough offshore to result in storms of hurricane winds, heavy rainfall, or high storm tides. However, tornadoes and hailstorms are extremely rare on Long Island.

Even if there were a high-wind event, it would be bounded by the analysis of hurricane winds up to 110 mph, which were evaluated in the "Brookhaven National Laboratory, FASTER Team, BGRR Hazards Summary and Recommendations Document (Draft)" [29]. The analysis showed that any such events are not expected to have any impact that would release the radiological inventory of the BGRR facility.



Explanation: The arrows formed by the wedges indicate wind direction. Each concentric circle represents a 5% frequency, that is, how often the wind is coming from that direction. The wind direction was measured at heights of 33 and 300 feet (10 and 90 meters). For example, this diagram indicates that the predominant wind direction at 300 feet (90 meters) was from the south-southwest.

Figure 2.5. Annual Wind Rose for 2000

2.5.5 Hydrology Description

Studies of Long Island hydrology and geology near BNL indicate that the uppermost Pleistocene deposits, which are between 102 to 200 feet thick, are generally sandy and highly permeable. Water penetrates these deposits readily and there is little direct runoff into surface streams, except during periods of intense precipitation. On the average, about half of the annual precipitation is lost to the atmosphere through evapotranspiration and the other half percolates through the soil to recharge groundwater. Runoffs form a very insignificant portion of the total rainfall, usually less than 2%. BNL lies on the western rim of the shallow Peconic River watershed. The marshy areas in the north and eastern sections of the site are a portion of the Peconic River headwaters. The Peconic River both recharges and receives water from the groundwater aquifer depending on the hydrogeological potential. In time of drought, the river water typically recharges to groundwater, while during normal to above normal precipitation, the river receives water from the aquifer.

2.5.6 Floods

The only water of any potential significance on the BNL site is the Peconic River, on the north-northeast side of the site. The Peconic here is frequently dry, and there is no record of the river producing any flooding that could encroach on the BNL site. Therefore, flooding from surface-water sources is not considered a concern.

As evidenced in the *Brookhaven National Laboratory Site Environmental Report for Calendar Year 1993* [30], there is a potential for the groundwater to rise to the surface in certain areas of BNL and according to this report, it has done so. Groundwater is generally 35 to 40 feet below ground surface around the BNL site, and therefore, flooding is not considered a threat.

While BNL is relatively near the coast, no tsunami flooding of the area has been recorded. While there can be mild ice-rain near BNL, it is not expected that the site will experience any severe ice jam, flood, wind-driven ice ridges, nor ice-produced forces that would affect the BGRR facility.

The BGRR facility is located at a high point on the BNL site. The base of the building is 134-feet above sea level. Flooding is not considered a major threat to the BGRR facility due to the sites characteristics and the elevation of the facility.

2.5.7 Geology and Seismology

Brookhaven National Laboratory is located on Long Island, which, as a whole, is the terminal moraine of the last two glaciations. The BNL site is in the upper part of the Peconic River Valley, which is bordered by two lines of low hills. These extend east and west beyond the limits of the valley nearly the full length of Long Island, and form its most prominent topographic features. The northern line of hills, known as the Harbor Hill moraine, lies along the north shore, and the southern line, the Ronkonkoma moraine, extends along the center of Long Island and passes just south of BNL.

Just west of the BNL site, a narrow north-south ridge connects the two moraines. East of this ridge, and enclosed by it and the two moraines, is the Manorville basin; the main BNL grounds are on the basin's relatively high west margin. The basin forms the upper drainage area of the Peconic River.

Six principal stratigraphic units, some of which include subdivisions of minor importance, were recognized in the test drilling at BNL. At the base is the oldest unit, the bedrock of the Pre-Cretaceous age, which has no formational name. Above the bedrock is the Raritan formation of Cretaceous age, which is as much as 500-feet thick and has two members: the lower, as much as 300-feet thick, is called the Lloyd sand member and is composed of coarse-grained sand, gravel, and some clay; the upper, about 200-feet thick, is mostly clay and is called the clay member. Overlying the Raritan formation is the Magothy formation, also of Cretaceous age. Beneath BNL, this formation consists of about 900-feet of mostly clayey sand, and it includes beds of clay, and of sand and gravel. Under most of the BNL tract, and, in general, under the southern half of central Suffolk County, the Magothy formation is overlain unconformably by the Gardiners Clay of Pleistocene age. The sixth major stratigraphic unit is called the upper Pleistocene deposits, an informal term for the glacial deposits which, in nearly all of Long Island, overlie the Gardiners Clay of the Magothy formation.

Most of these deposits consist of sand and gravel which, with local silt and clay, form the stratified outwash and morainal deposits of presumed Wisconsin age. Their maximum known thickness is about 200 feet. Most of the formations recognized here occur nearly everywhere beneath Long Island.

The bedrock underlying the unconsolidated deposits, as deep as 1,600 feet beneath BNL, includes hard dense schist, gneiss, and granite similar to that underlying much of the mainland in nearby parts of New York and Connecticut.

In recorded history (since 1638), the closest earthquakes of any significance occurred in 1929 at Attica, New York, with a Mercalli intensity of IX (with a maximum acceleration of 0.3 to 0.7 g), and in 1931 at Lake George, New York, with a Mercalli intensity of VII (with a maximum acceleration of 0.07 to 0.22 g). Attica is located 350 miles northwest of Long Island, and Lake George is approximately 250 miles north.

The BNL site was originally designated as a “moderate” seismicity zone as per *Interagency Committee on Seismic Safety in Construction (ICSSC) Technical Report 17, Appendix A* [31]. This ICSSC report designates a “moderate” zone as one having an acceleration velocity of between 0.10 g and 0.20 g, with a “low” zone being below 0.10 g. A more detailed analysis was made using the county-by-county maps from the 1994 *NEHRP Recommended Provisions for the Development of Seismic Regulations for New Buildings* [32] as allowed by the ICSSC report. This evaluation shows that BNL falls into an area where the acceleration velocity is slightly less than 0.10 g, and thus reclassified as a “low” seismicity zone. This classification has been agreed to by DOE during the recent project implementing Executive Order (EO) 12941, “Seismic Safety of Existing Federally Owned or Leased Buildings” [33], and documented in BNL memorandum, DeBobes to Helms, dated May 28, 1998, “Phase 2, 3, and 4 Submittal for Executive Order 12941” [34].

There are no active faults known in the Long Island area, and earthquake intensities greater than III (with a maximum acceleration of 0.003 to 0.007 g) (Brookhaven National Laboratory Hazard Assessment Document, Rev. 1, December 1997 [35]) have not been recorded. Furthermore, ER-83 (of DOE) concluded that BNL could be considered a low-seismicity zone for the purpose of completing EO 12941 activities, based on an examination of NEHRP Map 4. The objective of the EO 12941 program was to identify buildings with potential concerns about life-safety or the release of hazardous materials, and to estimate the approximate costs of rehabilitating deficient buildings.

The probability of an earthquake in the BNL area sufficiently intense to damage buildings and reactor structures was thoroughly investigated during construction of the Graphite Reactor [36] and several

subsequent reviews of the High Flux Beam Reactor. The consensus of seismologists is that no significant quakes are to be expected in the foreseeable future. No active earthquake-producing faults are known in the Long Island area.

3.0 HAZARD ANALYSIS

Section 3 provides the history, current analysis, and outcome of the hazards assessment, hazard analysis, and results of the various safety basis reviews that have been undertaken at the BGRR since April 1998. This section is arranged in the following order to set the basis and provide the outcome of these analyses:

- Section 3.1 discusses the PHA and Preliminary Hazards Classification (PHC) that established the basis, origin, and foundation of the BGRR-DP safety basis work performed since early 1998.

- Section 3.2 includes the method for the hazard analysis to be used as described in Section 3.2.1 and originally defined by BNL ES&H Standard 1.3.3 (which was itself supplanted by SBMS Subject Area "Hazard Analysis"). Sections 3.2.2 through 3.2.9 performs the analysis for each of the seven accidents described in the PHA / PHC, and one additional accident (008) that was added as part of the review cycle for the ASA. Each of these analyses defines the probability and severity of the pre- and post-mitigation accidents to arrive at a Risk Category as defined in Table 3.2.1-4.

- Section 3.3 summarizes the worst-case consequences from the eight accidents analyzes in Section 3.2, and describes the bounding dose accident.

- Section 3.4 collects the results of the eight analyses and compares those results with the requirements in the DOE *Hazard Baseline Documentation* and DOE-STD-1027-92 to define the hazards classification for the BGRR facility during the Decommissioning Project for the authorized work.

Despite the availability of actual (though not complete) characterization data and the generation of revised inventory estimates based on it, the Hazard Analysis remains unchanged from the approved version contained in the prior revision. The reasons for not modifying the approved Hazard Analysis include:

- There is no change in the scope of work covered by the BGRR-ASA
- There is no change in methodology for approval of work not covered by the BGRR-ASA (USID process)
- There is no change in Pile Material-at-Risk based on limited scope
- There is no benefit to the Margin of Safety by reducing the consequences of the BOP inventory based accident scenarios to reflect a reduction in total BOP inventory from an estimated maximum of 340% to a calculated maximum of less than 64% of the Category 3.
- There is no benefit to the Margin-of-Safety by reducing the consequences of the Graphite inventory based accident scenarios to reflect a reduction in fraction of Hazard Category 3 threshold based on the use of actual characterization data, versus the continued conservative use of the original estimated source term data.

3.1 Preliminary Hazard Analysis

In developing the authorization basis, a PHA was performed for the BGRR facility [29, 37]. It considered the entire facility in its current configuration, except for the 701 Nuclear Material Storage Vault. The vault was excluded since there was a separate PHA for that area, and, more importantly, the inventory of materials in the vault are segmented from the BGRR facility. The original analysis relied upon the information available and expertise of the hazard-analysis team, which included reactor systems and

ES&H subject matter experts. Consistent with DOE's guidance on developing authorization-basis documents, the hazard analysis evaluated both externally driven events and those related to work in the facility and their potential impacts on target receptors. These receptors included on- and off-site personnel, the environment, and facility workers. Based on a preliminary evaluation, no significant quantities of non-radiological hazardous material were identified, and, consequently, the PHA focused on the radiological consequences of the identified events.

Since the objective of an interim-authorization-basis document is to provide a means for the continued authorization of operations within the BGRR facility, the hazard analysis was planned to be a broad-brush analysis of hazards and potential accidents. Furthermore, the PHA process was selected on its ability to generate recommendations that could eliminate or reduce the risks associated with the facility.

The hazard-analysis team identified hazards and evaluated the possible causes and effects of potential scenarios involving them. Consistent with the PHA approach, they did not develop an exhaustive list of causes; rather, they listed sufficient causes to judge the credibility of the accident. The seven accidents developed by the team are shown below. An eighth accident was added in response to subsequent reviews (further explained in Section 3.2.9):

- 0.15g Seismic Event
- 111 mph Hurricane Winds
- Graphite Dust Detonation
- Loss of Pile Negative-Pressure Ventilation
- Loss of Pile Negative-Pressure Filtration
- Crane Load Drop
- Fire
- Facility Workers' Exposure to Toxic/Hazardous Materials

The team then assessed the effects of each scenario, limiting them to realistic but conservative impacts. In this way, a credible list of bounding scenarios was established. They are considered bounding, based on the associated overall risk of each one.

The following assumptions were made in evaluating all the BGRR unmitigated accident scenarios identified. These assumptions ensured that the analysis was conservative, and that it gave a technically bounding set of scenarios in the authorization-basis document:

- The entire inventory was considered at risk for every unmitigated scenario.

- The evaluation of each unmitigated scenario assumed worst-case conditions for the entire inventory, its location, form, and distribution.

3.1.1 Preliminary Hazard Classification

The gross inventories, discussed under Section 2.3, were compared to the threshold quantities (TQs) in DOE-STD-1027-92 and the reportable quantities (RQ) in 40CFR302.4 [38] and 40CFR68.130 [39] to determine the Preliminary Hazard Classification (PHC). The PHC for the BGRR facility was determined to be Nuclear Hazard Category 2. Subsequent analysis performed for Final Hazard Categorization followed the guidance of Section 3.1.2- Final Hazard Categorization (from DOE-STD-1027-92) and took into consideration material quantity, form, location, dispersibility and interaction with available energy

sources (for the work activities covered within the BGRR-ASA) and resulted in a final classification of 'Radiological Facility' (below Nuclear Hazard Category 3).

3.2 Risk Assessment

3.2.1 Method of Risk Assessment

The risk assessment of the BGRR was based on a methodical review of each initiating event and the severity, probability, and risk category of the corresponding hazards associated with the facility as originally defined by the PHA. Only one accident-initiating event is postulated to occur at one time. Several working sessions were held at BNL where all the accident scenarios were listed and analyzed by the working group supporting the PHA undertaken by the independent reactor-systems and ES&H subject-matter experts. In subsequent reviews of related draft documents and earlier versions of this document, non-credible and nonhazardous events were eliminated, while those that were retained had post-mitigation parameter values added to them; pre-mitigation parameter values also were refined as more and better information became available. The risk-assessment tables which follow, and are summarized in Section 3.4, represent the final determination of the extent of the hazards associated with the BGRR facility in its current state.

