Risk Identification, Analysis, and Mitigation Plan for Environmental Remediation Activities at Brookhaven National Laboratory - 11109

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ABSTRACT

This paper describes the on-going activities for updating the risk identification, analysis and mitigation plan for environmental remediation work at Brookhaven National Laboratory (BNL). Currently BNL is integrating risk identification and analysis results with other relevant information to make decisions about the need for and method of risk reduction. The focus is on those aspects of the planned activities that have significant uncertainties. The ultimate objective is to generate and implement risk mitigation plans that reduce, prevent or mitigate risks.

Some of the key remaining scope of legacy cleanup at BNL site includes deactivation and decommissioning (D&D) of the Brookhaven Graphite Research Reactor (BGRR). This work included the removal of the 7.62 m (25-foot) square graphite pile and the biological shield (called bioshield). The bioshield is a steel and concrete enclosure with walls and roof sections in varying thicknesses from 1.3 m (4 feet 3 inches) to 1.62 m (5 foot 4 inches) that functioned to shield personnel from radiation, and provided physical support and an airtight membrane around the graphite pile. Removal of the graphite pile was completed in May 2010, leaving the 9.14 m (30-foot) tall bioshield. The paper addresses key risks with the demolition, removal, packaging, shipment and disposition of this radiologically activated bioshield.

A comprehensive risk identification, analysis and mitigation plan update is intended to provide BNL the tools to be ready to meet the challenges resulting from unforeseen conditions during the implementation of bioshield removal/disposition activities. Risk management at BNL is a continuous process and the risk management plan is being updated on a regular basis. The process keeps track of identified risk, monitors residual risk and identifies new risks as they arise. To date, the process has been very effective and has resulted in mitigation/avoidance of major potential issues and impacts of unanticipated events to a minimum.

INTRODUCTION

The Department of Energy (DOE) Office of Environmental Management (EM) has completed a large portion of the legacy environmental remediation activities at the BNL site and is in the final phases of completing the cleanup work at the site. With the use of the American Recovery and Reinvestment Act of 2009 (ARRA) funds, EM is committed to complete the remaining EM

portion of the cleanup work by the end of FY-2011. Some of the key remaining activities at the site include deactivation and decommissioning (D&D) of the Brookhaven Graphite Research Reactor (BGRR). The initial scope of work for D&D of the BGRR included the removal of the 7.62 m (25-foot) square graphite pile and the biological shield (called bioshield). The graphite pile was removed in May 2010, leaving the 9.14 m (30-foot) tall bioshield. The bioshield is radiologically activated and contaminated as a result of the past operation of the BGRR facility. The paper addresses key risks with the demolition, removal, packaging, shipment and disposition of this bioshield.

BGRR BIOSHIELD CHARACTERISTICS

Construction of the BGRR at BNL was completed in August 1950. The BGRR operated until 1968 when deactivation of the facility was initiated. The reactor was de-fueled in 1972. The fuel was shipped to the DOE Savannah River site and the BGRR was placed in a safe shutdown condition as a surplus facility within the DOE complex [1]. In March 2005, the BGRR Final Record of Decision (ROD) was signed by the DOE, the United States Environmental Protection Agency (USEPA) Region II, and the New York State Department of Environmental Conservation (NYSDEC) [2]. Along with the other work required to fulfill DOE's responsibilities under the BGRR ROD, it required the DOE to remove of the BGRR biological shield.

The BGRR biological shield and associated components are the structures that shielded personnel from radiation, and provided physical support and an airtight membrane around the BGRR graphite pile. It is a steel and concrete enclosure with walls and roof sections in varying thicknesses from 1.3 m (4 feet 3 inches) to 1.62 m (5 foot 4 inches). Relatively small amounts of steel and aluminum are present inside the biological shield as part of the secondary air cooling system. Figure 1 is a sketch of a cutaway view of the biological shield and graphite pile.

