Resource Book - Decommissioning of Contaminated Facilities at Hanford

**September 1991
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**Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830**

**Pacific Northwest Laboratory
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Energy Systems Department

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Pacific Northwest Laboratory
Richland, Washington

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A. Introduction

A. INTRODUCTION

A.1 BACKGROUND

In 1942 Hanford was commissioned as a site for the production of weapons-grade plutonium by the Manhattan District of the United States Army Corps of Engineers.^(a) The years since have seen the construction and operation of several generations of plutonium-producing reactors, plants for the chemical processing of irradiated fuel elements, plutonium and uranium processing and fabrication plants, and supporting laboratories and other ancillary facilities. The same period has also seen the diversification of the Hanford site with the building of new laboratories, a fission product encapsulation plant, improved high-level waste management facilities, the Fast Flux test facility, commercial power reactors and commercial solid waste disposal facilities.

Obsolescence and changing requirements will, in time, result in the deactivation or retirement of hundreds of buildings, waste storage tanks, waste burial grounds and liquid waste disposal sites which have become contaminated with varying levels of radionuclides. Contaminated facilities and waste sites which are retired or probably due for retirement within a few years include:

- eight retired or standby plutonium production reactors and ancillaries, in five separate reactor areas (100 Areas)
- five main-line chemical separations plants in the 200 Areas
- plutonium and uranium purification and fabrication facilities
- hundreds of contaminated liquid and solid waste disposal sites.

Decommissioning retired nuclear facilities and sites has been a concern for several years to the Department of Energy (and predecessor agencies) and to the Hanford contractors. In 1974, Pacific Northwest Laboratory was commissioned

(a) Responsibility for operation of the Hanford site was transferred to the U.S. Atomic Energy Commission in 1946; to the Energy Research and Development Administration in 1975, and to the Department of Energy in 1977.

by the Division of Waste Management and Transportation of the Atomic Energy Commission to establish methods, costs and priorities for the decommissioning of retired contaminated facilities at Hanford. As the program developed, it became apparent that much of the required descriptive information of contaminated facilities at Hanford was scattered through many reference documents or resided only in the memories of a dwindling staff of operators and engineers. Accordingly, this manual was established as a written repository of information pertinent to decommissioning planning and operations at Hanford.

A.2 ORGANIZATION OF THE RESOURCE BOOK

The Resource Book contains, in several volumes, descriptive information of the Hanford Site and general discussions of several classes of contaminated facilities found at Hanford. Supplementing these discussions are appendices containing data sheets on individual contaminated facilities and sites at Hanford.

The main volume includes the following sections:

- Section A: Introduction
- Section B: Summary
- Section C: Hanford Reservation - A discussion of the topography, demography, seismology, hydrology, meteorology, terrestrial and aquatic ecology of the Hanford Reservation.
- Section D: Decommissioning at Hanford - A general discussion of decommissioning requirements for contaminated facilities at Hanford. Includes a discussion of the basic decommissioning modes, a discussion of the Hanford operating areas, and a generic description of contaminated facilities at Hanford, organized into twelve classes based on physical and radiological characteristics. Included in the description of each class of facility is a discussion of physical and radiological characteristics of typical facilities in the class, a generic discussion of decommissioning alternatives and waste management requirements for the class, and finally, an evaluation of the decommissioning modes.

- Section E: Decommissioning Priorities - A discussion of priorities for decommissioning of contaminated facilities at Hanford.
- Maps - Maps of the Hanford Site and the operating areas.

Twelve appendices are provided, corresponding to the twelve classes into which the contaminated facilities at Hanford have been organized. Within each appendix are individual data sheets containing administrative, geographical, physical, radiological, functional and decommissioning information on each facility within the class.

A system for notating revisions has been incorporated into the Resource Book appendices to provide for update of individual facility data sheets as changes in facility status are experienced and as additional characterization information becomes available. On the upper left hand corner of each data sheet is a date corresponding to the date of issue of that particular sheet (original issues are not dated). Revision dates should correspond with the list of revisions provided in the front matter of each copy of the Resource Book.

B. Summary

C. HANFORD RESERVATION

C. Hanford Reservation

C. HANFORD RESERVATION

The environmental statement for waste management operations at Hanford⁽¹⁾ contains detailed information concerning the natural features of the Hanford Reservation. Section C provides a brief summary, most of it directly from Reference 1, of the information pertinent to planning for the decommissioning of retired Hanford facilities.

C.1 TOPOGRAPHY

The Hanford site covers about 570 miles² located in the Pasco Basin, a semiarid region of southeastern Washington State in the rain shadow of the Cascade Range. This section of the State has a sparse covering of natural vegetation primarily suited for grazing, although large areas near the site have gradually been put under irrigation during the past few years. Most irrigated farms near the Hanford Plant obtain water from the Yakima River or from the Columbia River.

The Hanford Reservation boundaries lie between 46° 18' and 46° 48' north latitude and 119° 17' and 119° 52' west longitude. The project area is mostly within Benton County, with portions of Franklin and Grant Counties also included. The Columbia River flows through the northern edge of the Hanford site and forms part of the eastern boundary. The westernmost boundary is about 30 miles due east of Yakima, Washington, while the closest population center, Richland, Washington, is located about 3 miles from the most southern portion of the boundary. Figures C.1.1 through C.1.19 provide maps of the reservation and of the major nuclear facility areas as follows:

<u>Figure No.</u>	<u>Area Shown</u>
C.1.1	Hanford Area Map
C.1.2	100 B-C Reactor Area
C.1.3	100 D-DR Reactor Area
C.1.4	100-F Reactor Area
C.1.5	100-H Reactor Area

<u>Figure No.</u>	<u>Area Shown</u>
C.1.6	100-K Reactor Area
C.1.7	100-N Reactor Area
C.1.8	Separations Areas
C.1.9	200 East Separations Area
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C.1.11	BC Cribs Area
C.1.12	Well Location Map: 200 East Area, Eastern Sector
C.1.13	Well Location Map: 200 East Area, Western Sector
C.1.14	Well Location Map: 200 West Area, Northern Sector
C.1.15	Well Location Map: 200 West Area, Central Sector
C.1.16	Well Location Map: 200 West Area, Southern Sector
C.1.17	300 Area
C.1.18	300 Area (Cont'd)
C.1.19	400 Area - FFTF Site

C.2 REGIONAL DEMOGRAPHY

A 1970 survey of the population distribution surrounding the Reservation estimated that 246,000 people were living within a 50-mile radius of the Hanford Meteorological Station located between the 200 East and 200 West Areas; 227,000 within 50 miles of the 100-N Area; and 162,000 within 50 miles of the 300 Area.

C.3 GEOLOGY

Eastern Washington is dominated by the Columbia Basin geologic province, the northernmost extension of the Columbia River Basalt Plateau. The basin encompasses about 50,000 miles² of southeastern Washington and adjacent parts of Idaho and Oregon. It is underlain by the vast field of flood lavas of the Columbia River Basalt Group. Today those lavas and the ground surface generally dip radially inward toward the Pasco Basin, which is the near-central, physiographic low of the larger Columbia Basin. The Pasco Basin evidently was formed by slow and prolonged subsidence concomitant with filling of the basin by basaltic lavas.

Late in the Pleistocene epoch, catastrophic floods emanated from glacial Lake Missoula and other glacier-dammed lakes and repeatedly scoured the Pasco Basin. The floods stripped much of the eolian silt and underlying caliche from the basin. They also left a series of inter-connecting channels, resembling the Channeled Scabland, carved into the Ringold Formation surface beneath the Hanford Reservation.

Two of the floods were gigantic by any standards, involving about 500 miles³ of water with a calculated maximum flow rate between 9 and 15 miles³/hr. The first of these floods is dated at 18,000 to 20,000 years ago and the second at about 12,000 years ago. Evidence suggests that the earlier flood rose to 1200 ft above mean sea level and the latter to about 900 ft above sea level, the result of hydraulic damming in Wallula Gap and downstream constrictions.

Aggradation resulting from the floods reached a level of about 700 ft altitude in the basin center, where the effective width is greatest and the water was most slowed. The deposits are generally graded, both vertically and laterally. The coarsest sediments are in the northern reaches of the Reservation. Finer sediments prevail southward in the wider parts of the basin, with the finest sediments on the basin margins and on the flanks of the enclosing hills. The deposits of each flood also tend to be finer-grained upward, reflecting the decreased velocity of the flood waters as they ponded.

After the deposition of the basin fill sediments, the Columbia River cut its way across the Reservation, shifting generally northeastward as it lowered its base level and its grade. Estimates of its lateral rates of shift range up to a foot per year.

The eastward shift of the Columbia River evidently is continuing in the northern reaches of the Reservation. Thus the northern reaches of the White Bluffs (north of the Hanford townsite) are being actively undercut. Landslides into the Columbia River have occurred and will occur as the bluffs are oversteepened.

C.4 SEISMOLOGY

Eastern Washington is in a region of low to moderate seismicity, lying between the western Washington and western Montana zones of considerably greater seismicity. On the basis of the damage experienced since 1840, the U.S. Coast and Geodetic Survey (ESSA) designated eastern Washington as Zone 2 seismic probability, implying the potential for moderate damage from earthquakes. Periodic revisions between 1948 (the date of the first issuance of the risk map) and 1969 did not change the potential for eastern Washington, although damage potentials for other parts of the country were upgraded. Currently western Washington and western Montana are in a Zone 3 category, implying the risk of considerable damage.

Hanford facilities are exposed to the possibility of earthquake damage from two sources: 1) the active seismic zones of western Washington and 2) closer shocks originating in the seismic zone that includes Walla Walla. However, the underlying sands and gravels in the Hanford Reservation provide excellent protection against damage. As far as can be determined, earthquake intensities greater than four on the Modified Mercalli Scale (MM-IV) have not assuredly occurred in the immediate Hanford area, although intensities as high as MM-V or MM-VI were observed at surrounding towns.

The great Alaska earthquake of 1964 and recent shocks in western Washington were not felt as strongly at Hanford as in surrounding localities. Hanford, moreover, is not located in a historically active seismic zone. These considerations indicate that the area is one of the safest in the state.

For building purposes, the Hanford area was included in Zone 2 in the seismic probability map adopted as part of the Uniform Building Code by the International Conference of Building Officials. It implies the potential of only moderate damage as deduced from the historical record.

C.5 HYDROLOGY

C.5.1 Surface Water

The surface water bodies located within the boundaries of the Hanford Reservation consist of the Columbia River, various swamps and ponds in and near the 200 Areas and three ponds located in the 300 Areas. Two ephemeral streams, Cold and Dry Creeks, appear for a short time only after heavy rainfall or snowmelt.

The Columbia River in this reach has widely varying flow rates due to regulation by the power producing Priest Rapids Dam just upstream. Flows during the summer, fall and winter vary from a low of 36,000 ft³/sec (cfs) to as much as 160,000 cfs each day. The long-term annual average flow at Hanford is about 120,000 cfs.

C.5.2 Water Below the Surface

The subsurface of the Hanford Reservation is underlain by various geologic units having widely different water-bearing properties. The rock types include: unconsolidated silts, sands, and gravels; semiconsolidated lake and stream sediments; and dense basalts with interbeds separating individual flows. Hydrologically the most permeable horizons are the sands and gravels of the Upper Ringold Formation and the Pasco Gravels. The water table over the western portion of the Hanford Reservation lies at the top of the Ringold Formation. However, between the high terrace plateaus and the Columbia River, the water table rises above the Upper Ringold and intersects the overlying Pasco Gravels.

Above the water table lies the unsaturated or vadose zone. Any waste that percolates into the subsurface within the 200 Areas of the Hanford Reservation must flow through a thick section of unsaturated glacio-fluviatile sediment prior to reaching the water table. Waste-soil interactions in the unsaturated zone result in maximum sorption of radionuclides in this zone and minimum migration of radionuclides to the water table below.

The uppermost aquifer (water-bearing formation) lies between the water table and the silts and clays of the Middle and Lower Ringold Formation. In general, groundwater in these unconsolidated and semiconsolidated sediments occurs under unconfined or water-table conditions, although locally confined zones exist. Some semiconsolidated gravels and sands are locally found in the Lower Ringold Formation. These beds are usually separated from the overlying unconfined aquifer by a layer of silt and clay of variable thickness. These sands constitute the uppermost confined aquifer.

The Ringold Formation overlies a warped and severely deformed layer of basalt. The Columbia River basalt series has, in general, a saucer-shaped synclinal structure. It is an accordantly layered sequence of flows which were extruded as highly fluid lava in Miocene and early Pliocene time. Narrow zones of rubbly, permeable scoria somewhat similar to flow breccia, occur at the top of a few flows and may be quite permeable. Some of these permeable zones in the basalt may constitute rather good confined aquifer systems.

C.5.2.1 The Unconfined Aquifer

The unconfined aquifer consists of both glaciofluvial sand and gravel deposits and the Ringold silts and gravels. Since these materials are very heterogeneous, often greater lithologic differences appear within a given bed than between beds. The aquifer bottom is the basalt bedrock in some areas and silt/clay zones of the Ringold Formation in other areas. The impermeable boundaries of the unconfined aquifer within the Hanford Reservation and vicinity are the Rattlesnake Hills, Yakima Ridge, and Umtanum Ridge to the west and southwest. Gable Mountain and Gable Butte, as well as other small areas of basalt outcrop above the water table, also impede the groundwater flow. The Yakima River recharges the unconfined aquifer along its reach from Horn Rapids to Richland. The Columbia River forms a hydraulic potential boundary which is mainly a discharge boundary for the aquifer. However, the groundwater flow from 1 to 3 miles inland from the Columbia River is affected by seasonal river stage fluctuations. The flow pattern that originally prevailed in the unconfined aquifer prior to waste discharges was primarily to the east and northeast with discharge

into the Columbia River. Natural recharge occurs at the foot of Rattlesnake Hills and Yakima Ridge. Surficial flow sinks into the floor of the valley at the foot of and paralleling Rattlesnake Hills. Probably the underflow is largely interrupted by a buried extension of Yakima Ridge which parallels Rattlesnake Hills at a distance of about 2 miles and which rises above the water table.

The natural recharge due to precipitation over the lowlands of the Hanford Reservation is not measurable because the evaporation potential during summer greatly exceeds total precipitation. Data on migration of moisture from natural precipitation in deep soils (below 30 ft) show movement rates less than 1/2 in./year at one measurement site.

C.5.2.2 The Confined Aquifers

A confined aquifer is one where the water-bearing stratum is overlain and underlain by relatively impermeable beds. Confined aquifers in the Hanford Reservation include 1) permeable sands and gravels in the lower part of the Ringold Formation overlain by thick silts and clays and 2) extensive basalt interbeds confined by individual basalt flows. The confining beds include sequences of individual basalt flows, where they are continuous and greater than about 50 ft thick, and the silts and clays of the lower part of the Ringold Formation. Within the basalt sequence, groundwater is transmitted primarily in the interflow zones, either in sedimentary beds or in the scoria and breccia zones forming the tops and bottoms of the flows. Some of the basalt flows in the Pasco Basin have been eroded, particularly in the anticlinal ridges. In some locations, the basalts are highly jointed and contain breccia, pillow and palagonite complexes through which groundwater can move. The lowermost Ringold Formation silts and clays are of various thicknesses and distinct hydraulic potential differences have been observed below the silts and clays.

C.6 METEOROLOGY

The Hanford climate is mild and dry, with occasional periods of high winds. Summers are generally hot and dry; winters are not as dry and are

relatively mild for this latitude. The average maximum temperatures in July and January are 91.8°F and 36.7°F. The average minimum temperatures for the same months are 61.0°F and 22.1°F. The average relative humidity varies from a low of 31.8% in July to a high of 80.4% in December. The minimum diurnal temperature in winter seasons ranges from -27°F to 22°F, compared to diurnal maximum temperatures in summer seasons which vary from 100°F to 115°F.

Average annual precipitation is 6.25 in. November, December, and January contribute 42% of the total, whereas July, August, and September contribute only 10%. A slight secondary maximum in precipitation occurs in early summer. About 45% of all precipitation during the months of December through February is in the form of snow. A four-to fivefold increase in annual rainfall for many years would be required to slowly move the 200 Area crib waste. The maximum expected rainfall over the next 1000 years is about 18 in. (a threefold increase for 1 year).

Mean monthly wind speeds range from about 9 mph in the summer to 6 mph in the winter. July hourly average wind speeds vary from a low of about 5 mph in midmorning to a high of 13 mph in the late evening. The corresponding speeds in January have the same trend, but have less than a 1 mph difference. The prevailing wind directions at the Hanford Meteorological Station (HMS) are from the NNW through NW. The strongest winds tend to be from the SW. The highest observed peak wind gust at HMS was 72 mph from the SW. Winds with a peak gust of 40 mph or greater have been observed on the average of at least once in every month of the year, although the winter months tend to have a higher frequency of high wind periods.

Tornadoes are relatively rare in this region and tend to be small, with little damage when they do occur. A single small tornado was observed onsite during 29 years of observation. No damage from this tornado was reported. Fourteen tornadoes have been confirmed within 100 miles of the Hanford area between 1916 and the present. Data has been analyzed to determine the probability of a tornado hitting a particular facility onsite. During any year, it was estimated that the probability is six chances in a million.

C.7 TERRESTRIAL ECOLOGY

A term frequently used to describe the Hanford region is "steppe," referring to its general resemblance to the steppeland of central Asia. The region is called a shrub-steppe to differentiate it from true steppes having more grasses and fewer shrubs. Steppes have some traits in common: 1) little precipitation and 2) wide daily and annual temperature ranges. Hanford is arid because of its location in the rain shadow of the Cascade Mountains. Lying in the path of frequent winter storm tracks, the Hanford region has many winter storms that bring clouds but little water. However, precipitation is relatively high during all winter months (about 2 or 3 cm per month). Although June exhibits a secondary maximum, it is too little rain and too late to be of substantial importance to the vegetation. June rains usually wet the soil only to a depth of 20 cm or less, well within the reach of evaporation by the high isolation intensities and warm soil temperatures. Thus the precipitation important to vegetation is that stored as soil water during the cool season.

C.7.1 Vegetation

The vegetation mosaic of the Hanford Reservation consists of eight major shrub-steppe communities identified by the most conspicuous or most abundant plant species:

- Sagebrush/bluebunch wheatgrass
- Sagebrush/cheatgrass or sagebrush/sandberg bluegrass
- Sagebrush-bitterbush/cheatgrass
- Greasewood/cheatgrass-saltgrass
- Winterfat/sandberg bluegrass
- Thyme buckwheat/sandberg bluegrass
- Cheatgrass-tumble mustard
- Willow.

C.7.2 Mammals

The mule deer is the only big game mammal found on the Hanford Reservation. Most of the mule deer on the Hanford Reservation live along the Columbia River, with smaller concentrations near Gable Mountain and the 200 Area, at Rattlesnake Springs, and on the Snively Ranch area in the Rattlesnake Hills.

The cottontail rabbit is the most abundant small game mammal, with small populations scattered throughout the Reservation area. The raccoon is probably the most abundant furbearing mammal on the Hanford Reservation, mostly confined to shoreline areas of the Columbia River and waste ponds in the 200 Areas. Beaver and muskrats occur in backwater areas of the Columbia River; muskrats are found also in waste ponds and ditches in the 200 Areas. Mink occur along the Columbia River, while weasels are scattered throughout the Hanford area. The coyote is abundant on the Hanford Reservation as compared to adjacent land areas, although no accurate estimate of population density has been made. The bobcat and badger are present on the Reservation, but in low numbers.

The jackrabbit is widely distributed on the Hanford Reservation; however, it is less abundant in the sagebrush/bluebunch wheatgrass vegetation than in the sagebrush/cheatgrass and sagebrush-bitterbrush/cheatgrass vegetation-types. The jackrabbit is an important food item for coyotes and raptors.

The porcupine is widely distributed over the Reservation area but is especially abundant along the Columbia River. Porcupines occur in the 200 Areas and in the canyons and valleys of the Rattlesnake Hills.

Small mammals are abundant on the Hanford Reservation, particularly the Great Basin pocket mouse. Deer mice and ground squirrels are locally abundant, as is the pocket gopher. The kangaroo rat is not found on the Hanford Reservation although it is common in the steppe region of Oregon.

C.7.3 Birds

The chukar partridge is the most abundant upland game bird on the Hanford Reservation. Most of the population is concentrated on the ALE Reserve, especially the Rattlesnake Hills, but there are local populations in the Gable Mountain area. Chinese ring-necked pheasants are present on the Hanford Reservation but in small numbers, and California quail are present as scattered local populations along the Columbia River. Mourning doves are migratory birds that nest throughout the Hanford Reservation area during the spring months.

Sage grouse are present in small numbers. In recent years, sightings generally occurred in the Rattlesnake Hills on the ALE Reserve. Over the years the sage grouse population has declined in southeastern Washington as pristine habitat was converted to dryland wheat and irrigated agricultural fields. The most abundant birds in the steppe vegetation are the western meadowlark and the horned lark.

The Canada goose is the most important of the nesting waterfowl on the Hanford Reservation; the nesting habitat is confined to islands in the free-flowing reach of the Columbia River. The Columbia River also provides a resting sanctuary for migratory flocks of ducks and Canada geese. At peak migratory periods, 70,000 birds--mostly mallards--occupy the Hanford reach of the Columbia River.

Raptors use the Hanford Reservation as a refugium from human intrusions, especially during the nesting season. Trees around abandoned farms in the 100 Areas and around abandoned military installations provide nesting habitat for red-tailed hawks, Swainson's hawks, and great horned owls. Prairie falcon nests are located on Gable Butte and along Umtanum Ridge. The sparrow hawk is the most abundant of the raptors. The marsh hawk nests on the Hanford Reservation (as does the burrowing owl), but the osprey is only an occasional visitor along the Columbia River. The golden eagle and the bald eagle are both winter visitors. The raptors are of particular concern because their ranges are being steadily reduced by human encroachment. Relatively large areas of uninhabited land, such as the Hanford Reservation, provide nesting and foraging ground for raptorial birds.

C.7.4 Snakes and Lizards

As compared to southwestern United States desert areas, the herpetofauna of south-central Washington is sparse. The most abundant reptile in low elevation steppe vegetation is the sideblotched lizard. The horned lizard is not common, and the sagebrush lizard is scarce. The most abundant snake is the gopher snake, but the yellow-bellied racer and the Pacific rattlesnake are common. The coachwhip snake and the desert night snake are seldom observed. Snakes are an important food item for the Swainson's hawk.

C.7.5 Insects

Many different species of insects are found on the Reservation. The most abundant are:

- Leafhoppers, aphids, plant hoppers, and mealybugs
- Grasshoppers
- Beetles (Some of the most abundant animals in terms of biomass per unit area are darkling beetles, which have attained an estimated peak biomass of 2 g/m² in cheatgrass communities.)
- Ants, wasps and bees
- Springtails.

C.8 AQUATIC ECOLOGY

Various species of plant and animal organisms and fish are to be found in the Columbia River and in ponds on the Reservation. The fish species of greatest importance are the salmon and steelhead. These species begin in fresh water during their early life stages, spend most of their life in the ocean, and as adults return to the river to spawn. The fall run of chinook salmon spawn in the main stem Columbia River section from Ringold to Priest Rapids. Spawning is not suitable in other major main stem spawning areas, both upstream and downstream, due to impoundments by the river dams. Spawning salmon have markedly increased use of this last free-flowing stretch of the river. This seems partly the result of upstream displacement of populations that formerly spawned in the Columbia River downstream from Richland.

A special study of the local sport fishery for a year in 1966 to 1967 estimated the annual catch as 6000 fish in the section of the Columbia River from Richland (River Mile 339) to Ringold (River Mile 354). Since this survey, sport fishing, particularly from boats, has probably increased, presumably increasing the annual catch.

REFERENCE

1. Environmental Statement, Waste Management Operations, Hanford Reservation, Richland, Washington, ERDA Report WASH-1538, July 23, 1975.

[illegible]

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FIGURE C.1.2

2

FIGURE C.1.3

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FIGURE C.1.4

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FIGURE C.1.5

2

FIGURE C.1.6

WN-8500 WN-8000 WN-7500 WN-7000 WN-6500

NN-7500

NN-7000

NN-6500

NN-6000

NN-5500

NN-5000

NN-4500

NN-4000

WN-8500 WN-8000 WN-7500 WN-7000

CR18

1900 1322-B 1309

1715 166 1322 1308 1310 TC-106 1614

1716-N 1716-NA

1714-NA 1734 1714 1712 1705

1722 105 109 184-NA 184 153

181-N 1908

EMERGENCY DUMP BASIN (1304)

182 163 183 183

TANKS

CLEARWELL

CLEARWELL OVERFLOW

108

1100

1101

1102

HELIUM UNLOADING STA. (1314)

SUBSTATION (151)

1908-NE

181-NE

SUMPS

TILE FIELD

1614

TRANSFORMER AREA

185

WPPSS GARAGE

PIPE TRESTLE

WPPSS FIELD OFFICE

GATE HOUSE (1701)

BPA SUBSTATION

SWITCH YARD

GATE

0 100 200

FIGURE C.1.7

FIGURE C.1.8 SEPARATIONS AREAS (200-E, 200-W, 200-N)

FIGURE C.1.9

216-S-5, 6 CRIS

POND 216-S-16 FILLED IN

POND OVERFLOW 216-U-11

POND 216-U-10

CRIS 216-S-25

241-S-271 CONTROL HOUSE

2707-SX

241-SX-401, 402 CONDENSER BLDGS.

TILE FIELD

241-SX-152 DW. BOX

WASTE STORAGE TANK FARM (241-SX)

CRIS 216-S-6, S-1, S-2

RETENTION BASIN (207-S)

241-SX-151 CATCH TK

241-S-181

241-S-181

216-S-18

WASTE STORAGE TANK FARM 241-SY

271-S SHOP

CRIS 216-S-4

CRIS 216-S-21

WASTE STORAGE TANK FARM (241-S)

DIV. BOXES

241-U-151, 152, 232

241-UR-151, 152, 153, 154

241-U-301

241-S-301 CATCH TK

BLDG. (242-S)

CRIS 216-Z-18

PART & OIL STORAGE

PLUTONIUM RECLAMAT FACILITY (236-Z)

216-U-13 CRIS

WASTE STORAGE TANK FARM (241-U)

CRIS 216-Z-1A

WASTE

244-UR

CONTROL HO

241-U-271

241-U

RETENTION BASIN (207-U)

CONCRETE SLABS

UO₃ STORAGE YARDS

CRIS 216-S-23

SODIUM STORAGE (2727-W)

CRIS 216-S-6

240-S-151, 152 DIV. BOXES

240-S-302 CATCH TK

2706-WA RM STA

SOLVENT HANDLING BLDG. (276-U)

GATE HOUSE (2701-U)

UO₃ PLANT - UHM CALCINATION & LOADOUT BLDG. (224-UA)

CRIS 216-U-12

CRIS 216-U-6

PROPANE STORAGE (2726-U)

UHM STORAGE (203-U, 203-UH)

BLDC. SUBSTATION (252-U)

270-W

291-U

292-U

LABORATORY (223-U)

UO₃ PLANT UHM CONVE & CENTRAL CONTROL (224-U)

2004-SA COOL H₂O SAMPLER

REAGENT TANK FARM (211-S)

SOLVENT HANDLING (276-S)

2704-S

TILE FIELD

REDUX BLDG. (202-S)

REDUX LABORATORY (222-S)

216-S

207-SL RETENTION BASINS

CRIS 216-S-20

PROPANE STORAGE (2726-S)

216-S-19 POND

216-S-14 CRIS

CRIS 216-S-13

METAL SOLUTION STORAGE (202-S)

UHM LAG STORAGE (204-S, 206-S)

CONCENTRATION FACILITY (283-S)

2706-S STACK

291-S

STACK MORN. BLDG. (282-S)

SAND FILTER

OFF GAS TREAT & ACID RECOVERY BLDG. (293-S)

CRIS 216-S-22

FIGURE C.1.10

FIGURE C.1.1.1. SEPARATIONS AREA: BC CRIBS

FIGURE C.1.12. Well Location Map (March, 1973) 200 East Area, Eastern Sector

FIGURE C.1.15. Well Location Map (March, 1973) 200 West Area, Central Sector

FIGURE C.1.16. Well Location Map (March, 1973) 200 West Area, Southern Sector

2

BUILDING NUMBER	DESCRIPTION
301	EQUIPMENT STORAGE
303 A	PRODUCT STORAGE BUILDING
303 B	PRODUCT STORAGE BUILDING
303 C	HEAVY MATERIAL STORAGE BUILDING
303 E	ESSENTIAL MATERIAL STORAGE BUILDING
303 F	CHEMICAL STORAGE & DISPOSAL BUILDING
303 G	ESSENTIAL MATERIAL STORAGE BUILDING
303 J	MATERIAL STORAGE BUILDING
303 M	DECONTAMINATION AND BATTERY CHARGE BUILDING
303 L	OXIDE BURNING BUILDING
304	FUELS ENGINEERING LABORATORY
305	TEST REACTOR
305 A	OFFICE AND SHOP
305 B	EXPERIMENTAL TEST REACTOR BUILDING
306	METAL FABRICATION DEVELOPMENT
307	RETENTION BASIN
307 D	EFFLUENT HOLDUP TANK
308	PLUTONIUM LABORATORY
308 E	EMERGENCY STORAGE ANNEX
309	WATER OFFICES AND SHOPS
311	ACID CAUSTIC AND METHANOL TANK FARM
312	RIVER PUMP HOUSE
313	FUELS MANUFACTURING BUILDING
314	ENGINEERING DEVELOPMENT LABORATORY
314-A	GAS BOMBING AUTOCLAVE PIT
315	WATER FILTER PLANT
316	HIGH TEMPERATURE LATTICE TEST REACTOR (STANDBY)
316 A	DETECTOR BUILDING
316 B	WATER STACK
316 C	WATER FILTER
320	LOW LEVEL RADIOCHEMISTRY BUILDING
321	ENGINEERING DEVELOPMENT LABORATORY
323	METALS CREEP LABORATORY
324	CHEMICAL ENGINEERING LABORATORY
324 A	STACK GAS SAMPLING BUILDING
324 B	EXHAUST STACK
325	RADIOCHEMISTRY BUILDING
325 A	CESTRUM RECOVERY FACILITY
325 B	SHIELDED LABORATORY ANNEX
325 C	FLUORINE GAS STORAGE
325 D	MAINTENANCE SHOP
326	PHYSICS AND METALLURGY BUILDING
327	RADIOISOTOPE BUILDING
328	ENGINEERING SERVICES AND SAFETY
328 A	TECHNICAL SHOPS ANNEX
328 B	BIOPHYSICS LABORATORY
330	STRESS RUPTURE TEST FACILITY
331	LIFE SCIENCE LABORATORY
331 A	VIROLOGY LABORATORY
331 B	INHALATION FACILITY
333	WATER MANUFACTURING BUILDING
334	CHEMICAL HANDLING BUILDING
335	SODIUM TESTING FACILITY
336	SODIUM TESTING FACILITY
337	HIGH TEMPERATURE SODIUM FACILITY
338	LEAFER MOCK UP AND MAINTENANCE
340	RETENTION AND NEUTRALIZATION BUILDING
340 A	MAINTENANCE STORAGE
340 B	WATER
351	SUBSTATION
351-B	WATER TESTING & SWITCHGEAR FACILITY
352	SUBSTATION 34KV
352-A	SUBSTATION 115KV
352-C	SUBSTATION 24KV
353-D	2400 VOLT SWITCHGEAR BUILDING
353-E	SWITCH STATION EAST SIDE
360	FUEL OIL BURNER
360 A	FUEL OIL BURNER
362	PUMP HOUSE
362 A	WATER RESERVOIR 200 000 GAL
362 B	WATER RESERVOIR 335 000 GAL
364	POWERHOUSE
3603-A	ELECTRICAL CABLE PIT NO. 2
3603-B	ELECTRICAL CABLE PIT NO. 3
3608-A	TELEPHONE EXCHANGE FACILITY
3609	SEPTIC TANK
3609-A	SANITARIUM CHLORINATION TREATMENT FACILITY
3609-B	CHLORINE TANKS
3614 A	COLUMBIA RIVER MONITORING STATION
3621-B	EMERGENCY GENERATOR
3621-C	EMERGENCY GENERATOR CONTROL ROOM
3621-D	EMERGENCY POWER GENERATING STATION NO. 1
3622	LABORATORY WEIRWIND SHELTER
3701-A	GATE HOUSE WEST
3701-L	BADGE HOUSE SOUTH
3701-H	BADGE HOUSE NORTH
3701-B	CYPRESS ST BENTRY STATION
3701-E	QEO WASH WAY BENTRY STATION
3701-T	GUARD HOUSE - 308 BLDG
3701-TR	SECURITY TOWER
3703	OFFICE BUILDING
3704	OFFICES
3705	PHOTOGRAPHY BUILDING
3706	OFFICES AND SERVICES
3706-A	VENTILATION EQUIPMENT BUILDING FOR 3706
3707-A	ENGINEERING
3707-B	UTILITY OPERATIONS BUILDING
3707-C	NONDESTRUCTIVE TESTING
3707-D	STORAGE
3707-E	STORAGE
3707-F	PERSONNEL SURVEY BUILDING
3707-G	STORAGE
3708	RADIATION MEAS
3709	PAINT SHOP
3709-A	FIRE STATION
3710	OIL AND GREASE STORAGE
3710-A	OIL AND GAS STORAGE
3711	STORAGE (CONSTRUCTION)
3712	FUEL NATIONAL STORAGE
3713	CARPENTER AND PAINT SHOP
3714	ORGANIC CHEMISTRY LABORATORY
3716	FUEL MATERIAL STORAGE
3718	PROCESS DEVELOPMENT LAB
3717	SHEET METAL SHOP AND OFFICE BUILDING
3717-B	STANDARD LABORATORY
3717-C	PLANT OPERATIONS SERVICES BUILDING
3718	LABORATORY EQUIPMENT POOL
3718-B	LABORATORY EQUIPMENT POOL
3718-C	LABORATORY EQUIPMENT POOL
3718-D	LABORATORY STORAGE BUILDING - 308
3718-E	STORAGE BUILDING (324)
3718-F	SODIUM STORAGE
3718-G	SODIUM TANK STORAGE FACILITY
3718-H	STORAGE
3718-I	STORAGE

(CONTINUED ON SHEET 2)

FIGURE C.1.17

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(CONTINUED FROM SHEET 1)

- 331 LIFE SCIENCE BUILDING
- 331-A VIROLOGY LABORATORY
- 331-B INHALATION FACILITY
- 331-C ANIMAL CARE STORAGE BUILDING
- 331-D ANIMAL WASTE TREATMENT FACILITY
- 331-E GREENHOUSE
- 3720 CENTRAL SERVICE & LABORATORY
- 3721 CLASSIFIED SCRAP INCINERATOR
- 3722 CONSTRUCTION SHOP
- 3723 SOLVENT & ACID STORAGE FOR 327
- 3726 PROPANE GAS STORAGE TANK
- 3727 ARCHIVE FISSILE MTL. STORAGE
- 3730 GAMMA IRRADIATION FACILITY
- 3731 FISSILE MATERIAL STORAGE FACILITY
- 3731-A GRAPHITE MACHINE SHOP
- 3732 STORAGE BUILDING
- 3734 MAINTENANCE STORAGE
- 3734-A PAINT AND SOLVENT STORAGE
- 3745 RADIOLOGICAL CALIBRATIONS & STANDARDS BUILDING
- 3745-A ELECTRON ACCELERATOR
- 3745-B POSITIVE ION ACCELERATOR
- 3746 RADIATION PHYSICS
- 3746-D TECHNICAL SERVICES BUILDING
- 3760 TECHNICAL INFORMATION BUILDING
- 3762 OFFICE BUILDING
- 3763 OFFICE BUILDING
- 3764 OFFICE BUILDING
- 3765 OFFICE BUILDING
- 3766 OFFICE BUILDING
- 3767 OFFICE BUILDING
- 3802-A PRV STATION
- 3902-A ELEVATED TANK (WEST)
- 3902-B ELEVATED TANK (EAST)
- 3905-1 WATER WELL
- 3905-2 WATER WELL
- 3905-3 WATER WELL
- 3905-4 WATER WELL
- 3906 SANITARY & PROCESS LIFT STATION

FIGURE C.1.18

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FIGURE

D. D&D AT HANFORD

D. Decontamination and Decommissioning
at Hanford

D. D&D AT HANFORD

D.0 INTRODUCTION

Part D is concerned with the identification and evaluation of alternative decommissioning modes for the retired, contaminated ERDA facilities at Hanford. To facilitate the study, the facilities and sites were categorized into the 12 classes listed in Table D.1. When complete, Part D is to include a chapter for each class, with the following contents:

- Physical description
- Site characterization (kinds, amounts and locations of radioactive and chemical contamination; additional site characterization required to permit detailed D&D planning).
- Alternative D&D modes and the related procedures.
- Waste management requirements.
- Evaluation of D&D modes (cost, hazard, etc.).

D.1 ALTERNATIVE D&D MODES

Four alternatives have been defined for decommissioning contaminated excess facilities at Hanford: Layaway, Protective Storage, Entombment, and Decontamination/Dismantling. These alternatives are defined below and in Table D.2, described for each class of facilities in Sections 1-11 of Part D, and evaluated in Part E.

In considering the alternatives, it becomes apparent that one or more of the four alternatives may not be acceptable for a given class of facilities. For example, Entombment may not be a viable option for transuranic facilities or those containing ^{14}C because of the extremely long time required for these isotopes to decay to an innocuous level; and there appears to be little incentive to place a low-activity facility into Protective Storage to await Dismantling at some far distant date.