BNL's SBMS Subject Area "Hazard Analysis" provides the methodology for examining the safety of facilities at the BNL. It has guidance for assessing the appropriate level of severity, probability, and risk. Table 3.2.1-1 depicts the form used in this report to perform the risk assessment and used in this safety analysis. Tables 3.2.1-2 through 3.2.1-4 summarize the Risk Assessment Matrix found in Hazard Analysis Subject Area and used here.

Table 3.2.1-1. Risk Assessment Format

Severity	I ( ) Catastrophic	II ( ) Critical	III ( ) Marginal	IV ( ) Negligible		
Probability	A ( ) Frequent	B ( ) Probable	C ( ) Occasional	D ( ) Remote	E ( ) Extr Remote	F ( ) Impossible
Risk Category	1 ( ) High	2 ( ) Moderate	3 ( ) Low	4 ( ) Routine		

Table 3.2.1-2 summarizes the potential consequences of hazards falling into the four severity classifications established by BNL's Hazard Analysis Subject Area, which considers consequences for the following:

- Non-radiation release/exposure, on-site/off-site
- Radiation release/exposure, on-site/off-site
- Equipment loss
- Program downtime
- Program compromise
- Public-impact perception

Table 3.2.1-2. Hazard Severity

Category	Descriptive Word	Potential Consequences
I	Catastrophic	May cause death or system loss. >100 rem Committed Effective Dose Equivalent (CEDE) on-site or > EPA Protective Action Guidelines off-site. {Damage >$1,000,000; Down time >4 months}
II	Critical	May cause severe injury, severe occupational illness, or major system damage. >25 rem CEDE on-site or 10 mrem off-site. {Damage >$250,000; Down time >3 weeks but <4 months}
III	Marginal	May cause minor injury, minor occupational illness, or minor system damage.> 5 rem annual limit on-site. {Damage >$50,000; Down time >4 days but <3 weeks}
IV	Negligible	Will not result in injury, occupational illness, or system damage. > 3 rem admin annual limit or 1 rem admin quarterly limit. {Damage <$50,000; Down time <4 days}

Table 3.2.1-3 summarizes the probability categories established by BNL's Hazard Analysis Subject Area. They are based on the likelihood of the potential consequences occurring for a given hazard.

Table 3.2.1-3. Hazard Probability

Category	Descriptive Word	Potential Consequences
A	Frequent	Likely to occur repeatedly during life cycle of system.
B	Probable	Likely to occur several times in life cycle of system.
C	Occasional	Likely to occur sometime in life cycle of system.
D	Remote	Not likely to occur in life cycle of system, but possible.
E	Extremely Remote	Probability of occurrence cannot be distinguished from zero.
F	Impossible	Physically impossible to occur.

Table 3.2.1-4 summarizes the risk categories established by BNL's Hazard Analysis Subject Area. Choosing a severity and a probability for a given hazard determines its risk category. The Hazard Analysis Subject Area establishes the documentation and minimum approval required for each category.

Table 3.2.1-4. Risk Category

Hazard Severity	A Frequent	B Probable	C Occasional	D Remote	E Extremely Remote	F Impossible
I Catastrophic	1. High	1. High	1. High	2. Moderate	3. Low	4. Routine
II Critical	1. High	1. High	2. Moderate	3. Low	3. Low	4. Routine
III Marginal	2. Moderate	2. Moderate	3. Low	3. Low	4. Routine	4. Routine
IV Negligible	4. Routine	4. Routine	4. Routine	4. Routine	4. Routine	4. Routine

Hazard mitigation takes the form of engineered features, administrative controls, operator training, or a combination of these. Generally, the hazard's severity is not changed by mitigation, but its probability is reduced.

Risk Assessment for the facility is given on the following pages where operator's error, equipment/system failure, an accident or natural phenomenon is the initiating event. Each event is analyzed on four tables: Hazard, Risk Assessment Before Mitigation, Hazard Mitigation, and Risk Assessment After Mitigation.

The Hazard table first identifies the initiating event and lists its possible consequences and its specific hazards. A list of potential initiators is given.

The Hazard Mitigation table lists the administrative controls, training, and engineered features that will mitigate the effects of the event. The Risk Assessment tables contrast the risk involved due to an initiating event with and without mitigation.

3.2.2 Risk Assessment No. 001 covering 0.15 g Seismic Event

SYSTEM: BGRR Facility **NUMBER:** 001
HAZARD: Seismic Event

Event:	0.15 g Seismic Event
Possible Consequences & Hazards:	Damage to facility structures / equipment. Release of radiation / radioactive materials to environment. Exposure to radioactive materials through ingestion, inhalation, or dermal exposure. Building- or room-contamination. Program delays / interruptions
Potential Initiators:	Seismic activity

Risk Assessment Prior to Mitigation						
Severity:	I ( ) Catastrophic	II ( ) Critical	III (X) Marginal	IV ( ) Negligible		
Probability:	A ( ) Frequent	B ( ) Probable	C ( ) Occasional	D (X) Remote	E ( ) Extr Remote	F ( ) Impossible
Risk Category:	1 ( ) High	2 ( ) Moderate	3 (X) Low	4 ( ) Routine		

Hazard Mitigation:	Limited fraction of radiological inventory associated with BGD Filters at risk and available for release due to material form, location, dispersibility, and interaction with available energies (<Nuclear Hazard Category 3 threshold), in consideration of the activities covered by the BGRR-ASA. Crushed samples of filter mesh and media retrained over 50% of their radiological inventory based upon results of radiological analysis. Filters located below ground in separate reinforced concrete ducts. Reinforced concrete blocks forming the roof over the filters are designed for a live load of 470 lbs/ft^2. Recent inspections of the BGDs as part of the BGD Cooler Removal (completed under BGRR-SE-01-03) and for preliminary planning of the BGD Filter Removals confirmed the continued structural integrity of the BGDs. Continuous lining of concrete ducting with overlapping plates of steel at least 3/8" thick and in multiple layers.

Risk Assessment Following Mitigation						
Severity	I ( ) Catastrophic	II ( ) Critical	III ( ) Marginal	IV (X) Negligible		
Probability	A ( ) Frequent	B ( ) Probable	C ( ) Occasional	D (X) Remote	E ( ) Extr Remote	F ( ) Impossible
Risk Category	1 ( ) High	2 ( ) Moderate	3 ( ) Low	4 (X) Routine		

Description - 0.15 g Seismic Event

Hazard Probability (as defined in Table 3.2.1-3)

The probability of an earthquake in the BNL area sufficiently intense to damage buildings and reactor structures was thoroughly investigated during construction of the Graphite Reactor and several subsequent reviews of the High Flux Beam Reactor. The consensus of seismologists is that no significant quakes are to be expected in the foreseeable future. No active earthquake-producing faults are known in the Long Island area.

For these reasons, the unmitigated probability conservatively assigned to a 0.15 g seismic event was **REMOTE** (not likely to occur in life cycle of system, but possible).

Hazard Severity (as defined by Table 3.2.1-2)

Because the BNL area experiences high winds (e.g., Atlantic coast hurricanes), buildings on the site (including the BGRR Complex) were designed for significant wind loads and have no history of major lateral structural damage from high winds or wind gusts. Significant earthquake damage should not occur for such buildings at low seismicity sites, such as BNL. For structures that are buried below ground and made of reinforced concrete lined with metal plate, damage is even less likely.

Since the BGRR was defueled and shut down over 30 years ago, there have been no programmatic delays nor repair costs associated with minor damage caused by a seismic event. Personnel are not permanently assigned to the BGRR Complex. Approximately thirty temporary decommissioning staffers are currently located in office space in Building 701. There is only a small potential for occupational illness or injury.

Recently completed supplemental sampling and analysis of the BGD Filters (made in preparation for detail planning of Filter removals and after free access provided by removal of BGD Coolers) have resulted in the re-estimation of BGD Filter inventory as shown in Section 2.3.3, BGD Filter Inventory. The North Duct inventory (comprised of Filter and Fines) is now estimated at 48.5% of the Nuclear Hazard Category 3 threshold, while the South Duct inventory (similarly composed) is now estimated at 129% of the Nuclear Hazard Category 3 threshold.

As originally estimated in previous versions of the BGRR-ASA, for accidents that could potentially impact the BOP inventory, only a fraction of the overall BOP inventory would be involved. The overall BOP inventory was estimated at 340% of the Nuclear Hazard Category 3 threshold with no more than 25% of that entire inventory vulnerable to the effects of any single accident/event. Twenty-five percent of 340% equals 85% of the Nuclear Hazard 3 threshold. Of that 85%, no more than half of it (50% of 85%) was deemed releasable by the energies and effects of the accident/event (under the limited work scope authorized by the BGRR-ASA). This represents 42.5% of the Nuclear Hazard Category 3 threshold, which was considered to be the maximum BOP MAR inventory, making the BGRR-DP a **RADIOLOGICAL FACILTY** under the limited work scope of the BGRR-ASA. Based upon the guidance provided in DOE-STD-1027-92, Attachment 1, a release of 42.5% of the Nuclear Hazard Category 3 threshold represents a dose of 4.25 rem to an individual at 30 meters exposed for 24 hours.

As the South Duct inventory now is estimated to exceed the fraction of BOP inventory (85% of the Nuclear Hazard Category 3 threshold) previously utilized in the BGRR-ASA Hazard Analysis, the rest of

the analysis for the consequences of the accident/event must be repeated with 129% as the basis, in lieu of 85%.

DOE-STD-1027-92 states,

> "For the purposes of hazard categorization, 'unmitigated' is meant to consider material quantity, form, location, dispersibility and interaction with available energy sources, but not to consider safety features (e.g., ventilation systems, fire suppression, etc.) which will prevent or mitigate a release."

Under that definition, and in consideration of the fact that crushed samples of filter mesh and media retained over 50% of their inventory based on results of radiological analysis, the unmitigated release is estimated at 50% of the available inventory, and that was deemed releasable due to the energies and effects of the accident/event (assuming aboveground vulnerable structures were affected). This fraction is clearly conservative for underground structures like the BGDs (and the Filters contained therein). Fifty percent (or half) of the 129% allows for the release of 64.5% of the Nuclear Hazard Category 3 threshold, which represents the new maximum BOP MAR, and reconfirms the designation of the BGRR-DP (including the BGDs) as a **RADIOLOGICAL FACILITY**. Based upon the guidance provided in DOE-STD-1027-092, Attachment 1, a release of 64.5% of the Nuclear Hazard Category 3 threshold represents a dose of 6.45 rem to an individual at 30 meters exposed for 24 hours. Though this is below the Nuclear Hazard Category 3 threshold, it is an increase over the previous maximum release calculated within the BGRR-ASA and requires this update be made.

The unmitigated potential consequences discussed here most closely correspond to the definition of Hazard Severity III, **MARGINAL**, while consideration of the mitigation factors listed on Risk Assessment No. 001, reduce the post-mitigation severity (per Table 3.2.1-2, Hazard Severity) to **NEGLIGIBLE**.

<u>Risk Category (as defined by Table A.1-4)</u>

The pre-mitigation combination of Severity = **MARGINAL** with Probability = **REMOTE** define the Risk Category **LOW**, while the post-mitigation combination of Severity = **NEGLIGIBLE** with Probability = **REMOTE**, define the risk category as **ROUTINE** for the work activities covered under the BGRR–ASA.

3.2.3 Risk Assessment No. 002 covering 111-mph Hurricane Winds

SYSTEM: BGRR Facility **NUMBER:** 002
HAZARD: High Winds

Event:	111 mph Hurricane Winds
Possible Consequences & Hazards:	Wind-generated projectile strikes. Damage to building's housing facility and internal structures/equipment. Loss of containment for radioactive materials. Release of radioactive materials to the environment. Exposure to radioactive materials.
Potential Initiators:	Tornado, hurricane, and related natural phenomenon.

Risk Assessment Prior to Mitigation						
Severity:	I ( ) Catastrophic	II ( ) Critical	III (X) Marginal	IV ( ) Negligible		
Probability:	A ( ) Frequent	B ( ) Probable	C ( ) Occasional	D (X) Remote	E ( ) Extr Remote	F ( ) Impossible
Risk Category:	1 ( ) High	2 ( ) Moderate	3 (X) Low	4 ( ) Routine		

Hazard Mitigation:	Limited fraction of radiological inventory associated with BGD Filters at risk and available for release due to material form, location, dispersibility, and interaction with available energies (< Nuclear Hazard Category 3 threshold), in consideration of the activities covered by the BGRR-ASA. Crushed samples of filter mesh and media retained over 50% of their radiological inventory based upon results of radiological analysis. Filters located below-ground in separate reinforced concrete ducts. Reinforced concrete blocks forming the roof over the filters are designed for a live load of 470 lbs/ft^2. Recent inspections of the BGDs as part of the BGD Cooler Removal (completed under BGRR-SE-01-03) and for preliminary planning of the BGD Filter Removals confirmed the continued structural integrity of the BGDs. Continuous lining of concrete ducting with overlapping plates of steel at least 3/8" thick and in multiple layers.

