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RHO-CD-761

COST/RISK/BENEFIT ANALYSIS REPORT
ON THE DECONTAMINATION AND
DECOMMISSIONING OF Z-PLANT

J. P. Melvin
R. A. Sexton
M. L. Fort
S. E. Nunn

Decontamination and Decommissioning Unit
Waste Technology Group
System Engineering Department
Research and Engineering Function
Rockwell Hanford Operations

September 28, 1979

Prepared for the United States
Department of Energy
Under Contract EY-77-C-06-1030

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Rockwell International
Rockwell Hanford Operations
Energy Systems Group
Richland, Washington 99352

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EXECUTIVE SUMMARY

This study was performed to estimate the cost of decontaminating and decommissioning Z-Plant. All of the buildings in the Z-Plant exclusion area except Building 2736-Z, the plutonium storage vault, are included in the study. The study also excludes all underground facilities within the exclusion area which are not contained within a building and all Z-Plant related facilities outside the perimeter fence.

The contamination in Z-Plant is primarily ^{239}Pu which has a half-life of 24,360 years. Because of the long half-life of ^{239}Pu , it is not practical to consider the isolation of the facility to await reduction of the contamination level by natural decay. Therefore, this study analyzes the costs, risk and benefit of decontaminating Z-Plant to four different levels of residual contamination. The three principle criteria used in the analysis are cost, the risk of offsite dose to the public, and the occupational exposure to onsite personnel.

Z-Plant can be decontaminated to residual contamination levels of 200 dpm/100 cm^2 α fixed and 20 dpm/100 cm^2 α smearable for an estimated \$129 million. These limits permit release of the facility for "Uncontrolled Use" as defined by ANSI Standard N328. However, even at this endpoint some hidden contamination may exist. Total removal of all contamination from the site can only be assured by razing the facility for an additional \$29 million.

A portion of the decontamination cost can be deferred until the facility is razed if release of the facility for "Uncontrolled Use" is postponed. Approximately \$18 million can be deferred if high fixed contamination levels (2000 dpm/100 cm^2 α) are permitted on exposed surfaces while still removing all glove boxes, hoods, and contaminated pipes and ductwork. Approximately \$50 million more can be deferred if internally contaminated pipes and ventilation ductwork are left in the building.

Some savings are also possible. Approximately \$9 million can be saved if optimum technology is used to reduce the volume of all of the retrievable transuranic waste which will be generated by decontamination of Z-Plant to the ANSI Standard N328 "Uncontrolled Use" release limits. Approximately \$5 million of this \$9 million saving will accrue from processing of glove boxes and hoods while about \$4 million will accrue from processing of contaminated piping and ductwork.

The risk of offsite dose to the public due to accidental release of contamination of the environment will be approximately 12.6 man-rem/year after terminal cleanout. Consequently, there seems to be no necessity to initiate D&D before the building has served out its useful life. This figure is low because Z-Plant is isolated from the public by the Hanford Site.

The occupational dose to decontaminate Z-Plant to the uncontrolled release endpoint is 326 man-rem. This is equivalent to approximately three times the annual dose while the facility was fully in operation. It is also equal to only 22 times the 15 man-rem/year maintenance and surveillance dose which will continue until the facility is decontaminated.

The following recommendations are made concerning the decontamination and decommissioning of Z-Plant:

1. Areas such as the laboratories and RADTU, which are not presently scheduled for deactivation, should remain operative as long as productive use can be made of the floor space because the building does not represent an unacceptable offsite hazard in the short-term.
2. Process areas presently scheduled for deactivation should be decontaminated as they become available. This will reduce the radiological hazard of Z-Plant and release the decontaminated areas for other uses while the rest of the building remains operational.
3. A transuranic waste processing facility should be installed in Z-Plant at the commencement of the D&D effort in order to minimize the cost of transuranic waste management.

4. Extensive D&D of the drain tunnels and of the ventilation systems on the duct level, second floor, and in Building 291-Z should not be initiated until the entire building has been committed exclusively to D&D and transuranic waste processing.
5. Z-Plant should be decontaminated at the end of its useful life in order to effectively eliminate the long term radiological hazard associated with a plutonium contaminated facility. Ultimately the facility should be razed if absolute assurance is required for the complete removal of all transuranic contamination from the site.

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1.0 INTRODUCTION

1.1 Background of Z-Plant Complex

The Z-Plant complex was designed to convert plutonium nitrate product solutions from reprocessed spent fuel into plutonium metal for fabrication of weapons parts. Construction of the facility started in 1948 with production beginning in 1949. The plutonium reclamation facility, 236-Z, was constructed in 1964 to recover plutonium from scrap and from the solutions generated by the conversion process. Several other additions have been made to the plant. The buildings included in the Z-Plant exclusion area are shown in Figure 1.1-1.

The facility contains contaminated equipment and contaminated structural surfaces. The contamination is predominantly plutonium with lesser quantities of americium. The processing facilities in Z-Plant are scheduled for deactivation by 1983, but the laboratory facilities are expected to remain operative for a longer period.

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Figure 1.1-1 Buildings Included in the Z-Plant Exclusion Zone

1.3 Cost/Risk/Benefit Analysis

1.3.1 Background

On June 5, 1978, the Department of Energy (DOE) headquarters issued a telecommunications message to DOE-RL requesting a Conceptual Design Plan for the D&D of Z-Plant. That message requested a cost/benefit study of alternative endpoint objectives, and an evaluation of incentives and associated costs for developing new and improved techniques for D&D. This report is the response to that request.

