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S8ER FACILITIES DECOMMISSIONING

FINAL REPORT

DOE Research and Development Report

Prepared for the United States
Department of Energy,
Environmental Controls Technology Division
under Contract EY-76-C-03-0701

Rockwell International

Atomics International Division
Energy Systems Group
8900 DeSoto Avenue
Canoga Park, California 91304

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ABSTRACT

In 1974, the SNAP 8 Experimental Reactor (S8ER) Facility at the Santa Susana Field Laboratories (SSFL) of the Energy Systems Group (ESG) of Rockwell International was declared excess to the government's program needs. The resulting decommissioning program, commenced in 1976, provided for complete removal of all radioactive materials remaining from the operation of two SNAP space-type compact reactors. Careful study indicated that the safest and most economical removal of the reactor containment vessel, which had induced radioactivity and was located in the building, would be by totally razing the facility.

To safeguard against any inadvertent spread of radioactive material, the steel-frame building itself was used to provide as much weather and wind protection for the radioactive material removal activities as possible; therefore, it was taken down in pieces as the excavation progressed and control measures permitted. Concrete substructure vaults were decontaminated and demolished to gain access to soil adjacent to the facility that might have been contaminated. The reactor containment vessel was excavated, removed, and shipped to the burial site, complete with its original concrete shield attached.

Radioactive materials removed by excavation or decontamination were boxed and trucked to the licensed, commercial burial ground at Beatty, Nevada. The extra heavy and wide load of the reactor containment vessel required special handling and routing normally associated with conventional shipments of this size.

The project was completed with minimal radiation exposure of workers and no reportable off-site exposure.

The overall cost of the demolition and disposal of the facility is presented for comparison with other, similar proposed projects. Direct comparison is difficult, however, because some unusual circumstances concerning mixed government and private ownership and the ongoing but unrelated government-sponsored support activities at the ESG/SSFL have masked some of the resultant costs. For example, the close proximity of the Radioactive Material Disposal Facility (RMDF) proved significant in reducing radioactive material disposal costs.

1.0 GENERAL

1.1 FACILITY NAME

SNAP 8 Experimental Reactor (S8ER) Facility, or Building 010.

1.2 AFFILIATION

The facility structure and operating support equipment were owned by the U.S. Government and were under the responsibility of the Department of Energy, Division of Environmental Control Technology (DOE/ECT). The land is owned by Rockwell International and is on long-term lease with a purchase option to the U.S. Government.

1.3 LOCATION

The S8ER Facility was located at the Rockwell International Energy Systems Group Santa Susana Field Laboratories (ESG/SSFL), which is about 40 miles northwest of the Los Angeles Civic Center (see Figure 1).

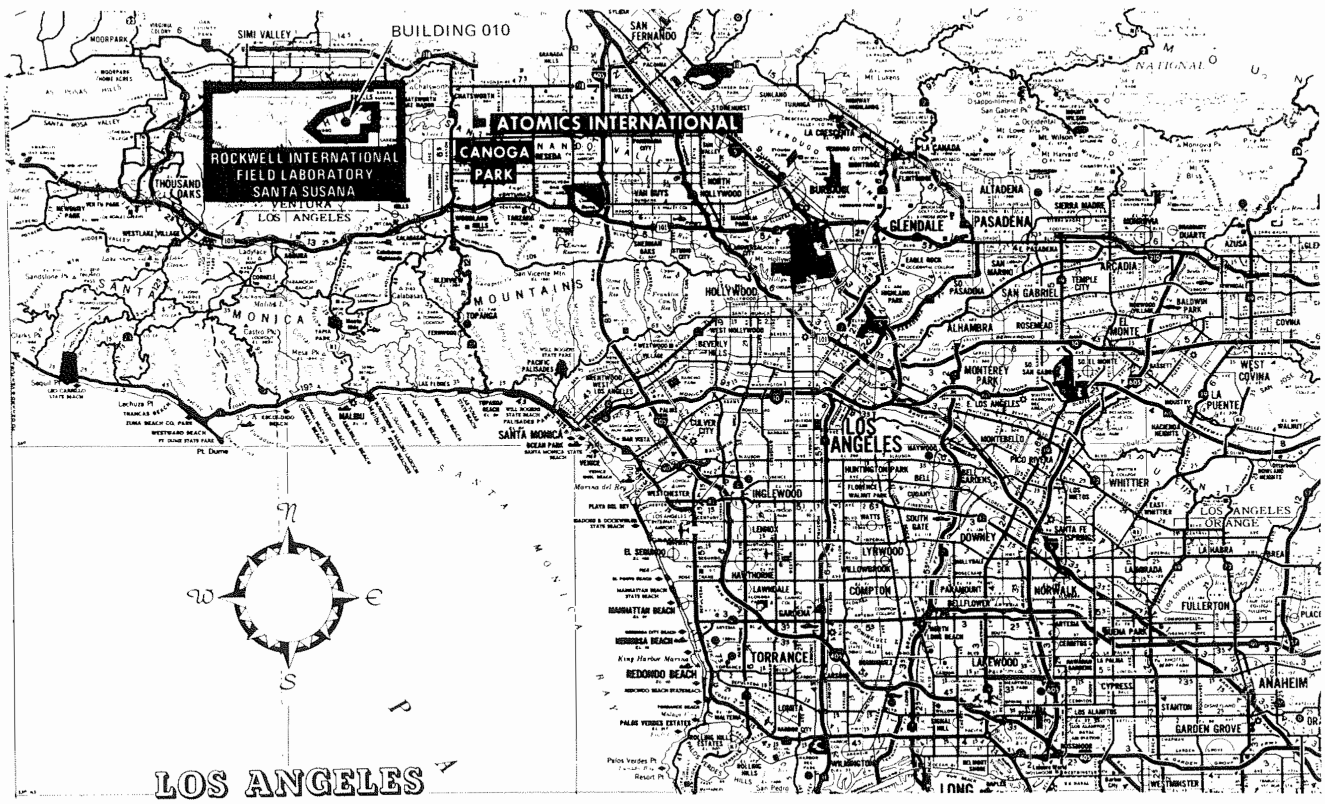

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Figure 1. Vicinity Map
(Courtesy of Automobile Club of Southern California with permission)

2.0 FACILITY TYPE AND POWER RATING

The S8ER Facility was an experimental reactor operation and testing facility. It was built specifically for small (less than 2-ft diameter) compact- or space-type reactor testing and data collection at full-power operation conditions.

2.1 PHYSICAL DIMENSIONS AND POWER RATING

The building was a rigid, steel-frame structure with corrugated metal siding and roofing with internal blanket thermal insulation. The foundation and floor were steel-reinforced concrete. The building was 60 ft long by 24 ft wide, with a 17-ft eave height (see Figure 2). The subsurface structure comprised three steel-reinforced concrete vaults, of which two were also steel lined. The maximum depth was 14 ft below grade. All of the vaults were located in the reactor room, which occupied the southern 34 ft of the building.

The reactors were operated in the 3-ft diameter, below-grade, concrete-shielded reactor containment vessel vault. Reactors were supported from the

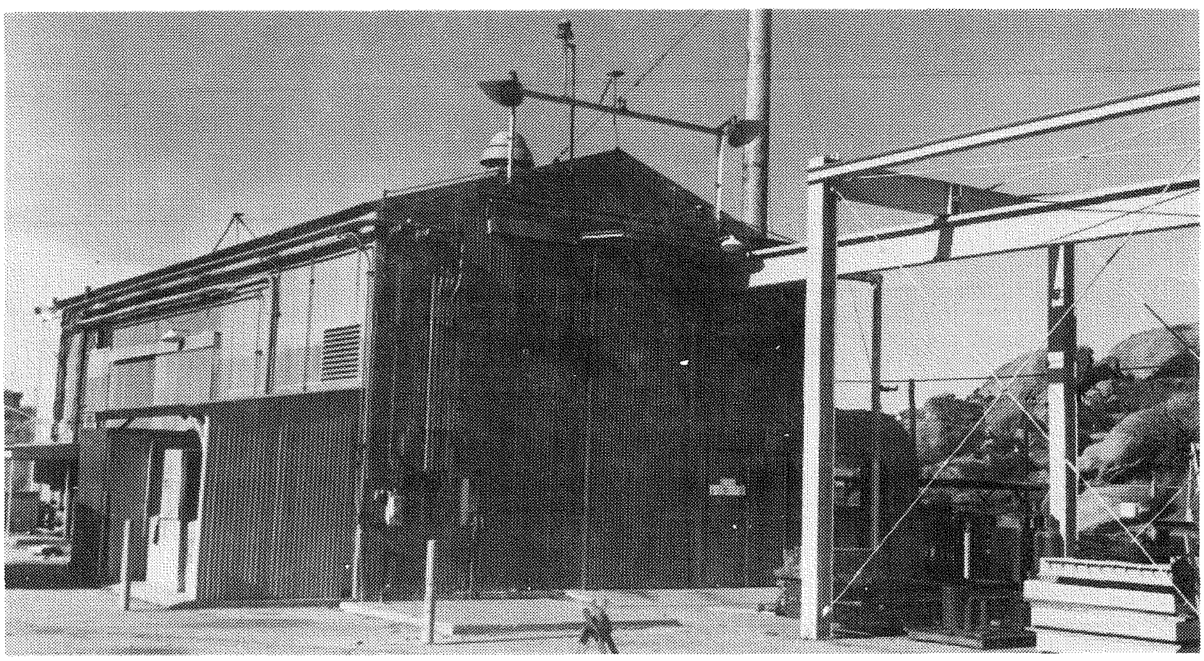

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Figure 2. Building 010 Facility Before Start of Decommissioning

removable top shield plugs and could be inserted and removed without disassembly or modification. The fixed-concrete shielding limited the reactor power rating to less than 550 kWt.

Support facilities exterior to the building consisted of equipment mounted on small, grade-level concrete pads, and a buried radioactive gas holdup tank and drainage sump. The equipment consisted of electric transformers, air conditioners, exhaust gas stack and fans, and auxiliary coolers for the shield cooling systems.

2.2 SYSTEM DESCRIPTION

The original reactor development projects removed and disposed of the reactors and supporting NaK systems for post-operation analysis before the conclusion of their programs in 1965. The facility was left in protective storage with some surface contamination and the residual induced radioactivity confined in situ. This radioactivity was shielded by the replacement of the concrete plugs and covers that had been used during reactor testing.

Only the reactor room was left with limited personnel access (see Figure 3). All of the doors were kept locked and were posted. A shielded containment vessel, primary system vault, and a secondary system equipment pit were located below the floor level. Access to the inside of the radioactively contaminated shielded containment vessel and primary system vault was through the removable shield plugs and the sealed covers. Plug and material handling capability in this room was provided by a hand-racked, single-beam underhung bridge crane. A 7-1/2 ton motorized hoist and trolley and a 1-ton hand-operated chain hoist operated off the bridge. Power was disconnected from the hoist to prevent unauthorized lifting of the plugs. Daily security patrols assured adherence to the posted limitations.

