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Removal Action Report on the Building 3001 Canal at Oak Ridge National Laboratory, Oak Ridge, Tennessee

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Removal Action Report on the Building 3001 Canal at Oak Ridge National Laboratory, Oak Ridge, Tennessee

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Environmental Management Activities at
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37831
managed by
LOCKHEED MARTIN ENERGY SYSTEMS, INC.
for the
U.S. DEPARTMENT OF ENERGY
under contract DE-AC05-84OR21400

DISCLAIMER

PREFACE

This *Removal Action Report on the Building 3001 Canal at Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE/OR/01-1599&D1) was prepared in accordance with requirements under the Comprehensive Environmental Response, Compensation, and Liability Act to document removal action activities for the Bldg. 3001 Canal. Background information and recommendation of the selected alternative were presented in the *Engineering Evaluation/Cost Analysis for Building 3001 Canal, Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE/OR/02-1502&D2).

This work was performed under Work Breakdown Structure 6.1.14.01.04.50.05. (Activity Data Sheet 3300W, "The Regulatory Agreement Implementation"). Publication of this document meets an Incentive Task Order milestone and a Federal Facility Agreement milestone for completion by July 31, 1997. This work was performed in accordance with criteria set forth in the *Action Memorandum for Building 3001 Canal, Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE/OR/02-1533&D2).

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ABBREVIATIONS

ARAR	applicable or relevant and appropriate requirements
CFR	*Code of Federal Regulations*
CLSM	controlled, low-strength material
DOE	U.S. Department of Energy
HEPA	high-efficiency particulate air
LLW	low-level (radioactive) waste
LMES	Lockheed Martin Energy Systems, Inc.
ORNL	Oak Ridge National Laboratory
PPE	personal protective equipment
PWTS	Process Waste Treatment System
RCRA	Resource Conservation and Recovery Act
TBC	to be considered
TDEC	Tennessee Department of Environment and Conservation

EXECUTIVE SUMMARY

Oak Ridge National Laboratory (ORNL) is a federal facility managed by Lockheed Martin Energy Research, Inc., for the U.S. Department of Energy (DOE). ORNL is on the Oak Ridge Reservation in East Tennessee at the Anderson and Roane County lines, approximately 38 km (24 miles) west of Knoxville, Tennessee, and 18 km (11 miles) southwest of downtown Oak Ridge. The Oak Ridge Graphite Reactor and its storage and transfer canal are located in Bldg. 3001 in the approximate center of Waste Area Grouping 1 in the ORNL main complex.

The Bldg. 3001 Storage Canal is an L-shaped, underground, reinforced-concrete structure running from the back and below the Graphite Reactor in Bldg. 3001 to a location beneath a hot cell in the adjacent Bldg. 3019. The Graphite Reactor was built in 1943 to produce small quantities of plutonium and was subsequently used to produce other isotopes for medical research before it was finally shut down in 1963. The associated canal was used to transport, under water, spent fuel slugs and other isotopes from the back of the reactor to the adjacent Bldg. 3019 hot cell for further processing. During its operation and years subsequent to operation, the canal's concrete walls and floor became contaminated with radioisotopes from the water.

The canal was found to be losing water contaminated with ^{137}Cs, ^{60}Co, and ^{90}Sr at the rate of approximately 1235 L/day (326 gal/day) to the ground underneath the canal and approximately 280 L/day (74 gal/day) to evaporation. Over the years, the contamination has been controlled at levels close to DOE's derived concentration guide levels by replacing lost water with demineralized water and continuously recirculating the water through a demineralizer. The destination of the water leaking from the canal was never conclusively determined, but surface water in the area primarily flows toward White Oak Creek. Remediation of contaminated water released from this canal was not in the scope of this effort and will be addressed as part of the Bethel Valley Watershed Record of Decision.

This report documents the activities involved with replacing the canal water with a solid, controlled, low-strength material (CLSM) in response to a Comprehensive Environmental Response, Compensation, and Liability Act non-time-critical removal action, as described in the Action Memorandum prepared by Jacobs Environmental Restoration Team (1996a).

Planning for this activity started in July 1996. Backfilling of the canal started on March 11, 1997. All canal water was completely replaced by CLSM, and the canal was completely filled by March 17, 1997. Approximately 314,800 L (412 yd^3) of CLSM were required to fill the canal to the top. The CLSM material used had a compressive strength of approximately 28 kg/cm^2 (100 $lb/in.^2$) after curing for 28 days, which should permit the use of conventional excavation tools to remove it at a later date for further remediation (if required). The low-permeability CLSM eliminates contaminated water out-leakage and groundwater in-leakage within the canal area.

1. SITE DESCRIPTION

1.1 PHYSICAL LOCATION

Oak Ridge National Laboratory (ORNL) is located in East Tennessee near the southern boundary of the U.S. Department of Energy (DOE) Oak Ridge Reservation, approximately 39 km (24 miles) west of Knoxville and 18 km (11 miles) southwest of the city of Oak Ridge business area (Fig. 1.1).

The Bldg. 3001 Canal is located within the ORNL main plant on the north side of a small rise in the center of Bethel Valley. Surface water and groundwater in the vicinity drain to the south toward White Oak Creak.

The canal is an L-shaped, underground, reinforced-concrete structure running from the back and below the Graphite Reactor in Bldg. 3001 to a location beneath a hot cell in the adjacent Bldg. 3019.

1.2 SITE BACKGROUND, CONFIGURATION, AND CONDITION

The Graphite Reactor was built in 1943 to produce small quantities of plutonium and was subsequently used to produce other isotopes for medical research before it was finally shut down in 1963. The associated canal was used to transport, under water, spent fuel slugs and other isotopes from the back of the reactor to the adjacent Bldg. 3019 hot cell for further processing.

