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SPENT FUEL POOL CLEANUP AND STABILIZATION

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ABSTRACT

Each of the plutonium production reactors at Hanford had a large water-filled spent fuel pool to provide interim storage of irradiated fuel while awaiting shipment to the separation facilities. After cessation of reactor operations the fuel was removed from the pools and the water levels were drawn down to a 5- to 10-foot depth. The pools were maintained with the water to provide shielding and radiological control.

What appeared to be a straight forward project to process the water, remove the sediments from the basin, and stabilize the contamination on the floors and walls became a very complex and time consuming operation. The sediment characteristics varied from pool to pool, the ion exchange system required modification, areas of hard-pack sediments were discovered on the floors, special arrangements to handle and package high dose rate items for shipment were required, and contract problems ensued with the subcontractor.

The original schedule to complete the project from preliminary engineering to final stabilization of the pools was 15 months. The actual time required was about 25 months. The original cost estimate to perform the work was $2,651,000. The actual cost of the project was $5,120,000, which included $150,000 for payment of claims to the subcontractor.

This paper summarizes the experiences associated with the cleanup and radiological stabilization of the 100-B, -C, -D, and -DR spent fuel pools, and discusses a number of lessons learned items.

INTRODUCTION

There are eight fuel storage basins at retired production facilities in the 100 Areas at Hanford. Two of these basins were modified and are used for N-Reactor fuel storage (105-KE and 105-KW). Two other basins (105-F and 105-H) were stabilized by filling with soil following the reactors' shutdown. The remaining four basins (105-B, 105-C, 105-D, and 105-DR) contained contaminated water, sediment, materials, and equipment left in the basins at the time the reactors were shut down between 1964 and 1969.

As part of the safe storage responsibilities for the retired reactor areas, DOE-RL requested that UNC proceed with the project to clean up and stabilize the 105-B, -C, -D and -DR fuel storage basins. The project included the removal of the contaminated water, sediment, materials and equipment in order to reduce the potential for a loss of radiological control and to minimize surveillance and maintenance efforts for these facilities while waiting for final decommissioning. One of the objectives of this interim stabilization project was to leave the basins in a condition that would not affect the decommissioning options to be considered through the National Environmental Policy Act (NEPA) process for the final disposition of the shutdown reactors. The project work was originally planned in nine phases. The first phase, preliminary engineering and project planning, was completed in January 1984. The ninth phase is project closeout, which included a final project report.

The other seven phases were divided into the work tasks to be done by UNC and tasks to be performed by a subcontractor.

<u>UNC</u>

- Small material/equipment removal (Phase II),
- Concrete surface cleaning (Phase III),
- Large material/equipment removal (Phase IV), and
- High dose rate item removal (Phase V).

<u>Subcontractor</u>

- Sediment removal and disposal (Phase VI),
- Contaminated water processing (Phase VII), and
- Final concrete sealing (Phase VIII).

These seven phases were to be completed sequentially for the D, DR, B, and C basins. The sediment removal and disposal and processing of the contaminated water by the subcontractor for all four basins was to be completed by September 30, 1984.

The actual work did not follow the planned sequence. The concrete surface cleaning (Phase III) was left until the final concrete sealing (Phase VIII) with both phases performed by UNC.

DISCUSSION

General

The fuel storage basins are located in the 105-B, -C, -D, and -DR reactor buildings which are in the 100-B/C and 100-D/DR dual reactor areas. These areas are located along the south side of the Columbia River where it traverses the northern part of the Hanford Site in south-central Washington State. The reactor areas are located approximately 30 miles from the city of Richland (Figure 1).

