Achieving Effective Risk Management Reduction Throughout Decommissioning at the Columbus Closure Project

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ABSTRACT

Nuclear facility decontamination, dismantlement, and demolition activities provide a myriad of challenges along the path to reaching a safe, effective, and compliant decommissioning. Among the challenges faced during decommissioning, is the constant management and technical effort to eliminate, mitigate, or minimize the potential of risks of radiation exposures and other hazards to the worker, the surrounding community, and the environment. Management strategies to eliminate, mitigate, or minimize risks include incorporating strong safety and As Low As Reasonably Achievable (ALARA) principles into an integrated work planning process. Technical and operational strategies may include utilizing predictive risk analysis tools to establish contamination limits for demolition and using remote handling equipment to reduce occupational and radiation exposures to workers. ECC&E2 Closure Services, LLC (Closure Services) have effectively utilized these management and technical tools to eliminate, mitigate, and reduce radiation exposures under contract to the U.S. Department of Energy (DOE) for the decontamination and decommissioning Columbus Closure Project (CCP). In particular, Closure Services achieved significant dose reduction during the dismantling, decontamination, and demolition activities for Building JN-1. Management strategies during the interior dismantlement, decontamination, and demolition of the facility demanded an integrated work planning processes that involved project disciplines. Integrated planning processes identified multiple opportunities to incorporate the use of remote handling equipment during the interior dismantling and demolition activities within areas of high radiation. Technical strategies employed predictive risk analysis tools to set upper bounding contamination limits, allowed for the radiological demolition of the building without exceeding administrative dose limits to the worker, general public, and the environment. Adhering to management and technical strategies during the dismantlement, decontamination, and demolition of Building JN-1 enabled Closure Services to achieve strong ALARA performance, maintain absolute compliance under the regulatory requirements and meeting licensing conditions for decommissioning.

INTRODUCTION

On April 16, 1943, Battelle Memorial Institute (BMI), acting through what is now its Battelle Columbus Operations (BCO), entered into Contract No. W-7405-ENG-92 with the Manhattan Engineering District to perform atomic energy research and development (R&D) activities. BMI performed nuclear materials research and development at privately-owned facilities in Columbus, Ohio and at the West Jefferson North (WJN) facility for the Manhattan Engineering District and its successor agencies – the U.S. Atomic Energy Commission (AEC), the U.S.

Energy Research and Development Agency (ERDA), and the U.S. Department of Energy (DOE). Research and development continued until 1988. [1, 2]

The WJN Site is bounded by the Big Darby Creek, a national scenic and state protected river on the east, and farm lands to the west, south, and north. Immediately east of the Big Darby Creek are a Girl Scout camp and several residential neighborhoods, all within ½ mile of the site. The CCP consists of the decontamination and decommissioning of an 11.7 acre site near West Jefferson, Ohio. Three radiological contaminated buildings ranging in size from 7,900 sq ft to 31,000 sq ft are located within the 11.7 acre site. Additionally, extensive sanitary sewer systems of 4,000 linear ft of contaminated underground piping and filter beds must be remediated. The filter beds are located in a designated wetland protection area and flood plain. The buildings previously contained a reactor, a plutonium test facility and radioactive analysis laboratory, three large hot cells, and 50 ft fuel pool basin contaminated with fuel residuals. Project tasks require the completion of decontamination and decommissioning activities initiated by the Site Owners under a cost sharing arrangement with the DOE. [1, 3]

Residual radioactive contamination remaining at the WJN facilities and connecting areas results from the research and development activities involving special nuclear material, source material, and by-product materials. Decontamination and decommissioning activities typically involved exposures to americium-241 (Am-241), curium-244 (Cm-244), cesium-134 and 137 (Cs-134 and -137), cobalt-60 (Co-60), europium-154 (Eu-154), plutonium 239 and 240 (Pu-239 and -240), strontium-90 (Sr-90), and a few other individual nuclides. Cs-137, Co-60, and Sr-90 are the prominent isotopes present.

