PHOTOCOPY 019248
DO NOT RETURN TO RHA
CONTROLLED COPY

UNCLASSIFIED

UNC NUCLEAR INDUSTRIES

Subsidiary of United Nuclear Corporation
A UNC RESOURCES Company
P O Box 490
Richland, Washington 99352

PREPARED FOR THE
UNITED STATES DEPARTMENT OF ENERGY
UNDER CONTRACT NUMBER DE-AC06-76RL01857

Document No.
UNI-2983

Date: September 1, 1984
Copy No. 22
(Reserved For Document Control Center Use Only)

RECORD CENTER FILE
REFERENCE COPY
RECEIVED
AUG 30 1984
UNC NUCLEAR INDUSTRIES
DOCUMENT CONTROL CENTER

Title
ACTION DESCRIPTION MEMORANDUM
DECOMMISSIONING OF THE SHUT-DOWN HANFORD 100 AREA REACTORS

Author
J. A. Adams, E. M. Greager, M. C. Hughes

DISTRIBUTION

NAME	BLDG.	NAME	BLDG.	NAME	BLDG.
DOE-RL					
1-5. CE Miller	FED/415	24. DJ Pisarcik	1114N/5		
6. JP Collins	FED/421	25. RF Potter	FED/422		
7. PFX Dunigan	FED/424	26. RA Winship	1155/J		
8. JH Slaughter	FED/655	27. UNI Record	FED/436		
		28. UNI File	FED/436		
UNC		29. Extra			
		30. Extra			
9. JA Adams	1155/J	31. Extra			
10. DF Brendel	1114N/5	32. Extra			
11. RN Coy	FED/395	33. Extra			
12. JJ Dorian	1114N/20	34. Extra			
13. AJ Eirich	FED/422	35. Extra			
14. JT Fulton	FED/422	36. Extra			
15. EM Greager	1114N/17	37. Extra			
16. PW Griffin	1155/J	38. Extra			
17. JA Hall	1114N/12	39. Extra			
18. MC Hughes	1155/J	40. Extra			
19. KD Jones	FED/475				
20. BS Kuntz-Hagan	FED/158				
21. MA Mihalic	1720K/8				
22. SR Morgan	FED/475				
23. MA Payne	1101N/119				

JUN 1990
RECEIVED
EDMC

ROUTE TO	PAYROLL NO.	LOCATION	FILES ROUTE DATE	SIGNATURE AND DATE
UNI-Record				

UNCLASSIFIED

UNC NUCLEAR INDUSTRIES, INC.

RICHLAND, WA. 99352

NOTICE

THIS REPORT WAS PREPARED AS AN ACCOUNT OF WORK SPONSORED BY THE UNITED STATES GOVERNMENT. NEITHER THE UNITED STATES NOR THE UNITED STATES DEPARTMENT OF ENERGY, NOR ANY OF THEIR EMPLOYEES, NOR ANY OF THEIR CONTRACTORS, SUBCONTRACTORS, OR THEIR EMPLOYEES, MAKES ANY WARRANTY, EXPRESS OR IMPLIED, OR ASSUMES ANY LEGAL LIABILITY OR RESPONSIBILITY FOR THE ACCURACY, COMPLETENESS OR USEFULNESS OF ANY INFORMATION, APPARATUS, PRODUCT OR PROCESS DISCLOSED, OR REPRESENTS THAT ITS USE WOULD NOT INFRINGE PRIVATELY OWNED RIGHTS.

DISCLAIMER

THIS REPORT WAS PREPARED FOR USE WITHIN UNC NUCLEAR INDUSTRIES, INC., IN THE COURSE OF WORK UNDER SUPPLEMENTAL AGREEMENT TO THE UNITED STATES DEPARTMENT OF ENERGY CONTRACT DE-AC06-76RL01857. ANY VIEWS OR OPINIONS EXPRESSED IN THE REPORT ARE THOSE OF THE AUTHOR ONLY. THIS REPORT IS SUBJECT TO REVISION UPON COLLECTION OF ADDITIONAL DATA.

SM-6000-305 (11-79)

UNI-2983

ACTION DESCRIPTION MEMORANDUM
DECOMMISSIONING
OF THE
SHUT-DOWN HANFORD 100 AREA
REACTORS

SEPTEMBER 1, 1984

ACTION DESCRIPTION MEMORANDUM
DECOMMISSIONING OF THE SHUT-DOWN HANFORD 100 AREA REACTORS

TABLE OF CONTENTS

	Page
1.0 PROPOSED ACTION	1
1.1 Decommissioning	1
1.2 Decommissioning Approach	1
1.2.1 In-Situ Decommissioning Action	3
1.2.2 Safe Storage/Deferred Dismantlement Action	4
1.2.3 Immediate Dismantlement Action	4
2.0 LOCATION OF THE ACTION	5
2.1 Existing Environment	5
2.1.1 Location and Topography	5
2.1.2 Geology	6
2.1.3 Seismology	7
2.1.4 Hydrology	7
2.1.5 Meteorology	8
2.1.6 Ecology	9
2.1.7 Demography and Land Use	9
2.1.7.1 Land Use on the Hanford Site	9
2.1.7.2 Land Use Adjacent to the Site	10
2.1.7.3 Regional Demography	10
2.1.7.4 Historic and National Landmarks	10
2.2 Facilities Description	11
2.2.1 105 Reactor Building	11
2.2.2 Reactor Block	11
2.2.3 Fuel Storage Basin	15
2.2.4 Radiological Condition of the 105 Reactor Buildings	16
3.0 POTENTIAL ISSUES	18
3.1 Allowable Residual Contamination Levels	18
3.2 The Disposal of Reactor Graphite Containing Carbon-14	19
3.3 Radiation Dose To The Public	19
3.4 Occupational Radiation Dose	21
3.5 Disposal of Radioactive Waste	22
3.6 Impact of Flooding	22
3.7 Air and Water Quality	23
3.8 Long-Term Land Use Commitment	23

TABLE OF CONTENTS - contd.

Page

3.9 Hazardous Wastes 24
3.10 National Historical Site 24
3.11 Socioeconomic Impacts. 24

4.0 REFERENCES 25

LIST OF FIGURES

FIGURE		Page
2-1	Map of Hanford Site.	6
2-2	Typical Hanford Production Reactor	12
2-3	Cutaway View of a Typical 105 Reactor Building	13
2-4	Reactor Block Construction Details	14
2-5	Side View of Fuel Element Storage Basin.	16

LIST OF TABLES

TABLE		Page
1-1	Total Estimated Cost, Occupational Exposure, and Schedule Data.	2
2-1	Hanford Production Reactor Design Data	15
2-2	Inventory of Radionuclides in a 100 Area Shut-Down Production Reactor	17
2-3	Inventory of Radionuclides in a Typical Fuel Storage Basin	18
3-1	Reactor Floor Elevations and Corresponding Water Elevatons at Probable Maximum Flood.	23

DECOMMISSIONING OF THE SHUT-DOWN HANFORD 100 AREA REACTORS

1.0 PROPOSED ACTION

1.1 Decommissioning

The Department of Energy, Richland Operations Office (DOE-RL) proposes to decommission the eight shut-down production reactors located in the 100 Areas of the Hanford Site, Richland, Washington. They are the 105-B, -C, -D, -DR, -F, -H, -KE and -KW reactors. (A ninth reactor, N Reactor was started in 1963 and is still in operation. The decommissioning of N Reactor is not within the scope of this action.)