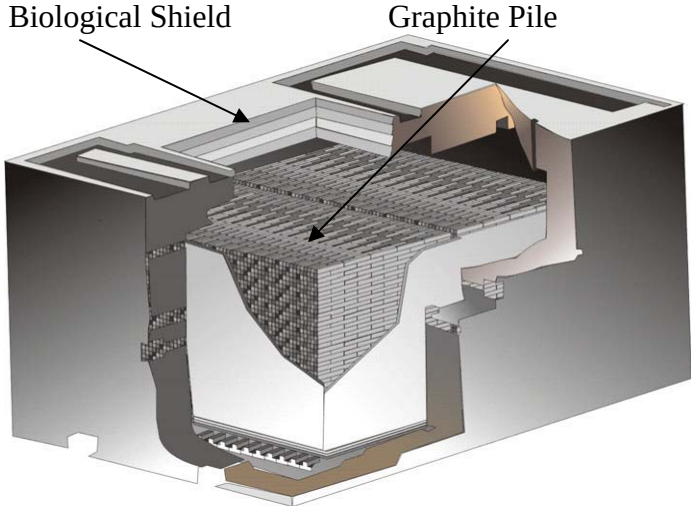

Fig. 1. Sketch of a Cutaway View of Biological Shield and Graphite Pile [1]

The bioshield characterization has indicated that outside steel samples have no activation of the metal and the outermost 0.61 m (2 feet) of concrete also has no activation. The most abundant radionuclides in the activated steel are nickel-63 (62%), cobalt-60 (32%), iron-55, and nickel-59; and the most abundant radionuclides in the activated concrete are tritium (98%), europium-152, nickel-63, and cobalt-60.

Hazardous materials identified in the biological shield are lead shielding in several locations, cadmium plating on control rod sleeves, cadmium coated boron shot in the shot wells, asbestos containing material (ACM) in the balcony floor tiles, and lead-cadmium alloy blocks in the helium system and fuel thermocouples.

ACTIVITIES PLANNED FOR BIOSHIELD REMOVAL AND DISPOSITION

As with any other D&D project, a number of activities are planned to be performed while removing the biological shield structure. The completion criterion for the remedial action of BGRR bioshield is the removal, shipment, and disposal of the biological shield. The planned activities include the following [1]:

a) Removal of the top of the biological shield structure;
b) Removal of the neutron shield;
c) Removal of the reinforced concrete including its size reduction for packaging, transportation and disposal;
d) Removal of the inner steel plates, including their size reduction for packaging, transportation and disposal;
e) Removal of the outer steel plates, including their size reduction for packaging, transportation and disposal;
f) Removal of the pile upper bedplates and sliding rails;
g) Removal of all visible debris within the biological shield footprint including the north and south plenums;
h) Sealing of all plenums, chutes, and experimental openings;
i) Removal and/or stabilization of loose radiological contamination in the Building 701 area associated with the removal of the biological shield, including the remaining pile support structure within the biological shield footprint; and
j) Installation of a permanent reinforced concrete cover over the footprint of the removed biological shield.

There is approximately 1758 cu meters (2300 yd^3) of material to be removed and disposed from the bioshield project. The steel and concrete will be loaded into DOT rated IP-1 intermodal containers. The intermodal containers will be placed on Articulating Bulk carrier (ABC) railcars and shipped to the Energy Solutions waste disposal facility in Utah.

RISK ASSESSMENT PROCESS

In federal capital planning and investment management, the Office of Management and Budget (OMB) requires effective risk management [3]. Consistent with the guidance provided in OMB Circular A-11, risk management is defined as a systematic process of identifying, analyzing, and responding to risk. The process includes initiation, planning, executing, monitoring, and close out of risk management throughout the life cycle of the project. Incorporating risk management into a comprehensive cost control strategy is vital to attaining better program and project performance.