TABLE D.1. Classes of Contaminated Facilities and Disposal Sites at Hanford

<u>Class</u>	<u>Facility/Site Locations</u>			
	100 Areas (6 areas)	200 Areas (2 areas)	300 Area	600 Area
1. Contaminated Liquid Disposal Sites (Cribs, Trenches, Ditches, Ponds)	x	x	x	x
2. Contaminated Solids Storage and Burial Sites (Burial Grounds, Tunnels, etc.)	x	x	x	x
3. Fuel Reprocessing Facilities (Chemical Separations Plant, Uranium Recovery Plant)		x		
4. Fuel Storage Basins (Reactor Basins and 200 North Areas)	x			x
5. Gas and Exhaust Air Systems (Reactors)	x			
6. Laboratories	x	x	x	
7. Reactors	x		x	
8. Retention Basin Systems	x	x	x	
9. Transuranic Facilities (Plutonium Concentration, Purification and Fabrication Plants and Laboratories)	x	x	x	
10. Uranium Facilities (Uranium Calcination and Fuel Fabrication Plants)		x	x	
11. Waste Management Facilities (Tank Farms, Waste Evaporators, Diversion Boxes, Pipelines, etc.)		x		
12. Miscellaneous	x	x	x	x

TABLE D.2. Comparison of Facility and Site Conditions for Various Decommissioning Modes (1)

Facility and Site Condition	Decommissioning Mode			Remarks
	Layaway	Protective Storage	Entombment	
A. Disposition of Process Materials 1. Solid Radioactive Material 2. Liquid Radioactive Material 3. Nonradioactive Material	Offsite Solidify Offsite	Offsite Solidify Offsite	Offsite Solidify Offsite	Except for Dismantling Mode, some Process Materials may be Retained On Site. Most are Expected to be Removed.
B. Access Control 1. Facility 2. Site 3. Security	Authorized Personnel Only Daily Check	Authorized Personnel Only Weekly Check	Controlled Public Access None	Intruder Alarms Installed for Layaway and Protective Storage Modes.
C. Inspections 1. Physical 2. Radiation 3. Environmental	Monthly Monthly Quarterly	Monthly Quarterly Quarterly	Biannually Biannually Biannually	Monitor Status of In-Service Equipment Continuously.
D. Protective Equipment Status 1. Ventilation 2. Radiation Monitoring 3. Fire Protection 4. Power to Facility	Operating Operating Operating Operating-Reduced Load	Shutdown-Restorable Limited Amount Operable Alarms in Service Lighting and Alarms Only. Large Load Capability Retained.	None None Alarms in Service For Lighting and Alarms Only	
E. Process Equipment Disposition 1. Radioactive 2. Nonradioactive	Left in Place (May be Decontaminated) Left in Place	Decontaminated-Left in Place May be Removed for Salvage	Placed in Entombment Structure May be Removed for Salvage	Removed Removed
F. Contamination Control Method	Ventilation	Temporary Physical Barriers	Permanent Physical Barriers	Removal
G. Final Structure Condition	Unmodified	Modified	Greatly Modified	Removed
1. Decontamination Requirements	Minimum Effort	Accessible Contamination Removed or Fixed in Place	All Surfaces Outside Entombment Structure Deconned to Unrestricted Use Levels.	Determined by Personnel Exposure and Shipping Requirements
H. Final Site Condition	Unchanged	Unchanged	Entombment Structures Remain	Returned to Pre-facility Condition
I. Use Category 1. Facility 2. Site	Nuclear Use-Typically Limited to Surveillance Activities Nuclear Use Only	Nuclear Use-Typically Limited to Surveillance Activities Nuclear Use Only	Conditional Use-Limited to Activities that do not jeopardize the Entombment Structure	Nuclear-Related Activities may be Allowed in the Facility During Layaway and Protective Storage. Each Case Treated Separately.

Layaway

The facility or site is preserved essentially in its current state as a temporary measure. Minimum effort is expended in deactivating the facility, and continuing maintenance is anticipated as long as it is in the Layaway mode. Use of Layaway assumes that the site will experience no catastrophes or sabotage greater than it was originally designed to withstand. The activities associated with this mode may include:

- Offsite disposal of all solid and liquid process materials in approved repositories
- Controlled access to site and facility (this may require erection of fences or other barriers)
- Periodic security, physical, radiological or environmental surveys or inspections.
- Operation and maintenance of protective equipment such as ventilation, radiation monitoring, fire alarms and electrical power and lighting systems.
- Decontamination or shielding of easily accessible contaminated structures and equipment to minimize occupational exposure.

The major benefits from the Layaway mode are: 1) reduced radiation levels at a future date when further D&D activities are undertaken, 2) postponement of decommissioning activities until ultimate disposal of D&D wastes can be accomplished, and 3) low initial outlay of funds.

Potential disadvantages are: 1) Layaway does not in general improve the containment capability of the structure, which may be a problem with the old Hanford plants; and 2) significant effort may have to be applied to maintenance and surveillance.

Layaway is particularly adaptable to situations where continuing nuclear activity is planned at the site, and radiation monitors, plant operators, and craftsmen skilled in radiation activities are readily available to conduct the required surveillance and to maintain equipment and structures in good order.

Protective Storage

The facility is prepared to be left in place safely for an extended period which might range from decades to centuries. Structures may be left intact or may require strengthening. Parts of structures not required as part of the containment may be dismantled. Any actions taken to prepare for Protective Storage are to be designed to allow subsequent retrieval of contaminated materials.

This mode may be adopted as a permanent measure for facilities which are not contaminated with long-lived radionuclides such as ^{14}C or the transuranics, providing control until the radioactivity has decayed and the facility can be released for unrestricted use or disposal. Or it may be adopted as a temporary measure, to delay decontamination or dismantling operations until radiation levels have dropped off significantly through decay.

Site preparation for Protective Storage will probably require the following activities in addition to some or all of the activities listed for Layaway:

- For a contaminated ground site, removal and/or fixing of accessible contamination above release limits, and erection of a physical barrier (such as a rock, asphalt or concrete cover) to prevent entry into the contaminated zone.
- For a reactor or processing plant, such actions as may be required to assure that the containment structure has adequate strength and durability to last through the Protective Storage period.

The major benefits from the Protective Storage mode are similar to those quoted for the Layaway mode, with these additions: 1) low initial outlay of funds, but higher than for Layaway, 2) reduced surveillance, maintenance and operating costs for the facility, 3) reduced hazard to the general public and workers on the site, and 4) potential use of the accessible uncontaminated portions of the facility.

This mode also has a number of potential disadvantages: 1) the residual radioactivity will be more susceptible to release to the environment than with Entombment or Dismantling; 2) continued operation and maintenance of building ventilation systems and other services may be required; and 3) continued surveillance and controls on use of the site must be maintained until the radioactivity has dropped to levels acceptable for release or until additional D&D action has been taken.

Entombment

The facility or site is prepared to be left in place safely, with a long-lasting barrier surrounding all contaminated materials and with no intent to allow for their subsequent retrieval.

Entombment may include the following site preparation and surveillance activities:

- Removal of all solid and liquid radioactive and nonradioactive process materials
- Removal of salvageable, uncontaminated equipment
- Erection of "permanent" (>100 years) barriers to prevent release of radioactivity to the environment, e.g., filling radioactive vessels and cells with concrete. Entombment of a ground disposal site would include surrounding or filling the contaminated zone with an impervious material such as concrete.
- Decontamination of areas outside the entombment structure.
- Control of public use of the site or facility
- Periodic physical, radiation and environmental surveys
- Maintenance and limited operation of lighting systems and fire protection alarms.

The end product from Entombment should be a facility or site containing radioactivity which is safely isolated from man and the environment until it decays to levels low enough to permit unrestricted release. Unrestricted access to all uncontrolled parts on the facility should be

possible, with restrictions relating only to excavation, drilling or otherwise breaching structures containing radioactivity. Adequate warning signs must be posted, and the necessary covenants endorsed on the relevant title, deeds and survey plants. Thus this condition provides radiological safety and alternative use of the site, but does not allow unrestricted future modification or development there.

The Entombment mode has the potential advantages that it 1) will be less costly than Dismantling, 2) offers much better protection against release of contamination than Protective Storage, and 3) will require very little maintenance or surveillance effort. It has the potential disadvantages that 1) technology is not available to assure containment of TRUs in an entombed structure for the hundreds of thousands of years required; and 2) if future changes in conditions should necessitate removal of radioactivity or reclamation of materials from an entombed structure, this might be very difficult and costly.

Dismantling

As a minimum, all radioactive components and materials which exceed the criteria for unrestricted release are removed from the site. In addition, nonradioactive components may be removed, structures dismantled, and the site prepared for an alternative use. Once all radioactive materials have been removed, all restrictions on use of the site are taken off.

This mode may be applied immediately after retirement or following a period in Layaway or Protective Storage long enough to allow decay of the short-lived nuclides. Potential advantages include 1) the opportunity for unconditional use of the site; 2) the elimination of long-term radiological and physical hazards; and 3) the elimination of long-term maintenance or surveillance requirements. Disadvantages include 1) the high cost normally associated with dismantling radioactive facilities; 2) the large volumes of contaminated wastes requiring transport and storage or disposal; 3) the potential exposure of D&D workers to high radiation fields or TRU contamination; and 4) potential release of radionuclides to the environment during the dismantling operation.

D.2 LAYOUT OF THE HANFORD OPERATING AREAS

As shown in Table D.1, most of the classes of Hanford facilities and disposal sites are represented in each of two or more Areas. The following sections provide a brief description of each Area and additional information as to the contaminated facilities contained therein. Maps of the Areas are provided in Section C, and photographs may be found in Reference 2.

D.2.1 100 Areas

The six Hanford 100 Areas (Figure C.1.1), locations of the nine plutonium production reactors at Hanford, border the Columbia River. Starting from the up-river corner of the reservation and moving downstream toward Richland, they are arranged in the order: 100 B/C; 100 KE/KW; 100 N; 100 D/DR; 100 H; and 100 F.

Each of the five Hanford reactor Areas designed only for production of plutonium (100 B/C, 100 D/DR, 100 F, 100 H and 100 KE/KW) contains either one or two reactors and their supporting facilities:^(3,4) the reactor plant itself, housed in the 105 Building; a water plant to purify Columbia River water and pump it through the reactor as a coolant; a system for return of the coolant to the river; an irradiated fuel handling and storage system, also housed in the 105 Building; a system for purifying and recirculating reactor blanket gas, housed partly in the 105 Building and partly in ancillary facilities; a reactor building ventilation and exhaust system also partly housed in the 105 Building, partly in ancillaries; supporting laboratory, maintenance and other service facilities; and sites for the ground disposal of contaminated liquids and solids.

The sixth reactor Area (100 N)⁽⁵⁾ is the site of the dual-purpose N-Reactor, designed for plutonium production and for the use of byproduct steam in electrical power production. This Area is similar to the others in many respects but differs in that it has a plant for power generation but no retention basin system.

The following pages contain for each reactor Area a brief description of its status in 1975, a map of the Area, and a list of contaminated facilities. Data sheets are provided in the appropriate appendices as listed in Tables D.3-D.8.

TABLE D.3. 100 Area Contaminated Systems, Buildings and Sites

100 B-C Area

Size: 640 Acres

Status: Standby

System or Class	Building or Site			Appendix No.
	Designation	No.	Size	
Reactor Plant	Reactor Building	105-B	42,500 ft ²	VII.1.1
	Reactor	105-B	Graphite Stack-- 28 x 36 x 36 ft	VII.1.1
Spent Fuel Storage System	Metal Storage Basin	105-B	7,500 ft ²	IV.1.1
Reactor Atmo- sphere System	Gas Storage (Uncontami- nated)	110-B	Storage Cylinders-- Outside	--
	Gas Recirculation Building	115-B	16,500 ft ²	V.1.1
Reactor Building Ventilation System	Exhaust Air Filter Building	117-B	59 x 39 x 35 ft high	V.2
	Reactor Stack	116-B	200 ft high	V.2
Reactor Effluent System	Retention Basin	107-B	110,000 ft ²	VIII.1.1
	Pumping Station	1608-B	2,000 ft ²	VIII.1.1
	Outfall Structure (1904-B)	116-B-7	200 ft ²	VIII.1.1
	Outfall Structure (1904-B)	116-B-8	200 ft ²	VIII.1.1
Liquid Disposal Sites	Cribs, Trenches	116-B-1 to 116-B-6		I.5.1 to I.5.6
Solids Burial Sites	Burial Grounds	118-B-1 to 118-B-6		II.1.1 to II.1.6
Miscellaneous	Tritium Separation Facility	108-B	9,600 ft ²	XII.
	Tritium Facility Stack	108-B	200 ft high	V.2
	Metal Storage Building	103-B	1,300 ft ²	XII.

TABLE D.3. (Contd)

100 B-C Area

System or Class	Building or Site			Appendix No.
	Designation	No.	Size	
Reactor Plant	Reactor Building	105-C	65,000 ft ²	VII.1.2
	Reactor	105-C	Graphite Stack-- 28 x 28 x 36 ft	VII.1.2
Spent Fuel Storage System	Metal Storage Basin	105-C	8,500 ft ²	IV.1.2
Reactor Building Ventilation System	Confinement Filter Building	117-C	59 x 39 x 35 ft high	V.2
	Reactor Stack	116-C	200 ft high	V.2
Reactor Effluent System	Retention Basin	107-C	340 ft diam Tanks (2)	VIII.1.1
	Outfall Structure (1904-C)	116-C-4	300 ft ²	VIII.1.1
Liquid Disposal Sites	Cribs, Trenches	116-C-1, 2		I.5.11, 12
Solids Burial Site	Burial Ground	118-C-1		II.1.7

TABLE D.4. 100 Area Contaminated Systems, Buildings and Sites

100 D-DR Area

Size: 960 Acres

Status: Retired

System or Class	Building or Site			Appendix No.
	Designation	No.	Size	
Reactor Plant	Reactor Building	105-D	42,500 ft ²	VII.1.3
	Reactor	105-D	Graphite Stack-- 28 x 36 x 36 ft	VII.1.3
Spent Fuel Storage System	Metal Storage Basin	105-D	7,200 ft ²	IV.1.3
Reactor Atmo- sphere System	Helium Storage (Uncontami- nated)	110-D	Storage Cylinders-- Outside	--
	Gas Recirculation Building	115-D	16,500 ft ²	V.1.2
Reactor Building Ventilation System	Confinement Filter Building	117-D	59 x 39 x 35 ft high	V.2
	Reactor Stack	116-D	200 ft high	V.2
Reactor Effluent System	Retention Basin	107-D	110,000 ft ²	VIII.1.2
	Lift (Pumping) Station	1608-D	2,000 ft ²	VIII.1.2
	Outfall Structure (1904-D)	116-D-5	250 ft ²	VIII.1.2
Liquid Disposal Sites	Cribs, Trenches	116-D-1 to		I.5.21 to
		116-D-4		I.5.25
Solids Burial Sites	Burial Grounds	118-D-1 to		II.1.11 to
		118-D-5		II.1.15
Miscellaneous	Laboratory	108-D	9,600 ft ²	VI.
	Metal Storage Building	103-D	1,300 ft ²	XII.

TABLE D.4. (Contd)

100 D-DR Area

System or Class	Building or Site			Appendix No.
	Designation	No.	Size	
Reactor Plant	Reactor Building	105-DR	42,500 ft ²	VII.1.4
	Reactor	105-DR	Graphite Stack-- 28 x 36 x 36 ft	VII.1.4
Spent Fuel Storage System	Metal Storage Basin	105-DR	8,000 ft ²	IV.1.4
Reactor Building Ventilation System	Confinement Filter Building	117-DR	59 x 39 x 35 ft high	V.2
	Reactor Stack	116-DR	200 ft high	V.2
	Reactor Exhaust Air Sample Building	119-DR		
Reactor Effluent System	Retention Basin	107-DR	180,000 ft ²	VIII.1.2
	Lift (Pumping) Station	1608-DR	2,000 ft ²	
	Outfall Structure (1904-DR)	116-DR-5	250 ft ²	VIII.1.2
Liquid Disposal Sites	Cribs, Trenches	116-DR-1		I.5.31 to
		to 116-DR-4		I.5.34
Solids Burial Sites	Burial Grounds	118-DR-1		II.1.16

TABLE D.5. 100 Area Contaminated Systems, Buildings and Sites

<u>100 F Area</u>				
Size: <u>540</u> Acres		Status: <u>Retired</u>		
System or Class	Building or Site			Appendix No.
	Designation	No.	Size	
Reactor Plant	Reactor Building	105-F	42,500 ft ²	VIII.1.5
	Reactor	105-F	Graphite Stack-- 28 x 36 x 36 ft	VIII.1.5
Spent Fuel Storage System	Metal Storage Basin	105-F	7,500 ft ²	IV.1.5
Reactor Atmo- sphere System	Gas Recirculation Building	115-F	16,500 ft ²	V.1.3
Reactor Building Ventilation System	Confinement Filter Building	117-F	59 x 39 x 35 ft high	V.2
	Reactor Stack	116-F	200 ft high	V.2
Reactor Effluent System	Retention Basin	107-F	110,000 ft ²	VIII.1.3
	Lift (Pumping) Station	1608-F	2,000 ft ²	
	Outfall Structure (1904-F)	116-F-8	250 ft ²	VIII.1.3
Liquid Disposal Sites	Cribs, Trenches	116-F-1 to 116-F-9		I.5.41 to I.5.48
Solids Burial Sites	Burial Grounds	118-F-1 to 118-F-6		II.1.21 to II.1.26
Miscellaneous	Laboratory	108-F	9,000 ft ²	VI.
	Concrete Slab for Building	146-F		XII.
	Metal Storage Building	103-F	1,300 ft ²	XII.
	Varied Biology Laboratory Facilities			VI.

TABLE D.6. 100 Area Contaminated Systems, Buildings and Sites

<u>100 H Area</u>				
Size: <u>320</u> Acres		Status: <u>Retired</u>		
System or Class	Building or Site			Appendix No.
	Designation	No.	Size	
Reactor Plant	Reactor Building	105-H	62,000 ft ²	VII.1.6
	Reactor	105-H	Graphite Stack-- 28 x 36 x 36 ft	VII.1.6
Spent Fuel Storage System	Metal Storage Basin	105-H	8,000 ft ²	IV.1.6
Reactor Atmo- sphere System	Gas Storage (Uncontami- nated)	110-H		--
	Gas Recirculation Building (Gas Wing)	105-H		V.1.4
Reactor Building Ventilation System	Confinement Filter Building	117-H	59 x 39 x 36 ft high	V.2
	Reactor Stack	116-H	200 ft high	V.2
Reactor Effluent System	Retention Basin	107-H	167,000 ft ²	VIII.1.4
	Lift (Pumping) Station	1608-H	2,000 ft ²	
	Outfall Structure (1904-H)	116-H-5	400 ft ²	VIII.1.4
Liquid Disposal Sites	Cribs, Trenches	116-H-1 to 116-H-4		I.5.51 to I.5.54
Solids Burial Sites	Burial Grounds	118-H-1 to 118-H-5		II.1.31 to II.1.35
Miscellaneous	Solar Pond	183-H		XII.

TABLE D.7. 100 Area Contaminated Systems, Buildings and Sites

<u>100 K Area</u>				
Size: <u>135</u> Acres		Status: <u>Standby</u>		
System or Class	Building or Site		Size	Appendix No.
	Designation	No.		
Reactor Plant	Reactor Building	105-KE	60,000 ft ²	VII.1.7
	Reactor	105-KE	Graphite Stack-- 33.5 x 41 x 41 ft	VII.1.7
Spent Fuel Storage System	Metal Storage Basin	105-KE	10,000 ft ²	IV.1.7
Reactor Atmo- sphere System	Gas Storage (Uncontami- nated)	110-KE		
	Gas Recirculation Building	115-KE	5,300 ft ²	V.1.5
Reactor Building Ventilation System	Confinement Filter Building	117-KE	59 x 39 x 35 ft high	V.2
	Reactor Stack	116-KE	300 ft high	V.2
	Exhaust Air Sample Room	119-KE		
Reactor Effluent System	Retention Basin	107-KE	250 ft diam Tanks (3)	VIII.1.5
	Outfall Structure (1904-K)	116-K-3	1,200 ft ²	VIII.1.5
Liquid Disposal Sites	Cribs, Trenches	116-K-1,2 116-KE-1,2		I.5.61 to I.5.64
Solids Burial Sites	Burial Grounds	118-K		II.1.41
Miscellaneous	Laboratory	1706-KE	6,000 ft ²	VI.
	Laboratory	1706-KER	18,700 ft ²	VI.

TABLE D.7. (Contd)

100 K Area

System or Class	Building or Site			Appendix No.
	Designation	No.	Size	
Reactor Plant	Reactor Building	105-KW	60,000 ft ²	VII.1.8
	Reactor	105-KW	Graphite Stack-- 33.5 x 41 x 41 ft	VII.1.8
Spent Fuel Storage System	Metal Storage Basin	105-KW	10,000 ft ²	IV.1.8
Reactor Atmo- sphere System	Gas Storage (Uncontami- nated)	110-KW		
	Gas Recirculation Building	115-KW	5,300 ft ²	V.1.6
Reactor Building Ventilation System	Confinement Filter Building	117-KW	59 x 39 x 35 ft high	V.2
	Reactor Stack	116-KW	300 ft high	V.2
	Exhaust Air Sample Room	119-KW		
Reactor Effluent System	Retention Basin	107-KW	250 ft diam Tanks (3)	VIII.1.5
Liquid Disposal Sites	Crib	116-KW-1		I.5.65

TABLE D.8. 100 Area Contaminated Systems, Buildings and Sites

<u>100 N Area</u>				
Size: <u>90</u> Acres		Status: <u>In Use</u>		
System or Class	Building or Site			Appendix No.
	Designation	No.	Size	
Reactor Plant	Reactor Building	105-N	96,000 ft ²	VII.1.9
	Reactor	105-N	Graphite Stack-- 39 x 33 x 33 ft	VII.1.9
	Heat Exchanger Building	109-N	95,000 ft ²	VII.1.9
Spent Fuel Storage System	Metal Storage Basin	105-N	5,000 ft ²	IV.1.9
Reactor Building Ventilation System	Confinement Filter Building Stack	117-N	4,100 ft ²	V.2
		116-N	200 ft high	V.2
Liquid Disposal Sites	Trench	116-N-1		I.5.71
Solids Burial Sites	Burial Grounds	118-N		II.1.51
Miscellaneous	Plant Assistance Facility	1705-N	12,000 ft ²	XII
	Radioactive Chemical Waste	1310-N	60-ft-diam Tank	XII
	Treatment Facility		600 ft ² Pump House	

100 B/C Area (Two reactors; see Figure C.1.2 and Table D.3)

Essentially all facilities in the area are on standby except for the B/C water system, which provides the water supply for the 200 Areas. Fire protection for all of the area and service utility water for some facilities are maintained. An electrical substation in the area supplies power to the pumps providing the 200 Area water.

100 D/DR Area (Two reactors; see Figure C.1.3 and Table D.4)

Both 100-D Area reactors are retired, but this area is extensively used, and its utilities and services are in operation. The electrical substation serves as backup supply for N Area. The water system in 100-D is a backup for systems from B Area supplying the 200 Areas. UNI operates an engineering laboratory (185-D) in support of N Reactor operations. This includes the NPR loop facility which was the original test facility for N Reactor.

Various contractors use facilities such as the 183-D settling basin, 190-D and others for special studies, for example, thermal hydraulics, emergency core cooling, and treatment of oil spills.

100 F Area (One reactor; see Figure C.1.4 and Table D.5)

The facilities in 100 F Area are shut down, including PNL biology laboratory facilities which operated there until late 1975.

100 H Area (One reactor; see Figure C.1.5 and Table D.6)

The area has been shut down and several major uncontaminated facilities (power house and stacks, and some of the water treatment buildings) removed. A portion of the 183-H settling basin has been retained as a solar evaporation pond used for disposal of liquid chemical wastes, including uranium.

100 K Area (Twin reactors; see Figure C.1.6 and Table D.7)

The two reactors are on standby and the fuel storage basins in use for storage of spent fuel from N-Reactor.

Considerable use is made of the shutdown 100-K Area, and all services and utilities except the power house are in operation. The Reactor Plant Services Section of United Nuclear Industries (UNI) operates from offices and laboratories in this area. UNI also operates a research and development laboratory in 1706-KE. This effort, which is in support of N Reactor activities, includes bench-scale studies of water quality, filtering and corrosion. Some small-scale decontamination studies are also carried out under this program.

PNL is also using 100-K Area facilities for research and development programs.

100 N Area (One reactor; see Figure C.1.7 and Table D.8)

N Reactor is the only Hanford Reactor still in operation which was designed for the production of plutonium. The reactor is a dual-purpose unit and provides low-pressure steam for the 860,000 kW WPPSS generating plant nearby.

D.2.2 200 Areas

The 200 East and West Areas (Figures C.1.1 and C.1.8-C.1.16) are located 18 miles northwest of Richland and near the center of the Hanford Reservation.* The two areas are part of an extensive fuel reprocessing complex with the mainline plants listed in Table D.9 and the following ancillary facilities: waste management systems (tank farms, waste evaporators and their associated piping systems--Section 11 and Appendix XI); waste disposal sites (cribs, trenches, ponds, burial grounds--Sections 1 and 2 and Appendices I and II); the Semi-Works, used for hot demonstration of the Redox, Purex and waste fractionation processes (Section 3 and Appendix III); and assorted laboratories.

D.2.3 300 Area

The 300 Area (Figures C.1.17 and C.1.18), located about 1 mile north of the Richland city limits on the bank of the Columbia River, includes

* The 200 North Areas, once used for storage of irradiated Hanford reactor fuels, are now included in the 600 Area.

TABLE D.9. 200 Area Plants

Plant	Area	Initial Use	Present Use	Resource Book Reference	
				Section	Appendix
B Plant	200 E	Recovery of Pu from irradiated uranium	Fractionation of high-level wastes; encapsulation and storage of selected fission products.	3	III
T Plant	200 W	Recovery of Pu from irradiated uranium	Equipment decontamination and repair	3	III
Redox	200 W	Recovery of Pu, U and Np from irradiated uranium	Canyon--retired; offices and lab. in use	3	III
Purex	200 E	Recovery of Pu, U and Np from irradiated uranium	Standby for future reprocessing of N-Reactor fuels	3	III
U Recovery Plant	200 W	Recovery of U from B Plant and T Plant first-cycle wastes	Retired	3	III
UO ₃ Plant	200 W	Calcination of product uranyl nitrate from Redox, Purex and Uranium Recovery Plants	Standby for future calcination of Purex product uranium	10	X
Z Plant	200 W	Plutonium finishing operations	In Use	9	IX

about 375 acres. However, northward expansion is planned to include another 200 acres for added waste management facilities. Most of the original facilities were related to the fabrication of reactor fuel. As increasing emphasis has been placed on the research and development at Hanford, the 300 Area has come to be the location primarily of laboratories and test facilities.

As of January 1975, the 300 Area included uranium fabrication plants (standby) and a wide variety of laboratories and test reactors--many of them contaminated.

D.2.4 400 Area

The 400 Area (Figure C.1.19) is the Fast Flux Test Facility (FFTF) construction area.

D.2.5 600 Area

The 600 Area includes all of the Reservation not included in the 100, 200, 300, or 400 Areas. Contaminated sites included are a number of burial grounds (Section 2 and Appendix II), liquid waste disposal sites (Section 1 and Appendix I), and the 200 North Areas.

REFERENCES

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3. Hazards Summary Report, Vol. 3, Description of the 100-B, 100-C, 100-D, 100-DR, 100-F and 100-H Production Reactor Plants, HW-74094, Prepared by the staff of the Irradiation Processing Department, General Electric Co., Richland, WA, April 1, 1963.
4. Hazards Summary Report, Vol. 3, Description of the 100 KE and 100 KW Production Reactor Plants, HW-74095, General Electric Co., Richland, WA, April 15, 1963.
5. 100-N Technical Manual, Vol. 1, Prepared by N Reactor Department, General Electric Co., Richland, WA, March 5, 1963.

1.0 CONTAMINATED LIQUID
DISPOSAL SITES

1.0 CONTAMINATED LIQUID
DISPOSAL SITES

1.0 Contaminated Liquid Disposal Sites

1.0 CONTAMINATED LIQUID DISPOSAL SITES

1.1 GENERAL

Many soil sites on the Hanford Reservation, ranging from a few square feet to many acres, are contaminated with various kinds of radionuclides and other toxic substances: neutron activation products; fission products; transuranic elements; and heavy metals. Contamination of the soil arose from three major sources: unintentional releases from pipes, tanks and ventilation systems; intentional ground disposal of liquid radioactive wastes from separations plants, fuels fabrication plants, reactor areas and laboratories; and burial of contaminated materials and equipment in selected areas (burial grounds).

Section 1 discusses the disposition of sites contaminated by ground disposal of liquid wastes and by unplanned releases. It does not include ground sites contaminated as a result of operation of the 100 Area retention basin systems: sludge disposal trenches and 107 liquid waste trenches. These are discussed in Section 8.0, Retention Basin Systems.

Ground disposal of liquid radioactive wastes from Hanford separations plants began on a limited basis in 1945.⁽¹⁾ Initially only small volumes of selected very low-level wastes were discharged to the ground. As more was learned about the selective retention of radionuclides by the soils in the Hanford area and about the regional geology and hydrology, it was concluded that the properly controlled disposal of greatly increased volumes of liquids and quantities of radionuclides would be safe. Consequently these activities were expanded, reaching a peak of 834,000 Ci put into the ground in 1955.⁽²⁾ Thereafter the amount of activity decreased as ground disposal of radionuclides was minimized and as the separations plants were shut down. The quantity of activity discharged to the ground in the 200 Areas during 1973 was 89 Ci.⁽³⁾

Forty-eight unplanned releases of radioactive liquids to the ground have occurred in or near the 200 Areas. Many of them resulted from leaks in underground waste storage tanks and radioactive liquid transfer pipelines, and hence were at varying distances from the surface of the ground.

Several types of disposal sites have been used for the discharge of liquid radioactive wastes to the ground at Hanford. The following are current definitions:⁽⁴⁾

Crib. A buried or covered liquid disposal facility, usually rock-filled and equipped with a liquid-dispersion system. Cribs were generally used for the discharge of intermediate-level effluents containing from 5×10^{-5} μCi per ml to 100 μCi per ml.

Various designs have been used in construction of cribs. A number of the earlier timbered cribs were built like boxes open only at the bottom and buried at depths great enough to preclude their causing radiation problems at the surface (14 to 30 ft deep). Cribs of this type range from 100 to 200 ft² in area. The liquid waste was discharged into the ground inside the box, which was also equipped with a vent line. Some cribs were a dual structure, with a second cavity catching any overflow from the first via an overflow pipe. Tile fields were also used in conjunction with boxlike cribs to disperse the liquid wastes over a wider area (see Figure 1.1). Over the years, the rotting of the timber structures has made these cribs vulnerable to cave-ins.

Numerous cribs were built by partly filling an excavation with sorted rock or gravel topped by an impermeable membrane or layer of asphalt. A distribution pipe was placed in the rock or gravel to provide uniform flow of the liquid over the crib bottom. The top of the crib was backfilled with soil to provide radiation protection and prevent dispersal of potentially contaminated soil just above the crib. A diagram of a typical rock-filled crib is shown in Figure 1.2. Cribs of this type range in area from 100 to 28,000 ft².

French Drain. A covered or buried rock-filled encasement with the bottom end open to allow seepage of liquid into the ground. French drains are essentially the same as cribs, except that the volume capacity is much smaller. They were used primarily for small-volume waste streams.

FIGURE 1.1. Wooden Structured Crib with Tile Field⁽¹⁾
(ready for dirt backfill)

Trench. A long, usually narrow, unlined excavation used for disposal of low- and intermediate-level wastes. The 100 Area trenches were usually used over long periods for disposal of reactor coolant water containing fuel rupture debris. The 200-Area trenches were generally used over short periods for disposal of limited quantities of liquid on a specific retention basis. Both open and covered trenches have been employed for disposal of liquid wastes. The potential for near-surface contamination is greater for a trench than for a crib since backfilling operations may have been performed while liquid remained in the trench. Backfilling under these circumstances might cause splashing of the liquid up the sides of the trenches. The potential for contaminated weed growth over retired trenches appears to be greater than that for retired cribs.

FIGURE 1.2. Typical Crib for Aqueous Waste⁽⁵⁾

Pond (Swamp). A body of water enclosed in a natural or diked surface depression used for the disposal of high-volume, low-level liquid effluents. Activity levels in these effluents were normally very low* so that spread of contamination by dispersal of the liquid was not a problem. As the liquids soaked into the ground, many of the radionuclides were absorbed by the soil, becoming sufficiently concentrated that subsequent drying of the pond muds could result in significant dispersal of activity by wind erosion. Hence the pond bottoms were covered with clean soil after deactivation.

Ditch. A long, narrow, unlined excavation in the ground used for conveying large volumes of liquid to a pond. Ditches have essentially the same levels of contamination as ponds, and must also be covered upon deactivation.

* The discharge limit was set at $\leq 5 \times 10^{-5} \mu\text{Ci/ml}$ after experience at the Redox Plant indicated the need for control of this type of stream. A few large radionuclide discharges to ponds and swamps have occurred.

Reverse Well (Dry Well). A buried or covered, encased, drilled hole with the lower end of the pipe perforated or open to allow seepage of liquid to the ground. Reverse wells were used to a limited extent early in Hanford history for some low-intermediate level wastes, but proved unsatisfactory because they plugged easily and introduced the wastes into the ground close to the water table.

The liquid disposal sites vary greatly in structure and radionuclide burden. To facilitate evaluation of the disposition alternatives, the sites have been categorized into six classes on the basis of their radionuclide content. Classes I-III, which contain significant levels of transuranics and/or fission products, are further categorized on the basis of chemical content of the waste. The classes are tabulated in Table 1.1. Sites into which >0.04 g Pu was discharged per square meter of bottom area are classed as transuranic facilities. This limit was set on the basis of a) the current regulation requiring retrievable storage for soil contaminated with plutonium at levels exceeding 10 n Ci/g of soil and b) the assumption that the bulk of the plutonium added to the crib is in the top six inches of soil and is uniformly distributed over the bottom of the site (in many instances, distribution was probably not uniform). Sites into which beta activity was discharged in amounts which would yield >0.04 Ci/m² after decay to 12/31/73 are classed as fission product sites. This limit was set on the basis that at higher levels, consideration must be given to a) protecting operating personnel against exposure to radiation if the crib is uncovered and b) preventing dispersal of the radioactivity by animals, plants and natural erosion.

Class I sites exceed the 0.04 g/m² transuranic limit but are below the 0.04 Beta Ci/m² fission product limit. Class III sites exceed the 0.04 Beta Ci/m² limit but fall below the transuranic limit. Class II sites exceed both limits. Classes I, II and III are further subdivided on the basis of salt content (high salt vs low) and acidity of the liquid discharged to the site. These distinctions were made because of the effect of chemical composition of the waste upon the extent of radionuclide migration through the soil (see Section 1.2.1).

TABLE 1.1. Contaminated Liquid Disposal Site Classification

Class I.	Transuranic Disposal Sites ($>0.04 \text{ g Pu/m}^2$, ^(a) $<0.04 \text{ Beta Ci/m}^2$ ^(b))
	A. Acidic Wastes
	B. Neutral-Basic Wastes
Class II.	Transuranic-Fission Product Disposal Sites ($>0.04 \text{ g Pu/m}^2$, ^(a) $>0.04 \text{ Beta Ci/m}^2$ ^(b))
	A. Acidic Wastes
	B. High-Salt, Neutral-Basic Wastes
	C. Low-Salt, Neutral-Basic Wastes
Class III.	Fission Product Disposal Sites ($<0.04 \text{ g Pu/m}^2$, ^(a) $>0.04 \text{ Beta Ci/m}^2$ ^(b))
	A. Acidic Wastes
	B. High-Salt, Neutral-Basic Wastes
	C. Low-Salt, Neutral-Basic Wastes
Class IV.	Low-Activity Sites ($<0.04 \text{ g Pu/m}^2$, ^(a) $<0.04 \text{ Beta Ci/m}^2$ ^(b))
Class V.	Induced Activation Product Disposal Sites (100 Areas)
Class VI.	Ponds and Ditches

-
- a. Grams Pu discharged to the site per square meter of bottom area, estimated from plant discharge records and assuming uniform distribution over the bottom of the site. (This assumption is useful for categorization purposes but does not represent actuality in many instances. In general, the plutonium is probably concentrated in the soil close to the pipe outlet. The level of 0.04 g Pu/m^2 is based on 1) current (April, 1975) regulations which require retrievable storage of wastes contaminated with transuranics at levels exceeding 10 n Ci/g and 2) the assumptions that most of the plutonium is located in the top six inches of soil.
- b. Beta curies remaining 12/31/73 out of those discharged to the site per square meter of bottom area. The level of 0.04 Beta Ci/m^2 is based on the assumption that it represents about the maximum activity level which could be excavated without requiring remote control equipment.

Class IV sites are low in all kinds of radioactivity. Class V sites are those located in the 100 Areas and used for the discharge of liquids containing principally induced activation products. Class VI sites are the low-activity surface disposal facilities, ponds and ditches.

1.2 SITE CHARACTERIZATION

1.2.1 General

Several different sorption mechanisms cause the soil to take up many of the radioactive and nonradioactive chemical species in liquid wastes.⁽⁶⁾ These sorption mechanisms are discussed in Section C, Hanford Reservation. Due to the low solubility of the rare earth and transuranic hydroxides and hydrous oxides, these materials generally precipitate in the top layer of soil when neutral or basic aqueous wastes are discharged to the ground. Cesium and strontium are removed largely by ion-exchange reactions which allow them to penetrate the soil column to greater depths. Strontium may also undergo mineral reactions in the soil, but these reactions are slow and generally allow some penetration of the strontium. Some species of ruthenium are poorly sorbed by the soil column and will penetrate to great depths and infiltrate the ground water. Tritium and anions such as nitrate also move rather freely through the soil column and travel long distances in the ground water. The relative mobility of these species is illustrated for a typical 200 Area crib in Figure 1.3. The approximate sorption patterns for a typical Hanford crib are presented in Figure 1.4. It is important to note that the sorption pattern for plutonium is not representative of all transuranic elements. The sorption pattern of americium, for example, will more closely approximate that of the rare earths and exhibit less sorption under acidic conditions than plutonium.⁽⁷⁾

The extent and rate of uptake of the various radioactive and nonradioactive species in liquid wastes are governed by the chemical characteristics of the species, the chemical make-up of the waste, and the nature of the soil. In general, soluble uncharged or negatively charged species, which do not interact with the soil, will be poorly removed by the soil. Greater penetration of radionuclides into the soil column will occur under acidic

FIGURE 1.3. Schematic of Typical Crib for Intermediate-Level Waste⁽⁵⁾

conditions than under neutral or basic conditions. However, components of the soil will tend to neutralize acidic liquid wastes. High concentrations of salt, the presence of complexing agents, and increased volumes of waste will also cause deeper penetration of certain radionuclides into the soil column. The uptake of sorbable components of the waste is generally increased in soils containing more silt and clays due to their greater surface area and higher ion-exchange capacity and mineralogical reactivity.

Lateral spreading of liquid from a disposal site occurs as a result of hydrodynamic dispersion. Lateral spreading is increased in a fine sediment zone overlying a coarse sediment zone since liquid will not cross the interface into the coarse zone until a significant level of saturation is attained at some place in the fine zone. Considerable unsaturated

FIGURE 1.4. Approximate Sorption Patterns for Typical Hanford Disposal Crib(5)

lateral flow in the fine sediment zone will normally occur before this level of saturation is reached. This layering effect can be repeated many times in soil beneath a liquid waste disposal site due to the presence of many alternating layers of differing porosity sediments. A relatively small localized silt lens in an otherwise uniform coarse sand zone can have a profound effect on the flow of percolating liquid through the zone.

Information concerning decontaminated soil sites resulting from the discharge of liquid wastes is presented in Appendix V, Contaminated Soil Sites.

1.2.2 Contamination Levels and Locations

Field studies to establish the inventory and spatial distribution of radionuclides at contaminated soil sites on the Hanford Project have been very limited by the high cost of core drilling and radiochemical analysis of the core samples. Initial determinations of radionuclide migration from three cribs in the 200 West Area indicated that the soil kept plutonium and fission products relatively close to the cribs.⁽⁸⁾ Also, plutonium was retained closer to the cribs than were fission products.

The most complete data regarding migration of radionuclides in the vadose zone beneath a liquid waste disposal facility were obtained from the 216 S-1,2 crib site. (See Figure 1.5.) This facility consisted of two timbered cribs which drained into a gravel fill measuring 40 ft wide, 90 ft long, and 6 ft deep. Three monitoring wells were first drilled through the bottom area of the crib site to a depth of 150 ft, ending 60 ft above the

FIGURE 1.5. Schematic of 216 S-1, and 2 Crib Site

water table. The crib site received much activity (750,000 Ci beta and 1200 g Pu) in a waste volume of 1.6×10^8 liters discharged from the Redox Plant within 3 years.

