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DECONTAMINATION AND DECOMMISSIONING OF THE FISSION PRODUCT

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DECONTAMINATION AND DECOMMISSIONING OF THE FISSION PRODUCT PILOT PLANT AT THE OAK RIDGE NATIONAL LABORATORY

by

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1. INTRODUCTION

The Fission Product Pilot Plant (FPPP) at the Oak Ridge National Laboratory (ORNL) was one of the first facilities used to extract radioactive isotopes from liquid radioactive wastes. During operations, the FPPP was extensively contaminated, resulting in high radiation levels even 30 years after the conclusion of operations. The facility has been abandoned for over 20 years and is now a candidate for decontamination and decommissioning (D&D). In fact, the ORNL management has begun activities toward the D&D of the FPPP. Two of these activities were completed in 1993 and 1994. The first activity was a facility characterization designed to assess the condition of the interior of the FPPP and to quantify, if possible, the amounts and identities of any radioactive contaminants and hazardous materials as defined by the U.S. Environmental Protection Agency. The facility characterization was intended to determine the condition of the interior, the complement of equipment left in the facility at the time of its closure, and the radiation environment that would be encountered during its D&D. The second activity was an alternatives assessment designed to determine the best approach to the D&D of the FPPP. The alternatives assessment examined five alternatives to decontaminate and decommission the FPPP and recommended the best alternative for its disposition. The first section of the paper describes the FPPP and its history. It includes the various conjectures on what exactly was done when the FPPP was entombed with the shield wall visible in today's pictures. The next section discusses the characterization that was performed concurrently with the alternatives evaluation. The next two sections detail the D&D plan for the complete dismantlement of the FPPP and its estimated cost and schedule.

2. SHORT HISTORY

The FPPP was initially constructed in 1948 and was modified throughout its operating lifetime. Originally, the FPPP contained only several tanks and associated equipment on a concrete pad. A concrete block shield wall was the only shielding. A canvas tent was later placed over the equipment.

In 1952, the block shield wall was replaced with a 45-cm poured concrete shield wall and a 30-cm ceiling. A control room was located on the east side of the structure and was moved to the southern end in 1952. The south cell was added in 1952, as was some more shielding.

Operations at the FPPP included extracting radioactive isotopes from waste liquids from off-site and ORNL activities. The radionuclides removed included ruthenium, strontium, cesium, cerium, and others. According to operators interviewed during previous studies, the radioactive material holdup in the equipment was such that whenever maintenance was required, the system was flushed for several weeks, resulting in the backfilling of the tanks and in purge liquid flowing out onto the floor and down the drain lines. At least one operator remembers that the control room had to be evacuated due to high radiation fields emanating from the drain below the concrete floor. The interior of the cells is extensively contaminated, and the equipment in the cells remains as it was on the last day of operations.

After the conclusion of its operating life, an additional 60–90 cm of concrete shielding was added to reduce the still high radiation field. Eventually, up to 150 cm of concrete was added for protection from the radiation. All current photographs, such as Figure 1, show only the exterior of the most recent shield wall addition. All of these modifications were done when record retention was limited, and the exact nature of the facility when it was entombed is currently unknown. All of the available pictures were taken in close proximity to the equipment, indicating that the equipment was not yet contaminated at the time of the pictures.

Since the facility characterization and the alternatives assessment were being performed concurrently, the development of the technical basis for the D&D of the facility had to use assumptions about the condition of the facility and its radiation fields. Up until the characterization drilled into the interior, there was no definitive answer to the question of activities prior to the final sealing of the building. It was conceivable that the interior was completely filled with concrete to minimize dose rates surrounding the building. It was also conceivable that all of the equipment had been removed. Consequently, the exact nature of the interior of the building was unknown until the characterization activities.

3. CHARACTERIZATION

A characterization study of the FPPP was completed in the spring of 1994. To gain access to the interior of the building, three holes were drilled into the concrete at the location of the two doors on the west side of the building. The instruments were mounted on telescoping rods which were inserted and controlled from the exterior. The instruments included radiation detectors and cameras, both still and video. In general, the interior of the facility looked in good condition and agreed, in almost all respects, with the photographs that were available from the 1950s. As expected, the radiation dose rates inside the building were quite high, ranging from approximately 4.5 $mSv \cdot h^{-1}$ (450 mR/hr) in the south cell to over 0.2 $Sv \cdot h^{-1}$ (20 R/hr) general area dose rates in the north cell. The major radionuclides found in the cells were ^{137}Cs and some ^{60}Co and ^{90}Sr. Since the facility has been shutdown since the 1960s, most of the short-lived radioisotopes have decayed away to trivial constituents in the overall dose rates.