The canal is located on the west side of the reactor in a concrete vault below grade (Fig. 1.2). The north-south leg of the canal west of the reactor (Fig. 1.3) is approximately 23 m (76 ft) long by 2.4 m (8 ft) wide behind the reactor and 2.1 m (7 ft) wide from the reactor to the intersection with the east-west leg. The east-west leg (Fig. 1.4) is 1.65 m (5.5 ft) wide and approximately 23 m (76 ft) long. The north-south leg contained a pit behind the reactor that was 2.1 m (7 ft) long by 2.4 m (8 ft) wide by 6.75 m (22.3 ft) deep. The adjacent canal had a depth of 3.45 m (11.5 ft). Under Bldg. 3019, the canal was 3.9 m (13 ft) deep. The quantity of water in the canal was automatically maintained at approximately 0.25 m (10 in.) below the top of the canal or at approximately 282,360 L (74,600 gal).

Although the canal water was continuously demineralized, analysis of the water in February 1997, 1 month before its removal, showed that it contained 74 Bq/L (2000 pCi/L) of ^{90}Sr and 60 Bq/L (1620 pCi/L) of ^{137}Cs. All other radionuclides were below the DOE-derived concentration guide. The canal was losing water at the rate of approximately 1235 L/day (326 gal/day) to the ground underneath the canal and approximately 280 L/day (74 gal/day) to evaporation. The work area around the canal was designated as both a radiation and contamination zone and required personal protective clothing, thermoluminescent dosimeters, respirators, and a radiation work permit to enter the area during the remediation.

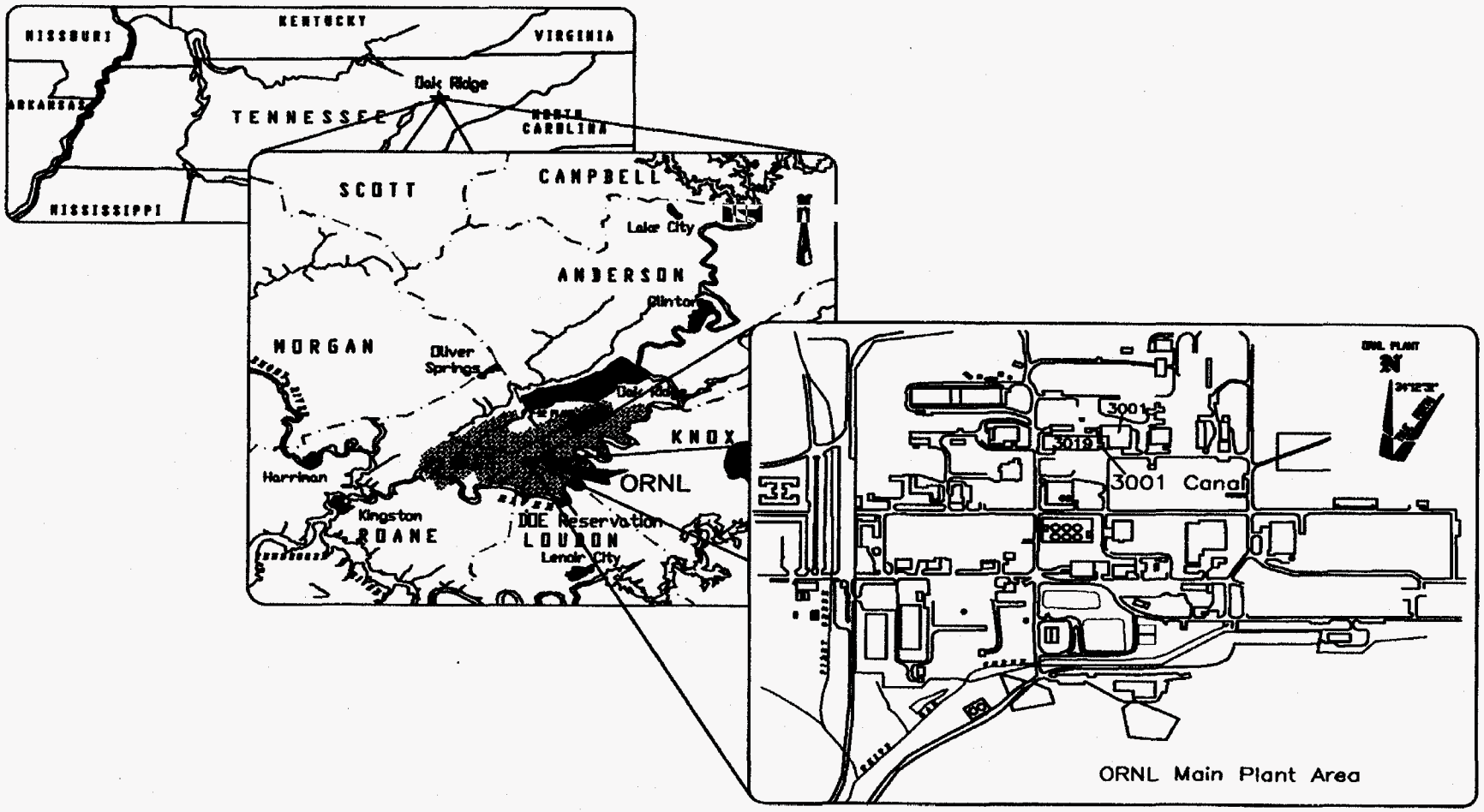

Fig. 1.1. Regional location map.

