Strategies for Decommissioning the Fuel Storage and Reprocessing Complex at Chalk River Laboratories - 16183

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ABSTRACT

For over 60 years, Canadian Nuclear Laboratories (CNL), previously Atomic Energy of Canada Limited (AECL), has been a world leader in developing peaceful and innovative applications from nuclear technology. Resulting from these years of nuclear research there are legacy liabilities consisting of outdated and unused research facilities and buildings, a wide variety of buried and stored wastes, and affected lands. In 2006, the Government of Canada established the Nuclear Legacy Liabilities Program (NLLP) to safely and cost-effectively eliminate, to the extent practicable, the nuclear legacy liabilities.

The National Research Experimental (NRX) fuel rod storage and handling facility, as well as two dedicated fuel reprocessing facilities at the Chalk River Laboratories (CRL) known as the Building 200 (B200) Complex, are examples of these legacy liabilities. It is planned to remove these facilities as part of a logical progression of activities to reduce CNL's liabilities under the NLLP and to prepare the property for the physical redevelopment of the CRL site.

INTRODUCTION

The B200 Complex consists of three (3) interconnected facilities: NRX Fuel Rod Storage and Handling Facility; the Plutonium Recovery Laboratory; and the Uranium Recovery Laboratory and Water Deionization Plant. Figure 1 shows how these facilities are connected.

Fuel Rod Storage and Handling Facility

The Fuel Rod Storage and Handling facility (B204) was designed and constructed in the mid-1940s to provide for the storage and handling of fuel rods from the NRX reactor that began operation in 1947. The main purpose of the bays was used-fuel storage with the water providing cooling and shielding. Fuel rods were removed from the reactor and discharged into the bays where they were held for a cooling period. Fuel rods were then transferred through a transfer chute to dissolvers located in the fuel reprocessing facilities, where they were reprocessed for plutonium or uranium-233 recovery. As of today, all reactor fuel assemblies have been removed from the bays, water has been drained from some of the bays and a fire separation was created between the bays and the NRX building. The building is currently unoccupied and in Storage with Surveillance (SwS). A Detailed Decommissioning Plan (DDP) has been approved by the Canadian Nuclear Safety Commission (CNSC) to decommission the fuel storage bays.

Plutonium Recovery Laboratory

The Plutonium Recovery Laboratory (B220) was a reprocessing facility used to extract plutonium from irradiated uranium fuel rods. Fuel rods from the NRX were transferred through the Fuel Rod Storage and Handling water trench to the dissolution cells in this facility. The fuel was dissolved in tanks and the plutonium was extracted from the dissolved fuel solution using various chemical techniques involving organic solvents. In 1954, the building plant extraction process was shutdown; however, the rod dissolution capability was retained and used until 1964. During the 1980s, all operations in this facility ceased and a dismantling campaign was undertaken to remove most of the process equipment outside the shielded concrete vault, as well as the removal of the laboratories and building ventilation system. The facility has been maintained in SwS since then and a DDP has been approved by the CNSC for to begin decommissioning activities.

Uranium Recovery Laboratory

The Uranium Recovery Laboratory (B200) was first used to recover uranium-233 from thorium fuel. By the late 1950s, the program was discontinued and the plant became obsolete. In the 1960s, the equipment used for reprocessing was removed and modifications were made to the building to build offices and a part of the building was modified to house a water de-ionization system, which operated until 2004. The facility is currently in SwS and CNL has approval to begin decommissioning activities.