No long-term beneficial use has been identified for the shut-down reactor facilities. Short-term use of the 105-KE and 105-KW reactor fuel storage basins is required for storage of N Reactor fuel. The fuel should be removed by 1987, after which the basins will be decontaminated and kept in standby condition until final disposition. The remaining reactor facilities were deactivated during the period 1964 to 1971 and have since been kept in a safe storage condition. Safe storage for the reactors has consisted of short-term "fixes" adequate to protect the environment, but not to assure stabilized, long-term storage. The reactors are all contaminated to some degree with low levels of radioactivity.

In compliance with the National Environmental Policy Act (NEPA) of 1969 (Council on Environmental Quality 1978), and the DOE-Environmental Compliance Guide 1981, this Action Description Memorandum (ADM) has been prepared to provide environmental input into the decision making process. The decision to be made is whether or not to carry out the proposed decommissioning action and what level of NEPA documentation will be required to support this action.

1.2 Decommissioning Approach

In support of the proposed action, UNC Nuclear Industries, Inc., a DOE-RL contractor, completed an "Assessment of Decommissioning Alternatives for the Shut-Down Hanford 100 Area Reactors," UNI-2619, Reference 1. In UNI-2619, three viable decommissioning alternatives were objectively evaluated to arrive at a recommended preferred decommissioning disposition. These alternatives are identified in Table 1-1, along with total estimated cost, occupational exposure, and schedule duration.

The data in Table 1-1 shows that the decommissioning alternative with the lowest dollar cost, lowest occupational exposure usage, and shortest project duration is in-situ decommissioning, the technique of disposing the reactor facility in its present location.

TABLE 1-1
TOTAL ESTIMATED COST,* OCCUPATIONAL EXPOSURE, AND SCHEDULE DATA

EIGHT REACTOR FACILITIES

Decommissioning Action	Cost Range ($ Million)	Occupational Exposure (Man-rem)	Project Work Duration (years)
In-Situ Decommissioning	$ 14	40	8
Deferred Dismantlement			
o Safe Storage for 75 years then,	$ 12	300	75
o Piece-by-Piece Removal	$ 145	600	28
	$ 157	900	103
Immediate Dismantlement (Block Intact)	$ 153	520	20

*Costs in constant FY 1983 dollars with no contingency.

The in-situ decommissioning mode has been determined to be feasible based on site specific pathway analysis and DOE dose standards comparisons. A comparison was also made between the pathway analysis results and the regulations developed by the Nuclear Regulatory Commission (NRC) in their licensing of low-level waste burial grounds. The NRC established allowable concentrations to permit 100 years of radionuclide decay before low-level waste burial sites are released from institutional control. In-situ decommissioning of the Hanford production reactors would yield results that are well within the NRC and Department of Energy (DOE) dose limits.

The safe storage/deferred dismantlement mode reflects 75 years of maintenance and surveillance and the associated costs that will be required while waiting for the short-lived radionuclides to decay, plus the costs of the ultimate hands-on dismantlement of the reactor facilities. As shown above, the resulting cost and occupational exposure levels make this model less acceptable as an ultimate disposition mode.

The immediate dismantlement and removal mode reflects the high waste volumes involved and the special equipment and procedures that would be needed to dismantle the contaminated reactor facilities before the resident radionuclides have had time to decay to more easily managed levels.

Upon approval of an action, additional review of the characterization analysis will be performed on individual facilities. The decommissioning actions are described in the following paragraphs.

1.2.1 In-Situ Decommissioning Action

In essence, in-situ decommissioning means disposing of the reactor facility in its present location (as opposed to hauling it away for disposal elsewhere), then installing a protective barrier designed to isolate the radioactive residues from pathways to man and the environment. In-situ decommissioning involves the following tasks:

- Establish allowable residual contamination levels* for each reactor facility.
- Prepare a project plan for the reactor in-situ decommissioning effort, including the necessary forms for recording decommissioning data.
- Where cost-effective, remove facility equipment, reactor components, and other material for possible reuse. The reactor block will be left in place on its foundation with special care taken to prevent damage to it during the in-situ process.
- D&D workers will fix loose contaminants, fill voids using cement slurry mix or earth, seal openings that permit pathways from outside the mound into the reactor, and demolish the perimeter of the 105 buildings.
- To complete the protective barrier, rubble will be used as backfill and covered over with selected material (earth and gravel) from borrow pits located near the reactor.
- Contaminated apparatus, components, debris and other material will either be left in place for the in-situ process, or will be removed and transported to the approved waste burial ground located in the 200 Area.
- Engineering estimates indicate that the earth mound will last a minimum of 500 years with little or no maintenance.

Minimum security, surveillance, periodic inspections, radiation surveys, and maintenance of the in-situ facilities will be provided for the period that will permit the sites to be released for unrestricted use.

*Allowable residual contamination levels for in-situ decommissioning are calculated by the methodology described in PNL-4722/UNI-2522, Allowable Residual Contamination Levels for Decommissioning Facilities in the 100 Area of the Hanford Site, Reference 2.

1.2.2 Safe Storage/Deferred Dismantlement Action

In the safe storage/deferred dismantlement decommissioning action, the facilities are maintained in a safe and secure status for a predetermined period of time to allow decay of resident radionuclides to a level permitting cost-effective hands-on dismantlement work to proceed. For the Hanford 100 Area decommissioning the time period is 75 years, based on the radionuclide inventory in the reactors. This approach includes the following tasks:

- Establish radiological release limits for each reactor facility requiring decommissioning.
- Prepare a project plan for the reactor safe storage/deferred dismantlement decommissioning effort, including the necessary forms for recording decommissioning data.
- Maintain the facilities in a safe storage status for 75 years, to allow decay of high energy gamma emitting radionuclides. Safe storage for the 105 Reactor Buildings will require upgrading the material integrity of the facilities and performing routine maintenance and surveillance, with major maintenance and repairs performed on 20-year intervals, then
- Where cost effective, remove facility equipment, reactor components, and other material for possible reuse. This will occur at the new users expense.
- Remove structures surrounding the reactor block and flood the reactor block with water to provide shielding. Cut and dismantle the reactor block from the top down.
- Prepare contaminated equipment, material, and structures, including the reactor block pieces, for shipment and disposal and transport the waste to the 200 Area waste burial site for disposal.

Minimum security, surveillance, periodic inspections, and radiation surveys will be provided until the sites are released for unrestricted use.

1.2.3 Immediate Dismantlement Action

In the immediate dismantlement action, all radioactive contamination above release limits is removed, allowing the site to be immediately released for unrestricted use. This approach includes the following tasks:

- Establish radiological release limits for each reactor facility requiring decommissioning.

basaltic lavas and interbed sediments of the Columbia River Basalt Group at the base; 2) the Pliocene-age Ringold Formation; and 3) the Hanford Formation, consisting of the Pasco (glaciofluvial) gravels and associated sediments of the late Pleistocene age at the surface.