Building JN-1 is the oldest and most contaminated building in the WJN site. BMI initiated operations within the building in 1955 and continued its use until 1988. Operational activities focused on nuclear research studies. Work included evaluations of both power and research reactor fuels; post-irradiation examination of fissile, control rod, source, and structural materials and components; and examination of irradiation surveillance capsules. In addition, the facility has been the site of radiation source encapsulation and physical and mechanical property studies of irradiated materials and structures [1, 2]

Constructed in 1955-56, Building JN-2 was a slab on grade, two story concrete building with brick facing. The building housed laboratories and a former vault in which plutonium and enriched uranium were once stored. Initially, the facility was used for reactor criticality experiments, experiment assembly, special nuclear material handling and vault storage, and plutonium research activities. These activities were performed within the large reinforced high bay and adjacent areas from 1957 through 1963, completing in 1970. Decommissioning of the vault and criticality laboratories was conducted during the 1970's. [1,4] Since 1970, a radioanalytical laboratory was operated in the facility providing health physics and environmental analytical services.

Constructed in 1955-56, Building JN-3 housed the first privately owned and licensed nuclear reactor facility of its type in the world. Over a period of 20 years, the reactor was used in irradiation and neutron activation studies for government and industry clients. The 2-megawatt Battelle Research Reactor (BRR) was designed to provide an intense source of neutrons and gamma rays for irradiation of various materials during experimentation. Reactor operations were ended in 1974 with the removal and shipment for reprocessing of the reactor fuel in the latter part of 1974. After the reactor fuel was shipped for reprocessing and reactor pool drained initial reactor decontamination and dismantling operation took place over a nine month period beginning in 1975, with final decontamination in 2001 and 2002. [1,4] During this latter period, diamond wire saw technology was used to remove 83 concrete blocks from the reactor wall with a total weight of 700 tons.

Connecting Areas of the site consist of a sanitary sewer system that supported ongoing operations for each of the three buildings. As such, lines associated with the sanitary sewer system exhibit residual contamination from past site operations. Additionally, the connecting areas include the subsurface and adjacent surface areas of the 11.7 acres site.

Decontamination activities at the WJN site were initiated in the mid-1980's. The DOE, as the successor to the AEC and the Government's earlier work, is the agreed party with predominant liability and responsibility for decontamination and decommissioning (D&D) of the BCO facilities. [1,2] The Assistant Secretary for Nuclear Energy of the DOE accepted the decontamination and decommissioning (D&D) of the WJN into the DOE's Surplus Facilities Management Program as a major project. [1,5] The DOE is the agency funding and managing the cleanup of the WJN. [1,6]

In November 2003, the DOE awarded the Columbus Closure Project (CCP) to ECC&E2 Closure Services, LLC (Closure Services). Closures Services contract with the DOE requires the safe removal of DOE radioactive material and contamination from the West Jefferson North (WJN) facility near West Jefferson, Ohio. Removal of the radioactive material is required to meet future use of the site without radiological restrictions. [1,7] Closure Services is planning, executing, and completing the following tasks to meet this goal:

- Remove all above and below ground facilities, trailers, equipment, drains, pipes and contaminated utilities within the contractor controlled areas and connecting areas as detailed in the Decommissioning Plan (DP) including amendments.
- Remove and dispose of all contaminated soil found within the affected and unaffected areas.
- Restore the site landscape to grade with all debris and extraneous material removed.
- Prepare, submit and obtain acceptance of the Final Certification Package by the DOE.

These tasks reflect the overall remediation plan for the WJN site. Closure Services is completing the remediation of the WJN Site in accordance with the Decommissioning Plan (DP) approved by the NRC Nuclear Materials License No. SNM-7, and its associated documents, revisions, amendments and milestones and the Radiation Protection Program implementing policies and procedures [1,2,7].

IMPLEMENTING RISK MANAGEMENT STRATEGIES FOR DECOMMISSIONING

In implementing the contract SOW and decontamination, dismantlement, and demolition objectives, Closure Services maintains a constant focus on risk management strategies. Risk management strategies focus on reducing, mitigating, minimizing, or eliminating the impact of project risks. Risk management strategies to eliminate, mitigate, or minimize risks include incorporating strong safety and As Low As Reasonably Achievable (ALARA) principles into an integrated work planning process. Technical and operational strategies may include utilizing predictive risk analysis tools to establish contamination limits for demolition and using remote handling equipment to reduce occupational and radiation exposures to workers. Closure Services has effectively utilized these management and technical tools to eliminate, mitigate, and reduce radiation exposures under contract to the DOE for the decontamination and decommissioning CCP.