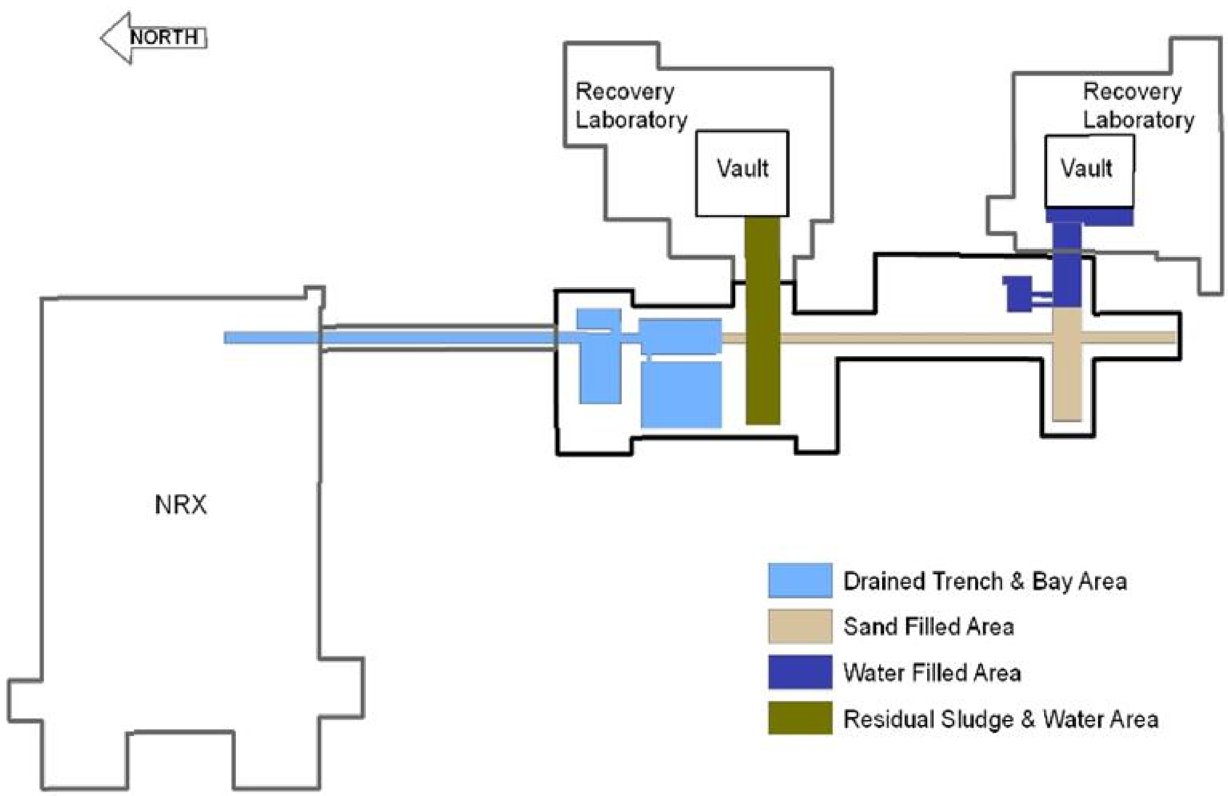

Fig. 1. The B200 Complex

DESCRIPTION - CURRENT FACILITY STATUS

The present status of the Building 200 Complex is as follows:

- All known fuel assemblies have been removed from the Building 204A Fuel Storage Bays; and
- The readily accessible areas of the Fuel Storage Bays are designated as a Radiological Safety Zone 3.

A Building Condition Assessment was completed in 2012 to evaluate the condition of the structures and the cost for maintaining it for the next 20 years. The general conclusion to this report stated:

- The wooden ceiling roofs and support joints are in fair to poor condition with degradation observed on the underside of the roof decks in several areas. The exterior transite shingles are aged and are in poor to fair condition overall.
- The cast-in-place concrete columns, beams and wood interior/exterior walls structure are in good condition and are functioning as intended.
- The concrete slab-on-grade and floor slabs have some minimal surface stress induced cracks in several locations but these do not represent a structural issue.
- The majority of the remaining steam and condensate piping, exhaust ductwork, service water and electrical in building B204 appears to be original to construction of the building in 1947 and in poor condition overall.
- The report concluded that the complex was in fair overall condition, but that replacement of certain building components, such as adding steel roofing and electrical heat, would be required to maintain configuration.