Risk Assessment Following Mitigation						
Severity:	I ( ) Catastrophic	II ( ) Critical	III ( ) Marginal	IV (X) Negligible		
Probability:	A ( ) Frequent	B ( ) Probable	C ( ) Occasional	D (X) Remote	E ( ) Extr Remote	F ( ) Impossible
Risk Category:	1 ( ) High	2 ( ) Moderate	3 ( ) Low	4 (X) Routine		

Description - 111 mph Hurricane Winds

Hazard Probability (as defined in Table 3.2.1-3)

Although uncommon, maximum wind speeds of 80- to 90-mph can be expected on Long Island. The highest wind speeds recorded at BNL occurred during hurricanes. On August 31, 1954, estimated 125-mph winds were experienced during Hurricane Carol. Hurricanes can occur in June through October, with a few weak or declining storms in May and November.

The probability of a hurricane of this magnitude striking this area in a given year is between 0 and 1%. According to the Federal Emergency Management Agency (FEMA), the probability of a Category IV or V hurricane (defined by the Saffir Simpson scale) with average winds in excess of 131-miles per hour is close to zero. Records from 1954 to date support this, and are maintained by BNL's Department of Applied Science (or their successor organization).

For these reasons, the unmitigated probability conservatively assigned to 111-mph hurricane winds was **REMOTE** (not likely to occur sometime in life cycle of system, but possible).

Hazard Severity (as defined by Table 3.2.1-2)

Because the BNL area experiences high winds (e.g., Atlantic coast hurricanes), buildings on the site (including the BGRR Complex) were designed for significant wind loads and have no history of major lateral structural damage from high winds or wind gusts. For structures that are buried below ground and made of reinforced concrete lined with metal plate, damage is even less likely.

Since the BGRR was defueled and shut down over 30 years ago, there have been no programmatic delays nor repair costs associated with minor damage caused by a hurricane. Personnel are not permanently assigned to the BGRR Complex. There are approximately 30 temporary decommissioning staffers currently located in office space in Building 701. There is only a small potential for occupational illness or injury.

The limited radiological material subject to release, conservatively estimated at 50% of the South Duct inventory (detailed under Seismic Event – Risk Assessment No. 001), represents a maximal potential dose of 6.45 rem effective whole-body dose where exposure is at 30 meters for 24 hours of inhalation and direct exposure, and even longer for ingestion pathway, if all inventory were located at one point and simultaneously released (based on Attachment 1 of DOE-STD-1027-92).

The unmitigated potential consequences discussed here most closely correspond to the definition of Hazard Severity III – **MARGINAL**, while consideration of the mitigation factors listed on risk Assessment No. A002, reduce the post-mitigation severity (per Table 3.2.1-2, Hazard Severity) to **NEGLIGIBLE**.

Risk Category (as defined by Table 3.2.1-4)

The pre-mitigation combination of Severity = **MARGINAL** with Probability = **REMOTE** define the Risk Category as **LOW**, while the post-mitigation combination of Severity = **NEGLIGIBLE** with Probability = **REMOTE**, define the Risk Category as **ROUTINE** for the activities covered under this ASA.

3.2.4 Risk Assessment No. 003 covering Graphite Dust Detonation

SYSTEM: BGRR Facility **NUMBER:** 003
HAZARD: To On-site Personnel, Equipment

Event:	Graphite Dust Detonation
Possible Consequences & Hazards:	Fire / Blast Wave Contamination of building's housing facility and internal structures / equipment Radiation exposure to on-site personnel Release of radioactive materials/ radiation to the environment Exposure to radioactive materials through ingestion, inhalation, or dermal exposure.
Potential Initiators:	Direct electrical short to ground, combined with a specific airborne concentration of particular sized particles of graphite dust inside the Bioshield.

Risk Assessment Prior to Mitigation						
Severity:	I ( ) Catastrophic	II ( ) Critical	III (X) Marginal	IV ( ) Negligible		
Probability:	A ( ) Frequent	B ( ) Probable	C ( ) Occasional	D ( ) Remote	E (X) Extr Remote	F ( ) Impossible
Risk Category:	1 ( ) High	2 () Moderate	3 ( ) Low	4 (X) Routine		

Hazard Mitigation:	Limited radiological inventory at risk and available for release from entire facility (<Nuclear Hazard Category 3 Threshold), in consideration of the activities covered by this ASA. Additional limitation on fraction of entire facility's inventory available for release due to graphite detonation as a result of the strength of the Bioshield and the physical forms and distribution of inventory materials. Enhanced stabilization of Reactor Pile, including, but not limited to, isolation of sources of electrical power inside the Bioshield. Limitations on uncontrolled torch-cutting in BGRR Facility. Lack of sufficient airborne loading and heating (as analyzed) of required sized graphite particles and limitations on production of same [40]. Building protected against lightning by proximity of Reactor stack.

Risk Assessment Following Mitigation						
Severity:	I ( ) Catastrophic	II () Critical	III (X) Marginal	IV ( ) Negligible		
Probability:	A ( ) Frequent	B ( ) Probable	C ( ) Occasional	D ( ) Remote	E ( ) Extr Remote	F (X) Impossible
Risk Category:	1 ( ) High	2 ( ) Moderate	3 () Low	4 (X) Routine		

Description - Graphite Dust Detonation

Hazard Probability (as defined in Table 3.2.1-3)

A graphite-dust explosion was considered to be an incredible event for the Hanford N Reactor [41]. The National Fire Protection Association (NFPA) (Fire Protection Handbook, 18th Edition, Chapter 3, Fire Prevention, Table 3-27B, "Explosion Characteristics of Various Dusts," National Fire Protection Association) handbook [42] discusses dusts and their potential for explosion. The table lists graphite as "not ignitable." However, Factory Mutual Engineering Association conducted sixteen tests on graphite powder and found that median-sized particle, 128-microns or smaller, can be ignitable (Proprietary Information, personal communication). Larger particles have a lower potential for ignition.

Graphite is considerably more difficult to ignite and burn than coal, coke, or charcoal. Graphite has a much higher thermal conductivity, therefore it dissipates the heat produced by burning and consequently, it is more difficult to keep hot. Coals, cokes, and charcoals develop a porous white ash on their burning surfaces that greatly reduces radiative-heat losses while simultaneously allowing air to reach the carbon surfaces and maintain burning. Also, they are heavily loaded with impurities that catalyze oxidation. Nuclear-grade graphite is one of the purest substances produced in massive quantities. For these reasons graphite dust sometimes is used as a fire-suppressant.

Of the sixteen samples tested by Factory Mutual, none were ignited with small sources, such as a 100-joule electric match or a glowing Nichrome wire. Hence, ordinary electrical equipment would not be an ignition source, nor would static sparks and "grinding wheel" sparks. The dust needs to be exposed to an open flame, welding torch, or full 120-volt circuit short to start burning.

Graphite dust can only explode if the airborne concentration is very high and particle size very small (<128 microns). While high airborne loadings conceivably could be created for short periods by mechanically stirring up dust that may be present, such loading cannot be sustained because the dust settles out. There is no evidence that the air in the biological shield has a high graphite-dust loading. If this were so, the dust would be entrained by the ventilation stream and deposited on the exhaust filter. To date, no radiation above background has been detected on expended filters. Therefore, no significant airborne loading of activated graphite dust routinely exists within the Bioshield.

For these reasons, the unmitigated probability conservatively assigned to Graphite Dust Detonation was **EXTREMELY REMOTE** (probability of occurrence cannot be distinguished from zero).

Taking into account the mitigation factors listed on Risk Assessment No. 003, and the limited life-cycle remaining, post-mitigation probability is reduced to **IMPOSSIBLE** (physically impossible to occur).

Hazard Severity (as defined by Table 3.2.1-2)

The Factory Mutual tests of the graphite dust indicated that such explosions generated only a moderate power. As the Pile's negative-pressure systems maintain the air pressure within the Bioshield slightly below that outside, any moderate pressure has ample relief capabilities, without damaging either the Pile or the Bioshield.

Since the BGRR was defueled and shut down approximately 30 years ago, there are no programmatic delays or repair costs associated with minor damage caused by detonation of graphite dust. Since personnel are not assigned to the BGRR Complex, other than a few temporary decommissioning staff

located in office space in Building 701, the potential for occupational illness or injury is small. However, in this particular case, the potential initiator implies the presence nearby of decommissioning worker(s), so minor injury is a possibility.

Because this event does not depend on the BOP's radiological inventory, an alternate estimate of radiological impact was needed. In the absence of detectable airborne levels of activated graphite on the replaceable HEPA exhaust-filters, the minimum adequate explosive concentration of activated dust will be the maximum inventory assumed present and available for dispersion.

Based on Table 4.15A, "Explosion Characteristics of Various Dusts," of the NFPA Handbook, and in the absence of any other reasonable values specifically for Graphite Dust, the Minimum Explosive Concentration for Carbonaceous Dusts (55-140 g/m^3) shall be used for these estimates. (While much higher values of graphite dust concentration are believed to be required for an explosion, the apparent absence of such concentrations negates the value of such estimates being used for this determination.) The estimated free volume inside the Bioshield is estimated at 558 m^3, less the volume of the Pile and not including any portion of the plenum. This represents a dispersible graphite inventory of 30,690 to 78,120 gm.

In section 2.3.3, Pile Inventory, Type A graphite (the more active of the two types analyzed) was originally estimated at residual activation levels of 2.5E-6 Ci/gm. The gamma activity comes primarily from Co-60, Eu-154, and Ag-108m with beta activity from C-14 and H-3. For 30,690 to 78,120 gm at 2.5 E-6 Ci/gm, this is between 0.07672 and 0.1953 Ci.

Isotope	Category 3 Threshold Activity, Ci
H-3	16,000
C-14	420
Co-60	280
Ag-108m	200
Eu-154	200

Assuming that all activity present was due to the isotope with the smallest Category 3 Threshold (200 Ci Ag-108m, Eu-154), the total dispersible activity would equal less than one-tenth of the 1% of the Category 3 threshold (0.1953/200). This represents a maximal potential dose of less than 10 mrem effective whole body where exposure is calculated at 30 meters for one day of inhalation and direct exposure, while the ingestion pathway is determined over a longer exposure (as per DOE-STD-1027-92, Attachment 1).[1]

To approach the dose consequences of Risk Assessments No. 001 and 002 would require dust inventories 500 times higher than is currently available.

[1] Despite the availability of actual graphite characterization data that differs from the isotopic inventories assumed in the original Hazard Analysis, the original estimated values for source term will be used because they are more conservative (higher fraction of Hazard Category 3 threshold) than the equivalent amount of characterized inventory. There is no perceived benefit to reducing the margin of safety between the hypothetical accident source term and any actual inventory source term potentially present. See also Section 3.0, Hazard Analysis.

The potential consequences discussed here most closely correspond to the definition of Hazard Severity III - **MARGINAL** (per Table 3.2.1-2, Hazard Severity), primarily due to the potential for minor personnel injury.

Risk Category (as defined by Table 3.2.1-4)

Both the pre-mitigation combination of Severity being **MARGINAL** with Probability being **EXTREMELY REMOTE**, and the post-mitigation combination of Severity being **MARGINAL** with Probability being **IMPOSSIBLE**, define the risk category as **ROUTINE** for the operations under this ASA.

3.2.5 Risk Assessment No. 004 covering Loss of Pile Negative-Pressure Ventilation

SYSTEM: BGRR Facility **NUMBER:** 004
HAZARD: To On-site Personnel

Event:	Loss of Pile Negative-Pressure Ventilation
Possible Consequences & Hazards:	Contamination of building's housing facility and internal structures / equipment. Radiation exposure to on-site personnel. Release of radioactive materials/ radiation to the environment. Exposure to radioactive materials through ingestion, inhalation, and dermal exposure.
Potential Initiators:	Failure of fan or loss o f power.

Risk Assessment Prior to Mitigation						
Severity:	I ( ) Catastrophic	II ( ) Critical	III ( ) Marginal	IV (X) Negligible		
Probability:	A ( ) Frequent	B (X) Probable	C ( ) Occasional	D ( ) Remote	E ( ) Extr Remote	F ( ) Impossible
Risk Category:	1 ( ) High	2 ( ) Moderate	3 ( ) Low	4 (X) Routine		

Hazard Mitigation:	Limited radiological inventory at risk and available for release from entire facility (<Nuclear Hazard Category 3 Threshold), considering the activities covered by this ASA. Additional limitation on fraction of entire facility's inventory available as a result of the physical forms and distribution of inventory materials. Fan alarm indicating loss of negative pressure. Results from BNL's draft *Committee Report on HVAC testing at the BGRR Complex* [43]. Lack of significant activity found on replacing HEPA filters.