The vault complex was composed of three separate enclosures: (1) shielded containment vessel, (2) primary system vault, and (3) secondary system equipment pit. Ground-water drainage for the entire vault complex was provided by a subfoundation system consisting of circuits of perforated metal pipe surrounded by a gravel fill. The system drained into a pipewell sump located to the east of

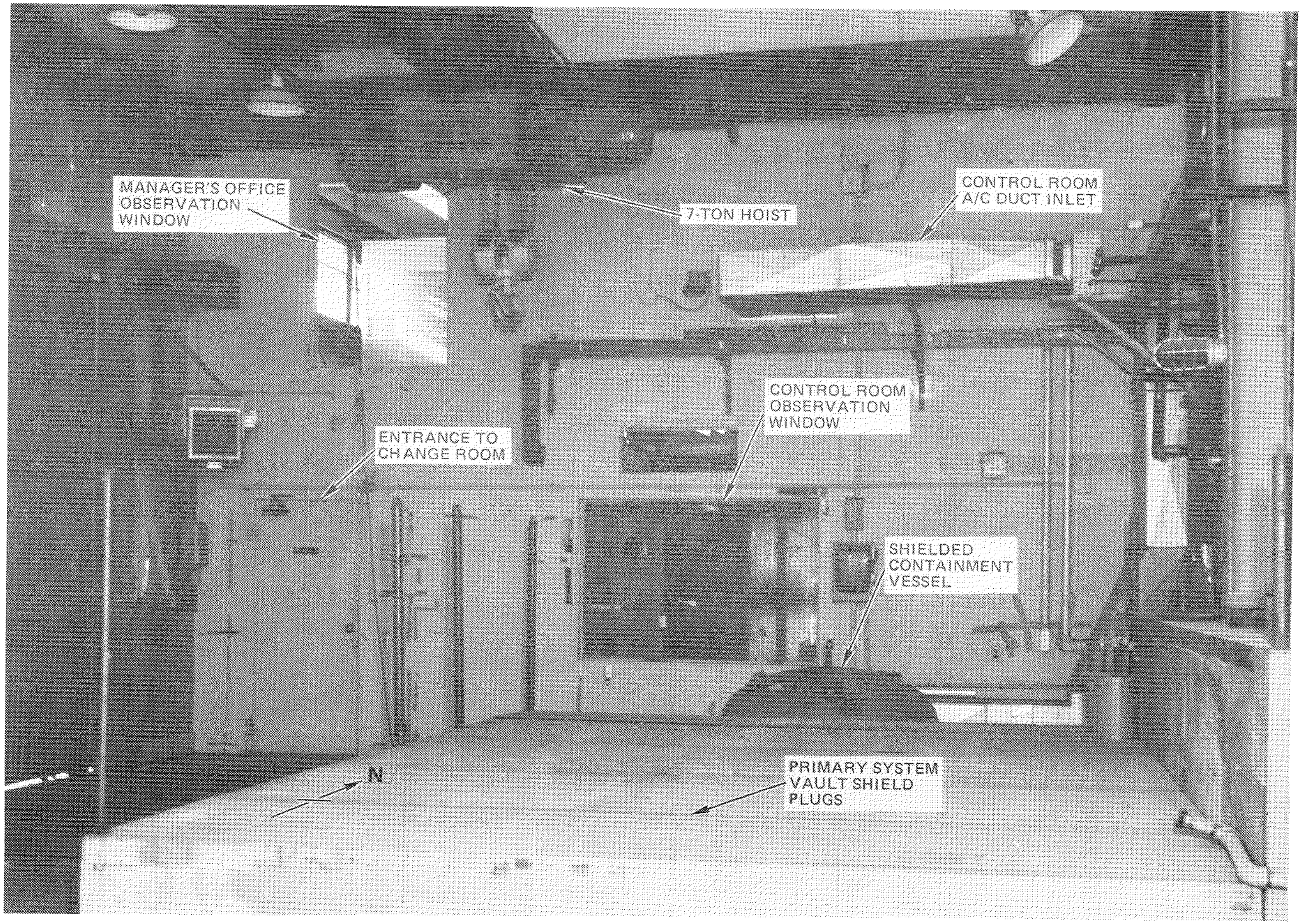

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Figure 3. Reactor Room Before Start of Decommissioning

the building where the intercepted ground water could be monitored. The water was then either pumped into a tank for controlled disposal if radioactive contamination was detected, or discharged to the site surface drainage system if no contamination was found.

The shielded containment vessel consisted of a 4-ft diameter by 14-ft high carbon steel pressure vessel embedded in concrete. The domed upper head of the containment vessel was removable and extended about 2 ft above the reactor room floor. The exterior surface of the containment vessel was wrapped with two coils of carbon steel water cooling pipes. Two 6-in. diameter carbon steel sleeves connected the upper compartment of the containment vessel with the primary system vault. Smaller penetrations of the containment vessel included: two inlet and outlet pipelines for control of vessel atmosphere, six shutdown shield air cooling pipelines, two shield vent pipelines, and four electrical and instrument conduits. All pipelines and conduits were seal welded to the containment vessel wall.

The primary system vault consisted of a carbon steel vault liner 10 by 12 by 10 ft deep embedded in concrete. The top was equipped with movable concrete shield plugs. Carbon steel pipe cooling lines were attached to the concrete side of the steel liner. Various pipe sleeves connected the primary system vault to the secondary system pit and to the shielded containment vessel.

The secondary system equipment pit was a small concrete vault. Steel floor plates forming the top were at the reactor room floor level. Connections to the primary system vault were welded shut for protective storage isolation.

The test facility was provided ventilation, heating, and air conditioning in accordance with the specific requirements of the building areas. The systems were separated into two major areas servicing the control room and the reactor room. The reactor room was ventilated by a filtered air exhaust system. Air was drawn into the area through wall louvers and was exhausted through filters to a fan, which discharged into the 50-ft facility stack. The exhaust fan and related ductwork were located outside the building on a concrete pad.

The amount of radioactive waste produced by the test reactor operation was quite small; therefore, major waste collection or processing systems were not

	LOCATION	JANUARY 25, 1966 mR/h	MARCH 5, 1969 mR/h
1	FILTER	22.0	1.2
2	COOLER	1.0	0.1
3	PIPING	2.0	0.3
4	BACKGROUND	0.3	0.03
5	PIPING	11.0	0.3
6	SURGE TANK	5.0	0.7
7	HEATER	3.0	0.5
8	F-61 FILTERS	9.0	1.0
9	PIPING	13.0	
10	OUTSIDE EAST WALL	0.5	
11	STACK FAN	4.4	
12	5 x 10^3 cfm STACK FAN	10.0	
13	STACK INTAKE	3.0	
14	TOP OF VAULT COVER (MAX)	18.0	
15	ON VAULT FLOOR (MAX)	500.0	
16	ON VAULT FLOOR (MIN)	250.0	
17	INSIDE CONTAINMENT VESSEL	120,000.0	
18	BY FRONT DOOR	0.07	
19	INSTRUMENT THIMBLE #1 (TOP)	0.4	
20	INSTRUMENT THIMBLE #2 (TOP)	80.0	
21	INSTRUMENT THIMBLE #3 (TOP)	0.4	
22	INSTRUMENT THIMBLE #4 (TOP)	0.4	
23	OUTSIDE SOUTH WALL	0.4	
24	OUTSIDE SOUTHWEST CORNER	0.2	
25	INSIDE NORTHWEST CORNER	0.1	
26	INSIDE ROOM 100	0.1	
27	NORTHWEST CORNER BUILDING 010	0.1	
28	NORTHEAST CORNER BUILDING 010	1.0	

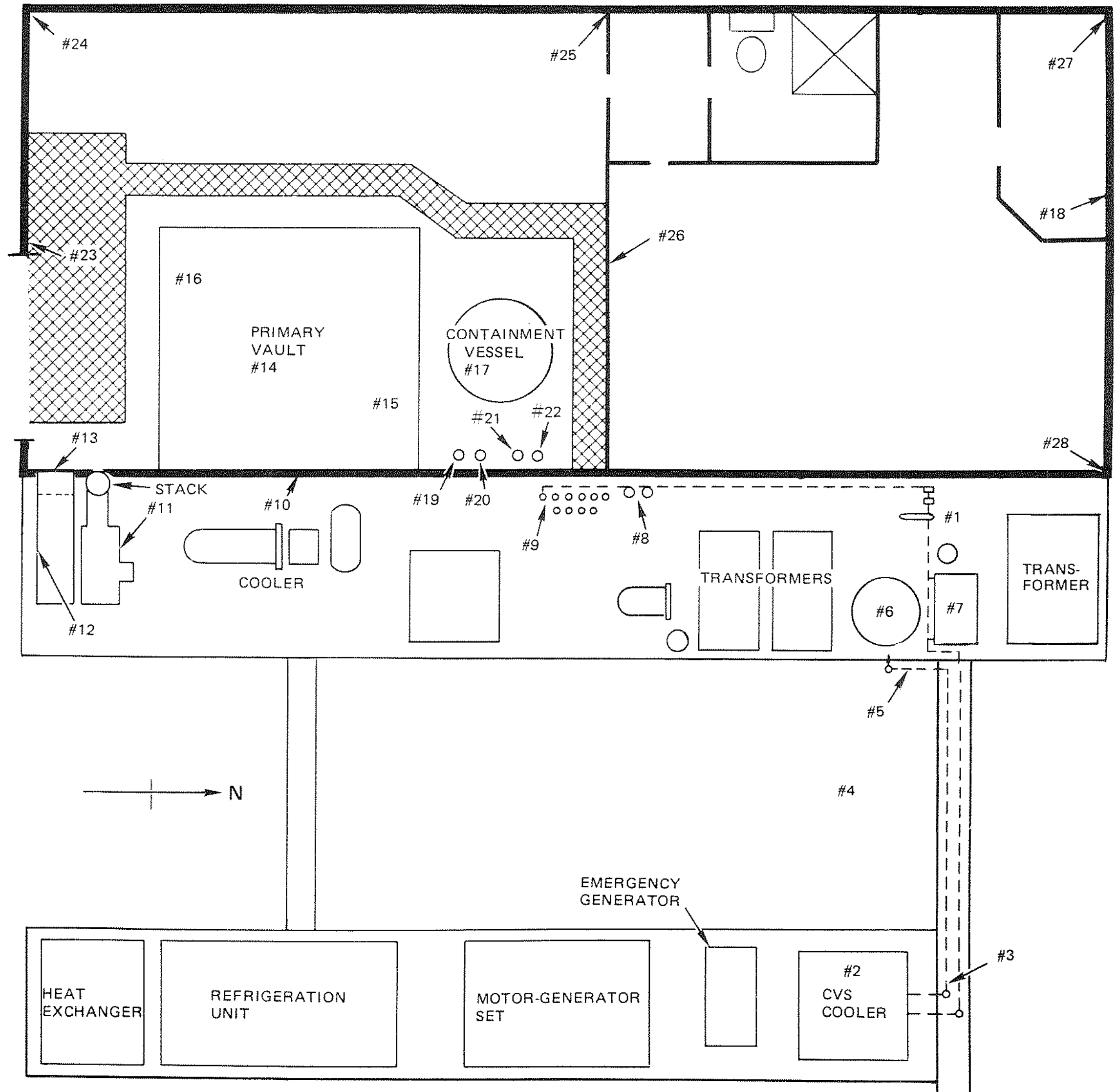

Figure 4. S8ER Building 010 Radiation Survey

provided for the facility. Small tanks were provided, however, for the temporary storage of both liquid and gaseous wastes that might have been radioactive.

Vent lines to the stack exhaust filters were provided from the containment vessel and primary system vault spaces and from those service systems capable of producing airborne radioactivity. A buried, 100-ft^3 gas holdup tank and a vacuum pump system were provided to permit holdup and monitoring of gases vented from the primary heat transfer system following shutdown. The tank was periodically vented through the stack filters.

2.3 OPERATING HISTORY RELATING TO DECOMMISSIONING

At the conclusion of the S8ER experiment in 1965, it was intended to preserve the facility for possible re-use to test future compact reactors. The S8ER reactor and the special-purpose support equipment (i.e., the primary and secondary sodium loops and control panels, etc.) were removed from the facility. Some surface contamination was also removed from the facility to allow unrestricted access to most of the building. However, the primary vault, which still had some surface contamination, and the reactor containment vessel, which still had induced radioactive materials, were covered with their shielding blocks to restrict access and to shield the remaining radiation. The radioactive contamination conditions at that time are shown in Figure 4.

The plans for facility re-use did not materialize; thus the building remained relatively unused for 9 years, and it was finally declared surplus in 1974. It was placed in a protective storage mode until razing started in September 1977.