The surface geology of the site is characterized by a surface layer of light brown, fine, slightly silty (wind-deposited) sand, sparsely covered by vegetation. Although the surface soil is fertile, it has little agricultural value without irrigation. Underlying the surface sands is a mixture of sand and gravel ranging in depth to about 60 m. Basalt rock starts at a depth of approximately 60 m and extends downward over 3,000 m.

Altitudes range from a low of about 105 m above mean sea level (msl) in the southeastern part of the Hanford Site to a maximum altitude of 1,091 m at the crest of Rattlesnake Mountain to the west.

Numerous geological faults have been hypothesized through topographic expression and aerial photointerpretation bases. The most important fault postulated as a potential earthquake generator is the Rattlesnake-Wallula-Milton Freewater segment and the Rattlesnake-Wallula segment of the Olympic-Wallowa Lineament. To date, no strike-slip faults of any magnitude have been demonstrated in the Pasco Basin.

2.1.3 Seismology

Eastern Washington is in a region of low to moderate seismicity that lies between the western Washington and western Montana zones of considerably greater seismicity. On the basis of the damage that has occurred since 1840, the U.S. Coast and Geodetic Survey designated eastern Washington as Zone 2 seismic probability, implying the potential for moderate damage from earthquakes.

The maximum earthquake intensity recorded in historic times within the surrounding areas of Washington and Oregon occurred in 1893 when the Umatilla, Oregon area experienced a shock estimated at VII on the modified-Mercalli intensity scale (MM-VII). An MM-VII earthquake was also experienced in the area of Walla Walla, Washington and Milton-Freewater, Oregon, in 1936. Eastern Washington earthquakes that have occurred in historic times have not been as intense or as frequent as those in western Washington. The strongest earthquakes at Hanford within historic time have not been greater than IV on the Modified Mercalli Scale (MM-IV).

2.1.4 Hydrology

The Hanford Site lies along the Columbia River just upstream of the confluence with the Yakima River. Surface runoff is minimal. The average annual precipitation of about 160 mm mostly evaporates, resulting in small amounts of water available for runoff or infiltration.

The Columbia River has a long-term annual average flow of about 3,600 m^3/s. The Yakima River flows an average of about 90 m^3/s. The flow rates of the Columbia are influenced by water usage and upstream reservoir projects. The reservoirs provide active storage of more than 4.6×10^{10} m^3 (37,000,000 acre feet) of water.

The groundwater below the Pasco Basin is in an unconfined aquifer that ranges between about 105 m above msl at the Columbia River to about 145 m above msl at the west boundary of the Hanford Site. The depth of the water table varies greatly from place to place, depending chiefly on local topography, and ranges from a few cm to more than 100 m below the land surface. Current estimates of the maximum saturated thickness of the unconfined aquifer is about 70 m. Beds of fractured basalt and occasionally permeable sediments between some of the basalt beds underlying the region form confined aquifers at various depths in the basalt. These confined aquifers are important sources of water in many parts of the Pasco Basin.

2.1.5 Meteorology

The Hanford Site lies east of the Cascade Mountains and, as a result, has a semi-arid climate reflecting the rain shadow effect of the mountains. The summer season is characterized by hot, clear, dry weather with occasional strong winds and some clouds associated with mild disturbances moving in from the Pacific. In the wintertime, the intrusion of clouds and rainfall becomes more frequent. Occasionally intrusions of continental polar air masses moving southward from Canada bring colder, dryer air to the Hanford Site.

The local topography also affects the area's climate. Due to the distribution and alignment of local hills and ridges and interlying valleys, the winds in various parts of the Site have preferred directions. The topography not only channels the winds that result from large-scale atmospheric pressure patterns, but also funnels the drainage winds which flow up or down the sloping valleys in response to differential ground heating and cooling.

On the average, January is the coldest month with an average temperature of -1.4°C; whereas July is warmest month of the year with an average temperature of 24.8°C. The coldest temperature recorded was -32.8°C in December of 1919. The maximum temperature recorded was 46.1°C in July of 1939. In the summer daily high temperatures of over 38°C may be expected for 13 days, and in the winter, daily low temperatures of below 0°C may be expected for 115 days of the year.

The relative humidity of the area averages 75.7% in January and 31.8% in July. Values as low as 6% were recorded in July of 1951.

The average annual precipitation for the Hanford Site measured at the Hanford Meteorological Station (HMS) is about 160 mm. About 10% of this amount falls from July through September, while 42% falls from November through January. The greatest amount of rainfall recorded in a 12-hr period was 47.8 mm.

Tornadoes are rare in the area, averaging less than one per year for the entire state. Thirteen tornadoes have been confirmed within 160 km (100 miles) of the HMS since 1916; no loss of life or major damage was associated with them. The maximum estimated wind speed for a tornado at the Hanford Site is estimated to be 200 km/hr (175 mph). The predominant wind direction over most of the region is southwesterly. However, because of local topographic influences, the predominant wind direction at the HMS and over much of the Site is northwesterly.

2.1.6 Ecology

The Hanford Site is an isolated, controlled access area and has been used for production and test reactor operations and related activities for nearly four decades. Much of the Site has been disturbed from its natural state, either by early farming activities or by post-1943 construction and operation of the plutonium production facilities at Hanford. Those areas that have not been disturbed are dominated by sagebrush and bitterbrush with an understory dominated by cheatgrass and Sandberg's bluegrass.

Mule deer, raccoon, beaver, muskrat, and mink are present within the Hanford Site and are usually found in the areas adjacent to the Columbia River. Coyotes and jackrabbits are widely distributed throughout the Site. Small mammals are abundant with the Great Basin pocket mouse being the most plentiful.

The chukar partridge, Chinese ringneck pheasant, California quail, ducks, and Canadian geese may be found during the year within the confines of the Hanford Site. Migratory waterfoul are usually found along the Columbia River, but occasionally use the waste ponds and ditches in the 200 and 300 Areas as resting and feeding stops.

The Columbia River (fifth largest river in North America) is the dominant aquatic ecosystem on the Hanford Site. Numerous dams have been built on the river, with the only free-flowing U.S. section occurring between Priest Rapids Dam and McNary Reservoir (along the Hanford Site). No significant tributaries enter the stream in this section.

2.1.7 Demography and Land Use

2.1.7.1 Land Use on the Hanford Site

Current major operations on the Site include a plutonium production reactor, fuel reprocessing and waste management activities, the Fast Flux Test Facility (FFTF) and support facilities. The Washington Public Power Supply System has completed construction of one commercial nuclear power plant and has mothballed two more plants on an area of the Site leased from the Department of Energy.

The 310-Km^2 area in the southwestern corner of the Hanford Site is set aside for long-term ecological studies. Other areas of the Site are managed for short-term ecological study. Islands in the upper portion of the Columbia River adjacent to the Hanford Site are excluded from public use by the DOE and are used for wildlife refuge and DOE environmental research. The land north of the Columbia River is owned by DOE and maintained under agreements between DOE and the Washington State Department of Game and the U.S. Bureau of Sport Fisheries and Wildlife as controlled hunting areas and game refuge.

2.1.7.2 Land Use Adjacent to the Site

Land use within a 50-km (30-mile) radius of the Site includes residential, suburban, corporate city, agricultural, industrial and commercial, scenic, recreational, and general use land areas. The predominant use of lands within the 50-km radius is agricultural, with the farms located along or near all the Site boundaries.