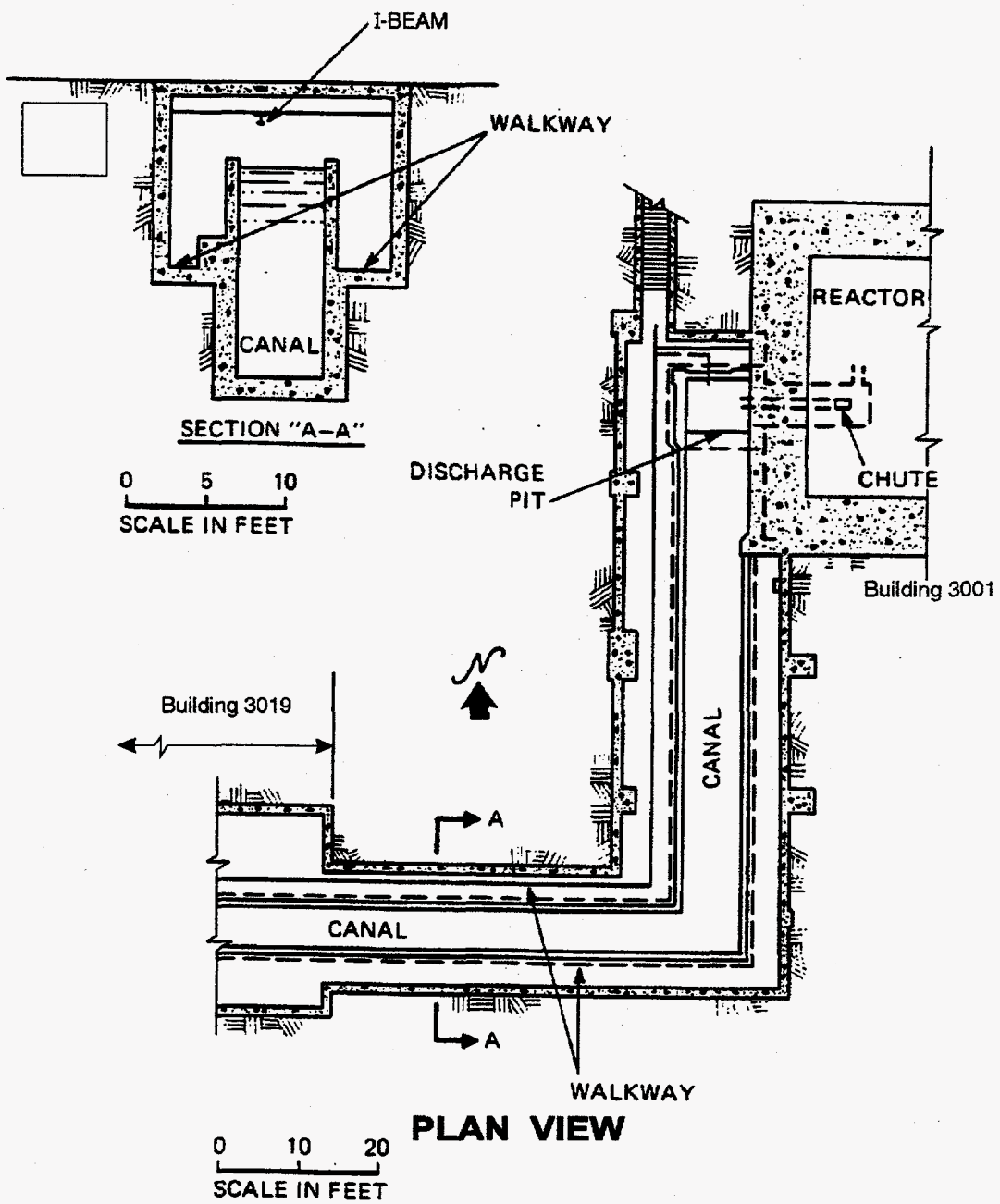

Fig. 1.2. Plan view of Bldg. 3001 Canal and typical cross section.

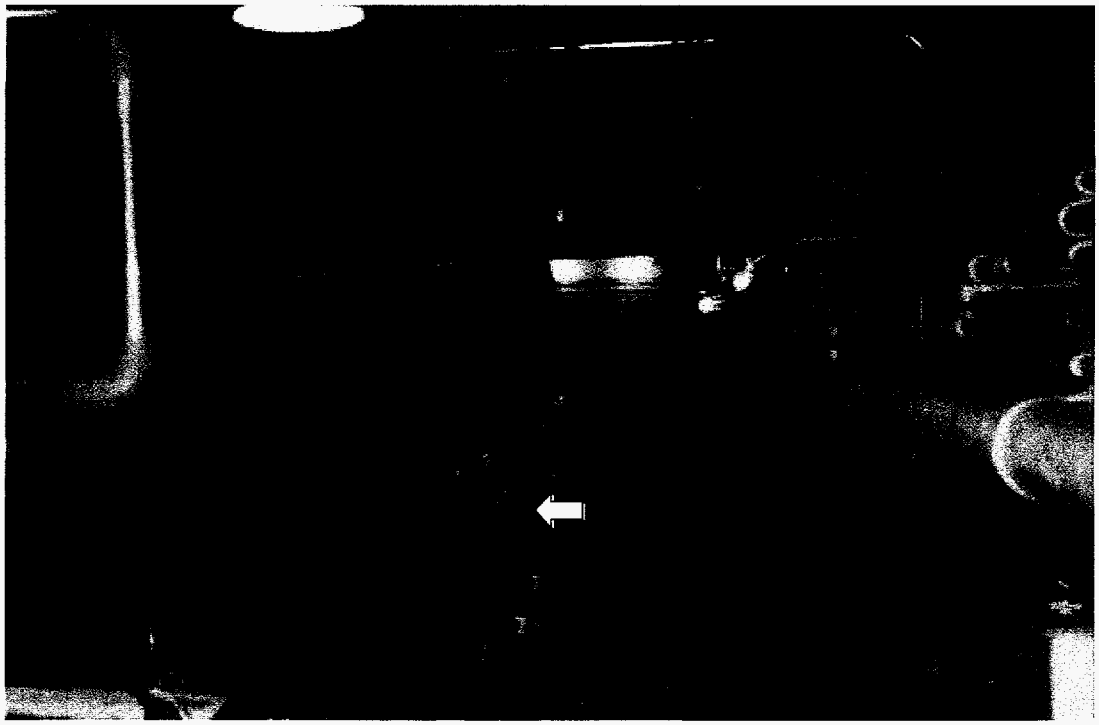

Fig. 1.3. North-south leg of canal under Bldg. 3001.