Developing and implementing risk management strategies focuses on improving overall base project performance. Base project performance elements include safety, maintaining exposures ALARA, schedule, cost, and overall project efficiency. Closure Services integrated risk management strategies through implementing the Risk Management Plan (RMP) developed prior to and during the project cost and schedule baseline. Risk management strategies were also achieved through establishing and integrating annual and quarterly does reduction goals for the project period. Finally, detailed assessments were performed prior to the demolition of Building JN-1, JN-2, and JN-3 to ensure that planning was sufficient to protect the health and safety of the workers, the public, and the environment.

Developing and Implementing the Risk Management Plan

The RMP Closure Services approach to identifying and distinguishing future risk events and their associated programmatic impacts reflected the requirements of DOE O 413.3. [8] The RMP describes the scope and the process for identification, evaluation of impact, and management of risk events, applicable to the CCP decommissioning activities. The RMP provides the process for resolving risk events by reducing, minimizing, eliminating, or avoiding the impact to radiation exposure, safety, and project cost and schedule. In developing the RMP, integrated teams identified, inventoried, assessed, mitigated handled, and reported risk events that could potentially jeopardize tasks set within the projected cost and schedule. The RMP establishes management strategies specific to project schedule and cost that are classified as programmatic risk.

The RMP specifically addressed the Work Breakdown Structure (WBS) that provides the basis for the project control system components, including estimating, scheduling, budgeting, performing, managing, and reporting, as required under the Contract. Together, the WBS jointly represents the Project Baseline Summary (PBS) level.

The purpose of the RMP was to describe the risk management and planning process, techniques, and tools that Closure Services utilized to eliminate, avoid, or mitigate the unwanted impacts of risk events associated with the technical and programmatic D&D activities. The plan establishes the framework and defines the procedures for managing identified, inventoried, assessed, and analyzed risk events. As described in the plan, risk management and planning included the identification, analysis, mitigation, handling, tracking, reporting, and closure of risk events. Project personnel roles and responsibilities for risk management functions and prescribes reporting and tracking requirements for risk-related information were also detailed in the RMP.

Closure Services risk management and planning approach is concerned with identifying and evaluating risk events that were held to impact the safety and health of the worker, public, environment, project schedule, and cost-performance. The approach to risk management and planning initially identified, then assessed, and finally managed risk events. Project execution strategies focused on mitigating risk events during the course of the project and the contract. The RMP established and documented the risk planning process against which responsible managers planned, evaluated, and allocated resources for tasks incorporated into the WBS. Fig. 1 details the elements of the RMP that incorporate the strategies detailed in Section 14 of DOE O 413.3.