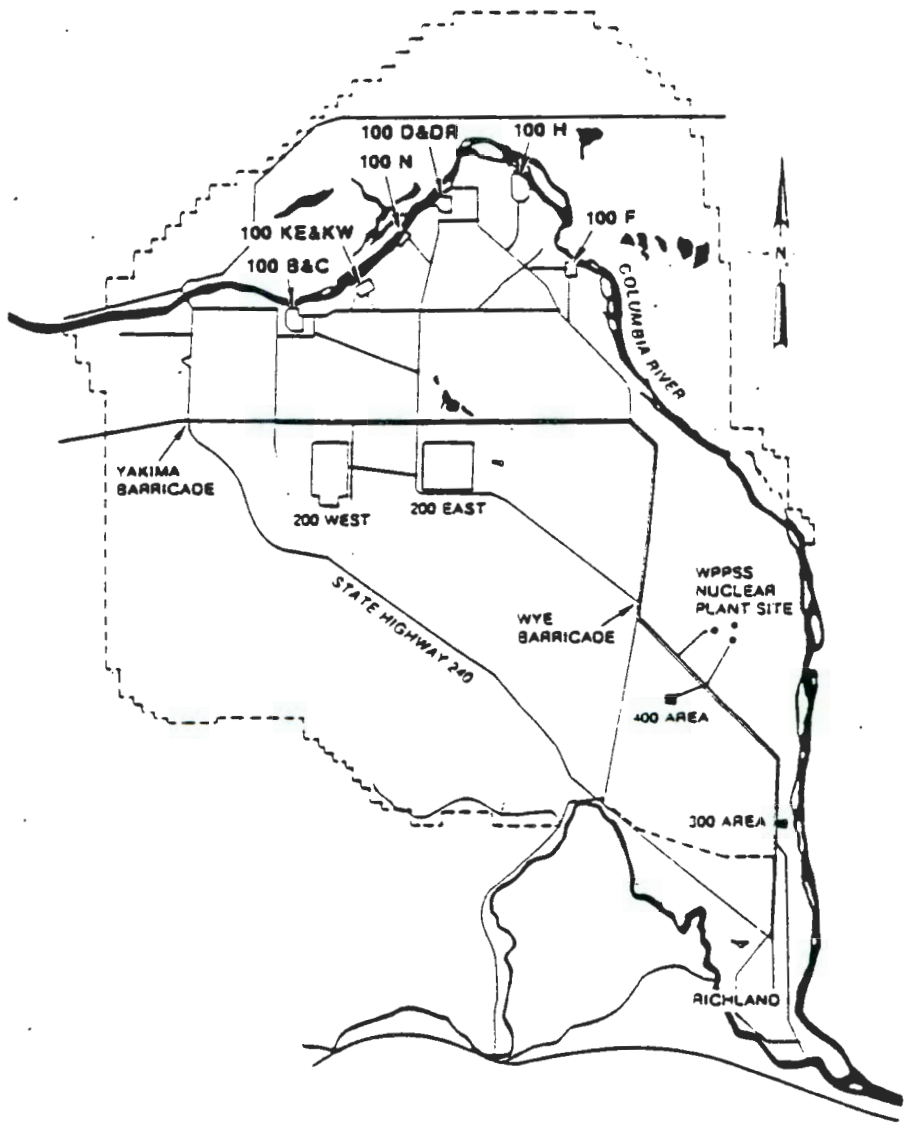

Figure 1. Hanford Site

The fuel storage basins are located at the rear of the reactors (Figure 2). The concrete basin area served as a collection, storage, and transfer facility for the irradiated fuel elements discharged from the reactor. The water in the basins served both as coolant and as shielding. Although the arrangement of the 105-C basin is slightly different, each reactor fuel storage basin consists of a discharge chute and fuel element pickup area, a storage area, a transfer area, and a wash pad area. The total floor area for these components averages between 7,000 and 10,000 ft^2.

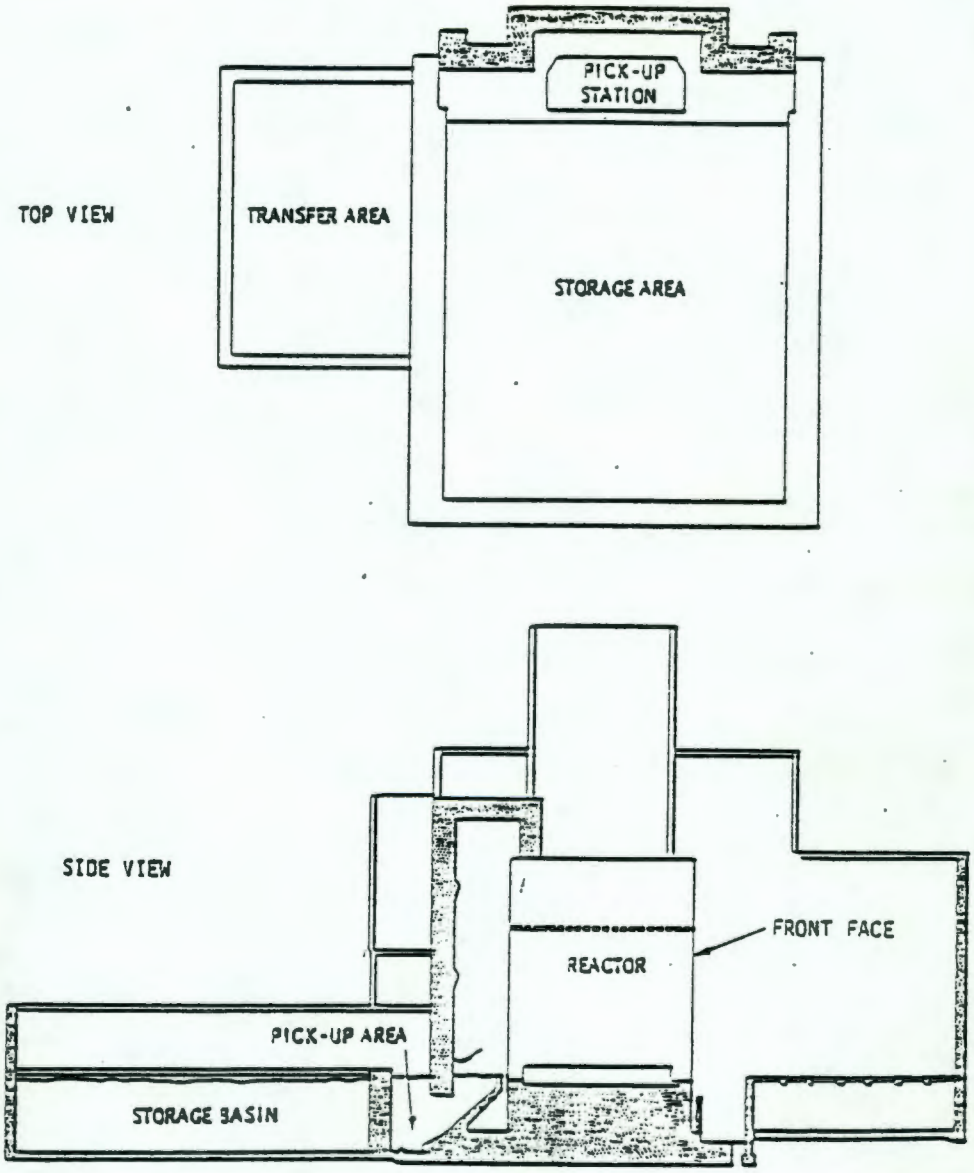

Figure 2. Layout of Fuel Storage Basin within Reactor Building

The transfer area pits which measure 6 ft-4 in. x 9 ft are located at one corner of the fuel storage basins and at the inner end of the fuel transfer areas. The transfer pits are 5 ft deeper than the basins and are connected to the basins by a canal and a monorail system (See Figure 3). Here the irradiated fuel was loaded into casks, then raised by an overhead crane and placed in special railroad cars for shipment to the chemical reprocessing facilities in the Hanford 200 Area.