BNL's risk assessment for the bioshield removal and disposition project included the overall process for risk identification and analysis. The process provided for identifying, analyzing, and quantifying potential risks in terms of probability and consequences. It evaluated the planned activities, underlying assumptions, residual uncertainties, and established the basis for risk mitigation conclusions. The process utilized the following elements: 1) plan risk management, 2) identify risk, 3) perform qualitative risk analysis, 4) perform quantitative risk analysis, 5) plan risk response, and 6) monitor and control risk. It started with initial planning of the remediation activities for the bioshield removal and disposition project and has been updated continuously for the execution of the planned remedial work. Early in the project, two summary level qualitative risk assessments were performed; one by the federal integrated project team and the other by the contractor. In addition, the contractor performed a more in-depth quantitative analysis of the project risks, including Monte Carlo analyses of cost and schedule outcomes [4].

The risk assessment process was constructed to implement the requirements of DOE O 413.3A, "Program and Project Management for the Acquisition of Capital Assets" [5] and used the guidance provided in DOE Guide, DOE- G 413.3-7,"Risk Management Guide [6]." For each possible risk, the process used a possible scenario for stating the event and the risk, evaluated the probability of the risk and a basis that the risk will come true without credit for risk handling strategy, and then determines the consequence. Based on the possible consequence, cost and schedule impacts were evaluated and the risk level was identified as low, moderate or high. The risk monitoring and control process then formulated a plan for risk handling/mitigation. The process was repeated and the results documented for each existing risk for the project. The results have been documented in a risk register that contains a description of the risk, the impact if the risk should occur, the probability of its occurrence, mitigation strategies, risk owners and a ranking to identify higher priority risks. Some general process details appear in Table I.

Updating the Risk Management Plan is designed to identify the relevant issues to be considered in managing risks and develop a set of actions to manage those risks. The focus of the Risk Assessment is on those aspects of the planned activities that have significant uncertainties. As part of this assessment and updating of risk management plan, BNL conducted a comprehensive examination of the alternatives for removal of the bioshield and analyzed risks associated with the alternative schemes.

Table I. General Characteristics of the Steps used in BNL Risk Assessment Process

Steps	Activities	Outcome
Plan Risk Management	Establish methods to manage risks, including the scales, metrics and mechanisms	Resources required for successful risk management
Identify Risk	Break the bioshield project elements into risk breakdown structure	Organized list of risks that represents a coherent portrayal of project risk
Perform Qualitative Risk Analysis	Adequately characterize the risk in words to develop an adequate risk handling strategy	Foundation for initiating the quantitative risk
Perform Quantitative Risk Analysis	Numerical analysis of probability and consequence of individual risks	View of risks that should receive focused attention
Plan Risk Response	Develop risk handling strategies	Contingency Adequacy Evaluation
Monitor and Control Risk	Tracking and evaluation of the effectiveness and appropriateness of risk handling strategies	Identification of any new risks or changes in the assumptions for risks captured previously

TYPICAL RISKS FOR BGRR BIOSHIELD REMOVAL PROJECT

After the removal of the graphite pile from the BGRR in May 2010, the remaining contamination within the complex consists primarily of activation and fission products within the biological shield, contaminated concrete within the fuel handling system deep pit and fuel canal, and contaminated steel and concrete within the belowground ducts. Additionally there are isolated pockets of contaminated soils associated with the belowground duct secondary cooling air bustle and expansion joints, fuel canal outer walls and construction joint, the reactor building pipe trench and reactor building drains.

The majority of non-radiological hazardous materials associated with the BGRR have been removed through previous interim measures. Isolated pockets of non-radiological hazardous material contamination are present within the reactor building pipe trench, and within embedded drain lines. Hazardous materials intrinsic to construction materials such as floor tiles, paint and insulating materials remain within the reactor building.

Key field activities for BGRR bioshield removal and disposition include bioshield interface removal, removal of ACM tile, ventilation modifications, contamination control enclosure modifications, installation of thermal cutting tools, cutting of equipment port and fuel channel ports, installation of a second crane hoist, demolishing bioshield and support equipment, packaging and shipment of bioshield and final decontamination of BGRR and installation of an environmental cap around the building perimeter. The operational objectives of this project include prevention of the spread of contamination during biological shield dismantlement and waste handling, removal, transportation and disposal of contaminated materials using safe and efficient methods; and completion of the project with no Occupational, Safety and Health Association (OSHA) reportable injuries or DOE reportable incidents.