Risk Assessment Following Mitigation						
Severity:	I ( ) Catastrophic	II ( ) Critical	III ( ) Marginal	IV (X) Negligible		
Probability:	A ( ) Frequent	B (X) Probable	C ( ) Occasional	D ( ) Remote	E ( ) Extr Remote	F ( ) Impossible
Risk Category:	1 ( ) High	2 ( ) Moderate	3 () Low	4 (X) Routine		

Description - Loss of Pile Negative-Pressure

Hazard Probability (as defined in Table 3.2.1-3)

After the BGRR was taken out of operation in 1969, the HVAC system was modified to keep the reactor at a negative pressure relative to Building 701 to ensure there was no potential for airborne transport of the residual radioactivity in Building 702 (Bioshield and Graphite Pile) into Building 701. This was done because Building 701 was being converted into the BNL Science Museum, which was to be open to the public, including school children.

Exhaust ducts were isolated from the stack by closing the valves at the discharge of the primary- and secondary-air fans to prevent reverse flow through them. Plywood covers were installed over the west- and east-air inlet ducts, separating the ducts from the intake bays and louvers. A small auxiliary fan and HEPA filter was installed in the east-intake bay, which drew suction from the Pile via a hole in the plywood cover separating the east-inlet duct from the east air-intake bay; it exhausted into the isolated east-intake bay. This reversed the flow through the east air-inlet duct (adapted from "BNL Committee Report on HVAC Testing at the BGRR Complex," December 1998, [43]).

During the approximately 20 years that the Science Museum was housed in Building 701, the Pile Negative-Pressure System shut down a number of times, including shutdowns for maintenance and accidental ones caused by power outages or equipment failures.

For these reasons, the unmitigated probability conservatively assigned to Loss of Pile Negative-Pressure Ventilation was **PROBABLE** (likely to occur several times in life cycle of the system).

Considering the limited mitigation factors listed under Risk Assessment No. 004, and the limited life cycle remaining, post-mitigation probability remains as **PROBABLE** (likely to occur several times in life-cycle of the system).

Hazard Severity (as defined by Table 3.2.1-2)

The event addressed under this Risk Assessment occurred several times during the history of the facility without any detected spread of airborne radioactivity or contamination from Building 702 to 701.

Since the BGRR was defueled and shut down approximately thirty years ago (and the Science Museum relocated in 1997 to another building not part of the BGRR Complex), there would be no programmatic delays or repair costs associated with minor damage caused by Loss of Pile Negative Pressure Ventilation. Since personnel are not assigned to the BGRR Complex, other than a few temporary decommissioning staff located in office space in Building 701, the potential is small for occupational illness or injury resulting from Loss of Pile Negative-Pressure Ventilation.

The limited activated/contaminated dust inventory available for airborne transfer from Building 702 to 701 (as defined in Risk Assessment No. 003 - Graphite Dust Detonation) was conservatively bounded at less than one-tenth of 1% of the Hazard Category 3 Threshold. This represents a maximal potential dose of less than 10 mRem effective whole body where exposure is calculated per DOE-STD-1027-92, Attachment 1.

The potential consequences discussed here most closely correspond to the definition of Hazard Severity IV - **NEGLIGIBLE** (per Table 3.2.1-2, Hazard Severity).

Risk Category (as defined by Table 3.2.1-4)

Both the pre-mitigation combination of Severity being **NEGLIGIBLE** with Probability being **PROBABLE,** and the post-mitigation combination of Severity being **NEGLIGIBLE** with Probability being **PROBABLE**, result in the Risk Category being defined as **ROUTINE** for the activities under this ASA.

3.2.6 Risk Assessment No. 005 covering Loss of Pile Negative-Pressure Filtration

SYSTEM: BGRR Facility **NUMBER:** 005
HAZARD: To On-site Personnel

Event:	Loss of Pile Negative-Pressure Filtration
Possible Consequences & Hazards:	Radiation exposure to on-site personnel. Release of radioactive materials/radiation to the environment. Exposure to radioactive materials through ingestion, inhalation, or dermal exposure.
Potential Initiators:	Failure of, or fire in, the filter.

Risk Assessment Prior to Mitigation						
Severity:	I ( ) Catastrophic	II () Critical	III ( ) Marginal	IV (X) Negligible		
Probability:	A ( ) Frequent	B (X) Probable	C ( ) Occasional	D ( ) Remote	E ( ) Extr Remote	F ( ) Impossible
Risk Category:	1 ( ) High	2 ( ) Moderate	3 ( ) Low	4 (X) Routine		

Hazard Mitigation:	Limited radiological inventory at risk and available for release from entire facility (<Nuclear Hazard Category 3 Threshold), in consideration of the activities covered by this ASA. Additional limitation on fraction of entire facility's inventory available as a result of the physical forms and distribution of inventory materials. CAM instrumentation. Analysis by BNL's draft *Committee Report on HVAC Testing at the BGRR Complex* [43] Lack of significant activity found on replacing HEPA filters.

Risk Assessment Following Mitigation						
Severity:	I ( ) Catastrophic	II ( ) Critical	III ( ) Marginal	IV (X) Negligible		
Probability:	A ( ) Frequent	B ( ) Probable	C (X) Occasional	D ( ) Remote	E ( ) Extr Remote	F ( ) Impossible
Risk Category	1 ( ) High	2 ( ) Moderate	3 ( ) Low	4 (X) Routine		

Description - Loss of Pile Negative-Pressure Filtration

Hazard Probability (as defined in Table 3.2.1-3)

After the BGRR was taken out of operation in 1969, the HVAC system was modified to keep the reactor at a negative pressure relative to Building 701 to ensure that no residual radioactivity in Building 702 (Bioshield and Graphite Pile) could be transported by air into Building 701 or to the environment. This was done because portions of Building 701 were being converted into the BNL Science Museum, open to the public, including school children.

Exhaust ducts were isolated from the stack by closing the valves at the discharge of the primary- and secondary-air fans to prevent reverse flow through them. Plywood covers were installed over the west and east air-inlet ducts, separating them from the intake bays and louvers. A small auxiliary fan and HEPA filter was installed in the east-intake bay, which drew suction from the Pile via a hole in the plywood cover separating the east-inlet duct from the east air-intake bay and exhausted into the isolated east intake bay. This reversed flow through the east air inlet duct (adapted from the draft "BNL Committee Report on HVAC Testing at the BGRR Complex," December 1998).

During the approximately twenty years that the Science Museum was housed in Building 701, the Pile Negative-Pressure System shut down several times, including shutdowns for maintenance and accidental ones caused by power outages or equipment failures, though never due to failures of the HEPA filter.

For these reasons, the unmitigated probability conservatively assigned to Loss of Pile Negative- Pressure Filtration was **PROBABLE** (likely to occur several times in life-cycle of the system).

Accounting for the mitigation factors listed under Risk Assessment No. 005, and the limited life-cycle remaining, post-mitigation probability is reduced to **OCCASIONAL** (likely to occur sometime in life cycle of system).

Hazard Severity (as defined by Table 3.2.1-2)

While the Pile Negative-Pressure Ventilation system failed several times during the history of the facility without any detected spread of airborne radioactivity or contamination from Building 702 to 701, the HEPA filters have never failed. When they are routinely replaced for preventive maintenance, no radioactive graphite-dust loading is detected.

Since the BGRR was defueled and shut down approximately thirty years ago (and the Science Museum relocated in 1997 to another building not part of the BGRR Complex), there would be no programmatic delays or repair costs associated with minor damage caused by Loss of Pile Negative-Pressure Filtration. No personnel are assigned to the BGRR Complex, other than the few temporary decommissioning staff occupying office space in Building 701, so there is a small potential for occupational illness or injury resulting from Loss of Pile Negative-Pressure Filtration.

The limited activated/contaminated dust inventory available for airborne transfer from Building 702 to 701 or to the environment (as defined in Risk Assessment No. 003 - Graphite Dust Detonation) was conservatively bounded at less than one-tenth of 1% of the Hazard Category 3 Threshold. This represents a maximal potential dose of less than 10 mRem effective-whole-body dose where exposure is calculated per DOE-STD-1027-92, Attachment 1.

The potential consequences discussed here most closely correspond to the definition of Hazard Severity IV - **NEGLIGIBLE** (per Table 3.2.1-2, Hazard Severity).

Risk Category (as defined by Table 3.2.1-4)

Both the pre-mitigation combination of Severity being **NEGLIGIBLE** with Probability being **PROBABLE**, and the post-mitigation combination of Severity being **NEGLIGIBLE** with Probability being **OCCASIONAL**, define the Risk Category as **ROUTINE** for the work planned under this ASA.

3.2.7 Risk Assessment No. 006 Covering Crane Load Drop

SYSTEM: BGRR Facility NUMBER: 006
HAZARD: To On-site Personnel, Equipment

Event:	Crane Load Drop
Possible Consequences & Hazards:	Radiation exposure to on-site personnel. Release of radioactive materials/radiation to the building and/or environment. Exposure to radioactive materials through ingestion, inhalation, and/or dermal exposure. Contamination of building or room.
Potential Initiators:	Equipment failure, power loss, operator's error, failure of handling equipment.

Risk Assessment Prior to Mitigation						
Severity:	I ( ) Catastrophic	II ( ) Critical	III (X) Marginal	IV ( ) Negligible		
Probability:	A ( ) Frequent	B () Probable	C (X) Occasional	D ( ) Remote	E ( ) Extr Remote	F ( ) Impossible
Risk Category:	1 ( ) High	2 () Moderate	3 (X) Low	4 ( ) Routine		

Hazard Mitigation:	Limited radiological inventory at risk and available for release from entire facility (<Nuclear Hazard Category 3 Threshold), in view of the activities covered by this ASA. Additional limitation on fraction of entire facility's inventory available as a result of the physical forms and distribution of the inventory materials, and the strength of the Bioshield. Inspection and maintenance of cranes and qualification of operators before using them. Building structure's design criteria in compliance with AEC's requirements (including main floor design loading of 500 lbs/sq ft; intermediate upper floor design loading of 125 lbs/sq ft; concrete slabs at base of each window bay design loading of 300 lbs/sq ft; and experimental balconies design loading of 1,000 lbs/sq ft). (Reference 36)

Risk Assessment Following Mitigation						
Severity:	I ( ) Catastrophic	II ( ) Critical	III (X) Marginal	IV ( ) Negligible		
Probability:	A ( ) Frequent	B ( ) Probable	C ( ) Occasional	D (X) Remote	E ( ) Extr Remote	F ( ) Impossible
Risk Category:	1 ( ) High	2 ( ) Moderate	3 (X) Low	4 () Routine		

Description - Crane Load Drop

Hazard Probability (as defined in Table 3.2.1-3)

The largest crane in the BGRR Complex is the 10-Ton Overhead Crane in Building 701. While routine surveillance and maintenance of the building was undertaken regularly—even after the BGRR was shut down and defueled—more stringent inspection and testing was completed in preparation for possibly using the crane during the BGRR-DP.

Although the crane will only be operated by licensed, qualified crane operators from the Riggers' Shop of BNL's Plant Engineering Division, it was conservatively assumed that the unmitigated probability of a Crane Load Drop was **OCCASIONAL** (likely to occur sometime in the life-cycle of system).

Considering the mitigation factors listed on Risk Assessment No. 006, as well as the limited life cycle remaining, post-mitigation probability is reduced to **REMOTE** (not likely to occur in life cycle of the system, but possible).

Hazard Severity (as defined by Table 3.2.1-2)

Since the BGRR was defueled and shut down approximately thirty years ago, there would be marginal programmatic delays (< 3 weeks) or repair costs (< $250,000) associated with any damage caused by any crane load drop. No personnel are assigned to the BGRR Complex (other than the few temporary decommissioning staff now in office space in Building 701), so the potential for occupational illness or injury is small. Considering the expertise and qualifications of the crane operator(s) and assistants, the potential for occupational injury being received by co-located workers is exceedingly small.

Any crane-load drop would be limited to only a fraction of the BOP radiological inventory (assuming a shielded waste-container was dropped). Impacts causing the need to consider the release of the Pile inventory are not credible based on the use of the 10-ton overhead crane and the design-basis for the Bioshield's confinement of the graphite Pile. Using larger cranes inside Building 701 lifting loads heavier than 10 tons is outside the scope of this analysis, and would have to be analyzed separately under a USI (using ER-OPM-4.4, "Safety Evaluations for Unreviewed Safety Issue Determinations").

Even assuming a limited BOP radiological inventory was available and at risk and could be released in a Crane Load Drop (a shielded waste-container), the material that could be released in the form of transferable contamination or contaminated dust is conservatively estimated at less than 12.5% of the BOP inventory. This represents a maximal potential dose of less than 5 rem effective-whole-body-dose where exposure is calculated in accordance with DOE-STD-1027-92, Attachment 1.

The potential consequences discussed here most closely correspond to the definition of Hazard Severity IV, **MARGINAL** (per Table 3.2.1-2, Hazard Severity).