At the time of the basin cleanup project each of the basins had from 4 ft to 10 ft depth of water for radiological control. A scum layer consisting of accumulated dust and algae covered the surface of the water. Each of the basins contained significant quantities of miscellaneous debris and hardware remaining from reactor operations. This miscellaneous material consisted mainly of contaminated piping pieces, thermocouple wires, fuel storage buckets, tongs, reactor process tubes, and fuel element spacers. Covering the floor of each basin was varying depths of sediment.

The sediment appeared to be primarily iron oxide and silt with a depth of less than one inch at 105-C and up to six to twelve inches at 105-D and 105-DR.

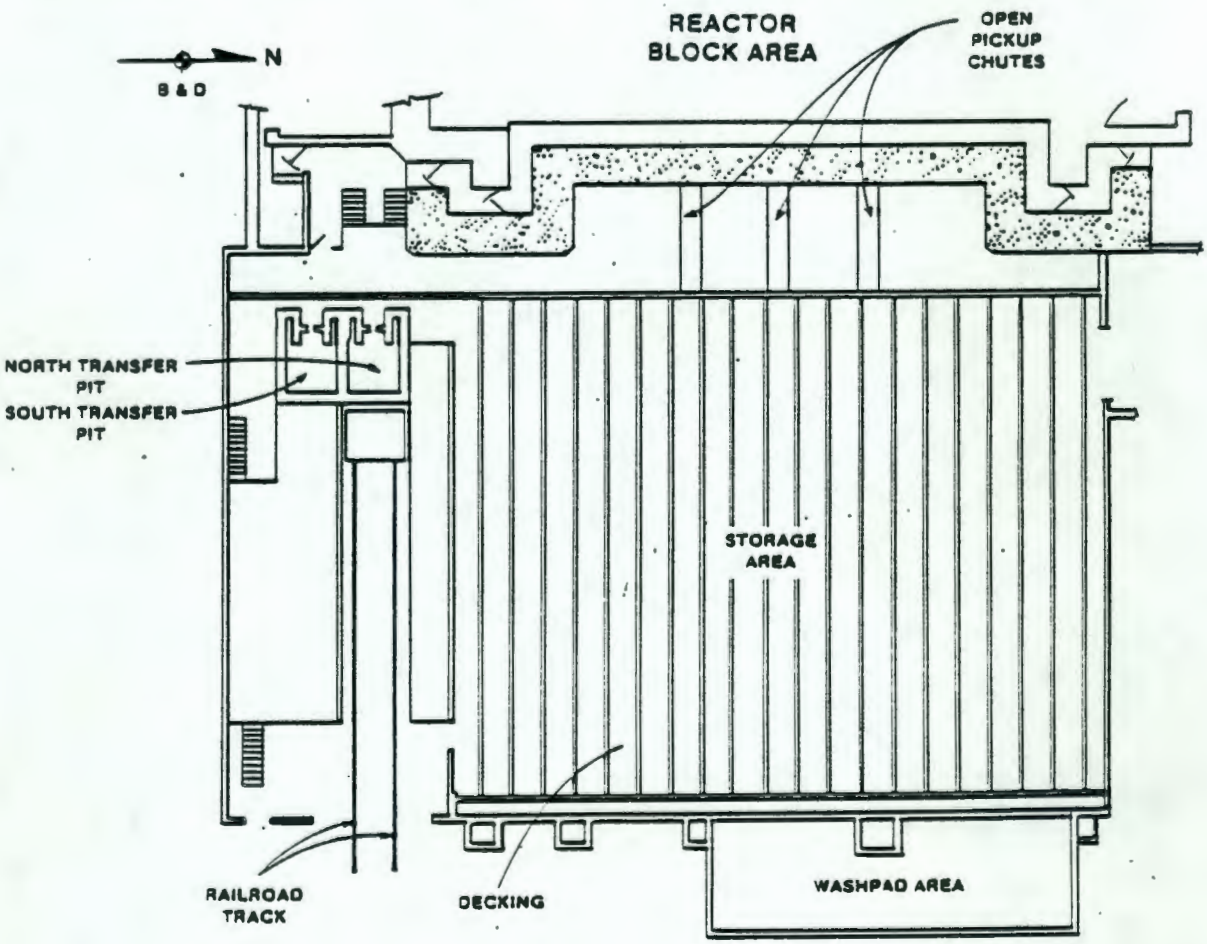

Figure 3. Typical Layout for Fuel Storage Basins

Radionuclide Inventory and Radiation Survey

Samples of the sediment and water were taken at each basin. Table 1 shows the concentration of each major radionuclide. The total mass of sediment at each basin was estimated at 50,000 kg. The average beta-gamma and plutonium-239/240 concentrations in the basin water were 2.2×10^{5} and 3.7×10^{1} p Ci/liter, respectively.

An underwater probe was used to measure the dose rates over the entire floor area of each basin. Dose rates ranged less than 100 mR/hr to hot spots of several R/hr at contact. The personnel working level above the basins was uniformly 1 mR/hr or less.

Project Plan and Objectives

The objective of the Fuel Storage Basin Cleanup and Stabilization Project was to remove the contaminated water and sediment from the 105-B, -C, -D, and -DR fuel storage basins and "fix" the remaining contamination in order to reduce the potential for a loss of radiological control and to minimize surveillance and maintenance of these facilities while waiting for final decommissioning disposition. The intent of this effort was to leave the basins in a condition that would not require any substantial subsequent decontamination to effect the final decommissioning mode.