2.1.7.3 Regional Demography

Human population within 50 miles of the Hanford Site totals about 250,000. The closest large population center is the Tri-Cities (Richland, Kennewick, and Pasco), with about 88,000 people. The Tri-Cities is located about 30 miles to the south of the Hanford 100 Reactor Areas, downstream on the Columbia River. The metropolitan Yakima area is about 45 miles to the east and has a population of about 53,000. Other population near the Hanford Site is spread out in small communities and agricultural land.

In 1980, an estimated 341,000 people were living within a 50-mile (80-km) radius of HMS; by 1990 it is estimated that the number will grow to 417,000.

2.1.7.4 Historic and National Landmarks

The Columbia River shoreline and islands from Vantage downstream to Umatilla are rich with Indian artifacts. Eight designated archeological districts located on or adjacent to the Site are included in the Washington State and/or National Registers of Historic Places or the National Register of Historic Landmarks. Six of these districts are located adjacent to or on islands in the Hanford reach of the Columbia River. The Snively Canyon Archeological District and the Rattlesnake Springs Archeological District are located on the west side of the Site near Rattlesnake Mountain. The age of archeological materials in the vicinity of the Hanford Site is approximately 13,000 years for artifacts found in the Horse Heaven Hills down to current times on the Hanford Site itself.

2.2 Facilities Description

2.2.1 105 Reacotr Building

The eight shut-down production reactors in the Hanford 100 Area were constructed during the period 1942 to 1955. All have been inactive since 1971 or earlier. The principal facilities involved in the action proposed in this memorandum include the reactor, and the reactor buildings (105 building). A typical Hanford Production Reactor (100-D) is shown in Figure 2-2.

The 105 reactor building houses the production reactor and related systems and equipment. A typical 105 reactor building (Figure 2-3) is a reinforced concrete and concrete block structure some 250 ft long x 230 ft wide x 95 ft high. The building has massive (3 ft to 5 ft thick) reinforced concrete walls around the reactor block at the lower levels to provide additional radiation shielding, with lighter concrete construction above -- either concrete block or corrugated asbestos cement. Roof construction is primarily precast concrete tile or poured insulating concrete.

Except for the reinforced concrete portions, these buildings can be classified as light, non-airtight, industrial structures.

As shown in Figure 2-3, the reactor block is located near the center of the building. Hydraulically operated, horizontal control rods penetrated the left side (when facing the reactor front face) of the reactor block. Vertical, gravity-drop safety rods enter the top of the reactor. Fuel discharge and storage-areas are located adjacent to the rear face of the reactor. Experimental test penetrations are on the right side of most of the reactors.

2.2.2 Reactor Block

The reactor block (Figure 2-4) consists of a graphite moderator stack encased in steel and masonite thermal and biological shields. The entire block rests on a massive concrete base and foundation arrangement. A typical reactor block assembly weighs approximately 9,000 tons, and has overall dimensions of 46 ft high, by 46 ft wide, by 40 ft deep.

The principal components of a production reactor block are:

- The reactor moderator stack, which is an assembly of graphite blocks cored to provide channels for process tubes, control rods, and other equipment,
- The process tubes, which contained the uranium fuel elements and provided channels for cooling water flow,
- Horizontal control rods,
- Vertical safety rods,

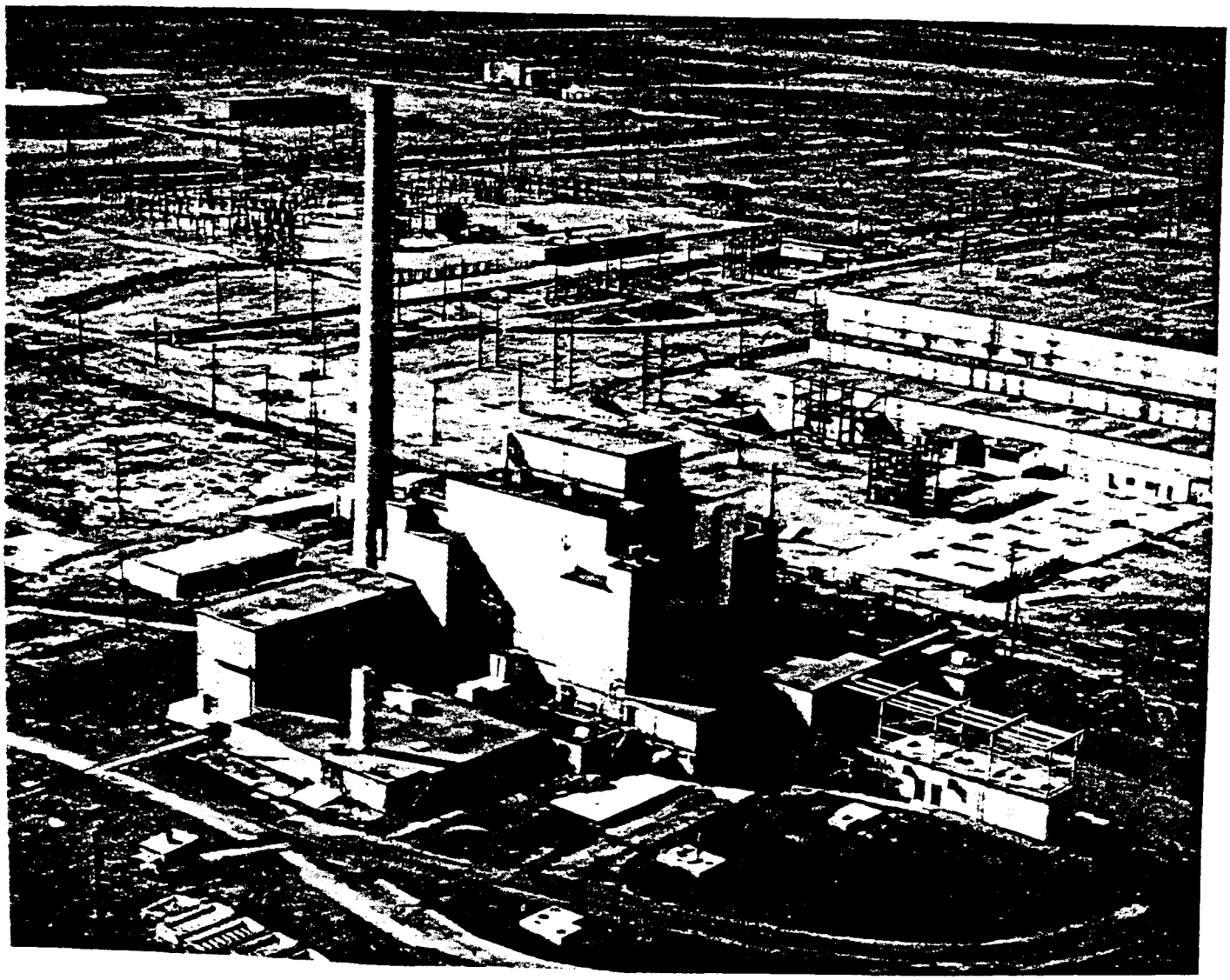

FIGURE 2-2. Typical Hanford Production Reactor.