The first study of the S-1,2 crib site⁽⁹⁻¹²⁾ was made in 1956, following deactivation of the cribs. The three monitoring wells were deepened and six additional wells were drilled; sediment core samples were taken for analysis to determine the spatial distribution of radionuclides in the underlying sediments; and a well-logging program was begun to detect possible changes with time in the distribution of gamma-emitting isotopes beneath the crib.

The results of the 1956 study showed that the wastes spread from an initial distribution area of 3,600 ft² to an area of about 80,000 ft² at the water table.⁽⁹⁾ The contamination zones where the concentrations of ⁹⁰Sr, ¹⁰⁶Ru, and ¹³⁷Cs exceed 10^{-4} μ Ci/g of soil beneath 216 S-1,2 are illustrated in the upper cross section of Figure 1.6. Very little migration of ¹³⁷Cs is indicated, while ⁹⁰Sr dispersed much more. The greater dispersion of ⁹⁰Sr was anticipated due to the acidic nature of the wastes discharged here. The contamination zone for ¹⁰⁶Ru gives some indication of the dispersion of the liquid beneath the site since the nonsorbable fraction of the ¹⁰⁶Ru travels rather freely with the liquid. The 1956 investigation showed that the bulk of the radionuclides were contained in the sediments beneath the crib site to a depth of 60 ft. The wells drilled directly beneath the crib site showed some ¹³⁷Cs and ⁹⁰Sr at the 140-ft level. But there is some doubt as to whether this represents normal migration through the soil column or resulted from channeling of waste liquid down the well casings.

In 1966 five additional wells were drilled to obtain more information on radionuclide distributions directly beneath the 216 S-1,2 site. Well-logging data indicated very little change around the periphery of the site. Therefore the characterization effort was focused on the soil zone directly beneath the cribs.

FIGURE 1.6. Radionuclide Distribution Beneath the 216 S-1, and 2 Crib Site from 1956 and 1966 Field Evaluation Data (11)

The results of the 1966 study are illustrated in the lower cross section of Figure 1.6. The 1966 field evaluation data indicates $>10^{-4}$ $\mu\text{Ci/g}$ contamination zones for ^{137}Cs and ^{90}Sr only, since the ^{106}Ru had decayed below the detection limit outside the zones shown for ^{137}Cs and ^{90}Sr . Evaluation of core sample data shows that greater than 99.9% of the ^{137}Cs and ^{90}Sr discharged to the 216 S-1,2 site were contained in the first 16 to 33 ft below the crib bottom. Small but measurable amounts of ^{137}Cs and ^{90}Sr migrated below the principal contamination zone directly beneath the crib site to form lenticular-shaped zones. The lenticular-shaped zones probably represent sedimentary interbeds with greater capacity for sorbing radionuclides. It is also possible, as stated previously, that the contamination zone at the 150-ft level may be ascribed to waste liquids channeling down the well casing. Either the waste liquids entered the soil at this level, or the mineral content of this zone maximized radionuclide sorption.

A plan view of 216 S-1,2 crib site is shown in Figure 1.7 with isoconcentration lines delineating the estimated maximum average subsurface ^{90}Sr concentration as of 1966.⁽¹⁰⁾ The pictured zone descends from about 40 ft below ground surface. The isoconcentration lines connect points of equal average ^{90}Sr concentration designated by the number on the contour lines. The 50 $\mu\text{Ci/g}$ zone was assumed to be about 1 ft thick, the 30 and 40 $\mu\text{Ci/g}$ zones 2 ft thick, the 20 $\mu\text{Ci/g}$ zone 3 ft thick, the 10 $\mu\text{Ci/g}$ zone 5 ft thick, and a 1 $\mu\text{Ci/g}$ zone was assumed to be 15 ft thick. The background contour was assumed to contain a 20-ft-thick zone with an average concentration of 0.1 $\mu\text{Ci/g}$ of soil. The pattern shown in Figure 1.7 accounts for a total of 4500 Ci of ^{90}Sr in 1966. This would have been 5800 Ci of ^{90}Sr in 1956. The reported ^{90}Sr inventory in this crib site, based on wastewater analysis from 1953 to 1956, was 3000 Ci. As a comparison, a zone 20 ft thick immediately above the existing water table (with the pattern shown in Figure 1.8) and containing an average of 2×10^{-3} $\mu\text{Ci/g}$ of soil would represent a total of only 4 Ci of ^{90}Sr .

The 216 S-1,2 study in 1966 used a "worst case" portrayal for which maximum concentrations and areas were chosen. For the 20-ft deep zone above

FIGURE 1.7. 216 S-1, and 2 Crib Site, Maximum Subsurface ^{90}Sr Concentrations (10)

FIGURE 1.8. 216 S-1, and 2 Crib Site, ^{90}Sr Concentrations in the Soil Zone 20 ft Above the Present Water Table(10)

the water table a maximum concentration of $1.2 \times 10^{-3} \mu\text{Ci/g}$ of ^{90}Sr was found. However, a value of $2 \times 10^{-3} \mu\text{Ci/g}$ was used in computing the ^{90}Sr inventory in this zone. Other disposal sites, such as the 216 BY cribs, were treated similarly in the 1966 field study and a maximum of about 60 Ci of long-lived radioisotopes was estimated to be in the 20-ft vadose zone above the water table in the 200 West Area and in the 25-ft vadose zone above the water table in the 200 East Area. A summation of the data is presented in Table 1.2. It is emphasized that the data given in Table 1.2 are semiquantitative estimates based on a limited number of well core analyses.

TABLE 1.2. Estimated Maximum Amounts of Long-Lived Radionuclides Subject to Leaching by a 25-Ft Rise in the Water Table Beneath 200-E Area and by a 20-Ft Rise Beneath 200-W Area

<u>Waste Disposal Site</u> ^(a)	$\frac{^{60}\text{Co}}{(\text{Ci})}$	$\frac{^{90}\text{Sr}}{(\text{Ci})}$	$\frac{^{137}\text{Cs}}{(\text{Ci})}$
<u>200-East Area</u>			
216 BY Cribs	15	7.5	15
216 A-5,10 Cribs	--	0.7	< 0.1
216 BC Cribs	--	7.0	0.5
216 A-8 Crib	--	4.0	1.2
216 A-24 Crib	--	1.7	< 0.1
Total	<u>15</u>	<u>20.9</u>	<u>16.7</u>
<u>200-West Area</u>			
216 S-1,2 Cribs	--	4	< 0.1
216 S-7 Crib	--	0.4	< 0.1
216 S-9 Crib	< 0.1	0.8	< 0.1
216 T-28 Crib	< 0.1	0.6	< 0.1
Total	<u>--</u>	<u>5.8</u>	<u>--</u>

a. Based on scintillation probe, well sampling and waste inventory data, the sites which were not investigated as part of this study are not expected to appreciably increase the totals shown.

In 1971⁽¹²⁾ a qualitative assessment was made of the ruthenium, strontium, and cesium inventory in the 50-ft zone above the water table in the 200 Areas. The amounts of these fission products were calculated using an empirically derived formula. Of the more than 180 cribs located in the 200 Area Control Zone, 42 were identified as having ruthenium, strontium and cesium in the lower most 50 ft of the vadose zone. The inventory for the zone was estimated to be about 2000 Ci of ruthenium and about 400 Ci of strontium plus cesium. About 80 Ci of strontium and cesium were estimated to be in the vadose zone, 20 to 25 ft up from the water table, below 39 cribs. A 1966 study^{*(10)} of the same zone for the 12 cribs thought to have the greatest penetration of radioactive waste had shown about 6 Ci of strontium and cesium.

1.2.3 Site Characterization Needs

Characterization studies conducted thus far on 200 Area contaminated soil sites have yielded, at best, only order-of-magnitude estimates of radionuclide inventories in the lower vadose zones. Many of the estimates on individual sites probably could vary by several orders of magnitude. Although total inventories of radionuclides are tabulated annually for each disposal site in the 200 Areas, these values are frequently based on crude analyses of liquid wastes and rough approximations of the volumes discharged. For example, specific fission products (e.g., ⁹⁰Sr and ¹³⁷Cs) were computed from total beta analyses assuming a fission product distribution which may have been subject to considerable variation. Waste volumes were often difficult to estimate.

Disposition planning will require further characterization of contaminated soil sites on the Hanford Project. Additional drilling of these sites is required to confirm the near-surface inventory and provide information to determine spatial distribution. Modeling techniques can be used to supplement the drilling program, minimizing the cost of characterizing each contaminated soil site. The near-surface inventory and spatial distribution

* This study was done to assess potential problems from construction of the Ben Franklin Dam.

will determine the need for possible excavation of transuranic contaminated soil and will provide data for establishing the size of a protective cover if required.

More accurate inventories and spatial distributions of radionuclides in the lower vadose zones will be required if the need arises for long-range predictions of the migration of radionuclides under current conditions as well as changing conditions (e.g., increase in ground water levels and alterations in present ground water flow patterns).

The 1971 study⁽¹²⁾ yielded a proposal to provide an accurate inventory of radionuclides in the 200 Area sediments. The proposed program included drilling, sampling, and analysis coupled with modeling techniques to provide an accurate inventory and a spatial distribution of radionuclides beneath the disposal sites. Initial work would include a more detailed sampling of some of the sites until model verification was adequate to reduce the number of wells to be drilled at the remaining sites. The cost of this program was estimated at \$2,750,000 and was to be carried out over a period of 6 years. At 1975 prices it is now estimated that this program would cost about four times as much.⁽¹³⁾

It is anticipated that improvements in technology will reduce the cost of characterizing contaminated soil sites. For example, new devices are available and being tested which are capable of determining specific radionuclides in core samples or within the soil surrounding a well casing without resorting to expensive and time consuming wet chemical analysis of soil samples. New shallow-well drilling techniques may also reduce the cost of well drilling.

It is now envisioned that an adequate characterization program could be conducted with mostly shallow wells (<50 ft) and a few deep wells (one per site) coupled with modeling techniques to confirm radionuclide inventories and define the spatial distribution, especially that near the surface where the bulk of the radioactivity normally exists. Additional work will be required to complete the chemical model for migration of radionuclides in soil and to incorporate this into the general transport model to define

both the movement of liquids, chemicals, and radionuclides. Existing wells would be used for probing with improved radionuclide detectors. All available information including inventory data based on wastewater analysis, previous well logging and analytical data, and other information (Appendix I, Contaminated Liquid Disposal Sites) will be used in characterizing the contaminated soil sites.

Complete characterization of a given site must also include engineering surveys to assess structural integrity and biological surveys to assess potential spread of contamination by plants and animals.

1.3 DISPOSITION ALTERNATIVES AND RELATED ACTIVITIES

Due to the diverse nature of the contaminated liquid disposal sites, it is unlikely that each disposition alternative would apply to all types of sites. In evaluating which alternatives apply to a given site and determining which is the preferred option, several factors must be considered including:

- site location
- radionuclide inventory
- salt content of the waste
- distance from ground level to the top of the contaminated zone
- distance to groundwater.

The four disposition alternatives and the activities required to implement them are described below in general terms for the liquid waste disposal site as a general group. Additional site characterization data and disposition criteria for the Hanford reservation are needed before the various activities can be defined specifically for the different disposal sites. Where the disposal alternative calls for excavation of the radionuclides, it is assumed that disposal of the contaminated solid wastes would be in retrievable storage or approved burial sites in the 200 Area plateau.

LAYAWAY

Plan of Action

Restrict access to the site, and control plant growth and soil erosion.

Major Activities

- Complete the required site characterization. Determine the radionuclide inventory and the distribution of activity. Install monuments or markers delineating the estimated contaminated zone and radionuclide inventory.
- Fence the site to restrict entry to authorized personnel.
- Fill or cover any disposal sites which present a danger of collapse.
- Provide routine maintenance, as necessary, to control soil erosion and undesirable plant growth and prevent burrowing animals from penetrating the contaminated soil zone.
- Provide routine surveillance, as required, during Layaway.

Special Procedures Required

Layaway of liquid waste disposal sites can be accomplished using established nuclear procedures. There is one area, however, where improved procedures are needed (the problem applies to the other disposition alternatives as well). This involves the characterization of the site with regard to the types, amounts, and distribution of radionuclides present. Currently available procedures are costly and time-consuming, and the accuracy and reliability of some procedures is rather poor. Considering the large number of liquid waste disposal sites on the Hanford reservation which need to be characterized, an extensive development program to provide less expensive and more reliable methods should be undertaken. The availability of rapid, inexpensive, and reliable analytical methods for characterizing the sites would greatly simplify their final disposal.

Waste Disposal

Very little contaminated wastes would be generated by placing the liquid waste disposal site in Layaway. There may be small amounts of contaminated plant growth to dispose of if deep-rooted plants should penetrate the contaminated zone.

PROTECTIVE STORAGE

Protective Storage could be applied to all types of liquid disposal sites. If the site contains significant quantities of transuranics, it

may be necessary to plan for excavation and controlled disposal of the transuranics at some future date (depending on the final disposition criteria established for the Hanford reservation).

Plan of Action

Place the liquid waste disposal site in protective storage and restrict use of the site until the radioactivity decays to an innocuous level or is removed from the site.

Major Activities

- Complete the required site characterization. Determine the radionuclide inventory and distribution. Install documents or markers delineating the contaminated zone, radionuclide inventory, and planned final disposition of the site.
- Install a protective cover over the contaminated area to prevent burrowing animals and deep-rooted plants from penetrating the contaminated soil and to limit precipitation soaking into the contaminated zone. Two types of covers can be considered:
 - a soft cover of rock, sand, top soil, and grass
 - a hard cover of concrete or asphalt similar to highway construction.
- Provide maintenance and routine surveillance, as necessary, during Protective Storage. Control plant growth and soil erosion as required. Provide a means for controlling use of the site during Protective Storage.
- Optional--At the end of the storage period excavate all remaining activity, above applicable release limits, and dispose of in accordance with existing disposal criteria. The need for removal of residual radioactivity from the site would depend on the regulations in existence for the area at the time in question.

Special Procedures Required

- Improved procedures for characterizing the liquid waste disposal sites are needed, as discussed in the previous section on Layaway.

- Providing adequate protective covers for the disposal sites, which would prevent plants, animals and precipitation from penetrating the contaminated zone for the required time period, would require some development effort. Hard covers of concrete or asphalt, similar to highway construction, are subject to degradation with time, and developing a suitable cover which retains its integrity with minimum maintenance could present a difficult problem. In addition, use of a hard cover could make subsequent excavation of the site (if required) more difficult.

Use of a soft cover appears to be the preferred approach if a suitable soft cover can be demonstrated. PNL is currently evaluating a soft cover which consists of a bottom layer of 2-10 in. diam cobblestones or crushed rock about 3 ft thick, an intermediate layer of coarse sand 1 ft thick and an upper layer of top soil 2 ft thick. The top soil layer would be planted with a shallow-rooted grass such as poa or cheat grass to control soil erosion. The effectiveness of the soft cover as a penetration barrier remains to be demonstrated.

- At some disposal sites it will be necessary to fill the void spaces before installing the protective cover. The filler material used would probably be clean dirt.
- If the residual activity is to be removed from the site at some future date, it would be highly desirable if some form of boundary layer could be placed between the contaminated zone and the filler material or protective cover. This would permit most of the filler material or protective cover to be disposed of as uncontaminated debris when the residual activity is removed.

Waste Disposal

Very little contaminated waste would be generated by placing the liquid waste disposal sites in protective storage. A small amount of contaminated plant growth may require disposal; filling the voids and/or

installing the protective cover may require the disposal of small amounts of contaminated soil. Disposal of the wastes would be in retrievable storage or authorized burial grounds in the 200 Areas depending on the radionuclide content.

ENTOMBMENT

Entombment could be considered for all types of liquid waste disposal sites, assuming that suitable entombment procedures can be developed. However, considerable development effort would be required to demonstrate acceptable entombment procedures. Entombment of the site would provide greater safety, improved containment and possibly lower maintenance and surveillance costs as compared to Protective Storage. Entombment would have a much higher initial cost than Protective Storage and would make subsequent removal of residual activity from the site more difficult. It is impossible to assess the usefulness of Entombment as a disposition alternative for liquid waste disposal sites until a successful procedure has been demonstrated.

Plan of Action

Entomb the contaminated zone, and restrict use of the site until the radioactivity decays to a level permitting release of the site for unrestricted use.

Major Activities

The activities required to entomb a liquid waste disposal site would be similar to those required for protective storage, except for the entombment process. The entombment of a liquid waste disposal site has not been demonstrated but could possibly utilize a hard protective cover of concrete or asphalt and a chemical agent or grout to stabilize the radionuclides in place in the soil and form a barrier against their further migration. Considerable maintenance of the entombment barrier, to insure its integrity as the radionuclides decay, might be required.

Special Procedures Required

- Improved procedures for characterizing the liquid waste disposal sites would be needed as discussed in the previous section on Layaway.
- Practical methods for entombing the liquid waste disposal sites will have to be developed and demonstrated if Entombment is to be considered as a possible disposition alternative for the sites. ARHCO is currently investigating the use of chemical grouting to fix the radionuclides in place in soil. The grouting agent could be used to form a barrier around the radionuclides in the soil and prevent their further migration, or it could be placed directly into the soil containing the radionuclides and fix them in place. The combination of chemical grouting and a protective hard cover of concrete or asphalt might provide sufficient containment of the radionuclides present at the site to be classified as Entombment. The effectiveness of the procedure in containing the radioactivity would have to be demonstrated. The useful life of the grouting agent in controlling radionuclide movement is unknown, and considerable maintenance might be required as the radionuclides decay. The use of a chemical grout and a hard cover to entomb the radionuclides would make any future removal of residual radioactivity more difficult.

Waste Disposal

Similar to Protective Storage except that installation of the chemical grout might produce some contaminated piping and equipment which would have to be disposed of. The volume should be small, however, since the piping and equipment would probably be reused a number of times at different sites.

DISMANTLING

Dismantling can be applied to all liquid waste disposal sites at Hanford. However, until final disposition criteria are established for the reservation, Dismantling of a liquid waste disposal site will simply involve the transfer of the radioactivity from one underground site to other underground sites without resolving the final disposition of the activity. There are some incentives to dismantle the 100 Area liquid waste disposal sites to allow immediate unrestricted use of the land, especially if the wastes can be disposed of in the 200 Areas. Similar incentives do not exist for Dismantling the 200 Area sites. Dismantling of the 200 Area sites would require the mining of enormous volumes of contaminated soil without adequate terminal disposition criteria being available for disposal of the wastes. Therefore, Dismantling is not considered a viable option for 200 Area liquid waste disposal sites at present even for those with high transuranic contents unless special considerations dictate dismantlement (as was the case with 216 Z-9, where criticality problems made it advisable to remove the plutonium).

Plan of Action

Remove all the radioactivity, above the release limits for subsequent use, from the site.

Major Activities

- Complete the required site characterization. Determine the radionuclide inventory and distribution.
- Design and install the equipment, containment and ventilation control required for excavation, packaging and removal of contaminated dirt and other contaminated materials from the site. Provide necessary shielding for personnel safety if radiation levels require it.
- Remove the uncontaminated overburden from the disposal site.

- Remove all contaminated materials above the pertinent release limits. Segregate and package the wastes for retrievable storage or burial depending on the radionuclide content. If the transuranic content is high in portions of the wastes, recovery of the transuranics from the wastes prior to disposal, may be appropriate.
- Remove the equipment and containment system; retain for future use or dispose of in the appropriate manner.
- Remove all uncontaminated debris from the site or bury in the excavation.
- Fill the excavation with clean dirt and plant with grass to control soil erosion.

Special Procedures Required

- Mining, packaging and disposal of contaminated soil can be greatly simplified if rapid and reliable field instruments can be developed for analyzing the radionuclide content of the soil. This would permit accurate segregation of contaminated soil and reduce the volume of soil requiring controlled disposal.
- The excavation and packaging of highly contaminated soil and other contaminated solids, at the liquid waste disposal site will require some form of containment barrier to prevent the release of radioactivity to the environment and to protect the workers. An inflatable or rigid containment barrier, with appropriate ventilation control, will probably have to be installed over the working area during the mining operations to prevent the spread of contamination.
- Depending on the radiation levels and the transuranic content, it may be necessary to use remotely operated and shielded equipment to mine and package the contaminated dirt and other materials. It may also be necessary to package some of the waste in shielded containers for disposal. An example of the procedures required for excavating a liquid waste disposal site involves the 216 Z-9

trench. (14-16) In this operation, remotely operated mining equipment is used to remove the contaminated soil from the trench; but packaging of the contaminated soil is carried out in a gloved box.

- If the soil contains substantial amounts of transuranics, it may be desirable to recover as much of the transuranics as possible. Improved methods for recovering transuranics from soil need to be developed.

Waste Disposal

The contaminated waste volumes and disposal requirements for dismantling of a liquid waste disposal site will depend primarily on two factors:

- the types, amounts, and distribution of the radionuclide present
- the disposition criteria in effect on the Hanford reservation at the time the radioactivity is being removed.

The latter factor can have a very significant effect on the waste volumes generated by Dismantling a liquid waste disposal site. Changes in the release limits as a result of technical or political decisions could change by orders of magnitude the waste volumes requiring controlled disposal.

If the radionuclides to be removed are transuranics, the volumes of contaminated wastes would normally be much less than if fission product activity is to be removed. This is because the transuranics do not migrate in the soil to the same extent as the fission products but are almost completely retained in the top 6-12 in. layer of soil. As an example, consider the 216 Z-9 enclosed trench, which has a bottom area of about 1800 ft². Assuming the transuranics are in the top foot of soil, about 70 yd³ of soil would have to be removed to recover the bulk of the transuranics. If the same crib were covered with a 20-ft soil column, about 3000 yd³ of overburden would have to be removed to reach the transuranic bearing layer (assuming sloped walls to prevent cave-ins).

Some of the overburden might also be contaminated. Removal of 99% of the contamination from a fission product crib of similar dimensions would require the mining of an estimated 10,000 yd³ of contaminated soil and 30,000 yd³ of overburden.*

Dismantling of contaminated liquid waste disposal sites in the 200 Areas would generate enormous volumes of contaminated soil and other wastes. ARHCO estimates the following volumes of soil would have to be mined.

- Two million yards of highly contaminated soil (approximately 0.06 Ci of beta and gamma activity per cubic foot) located near the crib surfaces.
- Nine million yards of moderately contaminated soil (approximately 0.01 μ Ci of beta and gamma activity per cubic foot).
- One-half million yards of soil contaminated with plutonium (Z-Plant cribs) and uranium.

In addition, millions of cubic yards of overburden would have to be removed.

Dismantling of liquid waste disposal sites in the 100 Area would generate much smaller but still significant volumes of contaminated wastes.

Because of the volumes of soil to be removed, and because adequate terminal disposal procedures are not available for transuranic or beta-gamma contaminated wastes, there is little technical incentive for dismantling the liquid waste disposal sites in the 200 Areas at this time.

* Assumes: a buried crib, 20 ft deep and 30 x 60 ft in bottom area; lateral spread of the contaminated zone to an area of 80 x 110 ft; downward migration of the activity for 30 ft; and removal of noncontaminated soil on the sides (part of the overburden) to give sides sloping enough to prevent cave-ins.(17)

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**2.0 CONTAMINATED SOLIDS
STORAGE & BURIAL SITES**

2.0 Contaminated Solids Storage and Burial Sites

2.0 CONTAMINATED SOLIDS STORAGE AND BURIAL SITES

2.1 GENERAL

Contaminated solid wastes (obsolete or failed equipment, ventilation system filters, paper, rubber gloves, etc.) generated at Hanford since startup in 1944 have been placed underground in trenches, caissons, and tunnels and on retrievable storage pads. As of December 1974, 64 active and inactive storage and burial sites for contaminated solid wastes were located on the Hanford Reservation:⁽¹⁻³⁾ 25 in the 100 Areas, 29 in the 200 Areas, and 10 in or near the 300 Area. They covered a total area of about 290 acres and contained about 900 kCi of beta activity and 300 kg Pu. Most of the radioactivity is contained in the 200 Area solid waste sites, used for all contaminated wastes generated at Hanford since 1973.

Most solid waste repositories in the Reservation are backfilled trenches of various sizes and shapes. Figure 2.1 is a schematic diagram of the solid waste trenches commonly used in the 200 Area. Waste materials have been placed in the trenches by various means: Large pieces of failed or obsolete contaminated equipment were placed in wooden, metal or concrete boxes and put in the industrial waste burial sites with the larger dimensions shown in Figure 2.1. A typical concrete burial box is 10 ft wide, 19 ft long and 8 ft high, with 4-in. thick walls. It may weigh over 30 tons when loaded. After the box is dragged into place, soil is pushed over the box to reduce the radiation level before placing another box in the trench. Thus boxes in a trench are separated by 15 ft or more of soil.⁽⁴⁾

Dry waste, consisting of contaminated rags, paper, filters, disposable supplies, soil, small pieces of equipment, etc., was generally packaged in 4.5 ft³ cardboard boxes prior to burial. Following placement in the burial trench, about 8 ft of earth cover was placed over the boxes. An average of about 15 linear ft of trench was closed for each burial. As a result, the bottom of a trench used for dry waste burial comprises pockets of radioactive waste separated by earth. Caissons built of various sizes of metal pipe have been buried in some sites and used for disposal of small items.

FIGURE 2.1. Solid Waste Burial Trenches Commonly Used in the 200 Areas

Starting in 1970, solid wastes containing transuranics were placed in "retrievable storage" in the following types of facilities:

- Special trenches containing materials packaged in iron drums and in iron, concrete or fiberglass impregnated boxes. Burial in iron drums or boxes was stopped when it was learned that container failure could occur in less than 20 years.
- A concrete V-trench containing waste barrels. The barrels are covered by metal and a layer of earth (Figure 2.2).
- Pad storage facilities containing waste drums stacked four-high (Figure 2.3). The layers of drums are separated with fire retardant-impregnated plywood. Stacks of drums 24 x 24 x 12 ft high are covered with plywood, plastic-coated nylon sheeting, and a 4-ft layer of earth.
- Buried concrete caissons, used for small items containing fission products as well as transuranics (Figure 2.4).

ADVANTAGES

PROTECTS DRUMS FROM SOIL

STORAGE CONDITIONS CAN BE MONITORED

FIGURE 2.2. Concrete Lined V-Trench Used for Retrievable Transuranic Waste Storage

FIGURE 2.3. The Transurinic Slab (Alternative method for retrievable transuranic waste storage)

FIGURE 2.4. Retrievable Solid Waste Burial Caissons

Large pieces of contaminated equipment removed from the Purex Plant, difficult to handle by the normal burial procedures, were placed on railroad flatcars and located in special tunnels next to the plant. Figure 2.5 is a schematic diagram of a storage tunnel for Purex Plant solid waste.

2.2 RADIOACTIVE CONTAMINATION LEVELS AND SITE CHARACTERIZATION NEEDS

Table 2.1 summarizes available data on the storage and burial of contaminated solid wastes at Hanford through December 1974. Information for each site appears in a data sheet in Appendix II.

Prior to 1967 only limited records were kept of waste volumes and radionuclide contents. Hence much of the inventory data for sites used before 1967 are estimates based on practices used in 1967. Since then each waste shipment to a burial ground has been accompanied by a ticket listing the type, source and volume of waste, the grams of plutonium and uranium, and the radioactivity in curies, with the major fission products identified if known. ⁽⁵⁾

FIGURE 2.5. Tunnel for Storage of Radioactive Equipment

TABLE 2.1. Contaminated Solids Storage and Burial Sites⁽¹⁻³⁾

Area	Number of Sites	Estimated Volume, ft ³	Total Area, Acres	Estimated Total, Curies	Estimated Pu, g	Estimated Uranium, kg
100-B, C	7	NA	15	2,700	0	0
100-D, DR	6	NA	20	3,900	0	0
100-F	6	NA	14	1,500	0	0
100-H	5	NA	7	2,700	0	0
100-K	1	NA	9	10,200	0	0
Subtotal 100 Areas	25	5.8×10^5	65	2.1×10^4	0	0
200-East	12	2.4×10^6	74	6.1×10^4	1.9×10^4	2.7×10^3
200-West	17	3.5×10^6	90	7.8×10^5	3.7×10^5	6.0×10^5
Subtotal 200 Areas	29	5.9×10^6	164	8.4×10^5	3.9×10^5	6.0×10^5
600 Area*	10	7.5×10^5	64	<4,000	up to 6,000	230
Total, all Areas**	64	7.2×10^6	293	8.6×10^5	$\sim 4 \times 10^5$	6.0×10^5

* Includes burial grounds around the 300 Area and the 300 North and 300 Wye burial grounds.

** Does not include burial ground in 100 N Area.

Detailed characterization of many of the burial grounds presents a difficult problem due to the nonhomogeneity of the buried wastes and to uncertainty as to their location within the trenches. To do it by core drilling would require many samples to accurately inventory the buried radionuclides.

Research efforts were started in 1974 to develop methods other than core drilling for burial ground characterization.

Various devices, such as magnetometers and seismic, radar and sonic units are being evaluated for mapping burial trenches and locating metal objects, voids or areas of low or high density. It is also planned to test directional radiation counters in strategically located wells to locate pockets of high radionuclide concentrations in the burial grounds.

Also being studied is the potential for transport of contamination from the burial grounds through precipitation, leaching or biological means (i.e., plant growth and burrowing).

2.3 DISPOSITION ALTERNATIVES AND RELATED ACTIVITIES

Because of the diverse nature of the solids burial and storage sites, it is unlikely that each of the four disposition alternatives would be applicable to all sites. In evaluating which alternatives would apply to a given site and determining which is the preferred option, the following factors should be considered.

- No final disposition criteria have been established for the Hanford Reservation. Retrievable storage is required for wastes containing >10 nCi transuranics/gram of matrix, but this is only an interim measure. Terminal disposal of contaminated solid wastes from existing burial or storage sites is not possible until the disposal criteria are established. To excavate and remove such wastes from existing burial grounds to other locations before the disposal criteria are set would simply transfer the ultimate disposal problem from one location to another.

- There is considerable incentive to free the 100 Areas (and possibly the 300 and 600 Areas) for unrestricted land use. Therefore there are incentives to move the buried or stored solid wastes from these areas as rapidly as possible even though terminal disposal of the solid wastes is not possible at present.
- The burial and storage sites are poorly characterized as to the radionuclide inventory and distribution. Also little is known of the current conditions of the containers in which the wastes were packaged. The specific activities required to implement the various disposition alternatives at a given site cannot be defined until additional site characterization data are available.

LAYAWAY

Plan of Action

Restrict access to and use of the site, and control plant growth and soil erosion.

Major Activities

- Complete the required site characterization. Determine the radionuclide inventory and the distribution of the radioactivity.
- Install monuments or markers delineating the contaminated zone and the radionuclide inventory.
- Fence the site to prevent unauthorized entry during Layaway.
- Provide routine maintenance, as necessary, to control soil erosion and prevent plant growth and burrowing animals from penetrating the contaminated zone. The shallowness of some burial grounds could make this a severe problem. In some cases it may be necessary to provide additional dirt to cover over the site to prevent access to the contaminated zone.
- Provide routine surveillance, as needed, during Layaway.

Special Procedures Required

A problem area, which applies to all four disposition alternatives, involves characterizing the site as to the radionuclide inventory and the distribution of the radioactivity. (The same problem applies to the liquid waste disposal sites--see Section 1.3.) Leaching of the radionuclides from the solid wastes by precipitation and their subsequent migration in the soil could extend the radionuclides far beyond the normally established boundaries for the burial grounds. The problem is further complicated by the lack of adequate records on the radionuclide content of the stored or buried wastes. Currently available procedures for characterizing the sites are costly and time-consuming, and the accuracy and reliability of some procedures are rather poor. Development of improved procedures for determining the distribution of radionuclides in the soil around the sites would help to simplify final disposition of the sites, and should be undertaken immediately.

Waste Disposal

Very little contaminated wastes would be produced by placing a solids waste burial or storage site in Layaway. There may be small amounts of contaminated plant growth to dispose of if deep-rooted plants should penetrate the contaminated zones.

PROTECTIVE STORAGE

Protective Storage could be applied to all of the contaminated solids burial and storage sites. If the site contains significant quantities of transuranics, it may be necessary to plan for the subsequent excavation and controlled disposal of the transuranics at some future date, depending on the final disposition criteria established for the Hanford Reservation. This option appears especially attractive for some of the 100 Area burial grounds which contain little radioactivity other than activation products. The high radiation levels associated with some of these burial ground wastes make their near-term excavation and removal a difficult operation. The short-half lives of the activation products mean that a relatively

short period of Protective Storage (50 to 150 years) would reduce the residual activity to an acceptable level for uncontrolled use of the site.

Plan of Action

Place the site in Protective Storage and restrict access to and use of the site until the radioactivity present decays to a level permitting release for unrestricted use or is removed from the site.

Major Activities

- Complete the required site characterization. Determine the radionuclide inventory and the distribution of the radioactivity.
- Erect monuments or markers delineating the boundaries of the contaminated zone and the radionuclide inventory.
- Install a protective cover over the contaminated zone to prevent plants and burrowing animals from penetrating the zone and to limit seepage of precipitation. Two types of covers can be considered:
 - a hard cover of concrete or asphalt similar to highway construction
 - a soft cover of rock, sand, topsoil and grass.

The procedure used might have to be varied somewhat with storage sites such as the Purex railroad tunnels. If the tunnels were placed in Protective Storage, it would probably be necessary to fill them to prevent collapse before installing the protective cover. Either dirt or concrete could be used to fill the void space.

- Provide maintenance and routine surveillance as required during Protective Storage. Control plant growth and soil erosion as necessary.
- Provide a mechanism for controlling use of the site during Protective Storage.
- Optional - At the end of the Protective Storage period excavate all remaining radioactivity above the applicable release limits, and dispose of in accordance with existing disposal criteria. The need

for removal of the residual radioactivity from the site would depend on the regulations in existence for the area at the time in question.

Special Procedures Required

- Provide improved procedures for characterizing the site as discussed in the previous section on Layaway.
- Providing adequate protective covers for the solid wastes burial and storage sites, which prevent animals, plants and precipitation from penetrating the contaminated zones, would require some development effort. The effectiveness of either hard or soft covers in providing the required penetration barriers remains to be demonstrated. The covers used would be similar to those proposed for the liquid waste disposal sites. (See Section 1.3 for a discussion of the hard and soft covers proposed for use with the liquid waste disposal sites.)
- Some burial and storage sites are relatively shallow. In some cases it may be necessary to provide additional dirt cover, in addition to the protective cover, to reduce surface radiation to an acceptable level.

Waste Disposal

Very little contaminated waste would be produced by placing the contaminated solids burial and storage sites in Protective Storage. Installation of the protective cover might require the removal of some contaminated soil, but the volume should be very small. Disposal of the contaminated dirt would be in retrievable storage or authorized burial grounds in the 200 Areas, depending on the radionuclide content. Disposal of very small amounts of contaminated plant growth might also be necessary.

ENTOMBMENT

Entombment can be considered for the contaminated solids burial and storage sites only if acceptable Entombment procedures can be developed. The problems involved in developing acceptable Entombment procedures for the solids burial and storage sites are similar to those for entombing

the liquid waste disposal sites (see Section 1.3). Entombment procedures suitable for one class of facilities should be acceptable for the other. Considerable effort would be required to develop and demonstrate an acceptable Entombment procedure. Entombment would require a higher initial investment than Protective Storage and would make any subsequent removal of radioactivity more difficult. However, Entombment could provide greater safety and containment and, possibly, reduced maintenance and surveillance costs compared to Protective Storage. Because of the many uncertainties involved, it is impossible to accurately assess the usefulness of Entombment as a disposition alternative for the solids burial and storage sites until an acceptable procedure has been demonstrated.

Plan of Action

Entomb the buried or stored wastes in place, and restrict use of the site until the radioactivity present decays to a level permitting release for unrestricted use or is removed from the site.

Major Activities

The activities required to entomb a solids burial or storage site would be similar to those required to place it in Protective Storage, except for the Entombment process. Entombment of a site has not been demonstrated but could involve use of a hard protective cover and a chemical grout to seal the soil beneath the buried or stored wastes against migration of radionuclides.

Special Procedures Required

- Provide improved procedures for characterizing the site as discussed in the section on Layaway.
- A practical method for entombing the solids burial and storage sites will have to be developed and demonstrated if Entombment is to be considered as a possible disposition alternative for the site. ARHCO is currently investigating the use of chemical grouting to fix radionuclides in place in soil and prevent their migration. A combination of chemical grouting and a hard protective cover of concrete or asphalt

might be developed which would provide sufficient containment of the radionuclides in the solid wastes to be classified as Entombment. The chemical grout would be used to form a barrier beneath and around the wastes to prevent further migration of radionuclides into the soil. The hard cover would serve to prevent penetration of plants, animals and precipitation into the contaminated zone. The useful life of the chemical grout as a migration barrier is unknown, and considerable maintenance might be required. Consideration could also be given to encasing the buried or stored wastes in concrete. However, installing a concrete barrier under the wastes and contaminated soil would be difficult and very expensive.

- Storage sites with large void spaces, such as the Purex railroad tunnel, would be filled with dirt or concrete, prior to Entombment, to prevent collapse.

Waste Disposal

Similar to Protective Storage, except that installation of the chemical grout could result in the contamination of pipe and equipment, which would require controlled disposal. The waste volume should be small, however, since the pipe and equipment would probably be reused at different sites.

DISMANTLING

Dismantling can be applied to all of the solids burial and storage sites, but may not be feasible for most sites until the final disposition criteria are established for the Hanford Reservation. It makes little sense to dismantle an existing 200 Area burial or storage site, for example, unless terminal disposal of the contaminated wastes is possible. For 100 Area and 300 Area burial and storage sites, however, it may be feasible to dismantle the sites, to make them available for unrestricted use, even though terminal disposal of the contaminated waste is not possible at the time of dismantling.

Plan of Action

Remove all radioactivity, above the release limits for subsequent use, from the site.

Major Activities

- Complete the required site characterization. Determine the radio-nuclide inventory and distribution of radioactivity.
- Design and install the equipment, ventilation control and containment barrier needed for excavation, segregation, packaging and removal of the contaminated wastes, dirt, and structural materials. Provide any shielding required for personnel protection.
- Remove the overburden and dispose of in the appropriate manner.
- Remove the contaminated wastes. Segregate the wastes, as necessary, to simplify final disposal. Consideration should be given to burning of combustible wastes. Package the waste, as necessary, for disposal.
- Remove any contaminated structural metal pipe or concrete and package for disposal.
- Remove any dirt, which is contaminated above release limits, and package for disposal.
- Transfer all contaminated wastes from the site to the appropriate disposal facility.
- Remove the equipment, ventilation control, and containment barrier from the site; retain for future use, or dispose of appropriately.
- Remove all nonradioactive debris from the site or bury in the excavation.
- Fill the excavation with clean dirt, and seed the area with grass to control soil erosion.

Special Procedures Required

- Excavation, removal and packaging of the solid wastes, contaminated and structural materials will require some form of containment barrier

to prevent release of radioactivity to the environs and to protect the workers. Ventilation control will also be needed. An inflatable or rigid containment barrier, with appropriate ventilation control, will have to be installed over the working area during all dismantling operations to control the spread of contamination.