DISCUSSION

As part of decommissioning planning, a number of strategies were considered to achieve the desired final decommissioned end state for the project, which is the removal of the B200 Complex and structures and qualification of the site for re-use.

Prompt Decommissioning

The first option considered was removal of the facility, including buildings and structures without delay. This option was rejected at that time because a permanent disposal facility for the waste generated was not available. Although additional engineered storage facilities could be constructed at CRL to manage the waste, it was concluded that it was preferable to remove the facility and disposition the waste when a permanent disposal facility becomes available to avoid double handling of the waste associated with placing waste in storage at CRL Waste Management Area's prior to placement in a permanent disposal facility. The benefits of prompt decommissioning are reduced risk of worker exposure as well as reduced waste handling costs.

Deferred Decommissioning

The second option considered was to maintain the facility in an extended Storage with Surveillance period. The historic leak from the bays has been addressed and there is currently minimal impact on the environment. In addition, there was no present need for the space occupied by the facility. However, a recently performed structural assessment concluded that substantial repairs would be needed to maintain the Building structure during the SwS period and that several areas of the building structure were in poor condition.

Combination of Prompt Removal and Deferred Decommissioning

A combination of the two (2) options discussed above was selected as the preferred option. This option includes removal of the Fuel Storage and Handling Bays water and sludge and also removal of all internal systems, relocation of any systems that continue to be needed for other site facilities, removal of the building superstructure with a cover placed over the bays to isolate the contaminated concrete from the environment until a permanent disposal facility is available for contamination concrete. This option introduces several sub-decommissioning alternatives with respect to the bays and the building superstructure removal.

Alternatives Considered for Decommissioning the Bays

Based on a review of lessons learned during the draining of the water from one of the bays in B204 and the creation of the fire break between NRX and B204, CNL has developed four (4) options for reducing hazards during the decommissioning of the superstructure and preparing the bays and basement of the facilities for storage with surveillance.

- Do nothing;
- Add shielding to the tops of the bays as was done with the trench (the loading bay and the vertical storage bay);
- Decontaminate the entire building; and
- Add shielding to the bay bottom and decontaminate the remainder of the bay walls.

Do Nothing:

As experience has shown during shutdown activities if shielding is not considered, once the water is drained from the bays the dose rates in occupied areas would be beyond levels that would permit proceeding with decommissioning activities as planned. Thus, the do nothing alternative is not considered viable.

Add Shielding to the Tops of the Bays:

This option would add shielding to the tops of the loading bays and the vertical storage bays without performing any decontamination or dose reduction in the bays.

For B204 the benefits of this approach are:

- With the exception of debris removal, no clean-up of the bays is needed at this time which;
- Has the potential to save a significant amount of exposure to decommissioning workers; and
- Several of the areas are already shielded.

The negative aspects of this approach are:

- There is limited crane access to the bays thus in order to provide crane access large portions of the B204 superstructure will need to be removed;
- Large amounts of additional potentially contaminated material will be added to the building;
- Inventory which will require disposition in the final phase of decommissioning;
- Additional preparations will be required in order to place shielding, (e.g., removal of handrails, removal of equipment adjacent to the bay, providing additional structural support for the shield blocks). This work would be performed in high dose rate areas and would offset any dose savings from not cleaning the bays;
- Additional industrial safety issues due to work being performed near the edge of empty bays with handrails removed; and
- Introduces the potential for a large load drop into the bays which could compromise building structural integrity and could lead to the release of radiological contamination through the building.

Decontaminate:

This option involves the decontamination and dose reduction of the concrete surface of the bay and igloos such that dose rates around the bays and igloos would achieve Radiation Safety Zone 2 criteria.

The benefit of this approach is:

- No additional material will need to be added to the bays, with the exception of weather covers and fall prevention prior to superstructure removal.