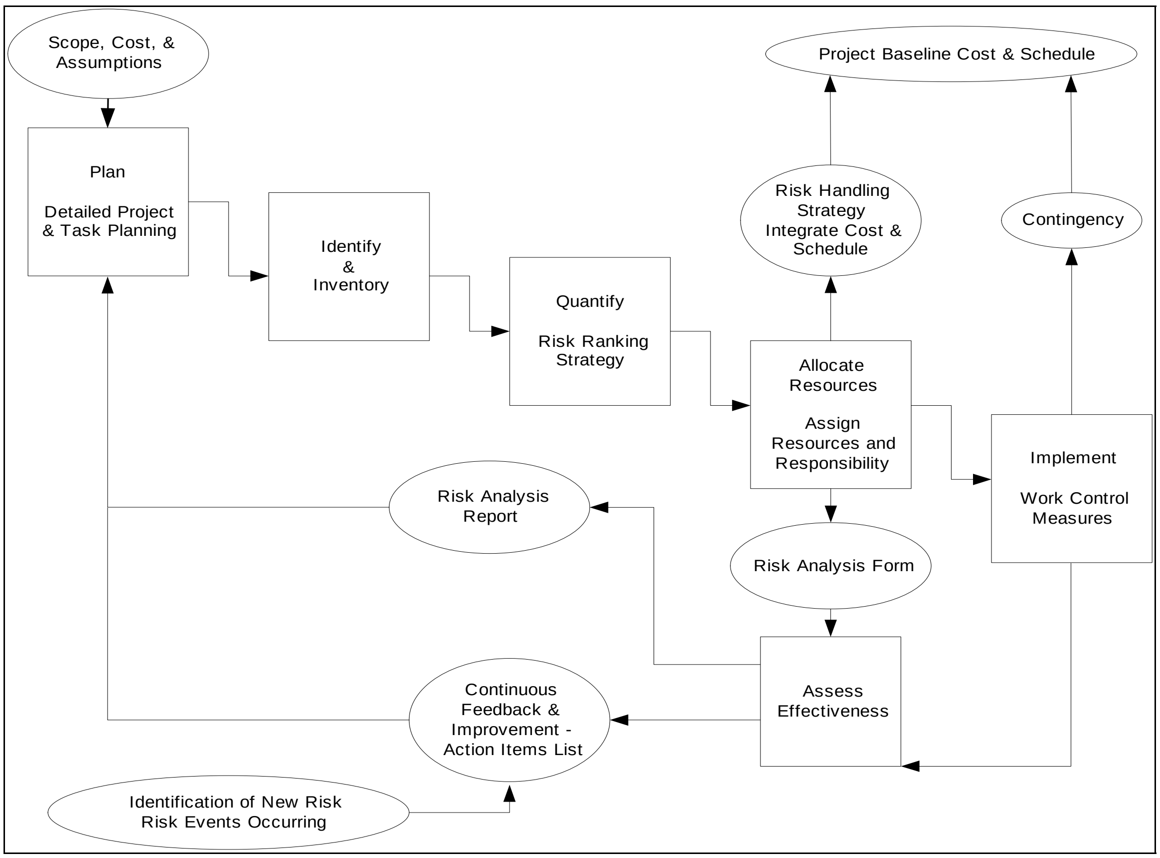

Fig. 1. Risk management planning flow diagram

These elements include:

- Planning tasks using a detailed process that reflects a compliance-based, graded approach task analysis
- Identifying and inventorying program, project, and task uncertainties (i.e., risk events) that impact safety, environment, and baseline cost and schedule performance.
- Quantifying the negative impact of risk events and ranking them according to other risk events, to aid project management in allocating limited resources
- Assessing the scope, cost and/or schedule impacts of uncertainties through analysis of probabilities of achieving project completion within baseline cost and schedule
- Allocating and assigning resources to responsible project team member

- Development of quantifiable cost and schedule contingencies to achieve predetermined probabilities of meeting project goals at or below baseline cost and schedule
- Implementing project and task control measure that eliminate, avoid, or mitigate impacts of the risk event
- Assessing effectiveness of risk management planning
- Providing continuous feedback to project team members

Closure Services' RMP implemented these primary activities throughout the project. Project teams consistently implemented the risk management strategies throughout the decommissioning activities at the CCP.

Primary risks and strategies discussed in this paper include dose reduction and control efforts for the decontamination and demolition of Buildings JN-1, JN-2, and JN-3. Risk management strategies involved using risk analysis tools to set limits for residual radioactive contamination prior to demolition.

Risk Managements Strategies for ALARA Planning

Closure Services developed and implemented risk management strategies for the decontamination and demolition of the three facilities. Pre-demolition planning included establishing residual contamination limits for decontamination activities, evaluating decontamination and demolition methods, and dust control processes. Assessment of the risks focused on evaluating the impact of the calculated radionuclide inventory through use of computer-based tools. Total inventories were also calculated and upper bounding limits set for decontamination tasks prior to demolition. Primary risks to the project related to minimizing the potential doses to the worker, the members of the general public, and the environment.

Building JN-1 Basis of Technical Assessment.