A detailed analysis of activation and contamination is reported in Section 5. It shows the levels of radioactivity and identifies the significant radionuclides expected to be present in the neutron-activated structures and components, including the containment vessel, shutdown shield, ordinary concrete in the reactor vault shielding, reinforcing rods, instrument thimbles, and cooling coils.

2.3.1 Data Supporting the Presence of Activation or Contamination

From operations logbooks and the published project documents, the facility total operating history can be reconstructed.

The reactor operation caused neutron activation of materials in the lower half of the carbon steel containment vessel, in the surrounding materials including some earth, and in the stainless steel and concrete containment vessel shield plug. The cumulative energy generated during reactor operation was 5.4×10^6 kWht. These components were therefore exposed to a total neutron fluence corresponding to this thermal energy generation.

Portions of the reactor containment vessel carbon steel cooling pipes were also in the neutron flux. Although demineralized water with hydrazine added as a corrosion inhibitor was circulated through closed loops, some radioactive contamination was found in the filters and pump seal gland leakage. Therefore, it was concluded that both cooling circuits contained radioactive residue.

The primary vault cooling shared the same coolant as the reactor containment vessel, and therefore also contained radioactive residues. A leak had occurred in this system, making the concrete supporting structure suspect for radioactive contamination.

The reactors were disassembled inside the primary vault with special remote handling equipment. Although the vaults were subsequently decontaminated, some radioactive material adhered to the vault surfaces producing a radiation level that would not have interfered with any future reactor testing.

2.3.2 Special Data on Incidents That Could Be Significant to the Appraisal of Activation or Contamination

This was a well-operated facility that was, for the most part, free from unplanned radioactive material releases. Only two significant incidents are recorded — a leak in the shield cooling water lines under the vault floor, and another leak in the reactor containment vessel cooling lines in the earth near the concrete shield. Both were repaired, and no extensive decontamination was found to be required or performed.

3.0 CONSTRUCTION

3.1 NUCLEAR DESIGNER

The nuclear design work was performed by Atomics International (AI) [now Energy Systems Group (ESG)] for the reactor systems operated in the facility.

3.2 FACILITY DESIGNER (A&E)

The structural and architectural design work was performed by Atomics International (AI). The facility was constructed by a general contractor under the direction of AI.

3.3 DATE AND DURATION OF CONSTRUCTION

The S8ER Test Facility was originally constructed in 1959 for the 50-kWt SNAP 2 Experimental Reactor Test. Following satisfactory completion of the SNAP 2 test in 1960, the reactor and associated test equipment were removed from the building. In 1961, improvements and modifications were made to the facility and equipment to enable safe operation of the facility for a similar testing program with the higher power level 600-kWt SNAP 8 Experimental Reactor (S8ER).

3.4 CONSTRUCTION PHOTOGRAPHS

Figures 5 and 6 are photographs taken during construction. These photographs show the below-grade details of the carbon steel vault liners. Later, concrete was placed between these liners and temporary forms. When the temporary forms were removed, the excavation was backfilled with compacted earth.

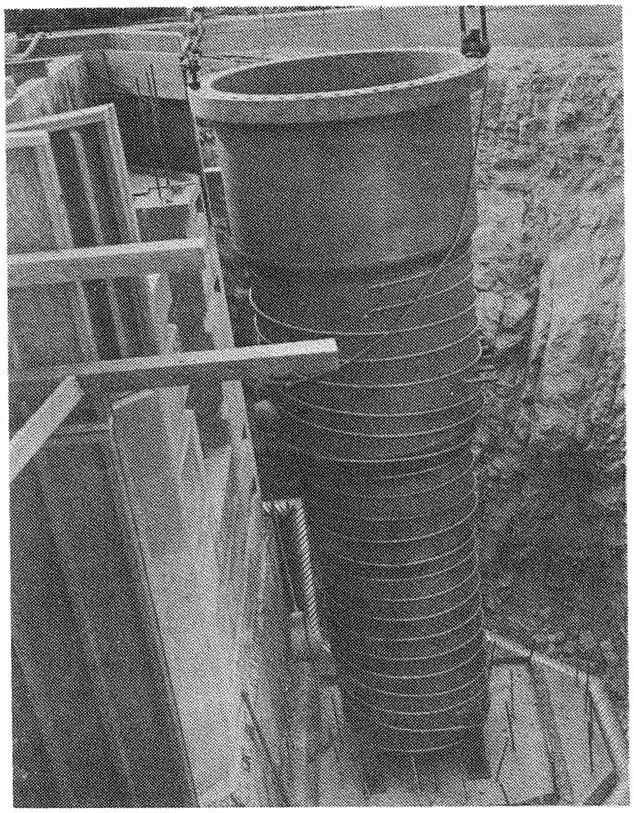

Figure 5. Reactor Containment Vessel Installation (5/8 in. thick steel cylinder, 3 to 5 ft in diameter and 14 ft high)

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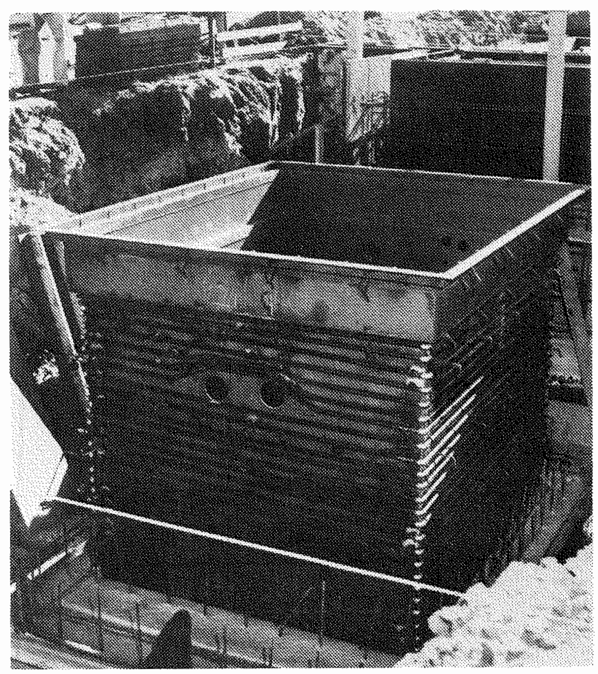

Figure 6. Reactor Side of the Primary Vault Liner (1/4-in. thick steel box, 10 by 12 by 10 ft)

4.0 DECOMMISSIONING OBJECTIVES

The objective of the Building 010 (S8ER) facility decommissioning was to place the area in a condition for unrestricted use by removing all radioactive contamination to below the levels that would require any radiological surveillance and licensing.

4.1 MODE

A dismantling mode was selected as the safest and most cost-effective approach to decommissioning. The driving feature was that more than half of the building and foundation would be razed just to gain access to the below-grade concrete vaults and activated earth. Any projected use for the building would not justify the restoration and remodeling costs.

4.2 REGULATORY REQUIREMENTS

4.2.1 Governing Regulatory Agencies

The use of radioactive materials in California is licensed and regulated by the U.S. Nuclear Regulatory Commission (NRC) in the case of special nuclear materials, or by the State of California, Department of Health in the case of source and byproduct materials. U.S. Government owned or controlled facilities are exempt from licensing when there is demonstrated government use or need. When DOE is the responsible agency, the DOE Operations Manual provides guidance and direction.

Industrial safety requirements at ESG-owned facilities are defined by the California Occupational Safety and Health Administration (OSHA) regulations, as administered by the California Department of Occupational Safety and Health. Industrial safety requirements at DOE-owned facilities are defined by DOE Immediate Action Directive No. 0504-33, as administered by DOE-OES.

4.2.2 Licensing Requirements

The objective was to have the site available for general access and free of all surveillance and control requirements. The performance of the decommissioning was during the period when the site was under federal government control and exempt from federal and state licensing regulations. This status will extend as long as the land is U.S. Government controlled; however, in the event the optioned land were to revert to ESG, the state regulations would apply. For this reason, the facility and land must be decontaminated to a level that is projected to be acceptable to the State of California for an unlicensed area.

4.2.3 Upper Radiation Level Limits Including As-Low-As-Practicable Considerations

All radioactive materials or components above the guide limits were to be removed from the Rockwell International properties. The objective was to leave all decontaminated areas at radiation levels as low as practicable, but in all cases to levels below those described in Table 1. Activated soil was to be removed as near as practicable to the natural background levels, but in all cases to less than 100 pCi/g gross detectable beta activity.

TABLE 1

SURFACE RADIATION LIMITS FOR DECOMMISSIONING THE S8ER BUILDING 010 FACILITY

	Total	Removable
Beta-Gamma Emitters	0.1 mrad/h at 1 cm with 7 mg/cm^2 absorber	100 dpm/100 cm^2
Alpha Emitters	100 dpm/100 cm^2	20 dpm/100 cm^2

4.2.4 Decommissioning Operational Regulatory Requirements

The decommissioning activity was performed while the facility was under federal government ownership and exempt from licensing requirements, but subject to the DOE Operations Manual requirements.

4.3 SUMMARY OF DECOMMISSIONING PROCEDURES

4.3.1 Decontamination and Razing Techniques

A Facilities Dismantling Plan was prepared, outlining the expected location and levels of residual radioactive contamination and establishing the basic requirements for the decommissioning of the site. Because of the deep excavations required near and under the building foundation, it was deemed that the most economical solution was to raze the entire site. Activity requirements and detailed working procedures were then prepared to guide the actual work to remove completely all structures and radioactive materials according to the limits set forth in Section 4.2. The building was preserved as long as possible to provide control of any possible airborne contamination from the deep excavations around the reactor containment vessel shield and the primary vault. Razing occurred only as the structures interfered with the excavation activity (Figure 7).

As work progressed, exposed walls and ducts were decontaminated to minimize spreading any radioactive materials. A radiological survey of the primary vault steel liner surface showed an average contamination level of 20,636 dpm/100 cm^2 β, and the highest level was 175,644 dpm/100 cm^2 β. The foam application process was employed to reduce the surface contamination of the steel-lined primary vault. The cleaning chemicals were applied with a 55-gal. barrel pump and spray foam air foamer (Figures 8 and 9). A wet-type absolute filter vacuum cleaner was used to

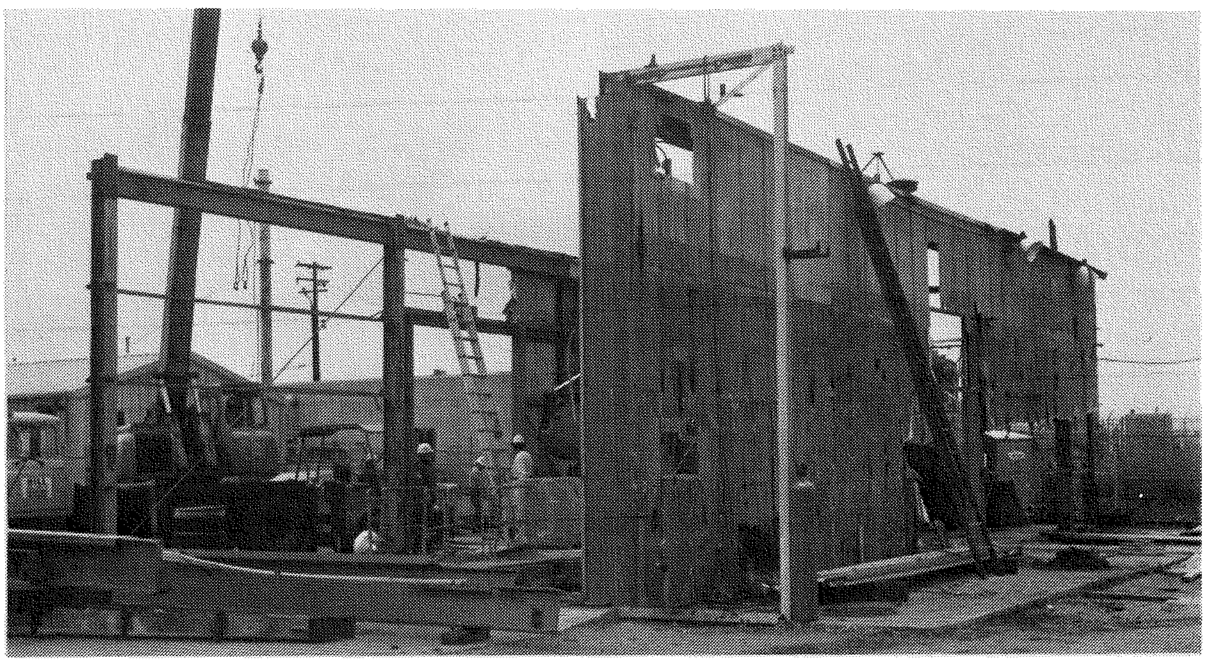

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Figure 7. Building 010 Partially Razed — Excavation of Vault and Reactor Containment Vessel Shield Are Underway