DOE has evaluated potential risks associated with all the activities associated with the removal/disposition of the bioshield [4]. Typical examples of identified risks are:

Risk 1:

Title: Inadequate management reserve funds for remaining scope of work.

Description: At the inception of the work, impacts from risks outside the contractor's control and management were addressed by allocating a percentage of project's funds as management reserve funds. However, the project has already used up a large portion of the management reserve funds to cover many of the realized risks identified during the development of the risk management plan. Critical vigilance is needed to ensure that the management reserve funds remaining to cover the rest of the work are adequate.

Probability: The probability of the risk of needing additional management reserve funds is considered to be low.

Consequence: The consequence of running out of management reserve funds will be that the work will not get completed because there are no additional funds available for this project and the work has to be finished by the end of FY-2011.

Mitigation Strategy: The risk is being mitigated by closely watching the progress on the project, tracking project activities performance at weekly team meetings, and minimizing the need for further use of management reserve funds.

Risk 2:

Title: Torch Cutting/Tool Deployment/Production Rates.

Description: The bioshield removal is a unique, one-of-a-kind project. There is risk that the adaptation and deployment of the bioshield removal technology, coupled with unforeseeable conditions inside of the biological shield, can lead to considerable variability in actual waste removal rates from those considered in the work plan.

Probability: The risk probability is determined to be high.

Consequence: The worst consequence is that the situation would result in considerable cost and schedule impacts.

Mitigation Strategy: The risk is being mitigated by using a highly disciplined and methodical approach to bioshield removal by design and qualification of special cutting tools.

Risk 3:

Title: Waste Disposal Pathway Disruption.

Description: Dismantlement of the bioshield will generate over 200 containers of waste, all of which is planned for shipment by rail to a commercial disposal facility. Should the rail pathway be disrupted, or the commercial disposal facility become unavailable, waste would have to be shipped by truck to a government-owned facility.

Probability: The risk probability is determined to be medium.

Consequence: This would have a significant impact on project cost and schedule.

Mitigation Strategy: The risk is being mitigated by rigorous planning and effective community outreach, communications and stakeholder involvement.

Risk 4:

Title: Waste Packaging Efficiency.

Description: The BGRR Baseline estimate for loading of bioshield waste assumes 25 metric tons (55K lb) of waste per intermodal container. Although previous experience affirms that 25 metric tons (55K lb)/container is achievable, this efficiency has not been demonstrated with a large number of containers.

Probability: The risk probability is determined to be low.

Consequence: Loading less than this will result in increased numbers of containers, transportation, and disposal cost.

Mitigation Strategy: This risk is being mitigated by rigorous upfront planning utilizing steel and concrete demolition plans to achieve optimum container loading.

RISK ANALYSIS AND MONITORING

BNL has adopted a risk analysis, monitoring and handling strategy that is aimed at reducing the likelihood of risk occurrence and/or impact of identified negative risks or threats. A comprehensive risk identification, analysis, and mitigation plan update has provided BNL the tools to be ready to meet the challenges resulting from unforeseen conditions during the implementation of bioshield removal/disposition activities. The process has kept track of identified risk, monitors residual risk and identifies new risks as they arise.

In addition to risk monitoring at the site level, DOE is also monitoring a selected risk profile at the DOE headquarter executive management level. The most significant site risks are monitored through compilation of these risks in a system known as eGov Risk Portfolio Manager. The following criteria is being used to determine if risks currently identified in the site's local risk register are of sufficient magnitude to warrant being captured in the Office of Environmental Management headquarters (EM-HQ) risk repository [7]:

- **a.** Risks which affect project Key Performance Parameters (KPPs);
- **b.** Risks which require EM-HQ assistance or action to mitigate/resolve; and
- **c.** Risks which have a potentially high or critical impact, regardless of probability, which can indirectly affect KPPs (high cost, increased schedule, or critical path, or would require a baseline change proposal to project), if realized.