- Special equipment will be needed to excavate and package the buried or stored wastes. Depending on the radiation levels and/or transuranic content, it may be necessary to use remotely operated equipment to excavate and package the wastes. The solid wastes were usually packaged before burial or storage, but the current condition of the containers is not known. It will probably be necessary to repackage most, if not all, of the wastes before removing them from the site for disposal. Shielded containers may be needed for some of the wastes if radiation levels are high.
- It is likely that segregating of contaminated wastes from a given burial or storage site would be desirable to simplify final disposal. Construction of a central facility for segregating the contaminated solid wastes from the various burial and storage site appears warranted if many of the sites are to be dismantled. For operator protection, shielded or remote operations would probably be required at the facility. Wastes from the various sites would be packaged in temporary containers and transferred to the central facility for segregation and final disposal. The facility would include an incinerator for burning combustible wastes, as well as capabilities for compacting noncombustible wastes to reduce the waste volumes. Consideration should also be given to providing the capability for partially decontaminating solid wastes containing substantial amounts of transuranics, and recovering the transuranics. The capability for packaging the segregated wastes for final disposal would also be provided.
- Metal or concrete pipe has been used in construction of some burial or storage sites (i.e., Purex railroad tunnels, 300 Y caissons). Methods may have to be provided onsite for segmenting these contaminated items into manageable sizes to simplify disposal.

Remotely operated cutting torches could probably be used for the caissons, while explosives or pneumatic hammers could be used with the concrete.

- Segregation and removal of contaminated dirt from the sites would be simplified if rapid and reliable field instruments were available for analyzing the radionuclide content of soils.

Waste Disposal

Large volumes of contaminated wastes will result from the dismantling of the solids burial and disposal sites. The wastes will consist of:

- the original buried or stored wastes and their containers
- materials of construction used to fabricate the burial or storage site, usually concrete or steel
- dirt contaminated by 1) disintegration or breakage of waste containers, 2) leaching of radionuclides from the wastes by moisture, and 3) excavation activities
- contaminated equipment, containment barriers, protective clothing, etc., used in the dismantling operations.

Wastes from the 100 Area burial grounds will be contaminated mainly with activation products, with lesser amounts of fission products. These wastes should contain little or no transuranics. The bulk of the new wastes from the other Areas will be contaminated with both transuranics and beta-gamma activity.

The diverse nature of the various sites and the lack of site characterization data makes it difficult to estimate waste volumes for the individual sites. There are several factors which would affect the potential waste volumes. They include:

- The amount of radionuclide leaching and migration in the soil that has occurred. The more leaching and migration the greater the volume of contaminated soils which may have to be removed. This should be a greater problem in 200 and 300 Area burial grounds than in the 100 Area

facilities. Many of the solid wastes buried in the 100 Area facilities are metals containing activation products which should not be readily leachable.

- The release criteria in effect on the Hanford Reservation at the time of disposition. The more restrictive the criteria, the more contaminated soil will have to be removed from a site.
- The amount of waste segregation, combustible waste burning, and other volume reduction that is attempted. An extensive effort in the area of volume reduction could reduce the wastes (except soil) requiring controlled disposal to a small fraction of the original volume.

While complete site characterization data are lacking for the various facilities, data are available on the wastes which have been buried in the 100, 200, and 300 Area burial grounds.^(2,6-8) The estimated waste volumes, radionuclide content, and land areas affected through FY 1975 are summarized in Table 2.1. Waste volumes generated by cleanup of the facilities would be much greater than those listed in Table 2.1 because of the large volumes of contaminated dirt requiring disposal. Based on earlier ARHCO estimates,⁽⁶⁾ it is estimated that excavation of current ARHCO burial sites would require removal of about 15 million cubic yards of dirt, plus an additional 1,500,000 cubic yards of overburden to hold the slopes of the excavations below one. The portion of the dirt volume which is contaminated is impossible to estimate but should represent a sizable fraction of the total. On a similar basis, dirt removal required at the 100 and 300 Area facilities should amount to about 6.7 and 2.7 million cubic yards respectively. Because contaminated dirt represents a sizable percentage of the contaminated wastes requiring disposal, additional site characterization data are greatly needed to permit more precise estimation of contaminated soil volumes.

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FACILITIES

3.0 Fuel Reprocessing Facilities

3.0 FUELS REPROCESSING FACILITIES

3.1 GENERAL

The Hanford fuels reprocessing (chemical separations) facilities discussed in this section include the following:

- B and T Plants, used for the recovery of plutonium from Hanford reactor fuels by the bismuth phosphate precipitation process
- U Plant, built as a bismuth phosphate plant but later converted to a solvent extraction plant for the recovery of uranium from bismuth phosphate process wastes
- Redox and Purex, used for the recovery of plutonium, uranium, and neptunium by solvent extraction processes
- the Semiworks, used initially for the hot demonstration of the Redox and Purex processes and later for the recovery of radioactive strontium and cesium from high-level wastes.

All the main-line separations plants were equipped for the following operations:

- receipt of the irradiated uranium fuel by rail from the 100 Areas; fuel decladding and dissolution; feed preparation
- separation of products from wastes
- purification, concentration and loadout of the products
- treatment of the wastes prior to discharge to the waste storage system.

The typical Hanford separations plant includes a large, reinforced concrete process ("canyon") building with shielding walls up to 11 ft thick; a large and complex building ventilation system which terminates in external filters and an exhaust stack; an analytical laboratory; and various other ancillary buildings and facilities which may have high- or low-level contamination.

The process building includes a canyon area, where most of the reprocessing occurs in cells below the canyon deck. The canyon area runs nearly the full length of the building and is equipped with one or more shielded-cab cranes. The cells are covered by thick concrete blocks which can be removed remotely by the crane to allow access to the equipment in the cells. The crane is also used for remote removal and replacement of equipment for maintenance, through the use of impact-type connectors. (If still operable at the time a canyon building were to be dismantled, the crane could be used in removing most of the process equipment and piping from the cells.) Figure 3.1 provides a cutaway view of B, T, and U process buildings, as an example of canyon construction. Figure 3.2 shows a cutaway of the Redox process building.

FIGURE 3.1. Building 221--Cutaway View(1)

FIGURE 3.2. Cutaway View of the Redox Process Building⁽²⁾

The building and process ventilation system includes scrubbers, tunnels and air ducts, blowers, filters and an exhaust stack. It was installed to remove particulate and chemically active radioactive materials from the ventilation air and process exhaust gases prior to their discharge to the atmosphere.

Figure 3.3 is a schematic drawing of a typical separations plant ventilation system. The air flows from the least to the most contaminated area. The regulated zones are maintained under negative pressure with respect to the atmosphere to prevent the spread of contamination into noncontaminated areas. Sources of contamination within the exhaust air system include volatile radionuclides, such as radoruthenium and radioiodine, and contaminants that are entrained from process materials or from contaminated surfaces.

Four of the plants, B, T, U, and Redox, are equipped with sand filters containing gravel and sand graded from coarse to fine in the direction of

FIGURE 3.3. Schematic of Ventilation of Typical Separations Plant⁽³⁾

the air flow. The filter media are contained in a concrete shell equipped with air distribution tubes. The sand filters at T Plant, U Plant, and Redox are still in service while the one at B Plant is on standby as backup for high-efficiency fiberglass filters. Purex has only fiberglass filters. All separations plant ventilation systems are in operation.

The retired canyon buildings were designed for static, vertical live and dead loads and have limited seismic resistance. A preliminary assessment indicates that the B Plant canyon building may not withstand a Design Basis Earthquake. Further seismic analysis of all the canyon buildings is required before one can be assured of their long-term structural integrity.⁽⁴⁾

3.1.1 B and T Plants⁽⁵⁾

B and T Plants included these major facilities:

- A process building (221-B and 221-T) which contains a row of 20 approximately 40-ft long concrete sections each containing two cells, with 7-ft thick concrete cell covers. In-cell equipment includes various sizes of tanks and centrifuges. Much of the process piping is imbedded in the cell walls. The canyon area has a 75-ton crane.
- A service building (271-B and 271-T) adjacent to the canyon building and used for preparation of chemicals and as administrative headquarters for the plant.
- A control laboratory (222-B and 222-T) which has been converted to office space.
- A concentration building (224-B and 224-T) used for additional purification of the plutonium product. Equipment was maintained by contact methods.
- An exhaust system filter and stack.
- The Waste Encapsulation and Storage Facility (225-B) built on to the B Plant canyon building.

3.1.2 U Plant⁽⁶⁾

U Plant was built for use as the third bismuth phosphate precipitation plant but was reequipped for service in recovering uranium from the bismuth phosphate process wastes. The process building (221-U) was outfitted with pulse columns and with ancillary feed preparation and waste treatment equipment. The concentration building (224-U) was equipped with continuous calciners for converting uranyl nitrate product to uranium trioxide. U Plant also has a service building (271-U) and a laboratory (222-U).

3.1.3 Redox⁽²⁾

Redox was designed and built for the recovery and purification of both plutonium and uranium from Hanford reactor fuels. The canyon area cells contain dissolvers, evaporators, tanks, piping, etc. The packed

columns used for solvent extraction are located in a silo (tower) at one end of the process building (202-S). Major ancillaries include the plutonium concentration building (233-S), the Redox Laboratory (222-S), which contains hot cells as well as gloved-box and open-hood laboratory rooms, and the external components of the ventilation system.

3.1.4 Purex⁽⁷⁾

The Purex Plant was built for the recovery of plutonium and uranium from Hanford reactor fuels by a solvent extraction process based on the use of pulse columns. The Purex control laboratory is included in the Purex process building, 202-A.

3.1.5 Semiworks⁽⁸⁾

The Semiworks was built as a pilot plant for Redox, was used also to test the Purex process, and then was converted to a facility for the recovery of ⁹⁰Sr from Hanford high-level wastes. The process building (201-C) contains three hot cells equipped only for contact maintenance and is supported by an aqueous makeup and control building (271-C) and a solvent handling building (276-C). The facility also includes a fiberglass exhaust filter and a 200-ft stack.

3.2 SITE CHARACTERIZATION

3.2.1 Contamination Levels and Locations

The process areas and ventilation systems of the separations plants contain gross contamination. The canyon areas of the Redox and Purex Plants may contain kilogram quantities of plutonium. For example, at the time the Redox Plant was shut down, acid flushes of the cells removed 9 kg of Pu; this is about half of that estimated to be present in the cells. The process cells used for fuel dissolution and first cycle extraction also contain high levels of fission product contamination.

The facilities are expected to be contaminated in various ways:

- Gross quantities inside the cells; deposits inside process equipment; collections of solids in relatively inaccessible locations such as

cracks and crevices in the concrete cell walls and external surfaces of equipment and in sumps. Contaminated organic "crud" deposits are also expected as a result of solvent extraction processing.

- Gross contamination inside the "hot" pipe trenches due to pipe leaks.
- Gross contamination inside the air vent system and the filters.
- Contamination in the canyon areas above the process cells from airborne dust deposits.

3.2.2 Site Characterization Requirements

For decommissioning planning, the following characterization work is needed on retired reprocessing facilities such as Redox and the Semiworks:

- 1) estimates of radioactive contamination within the various components of the ventilation system
- 2) smearable contamination levels on the interior surfaces of equipment and structural components
- 3) nonsmearable contamination levels under layers of paint, soaked into structural materials, and deposited into cracks, etc.
- 4) in-cell radiation levels and TRU contamination levels (quantities of plutonium present may be high enough to require critical mass controls during D&D operations).

3.3 DISPOSITION ALTERNATIVES AND RELATED ACTIVITIES

In planning the disposition of a fuel reprocessing facility and evaluating the various disposition alternatives, the following factors should be considered:

- Each fuel reprocessing facility consists of a canyon building with its exhaust air system, and a number of smaller buildings and external ancillaries. Most of the smaller buildings and external ancillaries are contaminated, but the high-level cells of the canyon buildings, with their process equipment and piping, and the exhaust air systems represent the major D&D problems. The main fuel reprocessing

buildings are built of reinforced concrete with massive walls, floors and covers to provide the required shielding. The highly contaminated segments of the exhaust air system are below grade. The smaller buildings are more lightly constructed, usually of wood, metal, concrete block or thin-wall concrete. Many of the smaller buildings are deteriorating rapidly. Because of the varying levels and types of contamination, differences in construction, and current conditions of the buildings it will probably be desirable to apply different alternatives to the various segments of a fuel reprocessing facility. In discussing the various disposition alternatives, it will be assumed that each facility consists of three separate segments:

- the process building (e.g., 202-S)
 - the smaller buildings and external ancillaries
 - the exhaust air system.
- The exhaust air systems are vital appendages to the process buildings and are necessary for their normal or standby operation.
 - The long half-lives of the transuranics must be considered when evaluating the disposition alternatives.
 - Current Federal regulations require 20-year retrievable storage of ERDA wastes containing greater than 10 nCi transuranics per gram of matrix.

The following discussions of the various disposition alternatives and the work activities and procedures required to implement them are directed specifically at the Redox facility. However, they are generally applicable to the other fuel reprocessing facilities. It should be remembered that the work activities, procedures and waste management problems described for each D&D alternative are based on limited site characterization data. Thus they may have to be changed or modified as additional data become available.

LAYAWAY

Plan of Action

Remove all exposed, loose contamination and seal all contamination and radiation zones against unauthorized entry.

Major Activities

- Complete the required site characterization.
- Maintain in operation all ventilation systems required for contamination control.
- Remove any exposed, loose contamination in areas accessible to personnel, and paint any exposed contaminated surfaces to fix the residual contamination in place.
- Survey the plant to determine the integrity of all contaminated buildings and auxiliaries. As necessary, renovate to provide the required structural integrity and containment during Layaway. Some of the contaminated auxiliaries and minor buildings may require considerable maintenance to provide the necessary containment. In such cases it may be desirable to dismantle or entomb them immediately rather than renovate and maintain them during Layaway. Additional data on the condition of the various auxiliaries are needed before a decision regarding their disposition can be made.
- Maintain all remote handling equipment in the 202-S Building in operable condition, to assist in final D&D.
- Install any needed protective equipment not already in operation (e.g., intrusion alarms, fire alarms, monitoring equipment, etc.).
- Seal all openings and entries in the various contaminated buildings to prevent unauthorized entry.
- Fence the site to restrict access to the facility.
- Provide routine surveillance and maintenance during Layaway.

Special Procedures Required

All activities required to place a fuel reprocessing facility in Layaway can be accomplished using established nuclear procedures. The only problem areas anticipated would involve personnel protection and contamination control if some of the minor buildings and external auxiliaries are dismantled rather than placed in Layaway. The procedures required for dismantling these appendages are discussed in the following sections on Protective Storage.

Waste Management

Very little contaminated waste would be generated by placing a fuel reprocessing facility in Layaway unless some of the minor buildings and external auxiliaries were dismantled. Removal of the exposed, loose contamination and subsequent painting of the contaminated surfaces would produce a small amount of contaminated solid wastes, including some combustibles, but the total waste volume would be insignificant. Renovation of the buildings to provide the required integrity, and sealing of building openings and entries to prevent unauthorized entry to radiation and contamination zones could also generate small amounts of solid wastes.

Removal of some of the minor buildings and external auxiliaries would generate substantial volumes of contaminated solid wastes, as discussed in the following section on Protective Storage. Total waste volumes cannot be estimated since it is not known which components, if any, would have to be dismantled.

Some of the solid wastes would be contaminated with transuranics and require appropriate disposal. Serious consideration should be given to storing any major quantities of contaminated solid wastes in the canyon areas of the main fuel reprocessing building (202-S canyon) until final disposition of the building is undertaken. All combustible solid wastes should be burned if an incinerator is available; otherwise they should be treated the same as the other solid wastes.

PROTECTIVE STORAGE

The fuel reprocessing facility would be placed in Protective Storage to allow the short-lived radionuclides to decay to a level permitting use of contact operations for final disposition of the facility, a period of 300 to 500 years. Safety considerations dictate that the radioactivity in the facility be adequately contained during Protective Storage; therefore, the structural integrity of the contaminated segments of the facility must be capable of withstanding all credible accidents for the required storage period. The process buildings such as 202-S are believed capable of providing the required containment with a minimum of modification and maintenance. With few exceptions, the smaller buildings and auxiliaries should be dismantled.

Plan of Action

Place the process building (202-S) and selected ancillaries in Protective Storage, and dismantle or entomb all other segments of the plant as rapidly as possible.

Major Activities*

- Complete the required site characterization.
- Dismantle all excess minor buildings and ancillaries external to the 202-S Building which are not needed during Protective Storage and do not have high radiation levels. Buildings and ancillaries to be dismantled would include:
 - 203-S - UNH Storage Facility
 - 205-S - Silica Gel House
 - 276-S - Solvent Handling Building
 - 291-S - Exhaust Fans, Stack and Control House
 - 292-S - Jet Pit House

* A few facilities in the Redox Plant area are not considered in this section: the 222-S Laboratory will remain in active use indefinitely, while the 233-S Plutonium Concentration Building, 207-S Retention Basin, Redox Waste system diversion boxes, and Redox cribs are discussed in other sections.

- 293-S - Acid Recovery
 - 2708-S - Lagers' Shop
 - 2710-S - Inert Gas Generation
 - 2711-S } - Stack Gas Monitoring Facilities
 - 2712-S }
 - 2718-S - Sand Filter Monitoring
 - 2904-S - Water Sampler
- Remove all excess lines, ducts and utilities leading into and out of the 202-S Building. Some of the lines and ducts are highly contaminated. Removal of underground lines would require removal of contaminated dirt. Seal all resulting building openings.
 - Package all contaminated solid wastes generated by the dismantling activities and store them in the canyon areas of the 202-S Building. If possible, burn the contaminated combustible wastes.
 - Install "breathing" filters for each of the canyon cells, the silo and silo trench, the sample galleries, and any other highly contaminated sections of the process building which can be readily sealed; seal all other openings into these sections.
 - Decontaminate remaining sections of the process building. It may be desirable to allow the canyon to breathe through a filter but still allow access for monitoring, etc. If so, install a filter and seal all other openings except for one entry.
 - Provide breathing filters for the sand filter and exhaust air tunnel, seal all other openings, and strengthen structurally if required. Dismantle other external components of the building exhaust system (the 291-S stack, control house and blowers; the 292-S jet pit house; and all exhaust air monitoring facilities). It may be desirable to flush the stainless steel liner in the stack prior to dismantling, using existing facilities.
 - Survey the process building (202-S) and the other buildings and auxiliaries to be retained and determine their structural integrity (including seismic resistance) and ability to meet containment

requirements during Protective Storage. Provide the maintenance, renovations and modifications needed to insure that the buildings will provide the required containment during Protective Storage.

- Provide any safety equipment, such as intrusion and fire alarms, which may be needed during Protective Storage and which are not already in place.
- Seal all the buildings and auxiliaries to prevent access to the contamination and radiation zones.
- Fence the site to restrict access to the facility.
- Provide maintenance and routine surveillance as required.
- At the end of the Protective Storage period, the process building and any other facilities still remaining would be decontaminated for plutonium removal, or dismantled, and any remaining radioactivity, above the appropriate release limits, would be removed from the site and disposed of in accordance with existing disposal regulations.

Special Procedures Required

Placing the main fuel reprocessing building (202-S) in Protective Storage would not present any serious difficulties, and the necessary actions could be accomplished using established procedures. However, dismantling of some of the external ancillaries and excess lines and ducts could require remote operations because of the radiation levels encountered. Additional site characterization data are needed before the required procedures can be adequately defined. Currently available data indicate it should be possible to dismantle most of the components directly without resorting to remote operations. If facilities for handling liquid wastes are available, it may be desirable (or necessary) to partially decontaminate accessible segments prior to dismantling them. Suitable containment and ventilation control will be required to protect the working personnel and environment when the excess facilities are dismantled. If the minor buildings cannot provide sufficient containment and ventilation control, it will be necessary to supply temporary containment-ventilation systems to prevent the spread of contamination. Such systems might also be needed

for the dismantling of external ancillaries and the excavation and removal of underground ducts and lines. It may be necessary to provide a small facility for packaging contaminated wastes generated by the dismantling operations. However, demolition of the exhaust air stack would require that the stack liner be decontaminated prior to demolition. It should be possible to decontaminate the liner using existing equipment designed for that purpose. Once the liner has been decontaminated it may be possible to demolish the stack using standard industrial procedures. In the event that the concrete portion of the stack is contaminated, it may be necessary to devise special procedures for razing the stack. This is not a major problem. The highly contaminated portions of the exhaust air system (sand filter and air tunnel) would be left in place. It would probably be necessary to fill the air tunnel with a noncompressible material to prevent collapse. The line from the sand filter to the blowers would be removed or filled and the exit end sealed. All entries to the sand filter would have to be sealed and a protective cover provided over the sand filter and air tunnel to prevent plants and burrowing animals from penetrating the contaminated zones if the tunnel and filter's concrete casing should fail in any way. Either a hard or soft cover, as described in Section 1, could be used.

Waste Management

Placing the main fuel reprocessing building in Protective Storage would generate only a limited amount of contaminated wastes. However, dismantling of the minor buildings, selected parts of the exhaust air system, and other external ancillaries would generate large volumes of contaminated solid wastes plus some contaminated liquid wastes from decontamination of the exhaust air stack liner.

The types of wastes produced would vary somewhat depending on the facility under consideration, but would generally consist of:

- contaminated metal equipment and piping
- contaminated structural materials (concrete, metal, wood, transite, etc.)

- contaminated liquids from aqueous decontamination activities
- contaminated soil
- contaminated combustible wastes.

A substantial fraction of the solid wastes would be contaminated with transuranics and would require retrievable storage. However, the transuranic content of the wastes should be low enough that it would not be necessary to maintain critical mass controls during dismantling, packaging and transport operations. Serious consideration should be given to storing the solid wastes in the canyon building. The combustible wastes should be burned if a shielded incinerator is available. High radiation levels due to beta-gamma activity might require that some of the solid wastes be packaged in shielded containers. Additional characterization data are needed on the minor buildings and other external auxiliaries before waste packaging and disposal requirements can be adequately defined.

The volume of contaminated wastes generated by dismantling the auxiliaries will depend on the facility being considered and on several other factors including:

- the amount of volume reduction attempted with the solid wastes (i.e., segmentation, compaction, nesting, etc.)
- the effectiveness of decontaminating structural surfaces, mainly concrete, to reduce the volumes requiring controlled disposal
- the extent to which combustible wastes can be disposed of by burning
- the amount of aqueous decontamination attempted
- the amount of contaminated soil requiring controlled disposal
- the disposal criteria in effect at the time the dismantling operations are carried out.

The waste volumes would vary greatly, depending on the size and complexity of the facility being considered and are impossible to estimate reliably without more site characterization data. Rough approximations for the Redox Plant indicate that removal of the minor buildings, external

ancillaries and excess lines and ducts could generate between 1200 and 2400 yd³ of contaminated solid wastes plus 200 linear ft of 45-in. diam stainless steel pipe (the stack liner). This assumes treatment of most of the concrete as contaminated waste, a minimum of volume reduction, and only a limited amount of contaminated soil requiring controlled disposal.

The waste volumes discussed above could be reduced substantially if the concrete portions could be decontaminated successfully and volume reduction techniques used on the contaminated equipment and piping. On the other hand, the total volume could be increased significantly if there is extensive soil contamination. Decontamination of the stack liner could generate several hundred gallons of liquid waste which would require controlled disposal.

ENTOMBMENT

In general, Entombment of fuel reprocessing facilities is not regarded favorably because of their TRU contamination. Entombment of the canyon buildings in the 200 Areas at Hanford may be an attractive alternative, however, if the decision is made to dedicate the 200 Areas for long-term nuclear use.

Plan of Action

Isolate the canyon building (202-S) and entomb contaminated sections in concrete. Dismantle all other components of the facility except possibly the sand filter and air tunnel, which would be entombed.

Major Activities

- Complete the required site characterization.
- Dismantle all excess contaminated minor buildings and other external auxiliaries, except the exhaust air system.
- Isolate the 202-S Building by removing all excess lines, ducts and utilities entering the building, except power and the exhaust air system.

- Store all contaminated solid wastes in the canyon areas of the 202-S Building.
- Survey the 202-S Building and evaluate its long-term structural integrity. Provide any renovations or modifications needed to insure that the building will retain its integrity for the required time. Seal all building entries with concrete.
- Fill the canyon cells and other contaminated zones in the 202-S Building with concrete.
- Dismantle the building's exhaust air system, and seal resulting building openings with concrete. Entomb those portions of the exhaust air system that are below grade (sand filter and air tunnel) and dismantle those components that are above ground. The latter would include the exhaust air stack and control house, jet pit house, and various monitoring buildings. The stack liner may have to be decontaminated before the stack is demolished. Dispose of contaminated solid wastes resulting from demolition of the exhaust air system in approved burial grounds or repositories. Incinerate any combustible wastes, if possible.
- Optional - cover the entombed facility with a layer of dirt stabilized with plant growth to prevent erosion.
- Provide routine surveillance as necessary during the period of Entombment.

Special Procedures Required

The procedures required to entomb a fuel reprocessing facility are very similar to those required to place it in Protective Storage. Handling of the minor buildings, external ancillaries, lines, ducts, etc., is the same for each alternative. The main differences between the two options are that in the Entombment process:

- The highly contaminated canyon and cells in the 202-S Building would be filled with concrete to provide added containment.

- Access to radiation and contamination zones in the 202-S Building would be completely sealed off against all entry.
- Additional containment would be provided for the highly contaminated sand filter and air tunnel. This would involve reinforcing the filter and tunnel's existing concrete casings, filling the air tunnel to prevent collapse, providing a protective hard or soft cover over the filter and tunnel, and sealing the soil around and below them with a chemical grout to prevent migration of radionuclides in the soil if the reinforced concrete casings fail.

Waste Management

The entombing of a fuel reprocessing facility would generate the same types and volumes of contaminated wastes as placing the facility in Protective Storage.

If possible, all combustible wastes would be burned; otherwise they would be treated the same as the other solid wastes.

DISMANTLING

Plan of Action

Dismantle the facility and remove from the site all radioactivity above the release limits for subsequent use. Alternatively, decontaminate the main fuel reprocessing building to a level permitting other use, and dismantle the unneeded components of the facility.

Major Activities⁽⁹⁻¹⁵⁾

- Complete the required site characterization.
- Dismantle all unneeded minor buildings, external auxiliaries, lines, ducts and utilities as discussed in the previous section on Protective Storage. Leave the 202-S Building exhaust air system and contaminated drain lines in place for use in decontaminating and dismantling the 202-S Building equipment, piping, cells and canyons.

- Renovate the 202-S Building's remote handling equipment, cell sprays and water fog system, etc., for use in the decontamination and dismantling operations.
- Provide the additional equipment needed to decontaminate, dismantle, segment, package and remove contaminated process equipment, piping and other solid wastes generated in the 202-S Building.
- Provide the capability for disposing of contaminated liquid wastes generated in the 202-S Building during decontamination activities.
- Decontaminate all process equipment, piping, etc., in the 202-S Building to the lowest practical level consistent with subsequent disposal of the contaminated wastes. Decontaminate piping leading through canyon and cell walls to lowest practical level and seal ends of the pipes. Appropriately dispose of contaminated liquid wastes generated by the decontamination activities. (See Section 9.3, "Transuranic Facilities," for a discussion of decontamination procedures.)
- Disassemble, segment as necessary, and package all contaminated equipment, piping, etc., for final disposal.
- Decontaminate all contaminated building surfaces to the lowest practical level consistent with final disposition of the building. Paint all contaminated building surfaces to fix the residual contamination in place (or cover concrete surfaces with a layer of cement) prior to Dismantling the building. The level of decontamination attempted would depend on safety considerations and an economic balance of decontamination costs versus dismantling and waste disposal costs. If the building is to be reused, rather than dismantled, it would be decontaminated to the level required for subsequent use.
- Demolish the 202-S Building and any remaining equipment and auxiliaries. The building would be demolished from the inside out, and it would be necessary to provide adequate containment of radioactivity during Dismantling of each segment of the building. The exhaust air system would be the last segment of the facility to be dismantled. It

would be difficult to decontaminate some segments of the exhaust air system such as the sand filter; and it would be necessary to use remotely operated equipment to dismantle the highly radioactive segments of the system. Temporary containment barriers, as well as shielding, would have to be provided for Dismantling the exhaust air system.

- Package any remaining contaminated wastes for disposal and remove from the site. Excavate any contaminated dirt, package for disposal if required, remove from the site, and dispose of in accordance with existing regulations. Dispose of uncontaminated debris in onsite excavations, or remove from the site and bury in approved burial sites.
- Fill all excavations with clean dirt and plant with grass.

Special Procedures Required

Dismantling the minor buildings, external auxiliaries, and lines and ducts leading to the main fuel reprocessing building would be accomplished using the procedures described in the previous sections.

Decontamination and Dismantling of the canyon building would present a number of serious problems, as would Dismantling the highly contaminated segments of the exhaust air system. Fortunately, some remote handling equipment is available in the canyon buildings (but not the Semiworks) which will simplify decontamination and Dismantling of process equipment and piping. The major problem areas would involve:

- Decontaminating the process equipment and piping in the 202-S Building (to simplify Dismantling and final disposal)
- Decontaminating building surfaces, particularly the concrete walls of the canyons, cells and silo area
- Segmenting or compacting the contaminated equipment and piping
- Removal and packaging of the contaminated solid wastes for subsequent disposal

- Dismantling of the exhaust air system's sand filter and air tunnel and packaging of the wastes for disposal
- Demolition of the canyon building. The many pipe headers which penetrate the walls of the canyons and cells will complicate the Dismantling operations and make the breakup of the massive concrete walls very difficult.

Because of the high radiation levels in the canyons and cells in the 202-S Building, attempts to decontaminate much of the process piping, equipment and canyon and cell surfaces will have to be carried out remotely. The decontamination of process piping and equipment can probably best be accomplished by using corrosive aqueous solutions, such as nitric acid-hydrofluoric acid mixtures, which attack the metal surfaces. Since the metal parts will not be reused, attack of the metal surfaces does not present a serious problem. A more detailed discussion of decontaminating metal surfaces is given in Section 9.3, "Transuranic Facilities." Use of aqueous decontaminating solutions does require that facilities be available for disposing of the contaminated liquid wastes. If the fuel reprocessing facility does not have lines for transferring the liquid wastes to storage tanks or disposal facilities, it will be necessary to provide equipment for handling the liquid wastes or bypass the use of aqueous decontamination procedures altogether.

In those cases where aqueous methods are not effective, or cannot be used, abrasive procedures such as sandblasting can be used on external equipment surfaces. These techniques generate airborne particulate contamination which must be controlled, but the building's exhaust air system should be capable of providing the required control of the particulates. The use of sandblasting, or other abrasive procedures, would generate additional contaminated solid wastes.

The level of decontamination required with the process equipment and piping would depend on its ultimate disposal. It would probably be impossible to decontaminate to levels allowing uncontrolled release of the materials. However, it would be highly desirable to decontaminate to:

1) a sufficiently low transuranic level that retrievable storage would not be required and 2) a sufficiently low beta-gamma level that the wastes would not have to be packaged in shielded containers. If these objectives cannot be met, there is little incentive to remove more than the gross contamination.

The process equipment and piping in the canyon building may contain gross amounts of transuranics. If this is the case, it may be necessary to observe critical mass control restrictions during the decontamination and dismantling activities and while disposing of the aqueous wastes. Additional site characterization data are required to determine whether criticality could be a problem.

The decontamination of building surfaces prior to demolition could present a particularly difficult problem, especially when it is necessary to use remote procedures. The fact that most of the surfaces are concrete makes the problem even more serious. It is difficult to decontaminate concrete effectively, especially if the surface has been exposed to radioactivity for long periods or to contaminated solutions. Concrete which has been exposed to radioactive solutions will be contaminated to greater depths than concrete exposed only to radioactive solids. The more porous the concrete the more difficult the problem. If the contamination has penetrated into the concrete, effective decontamination requires removal of the contaminated surface layer. The amount of concrete which must be removed will depend on the depth to which the activity has penetrated and on the level of residual activity which can be tolerated. If the concrete is to be disposed of, it would be highly desirable to decontaminate to a level where the bulk of the concrete could be released for uncontrolled disposal.

Various methods for decontaminating concrete have been used with varying degrees of success. See Section 9.3, "Transuranic Facilities," for a discussion of concrete decontamination procedures. Utilizing these procedures remotely could require considerable development effort.

Decontamination of porous surfaces, other than concrete, can also be a difficult problem and generally requires removal of the contaminated layer. In the fuel reprocessing building, however, there should be very few porous structural surfaces other than concrete.

Painted surfaces can also be a problem. Paints are usually applied to protect the surface and to simplify decontamination. However, if the contamination has penetrated into the paint, it would be necessary to remove the paint layer. This can be done by the judicious use of solvents or by abrasion (i.e., sandblasting, sanding, etc.).

A problem which is unique to a large fuel reprocessing building such as 202-S is the large number of pipes which pass through the massive concrete walls of the cells and canyons. Many of these lines are contaminated. If they are not effectively decontaminated, they can complicate final disposal of the concrete. It does little good to decontaminate the concrete if it is recontaminated by the contaminated piping during the breakup of the canyon and cell walls. It is essential, therefore, that the piping be adequately decontaminated, sealed, or removed before the concrete is demolished.

The fuel reprocessing facilities contain a large number of contaminated vessels, columns and tanks. Sectioning or segmenting of these items is desirable to reduce the bulk volume of contaminated wastes requiring controlled disposal. Similarly, sectioning and "nesting" of process piping is needed to reduce the waste volume. Since the sectioning operations may have to be carried out remotely in the cells and canyons, it may be necessary to develop remotely operated power tools and cutting torches. Consideration should also be given to the use of remotely operated compaction techniques to reduce the solid waste volume.

A large volume of contaminated solid wastes will be generated by dismantling the process equipment and piping in the 202-S Building and by decontaminating the canyon and cell surfaces. It will be necessary to provide a facility for removing these wastes from the canyon and cell areas and packaging them for subsequent disposal. Depending on the

radiation levels, the packaging facility may have to be operated remotely, and some of the wastes may have to be packaged in shielded containers. Wastes containing significant amounts of transuranics will have to be packaged for retrievable storage.

The approach used in dismantling the contaminated buildings will depend mainly on the residual activity present. A building which has been decontaminated to an acceptably low level can be razed using normal demolition techniques. If the residual contamination is above the acceptable level, it may be possible to fix the contamination in place and then demolish the facility using standard procedures. Painting exposed surfaces or covering concrete with a fresh layer of cement has been used to fix contamination in place. If the residual contamination is too high to be fixed safely in place, it will be necessary to provide a containment barrier during demolition to prevent the release of activity. In the case of the large fuel reprocessing buildings (e.g., 202-S), the appropriate procedure would be to remove the internal portions of the building while leaving the building shell and exhaust air system in place. Then the outer shell of the building could be demolished in stages using temporary barriers to contain any residual radioactivity.

If the residual activity on the building shell is very high, it might be necessary to provide a rigid containment barrier around the facility and carry out the dismantling operations remotely. The cost of such a containment system and remote operation would be very high, and it would probably be less expensive to decontaminate to a lower level and eliminate the need for the barrier and remote operations.

In demolishing the structure, care should be taken to reduce airborne particulates to a minimum. Thus the procedures used in razing the facility should be those which generate the least amount of fines and dust.

Preliminary indications are that portions of the exhaust air systems (such as the sand filter and air tunnel) are highly contaminated. It is very unlikely that these components could be adequately decontaminated prior to dismantling. It would be necessary, therefore, to develop

remotely operated techniques for uncovering the sand filter, breaking up the concrete casing, and removing the highly contaminated sand, gravel, rock and concrete rubble. Similarly, removal of the air tunnel would probably have to be carried out remotely. Packaging of the wastes would have to be done remotely, and shielded containers would be required for most of the waste. Since the wastes would contain transuranics, they would have to be placed in appropriate storage. Removal of the sand filter and air tunnel would also produce a significant amount of contaminated dirt which would require controlled disposal. The dismantling and packaging operations would have to be carried out under a suitable structure designed to provide adequate containment, ventilation and personnel protection. The containment barrier could be either an inflatable or rigid structure.

Dismantling of the less contaminated sections of the exhaust air system could probably be carried out using contact operations, but some form of containment barrier would have to be provided. The exhaust air stack could probably be demolished using standard industrial techniques after it was decontaminated.

Waste Management

Dismantling of the fuel reprocessing facility would generate much larger volumes of contaminated wastes than the other disposition alternatives. These additional wastes would result from three main operations:

- The decontamination and Dismantling of contaminated equipment, tankage and piping in the canyon building. In addition to the solid wastes, large volumes of contaminated liquids would result from the decontamination activities.
- The decontamination and dismantling of the silo and cell areas of the canyon building.
- The dismantling of the below-grade segments of the exhaust air system, i.e., the sand filter and air tunnel. These wastes would be highly contaminated, especially the sand, gravel and rock from the sand filter.

Lesser amounts of contaminated solid wastes would result from dismantling the outer shell of the canyon building and removal of any contaminated dirt at the site.

The contaminated solid wastes would consist chiefly of metal equipment and piping, concrete rubble, and lesser amounts of combustible solids. Waste volumes are difficult to estimate for a given facility because they depend on a number of factors. Assuming no attempt at volume reduction and that all of the concrete from the silo, canyon and cell areas of the 202-S Building requires controlled disposal, the estimated contaminated solid waste volumes generated by Dismantling the Redox facility are:

- Minor buildings and external auxiliaries 1,000 to 2,000 yd³
- Exhaust air system 3,000 to 4,000 yd³
- Dismantling of 202-S equipment and piping 1,000 to 2,000 yd³
- Dismantling of the 202-S Building 20,000 to 30,000 yd³

These estimates do not include the contaminated dirt which may require controlled disposal. The volume of concrete requiring controlled disposal could be reduced greatly if a satisfactory method for decontaminating the concrete can be developed.

A large volume of contaminated aqueous wastes will result from decontamination efforts in the 202-S Building. The aqueous waste volumes will depend on the level of decontamination required and are impossible to estimate. Depending on the transuranic levels in the 202-S Building, it may be necessary to observe critical mass controls during the decontamination operations and in handling and disposing of the aqueous wastes. Disposal of the aqueous wastes will depend on the facilities available for processing the waste when the dismantling operations are undertaken.

Much of the solid wastes will be contaminated with transuranics and will require appropriate storage or disposal. In addition, some of the wastes (i.e., from the sand filter) will contain high levels of beta-gamma activity and will have to be packaged in shielded containers for disposal.

A large volume of uncontaminated debris and rubble would have to be disposed of and could amount to many thousands of cubic yards. Successful decontamination of the structural concrete would greatly increase the volume of uncontaminated debris requiring disposal.

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4.0 Fuel Storage Basins

4.0 FUEL STORAGE BASINS

4.1 GENERAL

Each reactor building complex contains a fuel storage basin which served as a collection, storage, and transfer facility for the irradiated fuel elements discharged from the reactor.

The typical reactor fuel storage basin can be divided into three zones: the metal pickup area, the storage area, and the transfer area. Figures 4.1 and 4.2 provide schematic diagrams of the storage basins at 105-B, D, and F.