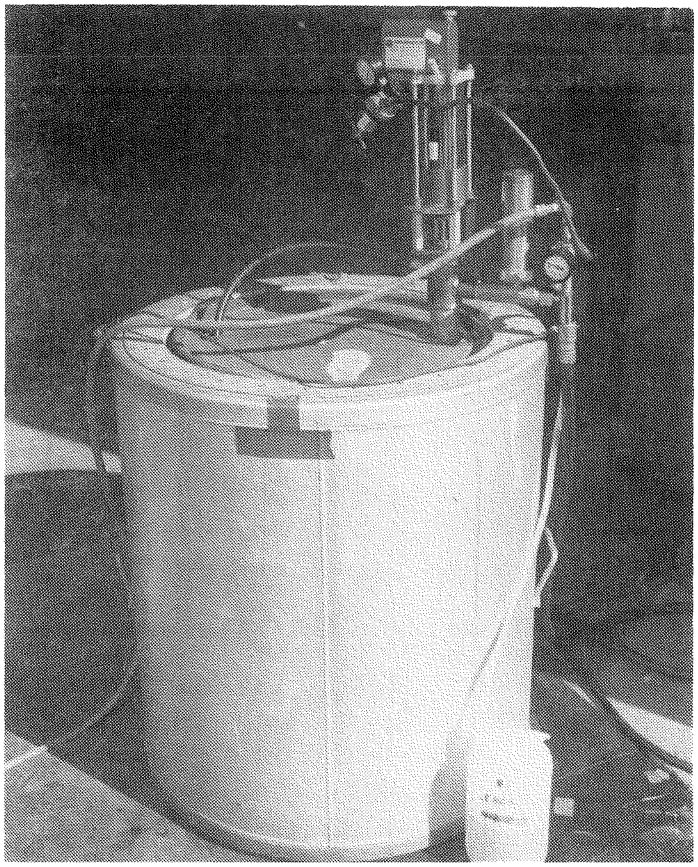

Figure 8. Barrel Pump and Spray Foamer

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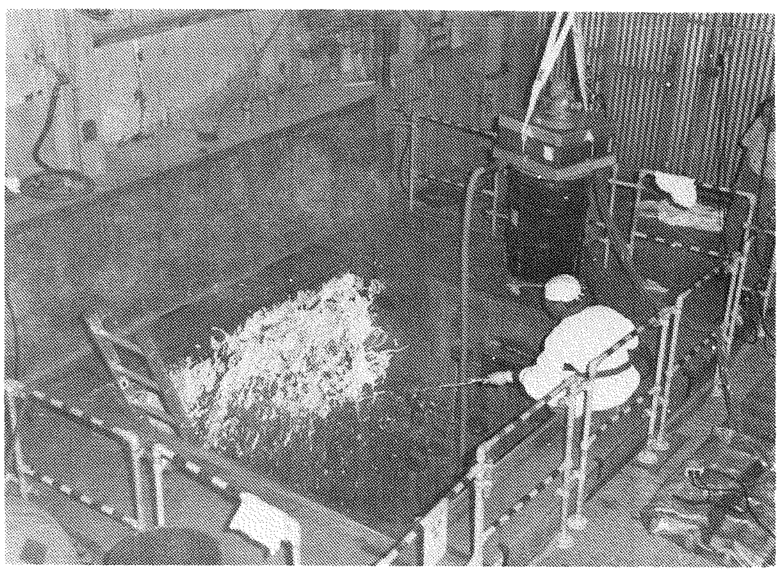

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Figure 9. Applying Spray Foam
(The vacuum cleaner in background was used for removing foam)

remove the cleaning chemicals after a hand scrubbing operation (Figures 9 and 10). The scrubbing was required to lift scale or porous adherents. After two applications of the foaming process, the average surface contamination was generally reduced several orders of magnitude; the highest area was reduced from 175,644 to 21,000 dpm/100 cm^2 β.

Following the foam process, the vault walls were painted with a fixative and were cut free of the reactor containment vessel shield with the Hy Ram (Figure 11). The remaining vault walls and floor were broken into large pieces for disposal without torch cutting.

The reactor containment vessel, its internal instrument thimbles, and attached concrete shield were removed and shipped as a unit to take full advantage of the existing shield (Figures 12 and 13). The total weight of this piece was 97 tons. This weight and the 8-ft width required highway transportation permits for California and Nevada. An extra courier vehicle was used behind the load to give added assurance of minimizing the potential of developing problems en route.

The lower half of the excavation, before the vessel and shield were removed, had readings of 300 to 500 mrad/h, βγ on a Juno Meter. After the vessel and concrete were removed, the radiation from the soil in the pit was recorded as 20,000 cpm with a pancake G-M probe and 10 mrad/h, βγ. The radiation reading on the lower 3 ft of the concrete was approximately 100 mrad/h, βγ at 18 in., and up to 400 mrad/h, βγ at spots. The concrete was wrapped with plastic sheeting and shipped from the site for burial. The excavation was enlarged after the concrete was removed to ensure that all radioactive materials above the radiation limits shown in Section 4.2 were removed (Figure 14). Imported new sand and noncontaminated concrete rubble from the site were used to backfill all excavations to the original grade.

The razing techniques for the nonradioactive or decontaminated structure were conventional disassembly and salvage of the main members. Minor noncontaminated components were sold for scrap. Contaminated material not found to be economical to decontaminate (for example the waste gas holdup tank shown in Figure 15) was boxed and shipped to the disposal site.

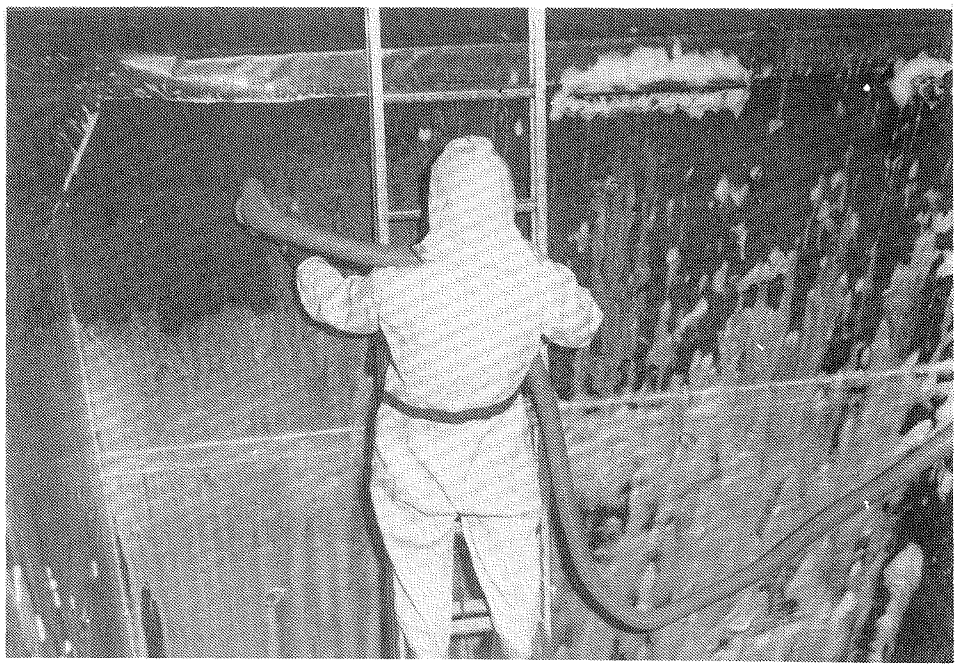

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Figure 10. Vacuuming Spray-Foamed and Scrubbed Wall Surface

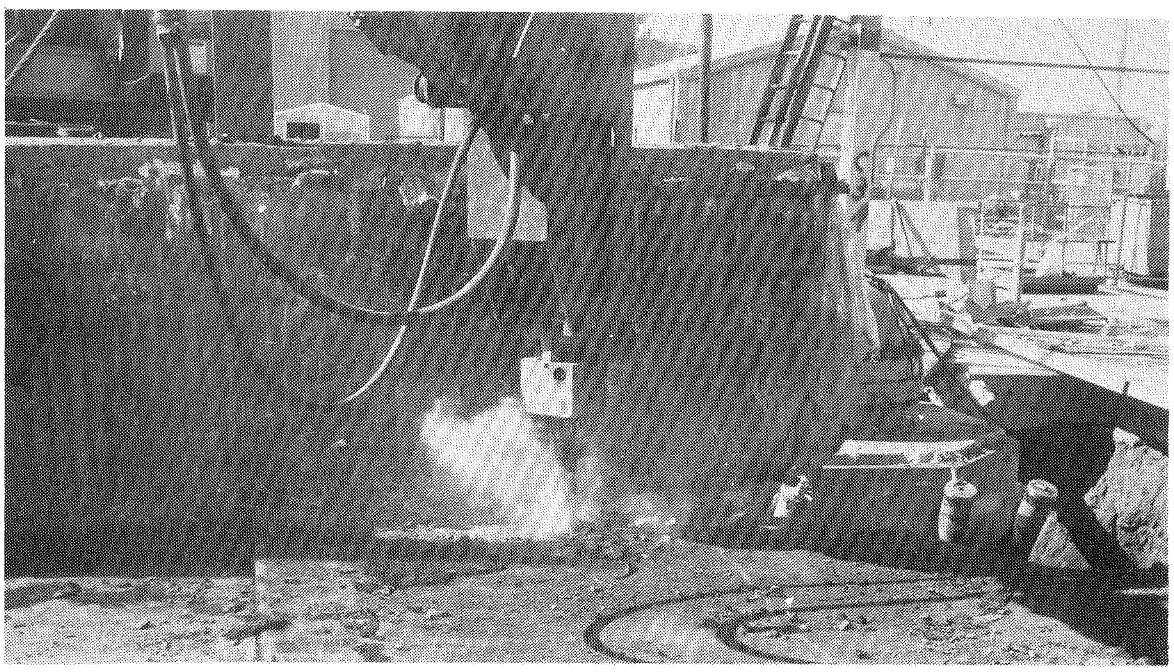

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Figure 11. Breaking Concrete With a Hydraulic Hy Ram Attached to a Back Hoe