Risk Category (as defined by Table 3.2.1-4)

Both the pre-mitigation combination of Severity being **MARGINAL** with Probability being **OCCASIONAL**, and the post-mitigation combination of Severity being **MARGINAL** with Probability being **REMOTE**, so that the Risk Category is defined as **LOW RISK.**

3.2.8 Risk Assessment No. 007 covering Fire

SYSTEM: BGRR Facility **NUMBER:** 007
HAZARD: To On-site Personnel, Equipment

Event:	Fire
Possible Consequences & Hazards:	Radiation exposure to on-site personnel. Release of radioactive materials/radiation to the building and/or environment. Exposure to radioactive materials through ingestion, inhalation, and/or dermal exposure. Contamination of building or room. Program delays.
Potential Initiators:	Natural phenomenon, operator's error, failure of equipment.

Risk Assessment Prior to Mitigation						
Severity	I ( ) Catastrophic	II ( ) Critical	III ( ) Marginal	IV (X) Negligible		
Probability	A ( ) Frequent	B ( ) Probable	C (X) Occasional	D ( ) Remote	E ( ) Extr Remote	F ( ) Impossible
Risk Category	1 ( ) High	2 ( ) Moderate	3 ( ) Low	4 (X) Routine		

Hazard Mitigation:	Limited radiological inventory at risk and available for release from entire facility (<Nuclear Hazard Category 3 Threshold), in consideration of the activities covered by this ASA. Additional limitation on fraction of entire facility's inventory available as a result of the physical forms and distribution of inventory materials. Limitations on inventory of combustible materials stored within the facility and restrictions on introducing new combustible material. Enhanced stabilization of Reactor Pile including, but not limited to, isolation of Building 702 and reduction of air in-leakage. Replacement of plywood covers on east and west air inlet ducts with metal or otherwise fireproofed material. Fire detection/alarm systems under regular program of surveillance and maintenance. Regular change of replaceable HEPA filters. Building protected against lightning by proximity of Reactor stack.

Risk Assessment Following Mitigation						
Severity:	I ( ) Catastrophic	II ( ) Critical	III ( ) Marginal	IV (X) Negligible		
Probability:	A ( ) Frequent	B ( ) Probable	C ( ) Occasional	D (X) Remote	E ( ) Extr Remote	F ( ) Impossible
Risk Category:	1 ( ) High	2 ( ) Moderate	3 ( ) Low	4 (X) Routine		

Description - Fire

Hazard Probability (as defined in Table 3.2.1-3)

Risk Assessment No. 003 covering Graphite Dust Detonation already provides information on the difficulties associated with trying to ignite graphite, even in the form of dust. Further, according to "A Safety Assessment of the Use of Graphite in Nuclear Reactors Licensed by the NRC," NUREG/CR-4981 [40], the following are the bounding conditions needed to initiate burning of graphite:

- Graphite must be heated to at least 650 ºC.
- This temperature must be maintained either by the heat of combustion or some outside energy source.
- There must be an adequate supply of oxidant (air or oxygen).
- The gaseous source of oxidant must flow at a rate that can remove gaseous reaction products without excessively cooling the graphite surface.

Although there is little exposed combustible-loading within the BGRR Complex (especially since the museum debris was removed), and automated fire-detection and alarm systems (although not automated fire-suppression) are present in the facility, the unmitigated probability conservatively assigned to Fire was **OCCASIONAL** (likely to occur sometime in life-cycle of system).

Considering the mitigation factors listed on Risk Assessment No. 007, and the limited life-cycle remaining, post-mitigation probability is reduced to **REMOTE** (not likely to occur in life cycle of system, but possible).

Hazard Severity (as defined by Table 3.2.1-2)

Since the BGRR was shut down and defueled approximately thirty years ago, there would be no programmatic delays or repair costs associated with any anticipated fire damage. No one is assigned to the BGRR Complex, other than a few temporary decommissioning staff occupying office space in Building 701, so the potential for occupational illness or injury is small.

Because of the lack of credible ignition scenarios for the Graphite Pile and the BGD Filters, and the great difficulty in keeping a fire burning even if one were ignited, the radiological impact of the fire will be assessed using the BOP radiological inventory.

Any such accident could realistically involve only a small fraction of the BOP radiological inventory, due to the form and distribution of the activity (widely dispersed low-level contamination on non-combustible surfaces).

Assuming limited BOP radiological material were available and at risk to be burnt and released in a fire, this inventory is estimated at less than 12.5% of the original BOP inventory estimate. That amount would create a maximal potential dose of less than 5 rem effective-whole-body-dose where exposure is calculated in accordance with DOE-STD-1027-92, Attachment 1.

The potential consequences discussed most closely correspond to the definition of Hazard Severity IV, **NEGLIGIBLE** (per Table 3.2.1-2, Hazard Severity).

Risk Category (as defined by Table 3.2.1-4)

Both the pre-mitigation combination of Severity being **NEGLIGIBLE** with Probability being **OCCASIONAL**, and the post-mitigation combination of Severity being **NEGLIGIBLE** with Probability being **REMOTE**, result in the Risk Category being defined as **ROUTINE** for the work contemplated under this ASA.

3.2.9 Risk Assessment No. 008 covering Facility Workers' Exposure to Toxic/Hazardous Materials

SYSTEM: BGRR Facility **NUMBER:** 008
HAZARD: To On-site Personnel, Equipment

Event:	Facility Workers' Exposure to Toxic/Hazardous Materials
Possible Consequences & Hazards:	Toxic exposure to on-site personnel. Release of toxic/hazardous materials to the building and/or environment. Exposure to toxic/hazardous materials through ingestion, inhalation, and/or dermal exposure. Contamination of building or room. Program delays
Potential Initiators:	Natural phenomena, operators' error, or failure of equipment breaching the deactivated piping or equipment containing residual hazardous/toxic material.

Risk Assessment Prior to Mitigation						
Severity:	I ( ) Catastrophic	II ( ) Critical	III ( ) Marginal	IV (X) Negligible		
Probability:	A ( ) Frequent	B ( ) Probable	C (X) Occasional	D ( ) Remote	E ( ) Extr Remote	F ( ) Impossible
Risk Category:	1 ( ) High	2 () Moderate	3 ( ) Low	4 (X) Routine		

Hazard Mitigation:	Limited hazardous/toxic inventory available for release from entire facility (no significant inventories of non-radiological hazardous material identified during PHA). Limitations on the inventory of combustible materials stored within the facility and restrictions on introducing new combustible material. Limitations on introducing new hazardous/toxic material to the facility during the remaining life of project. Work controls mandating the use of Personnel Protection Equipment (PPE) during hazardous-entry operations.

Risk Assessment Following Mitigation						
Severity:	I ( )Catastrophic	II ( ) Critical	III ( ) Marginal	IV (X) Negligible		
Probability:	A ( ) Frequent	B ( ) Probable	C ( ) Occasional	D (X) Remote	E ( ) Extr Remote	F ( ) Impossible
Risk Category:	1 ( ) High	2 ( ) Moderate	3 () Low	4 (X) Routine		

Description - Facility-Workers' Exposure to Toxic/Hazardous Materials

Hazard Probability (as defined in Table 3.2.1-3)

Because there are no significant inventories of non-radiological hazardous materials within the BGRR Complex, this accident scenario was not developed as part of the original draft of BGRR Hazards Summary and Recommendations Document, nor in the draft BGRR-DBIO (which evolved into this ASA document). However, during the most recent reviews and comments, it was suggested that this accident scenario should be added because it was present in the Safety Authorization Bases of other old reactor-decommissioning projects.

Among the non-radiological hazardous materials to be found within the BGRR Complex are the following:

- asbestos and/or asbestos-containing material (ACM)
- mercury
- lead shielding and/or lead-based paint
- PCBs
- cadmium

Despite the absence of significant quantities of non-radiological hazardous materials and the existence of a well-developed Industrial Hygiene and Work Planning/Control Program, the unmitigated probability conservatively assigned to Facility Workers' Exposure to Toxic/Hazardous Materials was **OCCASIONAL** (likely to occur sometime in life-cycle of system).

Taking into account the mitigation factors listed on Risk Assessment No. 008, and the limited life-cycle remaining, post-mitigation probability is reduced to **REMOTE** (not likely to occur in life cycle of system, but possible).

Hazard Severity (as defined by Table 3.2.1-2)

Since the BGRR was shut down and defueled approximately 30 years ago, there would be no programmatic delays or repair costs associated with any anticipated damage caused by Facility Workers' Exposure to Toxic/Hazardous Materials.

By definition, this event has no radiological impact.

Based on the extremely limited inventories of non-radiological hazardous materials known to exist within the BGRR Complex and the extensive Industrial Hygiene/Work Controls Program in effect for facility workers on the BGRR-DP, any potential accidental exposure should not result in any lost time, injury, or occupational illness.

The potential consequences discussed here most closely correspond to the definition of Hazard Severity IV, **NEGLIGIBLE** (per Table 3.2.1-2, Hazard Severity).

Risk Category (as defined by Table 3.2.1-4)

Both the pre-mitigation combination of Severity being **NEGLIGIBLE** with Probability being **OCCASIONAL** and the post-mitigation combination of Severity being **NEGLIGIBLE** with Probability being **REMOTE**, result in the Risk Category being defined as **ROUTINE** for the activities contemplated under this ASA.

3.3 Dose Assessment Summary

The analyses performed in Section 3.2.2 qualitatively defined logically, but conservatively, that up to 50% of the Duct inventory estimate for the higher of the two BGD Filters and Fines could possibly be released in a near incredible accident at the BGRR. This represents the worst-case radiological dose for the eight accidents analyzed in Section 3.2. In order to convert 50% of the higher of the two BGD Filters and Fines to an estimated dose, the following logic/thought process was applied:

North BGD Filter and Fines @ 48.5% of Hazard Category 3 Threshold
South BGD Filter and Fines @ 129% of Hazard Category 3 Threshold
Therefore, 50% of South BGD Filters & Fines = 64.5% of Hazard Category 3 Threshold

The basis of 100% of the Hazard Category 3 TQ values is 10 rem to the maximum exposed individual, at 30 meters away from the release, over a 24-hour period due to direct exposure, inhalation, and longer term ingestion exposure.

Therefore, the worst-case exposure was estimated at:

64.5% of 10 rem = 6.45 rem in 24 hours at 30 meters

3.4 Final Hazards Classification

This section and Tables 3.4-1 and 3.4-2 summarize the Risk Assessment for the BGRR given in Section 3.2. Eight types of events are addressed under the Risk Assessment for the BGRR in this ASA for the activities covered:

- 0.15% Seismic Event
- 111 mph Hurricane Winds
- Graphite Dust Detonation
- Loss of Pile Negative-Pressure Ventilation
- Loss of Pile Negative-Pressure Filtration
- Crane Load Drop
- Fire
- Facility Workers' Exposure to Toxic/Hazardous Materials

These are discussed in detail as part of the Hazards Analysis in Section 3.2. These failure modes represent the known or anticipated types possible for the current BGRR Facility. The specific examples represent the most severe combination of consequences and frequency deemed credible. Thus, each separate Risk Assessment Table represents an individual envelope encompassing a variety of similar or related events whose severity and probability fall within the bounds of the specific event. Each such event includes all lesser similar ones with lower overall risk (a product of the functions of

severity or consequence, and probability or frequency). This combination of assorted types of events caused by any of a variety of potential initiators defines a bounding spectrum of accidents. The spectrum can cover or subtend numerous specific but unnamed incidents under their overlapping umbrellas, as long as the specific event does not exceed the envelope for the type it represents.

As summarized in the tables below, with the administrative controls and mitigating factors considered, only low or routine industrial risks are associated with the BGRR-DP scope described in this ASA.

Table 3.4-1. Pre-Mitigation Risk Categories

No.	Event	Hazard Severity[1]	Hazard Frequency[1]	Risk[2]
001	0.15g Seismic Event	Marginal	Remote	Low
002	High Winds	Marginal	Remote	Low
003	Graphite-Dust Detonation	Marginal	Extremely Remote	Routine
004	Loss of Pile Negative-Pressure System Ventilation	Negligible	Probable	Routine
005	Loss of Pile Negative-Pressure System Filtration	Negligible	Probable	Routine
006	Crane Load Drop	Marginal	Occasional	Low
007	Fire	Negligible	Occasional	Routine
008	Facility Workers' Exposure to Toxic/Hazardous Material	Negligible	Occasional	Routine

1. Severity and frequency are discussed in Section 3.2.
2. Risk (based on severity and frequency) is defined in Table 3.2.1-4.