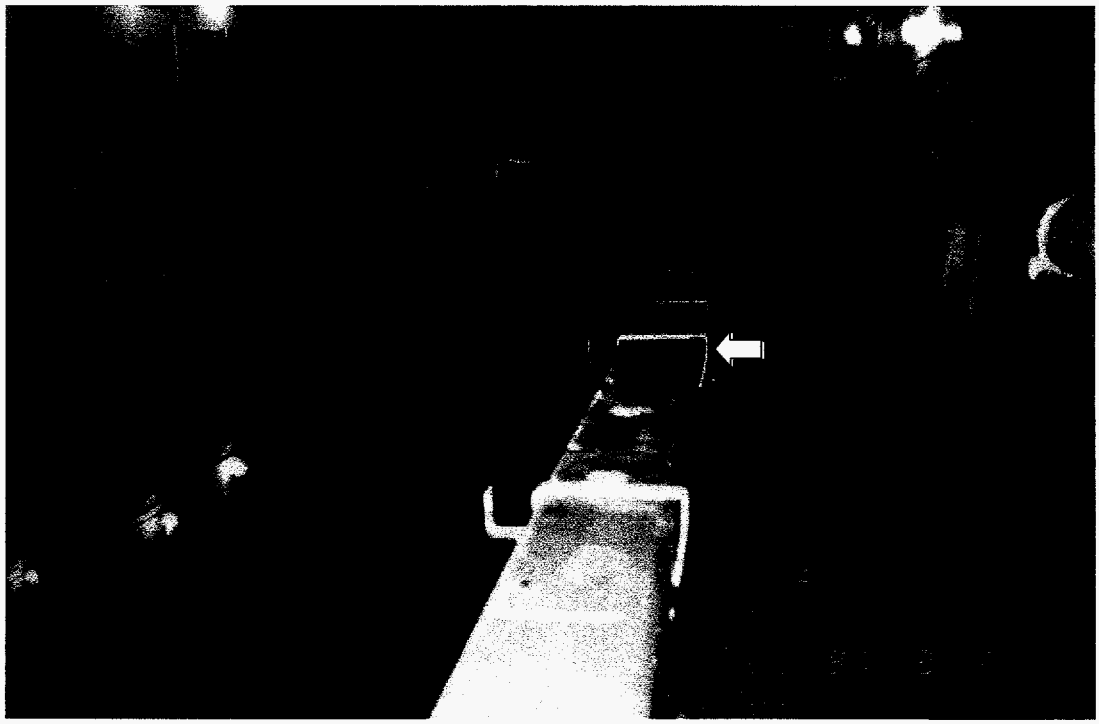

Fig. 1.4. East-west leg of canal between Bldgs. 3001 and 3019.

1.3 BUILDING 3001 CANAL PREPARATION

In a 1990 evaluation, sludge in the canal was found to contain lead and cadmium in quantities exceeding Resource Conservation and Recovery Act (RCRA) limits. As a result of this determination, the canal went through a RCRA interim closure in 1992 (Radian Corporation 1992). The Tennessee Department of Environment and Conservation (TDEC) concurred with this closure in 1993 (Tiesler 1993). Five 55-gal drums, approximately one-third full of solid, low-level waste, were left in the canal following the RCRA closure. A few higher radioactive waste items were distributed among four baskets and hung off the sides of the pool by ropes secured to the walls of the canal, and a few contaminated tools were left in the area.

In Fiscal Year 1996, Lockheed Martin Energy Systems, Inc. (LMES), removed the last of the stored material in the drums and baskets along with the contaminated tools as a maintenance action. In 1997, LMES prepared the canal for stabilization with a controlled, low-strength material (CLSM) to eliminate the continuous water loss, minimize the surveillance and maintenance costs associated with the canal area, and provide radiological shielding from contamination embedded in the canal walls.

A Comprehensive Work Plan (LMES 1997) was issued and approved January 30, 1997. This plan was designated as the equivalent Removal Action Work Plan.

2. PROJECT REQUIREMENTS

This report documents the Comprehensive Environmental Response, Compensation, and Liability Act non-time-critical removal action activities, as described in the Action Memorandum prepared by the Jacobs ER Team (1996a). The technical objectives were to replace the leaking water in the canal, used for shielding the radiologically contaminated walls of the canal, with a specially formulated CLSM. The CLSM would eliminate the internal sources of leakage out of the canal and mitigate the potential for groundwater in-leakage to the canal, thus reducing or eliminating the potential risk to human health and the environment. This action would also reduce surveillance and maintenance costs associated with the canal.

This removal action alternative was chosen after evaluating several previously studied alternatives because it offered the best potential for achieving the above objectives, it was achievable without interfering with future actions, and it could be accomplished within a reasonable schedule and costs (Jacobs ER Team 1996b).