The negative aspects of this approach are:

- Decommissioning workers would be exposed to high dose rates;
- A development program would be needed to specify the appropriate decontamination agents/methods;
- In order to achieve a residual dose rate suitable for long term storage, in some areas a considerable depth of concrete will likely need to be removed from the bay floors, which could lead to a loss of building integrity;
- Concrete was added to the bays during reconstruction, thus removal of the added concrete could expose previously contaminated concrete thus requiring

further removal and subject personnel to a very high dose rate from the previously covered contamination; and

- Weather covers and fall prevention will need to be installed prior to superstructure removal.

Add Shielding to the Bay Bottom and Decontaminate the Remainder of the Bay Walls:

For the current water filled bays, the plan would be to drain the bays to approximately 1 metre of water, remove the sludge and debris and inject grout underwater into the bay to provide shielding and to bind any sludge and debris that may still be present in the bay. This technique was used in the decommissioning of the P and R Reactors at the Savannah River National Laboratory in the United States. CNL is considering development of a similar process that is compatible with the conditions in Building B204 to reduce dose rates in the bays. Based on lessons learned approximately 0.3 to 0.6 meters of grout will provide a significant dose rate reduction.

For B204 the benefits of this approach are:

- Adding underwater grout to the bays will result in a lower whole body exposure than shielding the top of the bays. The water in the bay will provide shielding for the workers until grout is added, as well as, concrete can be added from a distance to minimize dose;
- Lower probability of shine through cracks/gaps of pre-cast shielding blocks shielding over top;
- Engineering and set-up cost will likely be lower as preparation for adding shielding to the tops of the bays will not be required;
- The amount of surface area requiring decontamination will be reduced and dose rates to decommissioning workers will be less than Option 3 - Decontaminate; and
- Flow of grout from the unshielded portion of the B204 bays into the shielded portion of the B204 bays will reduce the contribution of radiation emanating from these portions of the bays to whole body exposure rates.

The negative aspects of this approach are:

- Additional material, including grout, weather covers and fall prevention, will be added to the bays requiring disposition in the final phase of decommissioning; and
- A development program will be required to specify the appropriate grout.

Preferred Option

Three options were considered viable but Option 4 was selected as the preferred approach. The areas of the bays currently shielded will be left as is, as no further action is necessary to achieve the desired dose rates adjacent to these areas for the SwS period and the other areas will be grouted and decontaminated. This option will maintain superstructure integrity until the bays are decontaminated and will result in a lower personnel exposure than decontamination alone.

Building Superstructure Removal

The following Building Superstructure Removal alternatives were considered:

1. Building Demolition – Open Air
2. Building Demolition - Within Confinement Structure
3. Building Dismantlement

Building Superstructure Demolition Open Air:

The benefits of this approach are:

- A reduction in whole body exposure. General access areas are designated RSZ 3 and 2. Reduced building removal times and separation from sources of external radiation hazards will lessen exposure;
- Reduced potential for a conventional safety accident compared to a controlled dismantlement approach; and
- Building removal times would be reduced (faster schedule), thereby reducing project costs.

The negative aspects of this approach are:

- Airborne contamination - Given the history of facility, occurrences of leaks and spills, considerable contamination exists throughout B204. The contamination exists in both fixed and loose forms with activity embedded in the structure and behind surfaces. As a result additional controls will be required to reduce the potential for the dispersal of airborne contamination outside the decommissioning boundary.
- Building demolition may require the implementation of dust control measures.
- Larger work area required. There is a lack of available space around the B200 Complex. There is building located immediately east of B204 between B200 and B220 and there is an existing road on the west and limited land area to the north and south.
- Adverse effects on waste segregation. B204 waste will include asbestos containing material, wood, metal, etc., both radioactive and likely clean. Demolition will have adverse effects with waste segregation and potential loss of waste savings associated with controlled removal and processing waste. In addition, hazardous material would still need to be removed prior to building demolition to prevent the creation of mixed wastes. This would reduce any whole body exposure reduction gained from demolition.
- The cover over the bays would need to more robust due to the potential of falling building structure penetrating the cover and exposing the empty bays to the environment.