The work would remove the water from each storage basin to preclude any possibility of leakage, and to stabilize the dry basins such that the potential for spread of contamination to the environment would be minimized. In order to do this the sediment and debris had to be removed from the basin floor. Further, the basin walls needed to be hosed down as the water level was lowered so that the additional sediment generated by the cleaning action could also be removed. When the water was completely drained, the basin walls were surveyed and when a potential existed for possible spread of contamination, the applicable areas were "stabilized" in a manner to minimize the possibility of losing contamination control.

The objectives for this project supported the overall Decommissioning Programs' main objective, which is to decommission all of the shut-down facilities in the 100 Areas of the Hanford site in the safest, most environmentally sound, and most cost-effective way possible.

Project Activities

Small Material/Equipment Removal. Small material/equipment removal began at 105-B basin in early 1984. Equipment and hardware that would fit into the fuel storage buckets and have a contact dose rate of less than 200 mR/hr were removed. The loaded buckets were placed into 10 mil plastic bags with industrial grade vermiculite as an absorbent and then placed into fiberboard boxes for disposal. Other small items with contact dose rates of greater than 200 mr/hr were removed and packaged in shielded containers for transport and disposal. Any items having high dose rate and having the dimensions of a fuel element were stored in small underwater shielded casks for later packaging and

TABLE 1

105 STORAGE BASIN SEDIMENT SAMPLES

		Concentration (pCi/g)									
Area	Location	Pu-238	Pu-239/240	Sr-90	H-3	Eu-155	Cs-137	Eu-154	Co-60	Eu-152	Ni-63
105B	Techview Pit	8.0×10^{2}	1.7×10^{4}	4.3×10^{4}	1.2×10^{2}	5.7×10^{4}	3.6×10^{5}	2.6×10^{5}	8.7×10^{5}	4.1×10^{3}	
105B	Dumay Ele. Chute	5.0×10^{1}	1.3×10^{4}	6.2×10^{5}	1.1×10^{2}	4.5×10^{4}	2.9×10^{5}	2.4×10^{5}	8.6×10^{5}	4.0×10^{4}	
105B	Pickup Chute	5.0×10^{3}	9.5×10^{4}	7.3×10^{5}	2.1×10^{3}	4.4×10^{4}	7.9×10^{5}	9.2×10^{4}	5.0×10^{5}	6.5×10^{4}	
105B	Transfer Area	1.9×10^{2}	4.0×10^{3}	2.2×10^{4}	6.1×10^{1}	1.8×10^{4}	1.1×10^{5}	1.6×10^{5}	9.5×10^{5}	7.8×10^{4}	1.2×10^{6}
Ave.		1.5×10^{3}	3.2×10^{4}	3.5×10^{5}	6.0×10^{2}	4.1×10^{4}	3.9×10^{5}	1.9×10^{5}	8.0×10^{5}	4.7×10^{4}	
105C	Dumay Ele. Chute	1.7×10^{3}	6.8×10^{4}	2.3×10^{4}	1.1×10^{2}	7.5×10^{4}	1.4×10^{5}	3.4×10^{5}	1.2×10^{6}	1.8×10^{5}	
105C	Techview Pit	7.9×10^{2}	3.3×10^{4}	1.8×10^{4}	2.0×10^{2}	2.1×10^{4}	2.5×10^{5}	1.0×10^{5}	6.4×10^{5}	4.8×10^{4}	
105C	Transfer Area	6.6×10^{2}	1.6×10^{4}	1.0×10^{4}	5.4×10^{1}	1.4×10^{5}	1.3×10^{5}	5.8×10^{5}	1.4×10^{6}	3.0×10^{5}	
105C	Pickup Chute	2.5×10^{2}	3.6×10^{3}	1.8×10^{4}	7.2×10^{1}	2.4×10^{4}	1.4×10^{5}	1.8×10^{5}	1.5×10^{6}	1.1×10^{4}	3.1×10^{5}
Ave.		8.5×10^{2}	3.0×10^{4}	1.7×10^{4}	1.1×10^{2}	6.5×10^{4}	1.6×10^{5}	3.0×10^{5}	1.2×10^{6}	1.4×10^{5}	
105D	Pickup Chute	9.0×10^{1}	2.1×10^{3}	4.6×10^{3}	3.1×10^{2}	1.4×10^{5}	5.4×10^{4}	3.7×10^{5}	1.0×10^{6}	2.8×10^{5}	
105D	Transfer Pit	1.8×10^{2}	1.1×10^{3}	2.2×10^{4}	3.6×10^{2}	5.1×10^{4}	6.3×10^{4}	2.6×10^{5}	1.0×10^{6}	1.9×10^{5}	
105D	Northwall	8.8×10^{1}	4.9×10^{2}	7.5×10^{3}	4.9×10^{2}	6.4×10^{4}	2.1×10^{4}	2.2×10^{5}	1.1×10^{6}	1.5×10^{4}	2.0×10^{5}
105D	Techview Pit	5.0×10^{1}	9.4×10^{2}	6.4×10^{3}	5.4×10^{2}	3.5×10^{4}	3.1×10^{4}	1.7×10^{4}	5.3×10^{5}	1.7×10^{5}	
Ave.		1.0×10^{2}	1.2×10^{3}	1.0×10^{4}	4.2×10^{2}	7.2×10^{4}	4.2×10^{4}	2.6×10^{5}	9.1×10^{5}	1.6×10^{5}	
105DR	Techview Pit	1.0×10^{2}	1.4×10^{3}	8.5×10^{3}	7.6×10^{2}	4.2×10^{4}	6.4×10^{4}	2.8×10^{5}	1.3×10^{6}	2.2×10^{5}	4.3×10^{5}
105DR	Wash Pad	3.6×10^{1}	7.1×10^{2}	3.1×10^{0}	4.5×10^{2}	1.3×10^{4}	5.0×10^{4}	6.7×10^{4}	4.8×10^{5}	3.6×10^{4}	
105DR	Pickup Chute.	1.0×10^{2}	3.0×10^{3}	6.3×10^{4}	3.2×10^{2}	2.3×10^{4}	3.1×10^{5}	1.3×10^{5}	6.4×10^{5}	5.5×10^{3}	
105DR	Transfer Area	5.3×10^{1}	1.1×10^{3}	1.8×10^{4}	2.0×10^{2}	3.3×10^{4}	5.3×10^{4}	2.2×10^{5}	9.9×10^{5}	5.3×10^{4}	
Ave.		7.2×10^{1}	1.6×10^{3}	2.2×10^{4}	4.3×10^{2}	2.8×10^{4}	1.2×10^{5}	1.7×10^{5}	8.5×10^{5}	7.9×10^{4}	