An underwater inspection facility was included in the storage basin area in some instances and a wash pad in every basin. The total area of each fuel storage basin, including the metal pickup and transfer areas, is 7,000 to 10,000 ft². The basins are about 22 ft deep and contained about

FIGURE 4.1. Side View of Reactor Building Showing Location of Storage Basin

FIGURE 4.2. Top View of Fuel Element Storage Basin: For 100-B, D, and F

20 ft of water during operating periods. The fuel storage basins at 105-F and H have been filled with soil, whereas water levels below 20 ft have been maintained in the other inactive reactors to cover the contamination in the basins.

Operations in the storage basins consisted of sorting irradiated fuel elements in the collection area and transferring them to buckets, which were then transported by monorail to the storage basin for aging to allow decay of short-lived radionuclides prior to reprocessing. Following the storage period the buckets of fuel elements were transported to the transfer basin. There they were placed in railroad cask cars for transport to the chemical reprocessing facilities.

The storage area of the basins in all the reactors except N, 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 K and N-Reactor basins

consist of steel gratings suspended from the ceiling. The basins in 105-F and 105-H were filled with clean soil at the time of retirement.

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 20,000 ft³.

Buckets used to transport and store the fuel elements, and other equipment have been left in all the basins except in 100-K. The galvanized buckets at K-Area were removed and buried as solid waste. The stainless steel buckets were removed and stored inside the 105 Building.

Three additional irradiated fuel element storage basins are located outside the reactor areas. These basins are housed in the 212-N, P, and R Buildings in the 200-North Area, which is situated about 2 miles north of the 200-West Area (see Figure D.13). The 212 basins are similar in construction to the older reactor storage basins but smaller (see Figure 4.3). Each has about 4000 ft² of floor space and 10 rows of 6 steel posts that support the flooring over the storage area. No irradiated fuel has been stored in these basins since 1952, but the 212-N Building is presently being used to store contaminated equipment and 212-P is in use as an electrical distribution warehouse. Waste has been removed from the basins but no soil added. The floor over the basins has been covered with additional planking.

4.2 SITE CHARACTERIZATION

4.2.1 Contamination Levels and Locations

Sources of contamination in the fuel element storage basins include a) fission products and transuranics which leaked from the fuel elements and b) activation products from all types of elements irradiated in the reactor and discharged to the basin. Upon shutdown, a sludge layer was left in each basin. It is estimated that a few grams of plutonium and a few curies of ⁹⁰Sr are contained in the sludge, that the concrete surfaces are contaminated to an unknown depth, and that the surrounding soil may be slightly contaminated as a result of leakage. Recent (1975) characterization data for the 105-B and C Reactor basins showed average Pu-239/240

FIGURE 4.3. Building 212-Lay Storage

concentrations in the sludge of 3.2×10^4 and 3.0×10^4 pCi/g, respectively. Maximum concentrations found were 9.5×10^4 and 6.8×10^4 pCi/g, respectively.

Several irradiated uranium fuel slugs, left when reactor operations were terminated, were found in both 105-K basins when the sludge was removed in 1975. Old slugs may also be present in the sludge layers of the other basins.

4.2.2 Site Characterization Requirements

A 100 Areas characterization program, started in 1974, is intended to provide more detailed information.

Estimates of the depth and extent to which the concrete basins, walls and floor are contaminated may have to await removal of water, sludge and surface contamination from the basin.

4.3 DISPOSITION ALTERNATIVES AND RELATED ACTIVITIES

In developing the alternative disposition strategies and related activities for the fuel storage basins, the following factors must be considered:

- The fuel storage basins can be divided into two distinct groups: those in the 100 Areas, and those in the 200-North Area.
- The 100 Area basins are integral parts of the reactor buildings. The disposition modes for these basins must be compatible with the disposition alternatives for the reactor buildings. Also, the 100 Area basins are located close to the Columbia River, with attendant incentives to release the areas for unrestricted access and uncontrolled use.
- The 200-North Area basins are isolated facilities located a considerable distance from other facilities and from each other. There is less incentive to make these areas available for uncontrolled use; and the various disposition alternatives can be applied to the 200 Area basins without consideration of other facilities.

The alternative disposition strategies discussed below are generally applicable to both types of fuel storage basins. However, the work activities required for the various alternatives may differ for the two types of basins, and these differences are noted in the discussions. Only limited site characterization data are currently available for the fuel storage basins. Therefore, the work activities for the different disposition alternatives can be discussed only in general terms. As more specific site characterization data become available, the required work activities can be described in more detail. The data available on the basins indicate that the contamination levels outside the basins themselves are quite low. Therefore, only minimal removal of contaminated materials external to the basins should be required.

LAYAWAY

Layaway of a 100 Area fuel storage basin must be compatible with the decommissioning mode adopted for the associated reactor. The 200 Area fuel storage basins are treated as separate entities.

Plan of Action

Remove all exposed loose contamination from the facility, and prevent unauthorized entry to the basin area. Maintain basin equipment in operable condition if needed for subsequent Dismantling of the reactor.

Major Activities

- Complete the required site characterization.
- Remove all exposed loose contamination, and paint the exposed contaminated surfaces to fix the residual contamination in place.
- Remove the sludge from the floor of the water-filled basins.* Package the sludge for retrievable storage if the transuranic content requires storage. The basins at F and H Reactors are filled with dirt, which would be left in place.

*Some fuel elements may be present which will have to be removed and disposed of.

- Remove the water from the basin and dispose of as contaminated liquid waste.
- Paint the concrete surface of the basin, or apply a thin concrete cover layer, to fix any residual contamination in place.
- 100 Area basins - repair the 105 Building to insure its integrity during Layaway (see Part D, Section 7.3.1).
- 200 Area basins - repair the 212 Building to insure its integrity during Layaway.
- Seal all building openings to prevent unauthorized entry, including birds and animals, to the storage basin area during Layaway.
- Fence the site to restrict access to the facility.
- 100 Area basins (optional) - maintain basin equipment in operable condition if needed for subsequent Dismantling of the production reactor.
- Provide protective equipment (intrusion alarms, monitors, etc.) as needed.
- Provide maintenance and routine surveillance, as needed, during Layaway.

Special Procedures Required

Removal of contaminated sludge from the basin floor will require use of a vacuum filtration system designed to operate under water. Such a unit has been designed by UNI and used to move the sludge in the KE basin to the technical viewing pit.

Waste Management

Removal of exposed loose contamination and subsequent painting of the contaminated surfaces will generate some contaminated solid wastes, including combustibles, but the volumes will be insignificant.

Sludge removal from the basin would generate a substantial volume of contaminated solid waste. For a 100 Area fuel storage basin, such as D basin, the sludge volume is estimated to be 100 to 200 yd³. Since the sludge contains some transuranics, it may be necessary to package the sludge for retrievable storage in the 200 Areas.

The water-filled basins contain about 10^6 gal of contaminated water, which would probably be transferred to the 200 Areas. Ultimate disposal would depend on the transuranic content and total radioactivity present.

Any fuel elements removed from the basin would probably be placed in retrievable storage.

PROTECTIVE STORAGE

Plan of Action

Provide the basin with a suitable cover to prevent entry to the contaminated zone, and demolish the unneeded portions of the building containing the basin.

Protective storage of a 100 Area basin must be compatible with the D and D mode selected for its associated reactor.

Major Activities

- Complete the required site characterization.
- Remove all unneeded equipment, piping utilities, etc., from the facility.
- Remove the sludge (and any remaining fuel elements) from the water-filled basins.
- Remove the water from the basin, dispose of as contaminated liquid waste. Leave dirt in place in F and H basins.
- Optional - store contaminated equipment and waste (low in transuranics) in the basin.
- Provide the basin with a semi-permanent protective cover (steel or concrete) which will prevent access to the contaminated zone during Protective Storage.
- Dismantle any unneeded sections of the surrounding building.
- Transfer any remaining contaminated wastes to the 200 Areas.

- Dispose of uncontaminated rubble and debris in approved repositories.
- Fence the site to restrict access to the facility.
- Provide maintenance and routine surveillance as required during Protective Storage.

Special Procedures Required

Same as Layaway.

Waste Management

Similar to Layaway except that:

- The contaminated equipment and decking associated with the basin; amounting to a few hundred cubic yards, would require disposal and could be stored in the basin or transferred to the 200 Areas.
- Uncontaminated debris and rubble, amounting to several thousand cubic yards, would be generated by dismantling unneeded portions of the building containing the basin.

ENTOMBMENT

Entombment is not considered a viable option for either the 200 Area or 100 Area fuel storage basins, and there is little or no economic or technical incentive to entomb the facilities. Entombment would have the adverse effect of preventing unrestricted use of the site. If Entombment were used for some unforeseen reason, the following activities would be required.

Plan of Action

Fill and enclose the basin with concrete to prevent entry to contaminated zones, and dismantle the building surrounding the basin.

Entombment of the 100 Area basins must be compatible with the D and D mode selected for the reactor.

Major Activities

The activities required would be similar to those required for Protective Storage except that:

- Contaminated solid wastes and equipment (low in transuranics) would be stored in the basin.
- The basin and the discharge chute and pool would be filled with concrete to prevent access to the contaminated zone.

Special Procedures Required

Same as Protective Storage.

Waste Management

Similar to Protective Storage, but contaminated waste volumes would be reduced by the amount stored in the basin.

DISMANTLING

Plan of Action

Dismantle the fuel storage basin and remove all contamination above the release limits for unrestricted use from the site. Dismantling of the 100 Area basins must be compatible with the D and D mode selected for the reactor. For example, if the reactor is to be dismantled, the fuel storage basin would be used to transfer and package the highly radioactive reactor components. Therefore, the fuel storage basin would not be dismantled until after the reactor block is dismantled.

Major Activities

- Complete the required site characterization.
- Remove all unneeded lines, utilities, and equipment from the facility.
- Remove the sludge from the water-filled basins, and package the sludge for retrievable storage if necessary. Remove and dispose of any fuel elements which may be present.
- Install a temporary containment barrier-ventilation system over the basin.
- Remove the water from the basin, if present, and dispose of as contaminated liquid waste.

- Empty the dirt-filled basins (F and H). If possible, segregate the clean fill dirt from the contaminated sludge layer.
- Partially decontaminate the basins' concrete floor and wall if the concrete is contaminated with transuranics to a level requiring retrievable storage.
- Demolish the basin.
- Remove all contaminated water, equipment, and concrete rubble from the site and dispose of in 200 Area repositories.
- Remove the temporary containment barrier.
- Dismantle the building containing the basin.
- Remove any contaminated dirt under the basin and building which is above the release limits for unrestricted use (200 Area requirements will depend on existing regulations).
- Remove all uncontaminated rubble and equipment from the site and dispose of in approved repositories.
- Fill the excavation with clean dirt and plant with grass.

Special Procedures Required

- Sludge removal would require a special vacuum-filtration system designed to operate under water.
- Decontamination of basin concrete surfaces to reduce the transuranic content would require special procedures to remove the contaminated surface layer. (See Part D, Section 9.3, for a description of concrete decontamination procedures.)

Waste Disposal

Dismantling of the fuel storage basin would generate a substantial volume of contaminated wastes including metal equipment, concrete rubble, dirt and water. Estimates of the contaminated wastes volumes from a typical 100 Area basin are:

Contaminated water, if present	10 ⁶ gal
Contaminated sludge	100 to 200 yd ³
Contaminated concrete	500 to 1000 yd ³
Contaminated equipment, decking, etc.	200 to 400 yd ³
Contaminated dirt in F and H basins (assuming no segregation)	5000 to 6000 yd ³

Contaminated dirt beneath a basin, due to leaks, which requires removal is difficult to estimate but could amount to several thousand cubic yards.

Contaminated waste volumes from a 200-North Area basin would be less because of the smaller size.

Uncontaminated waste and rubble from demolition of equipment and buildings would amount to thousands of cubic yards. For a 105-Building the uncontaminated wastes are estimated to be 10,000 to 20,000 yd³. For a 200-North Area Building they would amount to 2000 to 5000 yd³.

5.0 Gas and Exhaust Air Systems

5.0 REACTOR GAS AND EXHAUST AIR SYSTEMS

5.1 RECIRCULATING GAS SYSTEMS

5.1.1 General

A recirculating gas system was included in each reactor facility to provide an inert, nonradioactive gas environment within the reactor.^(1,2,3) The gas served to: a) remove moisture and foreign gases from the reactor; b) transfer heat from the graphite to the process tubes; c) control reactivity (except for N Reactor); and d) allow detection of water leaks within the reactor. A mixture of helium and carbon dioxide was used in the gas systems of 105-B, C, D, DR, F and H. The K Reactors (105-KE and 105-KW) used helium and carbon dioxide until 1961, then a helium-nitrogen mixture. N Reactor has used only helium.

Control of the gas composition was maintained by: 1) circulation through heat exchangers, dewatering systems such as condensers or silica gel beds, and filters; and 2) replacement of part of the gas from time to time, the excess gas being routed to the ventilation exhaust system. Figure 5.1 shows the flow diagram for the single-reactor system which serviced 105-F.

The potentially contaminated components of the reactor gas recirculation systems are housed in the 115 Buildings* and tabulated in Table 5.1. The gas supplies are housed in the 110 storage areas.

5.1.2 Radioactive Contamination

Contamination in the recirculation gas system components resulted primarily from coolant which leaked into the graphite block and was vaporized and from activation products that were picked up by the gas as it passed through the reactor.

Past radiation surveys have indicated relatively low levels of contamination in the gas recirculation components.

* Except for 100-H Area, where the gas system is in the gas wing of 105-H, and 100-N Area, where the gas system is in the gas system area of 105-N. 115-B and 115-D each service two reactors, 105-B/C and 105-D/DR, respectively.

FIGURE 5.1. Gas Flow Diagram for Single Reactor⁽¹⁾

TABLE 5.1. Reactor Gas Recirculation System Components

Reactor System	115 Building	Silica Gel Beds		Filters		Heater-Coolers		Coolers		Condensers		Blowers	
		No.	Approx. Size	No.	Approx. Filter Area	No.	Approx. Size	No.	Approx. Size	No.	Approx. Size	No.	Approx. Size
100 B-C	115-B: Concrete Block 16,500 ft ²	5	7 ft diam 7 ft high	2	6 ft x 6 ft	5	3 ft x 3 ft x 1.5 ft	2	2 ft diam 6 ft long	5	2 ft diam 6 ft long	8	6 ea 1800 cfm 2 ea 200 cfm
100 D-DR	115-D: Concrete Block 16,500 ft ²	5		2		5		2		5		8	
100-F	115-F: Concrete Block 16,500 ft ²	3		2		3		2		3		5	1800 cfm
100-H	-- (System in gas-wing of 105-H)	3		2		3		2		3		5	
100-KE	115-KE: Concrete 5300 ft ²	2	5 ft diam 4.5 ft high	1	4 ft x 4 ft	2	2 ft diam 5 ft high	0	--	2		3	4000 cfm
100-KW	115-KW: Concrete 5300 ft ²	2		1		2		0	--	2		3	4000 cfm
100-N	-- (System in gas-system area of 105-N)	2	5 ft diam 6 ft high	2	4 ft x 4 ft	2				2		2	1000 cfm

5.1.3 Site Characterization Requirements

Because the contamination levels found in the 100-F gas recirculation system are indicative of those to be found in the other reactor systems, they should suffice for general D&D planning. For detailed planning, however, the following additional characterization work will be needed:

- a. Estimation of radioactive contamination within the silica gel beds, blowers, filters, heater-coolers, coolers, condensers, miscellaneous equipment, and piping.
- b. Estimation of smearable contamination levels on the surfaces of equipment and structural materials within the 115 Buildings (and the gas wing of 105-H) and the tunnels to the reactors.
- c. Estimation of nonsmearable contamination under layers of paint, soaked into structural materials, and deposited into cracks, etc.

5.2 VENTILATION EXHAUST SYSTEMS

5.2.1 General

The ventilation exhaust systems were installed in the reactor facilities to supply fresh, uncontaminated air to nonregulated working zones and to maintain low levels of air contamination.^(1,2,3) They were designed to move air from the least contaminated zones through zones with increasing levels of contamination and finally through an exhaust system for discharge from a stack. Until the 117 (filter) Buildings were installed in 1960, the air was discharged to the stacks unfiltered.

System components external to the 105 Buildings include: tunnels and ductwork outside the reactor buildings; the 117 (filter) Buildings; the 119 (stack gas monitoring) Buildings; and the stacks. Air supplied to the confinement zone of the reactor was collected by exhaust ducts which discharged into the exhaust tunnel leading to the exhaust fans. From there the exhaust air flowed through an aboveground concrete duct which runs to the base of an exhaust stack.* The air was diverted at the base of the

* The stacks for the K Reactors are 300 ft high; for the other reactors, 200 ft.

stack into an underground reinforced concrete duct which leads to the filter building. After flowing through the filters, the air went through an underground reinforced concrete duct back into an aboveground concrete duct and thence to the exhaust stack. Figures 5.2., 5.3 and 5.4 illustrate the system layouts as found in B/D/DR/F, C/H and KE/KW Reactors, respectively.

The exhaust air system provides four identical, nonoverloading, Class II, centrifugal fans. Two of the fans are electric-driven, V-belt connected, and the other two are steam-driven direct coupled. The steam-driven fans are part of a back-up system which was used in the event of power failures. Each fan is located in a separate fan room. Table 5.2 lists the ratings of the exhaust fans.

TABLE 5.2. Ratings of the Exhaust Fans

<u>Reactor Building</u>	<u>Flow, cfm</u>	<u>Electric Drive, hp</u>	<u>Steam Drive, hp</u>
B, D, F	50,000	150	150
DR	42,500	125	100
C	75,000	200	191
H	75,000	200	179
KE	142,000	200	~200
KW	135,000	200	~200
N	3 at 76,700		
	3 at 24,200		
	3 at 50,000		

Other components of the exhaust system related to air flow include a manually operated flow control damper downstream from the exhaust fans and a vacuum relief damper in one of the supply ducts open to the atmosphere.

The 117 Buildings are reinforced concrete structures located almost completely underground. One purpose of the underground installation was to facilitate abandonment in-place should that be the method chosen for ultimate decommissioning. Figures 5.5 and 5.6 show schematics of the 117 filter Buildings.

FIGURE 5.2. Confinement Facility Layout, B, D, DR and F Reactors (1)

FIGURE 5.3. Confinement Facility Layout, C and H Reactors⁽¹⁾

FIGURE 5.4. K Reactor Confinement Facility Layout⁽²⁾

FIGURE 5.5. Reactor Confinement Filter Building 117(1)

FIGURE 5.6. Reactor Confinement Filter Building 117(1)

The 117 Buildings are about 59 ft long, 39 ft wide, and 35 ft high. They are connected to the 105 Buildings by underground concrete ducts which extend along the length of the filter buildings and serve as intake and exhaust plenums to the filter cells. The duct adjacent to the filter cells is provided with turning vanes to deflect air in or out of the cells. This section also serves as a portion of the seal pit for isolating the filter cells.

Each 117 Building contains two identical filter cells separated by a two-storied operating gallery. Each cell has positions for three stages of filters; and each stage in each cell has aluminum inserts and concrete covers for sealing two aluminum filter frames fitted with individual filtering units, either charcoal or absolute filters. Most or all of the filter frames, however, are believed to have been removed from D, DR, F, and H Reactors.

The filter cells of each 117 Building can be isolated from the exhaust system by filling the seal pits with water. A 200-gpm pump empties the seal pits. The water is pumped to a collection basin at the rear of the reactor building, which in turn drains to the radioactive sewer crib in the area. Floor drains provided for decontamination in the upper and lower floors discharge into a common inlet seal pit.

Concrete covers are provided for each filter frame location. The 117 Buildings are equipped with metal dust covers which can be easily removed for access to the cells below. The interior surfaces of the building have been coated with a polyvinyl coating (Ply-On) to seal off cracks and imperfections in the concrete.

The 119 Buildings were installed to house most of the instrumentation for the exhaust air systems. They are located over the ventilation ducts leading to the filter buildings. A sample stream of the exhaust air was routed through a counting system in the building for monitoring radioactivity. The exteriors of the buildings are metal, while the interiors are painted wallboard.

5.2.2 Radioactive Contamination

Sources of contamination in the exhaust air systems include fuel elements which burned occasionally at the rear face of the reactors and contamination suspended into the air from surfaces of regulated zones within the 105 Buildings.

5.2.3 Site Characterization Requirements

For detailed planning, the following additional characterization work will be needed:

- a. Estimation of radioactive contamination within the 117 Building, 119 Building, exhaust fan rooms, and stacks and ducts for these facilities.
- b. Estimation of smearable contamination on the surfaces of equipment and structural material in the above-named facilities.
- c. Estimation of nonsmearable contamination under layers of paint, soaked into structural materials, and deposited into cracks, etc.

5.3 ALTERNATIVE DISPOSITION STRATEGIES AND RELATED ACTIVITIES

Although the reactor recirculating gas systems differ significantly from the exhaust air systems in design and potential contamination levels, the alternative disposition strategies described in the following sections apply to both.

In planning for the disposition of the reactor gas and exhaust air systems, the following factors need to be considered:

- a. These systems are integral parts of the overall reactor system and are located within the reactor exclusion areas. Any disposition activities involving them should, therefore, be compatible with the disposition alternative selected for the reactor.
- b. Available information indicates the gas and exhaust air systems are contaminated mainly with fission products and induced activation products (primarily ^{60}Co). Little information is available as to the level of activity present in the various portions of the systems.

- c. The radioactivity present in the gas and exhaust air systems was deposited on surfaces from the flowing gas streams (except possibly for portions of the systems immediately adjacent to the reactor where neutron activation of ductwork might have occurred). Therefore decontamination of accessible surfaces should be relatively straightforward.
- d. The facilities are located near the Columbia River. Strong incentives exist to make the shoreline accessible to the public. Hence the disposition mode selected should be compatible with eventual unrestricted public access to the site.

Each disposition strategy and the major activities associated with it are described below in general terms. Additional site characterization data and disposal criteria are needed before the various activities can be defined specifically. Where the disposition strategy calls for disposal of contaminated wastes outside the immediate area, it was assumed that disposal would be on the 200 Area plateau in authorized burial grounds. (The transuranic content of the wastes may be sufficiently low in nearly all cases that retrievable storage would not be required.) Packaging of the wastes prior to burial may be required, depending on the types and amounts of activity present.

Although the gas recirculation and exhaust air systems are quite different, the various disposition strategies described below apply equally well to both types. The activities required with the different strategies may vary somewhat for the two systems, and where significant differences exist they are indicated in the discussion.

LAYAWAY

Plan of Action

Remove all exposed loose contamination from the two systems, and seal all ducts, tunnels and buildings to prevent unauthorized entry.

Layaway of the gas and exhaust air systems must be consistent with the D&D mode selected for the associated reactor.

Major Activities

- Complete the required site characterization.
- Remove all exposed loose contamination and paint exposed contaminated surfaces to fix the residual contamination in place.
- Check all lines, ducts and tunnels to insure against subsequent release of activity.
- Seal the ducts, tunnels and associated buildings to prevent unauthorized entry, including birds and animals.
- Restrict access to the stack ladder (remove bottom rungs).
- Insure site is adequately fenced to restrict access.
- Install needed protective equipment, and provide maintenance and routine surveillance as necessary.

Special Procedures Required

None

Waste Management

A small amount of contaminated solid wastes, including some combustibles, would be generated by the decontamination and painting of exposed contaminated surfaces. The volumes would be insignificant.

PROTECTIVE STORAGE

There is little technical justification for placing the gas and exhaust air systems in Protective Storage. The possibility exists that the exhaust air systems might be used at some future date to assist in dismantling the reactor but this seems unlikely. The possibility exists also that the systems might be placed in Protective Storage to delay Dismantling for some undefined period until funding is available.

Plan of Action

Dismantle all uncontaminated segments of the system, enclose the 115 and 117 Building contents in a protective shell, and seal all ducts and tunnels to prevent unauthorized entry. Protective Storage of the two systems must be consistent with the D&D mode selected for the reactor.

Major Activities

- Complete the required site characterization.
- Dismantle all uncontaminated segments of the two systems, including the 110 Building.
- Decontaminate the exhaust air stack, then dismantle the stack and 119 Building.
- Remove all utilities and auxiliaries to the 115 and 117 Buildings.
- Enclose the 115 and 117 Building contents in a protective shell using the existing building structures wherever possible.
- Seal the ends of all system ducts and tunnels running between the various buildings and stack. If necessary, encase aboveground ducts with concrete to provide adequate containment during storage.
Optional--fill the underground tunnels and ducts with concrete or dirt to prevent collapse.
- Remove all system piping and ducts leading from the reactor block to the gas exhaust tunnels in the 105 Building, and seal the tunnels.
- Enclose the fan room in a protective shell to prevent entry.
- Fence the site to restrict access to the facility.
- Transfer all contaminated wastes to the 200 Areas.
- Provide maintenance and routine surveillance, as needed.
- At the end of the storage period dismantle the remaining components of the two systems, and dispose of all contaminated materials, above the release limits for unrestricted use, in the appropriate manner.

Special Procedures Required

- It may be desirable to decontaminate the exhaust air stack to simplify its demolition. Since the stack has not been exposed to contaminated liquids, it can probably be decontaminated by vacuuming the surface. The stack and 119 Building can probably be demolished using standard industrial procedures. The preferred approach would be to drop the stack into a specially prepared excavation and cover it with dirt and a protective soft cover. If the stack cannot be buried onsite, the contaminated rubble would be transferred to the 200 Areas.
- Radiation levels should be low enough that all activities required to place the system in Protective Storage can be carried out using contact operations and established nuclear procedures.
- The enclosure shell must be designed to provide adequate containment for the required storage period. Existing building structures should be used wherever possible in constructing the protective shells.

Waste Management

Placing the gas and exhaust systems in protective storage will generate a small but significant amount of contaminated solid wastes, chiefly concrete rubble and metal piping and ductwork. The transuranic content of the wastes should be low enough that retrievable storage would not be required. Demolition of the stack would produce 200 to 400 yd³ of concrete rubble. Contaminated metal and other solids should amount to 50 to 100 yd³, assuming some attempt at volume reduction. Combustible solid wastes would be only a few cubic yards. Uncontaminated equipment and rubble could amount to several hundred cubic yards.

ENTOMBMENT

There is no technical or economic justification for entombing the gas and exhaust air systems, and Entombment is not considered to be a viable option for the two systems. Entombment of the systems would have the

adverse effect of preventing unrestricted use of the site for an extended period. If the systems were to be entombed, the following actions would be required.

Plan of Action

Entomb all underground ducts and tunnels and the 115 and 117 Buildings in an impenetrable concrete shell. Entombment of the two systems must be consistent with the D&D mode selected for the reactor.

Major Activities

The activities required would be the same as for Protective Storage except that the 115 and 117 Buildings would be entombed in an impenetrable concrete shell and the underground ducts and tunnels would be filled with dirt or concrete and sealed.

Special Procedures Required

Same as for Protective Storage except that the Entombment procedure would require the design of massive, impenetrable concrete shells around the 115 and 117 Buildings. The shells would need to retain their integrity until all activity decayed to a harmless level. It may be desirable to fill all building voids with concrete prior to encasing them with concrete.

Waste Management

Same as for Protective Storage.

DISMANTLING

Plan of Action

The two systems would be completely dismantled, and all contamination, above the release limits for unrestricted use, would be removed from the site.

Major Activities

- Complete the required site characterization.
- Remove all uncontaminated segments of the two systems, including all auxiliaries and excess utilities.

- Remove all contaminated system equipment and piping from the 105, 115, 117 and 119 Buildings; provide temporary ventilation and containment barriers, as needed, for the dismantling operations.
- Decontaminate system buildings, ducts, and tunnels if it will simplify demolition and waste management.
- Decontaminate the inner surface of the exhaust air stack.
- Demolish the exhaust air stack and the 119 Building.
- Demolish the 115 and 117 Buildings.
- Remove all aboveground ducts.
- Excavate and dismantle the underground ducts and tunnels leading between the various buildings and the stack.
- Dismantle the gas and exhaust air tunnels in the 105 Building if demolition is consistent with the D&D mode selected for the Building.
- Dispose of all contaminated wastes in the 200 Areas. Remove all contaminated dirt, above the release limit for unrestricted use, from the site and dispose of it in the 200 Areas.
- Remove all uncontaminated rubble and debris from the site.
- Fill all excavations with clean dirt and plant with grass.

Special Procedures Required

- Currently available data indicates that the contamination levels in the two systems are sufficiently low that all dismantling activities can be carried out using contact operations and established nuclear procedures. It may be desirable to partially decontaminate various segments of the two systems to simplify the Dismantling operations and contaminated waste disposal. Since the contaminated surfaces (ducts, tunnels, stack, etc.) have not been exposed to significant amounts of contaminated liquids, it should be possible to remove much of the contamination from the surfaces by vacuuming or wiping with damp rags. If the contamination has penetrated into the

concrete, it may be necessary to remove the contaminated surface layer. A discussion of methods for decontaminated concrete is provided in Part D, Section 9.3.

- It will probably be necessary to provide some form of temporary containment during the Dismantling of certain segments of the two systems. This can probably best be accomplished using temporary barriers such as plastic greenhouses.

Waste Management

Dismantling of the gas and exhaust air systems would generate large volumes of contaminated wastes, mostly concrete and metal piping and equipment. The large volumes of concrete would result from the demolition of the stack, 115 and 117 Buildings, and the underground ducts and tunnels. The volume of contaminated concrete would vary between reactors because of the differences in the length of the underground tunnels plus the fact that some reactors share portions of the gas and exhaust air systems.

Estimated contaminated waste volumes for a typical production reactor are:

• Concrete	600 to 1200 yd ³
• Other noncombustible solids	200 to 500 yd ³
• Combustible solids	<100 yd ³
• Liquids	<100 gal

Some contaminated dirt may have to be removed from the site, but the volume is impossible to estimate.

The transuranic content of the contaminated wastes should be low enough that retrievable storage would not be required, especially if some effort is made to partially decontaminate the systems.

Uncontaminated rubble, which would have to be removed from the site, would amount to several hundred cubic yards.

REFERENCES

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2. Hazards Summary Report, Vol. 3, Description of the 100-KE and 100-KW Production Reactor Plants, HW-74095, General Electric Co., Richland, WA, April 15, 1963.
3. 100-N Technical Manual, Vol. 2, Prepared by N Reactor Department, General Electric Co., Richland, WA, March 5, 1963.

6.0 Laboratories

6.0 LABORATORIES

6.1 GENERAL

A number of laboratories have been constructed at Hanford for work involving radioactive materials. Included are facilities for research and development activities, process demonstration, and process monitoring and control activities. Because of the variety of functions laboratories have served, unlike most other classes of facilities at Hanford, they are very diverse in design and location. Uses range from biological research to plutonium fuel fabrication and fuel cycle waste immobilization studies. Exceptions to this diversity include the three similar buildings (108-B, 108-D [dismantled] and 108-F) originally built to provide laboratory support for reactor operations and the three buildings (222-B, 222-T and 222-U) built as process analysis laboratories for the bismuth-phosphate separation plants.

Included within this class of facilities are approximately 35 laboratories. Although several are currently in surplus or standby status, most will continue in service indefinitely.^(a)

Data sheets for most of the existing Hanford laboratories are provided in Appendix VI. Data sheets for the Strontium Semiworks, Critical Mass Laboratory and Plutonium Metallurgy Laboratory are included elsewhere in the appendices (see Table VI.2).

6.2 DISPOSITION ALTERNATIVES AND RELATED ACTIVITIES

Because there is a great diversity among the laboratories with regard to location, size, type of construction, current physical condition, and the types and amounts of radioactivity present, it is unrealistic to discuss a single laboratory as being typical of this class of facilities.

However, the laboratories possess a number of similarities which makes it possible to consider them as a single class of facilities when planning their disposition. Pertinent similarities include the following:

(a) Dismantlement of most of the 100-F Animal Farm laboratories during the recent 100-F site cleanup effort has eliminated many of the surplus facilities formerly included in this classification.

- While the laboratories may contain substantial amounts of radioactive contamination, the radiation levels are generally much lower than those encountered many other facilities, such as the fuel reprocessing plants and production reactors. In general, most laboratory operations involved direct handling of radioactive materials, except for hot cells and caves where high levels of radioactivity were handled remotely.
- Most of the radioactive contamination in the laboratories is restricted to specific work areas such as the hoods, glove boxes, caves and hot cells. Other contaminated components include "hot" ventilation systems, and drain and transfer piping.
- In general, most laboratory components, such as hoods and glove boxes, are designed so they can be decontaminated to relatively low levels; thus the various decommissioning activities can be conducted with a minimum of occupational radiation exposure and risk.
- Radioactive contamination of laboratory structural surfaces is usually low, or the surfaces can be effectively decontaminated, so that the offsite risks associated with dismantling a laboratory building are relatively low.

Considering these factors, disposition of the laboratory facilities should be relatively simple and present fewer problems than most other classes of facilities.

LAYAWAY

Plan of Action

Remove all exposed loose contamination, and seal all building openings and entries to prevent unauthorized entry.

Major Activities

- Complete the required site characterization.
- If necessary, establish building ventilation for Layaway.

- Remove all chemicals and samples, radioactive and other hazardous materials from the facility.
- Remove furniture and apparatus as desired.
- Remove all exposed loose contamination and paint all exposed contaminated surfaces to fix residual contamination in place.
- Install required protective equipment (intrusion, flooding and fire alarms).
- Renovate the building roof, closures, stairways and other structural features as needed to ensure building integrity and safety during Layaway.
- Seal all building openings and entries to prevent unauthorized entry.
- Fence the site if not within an exclusion area to restrict access to the facility.
- Provide maintenance and routine surveillance as required during Layaway.

Special Procedures Required

None anticipated.

Waste Disposal

Placing the various laboratory facilities in Layaway will generate a relatively small quantity of contaminated wastes. Removal of loose contamination from exposed surfaces and subsequent painting of the surfaces will generate a small amount of contaminated wastes, including some combustibles, but the volumes will be insignificant.

PROTECTIVE STORAGE

Because of the generally low levels of radioactivity associated with these facilities there is little technical or economic incentive for placing the retired laboratory facilities in Protective Storage. Priority-budget considerations may prevent the near-term disposition of the laboratories and require that they be placed in Layaway for an extended period of time, but this would not justify their being placed in Protective Storage.

ENTOMBMENT

Because of the generally low levels of radioactivity associated with these facilities there is no technical or economic incentive for entombing the retired laboratory facilities.

DISMANTLEMENT

Due to the diverse nature of the many laboratory facilities it is not practical to define, in this document, the specific work activities and procedures required for the dismantling of each laboratory. The activities outlined below are intended to serve only as a general guide for the disposition of the class of facilities and are not intended to be specific for any given laboratory.

Plan of Action

Dismantle the facility and remove from the site all radioactivity above the appropriate release limits.

Major Activities

- Complete the required site characterization.
- Renovate the building ventilation system and return it to operation, if required for dismantlement.
- Remove all chemicals, samples, radioactive and other hazardous materials, furniture and apparatus.
- Remove all lines, ducts and utilities not required for dismantling operations.
- Provide the capability to handle aqueous wastes resulting from decontamination activities. This could include the use of any "hot" building drain lines which are still in useable condition.
- Decontaminate equipment, hoods, glove boxes, hot cells, etc. to simplify subsequent dismantling and disposal. Highly contaminated components such as hot cells would be decontaminated to a level

which allows contact operations during their dismantling. If possible, components contaminated with transuranics would be decontaminated to a level which minimizes the quantity of contaminated solid waste requiring retrievable storage.

- Provide any supplemental containment and ventilation control required for dismantling the hoods, glove boxes, hot cells, ducts, etc.
- Dismantle the contaminated equipment, hoods, glove boxes, hot cells etc. and package for disposal.
- Decontaminate the building structural surfaces, as necessary, to simplify dismantlement. Fix residual contamination in place by paint or other means, before dismantling the building.
- Dismantle contaminated sections of the building in stages using the existing ventilation system and supplementary containment barriers to provide contamination control. Package the contaminated wastes for disposal.
- Dismantle any remaining contaminated components including the ventilation system, hot drain lines, and containment barriers, and package for disposal.
- Transfer all contaminated solid wastes to the appropriate disposal sites. If possible, burn all combustible wastes. Dispose of contaminated liquid wastes in accordance with existing disposal policy.
- Demolish uncontaminated sections of the building. Remove all uncontaminated debris and rubble from the site and transfer to disposal sites or bury in onsite excavations.
- Excavate any contaminated dirt exceeding the appropriate release limits, and package for disposal. Transfer to the appropriate disposal sites.
- Remove remaining utility services, contaminated drain lines and pavement.
- Fill all excavations with clean dirt and restore vegetation.

Special Procedures Required

All the required dismantlement activities can be accomplished using established procedures. One problem area would be personnel protection and contamination control during the dismantlement activities. During these operations, care must be taken to minimize generation of airborne particulates, and the preferred procedures are those which create a minimum of particulates. A second problem area may be decontamination of highly contaminated surfaces of caves and hot cells to a level permitting contact operations to be performed. Techniques such as vacuum blasting and concrete spalling may be applied to this problem. The dismantlement operations can be simplified by adequate decontamination of the laboratory and its components before the start of dismantlement. However, the cost and risks associated with the decontamination activities and the costs and risks of the dismantling operation must be balanced. See Section D.9 for a discussion of decontamination procedures that could be applied to the laboratory facilities.

Waste disposal problems can be simplified if bulky items such as hoods and glove boxes can be segmented prior to disposal to reduce the waste volume. This would be especially important for items contaminated with transuranics which require retrievable storage.

Waste Disposal

The diverse nature of the laboratory facilities make it impractical to estimate typical waste volumes and disposal problems associated with laboratory dismantlement. The contaminated waste volumes can vary by orders of magnitude in different laboratories. Some wastes would be contaminated with transuranics and require retrievable storage; other wastes would contain only beta-gamma activity. With the possible exception of wastes resulting from decontamination of certain caves or hot cells, it is unlikely that the wastes would be so highly contaminated that shielded packaging would be required for disposal. In general, the contaminated wastes generated by dismantling a laboratory facility can be divided into six different categories:

- building structural materials
- internal laboratory components (hoods, glove boxes, etc.)
- contaminated utilities (ventilation system(s), drain lines, etc.)
- combustible solid wastes
- contaminated soil
- decontamination solutions and debris.

The volume of contaminated waste will depend on the facility and may vary from a few hundred cubic feet to thousands of cubic yards. The solid waste requiring controlled disposal can be reduced significantly in volume if bulky items such as hoods and glove boxes can be segmented. Decontamination of structural materials, especially concrete, and partitioning of partly contaminated composite structures such as frame walls contaminated only on interior surfaces will also reduce the volume of wastes requiring controlled disposal.

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VI. LABORATORIES

VI.0 INTRODUCTION

Section D.3.6 and Appendix VI describe the potentially contaminated laboratories located on the Hanford Site.^(a) These facilities are listed in Table VI.1 and are individually described in the indicated data sheets with the exception of the dismantled biological research facilities at the 100-F Area which are briefly described in Table VI.2.

(a) Except for the Fast Flux Test Facility (400 Area).