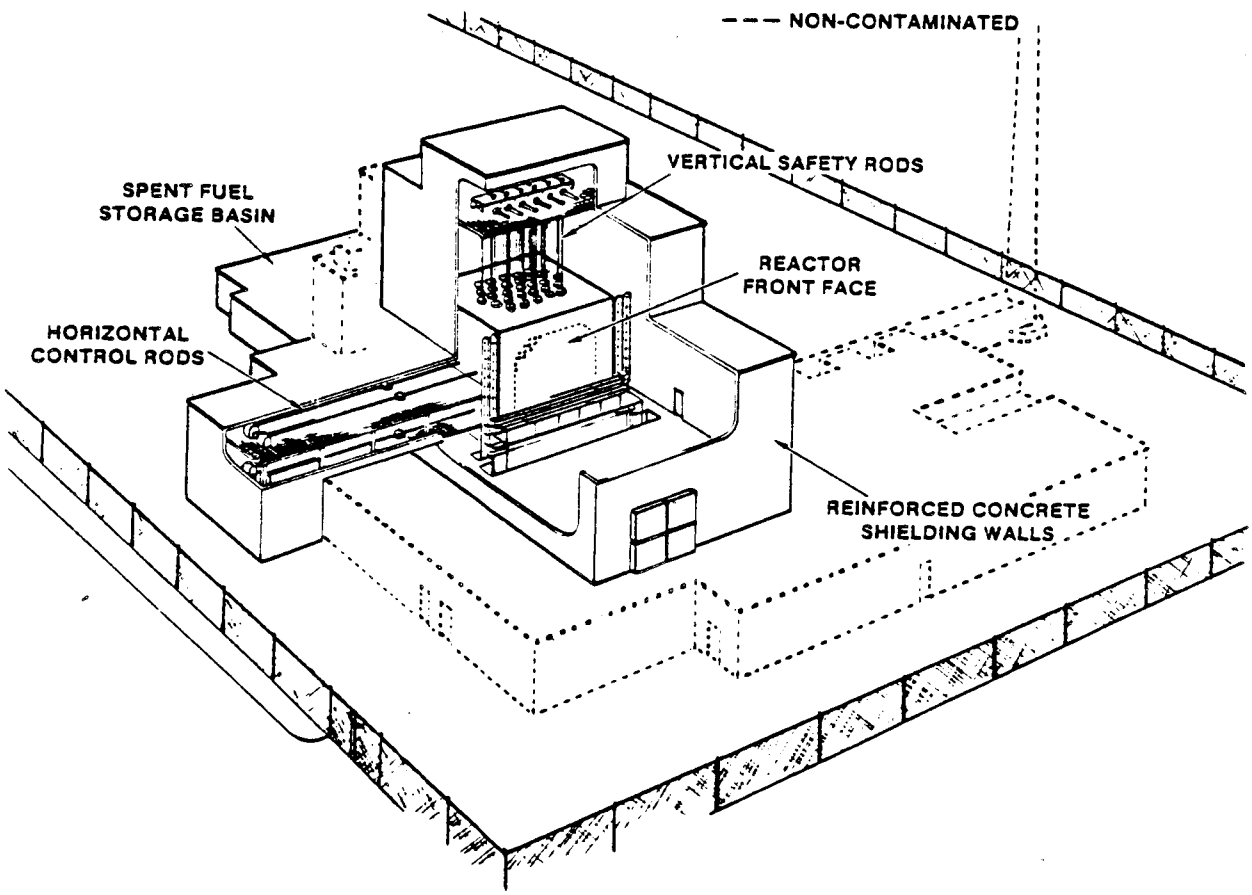

FIGURE 2-3. Cutaway View of a Typical 105 Reactor Building.

UNI-2983

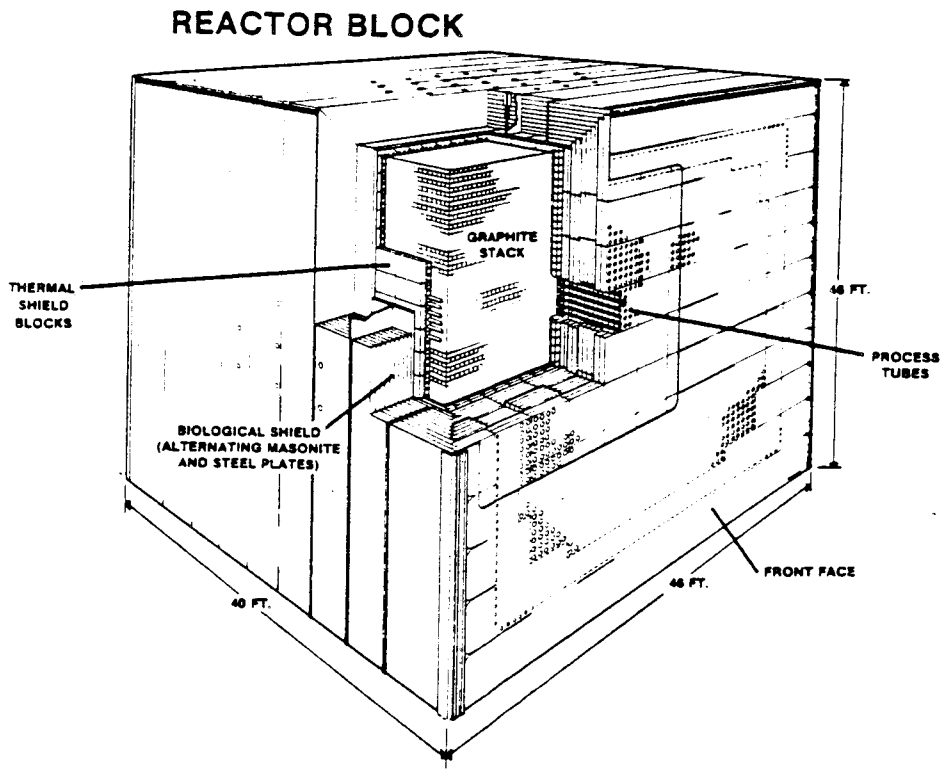

FIGURE 2-4. Reactor Block Construction Details

- Ball 3X system, for dropping "reactor poison" (neutron absorbing) steel balls into vertical safety rod channels for emergency reactor shutdown,
- Monitoring equipment and experimental and test equipment,
- Thermal and biological shielding, surrounded by a heavy, vault-like steel outer shell equipped with gas-tight seals for the reactor block penetrations.

As shown in Figure 2-4, shielding around the graphite stack consists of a thermal shield (cast iron 8 to 10 in. thick) and a biological shield (alternating layers of steel plate and masonite or heavy-aggregate concrete 40 to 83 in. thick). Some deterioration (powdering) of the masonite has probably occurred, but this deterioration has not reduced the structural integrity of the reactor block as a whole.

The shut-down production reactors are quite similar in design. The K Reactors differ from the older production reactors mainly in the number, size, and type of process tubes, the size of the moderator stack, and the type of shielding employed. Table 2-1 gives information on reactor block size and construction materials for all eight shutdown reactors. All remaining radioactive materials are classified as low-level waste as defined by DOE and NRC.