transport to 100-N Area for accurate identification. Remote handling techniques were used for removal of small items; consequently, personnel dose rates were usually less than 100 mrem/hr. The small material/equipment removal phase of the project proceeded as planned. Removal of all visible small items from 105-B basin was complete during the week of February 9, 1984, and completion of the other three basins shortly thereafter.

Large Material/Equipment Removal. Some special tooling was designed and fabricated to assist in the removal of large items. Large items were present in all the basins and ranged from pieces of large piping and structural steel to process tubing. The 105-C basin had the greatest quantity of large items mainly in the form of zirconium process tubing. The zirconium tubing required segmenting to piece sizes that would easily fit into shipping containers. Cutting of the longer pieces of tubing to lengths that would fit into the shipping containers was accomplished by use of a remote-controlled tubing cutter jig. Even though contact dose rates on some tubing sections were several R/hr, personnel dose rates averaged less than 100 mrem/hr during the packaging operation. Due to high dose rates, all zirconium tubing segments were packaged into special lead- or concrete-lined boxes (UNI-4476 containers).

When all visible hardware (small and large) was removed and packaged, the basin floors were raked to uncover any remaining items that may have been covered with sediment. A significant number of small items were removed as a result of the raking. The concrete walls and structures above the cover water in the basins were washed down with water to remove loose contamination.

Water and Sediment Removal. A subcontractor was obtained on a fixed-price contract to remove the water and sediments from the basins. The subcontractor began water and sediment removal at 105-D basin in July 1984. Subcontractor equipment consisted of a vacuum head to remove sediment, a filter press to remove sediments from the water, cation and anion exchange columns, final filters, holdup tanks to provide sample points before release of water, and associated piping and pumps to run the system.

The subcontractor processed about 620,000 gallons of water from the 105-D basin. Of this quantity, 120,000 gallons required reprocessing prior to discharge because the water would not meet the release levels[1]. The major difficulties experienced by the subcontractor during the liquid removal were related to plugging of the ion exchange columns, and failure of the filter press to remove particles. As a result of equipment problems, the holdup tanks became contaminated and required subsequent decontamination prior to resuming operations.

The subcontractor removed approximately 400 ft^2 of sediment from the 105-D storage basin. Two vacuum head designs were tried in unsuccessful attempts to collect the sediments on the filter press. Finally, the basin sediment was washed with a fire hose into the transfer pits and manually shoveled into 55-gal drums. The contact dose rate on the sediment in the pit was 1.5 R/hr. Personnel dose rates ranged from 200 to 350 mrem/hr while the sediments were shoveled into the drum.

During the washdown, it was discovered that what was thought to be the floor surface was actually compacted sediment. The compacted sediment ranged in thickness from less than an inch up to ten inches. During the removal of this compacted sediment, additional basin debris was uncovered which included two suspect fuel pieces. These suspect fuel pieces were shipped in shielded casks from 105-D to 105-C which served as a collection point until all suspect pieces could be transferred to 100-N for accurate identification.

The subcontractor completed removal of the water and sediment from 105-D basin after 90 working days at the end of September 1984 and began setting up at the 105-DR basin.

The subcontractor began processing water and sediment from the DR basin during October 1984. A bag filter had been added to their processing system at 105-D and was added at the pond discharge for 105-DR to protect against possibly contaminating the discharge pond. Approximately 70,000 gal had to be reprocessed from the holding tanks prior to discharge because the water failed to meet the release limits. The subcontractor again experienced problems with processing the basin water due to particulate material.

The subcontractor removed approximately 400 ft^3 of sediment from the DR storage basin. A new vacuum head design was tried in an unsuccessful attempt to collect the sediment on the filter press. As at 105-D basin, the sediment was finally removed by washing it into the transfer pits with a fire hose and manually shoveling it into 55-gal drums. Dose rates were similar to those experienced at the 105-D basin.

Fewer total items were found in the DR sediment, but of these items three were identified as suspect fuel elements. The suspect fuel elements were transferred to 105-C for examination, and were eventually sent to 100-N.

The subcontractor completed removal of the water and sediment from 105-DR basin after 30 working days at the beginning of November 1984 and began setting up at 105-B basin. An additional filter was added upstream of the ion exchange columns to prevent plugging of the columns by particulates.

The subcontractor processed approximately 100,000 gal of 105-B basin water, of which 60,000 gal were discharged following once-through processing to the 105-B discharge pond and approximately 40,000 gallons had to be reprocessed prior to discharge because the water failed to meet the release limits. Processing problems were traced to contamination by particulate material in the holdup tanks. As a result, basin cleanup work was again delayed while the tanks were decontaminated.

As the water was lowered to the 6-in. level, increased dose rates were encountered around the pickup chute. Attempts by the subcontractor to remove sediment from this area resulted in increased dose rates to personnel from the lowered water level and from particulates accumulated in the process equipment. As a result, UNC directed the subcontractor to raise the water level for shielding, to suspend operations at 105-B, and to mobilize his equipment to the 105-C fuel storage basin. The subcontractor had worked 30 days in 105-B. The final cleanout of the 105-B basin was completed later by UNC forces.