Table 3.4-2. Post-Mitigation Risk Categories

No.	Event	Hazard Severity[1]	Hazard Frequency[1]	Risk[2]
001	0.15g Seismic Event	Negligible	Remote	Routine
002	High Winds	Negligible	Remote	Routine
003	Graphite-Dust Detonation	Marginal	Impossible	Routine
004	Loss of Pile Negative-Pressure System Ventilation	Negligible	Probable	Routine
005	Loss of Pile Negative-Pressure System Filtration	Negligible	Occasional	Routine
006	Crane Load Drop	Marginal	Remote	Low
007	Fire	Negligible	Remote	Routine
008	Facility Workers' Exposure to Toxic/Hazardous Material	Negligible	Remote	Routine

1. Severity and frequency are discussed in Section 3.2.
2. Risk (based on severity and frequency) is defined in Table 3.2.1-4

The Risk Assessment concludes that the most severe event with or without mitigation presents only a Low Risk or Routine Risk. This analysis did not postulate any accidents or natural phenomena that could result in a credible release mechanism for any of the radiological inventories discussed Section 2.3. Therefore, it is the conclusion of this analysis that there is no material at risk for potential release at the BGRR given the scope of work discussed in Section 1.4.

In compliance with DOE-STD-1027-92 and using the methodology described in DOE's *Hazard Baseline Documentation* (and in Figure 1 therein) [2], the following logic is used to determine a **RADIOLOGICAL** classification for the BGRR:

- Preliminary Hazards Classification – Nuclear Category 2 described in Section 3.1, The "Potential Releasable Radiation Meets or Exceeds DOE-STD-1027, Attachment 1 Thresholds" – the answer is NO - There is no material at risk of potential release based on the risk assessment of all postulated accidents or natural phenomena presented in Section 3.3 in accordance with BNL's ES&H STD 1.3.3 (and subsequently the SBMS Subject Area, Hazard Analysis).

- Potential Releasable Radiation RQ Meets or Exceeds 40CFR302, - Assuming a maximal potential release of up to 50% of the estimated BGD Filters and Fines inventory for the highest duct defined under Section 3.0, the answer is YES.

- Potential Releasable Hazardous Material Below 29CFR1910.119 [44] or 40CFR355 Thresholds [45] - This analysis was not done because definitive inventory numbers were lacking, therefore, a YES answer (threshold is exceeded) is conservatively assumed.

Therefore **RADIOLOGICAL** is the correct classification for the BGRR.

4.0 CONTROLS AND COMMITMENTS

This section discusses the safety controls and commitments applicable to the BGRR-DP's work.

Overlaying all the Project's operations are BNL and Environmental Management Directorate (EM) work-process controls and procedures for all activities. (See Appendix A for a partial list of BNL, EM, and BGRR procedures that are used to control radiological and hazardous materials and work.)

4.1 Special Controls

To ensure that the conditions assumed in the hazard analysis are maintained, there will be strict adherence to the administrative controls defined in Section 1.3.

4.2 Project-Specific Controls

4.2.1 Safety-Significant Structures, Systems, and Components

The scope of work defined in this ASA does not employ safety-significant structures, systems, or components. This is based on the evaluations in Section 3.2 that show that the unmitigated consequences of credible events remain below the level of significance defined in DOE-STD-3009-94, *Preparation Guide for U.S. DOE Non-Reactor Nuclear Facility Safety Analysis Reports*, that is, death or multiple serious injury.

4.3 Programmatic Controls

4.3.1 Conduct of Operations

A formal DOE-approved Conduct of Operations (ConOps) program is imposed to ensure that work is performed in a controlled organized manner, that all facets of the work have been considered, and that necessary documentation is maintained. The defining documents for the ConOps Program are contained within ER-OPM-1.0, *"Procedure Development and Requirements,"* ER-OPM-1.2, *"Authorization Basis for Procedures,"* ER-OPM-2.0, *"Environmental Restoration Conduct of Operations,"* ER-OPM-2.1 *"Work Planning and Control System,"* and ER-OPM-4.5, *"Implementation, Control, and Configuration Management of Work Field Activities."*

Field activities and decontamination and decommissioning (D&D) projects are governed by the *EM Operations Procedure Manual* and applicable requirements in t*he BNL SBMS*. The *Project Management Plan for the BGRR-DP* (BGRR-001, Rev. 1) dated March 2, 2000 is based on a graded approach to the Conduct of Operations authorized by DOE's Order 5480.19 [46]. It applies to all BGRR Project personnel, assigned or matrixed, who work under the responsibility and direction of the BGRR's Project Manager.

ConOps strongly emphasizes technical competency, workplace discipline, and personal accountability to ensure a high level of performance. Project personnel are responsible for fully complying with the requirements that flow down through approved work packages in the field.

Environmental protection, safety, and health are co-equal first priorities and all planning shall include appropriate ES&H analyses to identify potential environmental, safety, and health risks and the means to mitigate them.[1] Workers shall not start work until approved procedures and training are provided.

ConOps requires workers to be alert and aware of conditions affecting the job site. Workers in the field should be notified of changes in the status of the facility and work areas, abnormalities, and any difficulties encountered in carrying out operations. Similarly, workers shall notify the chain-of-command of any unexpected situations. In accordance with the severity of a finding (i.e., emergency condition), notification requirements will be expanded to include upper-tier management and regulatory agencies.

4.3.2 Project Controls

Project controls have been established using existing SBMS programs, procedures, and accepted practices as supplemented by specific programs, procedures and instructions, and quality procedures necessary to acquire, analyze, and report defensible Project information for the BGRR. This includes controls for obtaining Project information sampling and analysis plans, quality control requirements, quality assurance, ES&H plans, and non-conformance reporting.

Project activities and discrete work packages to be performed will be compared with the scope of the approved BGRR ASA, as per EM-OPM-1.0. Where warranted, ER-OPM-4.4, "Safety Evaluations for Unreviewed Safety Issue Determinations," will be used to evaluate any activity and work package, and provide a safety analysis for DOE review and approval.

The project is controlled using a top-down approach. The BGRR Project Management Plan and the EM Training, Quality, and Self-Assessment system govern programmatic and field activities. Procedures, training, surveys, evaluations, and analyses will be performed using documents or procedures that have sufficient guidance to meet the project's requirements.

The primary method for controlling the fieldwork to ensure consistent, reproducible results is by using approved Environmental Management (EM) procedures and Safety Based Management Systems (SBMS). The Project will use Technical Work Documents to establish safe work conditions in conjunction with applicable work permits, radiological work permits, confined space, and cutting and burning permits.

Section 1.3, Hazard Classification Summary, has the five Administrative Controls governing the overall special project.

4.3.3 Radiological Controls

The BNL Radiological Control (RadCon) Manual https://sbms.bnl.gov/program/pd01/pd01t011.htm [47] and 10CFR835 [48] form the basis for a set of institutional RadCon policies and project-specific procedures. They provide for the following: Radiological Work Permits (RWPs) that identify the specific conditions and govern the specific requirements for an activity, periodic radiation- and contamination-surveys of the work area, and periodic or continuous observation of the work by radiological control technicians. In addition, ALARA (As Low as Reasonably Achievable) planning will be developed in accordance with BNL RWPs for all work packages. It will identify the requirements for

[1] In this usage 'mitigate' means not only to lessen the severity of the effects, but also and preferably to reduce or eliminate the likelihood of occurrence.

shielding, contamination control (including local-ventilation controls), radiation monitoring, and other radiation control for individual tasks conducted during the decommissioning.

4.3.4 Occupational Safety Controls

Workers' safety and health considerations, as per the requirements of the Occupational Safety and Health Act (OSHA) are integrated into the BGRR-DP (and subsequent BGRR-related work) during work planning. The workers' involvement in the levels of safety analysis required for the various BGRR tasks and the planning follows the guidance in BNL's ES&H Standard 1.3.6, "Work Planning and Control System" https://sbms.bnl.gov/ld/ld08/ld08d111.htm and DOE Policy 450.4, "Safety Management System Policy," [49] to ensure that all elements of work are useful, efficient, safe, and satisfactory to all concerned, as indicated by the solicited feedback ensuring continual improvement.

4.3.5 Environmental Health and Safety Plan

All work covered under this ASA will be conducted in accordance with the BGRR Project Environmental Health and Safety Plan, BGRR-006, Rev. 1, dated March 7, 2000 [50] and Procedures (described in BNL's SBMS). Additionally, work-package-specific ES&H planning documents are and will be developed as needed for the risks associated with the work. Health Physics support is present as necessary during characterization and decommissioning activities. The ALARA concept is followed during all phases of fieldwork. A detailed work package is prepared for each major task and Removal Action as defined in the Project's plan, to document the approved activities and the controls necessary to mitigate any hazard encountered. It is recognized that certain BGRR structures and systems have the potential for producing very high levels of radiation exposure and releasing radioactive contamination if boundaries are breached. Therefore, each work package will be reviewed and approved to assure appropriate work controls were incorporated to protect workers, the facility, the environment, and the public [51].

4.3.6 Training

BNL provides training to workers who may be exposed to radioactive materials. The training varies according to potential exposure and the employee's job duties, but all personnel receive a minimum of ES&H training as required by BNL SBMS. Training for radiological work consists of the appropriate training modules for the scope of work in accordance with BNL's Radiological Protection Training Program Description and the *Radiological Control Manual.* A training matrix and Job Training Assessment is generated for all members of the BGRR-DP. Documentation of training is retained as part of the BNL training database. Documentation of participation in work briefings is retained as part of the BGRR-DP Work Package. Requalification is mandatory at pre-established fixed intervals and maybe accomplished by retraining or the passing of a challenge exam.

As per ER-OPM-5.7.1, "*ER Training Management System,*" all personnel shall be trained and qualified according to job assignment. Training will include the appropriate BNL Radiation Control Training. All personnel working within the facility also will complete BGRR facility training, and training will include, as a minimum, the following:

- Radiological/hazardous material handling techniques
- Environmental Management Systems requirements for project work onsite.

- Recognition, control, and mitigation requirements for radiological, chemical, and physical hazards that may be present

4.3.7 Stop Work

Established Stop Work processes and procedures ensure that all workers are trained and qualified to stop work (their own or others they may see) when any of the following occurs:

- There is an imminent danger to personnel, equipment, or the environment and immediate action is required or
- Radiological work is being performed in violation of established site/DOE radiological-control requirements, or has the potential to result in significant radiological exposure or releases of radioactive material.
- There is risk of an uncontrolled release to the environment.

4.3.8 Occurrence Reporting

The Occurrence Reporting and Processing System, as defined by its SBMS Subject Area (https://sbms.bnl.gov/standard/20/2000t011.htm) [52], and as committed to and implemented by the BGRR-DP, requires that occurrences (including problems, concerns, and adverse events or conditions) are promptly reported to DOE and other appropriate organizations both external and internal, where those occurrences could:

- affect the health and safety of the public
- have a noticeable adverse effect on the environment
- endanger the health and safety of employees and other workers
- seriously impact the operations and intended purpose of BNL's facilities
- result in loss or damage of property
- adversely affect national security or the security interest of DOE or BNL.

In addition to Occurrence Reporting, lesser events which do not rise to the threshold for Occurrence Reporting shall be reported, as appropriate, according to ER-OPM-6.3, "Condition Reporting System," which complies with the Nonconformance and Corrective and Preventative Action SBMS Subject Area (https://sbms.bnl.gov/standard/07/0700i011.htm) [53] and/or the *Radiological Awareness Report* SBMS Subject Area, https://sbms.bnl.gov/standard/0v/0v02e011.htm [54].

4.3.9 Quality Assurance

The *EM Quality Assurance Program Description* [55] (http://www.bnl.gov/erd/erd/QAProgram Description.pdf) describe how EM (including BGRR-DP) implements the BNL Quality Program under DOE Order 414.1, *"Quality Assurance,"* [56] issued 11/24/98 (previously 5700.6C) and 10CFR830. Subpart A [57]. In general, the following quality elements are established:

- management responsibilities and quality system
- personnel training and qualification
- quality improvement system
- document and record-control

- work-process, item, and equipment control
- design-process control
- procurement
- inspection and acceptance testing
- management assessments
- independent assessments.

Environment Management also maintains a Self-Assessment Plan [58] and program that contains management and independent assessments (specifically including BGRR-DP) http://www.bnl.gov/erd/erd-self-assess.pdf.

4.3.10 Fire Protection

Manual fire protection shall be provided by the BNL Fire Department throughout the BGRR-DP. Fire-detection systems shall provide the level of protection required during the BGRR-DP work, in accordance with BNL's ES&H Standard 4.0.0, "Fire Safety Program."[59] The requirements of NFPA 241, "Standard for Safeguarding Construction, Alteration, and Demolition Operations" [60], shall be met for all activities. No flammable gases will be stored inside BGRR Complex buildings; only those gases connected for use will be there. Any temporary disconnections of fire-protection system equipment to support decommissioning shall be made in compliance with BNL's ES&H Standard 4.2.0, "Impairment of Fire Protection Systems and Fire Alarm Systems," https://sbms.bnl.gov.ld/ld08/ld08d451.htm. Additionally, as part of the High Flux Beam Reactor complex, Building 704 (Fan House) had a Fire Hazard Analysis (FHA) revision issued (Revision 3) dated November 15, 1999 [61]. It contains a comprehensive evaluation of the risks from fire and fire-related perils in Building 704 (Fan House). The impact of D&D activities within or upon Building 704 must be considered in terms of the FHA—with notification to Reactor Division or High Flux Beam Reactor (HFBR) successor organization—of changes that impact the accuracy of safety margins considered within the Fire Hazards Analysis.