TABLE 2-1
HANFORD PRODUCTION REACTOR DESIGN DATA

Reactors	Graphite Stack Dimensions (ft)			Process Tubes			Thermal Shield		Biological Shield	
	Front to Rear	Top to Bottom	Side to Side	Number	Type	ID (in.)	Type	Thickness (in.)	Type	Thickness (in.)
B, C,[a] D, DR, F, H	28	36	36	2004	Aluminum	1.75	Cast Iron	8-10	Steel and Masonite	52
KE, KW	33.5	41	41	3220	Zircaloy and Aluminum	1.8	Cast Iron	10	Heavy-Aggregate Concrete	45-83

[a]C Reactor has slightly larger diameter process tubes than the other reactors in this group. It contains about 60 Zircaloy process tubes, and has a heavy-aggregate concrete biological shield (7 ft thick) atop the reactor in place of steel and masonite.

2.2.3 Fuel Storage Basin

Each 105 Reactor Building contains a fuel storage basin. The basins served as a collection, storage, and transfer facility for the irradiated fuel elements discharged from the reactor. A typical reactor fuel storage basin (as shown in Figure 2-5) consists of the metal pickup area, the storage area, and the transfer area. Irradiated fuel elements were sorted in the pickup station, transferred to buckets, transported by monorail to the storage area and held to allow decay of short-lived radionuclides prior to reprocessing. Following the storage period, the buckets of fuel elements were moved to the transfer area, where they were placed in railroad cask cars for transport to the chemical reprocessing facilities.

An underwater inspection facility was included in some storage basins. A "wash pad" which was used for equipment decontamination, was included in every storage basin area.

The total area of each fuel storage basin, including the metal pickup and transfer area, is 7,000 ft^2 to 10,000 ft^2. The basins are about 22 ft deep and contained about 20 ft of water during operating periods. The fuel storage basins in 105-F and 105-H Buildings have been filled with soil, whereas the water levels below 20 ft have been maintained in the other inactive basins to cover the contamination in the basins.

The storage area of each basin (except for KE and KW Reactors) is equipped with 19 rows of 6 steel posts used to support a slotted wooden floor over the basin. The rows are 60 ft long and are centered about 4 ft apart. The floors in the KE and KW Reactor basins consist of steel gratings suspended from the ceiling.

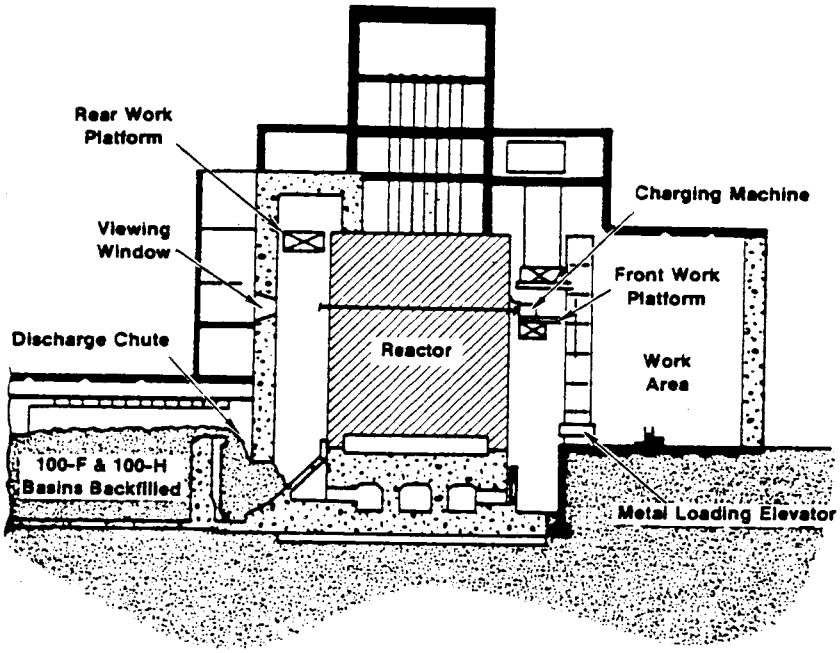

FIGURE 2-5. Side View of Fuel Element Storage Basin: For 100-B, D and F.

The average thickness of the outside walls and bottom of the basins is 20 in. and 6 in., respectively. The total volume of concrete in each basin is estimated to be about 750 yd^3.

Buckets were used to transport and store the fuel elements and other equipment. The galvanized buckets at K Area were removed and buried as solid waste, and the stainless steel buckets were removed and stored inside the 105 Building.

The 105-KE and 105-KW basins are currently being used to store irradiated fuel from N Reactor. The basins will continue to be used until the fuel can be processed at PUREX. The estimated date for completion of this work is 1987.

2.2.4 Radiological Condition of the 105 Reactor Buildings

All reactor fuel elements will be removed from the 105-KE and 105-KW fuel storage basins prior to decommissioning the 105-KE and 105-KW Reactor Buildings. The residual radioactive material that remains in each 105 Building is contained principally within the reactor block and in the irradiated fuel storage basin. The radioactive materials in the reactor block are contained in the graphite stack and in the thermal shield, process tubes,

and control rods. Table 2-2 shows the estimated radionuclide inventory, for one typical reactor block graphite stack and thermal shield. Based on these data, the graphite stack thermal shield and other reactor components classify as low-level waste.

The major source of radioactivity outside the reactor block is the sludge on the floors of the irradiated fuel storage basins. Table 2-3 shows the estimated radionuclide inventory, for one typical fuel storage basin. Based on these data, the sludge classifies as low-level waste. Prior to decommissioning the reactor building, the sludge and water will be removed from the basins, and the residual radioactivity will be fixed on the basin floor and wall surfaces.

TABLE 2-2
INVENTORY OF RADIONUCLIDES IN A 100 AREA
SHUT-DOWN PRODUCTION REACTOR*

Note: Typical inventory for one of eight production reactors. Radiological data calculated for March 1, 1985 inventory.

Radioactive Material	Half-Life (yr)	Total Inventory (Ci)
^{3}H	12.33	700
^{14}C	5,730	4,000
^{60}Co	5.27	3,000
^{63}Ni	100	700
^{90}Sr	29	0.002
^{93}Mo	3,500	2.0
^{94}Nb	20,000	2.0
^{137}Cs	30.17	0.002
^{152}Eu	13.4	8.0
^{154}Eu	8.2	0.3
^{238}Pu	87.74	4.0
$^{239/240}Pu$	24,110	3.0
Typical Reactor Total Ci present:		8,000

*Best estimate based on available data.

TABLE 2-3
ESTIMATED INVENTORY OF RADIONUCLIDES IN A TYPICAL FUEL STORAGE BASIN

Note: Typical inventory for one of eight fuel storage basins. Radiological data calculated for March 1, 1985 inventory.

Radioactive Material	Half-Life (yr)	Total Inventory (Ci)
^{3}H	12.33	0.01
^{60}Co	5.27	12.0
^{63}Ni	100	25.0
^{90}Sr	29	0.9
^{137}Cs	30.17	4.
^{152}Eu	13.4	2.
^{154}Eu	8.2	4.
^{155}Eu	4.76	0.3
$^{238}U+D$	1,500,000	0.001
^{238}Pu	87.74	0.004
^{239}Pu	24,110	0.08
Estimated Total Ci Present:		50.0

3.0 POTENTIAL ISSUES

3.1 Allowable Residual Contamination Levels

A major requirement for the successful decommissioning of radioactive contaminated facilities or sites is a determination of the Allowable Residual Contamination Levels (ARCL). The ARCL method has been under study at Pacific Northwest Laboratory since 1976. Its first application was part of a conceptual decommissioning study conducted for the U.S Nuclear Regulatory Commission (Schneider and Jenkins 1977, Reference 4).