The technical assessment to evaluate the potential risk was performed primarily to ensure that the CCP air emissions monitoring program was protective of the quality of the air resources surrounding the facility. Section 112 of the Clean Air Act authorized the U. S. Environmental Protection Agency (EPA) to promulgate the National Emission Standards for Hazardous Air Pollutants (NESHAPs). The EPA has promulgated the standards applicable to the emissions of radionuclides in 40 CFR 61, NESHAP, Subpart H, National Emission Standards for Emissions of Radionuclides other than Radon from Department of Energy Facilities. [9] Additionally, the Ohio Department of Health – Bureau of Radiation Protection (ODH/BRP) and the U.S. Nuclear Regulatory Commission (NRC) to demonstrate that decommissioning activities are with the limitation of 10 CFR 20.1101(d) for calendar year 2004. The CAP88 Code (CAP88-PC) and appropriate inputs will be used to demonstrate compliance to 10 CFR 20.1101(d).

CAP88-PC uses a modified Gaussian plume equation to estimate the average dispersion of radionuclides released from up to six sources. The sources may be either elevated stacks, such as a smokestack, or uniform area sources, such as a pile of uranium mill tailings. Plume rise can be calculated assuming either a momentum or buoyancy-driven plume. Assessments utilize a circular grid of distances and directions with a radius of 80 kilometers (50 miles) around the facility. [9]

The program computes radionuclide concentrations in air, rates of deposition on ground surfaces, concentrations in food and intake rates to people from ingestion of food produced in the assessment area. Estimates of the radionuclide concentrations in produce, leafy vegetables, milk and meat consumed by humans are made by coupling the output of the atmospheric transport models with the U.S. Nuclear Regulatory Commission Regulatory Guide 1.109 terrestrial food chain models. [9]

Multiple site-specific parameters were utilized for assessing the risk of potential dose to identified receptors. As an example, site-specific population files were selected that reflected region-specific census information for a distance of 80 kilometers (km) from the site. Dose and risks are estimated by combining the inhalation and ingestion intake rates, air and ground surface concentrations with the dose and risk conversion factors used in CAP-88PC. The individual effective dose equivalent is calculated using an occupancy factor of 1 (i.e. 24-hours per day continuous occupancy) and weighting factors from ICRP Publication 26. Risks are based on lifetime risk from lifetime exposure, with a nominal value of 4E-4 cancers/rem. Doses and risks can be tabulated as a function of radionuclide, pathway, location and organ. CAP88-PC also tabulates the frequency distribution of risk, showing the number of people at various levels of risk. The risk levels are divided into orders of magnitude, from one in ten to one in a million. [9]

Additional site-specific parameters include:

- Surface area of Building JN-1 (i.e. Source at 3,530 m^2 surface area)
- Regional annual temperature and precipitation;
- Site-specific radioisotopic concentration of residual radioactive material in and/or on the surface of the remaining walls and floor (average values);
- Site-specific total airborne release rates (curies per year);
- Region-specific wind directional files for the Battelle facility at West Jefferson, OH (file available in CAP-88PC); and
- Distance to hypothetical critical receptor (site-specific population distribution around Building JN-1 for maximally exposed individuall); and
- Site-specific population file used to estimate the collective population dose using data from the 2000 census.

The regional annual temperature and precipitation were obtained from previous CAP-88PC data presented by BMI in the annual environmental report. The values for annual temperature and precipitation are:

- Regional average annual temperature of 12º Celsius;
- Regional annual precipitation of 94 centimeter; and
- Default mixing height of 940 meters.

The total inventory of potential radioactive material available during the demolition and loading of Building JN-1 was determined using historical and actual monitoring data. Existing monitoring data and historical information available for Building JN-1 indicated that contamination consists of fission and activation products. The radioactive substances which have been identified in Building JN-1 include americium-241 (Am-241), curium-244 (Cm-244), cesium-134 and 137 (Cs-134 and -137), cobalt-60 (Co-60), europium-154 (Eu-154), plutonium 239 and 240 (Pu-239 and -240), strontium-90 (Sr-90), and a few other individual nuclides. Cs-137, Co-60, and Sr-90 are the prominent isotopes present. [9]

Total inventory was estimated utilizing historical data and verification surveys performed by Health Physics Technicians. Areas of known or suspected residual contamination were investigated throughout the building. Fixed and loose contamination surveys were then performed and survey results were then converted to isotope specific quantities. Conversion of surface measurements was performed using predetermined isotopic ratios presented in the CCP document, DD-98-04, *Waste Characterization, Classification, and Shipping Support Technical Basis Document for Battelle Columbus Laboratories Decommissioning Project (BCLDP) West Jefferson North Facility*. DD-98-04 supports a percentage of Cs-137 is 34% of the entire isotopic mixture. [6] The Cs-137 total activity includes all material in loose and fixed condition, with fixed representing 40% of the overall contamination resulting from Cs-137. The total isotopic inventory can then be calculated by applying this percentage and a pre-determined isotopic ratio to the Cs-137 activity concentration.