TABLE VI.1. Contaminated Laboratory Facilities at the Hanford Site^(a)

Building Number	Building Name	Operating Area	Operating Status ^(b)	Appendix Number
108-B	Tritium Separation Facility	100-C	Standby	VI.1.1
108-D	Technical Development Laboratory	100-D	Dismantled	VI.1.2
108-F	Biology Laboratory	100-F	Surplus	VI.1.3
141-C	Animal Barn	100-F	Surplus	VI.1.4
141-F	Animal Barn	100-F	Dismantled	(Table VI.2)
141-H	Large Animal Laboratory	100-F	Dismantled	(Table VI.2)
141-N	Sewage Pump House	100-F	Dismantled	(Table VI.2)
144-F	Inhalation Laboratory	100-F	Dismantled	(Table VI.2)
201-C	Strontium Semiworks	200-E	Surplus	III.2
209-E	Critical Mass Laboratory	200-E	Active	IX.6
222-B	Process Analysis Laboratory	200-E	Active	VI.2.1
222-S	Process Analysis Laboratory	200-W	Active	VI.2.2
222-T	Process Analysis Laboratory	200-W	Active	VI.2.3
222-U	Process Analysis Laboratory	200-W	Active	VI.2.4
231-Z	Plutonium Metallurgy Laboratory	200-W	Active	IX.7
306-E	Metal Fabrication Development Laboratory	300	Active	VI.3.1
306-W	Metal Fabrication Development Laboratory	300	Active	VI.3.2
308	Plutonium Laboratory	300	Active	VI.3.3
309	Offices and Shops	300	Active	VI.3.4
314	Engineering Development Laboratory	300	Active	VI.3.5
320	Low-Level Radiochemistry Building	300	Active	VI.3.6
321	Engineering Development Laboratory	300	Active	VI.3.7
323	Metals Creep Laboratory	300	Active	VI.3.8
324	Chemical Engineering Laboratory	300	Active	VI.3.9
325	Radiochemistry Building	300	Active	VI.3.10
326	Physics and Metallurgy Building	300	Active	VI.3.11
327	Radiometallurgy Building	300	Active	VI.3.12
329	Biophysics Laboratory	300	Active	VI.3.13
331	Life Sciences Laboratory I	300	Active	VI.3.14
331-A	Virology Laboratory	300	Active	VI.3.15
1705-F	Inhalation Toxicology Laboratory	100-F	Dismantled	(Table VI.2)
1706-KE	Reactor Loop Corrosion Testing Facility	100-K	Standby	VI.1.5
1706-KER	Reactor Loop Corrosion Testing Facility	100-K	Standby	VI.1.6
1706-KEL	Reactor Loop Corrosion Testing Facility	100-K	Standby	VI.1.7
1707-F	Dog Inhalation Laboratory	100-F	Dismantled	(Table VI.2)
1707-FA	Rodent Inhalation Laboratory	100-F	Dismantled	(Table VI.2)
1713-F	Instrument Laboratory	100-F	Dismantled	(Table VI.2)
1716-F	Storage	100-F	Dismantled	(Table VI.2)
3708	Radiation Measurement Laboratory	300	Active	VI.3.16
3720	Central Services and Laboratory	300	Active	VI.3.17
3730	Gamma Irradiation Facility and Storage	300	Active	VI.3.18
3745	Radiological Calibration and Standards Building	300	Active	VI.3.19
3745-A	Electron Accelerator Facility	300	Active	VI.3.20
3745-B	Positive Ion Accelerator Facility	300	Active	VI.3.21
3746-A	Chemical and Biological Physics Laboratory	300	Active	VI.3.22

(a) Excluding the Fast Flux Test Facility.

(b) 1979.

TABLE VI.2. Contaminated Biology Laboratory Facilities in the 100-F Area

Facility	Description	Status (1979)	Decommissioning Cost	Appendix
108-F Biology Laboratory	See Data Sheet	Surplus	\$500,000 (Est.)	VI.4.1
141-C Animal Barn	See Data Sheet	Surplus	300,000 (Est.)	VI.4.2
141-F Animal Barn	4769 ft ² single story concrete and concrete block building contaminated to 500 c/m	Dismantled	35,000 (1977)	--
141-H Large Animal Laboratory	2305 ft ² concrete block building contaminated to 5000 c/m	Dismantled	30,000 (1977)	--
141-N Sewage Pump House	414 ft ² single-story concrete block building contaminated to 3000 c/m	Dismantled	15,000 (1977)	--
144-F Inhalation Laboratory	3250 ft ² single-story concrete block building - moderate Pu contamination	Dismantled	110,000 (1978)	--
144-R Inhalation Toxicology Kennel	1400 ft ² corrugated transit shed. Contaminated duct work and drains.	Dismantled	7,000 (1977)	--
1705-F Inhalation Toxicology Laboratory	1600 ft ² Quonset hut	Dismantled	5,000 (1977)	--
1707-F Dog Inhalation Laboratory	1995 ft ² frame structure. Contamination levels to 50,000 c/m	Dismantled	25,000 (1977)	--
1707-FA Rodent Inhalation Laboratory	1980 ft ² single-story frame structure. Contamination levels to 50,000 c/m.	Dismantled	25,000 (1977)	--
1713-F Instrument Laboratory	4160 ft ² single-story frame building. Connected to a contaminated drain line.	Dismantled	5,000 (1977)	--
1716-F Storage	1760 ft ² single-story frame structure. Connected to a contaminated drain line.	Dismantled	5,000 (1977)	--
116-F-4 Animal Waste Leaching Trench	See Data Sheet	Surplus	See Data Sheet	I.5.48
118-F-5 PNL Sawdust Repository	See Data Sheet	Inactive	See Data Sheet	II.1.25
118-F-6 Solid Waste Burial Ground	See Data Sheet	Inactive	See Data Sheet	II.1.26

Revision Orig. 9/78

Appendix VI.3.1

306-E^(a) METAL FABRICATION DEVELOPMENT LABORATORY

Landlord: HEDL

Service Dates: 1956-Present

Status: Active

Location: 300 Area, NE
(Ginkgo St.)
(Figure C.1.17)

Site Coordinates (approx.):

N-55083
E-14967

Reference Drawings:

H-3-8221
H-3-10856
H-3-12752
H-3-12757

Elevations:

grade: 392 ft
floor: 392 ft (first floor)
water table: 341-342 ft (1977)

Reference: HEDL Facilities Catalog MG-17, January 1977

Purpose: Provides large, high clearance, heavy floor loading, metallurgical research and development laboratory and pilot plant space. Although designed for metallic reactor fuel element development, the utility grids and variety of metallurgical equipment make the building one of general utility.

Description: Building 306-E has two stories, no basement, and approximately 45,000 sq ft. Framework is bolted steel; roof is concrete with tar and gravel finish; exterior siding is fluted steel insulated panels; first floor is reinforced concrete. Ventilation system consists of three 50,000 cfm supply units with filters, steam coils, and spray chambers. Hoods have individual exhausters. Chemical and acid tanks exhaust through two 12,000 cfm fume scrubbers to a 40 ft x 3-1/2 ft stainless steel stack. Major equipment and structures include a 45-ft deep assembly pit, 3 industrial X-ray machines, 2 isotope sources, 2 electron beam welders, 5 open-face hoods.

(a) Building 306 was divided into two halves in 1972, 306-E and 306-W.

Revision Orig. 9/78

Appendix VI.3.1-1

Contamination: The hoods in Rooms 158 and 159 (old uranium oxide lab) are contaminated. Concrete acid trench (old chem. bay, NE corner of building) is contaminated with depleted uranium. Contamination has been painted over. A process sewer runs from old uranium hot shop in 306-W under 306-E and is probably contaminated with spent uranium.

Associated Facility:

306-E Metal Fabrication Development Laboratory Appendix VI.3.2.

Revision Orig. 9/78

Appendix VI.3.2

306-W^(a) METAL FABRICATION DEVELOPMENT LABORATORY

Landlord: PNL

Service Dates: August 1956-
Present

Status: Active

Location: 300 Area, NE
(Ginkgo St.)
(Figure C.1.17)

Site Coordinates (approx.):

N-55083
E-14768

Reference Drawings:

H-3-32503
H-3-10856
H-3-12757
H-3-12752

Elevations:

grade: 312 ft
floor: 392 ft (first floor)
water table: 341-342 ft (1977)

Reference: BNW Facilities Catalog BNWL-MA-87
Catalog of Hanford Buildings and Facilities 300 Area, April 1964

Purpose: Provides large, high clearance, heavy floor loading metallurgical research and development laboratory and pilot plant space. Although designed for metallic reactor fuel element development, the utility grids and variety of metallurgical equipment make the building one of general utility.

Description: Building 306-W has two stories, and no basement, and approximately 34,100 sq ft. Framework is bolted steel; roof is concrete with tar and gravel finish; exterior siding is fluted steel insulated panels; first floor is reinforced concrete. Some major equipment includes a 50 kW vacuum induction furnace, consumable arc furnace, 700-ton vertical extrusion press, swages, rolling mills, 3600 ft-lb pneumatic hammer, 125-ton hammer press, 400-ton hydraulic press, 5-roll tube straightener, 25-ton stretch straightener, 7-ton draw bench, roller leveler, 4400 ft-lb magneform, and a variety of welders.

(a) Building 306 was divided into two halves in 1972, 306-E and 306-W.

Revision Orig. 9/78

Appendix VI.3.2-1

Contamination: In past, building was used for pilot plant fuels work. Trenches, sumps, hoods and exhaust ductwork are contaminated with uranium. There is no known floor or wall contamination. Present work is with thorium and enriched, normal, and depleted uranium.

Associated Facility:

306-W Metal Fabrication Development Laboratory Appendix VI.3.1.

308 PLUTONIUM LABORATORY

Landlord: HEDL

Service Dates: 1960-Present

Status: Active

Location: 300 Area, SE
(Redwood St.)
(Figure C.1.18)

Site Coordinates (approx.):

N-53967
E-15232

Reference Drawings:

H-3-12005
H-3-12006
H-3-14378

Elevations:

grade: 404 ft
floor: 404 ft
water table: 341-342 ft (1977)

Reference: HEDL Facilities Catalog MG-17, January 1977

Purpose: This facility provides laboratory space for developing technology for the manufacture of plutonium-bearing fuels.

Description: The 308 Building has a framework of bolted steel and reinforced concrete. The roof is steel decked, topped with concrete, finished with tar and gravel, and is slightly sloped. The office wing roof is steel decked and has a tar and gravel finish. Exterior walls are reinforced concrete and concrete block. Floors are reinforced concrete with vinyl tile finish. Interior walls are concrete block. Building consists of a two-story laboratory section and a one-story office wing with approximately 60,000 sq ft of floor area.

Contamination: The labs are authorized to work with a diversity of radioactive materials, including plutonium. The majority of this work is done in glove boxes which are found throughout the building. Glove boxes in the first floor powder labs are in Rooms 106, 111, 112, 113, 117 and 119. Glove boxes for the second floor research and development labs are found in Rooms 208, 212, 213, 216, 219, 220, 223, and 225.

In addition, Room 111 has an open-face hood used for Pu work and a contaminated pit under the floor.

There is known fixed contamination in Rooms 111, 112, 113, 117, 119, and 138. Many of the exhaust systems are also potentially contaminated.

Room 160 contains the TRIGA reactor (Training and Research Isotope General Atomics), a neutron radiography facility.

Simplified Building Plan:

309 OFFICES AND SHOPS (PRTR)

Landlord: HEDL

Service Dates: 1960-Present

Status: Active

Location: 300 Area, SE
(New Mexico St.)
(Figure C.1.18)

Site Coordinates (approx.):

N-53563
E-15240

Reference Drawings:

H-3-11059
H-3-11060
H-3-26603

Elevations:

grade: 403 ft
floor: 404 ft (first floor)
water table: 341-342 ft (1977)

Reference: HEDL Facilities Catalog MG-17, January 1977

Purpose: Building was originally used to develop technology for using Pu as a fuel in thermal heterogeneous power reactors. The reactor was placed in layaway in 1969. Above-ground containment vessel was decontaminated and modified to provide "clean space" for fabrication and modification of components and test articles for liquid metal systems. The fuel storage basin area was cleaned and is used as a weld laboratory.

Description: The all-welded containment vessel with hemispherical dome and hemiellipsoidal bottom is 121 ft 6 in. high, 75 ft being above grade. Access to vessel is through an air lock 10 ft in diameter, 15 ft long. Adjoining service building has a weld lab, work area, offices, lunchroom, mechanical maintenance shop and computer facilities. Framework is welded steel; roof is steel deck with tar and gravel finish; exterior walls are fluted steel insulated panels; floor is concrete covered with vinyl tile. Containment ventilation exhausts through a 150-ft stack. Contaminated liquid waste from operation of the reactor was pumped to three 5000-gal tanks buried north of 309. Contents may be pumped to 340 building for disposal.

Contamination: Contaminated structures on basement level or below:

- A, B, and C cells within the containment vessel. The piping in A, B, and C cells is contaminated with Pu and fission products. The ion exchange columns in B cell are contaminated with ⁹⁰Sr.
- Rupture loop system, including the floor, piping, tanks, and vessels, with Pu, tritium, and fission products (a on the plan below).
- Ion exchange columns in the ion exchange vault (b)
- Three waste storage tanks and piping (NE of containment vessel) (c)
- Ion exchange columns in ion exchange vault (east of containment vessel). Exchangers have been dropped through a hole in the vault and sealed off. (d)
- Two manholes, Numbers 2 and 4 (NE and SE of building) (e)
- Stack filter (potential)(f)
- Storage basins, 8x20x30-ft deep, once held water. Have been boarded up, residual contamination is under the floor. (g)
- Three tanks, once contained heavy water (h)
- Critical facility (PRCF) cell, fixed contamination (fission products - ¹³⁷Cs) on small areas of wall near the transfer lock. Contamination has been painted over and is marked with signs. (m)

Contaminated structures on first floor:

- Concrete transfer basin, used for handling fuel elements (i)
- Load out facility, fixed contamination (j)
- Fixed contamination (k)
- Room 212, duct work and drains (potential) (l)
- White change room (North of 212), drains

The most concentrated contamination is within the containment vessel and rupture loop system. The rest is fairly low-level.

Revision Orig. 9/78

Appendix VI.3.4-2

Simplified Building Plan:

BASEMENT PLAN

FIRST FLOOR PLAN

Total area is 46,700 sq ft.

314 ENGINEERING DEVELOPMENT LABORATORY

Landlord: PNL

Service Dates: January 1945-
Present

Status: Active

Location: 300 Area, NW
(Ginkgo St.)
(Figure C.1.17)

Site Coordinates (approx.):

N-55050
E-14000

Reference Drawings:

H-3-26604

Elevations:

grade: 386 ft
floor: 387 ft (first floor)
water table: 341-342 ft (1977)

Reference: BNW Facilities Catalog BNWL-MA-87

Purpose: Provides high bay, heavy capacity space for mock-ups and test equipment. Includes autoclaves, geothermal tests, waste management studies, water augmentation test apparatus, and high temperature helium loops. Charging machines and reactor auxiliary equipment have been developed here.

Description: Building is rectangular with a rectangular addition along north side. Framework is bolted steel; gable roof is corrugated asbestos; exterior walls and partitions are concrete block; floor is reinforced concrete with test pits. At west end is a basement room and small second floor. Basement windows extend across north wall of addition. Total floor area is approximately 23,200 sq ft.

Contamination: Building was used as uranium facility in past. There is fixed uranium contamination (painted floors and walls) in many places. Trenches and drains are also uranium contaminated.

Dimensions: 90 ft (East Wall) x 218 ft

FIRST FLOOR PLAN

DRAWER #11	U. S. ATOMIC ENERGY COMMISSION RICHLAND OPERATIONS OFFICE PACIFIC NORTHWEST LABORATORY OPERATED BY BATTELLE MEMORIAL INSTITUTE	SIMPLIFIED BUILDING LAYOUT	1 1
DATE	U. S. ATOMIC ENERGY COMMISSION RICHLAND OPERATIONS OFFICE PACIFIC NORTHWEST LABORATORY OPERATED BY BATTELLE MEMORIAL INSTITUTE	SIMPLIFIED BUILDING LAYOUT	1 1
DATE	U. S. ATOMIC ENERGY COMMISSION RICHLAND OPERATIONS OFFICE PACIFIC NORTHWEST LABORATORY OPERATED BY BATTELLE MEMORIAL INSTITUTE	SIMPLIFIED BUILDING LAYOUT	1 1
DATE	U. S. ATOMIC ENERGY COMMISSION RICHLAND OPERATIONS OFFICE PACIFIC NORTHWEST LABORATORY OPERATED BY BATTELLE MEMORIAL INSTITUTE	SIMPLIFIED BUILDING LAYOUT	1 1
DATE	U. S. ATOMIC ENERGY COMMISSION RICHLAND OPERATIONS OFFICE PACIFIC NORTHWEST LABORATORY OPERATED BY BATTELLE MEMORIAL INSTITUTE	SIMPLIFIED BUILDING LAYOUT	1 1

320 LOW LEVEL RADIOCHEMISTRY BUILDING

Landlord: PNL

Service Dates: August 1965-
Present

Status: Active

Location: 300 Area, SW
(Cypress St.)
(Figure C.1.17)

Site Coordinates (approx.):

N-53050
E-14199

Reference Drawings:

H-3-26606

Elevations:

grade: 396 ft
floor: 400 ft (first floor)
water table: 341-342 ft (1977)

Reference: BNW Facilities Catalog BNWL-MA-87

Purpose: Provides a low-level radiochemistry building in which very sensitive radiochemical analyses, sample preparation, and methods development can be performed.

Description: 320 is a rectangular building with one story and a basement. Roof is flat with a tar and gravel finish. Main building is concrete with steel frame. Clean air is exhausted through roof vents. Air from laboratory No. 1, No. 2, and the heavy element chemistry laboratory is scrubbed and filtered and then exhausted through roof vents. Remaining air is filtered and exhausted through a 39-ft-high x 5-ft-diameter stack. Total floor area is approximately 25,300 sq ft.

Contamination: Drains in Room 113 are contaminated with silica.

FIRST FLOOR PLAN

BASEMENT FLOOR PLAN

U. S. ATOMIC ENERGY COMMISSION RICHLAND OPERATING DIVISION PLANT 1 OPERATING BY RICHMOND MILLS, WASHINGTON	
SIMPLIFIED BUILDING LAYOUT	
DATE: 10/1/78	BY: JED
SCALE: 1/8" = 1'-0"	NONE
H-3-26606 111	

ROOM NO.	AREA (SQ. FT.)	USE	REMARKS
100	100	STORAGE	
101	100	STORAGE	
102	100	STORAGE	
103	100	STORAGE	
104	100	STORAGE	
105	100	STORAGE	
106	100	STORAGE	
107	100	STORAGE	
108	100	STORAGE	
109	100	STORAGE	
110	100	STORAGE	
111	100	STORAGE	
112	100	STORAGE	
113	100	STORAGE	
114	100	STORAGE	
115	100	STORAGE	
116	100	STORAGE	
117	100	STORAGE	
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122	100	STORAGE	
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136	100	STORAGE	
137	100	STORAGE	
138	100	STORAGE	
139	100	STORAGE	
140	100	STORAGE	
141	100	STORAGE	
142	100	STORAGE	
143	100	STORAGE	
144	100	STORAGE	
145	100	STORAGE	
146	100	STORAGE	
147	100	STORAGE	
148	100	STORAGE	
149	100	STORAGE	

Revision Orig. 9/78

Appendix VI.3.7

321 ENGINEERING DEVELOPMENT LABORATORY

Landlord: HEDL

Service Dates: 1944-Present

Status: Active

Location: 300 Area, SW
(Idaho St.)
(Figure C.1.17)

Site Coordinates (approx.):

N-54282
E-14166

Reference Drawings:

H-3-4058 Sheet 1 and 2
H-3-5764
H-3-5690

Elevations:

grade: 392 ft
floor: 396 ft (first floor)
water table: 341-342 ft (1977).

Reference: HEDL Facilities Catalog MG-17, January 1977

Purpose: Provides facilities for hydraulic and mechanical research and development of reactor components. In the past the building was used as a chemical pilot plant and also did research and development work for the Redox plant.

Description: 321 is a one-story building with a full basement. The framework is concrete and bolted steel; roof is concrete finished with tar and gravel; exterior walls are concrete and concrete block; floors are concrete. Total floor area is approximately 23,400 sq ft.

321-B, 321-C, and 321-D are prefabricated metal one-story buildings attached to 321. Floors are concrete.

Contamination: There is fixed natural uranium contamination on the floors and walls of the old canyon area. Contamination is low level and in patches. Ceiling and roof vents are potentially contaminated with uranium from an explosion during pilot plant testing.

Simplified Building Plan:

323 METALS CREEP LABORATORY

Landlord: HEDL

Service Dates: 1959-Present

Status: Active

Location: 300 Area,
SW Corner
(Figure C.1.17)

Site Coordinates (approx.):

N-54116
E-14133

Reference Drawings:

H-3-5660

Elevations

grade: 393 ft
floor: 388 ft/393 ft
water table: 341-342 ft

Reference: HEDL Facilities Catalog MG-17, January 1977

Purpose: Provides test facilities in support of critical FFTF/LFMBR components such as the fuel assembly, reactor vessel, and primary system weldments. Complements the test facilities in the 326 Building.

Description: Sheet metal structure located on concrete foundation and floor. North end of building is at grade and rest is 5 ft below grade with ramp entrance. Subgrade portion is about 6 ft wider than the rest of the building. Total floor area is approximately 3950 sq ft.

Contamination: In past, building was a uranium facility. A tank under the building is uranium contaminated. A shielded cell, where work has been done with irradiated metal specimens, is the only probable place of contamination within the building, with approximate level less than 1 Ci.

Revision Orig. 9/78

Appendix VI.3.8-1

Simplified Building Plan:

324 CHEMICAL ENGINEERING LABORATORY

Landlord: HEDL

Service Dates: 1966-Present

Status: Active

Location: 300 Area, SE
(Locust St.)
(Figure C.1.18)

Site Coordinates (approx.):

N-53967
E-15669

Reference Drawings:

H-3-20156
H-3-26608

Elevations:

grade: 400 ft
floor: 401 ft (first floor)
water table: 341-342 ft (1977)

Reference: HEDL Facilities Catalog MG-17, January 1977

Purpose: A facility for studying chemical and metallurgical processes. 324 provides a single integrated facility for nonradioactive or radioactive development studies from laboratory or bench-scale to full engineering-scale pilot plant demonstrations. It also houses a nuclear material storage vault.

Description: Building is three story concrete and steel structure divided into 4 working areas: 2 engineering development laboratories (1 radioactive, 1 nonradioactive) and 2 shielded facilities (1 radiochemical, 1 radiometallurgy). Shielded facilities consist of 4-ft-thick high density concrete walls, closed circuit TV, manipulators, and periscopes. The cask handling area is equipped with a 30-ton crane and a 5-ton hoist. Building also contains 4 sodium loops for studying the interaction of reactor materials with sodium at temperatures up to 1300°F. Total floor area is approximately 81,500 sq ft.

Contamination: Chemical engineering cells A, B, C, and D, the drains and exhaust systems are grossly contaminated with a variety of transuransic and mixed fission products. Effluent lines from the cells to 2 waste tank vaults (each vault containing 4 tanks) in basement are also contaminated. Exhaust tunnel, filters, and stack for the tank vaults are also either contaminated or potentially contaminated. In addition, there are 3 cells in the shielded materials facility that are potentially to moderately contaminated.

A radioactive liquid waste (RLW) drain runs from Room 4 through the exhaust tunnel for the transfer of waste from the low level waste tank vault and the shielded materials facility to the 340 building.

Hoods in Room 146, 3F, and 3D are lightly or potentially contaminated with mixed fission products. Room 147 hood and glove boxes are grossly contaminated. Glove boxes in 3K are contaminated with uranium and plutonium powder. In most cases the contamination is both smearable and fixed.

Simplified Building Plan:

325 RADIOCHEMISTRY BUILDING

Landlord: HEDL

Service Dates: 1953-Present

Status: Active

Location: 300 Area, S Central
(Redwood St.)
(Figure C.1.18)

Site Coordinates (approx.):

N-54000

E-14818

Reference Drawings:

H-4-50016 H-3-27693

H-3-19178 H-4-50017

H-3-9306 H-4-50018

Elevations:

grade: 400 ft

floor: 402 ft (first floor)

water table: 341-342 ft (1977)

Reference: HEDL Facilities Catalog MG-17, January 1977

Purpose: Provides specially shielded, ventilated and equipped laboratories for radiochemical and related work in support of LMFBR program. Research instruments include emission spectrographs, mass spectrometers, spectrophotometers; electron microscopes, flame photometer, radiation measuring instruments, radiation source, laser apparatus and others.

Description: Building is rectangular with a front wing containing offices, conference room, and lunch room; east wing is equipped with chemical research cells; west wing has analytical shielded facilities. The main building has over 50 laboratories, 200 hoods, and many glove boxes. The three radiochemical cells have 4-ft-thick high density concrete walls with air exhausted through HEPA filters to 55-ft stack. The six analytical cells have 2-1/2-ft-thick concrete back walls and side walls of steel. Total floor area is approximately 139,200 sq ft.

Contamination: Contaminants include transuranics and mixed fission products. Contaminated areas include hoods, duct work, drains and vacuum system. There is fixed contamination at four places on laboratory floors, and in the hot cells.

Simplified Building Plan:

326 PHYSICS AND METALLURGY BUILDING

Landlord: HEDL

Service Dates: 1953-Present

Status: Active

Location: 300 Area, S Central
(Wisconsin St.)
(Figure C.1.17)

Site Coordinates (approx.):

N-54265
E-14497

Reference Drawings:

H-3-4501
H-3-4502
H-3-22548
SK-3-6706

Elevations:

grade: 401 ft
floor: 405 ft (main floor)
water table: 341-342 ft (1977)

Reference: HEDL Facilities Catalog MG-17, January 1977

Purpose: The 326 Building provides laboratories and facilities for the study of metallurgical, chemical, and physical behavior of reactor components and fuel elements. The basement contains heavy metallurgical laboratories and large laboratories for reactor mock-ups. Equipment includes X-ray diffraction apparatus, mass spectrometers, electron microprobe, quantitative image analyzer, electron microscope, creep test apparatus, and metallographic equipment.

Description: Building has two floors and a basement. The framework is bolted steel; roof is slightly sloped steel deck with tar and gravel finish; exterior walls are fluted steel-insulated panels; floors are steel with concrete finished with asphalt or vinyl asbestos tile; counting room has high density concrete walls. Building contains both offices and laboratories. Heavy equipment includes a two-ton monorail, a 3000-lb hydraulic elevator, and an 8000-lb hydraulic lift. Hoods for radiation work are exhausted via HEPA filters and fans to a 45-ft x 6-in. diameter aluminum stack. Total floor area is approximately 63,100 sq ft.

Contamination: Contaminants include plutonium, mixed fission products, and irradiated metal specimens from reactors.

In general, the laboratories are contaminated. This includes the small cells, waste lines, ductwork, and slight contamination in the hoods.

Simplified Building Plan:

FIRST FLOOR PLAN

SECOND FLOOR PLAN

327 RADIOMETALLURGY BUILDING

Landlord: HEDL

Service Dates: 1953-Present

Status: Active

Location: 300 Area, central
(Apple & Orange Sts.)
(Figure C.1.17)

Site Coordinates (approx.):

N-54530
E-14801

Reference Drawings:

H-4-50195
H-4-50196
H-3-19423

Elevations:

grade: 392 ft
floor: 395 ft (main floor)
water table: 341-342 ft (1977)

Reference: HEDL Facilities Catalog MG-17, January 1977

Purpose: The Radiometallurgy Building is designed for physical and metallurgical examination of irradiated nuclear materials in specially shielded, ventilated and equipped laboratories. Examination includes measurements, metallography, hardness testing, tensile testing, dilatrometry, density, and annealing. Radiation effects can be determined as an aid in developing stable materials.

Description: 327 is a one-story building with a basement. The additions are on grade. Framework is welded steel; roof is slightly sloped steel deck with tar and gravel finish; exterior walls are fluted steel; floor is reinforced concrete or steel decking with concrete finish. The main laboratory has cells with cast iron walls 18, 15-1/2, and 10-1/2 inches thick. Building also contains offices and storage areas. 20- and 15-ton bridge cranes serve the 10 hot cells. Air is exhausted through a 44-ft high x 5-ft diameter stainless steel stack. Located at the north side of the building is a 5500 gallon tank for liquid nitrogen storage. Total floor area is approximately 29,900 sq ft.

Contamination: The 10 hot cells all have moderate to gross smearable contamination.

- A. Contains mixed fission products. Alpha, beta, and gamma radiation to approximately 8,000 to 10,000 R/hr.
- B. Contaminants same as A, radiation levels to approximately 1,000 to 2,000 R/hr.
- C. Contaminants same as A. Cell is presently being cleaned up but will be recontaminated to radiation levels of approximately 3,000 to 5,000 R/hr.
- D. Contaminants same as A, radiation levels of approximately 5,000 to 8,000 R/hr.
- E. Contaminant same as A, radiation levels of approximately 8,000 to 10,000 R/hr.
- F. Wide diversity of contaminants, radiation levels of 20,000 to 25,000 R/hr.
- G. Contains mixed fission products, ^{60}Co , fuel cladding products. Beta, gamma radiation to levels of approximately 3,000 mR/hr.
- H. Contains no fission products; some beta and gamma radiation to approximately 200 to 300 mR/hr.
- I. Contains radiated structural material, radiation levels to approximately 10-20 mR/hr.

Serf - Mixed fission products, many elements include iodine, thorium cesium, cobalt, plutonium, fissile material. Contamination is grossly smearable. Radiation levels approximately 25,000 to 30,000 R/hr.

The canyon area and canyon basement walls, floors, and ceilings and all equipment have small amounts of nonsmearable contamination. The radioactive liquid waste system which runs under the building to 340 building tanks is highly contaminated with thorium and cesium. Alpha, beta, and gamma radiation is present. The retention process sewer, which holds up wastes in the event of an accidental release, is potentially contaminated.

Simplified Building Plan

329 BIOPHYSICS LABORATORY

Landlord: PNL

Service Dates: November 1952-
Present

Status: Active

Location: 300 Area, S. central
(Redwood St.)
(Figure C.1.17)

Site Coordinates (approx.):

N-53950
E-14497

Reference Drawings:

H-3-26612
H-11-4520 Sheets 1 and 2

Elevations:

grade: 396 ft
ground floor: 398 ft (main floor)
water table: 341-342 ft (1977)

Reference: BNW Facilities Catalog BNWL-MA-87
Catalog of Hanford Buildings and Facilities 300 Area, April 1964

Purpose: Provides physics laboratories for developing instruments primarily for radiation detection. Includes chemistry laboratories for radioanalysis and low-level laboratories for the study of isotopes in the environs.

Description: Building is rectangular with partial second story and partial basement. Framework is bolted steel; roof is sloped steel deck with tar and gravel finish; exterior walls are fluted steel-insulated panels; floors are reinforced concrete with vinyl asbestos tile and utility trenches. Counting rooms have 1-ft-thick shielding walls and roofs of concrete. Total floor area is approximately 36,000 square feet.

Contamination: Building contains trace amounts of contamination.

Section A - Drains are contaminated, hoods potentially contaminated with wide variety of materials, largely activation products.

Section B - Rooms 1B, 2B, 3B, hoods and exhaust systems are potentially contaminated. Small amount of fixed contamination may exist elsewhere. Room 6B, filters and hoods are contaminated; with a possibility of some uranium contamination.

Simplified Building Plan:

Orig. 9/78

Appendix VI.3.14

331 LIFE SCIENCES LABORATORY I

Landlord: PNL

Service Dates: January 1971-
Present

Status: Active

Location: 300 Area, SE
(Figure C.1.18)

Site Coordinates (approx.):

N-52669
E-16563

Reference Drawings:

H-3-29664

Elevations:

grade: 380-385 ft
floor: Approx. 380 (main floor)
water table: 341-342 ft (1977)

Reference: BNW Facilities Catalog BNWL-MA-87

Purpose: Used for a wide variety of biological and ecological research activities including studies in radiation biology on large and small animals. Special facilities are used for inhalation toxicology, large animal radionuclide metabolism and toxicity, physiology, pathology, ecology, and aquatic studies related to the effects of specific radionuclides and radiation on living systems.

Description: The laboratory consists of three basic elements molded together into a single building. The main element is a three story structure consisting of two laboratory floors with a mechanical-electrical services floor sandwiched in between. The second element consists of a swine barn, a dog run complex, and shared facilities consisting of a whole body counting facility, an examination room, a surgery, a diagnostic X-ray room, and supporting cold temperature rooms. The third element consists of an entrance foyer, a court and a two-story administrative wing. Total floor area is approximately 98,600 square feet.

Contamination: Drains, ductwork and fume hoods in all labs are potentially contaminated with small amounts of mixed fission products and transuranics. The drain in Room 122 is contaminated from ^{106}Ru spill which occurred in 1975. Drains are now plugged and wastes are held before being released.

U.S. CHEMISTRY RESEARCH AND DEVELOPMENT ADMINISTRATION		PACIFIC NORTHWEST LABORATORY		CHEMISTRY & NUCLEAR RESEARCH DIVISION	
PROJECT NO.		H-3-29864		212	
PROJECT TITLE		SIMPLIFIED BUILDING LAYOUT			
DESIGNED BY		NONE			
CHECKED BY					
DATE		9/78			
SCALE		1/8" = 1'-0"			
SHEET NO.		212			
TOTAL SHEETS		2			
PROJECT NO.		H-3-29864		212	
PROJECT TITLE		SIMPLIFIED BUILDING LAYOUT			
DESIGNED BY		NONE			
CHECKED BY					
DATE		9/78			
SCALE		1/8" = 1'-0"			
SHEET NO.		212			
TOTAL SHEETS		2			

331-A VIROLOGY LABORATORY

Landlord: PNL

Service Dates: June 1968-
Present

Status: Active

Location: 300 Area, SE
(Figure C.1.18)

Site Coordinates (approx.):

N-52752

E-16398

Reference Drawings:

H-3-27951

Elevations:

grade: 386 ft

floor: 386 ft

water table: 341-342 ft (1977)

Reference: BNW Facilities Catalog BNWL-MA-87

Purpose: Provides laboratory space for the study of viruses. Swine and cats are used in this endeavor.

Description: Facility is a rectangular, one story, concrete block building with a flat, wood frame, built-up roof. The ventilation system is zoned to control the potential spread of viral contamination. A central HEPA filtered exhaust system provides this control. Located to the east of the laboratory is a crematory. Total floor area is 2,800 square feet.

Contamination: There are four square feet of fixed contamination (fission products) on the concrete floor. Readings are approximately 1000 counts/min.

The ductwork and fumehoods are potentially contaminated.

FLOOR PLAN

DRAWING 811		U.S. ENVIRONMENTAL PROTECTION AGENCY PACIFIC NORTHWEST LABORATORY SPRINTS & BUILDING DESIGN SECTION	
PROJECT NO. 331-A		PROJECT NAME BIOLOGY LABORATORY FACILITIES	
DATE 10/78		SCALE 1/4" = 1'-0"	
DESIGNED BY 331-A		CHECKED BY 331-A	
DRAWN BY 331-A		APPROVED BY 331-A	
PROJECT NO. 331-A		PROJECT NAME BIOLOGY LABORATORY FACILITIES	
DATE 10/78		SCALE 1/4" = 1'-0"	
DESIGNED BY 331-A		CHECKED BY 331-A	
DRAWN BY 331-A		APPROVED BY 331-A	
PROJECT NO. 331-A		PROJECT NAME BIOLOGY LABORATORY FACILITIES	
DATE 10/78		SCALE 1/4" = 1'-0"	
DESIGNED BY 331-A		CHECKED BY 331-A	
DRAWN BY 331-A		APPROVED BY 331-A	

3708 RADIATION MEASUREMENT LABORATORY

Landlord: PNL

Service Dates: December 1948-
Present

Status: Active

Location: 300 Area, W. central
(Wisconsin St.)
(Figure C.1.17)

Site Coordinates (approx.):

N-54785
E- 4331

Reference Drawings:

H-3-762
H-3-32676

Elevations:

grade: 388 ft
floor: 388 ft
water table: 341-342 ft (1977)

Reference: BNW Facilities Catalog BNWL-MA-87

Purpose: Provides space for storage of fissile material and some laboratory work.

Description: The building is a one story concrete block structure, on grade, with concrete foundation and concrete slab floor. Floor area is 3,870 square feet. The roof is concrete slab with a tar and gravel surface. The building is equipped to work with small amounts of highly radioactive materials, including plutonium. The ventilation system includes several roughing and HEPA filters.

Potentially contaminated liquid wastes are deposited to a receiver tank for transfer to the 300 Area retention waste system or the 300 Area contaminated waste system.

Contamination: The entire building is contaminated with a wide variety of materials.

FLOOR PLAN

[illegible]

REVISIONS										DRAWING STATUS	
COMMENT PER ISSUE NO										DATE	
DESCRIPTION										DATE	
REMOVED SQ FOOTAGE BLK GOT ADDED ROOM TITLES										DATE	
OF ORIGINAL REDRAWN DUE TO COND T1-2A										DATE	

DWG NO	SHEET NO	DRAWING TITLE OR INDEX NO
		REFERENCE DRAWINGS
		NEXT USED ON

3720 CENTRAL SERVICE AND LABORATORY

Landlord: PNL

Service Dates: February 1966-
Present

Status: Active

Location: 300 Area, N. central
(Oregon St.)
(Figure C.1.17)

Site Coordinates (approx.):

N-55464
E-14569

Reference Drawings:

H-3-32556

Elevations:

grade: 391 ft
floor: 391 ft (first floor)
water table: 341-342 ft (1977)

Reference: BNW Facilities Catalog BNWL-MA-87

Purpose: Provides maintenance facilities for craft services and space for analytical laboratories.

Description: An all-metal building of 26,940 square feet. Double doors on south side of building open onto a 60 x 60-ft concrete storage pad from the shop. Facility has an underground propane storage tank that is disconnected; in the past this was used with heat treating facilities.

Contamination: Facility has large number of hoods that are contaminated with uranium, tritium, and beryllium. Room 150 has a separate exhaust system which has potential plutonium contamination. Uranium contamination is probable in many drains.

3730 GAMMA IRRADIATION FACILITY AND STORAGE

Landlord: HEDL

Service Dates: 1950-Present

Status: Active

Location: 300 Area, W Central
(Wisconsin St.)
(Figure C.1.17)

Site Coordinates (approx.):

N-54480
E-14348

Reference Drawings:

H-3-8401

Elevations:

grade: 390 ft
floor: 390 ft
water table: 341-342 ft (1977)

Reference: HEDL Facilities Catalog MG-17, January 1977

Purpose: Provides shielded facilities for studies on irradiated materials and houses a 300,000 Ci ^{60}Co source and facilities for radiation detection instrumentation development.

Description: A later addition includes a gamma pit facility (center lab, irradiation inspection (south lab), and radiation detection instrument development (north lab). Gamma pit is a 20-ft deep stainless steel tank which contains clustered ^{60}Co sources used for irradiating materials. The shielded cell facility has concrete walls and a vault. A one story building of 3,440 square feet constructed on a concrete pad. The original building consists of a prefabricated steel frame with aluminum siding and roof. The interior walls are lined with transite and the ceiling is asbestos board.

Contamination: In the center lab there is ^{60}Co contamination. Tank would require some decontamination or removal and burial. Floors and walls of south lab should be checked for fixed alpha, beta, and gamma contamination.