The primary objective of the ARCL method is to provide a formal system for determining if a site requires further decontamination. A secondary objective is to permit a determination of what remedial actions could be effective. The ARCL method does not choose the most appropriate disposal alternative; it does not set the exposure criteria, nor does it identify the best means of hazard mitigation.

The heart of the ARCL method is an analysis of the various pathways through which the radioactive material could reach man, and the potential maximum annual radiation dose an exposed individual could receive through the sum of those pathways. If the potential dose to the individual is lower than the

selected dose limit*, then no further actions are required for that site. If it is predicted that the potential dose may exceed the limit, remedial action will be required to 1) stabilize the site to allow time for the radionuclides to decay below the dose limit, or 2) decontaminate the site to achieve the dose limit potential.

The ARCL method has been approved by DOE for application during decommissioning of nuclear facilities at the Hanford Site. Further details about the general method for calculating the ARCL of various mixtures of radionuclides can be found in a recent document by Kennedy and Nappier, Reference 2.

3.2 The Disposal of Reactor Graphite Containing Carbon 14

In each shutdown Hanford production reactor the graphite moderator contains an estimated average of 4,000 Ci of Carbon 14. The graphite has a compressive strength near that of concrete. A portion of the graphite may have been damaged by mechanical means over the long operating period; therefore, a small quantity of it may exist in a particle form.

The average concentration of the C-14 is approximately 4 Ci/m^3. NRC regulations (10CFR61, Table 1 of Section 61.55) permits shallow land disposal of low-level waste of Carbon-14 in concentrations up to 8 Ci/m^3. The NRC limit was arrived at by assessing the potential pathways to man and the environment, including the possibility of inadvertent human intrusion.

In-situ, or immediate removal with total-block disposal of the reactor serves to keep the graphite inside the vault-like reactor shielding. The shielding acts as an intrusion barrier and consists of an 8 inch thick cast iron thermal shield surrounded by alternate layers of steel and masonite with a thickness of 52 inches. Process tubes and control rods penetrate the shielding creating openings for the graphite to migrate. However, the graphite in its present state is bound within the graphite blocks and is thus not easily dispersible. Significant realistic pathways to man, the water table, or the rest of the environment are not evident.

3.3 Radiation Dose to the Public

Decommissioning the shut-down 100 Area reactors is not expected to result in any measurable incremental radiation dose commitment to the general public. Procedures and practices for decommissioning will be applied to assure that the general off-site public does not receive a dose commitment from routine decommissioning activities. Depending upon the future use of the 100 Area, the type of access to the sites that will be allowed by DOE, and the decommissioning action taken, members of the public could receive an

*Onsite dose limits for unrestricted release are yet to be established by DOE. Offsite dose limits will be established by EPA.

incremental dose commitment only if they are actually in one of the 100 Areas. Any such radiation dose would be in compliance with appropriate guides and standards, as discussed in paragraph 3.1 and 3.2.

The radiation dose commitment to the public from postulated accidents during decommissioning has been evaluated in the Environmental Assessment for 100-F Area Decommissioning, U.S. DOE, 1980 Reference 5. Since the 100-F Area is the 100 Area closest to the local population center (the Tri-Cities), it is assumed that postulated accidents in the 100-F Area would have a more significant impact on the general public than like accidents at other 100 Areas. The "worst-case" postulated accident is a transportation accident involving moving the graphite from the 100 Area to the 200 Area burial ground as a result of the immediate removal/block intact or deferred dismantlement/ piece-by-piece decommissioning action.

Radioactive solid wastes produced in the 100-F Area immediate dismantlement or deferred dismantlement decommissioning action program will be transported by truck or rail to approved burial facilities in the 200 Areas.* Shipments will be made over approximately 15 miles of roadway or rail within the controlled area of the Hanford Reservation. At no point will the shipment routes intersect any highway with unrestricted public access. If the reactor block is moved intact, it will be transported on a crawler/tractor along a predetermined route to the 200 Area.

Approximately 100,000 ft^3/year of contaminated solid waste will be transported to the 200 Area as the result of a dismantlement project. The bulk of the wastes (70%) will contain only a few hundred curies of mixed fission and activation products. The remaining several thousand curies of radioactive waste will be contained within the reactor block. All of the radioactive solid wastes, however, will be low specific activity (LSA) wastes. As LSA materials, the wastes will be packaged in strong, tight, sealed containers which would withstand the conditions of transport under which they will be used. The exact packaging procedures have not been established. Utilization of modified retired rail freight cars is being considered as a possible economical method of packaging, shipping, and burial of the contaminated waste from 100-F Area.

A rail car carrying reactor thermal shield waste to the 200 Areas could contain up to 1,200 Ci of cobalt-60, and 30 Ci of nickel-63. Radioactivity within the reactor thermal shield wastes is induced activity within cast iron blocks, therefore, there would be little potential for dispersal of radioactivity to the environment from any shipping accident pertaining to these wastes.

*It is estimated that a total of 6,000 ft^3 or less of radioactive waste will be shipped to the 200 Area, if the in-situ decommissioning action is implemented. Therefore, the shipping accident scenario is of a much smaller scale with the in-situ action as it is to the immediate removal or deferred dismantlement action.

A shipping accident during which the entire contents of a railroad freight car filled with contaminated graphite were spilled out onto the surrounding ground area has been evaluated. The resuspension of radionuclides by wind currents would not be a likely occurrence, since the graphite will be wet or damp as the result of flooding the reactor core during dismantling operations. For purposes of dose assessment, however, 0.05% of the total radionuclide inventory was conservatively assumed to be suspended over an 8-hour period as the result of 22 mph (10 m/s) winds. Source terms for this accident are given in the Environmental Assessment for 100-F Area decommissioning, Reference 5.

The accident is assumed to occur near the 105-F reactor building, the point along the shipment route closest to unrestricted access by the general population. Moderately stable atmospheric conditions are assumed. Using the Hanford meteorological model and a ground level release, the 50-year dose commitment to the critical organ, bone, was calculated for a maximum individual located approximately 700 m northeast of the 105-F building. This maximum individual represents a fisherman (or equivalent) moored along the Columbia River at a point closest to the 105-F building during the duration of the release. The 50-year dose commitment to the bone of an individual in the closest residence to the 105-F building was also calculated. The maximum individual would incur a 50-year dose commitment to the bone of 1.0×10^{-1} rem, and the individual in the closest residence 3.0×10^{-3} rem. These dose estimates are lower than many of the dose commitments resulting from accidents described in ERDA-1538, Reference 2. Furthermore, the resuspension of radionuclides could be essentially eliminated if the graphite and surrounding soil were maintained wet until any loose material could be immobilized. The individual along the river bank would also be evacuated under such conditions drastically reducing his potential dose.

An analysis of credible accidents associated with decommissioning the shutdown reactor facilities will be performed. Recommendations from this analysis will be used in the design of work procedures to keep any radiological releases due to credible accident conditions at as Low as Reasonably Achievable (ALARA) levels.