One of the primary concerns in implementing this action was defining a method for removing the water without creating airborne contamination or radiation exposure to workers, which could possibly occur when the shielded walls of the canal were exposed. The method defined by the Action Memorandum required that the CLSM be pumped through a hose underneath the water to the bottom of the canal, thus displacing the water above it to a Process Waste Treatment System (PWTS) drain at the same rate that the CLSM was being delivered. This prevented any potential for the walls of the canal to be unshielded during the operation. After all of the water was displaced by the CLSM, a 10-cm (4-in.) layer of clean CLSM was to be added on top of the existing CLSM, which may have become slightly contaminated by mixing with the water, to ensure a noncontaminated surface. This

would bring the CLSM to a level 10 cm (4 in.) higher than the previous water level, thus providing additional shielding.

In accordance with Sect. 300.415(I) of the National Contingency Plan, on-site removal actions conducted under the Comprehensive Environmental Response, Compensation, and Liability Act are required to meet applicable or relevant and appropriate requirements (ARARs) to the extent practicable. The National Contingency Plan identifies two factors that should be considered in determining whether identifying and complying with ARARs is practicable: (1) the urgency of the situation and (2) the scope of the removal action to be taken. As required, ARARs were developed for the preferred alternative and were included in the Engineering Evaluation/Cost Analysis. The ARARs for this removal action are presented in Table 2.1. No endangered or threatened species or habitats, wetlands, or flood plains that would be impacted by this removal action were identified at the site. The National Historic Preservation Act and its implementing regulations were potential location-specific ARARs because the ORNL Graphite Reactor is a federally owned historic resource listed on the National Register of Historic Places. The project was designed so that none of the actions taken under this non-time-critical removal action altered or destroyed the building or affected the visual presentation of the Graphite Reactor to the public.

3. REMOVAL ACTIVITIES

The working schedule objective of the project was to complete water removal, CLSM filling, and demobilization by March 31, 1997, and complete painting of the canal top by May 30, 1997. All planning and training were completed by February 28, 1997. All Management Review actions were completed by March 10, 1997. Water removal and backfilling began March 11. Backfilling was completed March 17, 1997. All demobilization was completed, and waste generated by the project was picked up by Waste Management for final disposition by March 21, 1997.

Before the start of water removal and backfilling operations, the PWTS drain in the canal vault was dye tested to ensure that the water would go to the PWTS and also tested to ensure that it would handle the flow rate required to meet the projected backfill rates [i.e., approximately 151 L/min (40 gal/min)]. The actual rate achieved was approximately 204 L/min (54 gal/min). Contingencies were prepared in the event that the drain would not take the necessary flow or become clogged. These included having spare pumps present, in case of a pump failure, and having an alternate drain that could be used if the canal vault drain became blocked. The first pump failed after approximately 1.5 days of operation, and a new one was installed in approximately 20 min. Continual use of the drain in the canal vault gradually increased its ability to handle the flow.

Further preparation for backfilling included removing two immersion pumps in the canal that were used for water recirculation. Attached pipes in the canal that extended out of the canal were left in place if they did not hinder the backfilling operation. Two 7.6-cm (3-in.), polyvinyl chloride pipes were constructed in a "U-shape" and inserted under the air dam separating the portion of the canal under the hot cell in Bldg. 3019 from the rest of the canal (Figs. 3.1 and 3.2). This arrangement

Table 2.1. ARARs for the Bldg. 3001 Canal non-time-critical removal action, Oak Ridge, Tennessee

Resource/action	Requirement	Applicability	Citation
	Chemical-specific		
Control of airborne radionuclide emissions during installation, collection, and transport activities	Public exposure, airborne emissions—10 mrem/year	Applicable to releases of airborne emissions of radionuclides from all sources at DOE facilities	TDEC 1200-3-11-.08 40 *CFR* 61.92
	Radiological emission measurements must be performed at all release points that could discharge radionuclides into the air in quantities, which could cause an effective dose equivalent in excess of 1% of the standard (0.1 mrem/year). All radionuclides that could contribute greater than 10% of the standard (1 mrem/year) for the release point shall be measured		TDEC 1200-3-11-.08 40 *CFR* 61.93
	General public exposure all sources—100 mrem/year Temporary exemption, maximum limit—500 mrem/year	To be considered (TBC) (proposed as 10 *CFR* 834)	DOE Order 5400.5,II.1a, "Radiation Protection of the Public and Environment" (TBC guidance)
	All releases shall be as low as reasonably achievable	TBC (proposed as 10 *CFR* 834)	DOE Order 5400.5,I.4 (TBC guidance)
	Location-specific		
Presence of federally owned, administered, or controlled historic properties	Cultural resources included on the National Register of Historic Places (36 *CFR* 60) must be identified Action(s) that will affect such resources must be identified and alternatives to the action(s) examined and considered Steps must be taken to consider the historical, architectural, or archaeological significance of sites, structures, and objects and to consult with the state historic preservation officer When alteration or destruction of the resource is unavoidable, steps must be taken to minimize or mitigate	Applicable if any actions will impact the ORNL Graphite Reactor or its visual presentation to the public	National Historic Preservation Act Sects. 106 and 110 (16 *United States Code* 470 et seq.) Executive Order 11593 36 *CFR* 800

Table 2.1 (continued)