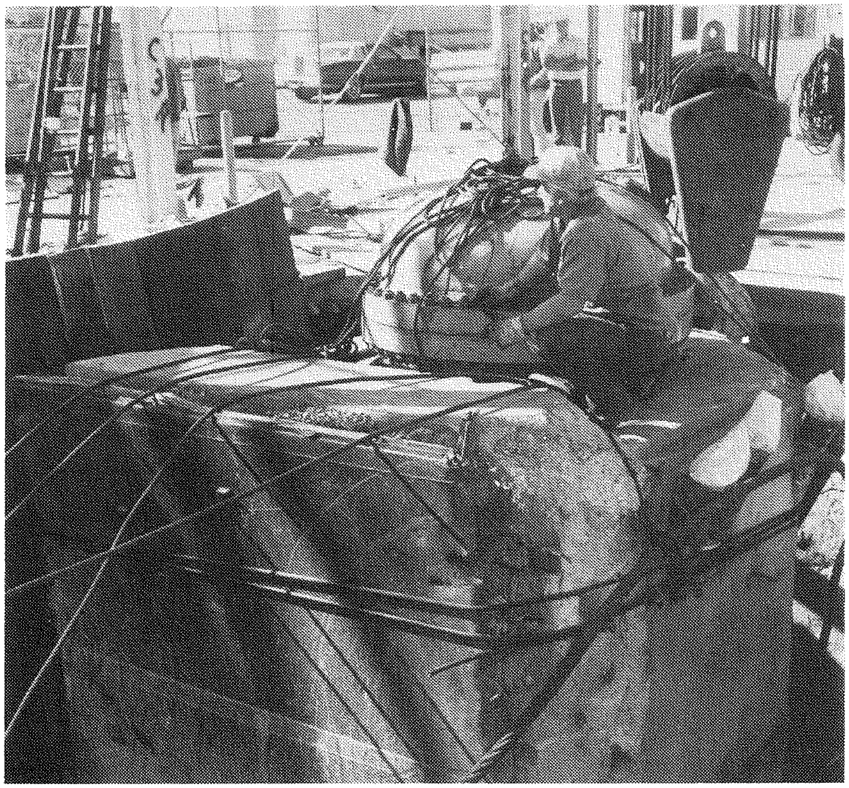

Figure 12. Reactor Containment Vessel and Shield Ready To Be Removed in One Piece

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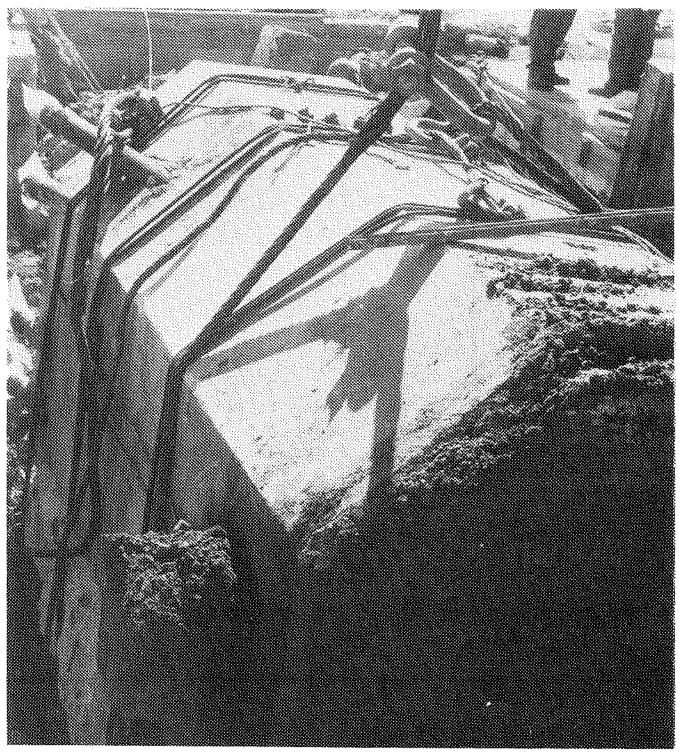

Figure 13. Reactor Containment Vessel and Shield Being Removed from Cavity

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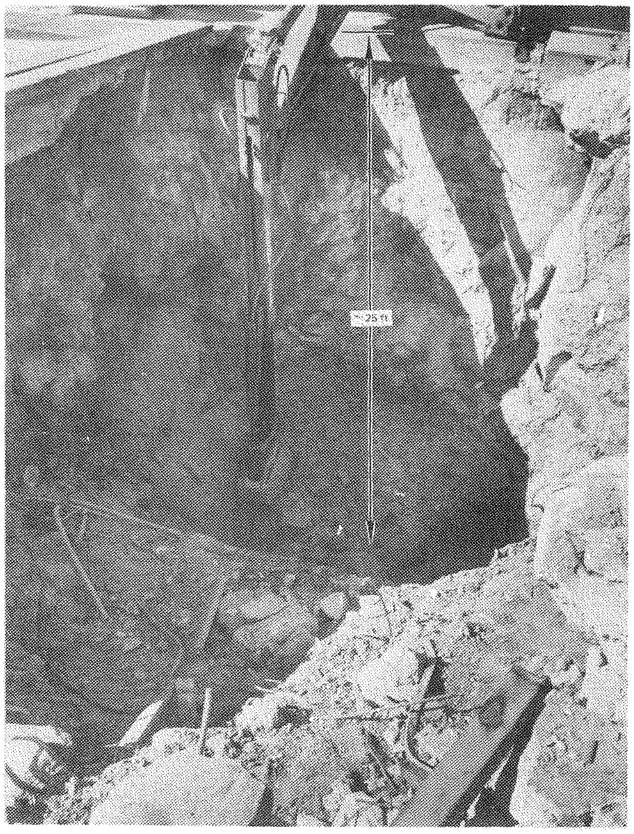

Figure 14. Final Cleanup of Contaminated Soil From Reactor Containment Vessel and Shield Excavation

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7704-621249

Figure 15. Radioactive Gas Holdup Tank Being Prepared for Burial

4.3.2 Special Tooling, Equipment, or Techniques Required

No unique equipment was used. The concrete-breaking (Figure 11) and hoisting equipment used were the largest commercial size locally available. The rental of this equipment from commercial sources allowed the planned removal of large pieces to proceed with dispatch and relative ease.

4.3.3 Special Access or Site Problems Affecting Decommissioning

The Building 010 site was in the midst of operating nonradioactive facilities. There was no interruption of the activities in these facilities as a result of the decommissioning activity at the Building 010 site. This was due in large part to the small size of the building and the relatively large surrounding paved area. The work area had a temporary fence erected around it, and the fenced area was posted to restrict access to that necessary for the project.

The work progressed through the Winter of 1977/1978, which was recorded as the second highest rainfall winter in the Los Angeles basin. This condition shut down work and forced temporary rain shelters to be erected (Figure 16). Mitigation of the effects of the rain was successful, and no unusual problems were experienced.

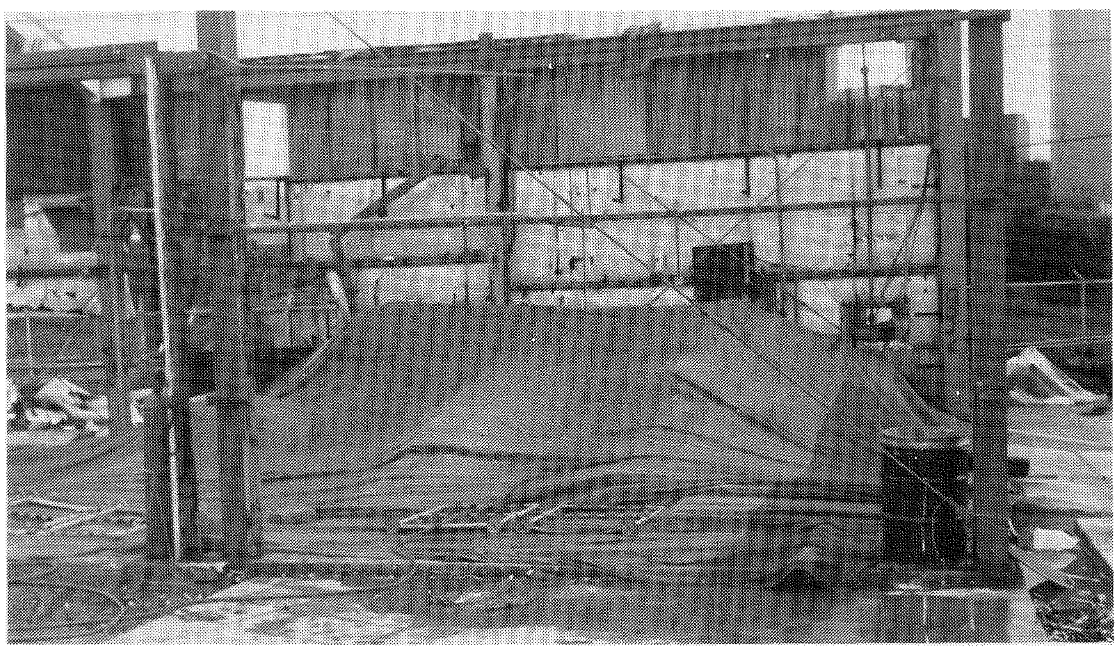

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Figure 16. Temporary Weather Protection Used to Keep Rain Out of the Excavations

4.4 SUBSEQUENT FACILITY USE PLANS

The site is to be used as a parking lot. Eventually, there could be a new structure erected on the site suitable for unrestricted use.

5.0 FACILITY RADIOACTIVITY STATUS

5.1 PRE-DECOMMISSIONING CURIE INVENTORY OF ACTIVATED STRUCTURE, MATERIALS, AND EQUIPMENT

Total activity expected to be present in the various activated structures was calculated on the basis of the total weight of each structure in the cases of the containment vessel, cooling coils, stainless steel, and reinforcing rods. In the case of ordinary concrete, the total activity present was evaluated on the basis of the volume of concrete present to the depth of one relaxation length for thermal neutrons over the total surface exposed to the neutron flux. No evaluation of total activity was performed in the cases of the stainless steel and high-density concrete, as both materials were in portable plugs and thimbles.

The portion of the containment vessel that was exposed to neutrons was a carbon steel right cyclinder, closed on one end, 38 in. in diameter by 48 in. high and 3/4 in. thick. The neutron-activated portion of the vessel weighed 670 kg. The vessel cooling coils, which were also carbon steel, were 1/2-in. pipe with a wall thickness of 0.109 in. The coils on the portion of the vessel walls that were exposed to neutrons weighed 26 kg. Table 2 displays the specific and total activities for the principal radionuclides expected to be present in the containment vessel and vessel cooling coils circa April 15, 1977.

TABLE 2

PRINCIPAL CALCULATED ACTIVITY IN VESSEL AND VESSEL COOLING COILS (At April 15, 1977)

Nuclide	Specific Activity (μCi/g)	Total Activity (μCi)
^{54}Mn	1.7×10^{-2}	2.4×10^{4}
^{55}Fe	2.1×10^{1}	1.5×10^{7}
^{60}Co	1.5×10^{0}	1.1×10^{6}
Total	2.7×10^{1}	1.6×10^{7}

The reinforcing rods in the concrete were specification A15-52T and A305-50T iron rods. The vertical and horizontal rods were 5/8-in. rods arranged on 12-in. centers with 3 in. of clearance from the concrete face. The reinforcing rods in the inner face of the portion of the containment vessel ordinary concrete shielding that was exposed to neutrons weighed 60 kg. Table 3 displays the principal radionuclides expected to be present in the reinforcing rods circa April 15, 1977.

TABLE 3
PRINCIPAL CALCULATED ACTIVITY IN REINFORCING RODS
(At April 15, 1977)

Nuclide	Specific Activity (μCi/g)	Total Activity (μCi)
^{54}Mn	1.7×10^{-1}	2.3×10^{4}
^{55}Fe	2.1×10^{2}	1.3×10^{7}
^{60}Co	1.5×10^{1}	9.0×10^{5}
Total	2.7×10^{2}	1.3×10^{7}

The ordinary concrete exposed to neutrons was limited to the concrete shielding at the base of the containment vessel and the lower 48 in. to the side of the containment vessel. The total concrete surface exposed was 1.1×10^{5} cm^{2}. Assuming a relaxation length of 11 cm, the total activity in the ordinary concrete was calculated by applying the maximum radioactivity concentration $\mu Ci/cm^{3}$ to a volume of 4.5×10^{5} cm^{3}. Table 4 displays the specific and total activities for the principal radionuclides expected to be present in the ordinary concrete circa April 15, 1977.