3.4 Occupational Radiation Dose

Workers dismantling and decontaminating the radioactive components of the shut-down 100 Area reactors will be exposed to some radiation. Radiation exposure to individuals will be limited to reflect DOE guidelines. As shown in Table 1-1, the total estimated occupational radiation dose is lowest with the in-situ decommissioning alternative. In-situ decommissioning would result in approximately 40 man-rem of exposure for the reactor buildings. The safe storage/deferred dismantlement approach would lead to an occupational exposure of about 900 man-rem for the reactor buildings. Using the immediate dismantlement alternative would result in approximately 520 man-rem of exposure for the reactor buildings.

Occupational and public safety and environmental protection will be of paramount importance in the performance of the 100 Area decommissioning activities. Working procedures will conform with DOE health and safety criteria and guidelines and with UNC health and safety specifications. The radiological safety program during decommissioning will employ the following strategies.

a) Trained health physics personnel will be at the job site at all times to provide dose rate evaluations and in general assist in maintaining good contamination and radiological control.

b) Air monitoring will be provided during all operations where measurable airborne contamination could potentially occur. The air monitoring equipment will be capable of providing an alarm should air contamination become a problem. Grab air samples will be taken as deemed necessary by health physics personnel.

c) Depending on the decommissioning mode that is implemented, special handling equipment plus a containment envelope in specific areas may be required. Persons working within these areas will be required to wear protective clothing and/or other protective gear as required.

d) Health physics personnel assure that decommissioning activities are carried out in accordance with all appropriate radiation protection standards, especially with regard to the ALARA principle.

3.5 Disposal of Radioactive Waste

Radioactive waste generated during the decommissioning of the reactors listed in this memorandum is classified as low-level waste. Clean materials will be salvaged for reuse, sold as scrap, or used as backfill material. The amount of low-level waste that will be removed from the sites to the approved waste burial site at the 200 Area will depend upon which decommissioning mode is used.

Approximately 6,000 ft^3 of low-level waste from the eight reactor buildings would result from the in-situ decommissioning alternative. The safe storage/deferred dismantlement alternative would result in the generation of 1,800,000 ft^3 of waste from the reactor buildings. Immediate dismantlement would involve 3,400,000 ft^3 of waste from the eight reactor buildings.

3.6 Impact of Flooding

The flooding conditions predicted by the Army Corps of Engineers indicates that at least portions of 100-D, 100-H, and 100-F Areas are in the floodplain of the probable maximum flood (PMF). The estimated Columbia River flow rate for the PMF at Hanford is 1.44×10^6 ft^3/s, however the 100-year flood peaks at a flow rate much less than the PMF. The ratio of river flow during the 100-year flood to that of the PMF has been predicted at 0.45. Portions of

100-H and 100-F Area may still be in the floodplain during the 100-year flood, however, flood damage during the 100-year flood would be much less than the damage incurred by the PMF.

A comparison of the floor elevations of the reactor buildings and water elevations during the PMF are in Table 3-1.

TABLE 3-1
REACTOR FLOOR ELEVATIONS AND CORRESPONDING WATER ELEVATIONS AT PROBABLE MAXIMUM FLOOD

Reactor	First Floor Elevation (Ft)	PMF Level (Ft)
105-C	494.0	434
105-D	466.5	419
105-DR	466	419
105-KE & KW	465	431
105-B	468.5	434
105-H	423	416
105-F	412.5	412

The stability and resistance to erosion of the mounds covering the decommissioned 105 buildings will depend, in part, on the material used and the natural angle of repose of the mounds. The mounds will be constructed with a slope that minimizes the potential for erosion.

Flooding is not expected to impact in-situ decommissioning of the 100 Area reactors. The PMF is lower than the first floor of every building. Flood levels are not expected to cause significant erosion of the mound surface nor cause release to the ground water of contaminants from within the mound.

3.7 Air and Water Quality

No atmosphere or liquid releases of radioactivity are anticipated as a result of decommissioning the shut-down 100 Area reactors. During piece-by-piece dismantlement, contamination control enclosures, with exhaust filtration will be used where necessary. Radioactive liquid wastes generated during the operation would be shipped to the 200 Areas using railway tank cars.

3.8 Long-Term Land Use Commitment

The most significant nonradiological impacts associated with decommissioning activities in the 100 Areas are the long-term land use commitments involved

with burial of low-level radioactive waste. Whether all the radioactive wastes are transported and buried in the 200 Area burial grounds or the in-situ decommissioning alternative is chosen and wastes are left in the respective 100 Areas, land will be committed for use as burial grounds for up to 100 years. The residual contamination levels of any land in the 100 Areas used as burial grounds will be established at levels such that the site could, if DOE wished, be released for uncontrolled use within 100 years.

3.9 Hazardous Wastes

Nonradioactive hazardous wastes and/or materials, including asbestos, PCB oil and mercury, are present in the shut-down reactor facilities. Work procedures will be written to control the possible release of asbestos fibers. Asbestos insulation will be disposed of in an approved way, to prevent fiber releases to the workers or the public. Mercury is present in some of the instrumentation that was used at the shutdown reactors. Procedures will be in place to identify, collect, and then either reclaim or dispose of the mercury. This mercury will be packaged and disposed of properly on the Hanford Site. PCB, used in electrical transformers will be removed from the site and disposed of properly as a hazardous waste.

3.10 National Historical Site

There is a potential to use the 105-B reactor as a national historical site that will be open to the public. For this reason, decommissioning of 105-B is scheduled to be performed after the other shutdown reactors have been decommissioned.

3.11 Socioeconomic Impacts

There are no adverse socioeconomic impacts to local communities expected due to the decommissioning of the shut-down 100 Area reactors. An additional work force of 40 to 100 people will be needed during the decommissioning program. This work force is very small compared to the current work force employed at the Hanford Site and the greater Tri-City area. The additional numbers of workers and their families will easily integrate into the local communities without putting a strain on the services (schools, hospitals, etc.) provided in these communities. This is especially true at this time. Since the halting of construction of two of the three commercial nuclear plants being constructed at Hanford, several schools in the area have recently closed due to a drop in enrollment.

4.0 REFERENCES

Reference 1 through 5 are cited in the text of this memorandum.

1. Adams, J. A., J. C. Chattin, P. W. Griffin, M. C. Hughes, Assessment of Decommissioning Alternatives for the shut-Down Hanford 100 Area Reactors, UNI-2619, UNC Nuclear Industries, Richland, WA 1984.

2. Kennedy, W. E., Jr., and B. A. Napier. 1983b. Allowable Residual Contamination Levels for Decommissioning Facilities in the 100 Areas of the Hanford Site. PNL-4722, Pacific Northwest Laboratory, Richland, Washington.

3. U.S. Energy Research & Development Administration. 1975. Final Environmental Statement Waste Management Operations Hanford Reservation, Richland, Washington. ERDA - 1538. Washington, D.C.

4. Schneider, J. K. and C. E. Jenkins, 1977. Technology, Safety, and Costs of Decommissioning a Reference Nuclear Fuel Reprocessing Plant. NUREG-0278, prepared for the U.S. Nuclear Regulatory Commission by Pacific Northwest Laboratory, Richland, Washington.

5. U.S. Department of Energy. 1980. Environmental Assessment F Area Decommissioning Program Hanford Site. DOE/EA-0120, Washington, D.C.

WP#1775F