Revision Orig. 9/78

Appendix VI.3.18-1

Simplified Building Plan:

FLOOR PLAN

3745 RADIOLOGICAL CALIBRATIONS AND STANDARDS BUILDING

Landlord: PNL

Service Dates: January 1945-
Present

Status: Active

Location: 300 Area, SW
(Figure C.1.17)

Site Coordinates (approx.):

N-54298

E-13917

Reference Drawings:

H-3-2662

H-3-6489

Elevations:

grade: 389 ft

floor: 390 ft (first floor)

water table: 341-342 ft (1977)

Reference: BNW Facilities Catalog BNWL-MA-87

Purpose: Provides a laboratory for calibrating radiation detection and measuring instruments using a 220 keV X-ray source or a wide range of gamma, alpha, and neutron sources. The wood frame of the X-ray room minimizes backscattering. Personnel area is shielded by a concrete wall.

Description: Two story, wood framed, rectangular building of 5,150 square feet having a multiple gable roof. Part of the roof is built-up hot mopped asphalt, rest is asphalt shingle. Exterior walls are asbestos shake and concrete block. Concrete main floor is on grade. Second floor is wood with asphalt tile. Building contains two 26-ft-deep wells, each containing 1/2 gram radium. Other sources are stored in a vault.

Contamination: When the sources are removed, the building should be free of contamination. Potentially contaminated areas include the vault and the wells.

3745-A ELECTRON ACCELERATOR FACILITY

Landlord: PNL

Service Dates: August 1949-
Present

Status: Active

Location: 300 Area, SW
(Alaska St.)
(Figure C.1.17)

Site Coordinates (approx.):

N-54398
E-13735

Reference Drawings:

H-3-26623
H-3-683

Elevations:

grade: 386 ft
floor: 387 ft
water table: 341-342 ft (1977)

Reference: BNW Facilities Catalog BNWL-MA-87

Purpose: Provides shielded laboratory space for research with electron bombardment utilizing a 200 MeV Van de Graff accelerator and a 600 kVp flash X-ray machine.

Description: The one story 1280 sq ft building is rectangular with a flat roof. Floor is concrete slab and is on grade. Concrete roof has tar and gravel finish. Walls are concrete and concrete block. Electron accelerator has 3-ft-thick concrete end walls and 8-in.-thick concrete block side walls.

Contamination: Upon removal of neutron source and Van de Graff accelerator, building should be free of contamination. The neutron well is a potential source of contamination.

FLOOR PLAN

U.S. ATOMIC ENERGY COMMISSION
RICHMOND OPERATIONS OFFICE
PACIFIC NORTHWEST LABORATORY
CREATED BY: BUREAU OF NUCLEAR ENERGY

SIMPLIFIED BUILDING LAYOUT

DATE: 3/74
H-3-26623
1/1

NO.	DESCRIPTION	DATE	BY	REVISION
1	REMOVED BY DOWNEY B.O.C.			
2	WORK AREA OF LABS 4000			
3	4000 SPACE ALLOC BLS			
4	4000 SPACE ALLOC BLS			
5	4000 SPACE ALLOC BLS			
6	4000 SPACE ALLOC BLS			
7	4000 SPACE ALLOC BLS			
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100	4000 SPACE ALLOC BLS			

3745-B POSITIVE ION ACCELERATOR FACILITY

Landlord: PNL

Service Dates: May 1954-
Present

Status: Active

Location: 300 Area, SW
(Alaska St.)
(Figure C.1.17)

Site Coordinates (approx.):

N-54464
E-13735

Reference Drawings:

H-3-26624
H-3-8157 Sheet 2
H-3-9084

Elevations:

grade: 386 ft
floor: 387 ft (first floor)
water table: 341-342 ft (1977)

Reference: BNW Facilities Catalog BNWL-MA-87

Purpose: Provides shielded laboratory space for research with positive ion bombardment using a 2 MeV accelerator.

Description: Building is rectangular with one story and flat roof. Floor, wall, and roof are concrete at target area. Rest of building is frame construction with asbestos shakes on the walls. Roof has tar and gravel finish. Floor area is 4160 sq ft.

Contamination: Upon removal of accelerator, building should be free from contamination.

[illegible][illegible]

3746-A CHEMICAL AND BIOLOGICAL PHYSICS LABORATORY

Landlord: PNL

Service Dates: April 1977-
Present

Status: Active

Location: 300 Area,
SW border,
(Spruce St.)
(Figure C.1.17)

Site Coordinates (approx.):

N-54298
E-13702

Reference Drawings:

H-3-39710

Elevations:

grade: 386 ft
floor: 386 ft
water table: 341-342 ft (1977)

Reference: None available

Purpose: The 3746-A Building provides laboratory and office space for radiation dosimetry and biophysics research. There are four general purpose laboratories and four offices.

Description: This rectangular, one-story flat roofed building has a concrete floor and block walls. The roof is wood with tar and gravel finish.

Contamination: Building is clean with the exception of a hood in Room 2.
Contamination is believed to be tritium.

DRAWER 811

U.S. ENERGY RESEARCH AND
DEVELOPMENT ADMINISTRATION
BUREAU OF RESEARCH
PACIFIC NORTHWEST LABORATORY
OPERATED BY BATTELLE RESEARCH INSTITUTION

**SIMPLIFIED
BUILDING LAYOUT**

DATE: 3/78
DRAWN: 0800
H-3-39710 1/1

NO.	DESCRIPTION	DATE	BY	CHKD.	STATUS
1	REVISION				
2	REVISION				
3	REVISION				
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7.0 Reactors

7.0 REACTORS

7.1 GENERAL

Nine production reactors (Table 7.1) and five test reactors (Table 7.2) are on the Hanford Reservation in the 100 Areas and the 300 Area, respectively. These reactors were installed between 1943 and 1963 and, except for N Reactor, have been inactive for 4 years or more.

The production reactors⁽¹⁻³⁾ are all graphite-moderated and water-cooled, all operated at high power levels, and all have high internal radiation levels. The test reactors vary greatly in design, and only one (the Plutonium Recycle Test Reactor) has achieved a substantial power level. The remaining test reactors have operated at essentially zero power levels and thus will have only very low levels of induced radioactivity. Appendix VII gives further details on each Hanford reactor.*

As described in Section D.2.1, the typical production reactor area includes one or two reactor buildings and the associated reactor support facilities. Each reactor (105) building contains a reactor block; a reactor control room; a spent fuel discharge pool, fuel storage basin and associated fuel handling equipment; fans and ducts for the ventilation and recirculating gas systems; and supporting offices, shops and laboratories.

7.1.1 Reactor (105) Buildings

The layout of the 105-B, D, DR and F Reactor buildings is shown in Figure 7.1, 105-KE and KW in Figure 7.2, and 105/109-N in Figure 7.3. The 105 Buildings for the C and H Reactors are similar to Figure 7.1 except that the ventilation fan room wing is located opposite, and in line with, the outer rod room wing rather than in the forefront of the building. The fan room wing of the 105-H Building also contains the reactor gas system, which is housed in a separate building (115) in 100-B, D, F, KE and KW Areas. In all but N-Reactor, the reactor is located in the center of the

* The ensuing discussion applies only to the production reactors. Descriptions and disposition alternatives for the test reactors are provided in the data sheets (Appendix VII).

TABLE 7.1. Hanford Production Reactors

<u>Reactor</u>	<u>Area</u>	<u>Initial Startup Date</u>	<u>Shutdown Date</u>	<u>Status</u>
B(a)	100-B	9/26/44	2/12/68	Standby
C	100-B	11/18/52	4/25/69	Standby
D	100-D	12/17/44	6/26/67	Inactive
DR	100-D	10/3/50	12/30/64	Inactive
F	100-F	2/25/45	6/25/65	Inactive
H	100-H	10/29/49	4/21/65	Inactive
KE	100-K	4/17/55	1/28/71	Standby
KW	100-K	1/4/55	2/1/70	Standby
N	100-N	1963	--	Active

a. B Reactor was shut down and held in standby status from March 19, 1946 to June 2, 1948.

TABLE 7.2. Test Reactors 300 Area

<u>Reactor</u>	<u>Building</u>	<u>Initial Startup Date</u>	<u>Shutdown Date(a)</u>	<u>Power Level, MW</u>	<u>Status</u>
Plutonium Recycle Test Reactor	309	1960	1968	70	Inactive
Physical Constants Test Reactor	305-B	1955	1970	0	Inactive
Thermal Test Reactor	305-B	1956	1970	0	Inactive
High-Temperature Lattice Test Reactor	318	1968	1971	0	Standby
Single Pass Fuel Test Reactor	305	1943	1970	0	Standby

a. Last year of super-critical activity.

FIGURE 7.1. Typical 105 (105-B, D, DR, F) Building Layout(1)

1. Control Room
2. Offices
3. Conference Room
4. Lunch Room
5. Change Area & Clean Clothes Storage
6. Shops
7. Offices
8. Front Work Area
9. Reactor Block
10. Experimental Levels
11. Top of Unit & VSR Pattern
12. Discharge Area
13. Storage Area
14. Horizontal Control Rod Inner & Outer Rooms
15. Ventilation Exhaust Fan Room
16. Ventilation Supply Fan Room

Figure 7.2. 105-K Building layout (2)

FIGURE 7.3. N-Reactor Model(3)

building with the charging or front face of the reactor adjacent to the cooling water pump room, or the 190 Building. The two buildings (190 and 105) are connected by one or two underground, reinforced-concrete tunnels which contain the process piping for the reactor coolant system. The experimental test holes are located on the right side of the reactor, and the horizontal control rods enter on the left side. The vertical, or gravity-drop, safety rods enter from the top of the reactor. The fuel discharge and storage areas are located behind the reactor rear face and are interconnected by an underwater chute.

In N-Reactor, heat generated in the reactor is transferred from the primary to the secondary coolant system in the heat exchanger (109) building, which shares a common wall with 105-N. All portions surrounding the primary loop are part of the confinement area.

The 105 Buildings are typically built with massive reinforced concrete walls (3 to 5 ft thick) at the lower levels to provide additional shielding, with lighter construction above. The upper walls of 105-B, D, DR, F and H are of concrete block; the upper portions of 105-C, KE and KW have corrugated asbestos-cement siding. Roof construction is precast concrete tile at 105-B, D, DR and F and is poured insulating concrete at 105-C, H, KE and KW. Roof construction over the inner rod room and the rear face enclosure is reinforced concrete. Door construction in these buildings is light, and, except for the reinforced concrete sections, the buildings can be classified as light, non-airtight, industrial structures.

7.1.2 Reactor Block

The typical production reactor block includes the main components listed below:

- The reactor moderator stack, an assembly of graphite blocks cored to provide channels for the process tubes, control rods and other equipment.
- The process tubes which held the uranium metal fuel elements and provided channels for cooling water. A cross section of a process tube channel is shown in Figure 7.4.

FIGURE 7.4. Process Tube Channel Cross Section
(105-B, C, D, DR, F, H Reactors)(1)

- Control rods, monitoring equipment, experimental test holes, etc.
- The thermal and biological shields.
- A welded steel-plate box which encloses the biological shield and serves to confine the gas atmosphere within the reactor.

The moderator stacks are of high-purity graphite blocks stacked in layers with the long dimensions of the blocks parallel within a layer and at right angles to the longer dimensions of the blocks in the adjacent layers. The graphite blocks are normally 48 in. long; shorter blocks are inserted at certain locations in the layers to stagger the block joints, giving the stack greater stability. Stability is further enhanced by the criss-cross stacking arrangement and by keying systems in both the horizontal and vertical directions of the stack. The cross sections of the graphite blocks are nominally 3-3/4 in. square for the K Reactors and 4-3/16 in. square for the older reactors. Graphite stacking for B, D and F Reactors is illustrated in Figure 7.5

The horizontal keying system shown in Figure 7.5 remained essentially the same in succeeding reactor designs, but the vertical keying system was changed in an effort to reduce block shifting. The design of the "tune" and "filler" blocks was also changed in succeeding reactor designs to prevent channel distortion in the stack.

Distortion of the graphite stacks occurred in all the reactors during irradiation. Typically the graphite on the outer edges of the stack expanded while that in the core contracted. The displacements are as much as 1 to 2 in. expansion and 1.5 to 3 in. contraction. Because of excessive distortion some of the process tubes were replaced. This was done by pulling the old tube and enlarging or broaching the channels prior to installing the new tube. Traverses in the vertical rod channels show that the center of the graphite stacks contracted inward. The movement was more pronounced in the side-to-side direction than in the front-to-rear.

In addition to process tube channels, a number of other penetrations in the graphite stack accommodate the following:

FIGURE 7.5. Graphite Stacking, B, D and F Reactors (1)

1. Horizontal control rods
2. Vertical safety rods (In N-Reactor, horizontal rods serve both control and safety functions.)
3. Experimental testing tubes
4. Ball 3X system, for dropping reactor-poison steel balls into the vertical safety rod channels for emergency shutdown of the reactor
5. Monitoring equipment.

The horizontal control rod channels penetrate the sides of the reactors and vary from 9 in the B, D, DR and H Reactors to 20 in the K reactors. The vertical safety rod channels penetrate the tops of the reactors and vary from 29 at B, D, DR and F Reactors to 51 at the K Reactors. N Reactor has 87 horizontal rods.

Shielding around the graphite stack, as noted in Table 7.3, comprises 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 (and powdering) of the masonite has probably occurred. Cooling was provided in the top and side thermal shields by circulating water through tubes imbedded in the cast iron blocks. The front and rear thermal shields are cooled by the process tubes. The inner surfaces of the biological shields on the top and sides of C, KE and KW Reactors are also cooled by circulating water tubes.

Table 7.3 gives information on reactor block size and construction materials. Except for N Reactor, the 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. N Reactor, built to produce plutonium and to supply byproduct steam for electrical power generation, is designed to operate at high coolant temperatures and recycles the reactor cooling water rather than returning it directly to the river.

7.1.3 Reactor Coolant Systems

N Reactor has a recirculating primary coolant system. In the other reactors, cooling water was supplied to the front face of the reactors and

TABLE 7.3. Hanford Production Reactor Design Data

Reactors	Graphite Stack Dimensions, ft			Process Tubes		Thermal Shield Thickness, in.		Biological Shield Thickness, in.	
	Front to Rear	Top to Bottom	Side to Side	Number	Type	ID, in.	Type	Type	
B, C, (a) D, DR, F, H	28	36	36	2004	Aluminum	~1.75	Cast Iron	Steel and Masonite	52
KE, KW	33.5	41	41	3220	Zircaloy and Aluminum	1.8	Cast Iron	Heavy-Aggregate Concrete	45-83
N	39	33	33	1004	Zircaloy	3.5	Boron Steel, Cast Iron	Heavy-Aggregate Concrete	40-65
									8

a. C Reactor has slightly larger diameter process tubes than the other reactors in this group, 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.

discharged from the rear face back into the river, via a retention basin system. For example, B, D and F Reactors were supplied from a 36-in. riser on each side. The water was then distributed across the reactor face through 4-in.-diameter, Schedule 40 stainless steel cross-headers connected to the risers at both ends (see Figure 7.6).

FIGURE 7.6. Valve Pit to Inlet Nozzle Coolant Piping, B, D and F Reactors⁽¹⁾

The standard inlet nozzle assembly for the B, D, DR, F and H Reactors is shown in Figure 7.7. The nozzle assembly is bolted directly to the gunbarrel flange to effect a water seal between the nozzle and the process tube. The gunbarrel is a steel supporting sleeve that fits over the end of the process tube and penetrates about 77 in. into the reactor. The end of the gunbarrel in the reactor, therefore, becomes radioactive during the irradiation process.

The reactor outlet piping arrangement on the rear face of the reactors is essentially a duplicate of the inlet piping arrangement. Since little leakage occurred and since irradiated coolant exited the rear face, the rear face is generally more contaminated than the front face. Effluent water was discharged into the retention basin system (Part D, Section 8 and Appendix VIII).

Floor drainage from certain reactor buildings was also discharged into the retention basin system via the 1608 Building (Appendix VII.1.10).

FIGURE 7.7. Inlet Nozzle Assembly, B, D, DR, F and H Reactors⁽¹⁾

7.1.4 Fuel Handling and Storage Systems

Each reactor has a fuel charging machine at the front face and a discharge chute and spent fuel storage basin at the rear (see Figure 7.8 for typical reactor charge-discharge facilities). During a reactor outage, new fuel elements were pushed into the front face end of uncapped process tubes, causing the displacement of the irradiated fuel elements in the tube and their discharge into the basin. The spent fuel storage basins are described in Part D, Section 4 and Appendix IV.

7.1.5 Gas Recirculation Systems

Each reactor has a gas recirculation and purification system (see Figure 5.1) to remove moisture and foreign gases from the reactor, serve as the heat transfer medium between the graphite and process tubes, and to detect water leaks within the reactor. The systems consist of equipment and piping located in the 105, 110 and 115 Buildings and in shielded connecting tunnels. The storage area, 110 Building, contains the high-pressure and low-pressure storage facilities for helium and carbon dioxide. The 115 Building contains the circulating gas blowers, silica gel dryers, filters, heat exchangers, valves, instrumentation and piping. The gas distribution manifolds, sampling lines, purge lines, and gas analytical equipment are located in the 105 Building. In the 100-H Reactor Plant there is no 115 Building, and the equipment is located in the gas wing of the 105 Building. These systems are described in more detail in Part D, Section 5, and in Appendix V.

7.1.6 Reactor Confinement and Ventilation

The arrangement of the major components of the 105 Building ventilation and exhaust system is shown in Figure 7.9 for B, D, DR and F Reactors. The other reactors have similar components, although arranged differently (see Part D, Section 5 and Appendix V). Fresh air was supplied to the 105 Building by two separate supply systems, one for the confinement zone and one for the rest of the building. Confinement exhaust air flowed from the confinement zone into the main exhaust tunnel and to the exhaust fans. From the exhaust fans, the air flowed through an aboveground

FIGURE 7.8. Reactor Charge-Discharge(1)

FIGURE 7.9. Confinement Facility Layout, B, D, DR and F Reactors(1)

concrete duct to the filter building (117) and thence out the concrete exhaust stack into the atmosphere.

Confinement facilities, installed to control the release of radioactive matter from the reactor buildings in the event of a nuclear incident, also include a fog spray system, located within the rear face enclosure. This produced a finely divided spray of water for absorbing a portion of the halogen vapors released during a uranium fire, settling out a portion of the airborne particulate matter released during fuel element fires and washing down exposed surfaces within the rear face enclosure for the removal of contaminated particles. This would provide some degree of thermal cooling to exposed fuel elements and would condense any steam that might form, and thus help prevent unnecessary pressure buildup within this area.

7.2 SITE CHARACTERIZATION

7.2.1 Contamination Levels and Locations

The principal radionuclides of concern in the reactor blocks are ^{60}Co and ^{14}C . The ^{60}Co inventory is estimated to vary from 4300 Ci in the old reactors to 13,000 Ci in each K Reactor. The ^{14}C inventory has not been clearly defined at this point. The ^{60}Co is believed to be largely contained in the metal components of the reactor core and in the inner 1/4-in. layer of the thermal shield, while the ^{14}C is found in the graphite blocks. Preliminary readings indicate that the thermal shield at the center of the front face of H Reactor has a maximum radiation level of 300 R/hr, which drops off to about 12 R/hr in the graphite stack. The radiation levels are lower at the periphery of the reactor block. Readings of <10 mR/hr are found outside the shielding at the front face of all of the inactive or standby reactors. Physical hazards are believed to represent a greater problem to the casual visitor at a retired production reactor than are radiation hazards.

7.2.2 Site Characterization Requirements

Further characterization work is being done by United Nuclear personnel to define more accurately the radionuclide inventories in the inactive reactors. Particular attention is being given to determining the ^{14}C content of the graphite stacks because this isotope, with a 5700-year half-life, will govern long-term disposition activity.

7.3 DISPOSITION ALTERNATIVES AND RELATED ACTIVITIES FOR THE HANFORD PRODUCTION REACTORS

The work activities required for application of the four standard disposition alternatives (Section D.1) to the Hanford production reactors are described below. Since the various reactors are not well characterized as to their radionuclide content, the work activities required with a given alternative could change significantly as additional data become available.

In evaluating the different disposition strategies for the retired reactors, these factors should be considered:

- The reactors are located in an area easily reached by the public. There is considerable pressure to release the area for uncontrolled use.
- The disposition strategies for the reactors should be compatible with the disposition strategies developed for other components of the total reactor system (the fuel storage basin and the gas and exhaust air systems--see Part D, Sections 4 and 5).
- The high radiation levels in the reactor blocks are dropping off at a relatively rapid rate. Delay in dismantling the block for about 75 years would reduce the radiation levels of the activation products to a negligible level and should simplify dismantling operations significantly.

LAYAWAY

Plan of Action

Remove all exposed, loose contamination from the 105 Building, and seal all building openings to prevent unauthorized entry.

Dispose of other segments of the reactor system (fuel storage basin, gas and exhaust air systems and retention basin systems) in appropriate manner--see Part D, Sections 4, 5 and 8.

Major Activities

- Complete the required site characterization.
- Remove all exposed, loose contamination from the 105 Building, and paint all exposed contaminated surfaces to fix the residual contamination in place.
- Repair the 105 Building, as necessary, to insure its integrity during the Layaway period.
- Install required protective equipment (intrusion alarms, monitoring equipment, fire alarms, etc.) in the 105 Building.
- Activate necessary utilities in the 105 Building (lights, etc.).
- Seal all building openings to prevent unauthorized entry, including birds and animals, during Layaway.
- Repair the 1608 Building (Lift Station) as necessary to insure its integrity during Layaway. Seal all building openings and entries to prevent unauthorized entry.
- Maintain a fence around the facility during Layaway to prevent unauthorized entry to the site.
- Dispose of any contaminated wastes generated by the Layaway operations in the 200 Areas.
- Provide routine surveillance and maintenance as required during Layaway.

Special Procedures Required

None

Waste Management

Removal of loose contamination from exposed surfaces in the 105 Building and subsequent painting of the surfaces would generate a small amount of contaminated solid wastes including some combustibles such as rags, gloves, brushes, etc. The total volume of these wastes would be insignificant. The transuranic content of the wastes is expected to be low enough that retrievable storage would not be required. Small volumes of contaminated liquids could result from aqueous decontamination activities.

PROTECTIVE STORAGE

The reactor block is placed in Protective Storage until radiation levels decay sufficiently to permit dismantling of the block using contact operations--nominally 50 to 100 years.

Plan of Action

Isolate the reactor block and enclose it in a semi-permanent protective shell. Demolish all unneeded portions of the 105 Building and the 1608 Building. Treat other segments of the reactor plant (fuel storage basin and gas and exhaust air systems) in a manner compatible with Protective Storage of the reactor block--see Part D, Sections 4 and 5.

Major Activities

- Complete the required site characterization.
- Remove all of the uncontaminated lines, utilities, equipment and auxiliaries from the 105 Building which will not be needed during Protective Storage or for subsequent dismantling of the reactor block.
- Remove all contaminated lines and ducts to the reactor block and package for disposal.

- Enclose the reactor block and discharge chute in a containment shell using existing portions of the 105 Building wherever possible. The shell would probably be a combination of steel and concrete, designed to provide the required containment and prevent access to the block during the storage period.
- Place the fuel storage basin in Protective Storage--see Part D, Section 4.
- Dispose of those portions of the gas and exhaust air systems in the 105 Building as described in Part D, Section 5.
- Remove all remaining contaminated lines, equipment, and auxiliaries from the 105 Building.
- Dismantle the unneeded portions of the 105 Building.
- Dismantle the equipment in the 1608 Building.
- Demolish the 1608 Building. Seal the discharge line exiting the building and leave it in place. Remove all contaminated rubble and dirt. Fill the excavation with clean dirt and plant with grass.
- Dispose of all contaminated wastes, generated during protective storage operations, in the 200 Areas. Dispose of uncontaminated rubble and debris in approved repositories.
- Install and maintain needed protective equipment (alarms, monitors, etc.).
- Maintain a fence around the site to restrict access during Protective Storage.
- Provide routine surveillance and maintenance, as needed.
- At the end of the storage period dismantle the protective shell and reactor block. Remove all remaining radioactivity, above the release limits for unrestricted use, from the site and dispose of in the appropriate manner (probably in the 200 Areas). Since the radiation levels are low, the block would be dismantled using contact operations.

Special Procedures Required

- The protective shell must be designed to provide adequate containment of the radioactivity against all foreseeable accident conditions for the required storage period, which would be 50 to 100 years. The preferred choice appears to be a combination steel-concrete shell using the existing massive concrete walls wherever possible and new steel walls where needed (i.e., front face and back face).
- The required dismantling of contaminated lines and equipment can probably be carried out using contact operations and established procedures. Temporary barriers such as plastic greenhouses would be used to provide containment during the dismantling operations. If the radiation levels associated with a lift station are high (e.g., 1608-H), it may be necessary to use remote techniques to dismantle the equipment and demolish the building.
- Metal compaction and the segmenting and nesting of piping and equipment should be used to reduce the waste volume.
- Final disposition of the reactor block, after storage, can probably be carried out using contact operations and established procedures. Radioactivity from the ^{14}C would not present a serious hazard, but a containment barrier-ventilation system would be required to contain the activity during dismantling.

Waste Management

The contaminated wastes generated by placing the reactor block in Protective Storage would consist primarily of metal piping, ducts, valves and equipment with lesser amounts of concrete and combustible solids. Small volumes of liquid wastes will be generated if any aqueous decontamination is required. Assuming an effort at volume reduction of solid wastes, the estimated contaminated waste volumes for a typical production reactor are as follows:

- Concrete 100 to 200 yd³
- Other noncombustible solids 200 to 300 yd³
- Combustible solids <100 yd³
- Liquids <5000 gal

The transuranic content of the solid wastes should be sufficiently low that retrievable storage would not be required.

When the unneeded portions of the 105 Building are dismantled, it may be possible that some contaminated soil will be found under the building and will require disposal. The potential volume of such soil is impossible to estimate. Removal of the 1608 Building would also expose some contaminated dirt which would have to be removed. The volume of dirt requiring removal will depend on the leaks which have occurred from the building sump and are impossible to estimate.

The volume of uncontaminated rubble and debris requiring disposal would amount to several thousand cubic yards and would consist primarily of concrete, transite and metal pipe and equipment.

ENTOMBMENT

Entombment may not be a viable decommissioning alternative for the Hanford production reactors because of the ¹⁴C (~5700 years) present in the graphite cores. Entombment could be considered if the graphite core is removed prior to Entombment or if radiological studies should show that the ¹⁴C in the graphite poses little or no potential hazard to the environment. Removal of the core would be a costly operation, however, and it would probably not be considered unless the entire reactor block were to be dismantled.

Plan of Action

Isolate the reactor block and entomb it in an impenetrable concrete shell. Remove the unneeded portions of the 105 Building and the 1608 Building. Dispose of the other segments of the reactor system (fuel storage basin and gas and exhaust air systems) in a manner compatible with Entombment of the reactor block--see Part D, Sections 4 and 5.

Major Activities

The activities required would be similar to those required for Protective Storage, except for erection of the concrete shell. It would also be desirable that voids in the reactor block be filled with concrete. The concrete shell should be designed to provide maximum possible containment for the longest possible time.

Once the reactor block is enclosed, the 105 Building would be dismantled, except for the reactor block base, and all contaminated wastes removed from the site.

Special Procedures Required

Same as Protective Storage.

Waste Management

Waste management would be similar to that for Protective Storage, except that the waste volumes would be slightly larger because more of the 105 Building would be dismantled.

DISMANTLING

Plan of Action

Dismantle all equipment in the 105 and 1608 Buildings and demolish them. Remove all contamination, above the release limits for unrestricted use, from the site. See Part D, Sections 4 and 5 for a discussion of decommissioning of the fuel storage basin and portions of the gas and exhaust air systems in the 105 Building.

Major Activities

- Complete the required site characterization.
- Remove all uncontaminated utilities, lines and equipment in the 105 Building which are not needed for dismantling the reactor.
- Remove all contaminated lines and ducts to the reactor block and package them for disposal.

- Install a temporary containment barrier and ventilation system around the reactor block. (Renovate and use the exhaust air system if possible.)
- Remove all peripheral equipment around the reactor block.
- Dismantle the reactor block, using remote techniques where needed. Package the contaminated segments of the block for disposal, using the fuel storage basin to facilitate transfer and packaging of the highly radioactive wastes.*
- Dismantle the fuel storage basin and portions of the gas and exhaust air systems in the 105 Building--see Part D, Sections 4 and 5.
- Remove the temporary containment barrier and ventilation system, and package for disposal.
- Remove any remaining utilities, piping equipment, etc., from the 105 Building, and package contaminated portions for disposal.
- Demolish the 105 Building.
- Remove all contaminated soil under the 105 Building which is above the release limits for unrestricted use.
- Dismantle the equipment in the 1608 Building, and remove the lines, ducts and tunnels entering and exiting the building. Demolish the 1608 Building. Remove all contaminated dirt which is above the release limits for unrestricted use, from beneath the building.
- Dispose of all contaminated wastes in the 200 Areas and uncontaminated debris in an approved burial site.
- Fill all excavations with clean dirt and plant with grass.
- (Optional) Depending on the radiation levels and transuranic content, it may be desirable to partially decontaminate some parts of the reactor system, external to the reactor block, to simplify the Dismantling operations and waste disposal.

* The basins at F and H Reactors are filled with dirt and would have to be emptied before they could be used.

Special Procedures Required

- The reactor system, except for the reactor block, can be dismantled using established procedures and safety precautions. Remote procedures should not be required. Temporary containment barriers, such as plastic greenhouses, could be used for contamination control during the Dismantling operations. If desired, partial decontamination of lines and peripheral reactor components can be carried out using established procedures.
- Because of the high radiation levels associated with the reactor block, special procedures will be needed for its dismantlement. In addition, a suitable containment barrier, ventilation system and adequate shielding will be required to protect personnel during Dismantling. Remote tooling and procedures will be required for removing the thermal and biological shields and possibly the process tubes, control rods and peripheral equipment. Transfer and packaging of the highly radioactive segments of the block will also require remote operations, and shielded containers will be required for packaging much of the wastes. The discharge chute, discharge pool and fuel storage basin can be used to transfer and package the highly radioactive components of the reactor block. Special tooling will be needed to segment block components into easily managed sections. Remotely operated cutting torches (plasma and/or flame) and power saws will be needed to dismantle the thermal and biological shields.
- A suitable method will have to be developed for disposing of the graphite core, which contains a high level of ^{14}C .
- Decontamination of concrete surfaces, to simplify waste disposal, may be desirable. A discussion of methods for decontaminating and breaking up concrete is given in Part D, Section 9 (Transuranic Facilities).
- Volume reduction techniques should be utilized wherever practical to simplify disposal of the contaminated wastes. Volume reduction techniques, which may apply to the production reactors, are also discussed in Part D, Section 9.

Waste Management

Dismantling of the reactor block and the 105 and 1608 Buildings will generate large volumes of contaminated and uncontaminated wastes. Some of the contaminated wastes (e.g., the thermal shield) will require packaging in shielded containers. But current indications are that the transuranic content of the bulk of the wastes is low enough that retrievable storage will not be required. Estimated contaminated waste volumes for a Hanford production reactor, assuming some attempt at volume reduction, are as follows:

- Graphite 1500 yd³
- Noncombustible Solids 1500 to 2000 yd³
(Shielded Containers)
- Other Noncombustible Solids 500 to 1000 yd³
- Combustible Solids <200 yd³
- Liquids <10,000 gal

The possibility exists that dirt under the 105 Building may be contaminated and require removal. The volume of dirt requiring removal is impossible to estimate at this time.

The above estimates do not include the contaminated wastes generated by Dismantling of the fuel storage basin and parts of the gas and exhaust air systems in the 105 Building.

Uncontaminated rubble and debris requiring disposal from Dismantling of the 105 Building and its equipment would amount to 10,000 to 20,000 yd³.

REFERENCES

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2. Hazards Summary Report, Vol. 3, Description of the 100-KE and 100-KW Production Reactor Plants, HW-74095, General Electric Co., Richland, WA, April 15, 1963.
3. 100-N Technical Manual, Vol. 1, HW-69000, prepared by N-Reactor Department, General Electric Co., Richland, WA, March 5, 1963.

8.0 Retention Basin Systems

8.0 RETENTION BASIN SYSTEMS

8.1 REACTOR EFFLUENT WATER SYSTEMS

8.1.1 General

The cooling water supplied to the Hanford production reactors was pumped from the Columbia River and used on a once-through basis after passage through a conventional water treatment plant to remove silt and river sediments. Sulfuric acid and sodium dichromate were added to the filtered water to reduce aluminum corrosion rates. The treated water was then pumped through the reactor tubes containing the jacketed uranium fuel elements. During reactor operation, the intense neutron flux caused a number of the macro and trace constituents of the water to become radioactive. The effluent water was returned to the river through a gravity flow system (shown schematically for 100 D-DR in Figure 8.1) including these components:⁽¹⁾

- a. Effluent Water Lines. These run from the outlet of the downcomer, at the rear of the reactor building, to the retention basin, from the retention basin to the outfall structure, and from the outfall structure to the middle of the river. In general, the main-flow water lines are sections of 54-in. to 66-in.-diam carbon steel pipe, approximately 0.5-in. wall, joined with Dresser couplings. In some areas, reinforced concrete pipe was used for some of the lines. The water line systems also include inspection manholes, junction boxes, tie-lines between parallel legs, and provision for routing excessively radioactive effluent from the basin into a 107 liquid waste trench. The water lines in the various 100 Areas range from approximately 1 to 3.5 miles. With the exception of the 100-F system, where approximately half the effluent lines are exposed, the piping systems were placed underground to provide shielding from short-lived gamma radiation. The pipe is believed to be in good mechanical condition, with little evidence of extensive rusting.
- b. A 107 Retention Basin. Located about halfway between the reactor and the river, the retention basin held the water up long enough to allow

FIGURE 8.1. Effluent System, D and DR Reactors⁽¹⁾

decay of many of the activation products before the water was released to the river. The reactor retention basins are of two general types: 1) rectangular concrete reservoirs designed for pool depths of about 15 ft and ranging in area from 110,000 to 180,000 ft² and 2) cylindrical open-topped carbon steel tanks about 16 ft deep and either 250- or 330-ft diam. Most of the basins had vertical dividers or baffles of various types and materials to control water flow paths. In the retired basins many of the dividers have been broken up and left as rubble on the floor of the basin, and the basins themselves have been partly backfilled with soil to cover the contaminated walls and floors. Portions of the concrete walls above the soil layer in the D, F and H basins were sprayed with asphalt to hold down loose, contaminated particulate matter.

- c. An Outfall Structure, Discharge Lines and Spillway. The outfall structures are open, reinforced concrete water boxes divided into compartments. The effluent water was normally discharged underwater near the center of the river. On occasions of obstruction in the river discharge lines or of high river water levels, the outfall structure could discharge to the river through the spillway. The outfall structures range from 250 to 1200 ft² in area. Many of them have been filled with soil.
- d. Sludge Disposal Trenches and 107 Liquid Waste Trenches. The sludge disposal trenches were burial trenches dug near the 107 retention basins for occasional disposal of sludge accumulated in the bottom of the basins. The 107 liquid waste trenches were used for diversion of effluents containing debris from fuel cladding failures and in most instances received water used to wash down the 107 basin walls during basin deactivation.

Retention basin dimensions and estimated effluent pipe line lengths are summarized in Table 8.1.

8.1.2 Radioactive Contamination Levels and Site Characterization Needs

The cooling water discharged from each reactor contained small quantities of fission products and transuranics in addition to the activation

TABLE 8.1. Retention Basin Systems: Estimated Dimensions and Waste Volumes

Retention Basins		Effluent Pipe Lines												
		Retention Basins	Dimensions(b)	Total Volume yd3	Approximate Backfill, ft	Concrete Volume yd3	Steel Pipe Diam, in.			Concrete Pipe Diam, in.			Total Volume Displaced(a)	
							12-16	18-24	36-42	60-72	84	30-36		42-48
B	107 B	230 x 467 x 20 ft deep	80,000	4	4,200	180	1,445	750	14,710	--	2,085	3,240	50	20,000
	107 C	2 tanks, 330 ft diam, 16 ft deep	101,000	4	(steel)									
U	107 D	230 x 467 x 20 ft deep	80,000	2	4,200	140	1,470	3,720	9,900	--	300	400	2,340	14,000
	107 DR	273 x 600 x 20 ft deep	120,000	2	7,000									
F	107 F	230 x 467 x 20 ft deep	80,000	5	4,200	--	--	2,605	--	--	470	2,300	350	2,900
H	107 H	273 x 600 x 20 ft deep	120,000	4	7,000	350	1,090	--	4,400	--	--	--	--	4,400
K	107 KE	3 tanks, 250 ft diam x 29 ft deep	158,000	4	(steel)	6,010	410	6,725	5,380	2,600	--	--	835	16,400
	107 KW	3 tanks, 250 x 29 ft deep	158,000	4	(steel)									

a. Includes 30% for voids between pipes and miscellaneous.
b. Depth of concrete basins does not include concrete block found on some of the concrete walls.

products. The presence of fission products and transuranics was due to leaks in the fuel element cladding and to irradiation of traces of uranium naturally present in the cooling water. Most of the short-lived activity decayed before the water was discharged to the river. Some of the residual activity was deposited with the sludge which settled out in the 107 Retention Basins, some was adsorbed by the concrete structures, and some was deposited in the soil around leaks in the basin and in effluent water lines. Although the retired retention basin systems have been inactive since 1965-1967, considerable radioactivity remains, primarily in the few-inch thick sludge layer left in the basins when they were retired, in the sludge disposal trenches and in the scale and debris in the water lines. Fifty curies of radioactivity (mostly ^{154}Eu , ^{152}Eu , ^{90}Sr , ^{137}Cs) is estimated to be in each of the F and H Area retention basin systems, and 100 Ci in the combined D and DR basin systems. Characterization studies on the 107-DR basin⁽²⁾ have disclosed an estimated total of 70 Ci (including 0.13 Ci of ^{239}Pu) within the basin itself.

8.1.3 Alternative Disposition Strategies and Related Activities

In planning for the disposition of the reactor effluent water systems the following factors should be considered.

- Existing records and preliminary site characterization data show that the radionuclides present are primarily fission products and induced activation products having short half-lives (≤ 30 years).⁽²⁾
- The transuranics (mainly plutonium) are present in some places in very low but measurable concentrations.
- The facilities are located in sensitive areas (the Columbia River Shoreline) and are at present easily accessible to unauthorized personnel.

LAYAWAY

Plan of Action

Cover or remove any exposed contamination and prevent access to the facility.

Major Activities

- Complete the required site characterization.
- Cover or remove any exposed contamination in the retention basin or other segments of the system. The exposed inner surfaces of the metal basins would be painted to fix any residual contamination in place.
- Seal all pipeline openings to prevent unauthorized entry.
- Cover with dirt the effluent line and spillway leading from the outfall structure to the river.
- Fence the retention basin, outfall structure (and other segments of the system if necessary) to restrict access.
- Control plant growth and soil erosion in contaminated soil areas during Layaway.
- Provide maintenance and routine surveillance, as needed, during Layaway.

Special Procedures Required

None

Waste Disposal

Very little contaminated waste would be generated by Layaway of a retention basin system. Some contaminated plant growth may have to be removed during Layaway, but the volume would be insignificant. Painting the contaminated surfaces of the metal basins would generate some contaminated combustible wastes, but again the volumes would be insignificant.