The shutdown shield was composed of stainless steel, carbon steel, lead, Thermobestos insulation, high-density concrete, and extensive silver braze. Although maximum specific activities were determined for the components of the shield, total activities were not evaluated. The bottom surface of the shutdown shield was exposed to a maximum neutron flux of 1.5×10^{12} n/cm^{2}-s during the operation of the S8ER reactor. Table 5 displays the maximum specific activity of the significant radionuclides expected to be present in the shutdown shield circa April 15, 1977.

TABLE 4

PRINCIPAL CALCULATED ACTIVITY IN ORDINARY CONCRETE
(At April 15, 1977)

Nuclide	Radioactivity Concentration ($\mu Ci/cm^3$)	Total Activity (μCi)
^{3}H	6.4×10^{2}	2.8×10^{8}
^{39}Ar	1.4×10^{0}	6.0×10^{5}
^{41}Ca	1.2×10^{-1}	5.2×10^{4}
^{55}Fe	5.6×10^{1}	2.4×10^{7}
^{60}Co	1.4×10^{1}	6.0×10^{6}
^{14}C	1.5×10^{-2}	6.5×10^{3}
Total	7.1×10^{2}	3.0×10^{8}

TABLE 5

PRINCIPAL CALCULATED ACTIVITY IN THE SHUTDOWN SHIELD
(At April 15, 1977)

Material	Nuclide	Specific Activity ($\mu Ci/g$)
Stainless Steel	^{54}Mn	1.8×10^{-2}
	^{55}Fe	1.5×10^{1}
	^{63}Ni	1.7×10^{1}
	^{60}Co	4.2×10^{1}
Thermobestos Insulation	^{41}Ca	5.5×10^{-1}
Silver Braze	^{108}Ag	1.4×10^{4}
High-Density Concrete	^{55}Fe	1.0×10^{2}

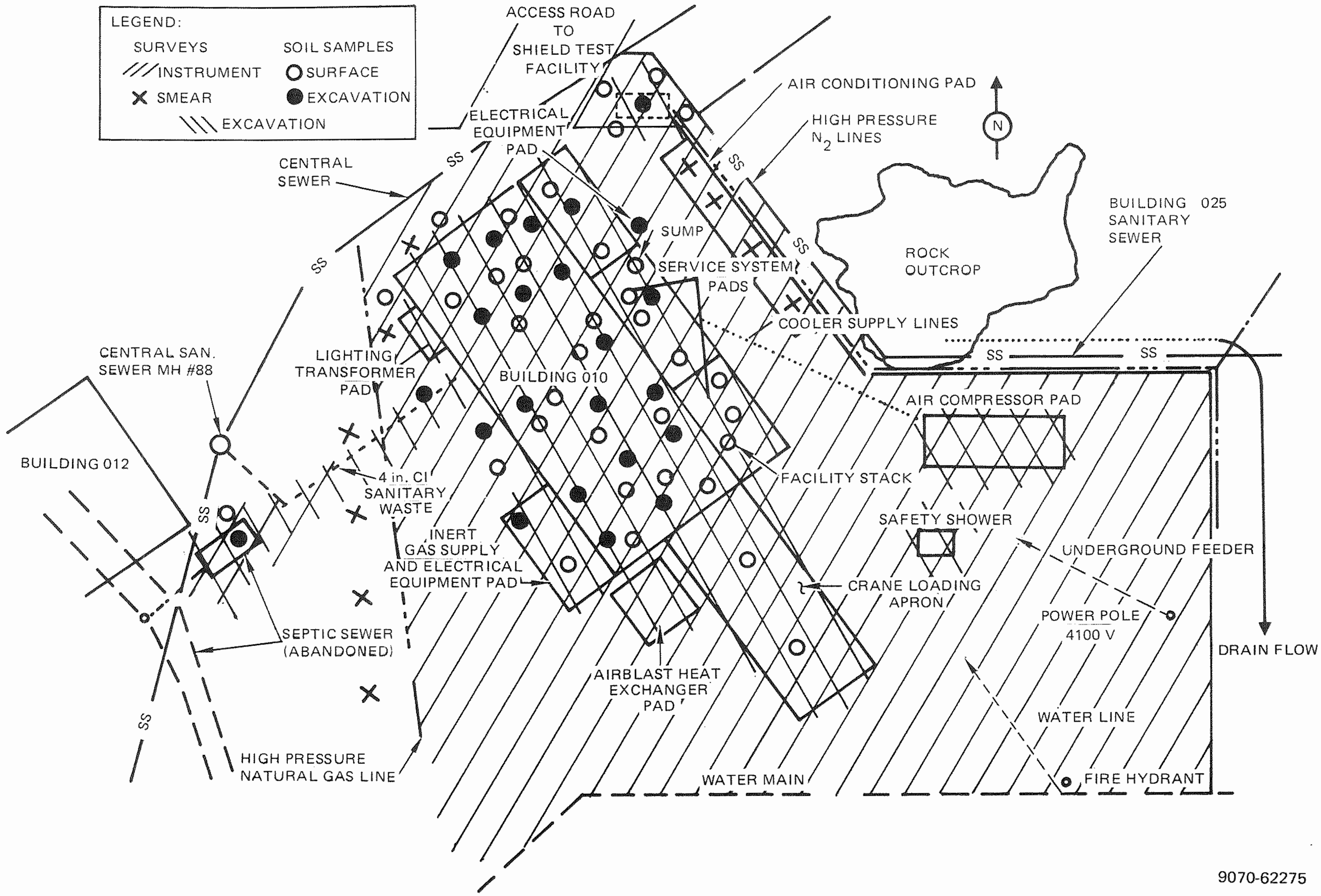

Figure 17. S8ER Facility Final Radiation Survey Plot

The instrument thimble liners were stainless steel. Table 6 displays the maximum specific activity of the significant radionuclides expected to be present circa April 15, 1977.

TABLE 6

PRINCIPAL CALCULATED ACTIVITY IN STAINLESS STEEL INSTRUMENT THIMBLES (At April 15, 1977)

Nuclide	Specific Activity (μCi/g)
^{54}Mn	6.6×10^{-2}
^{55}Fe	0.5×10^{1}
^{63}Ni	5.9×10^{0}
^{60}Co	1.5×10^{1}

A radiation measurement taken at the bottom of an instrument thimble during October of 1977 indicated a maximum radiation level of 60 R/h. The major source of this gamma radiation appeared to be the activated stainless steel in the thimbles and the face of the shutdown shield.

5.2 DECOMMISSIONING RADIOLOGICAL SURVEY OF BUILDINGS, INTERIORS, AND SUPPORT SYSTEMS

Two post-operation surveys were conducted — one as the facility was being released from the reactor operation project for other activities and one several years later as routine surveillance. These two surveys are shown on Figure 4. Surveys for the final decommissioning work were made as the work progressed. The essential survey points are recorded in Figure 17.

Prior to backfilling the excavations, approximately 200 smear samples were taken on the concrete rubble and underground plumbing, including the sanitary sewer leading to the abandoned leach field, that was to remain on the site. All results were documented at less than 50 dpm/100 cm^2 β. All smears were counted for α and β activity on a Nuclear Measurements Corporation automatic counting system, with an average background count of 25 cpm in the β channel and a counting efficiency factor of 2.35 dpm/cpm for β. The efficiency factor corrects the net count rate for geometric and electronic detection efficiency and for absorption in the sample. Alpha contamination was not suspected for this area; however, had any occurred, it would have been detected with this automatic counting system.

All material samples were counted on a Nuclear Chicago automatic counting system with a KCl standard, average background of 20 counts per minute, and a counting efficiency factor of 6.5 dpm/cpm.

The contaminated soil originated from below 10 ft deep along the sides of the reactor shielding and below the primary vault. The contaminated concrete originated from the floor and lower sides of the primary system vault. Concrete samples were obtained from a portion of the primary system vault wall. All samples were less than 50 pCi/g gross β. The ventilation stack and some other reactor support system buried piping had the highest level of radioactive contamination. Smear samples indicated 2500 dpm/100^2 cm maximum removable beta activity.

During the dismantling and excavation activities, water and air samples were collected for analysis and detection of radioactivity. The results were used to assure the safety of the workers and to monitor the discharge of effluents. Water was collected from the sump drain system and vessel pit where rain water accumulated. Air was collected by a continuous air sampler located in the immediate vicinity of the work area, and was periodically examined for any collection of radioactive material.

None of the water samples indicated over 4.5×10^{-8} μCi/ml, β, which is well below the limit of 3×10^{-7} μCi/ml, β for strontium-90 in water released in unrestricted areas. The 200-ml samples were evaporated to about 10 ml on a hotplate and then dried in a heated counting planchette. An automatic counting system with an average background of 20 cpm and 2.59 dpm/cpm efficiency factor was used to measure the radiation. No water samples were collected at the conclusion of the decommissioning, as there was no water remaining at the facility site.

None of the air samples indicated airborne radioactive particulate concentrations, other than the naturally occurring airborne radioactivity, exceeding 10^{-11} μCi/ml, β. This is well below the MPC for cobalt-60, 3×10^{-10} μCi/ml,

$\beta^{-}\gamma$ in unrestricted areas. The samples were collected on filters in a vacuum air sampler located in the immediate vicinity of the decommissioning workers. Air was drawn through the filter at approximately 3 ft^3/h. Each sample comprised the filtrate from 2 to 20 ft^3 of air, depending on the potential exposure and duration of the work. The filter with the captured material was immediately placed in a β, γ counter for a radiation measurement. Delayed counting 24 h later showed a normal background decay to 0.1 to 0.01 of the immediate count.

5.3 FINAL RADIOLOGICAL SURVEY OF REMAINING FACILITIES EQUIPMENT, MATERIALS, AND SYSTEMS

At the conclusion of the decommissioning effort and prior to placing the asphalt paving (Figure 18), a complete walk-through survey of the area was conducted using a Technical Associates Model CP-7 β-γ ion chamber detector. The maximum dose rate detected was 0.05 mrad/h with an average background of

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Figure 18. Final Cleanup and Building Foundation Removal

0.04 mrad/h outside the perimeter fence line. All readings were below the 0.1 mrad/h limit. Background on this instrument is 0.04 ± 0.05 mrad/h. Surface drain lines were specifically checked with this instrument.

The site was declared to be free of all radioactive contamination greater than the limits of Table 1 and the soil to be less than 100 pCi/g gross detectable beta. New imported materials then were used for backfill and finishing.

6.0 QUANTITIES OF RADIOACTIVE WASTE PROCESSED

6.1 CONSTRUCTION MATERIALS — VOLUME AND TONNAGE

A total of 188 boxes of contaminated soil, concrete, and miscellaneous pipe and structural materials were shipped for burial. In addition, the reactor containment vessel and surrounding concrete shield weighing 97 tons were moved in one piece to burial. The total volume buried is 7000 ft^3 and the total weight buried is 250 tons.

6.2 REACTOR SUPPORT SYSTEM — VOLUME AND TONNAGE

Two buried waste holdup tanks and the reactor room ventilation system were removed from reactor support systems. The burial disposition volume was 150 ft^3 and the total weight was 0.5 tons.