During the characterization effort, a 45-minute videotape was produced as well as dozens of still photographs. In general, the still photographs agree quite well with the photographs obtained from the historical files at ORNL. Figure 2 shows the interior of the north cell when the equipment was installed in the 1950s. Figure 3 is the current photograph showing essentially the same location. Figure 4 is the interior of the south cell in the 1950s, and Figure 5 is a similar view from 1994. The conclusion to be drawn from this information is that the D&D Plan developed assuming the equipment is essentially the same as it was when the historical photographs were taken is valid.

4. D&D PLAN

The five alternatives examined for the alternatives assessment were: (1) continued surveillance, (2) free release, (3) entombment, (4) partial dismantlement, and (5) complete dismantlement. The first alternative is not D&D at all, but continued surveillance and maintenance as required to keep the facility in its current condition until D&D is eventually performed. This alternative is not acceptable if removing the facility in the near future is desired. The second alternative is to decontaminate the facility to such an extent that a future occupant can enter the facility without regard to its radioactive past. Given the history of the FPPP and the radiation levels historically documented and currently measured, decontamination of the FPPP to free release criteria would essentially remove the entire facility at great cost. In addition, the facility is not configured to be useful to a future occupant. Therefore, this alternative is also unacceptable. The third alternative is entombment. Entombment would essentially cover the FPPP with earth and concrete materials to preclude the release of radioactive materials for the foreseeable future. Unfortunately, the FPPP is located in the middle of ORNL and very near to other environmental remediation projects that would be adversely affected if the FPPP were entombed and covered with a mound of earthen materials. Therefore, like the first two, this alternative is not acceptable.

The fourth alternative, partial dismantlement, is potentially acceptable. This alternative would have the FPPP removed to the ground and the floor slab partly decontaminated, covered with a concrete cap and clean soil for radiation shielding purposes, and left for a later remediation project. This alternative, however, would be more expensive than the last alternative because the soils remediation project would have concrete and a higher radiation field in which to work. The last alternative, complete dismantlement, is recommended because it would remove all radioactive materials from ORNL and dispose of them in a radioactive waste facility. This alternative would leave no materials save the soil for the remaining remediation to be performed at the site.

The D&D of the FPPP would begin with drilling a hole in the roof over the south cell and installing a HEPA-filtered exhaust system to constantly draw a vacuum in the interior. This would keep activity from being released through unmonitored pathways. This system would also allow no exterior superstructure to be built to prevent the release of radionuclides since the facility would be dismantled from the inside out.

The next activity would be drilling access holes in the roof over the north and south cells, upon which remotely controlled robotic arms would be mounted. Each robotic arm assembly would contain three arms. The first arm would hold a video camera and light to allow the operators to view the work being performed. The second arm would be a lifting arm to hold the objects and to move them to the egress panel. The third arm would be installed with any of several tools that would cut or otherwise disassemble the equipment within the cells.

Access to the interior of the north and south cells would be by egress panels cut into the bottom portion of the doorway. A shielded tunnel would be constructed to provide for a completely shielded passage from the loading area for the disposal boxes located outside the FPPP. A track system would be installed to allow empty disposal boxes to be pushed into the interior and filled with contaminated equipment and materials. When the disposal boxes are filled, the box would be pulled outside the cell and closed, placed into a shielded shipping container, and removed to be disposed of in a licensed radioactive waste disposal facility at ORNL. Figure 6 illustrates the access of the disposal boxes from the cell to the unloading area.

The removal of equipment and materials from the cell would be entirely remotely controlled. The robotic arm would grab a piece of piping to be cut, and the third arm would cut the pipe at the two ends. The holding arm would place the pipe in the disposal box and return to the work area to grab another pipe or other item, whereupon the process would be repeated. Items too large to be placed into the disposal boxes intact would have to be crushed or cut apart to fit inside the box.