Water and sediment processing from the 105-C basin began in December 1984. When the cover water was processed down to about the 1-ft level, the dose rate above the water and at the work areas began increasing significantly. Work was then suspended at the direction of UNC after 15 working days.

The agreement with the subcontractor was renegotiated to allow completion of the subcontract with the current status of the basins. UNC purchased the subcontractor's processing equipment by exercising the options provided in the original contract. The subcontractor left the facilities in April 1985 and UNC resumed operations at the 105-C basin in May 1985.

Prior to resuming operations, the process equipment utilized by the subcontractor was evaluated and several modifications were made to both the equipment and operating procedures. The following is a brief summary outlining these changes.

1. The major cleanup problem was the inability of the subcontractor's equipment to process the particulates and water simultaneously. The particulate material caused low flow rates through the system due to plugging and process water contamination. To eliminate these problems, the following design and procedural modifications were made by UNC:

   A. Particulate bursts from the filter press were eliminated by recirculating the water through a 1300-gal mix tank during interruptions in system flow, which eliminated pressure and flow transients across the filter press. In addition, the filter press was precoated with diatomaceous earth and water clarity was checked prior to commencing operations.

   B. Two "CUNO" filter units were placed between the filter press and ion exchange columns to protect the inlet screens from becoming plugged with particulate material. The plugged screens were replaced with clean screens to ensure good system flow rates.

   C. An ion exchange column containing IRA-938 Anion Resin was included in the system to remove any colloidal material from the process water.

   D. A bag filter was placed downstream of the ion exchange columns to capture possible resin fines.

   E. Two 20,000-gal holdup tanks were thoroughly decontaminated prior to commencing operations. In addition, the tanks were coated with ALARA Coat to ensure that any residual contamination remained fixed.

2. Only three ion exchange columns were utilized: two 25-ft^3, sodium-form, cation exchange resin columns and one IRA-938 anion exchange resin column.

3. A new vacuum head was designed by UNC. A bronze, swimming pool-type, vacuum head was utilized. In order to maintain the sludge in suspension, several high pressure water nozzles were added to the head (Figure 4).