Resource/action	Requirement	Applicability	Citation
	Action-specific		
Characterization/disposal of any decontamination fluids, personal protective equipment (PPE), contaminated piping, or other treatment residuals	A person who generates solid waste must determine whether that waste is hazardous by using various methods, including the Toxicity Characteristic Leaching Procedure or application of knowledge of the hazardous characteristics of the waste based on information regarding the materials or processes used. If the waste is determined to be hazardous, it must be handled in accordance with 40 *CFR* 260-268	Applicable to water removed from the canal and/or any incidental waste generated (e.g., PPE, contaminated piping) that is determined to contain RCRA hazardous waste	TDEC 1200-1-11-.03(1)(b) 40 *CFR* 262.11(c) and (d)
	Low-level waste (LLW) generators must characterize and segregate LLW from uncontaminated waste and otherwise minimize the amount of LLW generated. Subsequent management of LLW must be in accordance with DOE Order 5820.2A. The Commissioner's Order for the site treatment plan and Sect. 105 of the Federal Facilities Compliance Agreement will allow storage of mixed waste until treatment technologies are available	Applicable to storage/disposal of any radioactively contaminated waste and/or mixed waste TBC guidance	Federal Facilities Compliance Agreement of 1992 Sect. 105; TDEC Commissioner's Order for the Oak Ridge Reservation Sanitation Treatment Plant (October 1) DOE Order 5820.2A (III.3) 1995
	Nonhazardous waste may be disposed of at a permitted landfill if it meets the permit requirements and the waste acceptance criteria; a "special waste approval" may be necessary	Applicable to disposal of nonhazardous waste	TDEC 1200-1-7-.01 et seq. 40 *CFR* 258
Residual radioactive material left in place	Access to residual radioactive material shall be controlled through appropriate administrative and physical controls. Controls include periodic monitoring, as appropriate; appropriate shielding; physical barriers (i.e., fences, warning signs) to prevent access; and appropriate radiological safety measure to ensure protection during activities at the site	TBC guidance for the interim management of residual radioactivity left in place	DOE Order 5400.5, IV.6

allowed the rise of CLSM on the hot cell side of the air dam while allowing the displaced water and air to flow back to the other side of the dam to prevent pushing the water into the hot cell. It also allowed detection, with the proper placement of the ends of the pipes on the hot cell side, of when the CLSM had displaced all of the water and had risen at least 10 cm (4 in.) above the previous water level, which was the point where the pipes filled with CLSM.

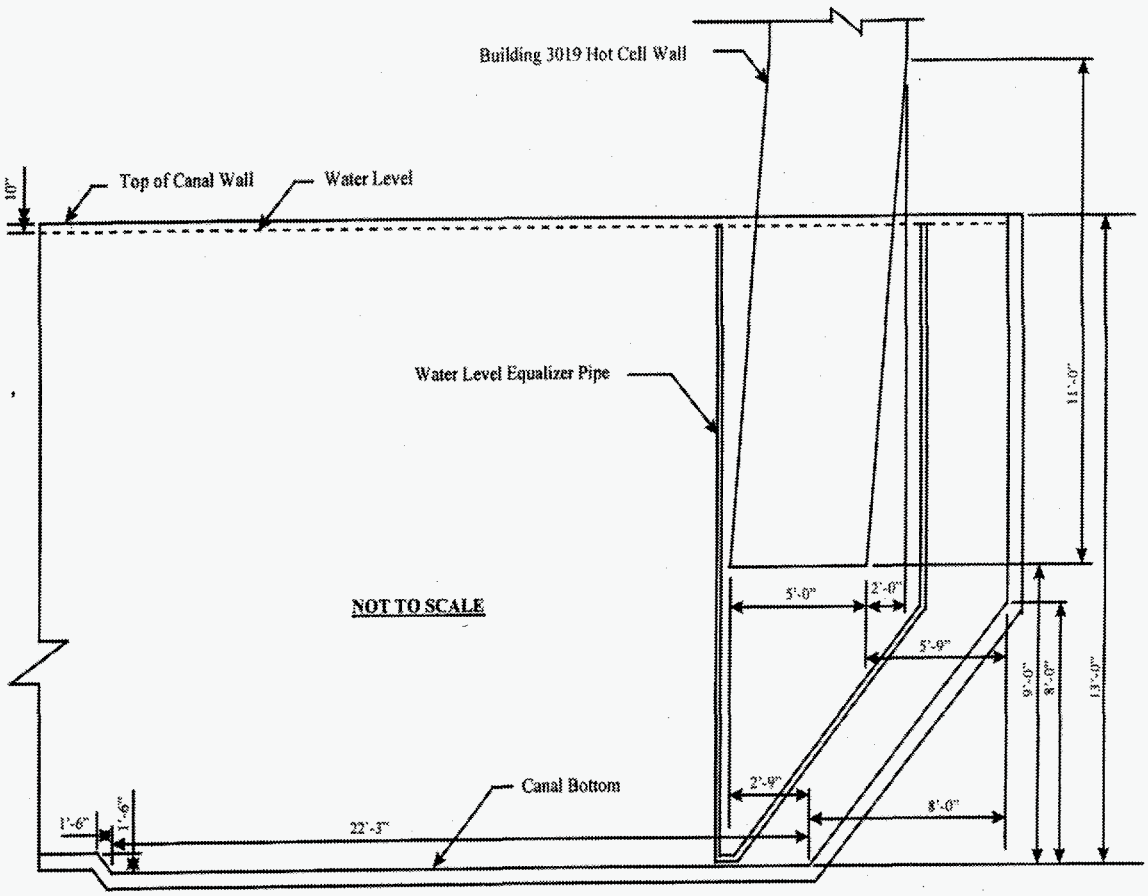

Fig. 3.1. Longitudinal section of Bldg. 3001 Storage Canal at Bldg. 3019 air dam.