Hypothetical release quantities of the total calculated inventory were than calculated using suppression and release fractions obtained following perusal of technical literature. Fig. 2 show the release estimate for Building JN-1 with decontamination of the High Energy Cell overhead, while incorporating dust suppression as an effluent control.

Technical literature reviewed included DOE-HDBK-3010-1994. The DOE reference provides a resuspension rate for a homogeneous bed of powder as 4E-5 per hour (hr^{-1}) [11] In all cases, the release fraction was calculated by multiplying the resuspension rate by the duration of the activity, i.e. the duration of demolition. For Building JN-1A, the demolition period was estimated to be 2 days and the resulting unitless release fraction would be 1.9E-3. For Building JN-1B, the demolition period was estimated to be 5 days and the resulting unitless release fraction would be 4.8E-3. For JN-1C, the demolition period was estimated to be 1 day and the resulting unitless release fraction would be 9.6E-4.

DOE-HDBK-3010-1994 further provides a resuspension rate for a homogeneous bed of powder buried under structural debris as 4E-6 hr^{-1}. [11] For Building JN-1A, the demolition period was estimated to be 2 days and the resulting unitless release fraction would be 1.9E-4. For Building JN-1B, the demolition period was estimated to be 5 days and the resulting unitless release fraction would be 4.8E-4. For Building JN-1C, the demolition period was estimated to be 1 day and the resulting unitless release fraction would be 9.6E-5.

A resuspension rate of 4E-5 hr^{-1} from DOE-HDBK-3010-1994 was selected to estimate the releases of radioactive material from the demolition of Building JN-1. The primary reasons for this choice was that it provided a conservative estimate of releases and it allowed incorporation of available data concerning duration of demolition into the analyses.

Demolition of Building JN-1 also involved loading debris into containers for transport offsite for disposal. This operation was determined to be similar to dropping overburden into trucks at coal mines. AP-42, Section 11.9, *Western Coal Mining*, provides an emission factor of 0.018 kg/Mg, or 1.8E-5 in terms of a resuspension faction. [12]

Table I. Release Estimate for JN-1 with HEC Overhead Decontamination Incorporating Dust Suppression as an Effluent Control

Radionuclide	JN-1A First Floor Release (Ci)	JN-1A Basement Release (Ci)	JN-1B First Floor Release (Ci)	JN-1C First Floor Release (Ci)
Cs-137	7.7E-06	1.1E-07	8.4E-06	1.5E-07
Sr-90	5.1E-06	7.0E-08	5.5E-06	9.5E-08
Co-60	2.4E-06	3.3E-08	2.6E-06	4.5E-08
Am-241	3.9E-07	5.3E-09	4.2E-07	7.3E-09
Pu-238	3.7E-07	5.2E-09	4.1E-07	7.0E-09
Cm-244	3.1E-07	4.3E-09	3.4E-07	5.9E-09
Pu-241	6.3E-06	8.7E-08	6.9E-06	1.2E-07
Pu-240	7.8E-08	1.1E-09	8.5E-08	1.5E-09
Pu-239	4.8E-08	6.6E-10	5.2E-08	9.0E-10
Eu-154	1.2E-07	1.6E-09	1.3E-07	2.2E-09
Cs-134	3.2E-08	4.4E-10	3.5E-08	6.0E-10
Am-243	2.9E-09	4.0E-11	3.2E-09	5.5E-11
Cm-243	2.0E-09	2.8E-11	2.2E-09	3.8E-11
Am-242m	7.7E-10	1.1E-11	8.4E-10	1.5E-11
Sb-125	3.5E-08	4.9E-10	3.9E-08	6.7E-10
Cd-113m	3.1E-09	4.3E-11	3.4E-09	5.9E-11
Pu-242	2.3E-10	3.2E-12	2.6E-10	4.4E-12
Tc-99	1.5E-09	2.0E-11	1.6E-09	2.7E-11
Sn-126	9.3E-11	1.3E-12	1.0E-10	1.8E-12
Cm-245	5.0E-11	6.8E-13	5.4E-11	9.3E-13
Eu-152	2.9E-10	4.0E-12	3.2E-10	5.5E-12
U-234	1.3E-10	1.8E-12	1.5E-10	2.5E-12
Np-237	3.5E-11	4.8E-13	3.8E-11	6.6E-13
Cm-246	1.7E-11	2.3E-13	1.9E-11	3.2E-13
Ni-63	7.0E-09	9.7E-11	7.6E-09	1.3E-10