4.3.11 Emergency Response

The BNL Emergency Plan [62] describes the organization, facilities, and procedures that would be used to protect Laboratory employees, the general public, emergency workers, and the environment in the unlikely event of an Operational Emergency anywhere within the Laboratory. The plan implements and complies with applicable DOE Orders and Federal regulations.

The BGRR-DP's personnel are not members of BNL's Emergency Response Organization, nor do they have any special emergency-responder functions.

In accordance with BNL's ES&H Standard 1.17.0, "Local Emergency Plans," https://sbms.bnl.gov/ld/ld08/ld08d281.htm [63], ER-OPM-3.0, "BGRR-DP Local Emergency Plan and Building Requirements," describes the actions to be taken by Project personnel present whenever any emergency occurs at BNL, including potential emergencies at the BGRR Complex.

4.4 Commitments

4.4.1 Authorized Work Scope

Only the scope of work defined by this ASA will be executed under it. See Section 4.4.4, USI Procedure, for conducting work potentially outside the scope of this ASA on the BGRR-DP.

4.4.2 Compliance with Special Controls

All special controls, e.g., Lockouts/Tagouts (LO/TOs), RWPs, Fire Protection Impairment Tags, Cutting (Welding Permits) shall be employed and followed where required.

4.4.3 Characterization and Hazards Analysis

The results of Radiological/Hazardous Material Characterization for ES&H and Waste Management shall be reviewed and factored into the USID/SE performed for any activity not totally covered by the ASA.

4.4.4 USI Procedure

In accordance with Section 1.4, Scope of Work, and Section 1.5, Unreviewed Safety Issue (USI) Process, ER-OPM-4.4, "Safety Evaluations for Unreviewed Safety Issue Determinations," shall be used whenever called for by Table 1.4-1, ASA Applicability Table, or whenever a question arises about the coverage by the ASA of the work to be performed. The only exception to this requirement is in circumstances where gross inventory involved (not the same as MAR inventory) may reach or exceed the Category 3 Threshold and the USQ Process, as defined under WMD-ADM-910, "Unreviewed Safety Question Determination (USQD)," shall be used. An example of such is USQD No. BGRR-USQD-02-01, "Challenge to BGRR-ASA by Increase in Estimated Below Ground Duct (BGD) Filter Inventory." Additional USQ-required activities may include activities associated with removal or remediation of the BGD Filters and/or the Graphite Pile itself.

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6.0 GLOSSARY

Activity: Sometimes used for **radioactivity**, particularly when referring to an amount of radioactivity (i.e., the number of nuclear transformations occurring in a given quantity of material per unit of time).

Airborne radioactivity: Radioactive particulates, mists, fumes, and gases in the air.

ALARA: A philosophy to maintain exposure to radiation As Low As Reasonably Achievable.

Alpha-bearing waste: Waste containing alpha-emitting radionuclides.

Alpha decay: Radioactive decay in which an alpha particle is emitted. This transformation lowers the atomic number of the nucleus by two and its mass number by four.

Alpha particles: The least penetrating but most energetic of radiation types. The particle is positively charged and relatively massive. Because of its size, it may easily be stopped in a few centimeters of air. Alpha-emitting wastes require no shielding. Alpha-emitting nuclides can be dangerous when ingested or inhaled because the particle's energy is transferred directly to adjacent cells.

Auditable Safety Analysis (ASA): The Authorization Basis documentation for safety of a DOE facility below the threshold for Nuclear Hazard Category 3, also known as "Radiological Facility," per DOE-EM-STD-5502-04, "Hazard Baseline Documentation."

Background: The radiation dose received by everyone as a result of living on the Earth. Natural sources of radiation include cosmic rays (25% of total); terrestrial, including inside the body and in the environment (40% of total); and technological sources, including medical X-rays, fallout, nuclear facilities (35% of total).

Beta decay: Radioactive decay in which a beta particle is emitted.

Beta particles: These are charged particles (electrons or positrons) emitted from the decay of some radioactive elements and are more penetrating than alpha particles. Beta particles can penetrate skin and cause burns. They can travel several meters in air, but the principal hazard still comes from ingestion or inhalation of material that emits beta particles. Depending on the concentration, wastes containing material that emits beta particles may require some level of shielding. Beta particles can be stopped by a thick sheet (up to ½ inch) of plastic.

Biological shield: A mass of absorbing material placed around a reactor or radioactive source to reduce the radiation to a level that is safe for humans.

Characterization: An information-gathering process usually involving measurement or sampling and analysis of contaminants present.

Chemical hazards: Hazardous material (i.e., solids, liquids, or gases) with the potential for causing harm to people, the environment, or property.

Containment: A device used to prevent or minimize the spread of contamination, often a plastic enclosure with High Efficiency Particulate Air-filtered ventilation.

Contamination: Radioactive or hazardous material that has been deposited on the surfaces of structures or equipment or that has been mixed with another material.

Curie (Ci): The quantity of a radioactive material that has a disintegration rate of 3.7×10^{10} nuclear transformations per second.

Daughter product: A nuclide formed by the radioactive decay of another nuclide which, in this context, is called the parent.

Deactivation: The process of placing a facility in a safe and stable condition, including the removal of readily removable hazardous and radioactive materials to minimize the long-term cost of surveillance, and the implementation of maintenance programs that protect workers, the public, and the environment. Deactivation can include one-of-a-kind and first-of-a-kind tasks, such as removal of radioactive materials in ventilation duct work. It also includes routine surveillance and maintenance that are typically part of facility operation.

Decay, radioactive: A spontaneous nuclear transformation in which particles and/or gamma radiation is emitted.

Decommissioning: Takes place after deactivation and includes surveillance and maintenance, decontamination, or dismantlement. These actions are taken at the end of the life of a facility to retire it from service, with adequate regard for the health and safety of workers and the public and protection of the environment. The ultimate goal of decommissioning is unrestricted release or restricted use of the site. Surveillance and maintenance tasks during decommissioning are typically routine activities similar to those to any other life-cycle phase. A disposition project can also be in a long-term surveillance and maintenance (e.g., quiescent state) if no deactivation, decontamination, or dismantlement activities are conducted. This definition is not meant to imply that the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) is the controlling regulation for long-term surveillance and maintenance when decommissioning is not immediately undertaken.

Decontamination: The removal or reduction of residual radioactive and hazardous materials by mechanical, chemical, or other techniques to achieve a stated objective or condition. Decontamination may occur during all phases of facility disposition; however, the greatest decontamination activity usually occurs during decommissioning.

Decontamination agents: Those chemical materials used to effect decontamination.

Disintegration, nuclear: Spontaneous nuclear transformation (radioactivity) characterized by the emission of energy and/or mass from the nucleus. The process is characterized by a definite half-life.

Disintegration rate: The rate at which disintegrations occur, characterized in units of time, e.g., disintegrations per minute (dpm).

Dismantlement: Those actions required to remove material, including radioactive or contaminated material, from the facility.

Disposal: The disposition of materials with the intent that the materials will not enter the environment in sufficient amounts to cause a health hazard.

Dose, occupational: The exposure of an individual to radiation imposed by employment.

Dose rate: The radiation dose delivered per unit time and measured, for instance, in rems per hour.

Entombment: The encasement of radioactive materials in concrete or other structural material sufficiently strong and structurally long-lived to ensure retention of the radioactivity until it has decayed to levels that permit restricted release of the site.

Exposure: The general result of occupying an area where radiation is incident on the body or where airborne radioactive or hazardous materials are inhaled. The unit for exposure to X-ray or gamma radiation is the Roentgen (R).

Facility: The physical complex of buildings and equipment within a site.

Facility disposition: Those activities that follow completion of program mission, including, but not limited to, surveillance and maintenance, deactivation, and decommissioning.

Facility hazard analysis: Analysis of identified hazards that arise within a facility and which may be encountered during its disposition. This includes the type, form, quantity, concentration, and locations of radioactive, chemically hazardous, and biological substances and materials within a facility; the hazardous substances' inherent harmful characteristics and conditions under which exposure may occur; and the physical hazards related to carrying out the work.

Fission: The splitting of a heavy nucleus into two or lighter nuclei (nuclides of lighter elements), accompanied by the release of a relatively large amount of energy and generally one or more neutrons. Fission can occur spontaneously, but usually it is caused by nuclear absorption of gamma rays, neutrons, or other particles.

Fission products: The lighter nuclides formed by the fission of heavy elements. The term also refers to the nuclides formed by the fission fragment's radioactive decay.

Gamma radiation: Electromagnetic radiation of extremely short wavelength similar to X- rays. Gamma radiation is highly penetrating. Therefore, gamma-emitting nuclides are a hazard both when ingested or inhaled and when exposure is external to the body. Heavy materials such as lead (or massive amounts of lighter materials) are effective protective shields.

Greenfield: Returning the footprint of the decommissioned facility to grass on top of clean soil.

Half-life, radioactive: The time in which half the atoms of a particular radioactive substance disintegrate to another nuclear form. Each radioactive isotope has a characteristic half-life, and measured half-lives vary from millionths of a second to billions of years.

Hazard: A chemical property, energy source, or physical condition that has the potential to cause illness, injury, death to personnel, or damage to property or the environment. This definition does not include the likelihood or credibility of potential accidents or the mitigation of consequences.

Hazard baseline documentation: A formal record of a facility disposition's safety basis, which includes all identified hazards and the controls established to support safe work-execution. The type and extent of

hazard baseline documents will vary depending on the disposition work's scope and hazards, but typically include a combination of either a Safety Analysis Report (SAR), Health and Safety Plan (HASP), Basis for Interim Operation (BIO), Technical Safety Requirements (TSR), or other types of documented analysis (e.g., Auditable Safety Analysis [ASA]) and work packages used to plan and control work tasks.

Hazardous material: A substance or material that has been determined by the Secretary of Transportation to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce and that has been so designated.

Hazardous substance: Used synonymously with the term "hazardous material," this includes any substance designated or reflected in 29 CFR 1910.120, to which exposure may result in adverse effects to the worker, public, or environment, including (1) any substance defined under Section 101(14) of CERCLA, (2) any biological agent and other disease-causing agent that after release into the environment and upon exposure, ingestion, inhalation, or assimilation by humans, either directly from the environment or indirectly by ingestion through food chains, will or may reasonably be anticipated to cause death, disease, behavioral abnormalities, cancer, genetic mutation, physiological malfunctions (including malfunctions in reproduction), or physical deformations in such persons or their offspring, (3) any substance listed by the U.S. Department of Transportation (DOT) as a hazardous material under 49 CFR 172.101 and appendixes, and 4) hazardous waste (i.e., a waste or combination of wastes as defined in 40 CFR 261.3 or substances defined as hazardous waste in 49 CFR 171.8).

Hazardous waste: As defined in 40 CFR 261, any solid waste; concentration; or physical, chemical, or infectious characteristics that may "(1) cause, or significantly contribute to, an increase in mortality or an increase in serious irreversible or incapacitating reversible, illness; or (2) pose a substantial present or potential hazard to human health or to the environment when improperly treated, stored, transported, disposed of, or otherwise managed."

High-level waste: The highly radioactive waste material that results from reprocessing spent nuclear fuel.

Hold point: A predetermined step, specified in work planning documents, that requires specific actions or hazard controls before continuing work (e.g., project activities or radiological controls).

Holding time: The maximum amount of time that a sample can be held before analysis begins.

Hot spot: The region in a radiation/contamination area in which the level of radiation/contamination is noticeably greater than in neighboring regions in the area.

Immobilization: Treatment and/or emplacement of material (e.g., radioactive contamination) to impede its movement.

Interim storage: Storage operations for which (1) monitoring and human control are provided and (2) subsequent action in which final disposition is expected. Concepts for interim storage include bulk or compartmented storage of solid, liquid, and gaseous wastes.

Ion exchange: A chemical process involving the absorption or desorption of various chemical ions in a solution onto a solid material, usually a plastic or resin. The process is used to separate and purify chemicals, such as fission products, or to adjust the "hardness" of water (i.e., water softening).

Ionization: The process by which a neutral atom or molecule acquires a positive- or negative-charge through the loss or gain of electrons.

Isotope: A variation of an element that has the same atomic number but a different weight because of the number of neutrons it carries. Different isotopes of an element may exhibit distinctly different radioactive behaviors, but all behave the same way chemically.

Kerf: The width of the slit or notch made by a saw or cutting torch.

Low-level residual fixed radioactivity: Remaining radioactivity following reasonable efforts to remove radioactive systems, components, and stored materials that is comprised of either (1) surface contamination that is fixed following chemical cleaning or some similar process, (2) a component of surface contamination that can be picked up by smears, or (3) activated materials within structures. These components can be characterized as low level if the smearable radioactivity is less than the levels defined by 10 CFR 835, Appendix D, Surface Contamination Values, and hazard results shows that no credible accident scenario or work practice(s) would release the fixed or activation components of radioactivity remaining at levels that would prudently require the use of existing active safety systems, structures, or components to prevent or mitigate a release of radioactive materials.