4. A new diaphragm pump was ordered. The 2-in. flap valve design could pump material as large as 1-3/4 in. in diameter.

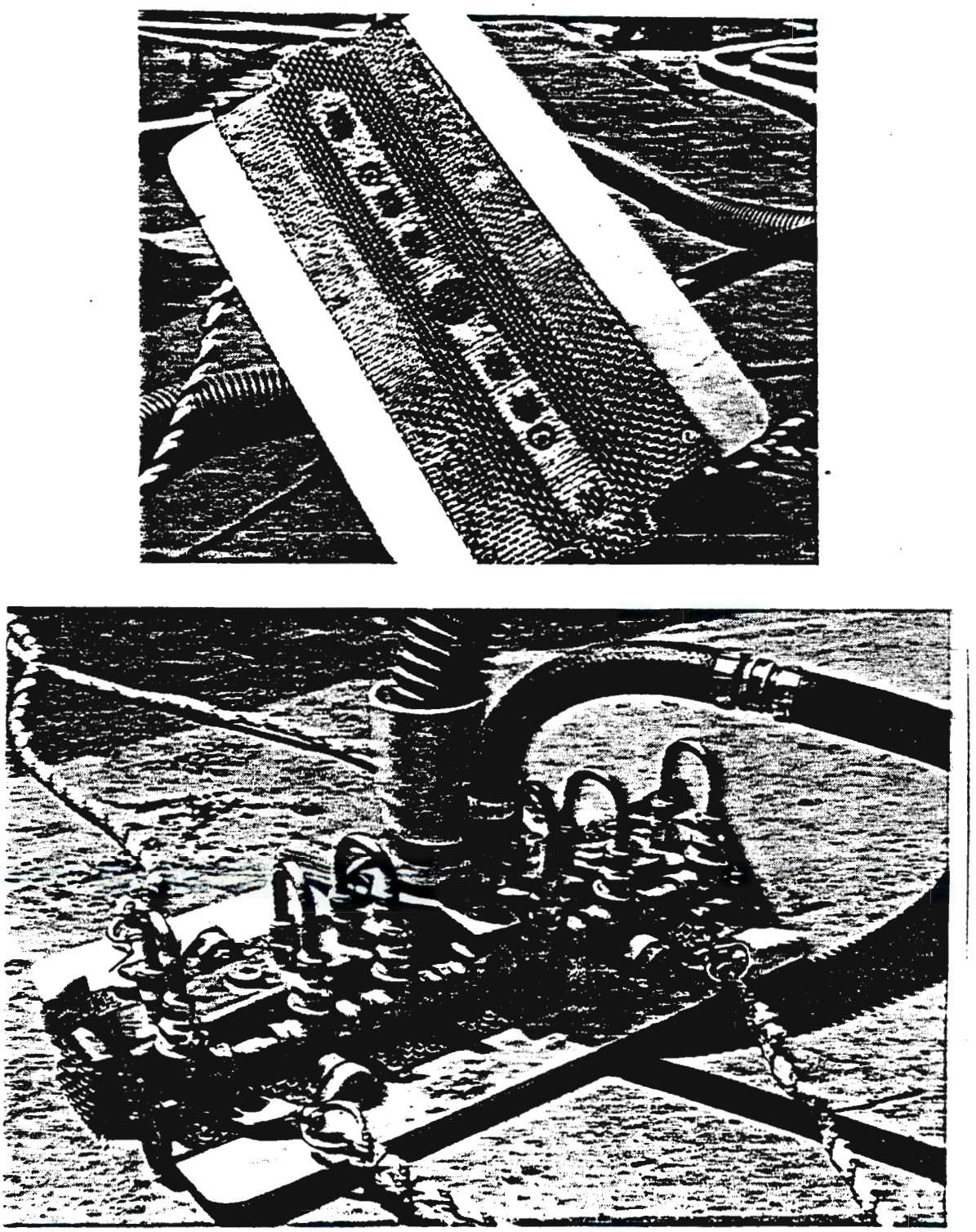

Figure 4. The Vacuum Head as Modified for Use in the Fuel Storage Basin

After considering personnel radiation exposure and waste packaging requirements, a decision was made to move the sediments to the transfer pits for interim storage. Following cleanup of the transfer pits to ensure that no fuel elements remained prior to sediment storage in the transfer pits, dams were fabricated for the transfer pit areas at the basins to add depth and prevent solid items from entering the pits. Portable dams were devised to help direct the sediment to the pits and to provide sufficient settling time for the sediment. See Figure 5 for the conceptual drawing of the sediment transfer. In addition, dewatering manifolds consisting of a matrix of CUNO filters (Figure 5) were placed at the bottom of the transfer pits along with 18 in. of sand and gravel to dewater the sediment after transfer was complete.

UNC processed approximately 80,000-gal of water from C basin and discharged it to the 105-C discharge pond. All water processed was well within the release limits.

UNC moved approximately 600 ft^3 of sediment to the C basin transfer pits. Approximately 50% of the sediment was transferred utilizing the vacuum head described above. Because of the large amounts of debris (plastic sheeting, paper, clothing, etc.) present in the sediment, it was necessary to transfer the remaining material using fire hoses. It had proved too difficult to manipulate the vacuum head through the debris. The water was supplied to the fire hoses by recirculating water out of the transfer pits, through the filter press, and back to the basin. As a result, approximately 30 ft^3 of sediment were removed by the filter press and subsequently packaged for disposal as low-level waste based on sediment sample analysis. Final sediment transfer was performed manually using shovels. Screens were devised to make sure that no fuel fragments or other debris were accidentally allowed into the pits.

While fuel elements (real or suspect) were stored at the 105-C basin facility it was necessary to provide additional security measures to protect the material.

A full-time security patrolman was assigned to the basin area. The security procedure called for a patrolman to check the building and to all entrances to the storage basin area.

UNC completed the sediment transfer and water removal from the 105-C basin in August 1985. Containment covers fabricated to place over the sediment in the pits were put in place August 16.

UNC resumed water processing at 105-B basin in September 1985 with the improved system developed at 105-C basin. Approximately 650,000 gal of water were processed to release limits and discharged to the 105-B discharge pond. UNC's experience at the 105-C basin with the equipment and the situation led to two major decisions about handling the sediment at the 105-B basin: 1) Because of personnel exposure and waste packaging requirements, a decision was made to move the sediments into the transfer pits for interim storage; 2) Because of the operational difficulties experienced with the vacuum head at the C basin, the decision was made to utilize the washdown approach for transferring the sediments into the transfer pits except for high dose-rate areas, where the vacuum system was required to reduce dose rates prior to washdown. The vacuum system removed enough sediment from the high dose-rate areas so that the use of the dams that had been built as a contingency to maintain water levels for shielding were not required.