Spill basins were constructed in the alley outside Bldg. 3001 to contain any CLSM that might be spilled by the trucks transferring the material to the pumper. Any spillage was removed from the basin at the end of each shift and placed into 132-L (35-gal) and 207-L (55-gal) drums, with secondary containment to be disposed of as noncontaminated waste. All storm drains in the immediate area were protected by hay bales, plastic, and pigs as a best management practice to prevent CLSM from entering a drain in the event of a spill. A temporary shelter was constructed to protect the pumper and the delivery chute attached to the concrete truck from rain, which could change the pumping consistency of the CLSM. It rained 2 days during the action. The pumper was placed in the alley over the canal vault to prevent the trucks from driving and parking on the canal vault top in the alley (Fig. 3.3). The top of the vault has a load limit that prohibited the concrete trucks from entering the area. The 5-cm- (2-in.-) diam pumper hose was routed through the hatch room in Bldg. 3001 and through the overhead hatch into the canal vault, where it was routed manually to the fill location. The delivery end of the hose was placed on the floor of the canal at the

onset; as the CLSM level rose, the hose was adjusted upward so that the tip was kept beneath the surface of the water/CLSM interface. This allowed the CLSM to flow freely on the bottom of the canal with minimum turbulence and mixing with the water to minimize contamination of the CLSM by the contaminated water (Fig. 3.4).

Continuous air sampling was conducted using a low-volume sampler located in the work area. The samples were counted for contamination twice per day. The contamination detected on the filters indicated that respiratory protection was needed for the workers in the canal vault area.

The pump that was to remove the bulk of the water from the canal was stationed approximately half-way between the ends of the 46-m-long (150-ft-long) canal and adjacent to the drain in the canal vault floor (Fig. 3.5). The canal was filled from both ends, thus pushing the remaining water toward the pump until the only water remaining was a few gallons approximately 5 cm (2 in.) deep within an 2.4-m (8-ft) radius of the pump. The pump was then removed. At this point the CLSM was at the same level as the prior water level. The CLSM was allowed to cure over the weekend. The remainder of the water not consumed by the hydrating process was removed by using a wet/dry vacuum container, which was emptied down the PWTS drain. The remainder of the canal was then filled to the top with clean, uncontaminated CLSM. Figures 3.6 and 3.7 depict both legs of the canal filled to the top with CLSM.

After removing generated waste, covering the filled canal with plastic sheeting, and vacuuming the floor with a high-efficiency particulate air (HEPA) filtered vacuum cleaner, the floors, walls, and ceiling of the canal vault were washed with high-pressure water to remove any loose contamination.

Approximately 314,800 L (412 yd^3) of CLSM were used to fill the canal to the top. A total of 56 truck loads were purchased. Approximately 150 sets of personal protective equipment were used, including HEPA-filtered respirators, during the project.

4. DEVIATIONS FROM THE RECORD OF DECISION OR ACTION MEMORANDUM

Two deviations from the criteria set forth in the Action Memorandum occurred. To achieve radiological contamination levels in the work area as low as reasonably achievable, additional CLSM was delivered to completely fill the canal instead of stopping 10 cm (4 in.) above the prior water level. Because of the additional CLSM, the radiation levels on top of the canal are below normal background levels in the canal area. This required 19,100 L (25 yd^3) more of CLSM than originally planned. In addition, the hose used for delivery of CLSM to the canal was supported by laying it on the walkway beside the canal instead of suspending it from an I-beam over the canal. The workers considered the approach defined in the Action Memorandum (Jacobs ER Team 1996a) and recommended that laying it on the floor would be simpler, less costly, and less likely to lead to splashing and contamination to themselves, while not presenting an unacceptable trip hazard.

Fig. 3.2. View of water level equalizing pipes installed in Bldg. 3001 Canal under air dam.

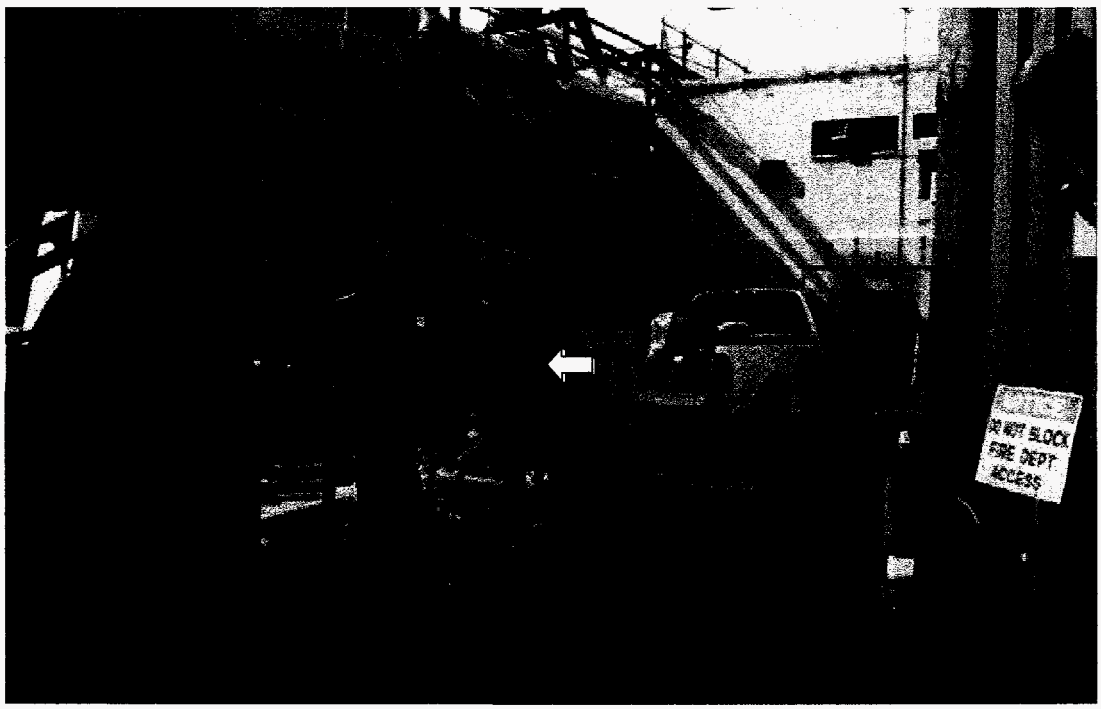

Fig. 3.3. CLSM pumper location over canal vault between Bldgs. 3001 and 3019.