The entire interior of each cell would be stripped in an identical way. After the interior is empty, the concrete walls would be removed by diamond wire saw cutting. In this technique, holes are drilled at the extremes of the desired cut piece. A diamond studded wire cable is then routed through the holes, and the ends are connected to form a complete circle. The wire is drawn through the holes at a high speed and high tension, effecting a smooth cut through the concrete and any embedded materials such as rebar, pipe sleeves, conduit and all other construction materials. At the FPPP, the interior wall separating the north and south cells would be removed first, followed by the exterior walls. The roof is supported by the final exterior concrete block wall; therefore, the entire FPPP would be removed from the inside out. Once the original walls have been removed, the remaining walls could be removed using the same technique; but the radiation hazard of these concrete pieces would be such that the shielded transport tunnel would not be necessary for their removal and measurement of surface radioactive contamination. At this time the robotic arms would be dismantled and decontaminated for reuse at another project. The roof would be cut apart next to fit into the disposal boxes.

After the roof and walls are removed, the floor—which is still highly radioactive—would be segmented using remote controlled floor saws that would cut the floor into pieces suitable for placing into the disposal boxes. Finally, the underground pipes and drains would be dug out and placed into the disposal boxes.

Given the operational history of the facility, and known operations at nearby structures, the soil within which the drains and pipes are buried is known to be highly contaminated. Soil disturbed by the excavation would be disposed of in the boxes along with the pipes and drains. However, the remaining soil that is still highly contaminated would be left for a later remediation project.

At the end of the removal of the FPPP, the contaminated soil would be covered with an impermeable plastic layer to prevent rainwater intrusion, and a 30-cm layer of clean soil would be placed to act as shielding for the highly contaminated soil.

The quantities of waste generated in this D&D project are tabulated in Table 1. The volume of radioactive waste being disposed of totals 184 m^3. The volume of noncontaminated waste, generally from the shield building built in the 1960s, totals 25 m^3. The quantity of hazardous waste as defined by the U.S. Environmental Protection Agency is small, as is the quantity of waste that is both hazardous and radioactive.

Table 1 Waste Volumes Generated Waste Type	Volume (m^3)
Equipment in shielded boxes	7.1
Lead bricks in shielded boxes	0.9
Miscellaneous materials in boxes	2.9
Contaminated concrete waste	173.1
Contaminated waste volume	184
Noncontaminated concrete waste	25
Noncontaminated waste volume	25
Total waste volume	184.0

5. D&D SCHEDULE AND COST

The D&D Plan developed in the alternatives assessment not only developed the technical activities involved in the D&D, but also included an estimated schedule for completion of the work and an estimated cost of the D&D project. The engineering performed during the alternatives assessment was of a conceptual nature, and detailed engineering is still required to design the robotic arms and the shielded transport tunnel, and to complete the details on all of the demolition activities involved in the D&D of the FPPP. This engineering is estimated to take up to 6 months. All of the activities associated with procuring subcontractors to perform the actual work is estimated to take up to 10 months. Once the subcontractors are mobilized at the site and actual demolition work is started, the facility is estimated to be completely removed in 9 months. Figure 7 illustrates the schedule for this project.