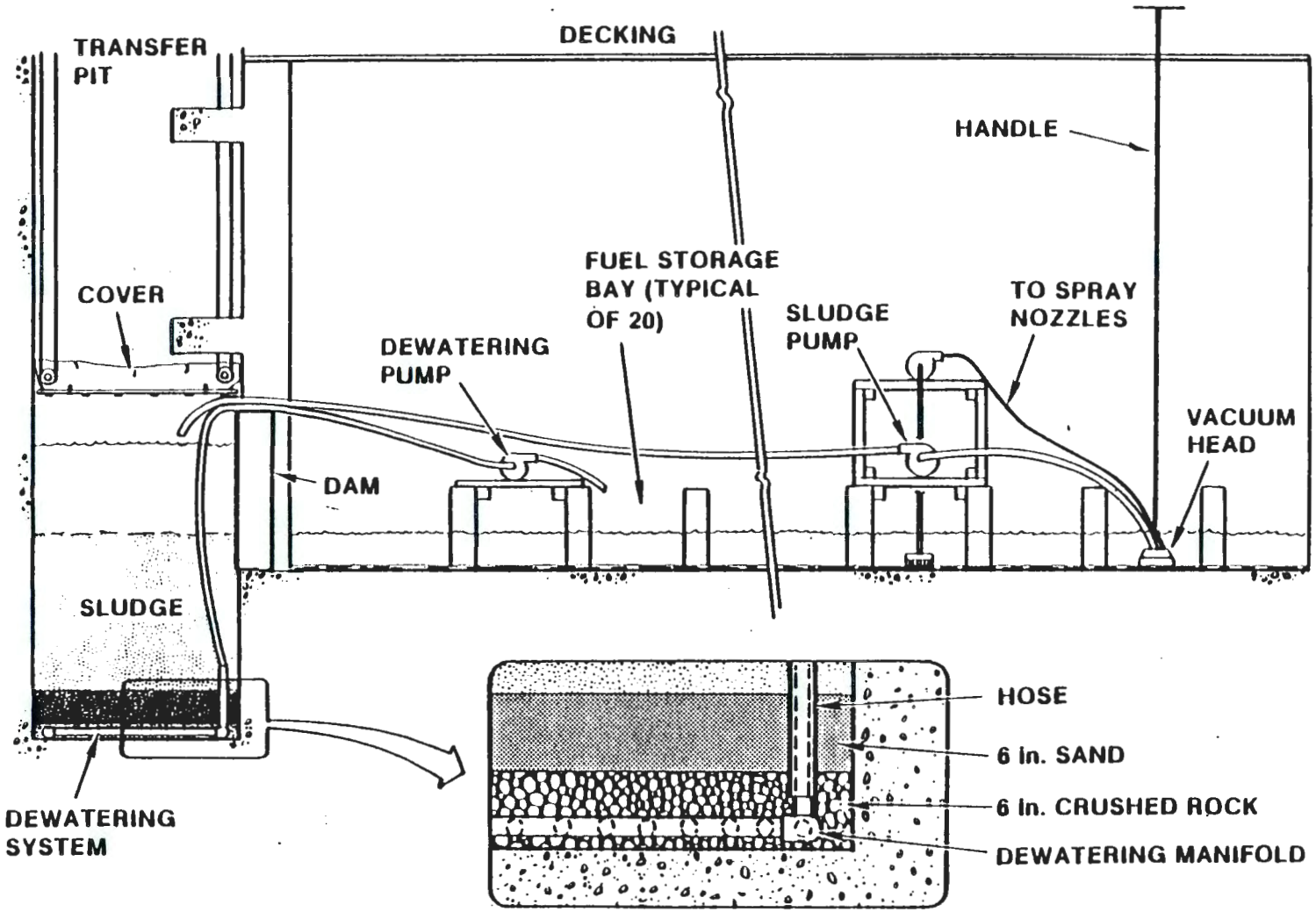

Figure 5. Transfer Pit Containment Design

Approximately 600 ft^3 of sediment was moved to the transfer pits. Approximately 30 ft^3 of sediment was removed from the filter press after the recirculation of washdown water from the transfer pits.

UNC completed removal of the water and transfer of the sediment in the 105-B storage basin in December 1985. Containment covers were placed over the sediment in the pits January 20, 1986. Figure 6 shows a cover in place. Final dose rates over the sediment were 15 mR/hr at the deck level at each pit except the south pit at 105-C, where the rate was 5 mR/hr. Dose rates on contact (the cover was not shielded) were 1 R/hr at both 105-B pits and 1.5 R/hr (south pit) and 350 mR/hr (north pit) at 105-C.

A total of 14 suspect fuel elements were found during the 105-B basin cleanout. These elements were ultimately transferred to 100-N for final examination and identification.

Figure 6. 105-C Transfer Pit after Installation of Cover

While the final cleanout of the 105-B and 105-C basins was still underway, preparation for the final fixing of contamination on the concrete walls and floors of the basins was initiated. Several sealers were tested and an asphalt emulsion (ATCO 1840) was selected as the stabilizing material.

Due to the deterioration of the concrete in many areas, the walls were swept and vacuumed to remove dust and loose pieces. To control airborne contamination during this task, the basin deck was covered with plastic and two HEPA ventilation units were installed. Before the asphalt was applied, concrete samples were taken for final characterization[2]. The average working dose rate before and after fixing the contamination was less than 5 mrem/hr.

The ATCO 1840 was rolled on and stabilization of the 105-D basin was completed on September 3, 1985. Similarly, stabilization was completed at the 105-DR basin on September 23, 1985.

Sweeping of the 105-C basin was completed on October 17, 1985. A new Graco Bulldog airless sprayer was used to apply the ATCO 1840. The use of the sprayer reduced the time required to coat the basin from 14 days to 4 days. Similarly, sweeping and coating of the 105-B basin was completed on January 24, 1986.

The present condition of the four fuel storage basins is considered to be sufficiently stable to require minimal surveillance and maintenance until final disposition. The final disposition of the basin facilities will be determined by the NEPA process currently underway for decommissioning the surplus Hanford production reactors.

Over the course of the project, there was one lost workday accident, ten minor first aid injuries, and eleven skin contamination cases. Five of those individuals received skin contamination when a hose clogged, became disengaged, and sprayed the workers. They were all successfully decontaminated. One Radiation Occurrence Investigation was held. During packaging of radioactive waste, radiation dose rates exceeded those permitted by the Radiation Work Permit. One individual received 160 mrem which could have been avoided if proper work methods had been followed. Disciplinary action was taken against a Supervisor and a Manager as part of the corrective action. A total of 41 man-rem of exposure was used over the course of the project.

Of the final inventory of suspect or identified fuel elements, 45 pieces were identified as fuel, 55 pieces were identified as non-fuel (spacers, test material holders), and 33 pieces required further testing.

Waste Management. A total of 24,300 ft^3 of solid wastes were removed from the basins and packaged and transported to the Hanford 200 Area low level waste burial facility. The total volume of liquids that were treated and released to the environment was about 1,210,000 gallons.

Lessons Learned. The complexity and duration of the basin cleanout project provided several areas where the original approach to the task did not provide the most efficient or cost-effective solution. As the project progressed, there were a number of design and operation changes that were made to the equipment systems and a number of evaluations and decisions made that can benefit future decommissioning projects. Of special note are the following items:

- The division of project tasks between UNC and the subcontractor caused some delays in the project schedule when high-dose-rate items were found in the hard packed sediment.
- A Project Engineer with the necessary responsibility and authority must be assigned to major projects; this in lieu of an engineer assigned only as a technical advisor.
- Major projects where the exact complexity of the work is not entirely understood require detailed up front planning and engineering rather than attempting to "fast track" the project.
- Subcontractor equipment design should be reviewed in depth to provide assurance that the design is adequate for the work.
- A realistic assessment of the complexity and magnitude of a project must be made before commitments to milestones, schedules, and costs are made.
- Adequate contingency must be included in decommissioning project cost and schedule estimates to allow for the unexpected.

REFERENCES

1. Table II of Department of Energy Order 5480.1 Change 2, "Environmental Protection, Safety, and Health Protection Program for DOE Operations", Washington, D.C. April 29, 1981.

2. Miller, R. L. and J. M. Steffes, "Radionuclide Inventory and Source Terms for the Surplus Production Reactors at Hanford", UNI-3714, June 1986 (Rev 1, April 1987).