Fig. 3.4. CLSM delivery hose placement looking north in canal vault at start of backfill operation.

Fig. 3.5. Water removal pump location and setup in Bldg. 3001 Canal.

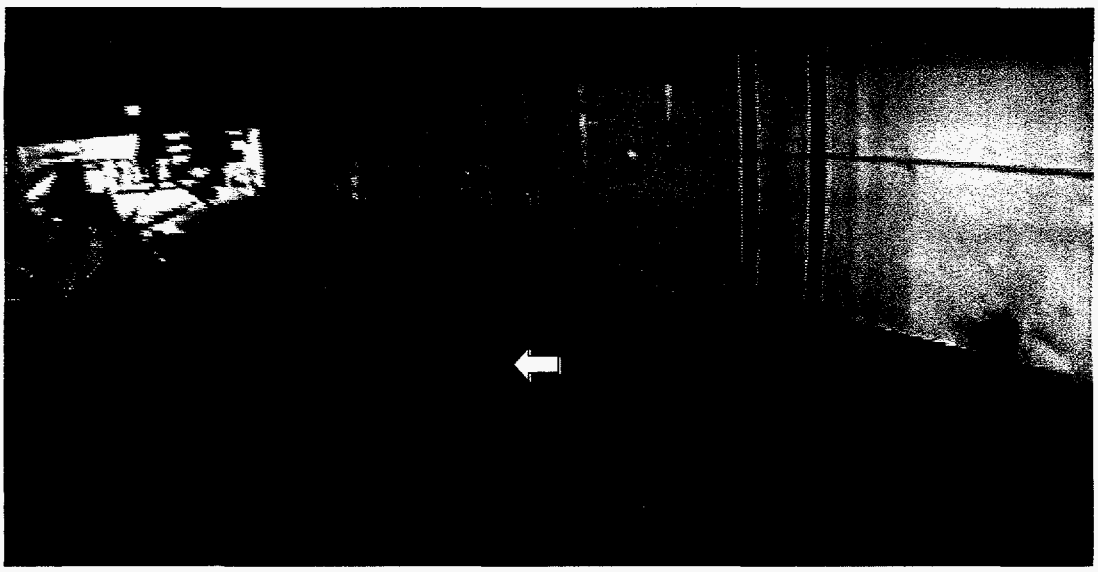

Fig. 3.6. Bldg. 3001 Canal filled with CLSM, looking north.

Fig. 3.7. Bldg. 3001 Canal filled with CLSM, looking west.

5. WASTE MANAGEMENT AND TRANSPORTATION ACTIVITIES

Approximately 1100 L (290 gal) of uncontaminated CLSM from spillage collected from the spill basins was collected in four 207-L (55-gal) and two 132-L (35-gal) drums. These drums were transferred to the ORNL Waste Management Division to be transported to a sanitary landfill. Approximately 452 L (16 ft^3) of scrap wood was collected from the spill basins and shelter. The wood was transported to an on-site, uncontaminated incendiary waste pile.

Approximately 282,360 L (74,800 gal) of canal water were pumped to the PWTS.

Approximately 5.4 m^3 (192 ft^3) of noncompactible, radiologically contaminated waste were generated in the canal area, including pumps, hoses, and temporary hand-finishing tools. This waste was double bagged, surveyed, placed into B-25 boxes, and transferred to the ORNL Waste Management Division for final disposition in accordance with the project Waste Management Plan.

Approximately 8.2 m^3 (288 ft^3) of compactible radiologically contaminated waste were generated in the canal area, including personal protective clothing, HEPA filters, and rags. This waste was double bagged, surveyed, placed into B-25 boxes, and transferred to the ORNL Waste Management Division for final disposition in accordance with the project Waste Management Plan.

6. OPERATION AND MAINTENANCE PLANS

The Comprehensive Work Plan (LMES 1997) required that two pumping systems be used to remove the water: the demineralizer pump and a pump hanging on the side of the canal. The demineralizer pump noise level exceeded the Occupational Safety and Health Administration noise limit of 80 decibels without hearing protection. Because the workers were required to wear full-face respirators, also wearing hearing protection would make communication between workers in the canal and between them and the pumper operator outside the building extremely difficult. An engineering control in the form of a noise insulator box was constructed to surround the demineralizer pump to reduce the noise level to below 80 decibels. It was believed in the planning stage of the project that both pumps would be needed to achieve the pump rate goal of 151 L/min (40 gal/min). When the demineralizer pump was started, it was discovered that both pumped to the same drain. Because the suspended pump was using the full capacity of the drain and it appeared to be exceeding the planned pump rate goal, the team decided that the demineralizer pump would not be required to meet the project goals. This decision also improved the communication between workers in the area as a result of reduced noise levels, which improved coordination and teamwork between the workers in the canal vault and the pumper operator, who controlled the CLSM flow rate.

7. MONITORING SCHEDULE AND/OR EXPECTATIONS

The condition of the grout and paint will be inspected monthly for 1 year to check for significant cracks and chipping.

8. REFERENCES

Jacobs ER Team 1996a. *Action Memorandum for Building 3001 Canal, Oak Ridge National Laboratory, Oak Ridge, Tennessee*, DOE/OR/02-1533&D2, Oak Ridge, Tenn.

Jacobs ER Team 1996b. *Engineering Evaluation/Cost Analysis for Building 3001, Oak Ridge National Laboratory, Oak Ridge, Tennessee*, DOE/OR/02-1502&D2, Oak Ridge, Tenn.

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