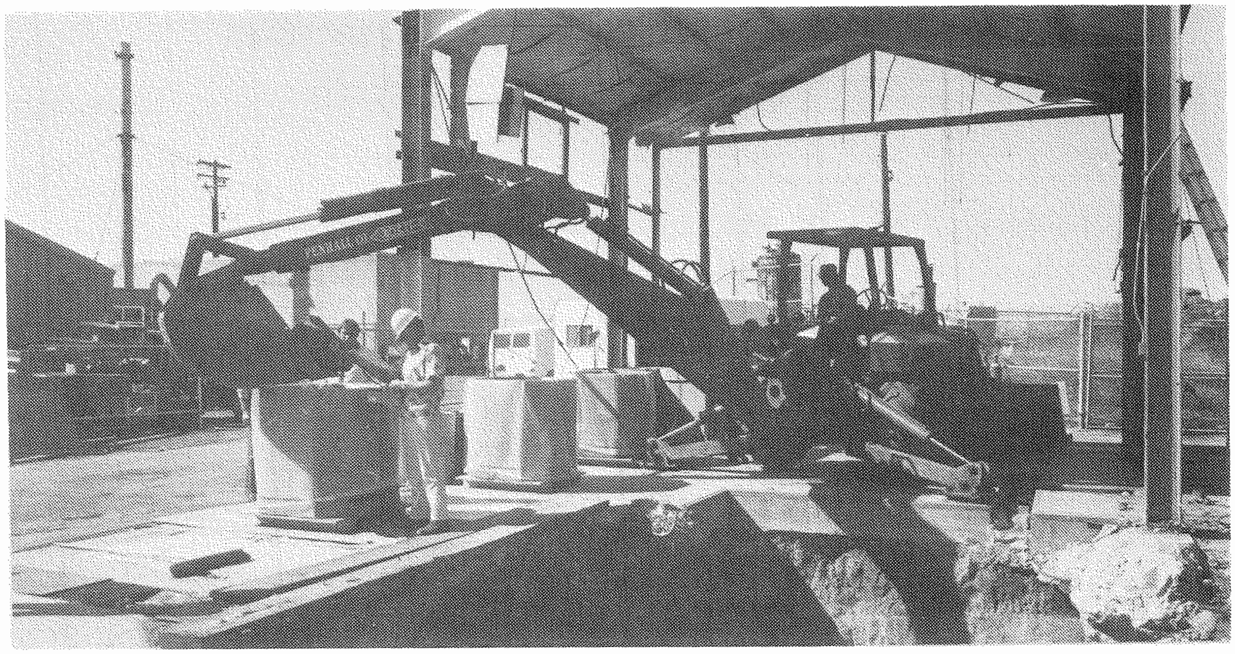

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Figure 19. Surveying Contaminated Soil and Packaging for Burial

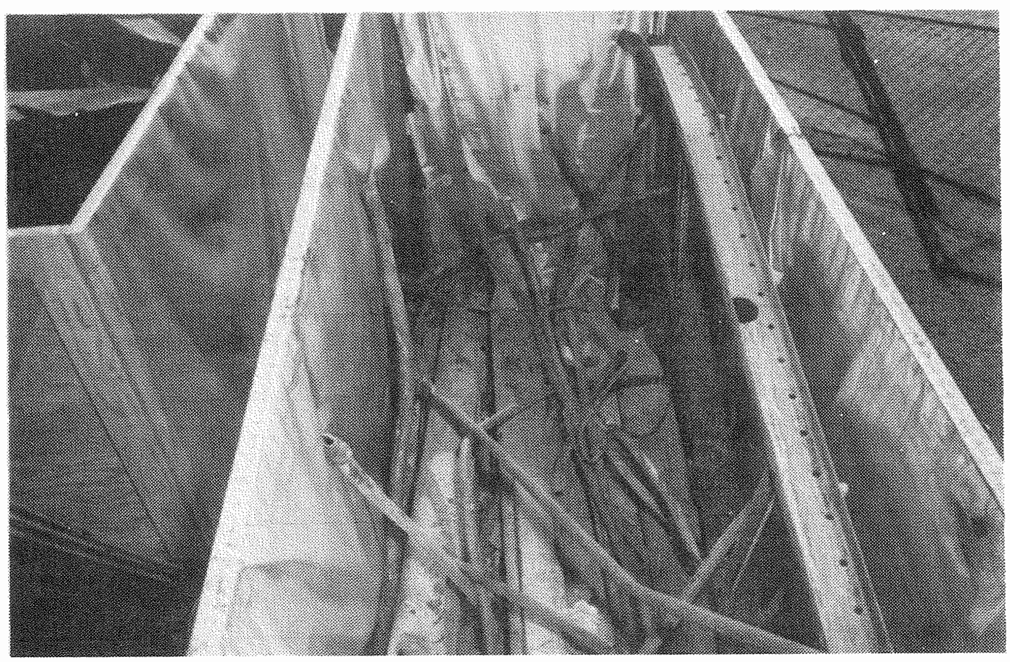

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Figure 20. Special Boxes for Burial of Contaminated and Radioactive Scrap Metal

7.0 TRANSPORTATION AND BURIAL OF RADIOACTIVE WASTE

7.1 LOW SPECIFIC ACTIVITY (LSA) AND HIGH SPECIFIC ACTIVITY (HSA) TRANSPORTATION AND BURIAL COST

There was only LSA material to be disposed of, as the reactor and associated contaminated equipment had been removed and disposed of several years earlier, before the facility was declared surplus to program needs.

All loose contaminated material was boxed and transported by commercial truck to the licensed NECO burial site at Beatty, Nevada. The reactor containment vessel and shield were wrapped with plastic sheeting and tarpaulins for the trip.

The cost of burial at Beatty was increased significantly during this project from $\$2.65/ft^3$ to $\$3.85/ft^3$. The containment vessel was buried at the higher rate.

The cost of transportation was approximately $653 to $775 per trip with a 20-ton load. The one extra wide and heavy load of the shield and vessel cost $31,127, including the crane service for loading and unloading and the wide load escort service.

7.1.1 Special Packaging Costs

The packaging was standardized as much as possible (Figures 19 and 20). The standard box is a knockdown, corrugated-cardboard, double-wall container that will contain 33 ft^3. This is lined with a plastic bag and banded for added strength. The filled box is banded for closure. Each box costs $30 to produce. Several larger special boxes were prepared for odd-shaped structures. Their cost is estimated at $100 each. The wrapping of the containment vessel and attached concrete shield involved placing some extra, temporary lead shielding on the sides and wrapping the complete item with plastic sheeting. The total cost of the extra shielding and shipping protection is estimated at $3000, including labor and materials.

7.2 DISPOSITION SITE

The disposition site for all radioactive waste taken from the Building 010 site is the NECO Site at Beatty, Nevada (Figure 21). It is operated by Nuclear Engineering Company under a State of Nevada license.

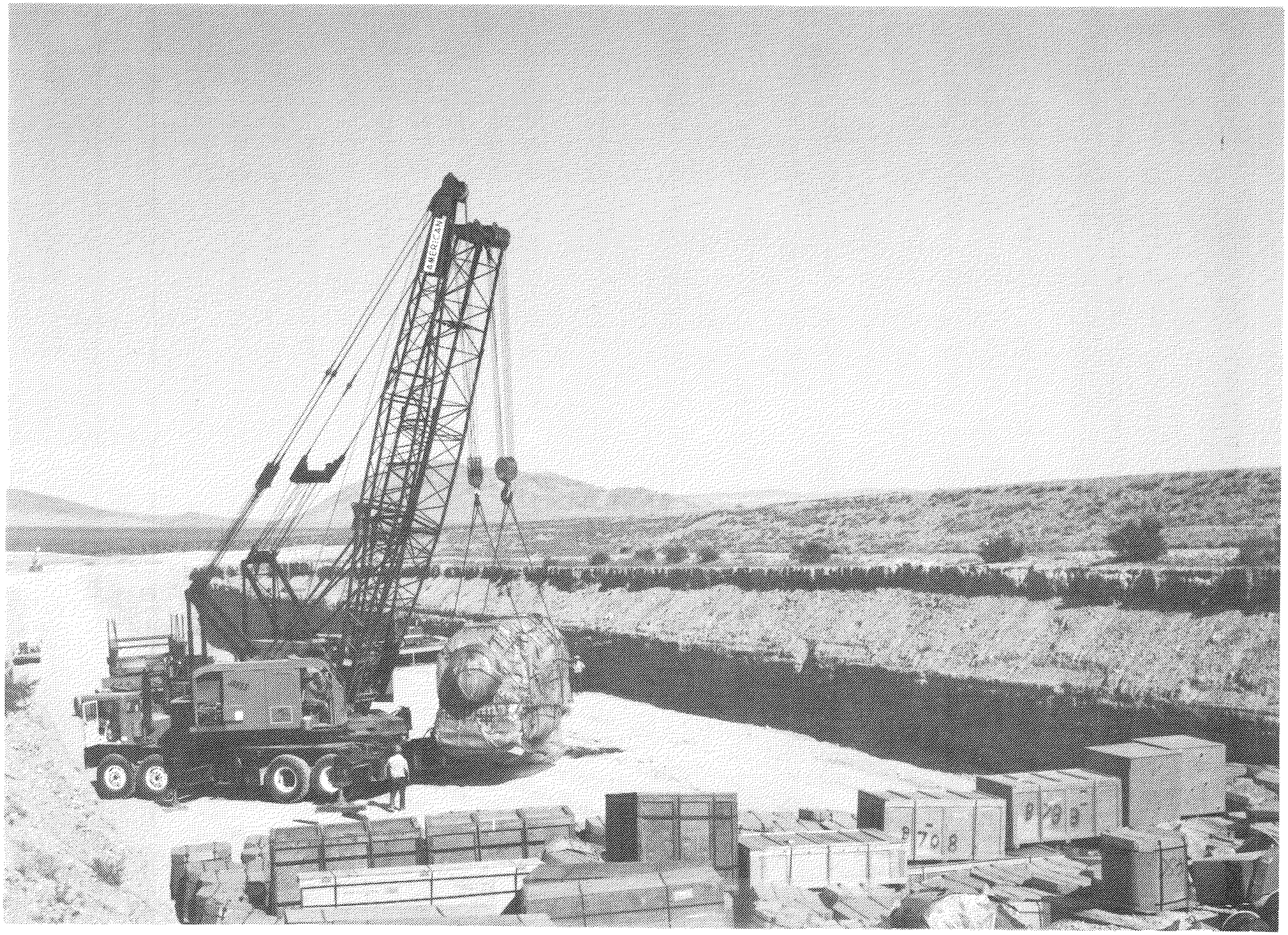

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Figure 21. Burial in the NECO Facility at Beatty, Nevada

8.0 PERSONNEL RADIOACTIVITY EXPOSURE LOG

8.1 TOTAL MAN-REM FOR PROJECT

The group of people working on the S8ER Facility decommissioning project varied in composition as particular talents and personnel availability from other similar assignments permitted. Over the period of project duration, the total group exposure was 2.3 man-rem.

Packaging, handling, and warehousing radioactive waste materials at the nearby RMDF is not included in the above total exposure because the operation involves simultaneous exposure to radioactive waste from several projects.

The RMDF exposure due to processing the large reactor containment vessel shield can be estimated, however, because it was not mixed with other waste and was shipped separately. The preparation for shipment, which included placing temporary lead shielding and wrapping it with plastic sheeting, is estimated to increase the total exposure by 0.75 man-rem. The shield was warehoused for 6 months at the RMDF because of some non-project-related shipping delays. During this time normal operations not associated with this project that were conducted nearby had an estimated increased exposure from the shield source of another 0.5 man-rem. The added exposure that was incurred by loading the shield onto the truck and monitoring the shipment is estimated to increase the total exposure by another 0.96 man-rem.

Including all of these activities together, the total estimated exposure would be 4.5 man-rem.

8.2 MAXIMUM INDIVIDUAL DOSE

The maximum integrated dose received by an individual assigned to the project over the time of active decommissioning was 660 mrem from all sources.

8.3 AVERAGE INDIVIDUAL DOSE

The average individual dose for all workers assigned to the decommissioning project, exclusive of supervision and other nonexposed personnel, was 140 mrem as read from external dosimeters. Including the estimated RMDF exposure will increase the average individual dose to 180 mrem. The routine bioassay of all workers assigned to this project showed negligible internal exposure.