Low-Level Waste (LLW): Waste that contains radioactivity and is not classified as high-level waste, spent nuclear fuel, or some by-product material.

Monitoring: Taking measurements or observations for recognizing the adequacy, significant changes in conditions, or performance of a facility.

Neutron radiation: High-energy neutral particles form this radiation. Neutrons can travel long distances in air and other materials and, along with gamma rays, present the greatest hazards for external exposure. Neutron radiation requires special shielding, usually light materials containing hydrogen.

Non-nuclear facility: Those activities, processes, or operations that may involve hazardous substances in such forms or concentration that a potential danger exists to cause illness, injury, or death to personnel within the facility's site boundary or to members of the public.

Nuclear facility: Those activities, processes, or operations that involve radioactive materials or fissionable materials in such form, quantity, or concentration that a nuclear hazard potentially exists to the employees or general public. Included are activities or operations that (1) produce, process, or store radioactive liquid, solid waste, fissionable materials, or tritium; (2) conduct separations operations; (3) conduct irradiated materials inspection, fuel fabrication, decontamination, or recovery operations; (4) conduct fuel enrichment operations; and (5) perform environmental remediation or waste management involving radioactive materials. Incidental use and generation of radioactive materials in a facility's operation (e.g., check and calibration sources, and use of radioactive sources in research, experimental and analytical laboratory activities, electron microscopes, and X-ray machines) would not ordinarily require the facility to be included in this definition. Accelerators and their operations are not included.

Nuclide: A species of atom characterized by its mass number, atomic number, and nuclear energy state, provided that the mean lifetime in that state is long enough to be observable.

Offsite: Beyond the boundary line marking the limits of BNL property.

Pathway: A route and sequence of processes by which radioactive material may move through the environment to humans or other organisms.

Physical hazards: Hazards that are routinely encountered in general industry and construction, and for which national consensus codes or standards (e.g., Occupational Safety and Health Administration [OSHA] or DOT) exist to guide safe design and operation without the need for special analysis to define these parameters. Physical hazards are those encountered during routine work and construction including excavation, electrical hoisting and rigging, noise, and slips, trips, and falls.

Primary wastes: Wastes that are generated as part of the cleanup of existing contaminants. Secondary wastes are generated from a supporting operation, such as using personal protective equipment.

Process equipment: The functional equipment items or systems associated directly with operating a chemical or mechanical process.

Protective clothing: Special clothing worn by persons in a contaminated area to prevent contamination of their body or personal clothing.

Radiation: (1) The emission and propagation of radiant energy; for instance, the emission and propagation of electromagnetic waves (X or gamma radiation). (2) The emission and propagation of energetic particles such as alpha particles, beta particles, and neutrons.

Radioactive material: Any material or combination of materials that spontaneously emits ionizing radiation.

Radioactive waste: Any material containing or contaminated with radionuclides at concentrations greater than the values that competent authorities would consider acceptable in materials suitable for unrestricted use or release and for which there is no foreseen use.

Radioactivity: The property of certain nuclides of spontaneously emitting radiation, either electromagnetic, particulate, or both.

Radioactivity, induced: Radioactivity produced in a substance after bombardment with neutrons or other particles. Also called activation.

Radiological facility: Facilities that do not meet or exceed the nuclear hazard Category 3 thresholds published in DOE-STD-1027-92, but still contain some radioactive material (see DOE-EM-STD-5502-94).

Radiological hazards: Hazards that contain radioactive isotopes that have the potential to cause harm from ionizing radiation.

Radiological protection: Protection against the effects of internal and external human exposure to radiation and to radioactive materials.

Rem: A unit of dose equivalent. A rem is numerically equal to the absorbed dose in rads multiplied by the quality factor, the distribution factor, and any other necessary modifying factors.

Repository: The site and all facilities where waste disposal takes place.

Roentgen: A unit of exposure to ionizing radiation, abbreviated "R."

Safe storage: Those actions required to place and maintain a nuclear facility in such a condition that future risk to public safety from the facility is within acceptable bounds and that the facility can be safety stored for as long as desired.

Secondary wastes: Forms and quantities of all wastes created during the treatment of primary wastes or effluents.

Shield: Material used to reduce the passage of particles or radiation. A shield may be designated according to what it is intended to absorb (as a gamma shield or neutron shield) or according to the kind of protection it is intended to give (as a background, biological, or thermal shield). It may be required for the safety of personnel to reduce radiation enough to allow counting instruments to be used.
Shutdown: The time during which a site is not in operation.

Site: The geographic area upon which the facility is located that is subject to controlled public access by the facility's licensee (includes the restricted area as designated in the NRC license).

Solidification: Conversion of radioactive and/or hazardous wastes (gases or liquids) to dry, stable solids.

Surface contamination: Radioactive and/or hazardous material adhering to an otherwise uncontaminated surface.

Surveillance and maintenance: These activities are conducted throughout the facility life-cycle phase including when a facility is not operating is not expected to operate again, and continues until phased-out during decommissioning. Activities include providing, cost-effectively, periodic inspections and maintenance of structures, systems, or components necessary to satisfactorily contain contamination and protect workers, the public, and the environment. A disposition project can be in a quiescent state of long-term surveillance and maintenance before deactivation or decommissioning.

Survey: An evaluation of the radiation hazards incident to the production, use, release, disposal, or presence of radioactive materials or other sources of radiation under a specific set of conditions.

Swarf: The amount of material (as metallic particles and abrasive fragments) removed by a cutting tool.

Task hazard analysis: An analysis of individual facility's disposition tasks (i.e., discrete units of work that comprise a project) to understand hazards that may be introduced during the work. This analysis supports the establishment of worker safety controls and development of work packages or other methods used to plan tasks.

Transuranic elements: Elements with atomic number (Z number) greater than 92.

Transuranic waste: Any waste material measured or assumed to contain more than 100 nCi/g of transuranic elements that emit alpha radiation and have a half-life of greater than 20 years.

Unreviewed Safety Issue (USI): Analogous to Unreviewed Safety Question for Radiological Facility (Facility below threshold for Nuclear Hazard Category 3). See Section 1.5, Unreviewed Safety Issue (USI) Process, for a discussion of how the process will be applied in conjunction with the BGRR-ASA.

Waste Management: The planning, execution, and surveillance of essential functions related to controlling radioactive hazardous or mixed waste, including treatment, solidification, interim or long-term storage, transportation, and disposal.

X-ray: A penetrating form of electromagnetic radiation emitted either when the inner orbital electrons of an excited atom return to their normal state (characteristic X-rays), or when a metal target is bombarded with high-speed electrons. X-rays are always non-nuclear in origin (i.e., they originate external to the nucleus of the atom).

APPENDIX A

BNL PROCEDURES FOR RADIOLOGICAL AND HAZARDOUS MATERIAL PROTECTION AT THE BGRR

APPENDIX A

BNL PROCEDURES FOR RADIOLOGICAL AND HAZARDOUS MATERIAL PROTECTION AT THE BGRR

This Appendix contains a partial list of BNL, Environmental Management (EM), and BGRR procedures that are used to control radiological and hazardous materials and work.

On October 1, 1999, the BGRR Decommissioning Project was integrated into the former Environmental Restoration Division (ERD). In July 2001, ERD was integrated into the EM Directorate. EM procedures will, in general, be used where available and not superseded by BGRR Project-specific procedures. As such, BGRR-DP procedures have all been revised and/or renumbered in accordance with administrative record requirements.

EM-OPM-1.0	Procedure Development and Requirements
EM-OPM-1.2	Authorization Basis for Procedures
EM-OPM-2.0	EM Conduct of Operations
EM-OPM-2.1	Work Planning and Control System
EM-OPM-3.0	BGRR-DP Local Emergency Plan and Building Access Requirements
EM-OPM-4.2	BGRR-DP Monitoring and Surveillance Procedure
EM-OPM-4.3	ASTD Soil Sample Processing to Support BGRR Excavations
EM-OPM-4.4	Safety Evaluations for Unreviewed Safety Issue Determinations
EM-OPM-4.5	Implementation, Control, and Configuration management for BGRR Decommissioning Project Work Activities.
EM-OPM-4.6	Hazardous Materials Assessment Analysis, and Mitigation for BGRR Decommissioning Activities
EM-OPM-4.7	Waste Management Procedure
EM-OPM-5.6.5	Environmental Management Planning Form for BGRR Decommissioning Project
EM-PM-5.6.11	Operational Control Form for BGRR Decommissioning Project

EM-OPM-5.7.1	EM Training Management System
EM-OPM-6.3	Condition Reporting System
EM-BGRR-TP-00-01	Technical Work Document - Instrument House (708) Components Removal and Isolation
EM-BGRR-TP-00-02	Technical Work Document - Buildings 701 and 703 Isolation
EM-BGRR-TP-00-03	Survey and Sampling Plan for Coating on Exterior Surface of the Above Ground Ducts
EM-BGRR-TP-00-04	Sampling and Analysis Plan for the Above Ground Ducts
EM-BGRR-TP-00-05	Characterization Sampling Analysis Plan for Primary Air Cooling System Coolers
EM-BGRR-TP-00-06	Characterization Sampling Analysis Plan for Primary Air Cooling System Filters
EM-BGRR-TP-00-07	Characterization of Reactor Pile
EM-BGRR-TP-00-08	Characterization Sampling Analysis Plan for Deep Soils beneath the Below Grade Ducts
EM-BGRR-TP-00-09	Characterization Sampling Analysis Plan for Below Grade Duct Interiors
EM-BGRR-TP-00-10	Characterization Sampling Analysis Plan for the Canal and Water Treatment Houses and Associated Soils.
EM-BGRR-TP-00-11	Characterization of the Sealing of the Reactor Pile (702)
EM-BGRR-TP-00-12	Isolation of the Pile Filter Inlets
EM-BGRR-TP-00-13	Identification & Characterization of Leak Pathways in the Below Grade Ducts
EM-BGRR-TP-01-01	Technical Work Document - De-Energize, Stabilize and Remove Abandoned Equipment from the Canal and Water Treatment Houses
EM-BGRR-TP-01-02	Technical Work Document-Demolition of the Canal and Water treatment Houses
EM-BGRR-TP-01-03	Technical Work Document - Remediation of Lower Canal House, Below Grade Piping, and Associated Soils
EM-BGRR-TP-01-04	Was initially drafted but never issued and was replace by TP-01-08
EM-BGRR-TP-01-05	Technical Work Document - Soil Sample Screening for Excavations

EM-BGRR-TP-01-06	Technical Work Document - Segmentation of AGD Sections 4, 1N and 1S
EM-BGRR-TP-01-07	Technical Work Document - AGD Pedestal Removal
EM-BGRR-TP-01-08	Technical Work Document - BGD SAP Implementation
EM-BGRR-TP-01-09	Technical Work Document – Coolers Removal Action
EM-BGRR TP-01-10	Technical Work Document – Filters Removal Action

Procedures for implementing work control in accordance with ES&H manual guidance:

HP-SOP-015	Radiological Lessons Learned Program
HP-SOP-016	Radiological Awareness Report (RAR) Program
HP-SOP-020	ALARA Program
HP-SOP-022	Radiological Dose Limits and Administrative Control Levels
HP-SOP-025	Radiation Protection Training and Qualification
FS-BGRR-0001	Monitoring and Surveillance at the BGRR Decommissioning Project
FS-SOP-0002	Vehicle Radiation Monitor Procedure
FS-SOP-0006	Termination of Dosimeter Service
FS-SOP-1000	Radiation Survey Techniques
FS-SOP-1001	Contamination Survey Techniques
FS-SOP-1005	Release of Materials from Areas Controlled for Radiological Purposes
FS-SOP-1040	Airborne Radioactivity Sampling and Analysis
FS-SOP-1090	Radiological Surveys-Hazwaste Containers
FS-SOP-2010	Periodic Instrument Response Check
FS-SOP-2020	Ludlum Floor Walker Model 239-1F Set-up and Operation
FS-SOP-2051	Operation of the Tennelec Low-Background Count

FS-SOP-3000	Radiological Posting Requirements
FS-SOP-3010	Labeling, Documentation, and Handling of Radioactive Material
FS-SOP-4001	Use of Protective Clothing and Step-off Pads in Contamination Areas
FS-SOP-4002	Use and Issuance of Respiratory Protection
FS-SOP-4010	Personnel Decontamination
FS-SOP-4011	Personnel Contamination Reporting
FS-SOP-4020	Use of Dosimetry
FS-SOP-4025	Bioassay Requirements for Performing Radiological Work
FS-SOP-4026	DAC-Hour Tracking and Bioassay Dose Assessment
FS-SOP-4027	Entry and Egress Requirements for Areas Controlled for Radiological Purposes
FS-SOP-4031	Radiological Work Permit