Total inventories as presented in Fig. 2 were then input into the CAP88-PC for computer analysis.

The results of the CAP88-PC analysis indicated that for the closest receptor during the demolition, the effective dose equivalent ranged from 0.051 to 0.41 mrem/yr, with the larger radiation dose being for the case where areas of higher contaminated within Building JN-1 were not decontaminated prior to demolition. Although these individuals are not members of the public subject to the 40 CFR 61.92, the radiation doses were well below the 10 mrem/yr standard.

For the collective population surrounding Building JN-1, the radiation doses ranged from 0.0093 to 0.074 person-rem/yr. Again, where areas of higher contaminated within Building JN-1 were not decontaminated prior to demolition.

Operational Control Measure for Performing Decontamination and Demolition

Closure Services applied further risk management strategies to maintain exposures ALARA. Strategies included prior decontamination within the building to pre-determined contamination levels, adhering to a precision demolition process, and the planned tasks to control fugitive dust emissions.

Pre-demolition decontamination was performed within Building JN-1 prior to demolition. Decontamination was performed with the facility safety systems in tact and supplemental localized ventilation. Initially, decontamination and interior demolition was performed using the BROK Unit and a Bobcat Loader. Using the mechanized equipment allowed Decontamination Crews to increase physical distance from high radiation sources and decreased the total time required to performed interior demolition and decontamination. Decontamination Crews then utilized hand operated tools such as grinders and power washes to remove remaining per-determined upper contamination levels. Adhering to these methods enabled Closure Services to exceed ALARA goals for 2004 by more than 75% below the Administrative Limit.

The following sequence was implemented for the three-phased demolition of Building JN-1, starting in early 2005 and completing in June 2005. Demolition sequences involved the use of heavy equipment to perform the mechanical demolition of Building JN-1. Heavy equipment included the following:

- Track hoe mounted shear, supplemented by a concrete/masonry processor,
- Track-hoe-mounted grapple equipped with demolition/bucket attachment,
- Skid-steer loader equipped with demolition/grapple bucket attachment, and a Fork lift.

Vertical and horizontal structural supports for the building were identified prior to executing the demolition sequence. Track-hoe mounted shears were used to peel the building open by pulling off metal or brick siding, purlins, wind bracing, etc, exposing the support columns. Closure Services Demolition Crews then sheared the vertical support columns, pulling them away from the building. Pulling the columns away from the building lowered the roof to the ground. This same sequence was followed throughout the demolition.

Fugitive dust control measures were implemented at all times during the demolition of steel and concrete/masonry structures. Fugitive dust control measures relied on wetting of the materials. Perimeter air monitoring used during the demolition supported the protectiveness of the dust suppression measures.

Perimeter air monitoring performed during demolition indicated that no release of radioactive materials occurred. Further, worker breathing zone sampling showed airborne radioactivity levels to be at background during the demolition.

CONCLUSIONS

Developing and implementing effective risk management strategies prior to and during task execution is essential to eliminating, mitigating, and reducing risks to safety and overall project performance. Closure Services effectively utilized risk management strategies eliminate, mitigate, and reduce radiation exposures under contract to the DOE for the decontamination and decommissioning CCP. This was seen to be particularly effective by maintaining radiation exposures ALARA during pre-demolition activities of Building JN-1 and eliminating emissions during the demolition.

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