PROTECTIVE STORAGE

Protective Storage for the retention basin systems will probably be considered only if no subsequent disposition activities (i.e., Dismantling) are required. This would require that any transuranics left in the system or environs be below the existing unrestricted release limits. Thus preparation for Protective Storage is scoped to include 1) removal of

sludge, soil or scale which exceeds TRU unrestricted release limits and
2) stabilization of sites containing above-release levels of fission
products and activation products.

Plan of Action

Remove TRU-contaminated materials which exceed the unrestricted
release limits. Provide a protective cover over the remaining contaminated
areas to prevent access to the contaminated zones.

Major Activities

- Complete the required site characterization.
- Cover with dirt the effluent line and spillway leading from the
outfall structure to the river.
- Remove the contaminated sludge and scale from the effluent lines.
- Remove from the retention basin any sludge, scale and soil which has
TRU concentrations in excess of the unrestricted release limits.
- Remove any soil from around or beneath the retention basin and the
pipeline joints, junction boxes, etc., which exceeds the TRU
unrestricted release limits.
- Fill the effluent lines with a noncompressible material (dirt, plastic,
foam, etc.) to prevent collapse from corrosion during protective
storage. Alternatively, collapse the lines by sectioning them in
place using explosives or other procedures. Fill the voids with
clean dirt.
- Provide a protective cover, as needed, over the lines, junction boxes,
etc., to reduce surface radiation to an acceptable level and restrict
access to contaminated soil at the line joints.
- Decontaminate any concrete surfaces in the basin which have trans-
uranic levels above the unrestricted release limits.
- Collapse the basin walls and dividers. Fill the basin with clean dirt
and provide the basin with a hard or soft protective cover designed
to prevent humans, plants and burrowing animals from penetrating the
contaminated zone.

- Provide a similar cover over the sludge and liquid waste disposal trenches.
- Fill the outfall structure with dirt and cap with concrete (if not already covered).
- Control use of the site during Protective Storage.
- Install markers delineating the boundaries of the basin.
- Provide maintenance and routine surveillance, as needed, until the radioactivity decays to an innocuous level.

Special Procedures Required

- If the sludge and scale are to be removed from the effluent lines, a special procedure will have to be developed to accomplish the removal safely and economically. The contamination levels and characteristics of the sludge and scale deposits will have to be determined before removal procedures can be defined. However, it is possible that vacuuming could remove much of the contamination.
- Collapse of the effluent lines due to corrosion represents a distinct physical hazard if the lines are not filled. Filling the lines with a noncompressible medium would be expensive. Selection of a filler medium would probably be based on economics, and dirt is the logical choice if a cheap filling procedure can be developed. Filling the lines using an aqueous slurry of dirt may be the best approach. Another alternative would be to section and collapse the pipe, using explosives or cutting torches.
- Removal and disposal of the dirt and sludge from the retention basin could be simplified if a satisfactory method could be developed for segregating the uncontaminated upper dirt from the sludge layer in the bottom of the basin. This would greatly reduce the volume of contaminated dirt requiring disposal. This would also apply at other areas where it is necessary to remove contaminated soil.

- To reduce the transuranic level to an acceptable level it may be necessary to decontaminate some concrete surfaces. Methods for decontaminating concrete are discussed in Part D, Section 9.3 on transuranic facilities.
- Providing a protective cover for the retention basins and other contaminated soil areas, which would prevent humans, burrowing animals, and plants from penetrating the contaminated zones, would require some development effort. Two types of covers can be considered--hard covers and soft covers. Hard covers of concrete or asphalt, similar to road construction, are costly and subject to degradation with time; and developing a suitable cover which retains its integrity with minimum maintenance could be a problem. The soft cover would also be a problem. The cover currently being evaluated consists of: a bottom layer of 2-to 10-in.-diam cobblestones or crushed rock 3 ft thick; an intermediate layer of coarse sand 1 ft thick; and an upper layer of topsoil 2 ft thick. The topsoil layer would be planted with shallow-rooted grasses such as poa or cheat grass. The effectiveness of the cover will have to be demonstrated. The soft cover would also have to be effective against erosion. A possible alternative would be to place the soft cover over a relatively thick layer of asphalt.
- The contamination levels in the retention basin systems would be low enough that all activities could be carried out directly with a minimum of personnel protection. The workers would probably require protective clothing and respirators, but temporary containment barriers would not be required.

Waste Management

Placing the retention basins in protective storage would generate a significant volume of contaminated wastes, chiefly dirt and sludge plus some concrete and piping. The transuranic content of the wastes should be low enough that retrievable storage would not be required except possibly for some of the sludge. Also, the total activity may be low enough that the wastes would not have to be packaged for disposal.

Using the 107-DR basin as an example, the estimated contaminated waste volumes are as follows:

- The sludge and scale from the effluent lines are difficult to estimate but could amount to 100 to 300 yd³.
- Removal of the effluent line and spillway to the river would generate about 1600 ft of 60-in.-diam steel pipe and 100 to 150 yd³ of concrete rubble.
- Dirt and sludge from the basin would amount to about 20,000 yd³. The contaminated waste would be much less if the clean dirt could be segregated from the sludge layer.

ENTOMBMENT

Entombment is not considered a viable option for the reactor retention basin systems. If the systems were entombed, it would interfere with the unrestricted use of the site for an inordinate length of time. Entombment should be considered only if the transuranic content of the system is below the release limits (this could probably be accomplished by removing the sludge from the basin). If this is the case, however, Protective Storage would be just as effective as Entombment and less costly.

DISMANTLING

Plan of Action

Dismantle the system and remove from the site all materials which are contaminated to levels above the release limits for unrestricted use.

Major Activities

- Complete the required site characterization.
- Remove all dirt and sludge from the retention basin and dispose of in the 200 Areas. It may be necessary to package the sludge layer for retrievable storage, depending on the TRU content.

- Dismantle the basin and dispose of the contaminated debris in the 200 Areas. It may be desirable to decontaminate the concrete basin walls and dividers, prior to dismantling, to avoid the need for retrievable storage of large quantities of concrete. The contaminated surfaces of the metal basins would be painted, prior to segmenting, to fix the contamination in place.
- Remove all dirt under the basin and dirt associated with the sludge disposal and liquid waste trenches which is contaminated above the release limits for unrestricted use, and dispose of it in the 200 Areas.
- Remove the sludge and scale from the effluent lines to simplify their dismantling and disposal.
- Excavate, dismantle and remove all effluent lines, crossover lines, junction boxes, etc., and dispose of them in the 200 Areas. Remove any contaminated dirt.
- Remove the outfall structure, spillway and any contaminated dirt and dispose of in the 200 Areas.
- Remove all uncontaminated debris from the site.
- Fill all excavations with clean dirt and plant with grass.

Special Procedures Required

Based on existing records and preliminary site characterization data, it appears likely that the reactor retention basin systems can be dismantled using established procedures which provide for contamination control. The radionuclide content of the contaminated component of the systems, including the contaminated soil, should be sufficiently low that standard industrial equipment and procedures can be used to excavate, dismantle and remove the lines, basins, dirt, etc. The metal lines and basins could be segmented directly using hand tools (saws, torches) or explosives. The concrete would be segmented using industrial procedures. Care would be taken to minimize generation of airborne particulates. The contaminated wastes would be packaged in burial boxes or loaded directly into trucks for transfer to the 200 Areas, depending on the activity levels. Trucks

hauling unpackaged wastes would be covered to prevent the spread of contaminated material to the environs. To reduce the volume of contaminated concrete requiring controlled disposal, it may be desirable to decontaminate the concrete in the basin prior to dismantling. Methods for decontaminating concrete are discussed in Part D, Section 9--Transuranic Facilities. To reduce the spread of contamination, the contaminated surfaces of the metal basins would be painted to fix the residual contamination in place prior to segmenting. The sludge and scale in the effluent lines would be removed prior to dismantling the lines. A method for removing the sludge would be required as discussed in the earlier section on Protective Storage.

Waste Management

The contaminated wastes generated by dismantling the reactor retention basin systems will be mainly concrete, steel pipe, plate and fittings, sludge and scale from the pipelines and basins and dirt. Preliminary site characterization data indicate that the radioactivity associated with the wastes will chiefly comprise fission products and activation products with lesser amounts of transuranics. Currently available data indicate that the transuranic content should be low enough that retrievable storage of the wastes will not be required, except possibly for the sludge layer in the lines, basins and sludge disposal and liquid waste disposal trenches. Assuming retrievable storage is not required, the wastes would be disposed of in 200 Area burial grounds. Depending on the activity levels, it may be necessary to package the wastes for burial. It appears likely, however, that much of the wastes could be buried without packaging.

Due to the similarity of the various retention basin systems, the types of wastes generated would be similar for all systems. The only major differences would be in the C, KE and KW systems, where the retention basins are steel rather than concrete. The volumes of waste generated could vary significantly between systems because of size differences and the volumes of soil contaminated by system leaks. Using the 107-DR system as an example, the estimates of contaminated wastes generated by dismantling the system are:

- Dirt and sludge from within the basin would amount to about 20,000 yd³. The volume could be reduced if the uncontaminated upper dirt layer could be segregated from the sludge layer.
- Contaminated dirt from the sludge disposal trench would amount to 1000 to 2000 yd³.
- Concrete rubble from dismantling the basin would amount to 7000 to 7500 yd³. However, it might be possible to decontaminate the concrete so that the major portions could be disposed of as uncontaminated debris.
- Sludge and scale from the effluent lines are difficult to estimate but could amount to 100 to 300 yd³.
- About 10,000 ft of 60-in. diam steel pipe plus associated fittings (i.e., Dresser couplings). The bulk of the pipe would be in about 30-ft sections, except for about 1600 ft of welded pipe leading to the river. It may be desirable to split the sections of pipe to reduce the bulk volume.
- The outfall structure, spillway, junction boxes and line supports would generate several hundred cubic yards of concrete rubble.
- Excavation of the effluent lines would require removal of considerable dirt, part of which would be contaminated due to leaks at the joints. Leaks from the retention basin would result in the contamination of dirt under and around the basin. Dirt adjacent to the liquid waste and sludge disposal trenches would also be contaminated. It is impossible to estimate the volume of contaminated dirt requiring removal from the site, but it could amount to hundreds of thousands of cubic yards.

9.0 Transuranic Facilities

9.0 TRANSURANIC FACILITIES

9.1 GENERAL

The transuranic facilities discussed in this section include the Hanford plants and laboratories used to process, handle, or store transuranic materials which are primarily alpha-emitters and are not contaminated with significant quantities of beta-gamma emitters. Hence the shielding requirements are minimal, and the facilities are customarily designed for contact maintenance. Because these nuclides are highly toxic, great care must be exercised in working with them to avoid inhalation, ingestion, or skin absorption and to prevent their escape into the environs.

These facilities were used primarily to process, handle or store plutonium metal or alloys, plutonium compounds, and plutonium-containing solutions and solid materials. A few were also used for work with other transuranics, primarily neptunium and americium. To facilitate this discussion, we refer only to plutonium, as representative of the transuranics possibly present in significant quantities.

Processing and handling of large quantities of unencapsulated plutonium generally occur in appropriate enclosures such as cells, closed hoods, and greenhouses kept under negative air pressure with respect to the surrounding area. The air from these enclosures is vented through high-efficiency filters to remove contaminated particulate matter prior to exhausting the air to the atmosphere. Operations in the enclosures may be conducted either remotely or directly, with manual operation accomplished through use of rubber gauntlets sealed to ports on the enclosure. Entry inside the enclosure is possible in many instances by use of plastic suits and independent air supplies.

Small quantities of plutonium can be processed and handled in open hoods with adequate air flow to prevent loss of contaminated dust or aerosols from the hood. Work in open hoods generally involves plutonium solutions which do not ordinarily contribute to severe dust problems.

Examples of activities which have been conducted in Hanford plutonium facilities include:

- a. purification and concentration of plutonium solutions
- b. dry chemistry operations (preparation of various solid compounds)
- c. metal reduction and fabrication
- d. fabrication of nuclear fuels, radiation sources, etc.
- e. waste processing and storage
- f. laboratory operations: research and development; analytical chemistry; physical testing; etc.

Construction of plutonium facilities at Hanford has evolved from the more or less conventional process and laboratory structures of the mid-1940s to the specialized structures of today. Earlier construction often was of wood or inadequately protected concrete, both of which are very difficult to clean. Later structures were designed to facilitate clean-up of spills by use of stainless steel surfaces.

Plutonium facilities at Hanford range in size and complexity from small laboratories with contaminated hoods or gloved boxes to facilities used for manufacture of plutonium fuel elements and fabrication of metal pieces in various configurations. They may include production-scale chemical processing equipment for wet or dry operations as well as sophisticated machine tools, presses, etc., contained in large process enclosures.

9.2 RADIOACTIVE CONTAMINATION

9.2.1 Contamination Levels

Plutonium facilities may be contaminated in various ways:

- a. Gross (possibly kilogram) quantities inside the process hoods and gloved boxes; deposits inside the process equipment; collections of solids in relatively inaccessible locations on hood floors and external surfaces of equipment and machines and in sumps; and generalized contamination on all surfaces.

- b. Gross contamination inside the exhaust air system, especially the ducts and filters.
- c. Smearable contamination on structural surfaces and equipment outside the process enclosure. This may occur when painted-over contamination breaks loose, from dust deposits, etc.
- d. Nonsmearable contamination--under layers of paint, soaked into concrete or wood surfaces, deposited in cracks, etc.

9.2.2 Site Characterization Requirements

Three types of site characterization are important to planning for the D&D of plutonium-contaminated facilities:

- a. A beta-gamma survey to determine if excessive radiation levels exist anywhere which may require special shielding or remote tooling.
- b. An alpha survey of the facility, outside the process enclosure, to locate contaminated areas, determine if the contamination is smearable or fixed, ascertain the personnel protection measures required, etc.
- c. Estimation of the plutonium content of the process enclosure, to determine if maintenance of criticality controls during project operations is required.

9.3 DISPOSITION ALTERNATIVES AND RELATED ACTIVITIES

The diverse nature of the transuranic facilities and the lack of data on transuranic content of the facilities make it necessary to discuss the various disposition alternatives in very general terms. Each facility would have to be considered individually to determine the specific work activities and procedures required to implement a given disposition alternative and to estimate the types and volumes of wastes generated.

Disposition of the transuranic facilities is complicated by the fact that the necessary policies and technology are not yet in place for the

ultimate disposal of transuranic containing wastes. Current general regulations require 20-year retrievable storage for wastes containing more than 10 nCi transuranics per gram of matrix.

LAYAWAY

Plan of Action

Seal all entries and openings to the facility to prevent unauthorized entry, and insure that the facility provides adequate containment of the radioactivity during Layaway.

Major Activities

- Complete the required site characterization.
- Remove any gross amounts of transuranics from the facility while observing all critical mass controls.
- Remove any loose, exposed contamination, and paint the exposed, contaminated surfaces to fix the residual contamination in place.
- Renovate the ventilation system, and maintain it in operation during Layaway.
- Renovate the facility's basic structure, if necessary, to insure that transuranics are adequately contained during Layaway.
- Seal all entries and openings to prevent unauthorized entry, including birds and animals.
- Install and maintain protective equipment as deemed necessary (i.e., intrusion alarms, fire alarms, monitoring equipment, etc.).
- Fence the site to restrict access to the facility.
- Provide maintenance and routine surveillance, as necessary, during Layaway.

Special Procedures Required

None required; established nuclear procedures can be used to place the facility in Layaway. If gross amounts of fissionable transuranics

(i.e., plutonium) must be removed from the facility, all critical mass controls and established work procedures must be rigidly observed.

Waste Management

Any gross amounts of transuranics removed from the facility would be packaged and sent to the appropriate recovery or storage facility. Removal of exposed, loose contamination and painting of contaminated surfaces would generate a small amount of contaminated solid wastes, mainly combustible solids such as plastics, gloves, rags, etc. Contaminated liquid wastes may also be generated by the decontamination efforts. The volumes of contaminated liquid and solid wastes are difficult to estimate because they will depend on the specific facility being considered. Even for the largest facilities, however, the solid wastes should be no more than a few hundred cubic feet, and the liquid waste volumes should be insignificant.

Disposal of the contaminated wastes will depend on the type of waste and the contamination level, and must meet current restrictions for handling transuranics, including the observance of critical mass controls. The contaminated wastes can be categorized as follows:

- noncombustible solid wastes
- combustible solid wastes
- liquid wastes.

Ultimate disposal of the solid wastes will depend on the transuranic content.

- If the transuranic content exceeds 10 nCi/g, the wastes must be placed in retrievable storage.
- If the transuranic content is <10 nCi/g but too high for uncontrolled release, the waste must be buried in an authorized burial ground.

In the case of combustible solid wastes, the only restrictions on packaging, handling and incineration involve criticality control during all operations. If the combustible wastes are to be stored, they are treated in the same way as the noncombustible solids.

The handling and processing of contaminated liquid wastes will be governed by the transuranic content and existing disposal regulations. If the liquid wastes contain a significant amount of transuranics, it would probably be necessary to recover the transuranics from the wastes.

PROTECTIVE STORAGE

There is little technical or economic incentive for placing a transuranic facility in Protective Storage. By definition a transuranic facility does not contain a significant amount of beta-gamma activity; therefore radiation levels are relatively low, shielding requirements are minimal, and any Dismantling activities can be carried out using contact operations. However, if priority and budget considerations force a long delay before a given transuranic facility can be dismantled, it may be desirable to place it in Protective Storage rather than extended Layaway.

Plan of Action

Enclose the facility in a protective shell designed to insure adequate containment of the TRU during the period of Protective Storage.

Major Activities

- Complete the required site characterization.
- Remove any gross amounts of TRUs which may be present in the facility while maintaining required critical mass controls.
- Remove all unneeded utilities, lines, and ducts into and out of the facility.
- Remove all external auxiliaries except the ventilation system.
- Enclose the facility in a protective concrete shell using the existing facility structure wherever possible. Maintain the existing ventilation system or provide the protective shell with a special high-efficiency filter system.
- Install needed protective equipment such as intrusion alarms, fire alarms, etc.

- Fence the site to restrict access to the facility.
- Provide routine surveillance and maintenance, as needed, during Protective Storage, with special attention to the ventilation or filter system.

Special Procedures Required

- The protective shell must be designed to insure adequate containment of the transuranics during Protective Storage. The shell must be capable of withstanding all credible accidents without releasing transuranics to the environs. The shell should be equipped with an adequate ventilation system (or a filter system which permits it to breathe).
- The toxic nature of the transuranics requires that extreme care be taken to prevent contamination of the workers and release of transuranics to the environs during all operations. If gross amounts of fissionable transuranics are present, critical mass control regulations must be observed. Removal of contaminated lines and auxiliaries external to the main structure may require the use of temporary containment barriers and ventilation systems.

Waste Disposal

Due to the diverse nature of the transuranic facilities at Hanford, it is impossible to define specifically the types and amounts of waste generated by placing a facility in Protective Storage. However, this option could produce a significant volume of contaminated solid waste due to removal of excess lines and ducts and dismantling of external auxiliaries. If removal of underground auxiliaries is required, some contaminated soil may require disposal. Construction of the protective shell could require the excavation of potentially contaminated dirt from around the foundation of the facility. Some combustible wastes would be generated through the use of protective clothing (gloves, plastic suits, etc.) and temporary containment barriers (greenhouses). Small amounts of contaminated liquid wastes might be generated if attempts are made to decontaminate the lines and auxiliaries prior to removal.

Disposal of the wastes would depend on the types of wastes and the contamination levels as discussed in the section on Layaway.

ENTOMBMENT

Entombment may not be a viable disposition alternative for the transuranic facility. Because of the extremely long half-lives of some transuranics, such as ^{239}Pu , it could require hundreds of thousands of years for the radionuclides to decay to a level permitting unrestricted use. It is not possible at this time to define an entombment concept which would guarantee containment of the transuranics for the required decay period. Entombment could be considered if subsequent dismantling of the facility was planned within some reasonable time frame. However, the cost of entombment would be high, and entombment would make subsequent dismantling of the facility extremely difficult and expensive. If a transuranic facility were entombed, the procedure would be similar to that required for Protective Storage, but would provide greater integrity and less possibility of a breach of containment.

Plan of Action

Encase the facility in an impenetrable concrete shell designed to insure containment of the transuranics for the required time period.

Major Activities

- Complete the required site characterization.
- Remove any gross amounts of transuranics present, while observing all critical mass control regulations.
- Remove all external auxiliaries.
- Isolate the facility by removing all lines entering or leaving the facility, except for the power and ventilation system.
- Encase the facility in an impenetrable concrete shell. The ventilation system would be removed as the shell is erected. It may be desirable to fill the void space inside the facility with concrete (or dirt) prior to completing the enclosure.

- Optional--the entombed facility could be covered with a layer of dirt stabilized with plant growth to minimize erosion.
- Provide routine surveillance as required.

Special Procedures Required

- Because of the long half-lives of the transuranics, it is not possible to define an entombment procedure which would assure containment of the transuranics until they decay to unrestricted use limits. The best that can be hoped is that the entombed facility would provide containment for several hundreds or thousands of years. Thus provisions would have to be made at some future time for the ultimate disposal of the facility, and the entombment procedure would make ultimate disposal much more difficult. The method used for entombment would depend largely on how the facility is built, but would probably consist of filling any void spaces with concrete or dirt and encasing the building in a massive concrete shell. For a well designed structure of reinforced concrete construction, the building shell would form an integral part of the enclosure shell. If the filler material were concrete, the entombed facility would be essentially a monolithic block of concrete. Such a procedure could not be used with buildings of less durable construction (i.e., wood, metal, concrete block). With such a building, entombment would probably require erecting a massive concrete shell around the building and then filling the internal void space with concrete. Concrete appears to be the safest, most durable filler material, but it would also be the most difficult to remove if disposal should become necessary. Dirt, or a filler such as plastic foam, would be easier to remove, but would be much less safe.
- The other procedures required would be similar to those discussed in the section on Protective Storage.

Waste Management

Waste volumes generated and waste disposal would be similar to those for Protective Storage.

DISMANTLING

Plan of Action

Dismantle the facility and remove all contamination, above the release limits for subsequent use, from the site.

Major Activities

- Complete the required site characterization.
- Renovate the facility's ventilation system to handle airborne contamination generated during the disposition activities.
- Remove all excess lines and auxiliaries external to the facility. Seal all resulting openings in the facility. Package contaminated wastes generated for disposal.
- Remove all gross amounts of transuranics from the facility while maintaining required critical mass controls.
- Decontaminate all equipment, piping, etc., in the facility to lowest practical levels consistent with subsequent disposal, while maintaining appropriate critical mass controls.
- Dismantle and/or section contaminated equipment, piping, etc., and package for disposal.
- Decontaminate building surfaces to facilitate dismantling of the building and subsequent disposal of the contaminated wastes. Paint the surfaces to fix any residual contamination in place.
- If necessary, provide a temporary containment barrier-ventilation system to insure containment of the transuranics during dismantling of the building.
- Dismantle the facility and prepare the contaminated wastes for disposal.
- Remove the temporary containment barrier, and package it for disposal.
- Remove all contaminated dirt under the facility which is contaminated above the appropriate release limits, and prepare it for disposal.

- Remove all contaminated wastes from the site, and dispose of them in the appropriate manner.
- Remove all uncontaminated debris from the site.
- Fill all excavations with clean dirt and plant with grass.

Special Procedures Required

In addition to the extreme care required to prevent personnel contamination and release of activity to the environs during dismantling operations, there are several areas where special techniques and procedures are needed for the dismantling of transuranic facilities. These include:

- decontamination of metal surfaces
- decontamination of concrete
- decontamination of other nonmetallic surfaces
- dismantling and sectioning of contaminated equipment, piping, etc.
- dismantling of contaminated buildings and structures.

Each problem area is discussed in the following sections. The discussions address themselves specifically to the treatment of transuranic facilities, but most of the comments would apply to other nuclear facilities as well.

The radiation levels associated with transuranic facilities are relatively low. Therefore, personnel entry into the contaminated areas for extended periods is possible, and remote techniques are not required. Remote operations may reduce the risk to the personnel, but at a considerable cost increase.

The extremely toxic nature of the transuranics requires that extreme care be taken to prevent contamination of workers. The personnel protection required can vary from shoe covers, gloves and coveralls to full plastic suits and fresh air masks, depending on the level of activity present. Extreme care must also be taken to prevent release of activity to the environment. This means that adequate containment and ventilation must be provided during critical disposition activities. Care should be taken to

minimize airborne contamination. In some cases this can be accomplished by use of water sprays or mist to hold down the particulates during critical operations.

The radiation levels in facilities contaminated with beta-gamma emitters may be sufficiently high that personnel entry into the contaminated zone is not possible, and the various decontamination and dismantling operations must be carried out remotely. Most of the techniques and procedures used with transuranic facilities can be adapted to remote operation and used in the highly radioactive facilities.

The Decontamination of Metal Surfaces

A wide variety of procedures can be used to clean metal surfaces contaminated with alpha activity (and beta-gamma activity as well). The optimum method for a given situation will depend on a number of factors including:

- the types and amounts of contamination present
- accessibility of the contaminated surface
- the degree of decontamination required
- the methods available for disposing of contaminated wastes generated by the decontamination operations.

The decontamination of metal surfaces normally involves the use of liquid decontaminating solutions. This requires, however, that facilities for disposing of the contaminated liquid wastes be available. If disposal facilities are not available, dry decontaminating procedures must be used (this can include the use of wet rags and swabs, which can be disposed of as solid waste).

Experience at various nuclear facilities has shown that the removal of alpha emitters from exposed metal surfaces is most readily accomplished by manual techniques. Vacuuming of the surface to remove loose contamination followed by mopping, wiping, or brushing with an appropriate cleaning solution has proved very practical for removing alpha activity. The cleaning

solution used will depend on the particular situation, but complexed acid solutions or commercial decontaminating solutions have proved quite effective.⁽¹⁻⁶⁾ Sequential cleaning steps using two or more cleaning agents provide even better decontamination. Steam cleaning or foam spraying followed by mopping or wiping has also proved effective.⁽⁴⁾ Since the metal being cleaned will normally be scrapped, corrosive solutions which attack the metal surface can be used effectively.⁽³⁾ Using these procedures it should be possible to decontaminate most metal surfaces to levels where respirators (assault masks) are no longer required by those working in the facility.

In those cases where manual techniques are not effective, abrasive procedures such as sandblasting or mechanical abrasion (wire-brushing, sanding, etc.) can be used.^(1,5) These techniques generate airborne contamination which must be controlled. They also remove a portion of the metal and may not be applicable to all situations. Vacuum blasting can be used to reduce airborne contamination; or water sprays or mists can be used to hold down the particulates.

Inaccessible metal surfaces, such as the inner surfaces of process equipment and piping, can be cleaned in place by flushing with the appropriate decontaminating solutions. The cleaning agents used are similar to those used in the manual operation. Again, corrosive cleaners can be used if the metal is to be disposed of. Sequential flushing with two or more different decontaminating solutions improves the activity removal.

Complex metal equipment, such as lathes and other machine tools, may have to be disassembled or cut up prior to decontamination. The individual parts can then be decontaminated manually or in cleaning baths (i.e., ultrasonic cleaner, electrolytic cell, agitated bath). Similarly, process equipment and piping can be disassembled (and segmented if necessary) and treated in the same way.

The degree of decontamination required for a particular item will depend on its ultimate use or disposal. If the metal is considered excess, it would be desirable to decontaminate it to a sufficiently low level that retrievable

storage of the material would not be required. If this is not possible, then there is little incentive to remove more than the gross contamination.

Decontamination of Nonmetallic Surfaces

Effective decontamination of nonmetallic surfaces depends largely on the type of surface to be cleaned. Relatively nonporous surfaces such as glass, plexiglass and other plastics can be cleaned quite easily, while porous surfaces such as wood, Transite and Masonite present much more difficult problems (concrete is discussed in a subsequent section). Nonporous surfaces can be effectively decontaminated manually, using the appropriate cleaning solutions. Materials such as glass and lucite can be decontaminated to quite low levels by wiping the surfaces with dilute nitric acid, or nitric acid-hydrofluoric acid mixtures, and flushing with water.⁽³⁾

Effective decontamination of porous surfaces depends on the depth to which the activity has penetrated. If the activity is mainly at the surface, it may be possible to partially decontaminate by vacuuming the surface and then scrubbing with a mild detergent solution or solvent. If the activity has penetrated into the material, it will probably be necessary to remove the contaminated layer. This can be done by various methods including sand-blasting, vacuum blasting, flame spalling, or sanding, depending on the material.

Painted surfaces can also be a problem. Paints are normally applied to protect the surface. If the activity has penetrated the paint, it will be necessary to remove the paint layer. This can be done by the judicious use of solvents or by abrasion (i.e., sandblasting, sanding, scraping, etc.).

Decontamination of Concrete

It is difficult to decontaminate concrete effectively, especially if the surface has been exposed to radioactivity for long periods or to solutions. The more porous the concrete surface, the more difficult the problem. Concrete exposed to radioactive solutions will be contaminated to greater depths than concrete exposed only to radioactive solids or slurries.

Concrete surfaces which have been exposed only to radioactive solids or slurries, where the activity has not penetrated significantly, can be decontaminated reasonably well by the following sequence of operations:⁽⁷⁾

- Vacuum the surface to remove loose contamination.
- Mop or wipe the surface with a mild detergent solution or solvent to remove any oil, grease or adherent dirt. A minimum of liquid should be used, and the contact time should be as short as possible. Alternatively, dry steam could be used.
- Vacuum the surface again after it has dried.

This approach or modifications thereof will remove most of the surface contamination.

If the radioactivity has penetrated into the concrete, effective decontamination requires removal of the contaminated surface layer. The amount of concrete which must be removed will depend on the depth to which the activity has penetrated and on the level of residual activity which can be tolerated. If the concrete is to be disposed of, it would be highly desirable that the alpha activity level be less than 10 nCi/g so that retrievable storage would not be required for the total volume of concrete.

Several methods for removing the contaminated surface layer from concrete have been used with varying degrees of success. They include:

- dry sandblasting^(1,6,8) or shot blasting
- vacuum blasting^(1,5)
- mechanical abrasion (i.e., pneumatic hammers, sanders, grinders, wire brushes, rock splitters, etc.)
- abrasive sawing
- flame spalling⁽⁸⁾
- explosive spalling^(9,10)

All of these methods except vacuum blasting create substantial amounts of airborne contamination. Special precautions must be taken to minimize the spread of airborne contamination and prevent recontamination of clean surfaces.

Sandblasting and mechanical abrasion using pneumatic hammers and chisels are probably the most widely used methods for removing contaminated concrete surfaces. Vacuum blasting, which reduces the problem of airborne contamination, can be used effectively over large areas if the depth of concrete to be removed is not too large. It can also be used to remove a considerable depth of concrete over a small area, but the operating time required can become excessive if the area to be cleaned is large. Rock splitters can be used effectively to remove a considerable depth of concrete over large areas.

Explosives can be used to remove concrete to various depths. Their use, however, is limited to certain applications which can tolerate the side effects (pressurization, airborne contamination, structural damage to the concrete, etc.). Because of the possibility of structural damage, explosives can not be used effectively with thin concrete sections which must retain their structural integrity. Explosives were used successfully during demolition of the Elk River reactor to remove contaminated layers from massive concrete sections.^(9,10)

Flame spalling and abrasive sawing have found only limited use in decontaminated concrete. Flame spalling by itself is only partially successful in removing contaminated layers from concrete, but a combination of flame spalling and mechanical abrasion has been used successfully.

PNL is currently investigating other methods for decontaminating concrete including the use of a water cannon. Additional work is needed, however, before the procedure's potential can be evaluated.

Depending on the method selected for surface removal, some control of airborne contamination can be achieved by use of water sprays and mists. With explosive spalling, heavy mats can be used to reduce airborne particulates.

Dismantling and Sectioning of Equipment

Generally the contaminated equipment and piping to be dismantled in a transuranic facility are relatively small and represent no major handling problems. The largest items encountered are usually the process hoods and

gloved boxes which contain the process equipment. Equipment contained in hoods or boxes having adequate ventilation control can be disassembled by normal manual methods. If the equipment is welded, or if size reduction is desired, the equipment can be segmented using hand tools such as power saws or pipe cutters. Flame cutting can be used, but has not found widespread application in transuranic facilities.

If the process hoods and gloved boxes are to be disassembled, they should be decontaminated to a low level prior to dismantling. This will help to reduce the spread of contamination during disassembly. If the contamination level is still high after decontamination, it may be necessary to enclose the hood or box within a contamination barrier, such as a "greenhouse," prior to dismantling. It may also be desirable to paint all contaminated surfaces to fix the contamination, prior to dismantling. Dismantling of the hoods and boxes can best be accomplished using power hand tools.

Dismantling of contaminated equipment outside controlled ventilation areas requires use of a protective "greenhouse" equipped with adequate ventilation control. Piping can be disassembled inside plastic sleeves, which can then be sealed over the pipe openings to contain the activity.

Dismantling of Buildings and Structures

The approach used in dismantling transuranic-contaminated buildings will depend mainly on the residual activity present. A building which has been decontaminated to an acceptably low level can be razed using normal demolition techniques. If the residual contamination is above the acceptable level, it may be possible to fix the contamination in place and then demolish the facility using standard procedures. Painting exposed surfaces and covering concrete with a new layer of cement are methods that have been used to fix the activity in place. If residual contamination is too high to be safely fixed in place, it will be necessary to provide a containment barrier around the facility during demolition. This is best accomplished using plastic "greenhouses" and dismantling the building in sections. Some

ventilation control must be provided during the demolition activities. Use of an inflatable building should also be considered if the facility is not too large.

If the residual activity is very high, it may be necessary to provide a rigid containment barrier around the facility during dismantling. The cost of such a containment barrier would be high, and it might be less expensive to decontaminate the facility to a lower level so that a rigid barrier would not be required.

In demolishing the structure, care should be taken to reduce airborne particulates to a minimum. Therefore, the razing procedures should be those which generate the least amount of fines and dust. Methods used in dismantling several transuranic facilities are discussed in References 11-13.

Volume Reduction

Since wastes contaminated with greater than 10 nCi/g of transuranics require retrievable storage, serious consideration should be given to the use of volume reduction procedures, whenever possible, to reduce the waste volume. Compaction techniques should be investigated, and the segmenting and nesting of bulky equipment and piping should be used as much as possible.

Waste Management

Dismantling of a transuranic facility would generate a large volume of contaminated wastes. Typical waste volumes are impossible to estimate because of the diverse nature of the facilities, and each facility must be considered individually.

Considerable volumes of contaminated aqueous wastes could result from decontamination activities. The volume of liquid waste generated would depend on the facility being considered, the decontamination methods used, and the level of decontamination required. Generally, the easier it would be to dispose of the contaminated liquid, the more liquid wastes would be generated through decontamination activities. Depending on the transuranic content, the liquid wastes would probably have to be treated to recover the transuranics, and then disposed of in the appropriate manner (i.e., as low-level waste).

Removal of contaminated process equipment, piping, glove boxes, hoods, etc., would generate substantial volumes of solid waste. Actual volumes would depend on the specific facility and on how effectively volume reduction procedures can be used. The percentage of the wastes requiring retrievable storage would depend on how effectively the material can be decontaminated before disposal.

Decontamination of internal building surfaces would produce additional wastes. Decontamination of metal and plastic surfaces could produce small amounts of liquid wastes as well as combustible wastes such as gloves, rags, brushes, etc. Decontamination of concrete surfaces using abrasive procedures (sandblasting, rock splitters, etc.) would produce significant amounts of contaminated solids which would probably require retrievable storage.

Demolition of the facility's basic structure would generate a large volume of waste. If the structure is concrete, a sizeable fraction of the concrete would probably have to be packaged for retrievable storage unless it could be adequately decontaminated. There is, therefore, considerable economic incentive to develop procedures which can be used to decontaminate concrete sufficiently that the major portion would not require retrievable storage. Contaminated metal structures would be handled in the same way as contaminated equipment, while wooden structures could be disposed of by incineration.

Substantial volumes of combustible solid wastes would result from the dismantling operations. The chief sources of combustibles would include:

- plastic protective clothing for the workers
- "greenhouses" used in packaging the solid wastes and for contamination control during dismantling operations
- gloves, rags, brushes, etc., used in the aqueous decontamination activities
- plastic process hoods and windows
- plastic and wooden structural components.

The contaminated combustibles can best be disposed of by burning if a suitable incinerator is available. If the combustibles can not be burned, they would be disposed of in the same way as the noncombustible solid wastes.

There will likely be some contaminated soil beneath the facility which will have to be removed. It would be treated the same as the other solid wastes.

Disposal of the noncombustible solid wastes would depend on the contamination levels as discussed in the section on Layaway.

9.4 POLICIES AND CRITERIA FOR WASTE DISPOSAL

ERDA is responsible for regulation, implementation, and enforcement of radiation protection and for specific radioactive waste management requirements for waste generated within the Hanford Reservation.

ERDA's requirements are based primarily upon International Committee on Radiation Protection (ICRP) dose limits. In essence, the ERDA regulations⁽¹¹⁾ state that all wastes which can not be released to the air or water environment within specified maximum permissible concentrations must be stored safely. The ERDA regulations are reflected in the Atlantic Richfield Hanford Company's (ARHCO) requirements for disposal of transuranic contaminated materials.⁽¹²⁾ ERDA has assigned ARHCO responsibility for managing contaminated wastes within the 200 Areas of the Hanford Reservation and, as such, any wastes generated by Hanford disposition programs in the 200 Areas must adhere to the ARHCO's disposal requirements. The following discussion summarizes these requirements for various waste forms.

9.4.1 Solid Transuranic Wastes

ERDA has recently established that transuranic wastes at ERDA sites with concentrations in excess of 10 nci/g must be segregated from other radioactive contaminated solid waste and stored in a retrievable

manner^(12,13) and in containers which meet the requirements of the ARHCO standards in use at the time the material is placed in storage.*

In preparing the wastes containing greater than 10 nCi/g transuranics for packaging, precautionary guidelines must be followed:

- Combustible and noncombustible retrievable wastes shall be segregated and packaged separately.
- Pyrophoric, explosive, and spontaneously combustible materials must be treated to remove their hazardous properties.
- The waste shall contain no free liquid.
- The bulk volume should be reduced as much as possible.
- The quantity of fissile material per 55-gal container shall not exceed 12 g of plutonium.

Transuranic-contaminated solid low-level combustible and noncombustible radioactive wastes containing less than 10 nCi/g shall be packaged and disposed of as specified by ARHCO.

9.4.2 Liquid Wastes

Transuranic-contaminated liquid wastes containing toxic chemicals or oxidizing agents such as nitric acid, permanganates, etc., shall be pumped into stainless steel tanks and sampled for composition. Depending upon criteria established by ARHCO, the stainless steel vessels shall be transported to the Z plant for reprocessing of their contents or directly to the tank farms for solidification.

* Current practice (1975) is to seal the waste in a plastic wrapping at least 0.006 in. thick and package it in rigid polylined 55-gal or 83-gal steel drums or in 4 ft x 4 ft x 7 ft fiberglass-coated wooden boxes.⁽¹⁴⁾

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10.0 Uranium Facilities

11.0 Waste Management Facilities

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