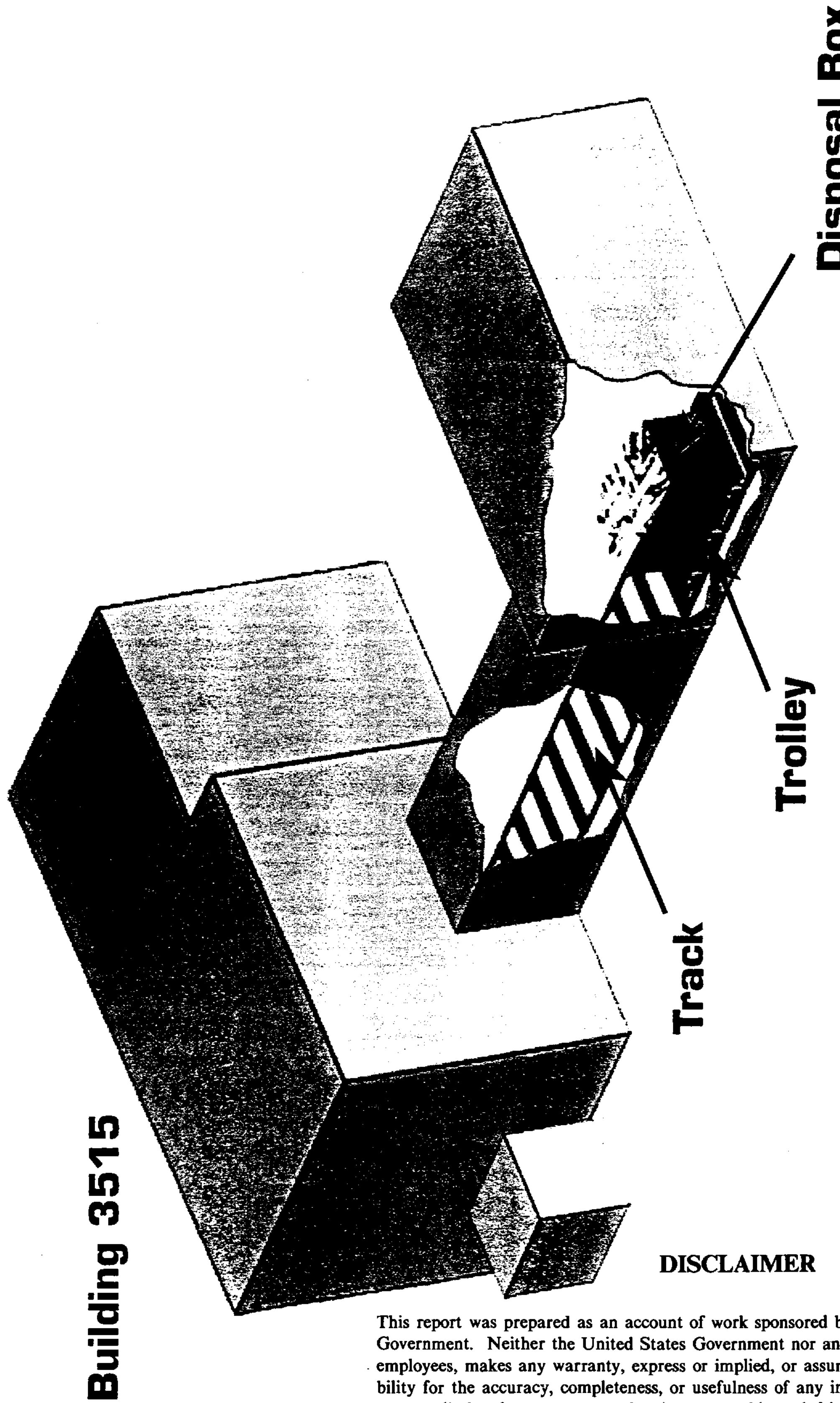
The cost estimate for the D&D of the FPPP was developed in concert with the technical basis of the demolition. The various costs associated with the D&D of the FPPP are shown in Table 2. The total cost for the D&D is estimated to be $3.73 million. Of this total, $0.66 million is in waste disposal costs, and $0.40 million is in engineering costs.

6. CONCLUSION

The FPPP at ORNL was one of the first facilities to extract radioactive isotopes from liquid radioactive wastes. During its operation, it was extensively contaminated, abandoned, and eventually entombed in a concrete shield wall and roof. This facility is now a candidate for D&D; thus, studies to support the performance of its D&D have been begun by ORNL management. A characterization study has been performed, as well as an alternatives assessment for the D&D of the FPPP.

The alternatives assessment looked at the existing characterization, the building's operating history, and radiation dose rates inside the building in order to develop a D&D plan that removes and disposes of the radioactive materials safely in a radioactive waste facility. To accomplish this task, the use of robotics is required to minimize the radiation exposure to workers. A scheme for the dismantlement of the FPPP and its disposal was developed and is described above. All of the activities described in this paper have been performed, so no development of new technology or operations is required.

The conclusions concerning this project are that the D&D of the FPPP does not require the use of untested technologies for the demolition and safe removal of the radioactive materials. Nor does it require special techniques that would make the project incredibly expensive and difficult; and that would result in significant exposures to radiation for the D&D workers. Currently available techniques can be used in a relatively short period of time to complete the project. Therefore, the project can be pursued in the next couple of years, assuming that funding is available for the D&D.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