9.0 HEALTH PHYSICS

The S8ER Facility decommissioning program followed guidance contained in ERDA (now DOE) Manual Chapter 0524 for radiological safety and for maintaining personnel exposure to as low as practicable (ALAP). This overall plan was implemented for the specific task of Building 010 decommissioning in the ESG Safety Plan.

The Energy Systems Group Manager of Health, Safety, and Radiation Services (HS&RS) was responsible for establishing standards of safety, examining proposed operations for hazards, determining the safety measures that were necessary, and evaluating the degree of compliance with safety measures, contract safety requirements, licenses, and regulations. Members of the HS&RS staff prepared an Operational Safety Plan in support of the decommissioning program, reviewed all operational procedures documentation, and provided day-to-day health physics and industrial hygiene and safety surveillance of program activities. They also reviewed the qualifications of persons assigned to work in the radiologically posted areas, and established that these persons were fully qualified "radiation workers" possessing sufficient familiarity with the operations in the posted areas to allow them to work safely in these areas.

Since a decommissioning program is a series of nonroutine activities, primary protection was provided by continuous monitoring of radiation exposures and contamination, and by a continuing review and evluation of the individual activities to minimize potential exposures to radiation and radioactive contamination.

Written plans for the decommissioning had detailed reviews, including consideration of various approaches and their effectiveness in minimizing radiation exposure. These reviews considered working times, the radiological hazards involved, and the proper use of protective clothing, shielding, and remote handling equipment, although no remote handling was employed.

Facility equipment, such as necessary ventilation, cooling, and lighting systems, were checked prior to use and had continuing surveillance to ensure proper operation.

A monitoring program was implemented, as required by the operations underway. This included, wherever appropriate, the use of area air samplers, and radiation and contamination surveys. Monitoring and protective equipment was designated as necessary and included personal film badges, special badges for tasks with potential high exposure risk (processed at suitable intervals), protective clothing appropriate to the working conditions, and respirators chosen according to the hazard.

Dosimetry results, as recorded by film badges and bioassay data, and radiation and contamination surveys were evaluated to determine possible means of improving the control procedures and to ensure maintenace of exposures to as low as practicable.

For operations in areas in which conditions were not changing, radiation levels were posted. In most instances, however, the radiation level changed significantly during the course of the work and was monitored frequently.

Procedures for major operations were submitted for review and approval to the Isotopes Committee of the AI Nuclear Safeguards Review Panel, who include in their considerations effective implementation of the ALAP program in the activities under review.

9.1 PUBLIC AND PERSONNEL SAFETY

There were no anticipated large or difficult radiation control problems with the S8ER Facility decommissioning activity. Therefore, no special procedures or precautions beyond the normal project activities were prepared. The work proved to be adequately controlled using the standardized procedures developed for other similar projects at the ESG/SSFL.

9.2 PROTECTIVE PROCEDURES

The protective procedures included those designed to protect workers and the public from unacceptable exposure to the low-level radiation present at the site. Continuous air sampling was performed during concrete-breaking operations. Protective clothing was required. Complete containment of all transported radioactive waste was required. Frequent monitoring of waste prior to removal ensured that no unplanned exposure would occur. The containment vessel was removed with its shield intact to avoid handling an unshielded, high-intensity source. Deep digging was performed with long reach equipment to avoid having workers entering the excavation (Figure 14).

Building 010 was fenced and posted as a radiologically controlled area during the decommissioning activities. The boundaries of the controlled areas varied in order to meet conditions and operations being performed in the facility at the time.

A Restricted Access Area Entry Permit was completed for each shift (depending on the operation to be performed). The HS&RS representative specified on the permit the protective clothing, monitoring devices, and respiratory protection required to proceed with the described task. The requirements varied depending on the degree of contamination and radiation levels involved.

9.3 EQUIPMENT, MATERIALS, AND INSTRUMENTATION REQUIREMENTS

The following types of radiation monitoring equipment were operational and available during the site preparation and removal of radioactive or contaminated components:

a) α Counting System	(1) minimum
b) $\beta\gamma$ Counting System	(1) minimum
c) Juno Survey Meters	(4) minimum
d) G.M. Survey Meters	(2) minimum
e) Contamination Monitors	(2) minimum
f) Air Samplers	(2) minimum
g) Dosimeters	(10) minimum
h) Dosimeter Charger	(1) minimum
i) Visitor Film Badges	(12) minimum

Film badges were worn by all persons entering the radiologically posted areas. Radiation exposure to personnel was maintained at as-low-as-practicable levels.

9.4 ON-GOING RADIATION SURVEYS AND RECORDS

The site was left radiologically noncontaminated and paved with new imported asphalt for use as a parking lot (Figure 22). No further radiation surveys are required.

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Figure 22. Completed Site Paving

9.5 HEALTH PHYSICS COSTS

There were no costs compiled for the instruments and recorders used, since these are all government-owned general laboratory equipment used for many government contract activities. Only the direct charge personnel costs are recorded. The total of these costs is $27,000.

10.0 RECOVERABLE COSTS

10.1 SALVAGEABLE MATERIAL AND EQUIPMENT

Very little of the original structure was salvaged. The principal items were the electrical transformers, crane dollies, and a few electric motors in the heating and ventilation system. Only the crane dollies required decontamination. It was performed at the Radioactive Material Disposal Facility (RMDF), which is fully equipped for this activity. Estimated salvage value on the government surplus list is $10,000.

The noncontaminated sampled concrete was used for some of the excavation backfill and for drainage ditch repair in another nearby area.

10.2 FACILITIES AND SITE

No structures remain. The site is paved over for use as a parking lot. Since this is a small area (1/4 acre) in a large leasehold (90 acres), there is little if any value assigned to the recovery of the site as land area. The principal benefit is the freedom from future surveillance and licensing requirements.

11.0 PROJECT MANPOWER EXPENDITURE

11.1 ADMINISTRATIVE

The administrative hours required to manage the task comprise monitoring of cost and schedule performance, quality assurance, and procurement. The total time is recorded as 2100 manhours.

11.2 ENGINEERING AND LABOR

The Engineering and Labor activity includes preparation of plans and procedures, decontamination operations, radioactive waste handling and packaging, maintenance support, Health Physics support, etc., for the decommissioning work and supervision of the contractors employed to do the work. It is recorded as 6400 manhours.

11.3 SPECIAL PURCHASED SERVICES

Purchased labor from contractors includes all of the skilled and unskilled labor. Skilled labor includes machine operators, pipefitters, and riggers. Unskilled labor includes general laborers for hand digging and material sorting. The contract labor provided 3500 manhours.

12.0 PROJECT SCHEDULE

The project schedule, Figure 23, reflects the planned and actual progress of the job. The prolonged inclement weather disturbed some activities, but the overall schedule performance reflects the flexibility that can be made available in razing operations.

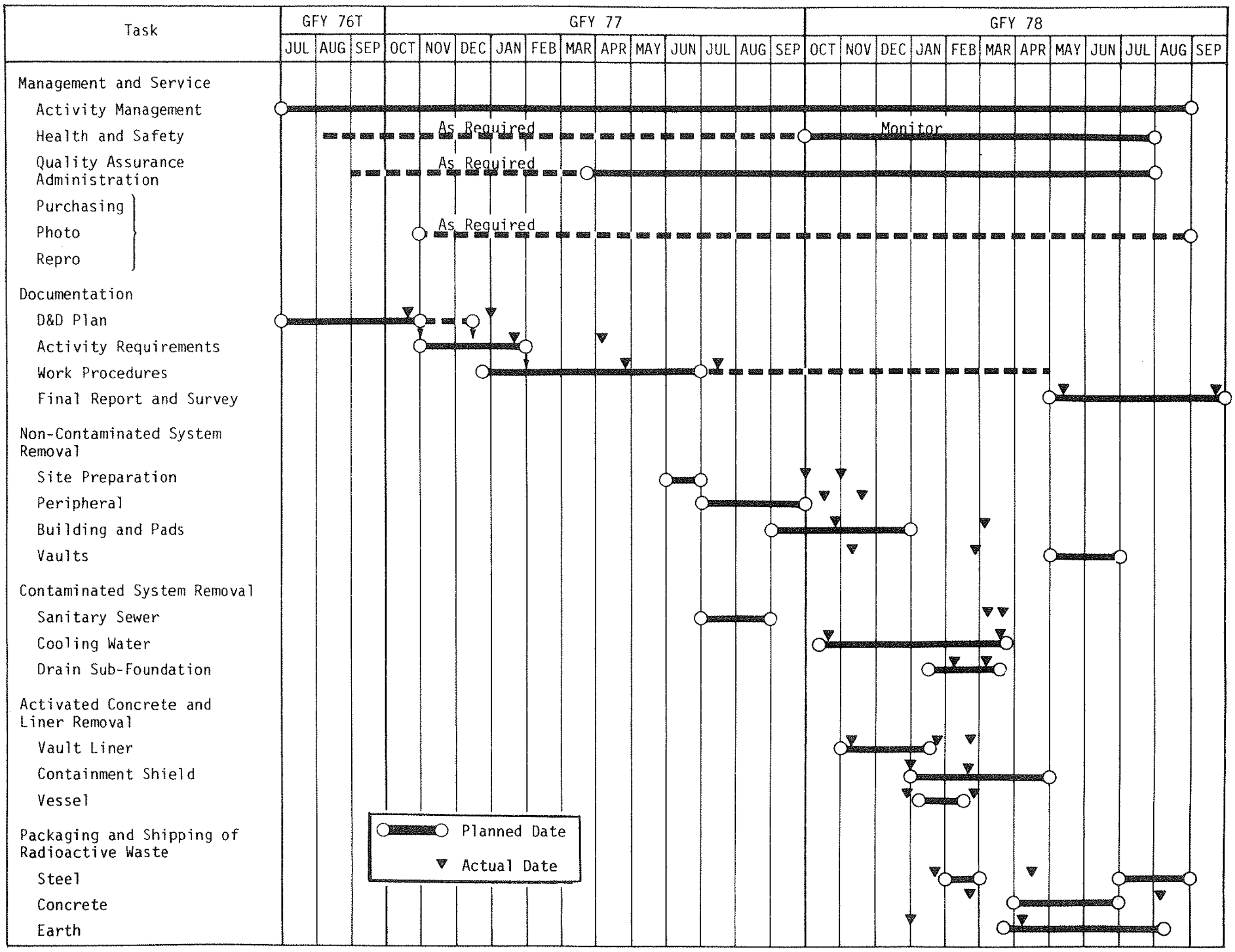

Figure 23. Schedule

13.0 DECOMMISSIONING COSTS

13.1 GENERAL

The reported cost of decommissioning Building 010 was accumulated by the Rockwell International accounting system. The effects of having an experienced work force and well-equipped support facilities in close proximity to the decommissioned site must be considered in making comparisons with other projects.

The Radioactive Material Disposal Facility (RMDF) was a significant advantage in that waste materials could be processed easily, e.g., concentrating liquids, combining box loadings, and filling shipments to the burial site with a mix from other waste-generating activities. The availability of an experienced Health Physics laboratory that could rapidly process and analyze the radioactivity of soil samples minimized the delays in excavation associated with the sampling required to ensure complete removal of all radioactive materials.

The work crews were drawn as needed from an experienced group working on other similar activities, thus also reducing idle time accumulation. Independent contractors were also working several jobs together to contribute availability of specialty machinery at the site and on short notice.

13.2 COST SUMMARY

	Hours	Dollars
Labor Hours (Rockwell)	8500	
Labor Dollars (Rockwell)		$235,000
Material and Purchased Labor (including transportation and burial from Section 7.0)		197,000
General Expense and Fee		67,000
Total Cost		$499,000
Less Estimated Salvage		10,000
Net Cost		$489,000