Building Superstructure Demolition - Within Confinement Structure:

The advantage of this approach is:

- A significant reduction of the potential or extent of adverse environmental affects.

The negative aspects of this approach are:

- Lack of space, the amount of land available for a confinement structure is limited;
- Increased cost for both the design (structure to withstand snow loads, tornadoes, etc.) and procurement of the confinement structure and waste associated with the eventual demolition of the structure;
- Adverse effects on waste segregation. Demolition will have adverse effects with waste segregation and potential loss of waste savings associated with controlled removal and processing waste. In addition, hazardous material would still need to be removed prior to building demolition to prevent the creation of mixed wastes. This would reduce any whole body exposure reduction gained from demolition;
- Additional decontamination effort would be required;
- Increased industrial safety hazard associated with confinement structure erection; and
- A confinement structure would also require additional assessments and fire protection measures (e.g., heat detection, fire suppression, etc.).

Building Superstructure Dismantlement:

The primary benefits of this approach in comparison with standard demolition are:

- Improved waste management practices through waste segregation and characterization;
- Reduction in dust emissions and noise levels associated with building removal. A reduction of dust emission will also result in a reduction of dust mitigation techniques such as misting, thereby lowering the potential for surface water run-off;
- A reduced potential for dispersal of dust and radioactive contamination outside the decommissioning boundary;
- Improved detection capabilities for radioactive contamination, in particular the ability to monitor previously non-accessible surfaces; and
- Improved control of material handling reducing the potential for dropping debris through the covers over the bays.

The negative aspects with this approach are:

- Greater potential for higher whole body and internal exposures of the workforce to radiological hazards;
- Increased potential for a conventional safety accident;
- Higher volume of secondary waste generated (i.e., PPEC) - Workers undertaking dismantling will require PPEC, typically either full tyvek suits or airline suits. PPEC will be stored as active waste;
- Deconstruction costs are higher due to the longer time period required to perform the work; and
- Additional engineering will be required to design a safe building removal plan (bracing, lifts, etc.).

Building Superstructure Removal Preferred Option

There has been no final decision yet for building superstructure removal but a combination of building demolition, building demolition within a confinement structure and building dismantlement will likely be utilized.

Characterization data will guide in the selection of the most appropriate action. Building demolition is a potentially acceptable approach once the removal of equipment, hazardous materials and loose contamination has been completed.

A survey and release criteria that are agreed with CNL's compliance organizations (Radiation Protection, Environmental Protection, Waste Management Operations, etc.) will be required to make a final decision. Where possible, the existing structure will be used as the confinement structure for demolition work. For example the existing structure can be used as a shell for the removal of interior finishes, building services, electrical equipment, wiring and conduit. Where confinement is needed, and the existing structure can not be used as a shell, a temporary confinement structure can be installed.

CONCLUSION

The current decommissioning strategy for the B200 Complex consists of the prompt removal of the building superstructure with the concrete left in place for an extended period and will be executed in three phases. In Phase 1, the complex will be partially decommissioned. Material (e.g., sludge, debris, etc.) and water within the fuel rod handling and storage bays will be removed, and grout will be added to shield the bays. The facilities will have temporary services installed (electrical power, ventilation, etc.) to support decommissioning activities. Process equipment, including tanks, and other components in all three facilities will be characterized, stabilized and removed where possible. Phase 1 will include the dismantling and removal of the building superstructures, including systems and services within the buildings leaving only the concrete foundations and structures in place. In Phase 2, the remaining infrastructure will be monitored, inspected and maintained until its final decommissioning. Phase 3 will be the final decommissioning of the facilities. This phase will include the removal of the concrete, capping of services and process lines to a distance of one metre from the building footprint, soil remediation and release of the land for industrial or site reuse that is consistent with its location in CRL's built-up radiological protected area.