If a risk item does not meet the above criteria, the site opts to monitor the risk locally and not include it in the HQ risk repository. Using this comprehensive approach, DOE is monitoring risk both at the HQ as well as the site level. The approach uses a systematic, continuous tracking and evaluating of the effectiveness and appropriateness of the risk handling strategy, techniques, and actions established within the risk management plan. Risk monitoring has provided the needed information that is assisting the site in reviewing/validating the assumptions used for the risk assessment and the accepted risks have not changed significantly since they were first identified. The outcome of risk identification and analysis has been to reduce the risk to an acceptable level.

One of the key results of risk monitoring has lead BNL to an evaluation of the contractor management reserve funds adequacy. In general, the criterion used is that management reserve value at every stage of the project should be commensurate with the maturity and type of the project, project size, and risks, including technical and technology uncertainties, and remaining scope of project work. The BNL's initial estimated cost and schedule management reserve exceeded the amount estimated to account for the known risks because it was realized that not all risks can be identified at the onset. However, because a number of risks were realized early in the project implementation phase, the remaining management reserve funds at this stage of the project have to be tracked with vigilance and great care. The site has implemented an approach to ensure that the contractor management reserve is sufficient to deal with future risk mitigation needs.

LESSONS LEARNED

The BGRR Bioshield D&D project is an ongoing project and there are risk assessment lessons being learned continuously as a result of insights gathered from the new information as it develops. The process allows for continuous refinement of the risk handling strategies. BNL has so far captured, checked, learned, and closed several important lessons learned from the planning and execution of environmental remediation activities at the site. The process of identifying and disseminating lessons learned is aimed at curtailing repeated mistakes during project execution and providing a conduit for transmitting information to all active DOE and other organizations doing similar work. The lessons learned and recommendations create a Department-wide learning platform, provide relevant lessons for cross-pollination and ensure a successful risk analysis process. Continuous improvement in risk assessment cannot occur without sharing these lessons. DOE-HQ has begun collection of lessons learned data as a part of the monthly project reviews for the BGRR Bioshield D&D and all other Recovery Act projects. Some of the lessons learned at BNL so far include the following:

1. The project's initial estimated total cost and schedule contingency should exceed the amount estimated to account for the known risks because not all risks can be identified at the onset.
2. The risk management should be based on the principles that risk management is analytical, forward-looking, structured, informative, and continuous.
3. Risk assessments should be performed as early as possible. Early planning and scoping helps organize and identify problem scenarios and potential risk management options to address them and should result in a smoother and better quality risk assessment.

4. Risk assessments should identify critical risks in all important areas of concern, including technical, performance, schedule, and cost risks.
5. Effective risk management requires involvement of the entire project team.
6. Early input from decision makers and stakeholders is essential.
7. A close working relationship between the Federal Project Director staff and the contractor promotes a better understanding of program risks and assists in developing and executing the risk management efforts.
8. Oversight of risk evaluation process is necessary to maintain consistency, eliminate bias, and avoid misinterpretations that may occur through lack of misunderstanding.
9. Risk analysis training for both technical professionals and management is essential.

Additional lessons learned are being collected, reviewed and will be promptly distributed to aid in achieving the goal of improving project management performance within the DOE complex. However, identification alone is insufficient to promulgate change in project operations. Each negative lesson learned needs to be evaluated for appropriate corporate/program actions to prevent the recurrence of the situation.

CONCLUSIONS AND PATH FORWARD

The concepts presented in this paper are considered to be beneficial to other similar projects and can be tailored to suit the needs and complexity of these projects. BNL risk assessment activities have been very effective and have resulted in mitigation/avoidance of major potential issues and impacts of unanticipated events to a minimum. So far BNL has learned many helpful lessons from risk identification, analysis, and mitigation activities for BGRR bioshield removal that can be considered for possible application on similar projects at other DOE sites.

After the project is completed, a Lessons Learned Report will be submitted to DOE's Office of Engineering and Construction Management (OECM) for broader sharing among the DOE project management community. The Department attains enhanced credibility for effective project management when, as a learning organization, positive project performance is realized and lessons learned from similar projects are applied effectively for similar work on projects at other sites.

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