Budget constraints have limited the scope of this study to all of the buildings, except 2736-Z, which are within the perimeter fence. The study also excludes 241-Z, 231-Z, all underground facilities not contained within a building, and all Z-Plant related facilities outside the perimeter fence.

1.3.2 Objective

This study quantifies the costs, risks, and benefits of decontaminating and decommissioning Z-Plant. Cost is measured in dollars. Risk, measured in man-rem, is the actual or potential increase in radiation exposure due to the D&D operation. Benefit, measured in man-rem, is the reduction in the radiation hazard posed to the public by an uncontrolled release of radionuclides to the environment.

A subjective decision about the dollar value of a man-rem is a prerequisite to equating cost measured in dollars to risk and benefit measured in man-rem. The objective of the report is to provide quantified data relevant to this decision in order to facilitate planning for the D&D of Z-Plant.

1.3.3 Approach

Since Z-Plant is contaminated primarily with ^{239}Pu , which has a half-life of 24,360 years, isolation of the facility for any period to await reduction of the contamination level by natural decay is not practical. Therefore, this study analyzes the costs, risks and benefits of decontaminating Z-Plant to four different endpoint residual contamination levels, as shown in Table 4.1-1.

One endpoint, "unrestricted", is defined by the residual contamination levels required by ANSI Standard N328 for release of the facility for "Uncontrolled Use." Another endpoint, "restricted non-use," is defined as the safe and stable condition which will exist at the end of terminal cleanout. Two intermediate endpoints, "conditional" and "restricted use," are also analyzed.

Data was gathered on each room in Z-Plant. Six generic D&D tasks were developed which comprise all of the work activities necessary to decontaminate a transuranic contaminated facility. A computer program was written to store and retrieve the characterization data, and to perform the numerous repetitive calculations. The cost, risk, and benefit of attaining each of the four endpoints has been calculated.

Technology which will decrease the cost of decontaminating transuranic facilities is developing rapidly. The potential reduction in decontamination costs by using technology currently under development is estimated. Recommendations are made concerning areas of development which are not presently funded, but which could contribute substantial savings to major decontamination efforts.

2.0 SUMMARY

2.1 Alternatives

There are a number of alternative approaches to the planning of any D&D project. The major questions addressed by this Cost/Risk/ Benefit Analysis are what level of residual surface contamination should be permitted to remain in the facility, and what combination of D&D methods should be used.

A D&D "endpoint" is defined by the residual surface contamination level in the facility at the end of D&D. This study has assessed the cost and impact of achieving each of four endpoints for the entire facility and for certain areas within the facility.

The study also evaluates the D&D methods to be used. The cost effectiveness of using newly developed volume reduction and decontamination techniques on plutonium contaminated equipment is estimated. These techniques convert grossly contaminated equipment to non-transuranic waste, thereby precluding the substantial cost of the 20-year retrievable storage requirement. Various approaches to decontamination of the structure itself are also examined.

2.2 Decision Criteria

The three criteria used to evaluate the available D&D alternatives are 1) net cost, 2) occupational exposure to onsite personnel, and 3) potential offsite risk. Comparison of these dissimilar criteria obviously becomes subjective. The study calculates values for each of the three criteria at each alternative endpoint in order to provide a quantified input to the subjective evaluation. Calculated values include the costs and risks incurred during the D&D project as well as the ongoing costs, risks, and benefits which remain after conclusion of the D&D work. A successful D&D project will create a reduction in annual costs and occupational exposure from on-going maintenance and surveillance and a reduction in offsite risk.

The components which make up net cost include decontamination, managing the waste generated by D&D including geological storage if required, surveillance and maintenance of any remaining contaminated facility, and the value of any facility or real estate made available by decontamination. Occupational exposure includes exposure from the decontamination activity, from management of the generated waste, and from surveillance and maintenance of any remaining contaminated facilities.

Potential offsite risk is the potential dose to the public associated with a given endpoint. The dose calculation takes into account potential releases of contamination from the facility as it exists upon completion of D&D, potential releases from the disposed waste, and potential releases from any accident which might occur during decontamination. Potential offsite risk for each endpoint is compared to the risk of the facility in its pre-D&D configuration. Risk is expressed as the mathematical product of the consequences of a release in man-rem and the probability of that release.

The primary contaminant in the facility is ^{239}Pu which has a half-life of 24,360 years. Clearly, risk cannot be quantified for the distant future when demography, meteorology, or release probabilities are unknown. Therefore, the study attempts to make general statements on long-term risk and quantify risk in the near term (50-100 years).

2.3 Results

Table 2.3-1 summarizes the information obtained from this study. Chapters 7, 8, and 10 present this information in greater detail.

The D&D cost shown in Column 1 of Table 2.3-1 includes waste management. Waste management involves the shallow land burial of non-transuranic waste, and the initial burial, retrieval, and final disposition of transuranic waste. The Column 1 values reflect current burial practices which do not encompass any processing of the transuranic waste prior to initial burial.

Column 2 presents the D&D cost when using the optimum combination of advanced technologies to process the transuranic and non-transuranic waste.

TABLE 2.3-1
SUMMARY OF COST, RISK, AND
OCCUPATIONAL DOSE DATA

Endpoint	D&D Cost ¹ (Current Practice)	D&D Cost ¹ (Optimum Technology)	Annual Maintenance and Surveillance Cost ¹	Innate Residual Offsite Risk (man-rem/yr)	D&D Related Offsite Risk (man-rem)	Maintenance and Surveillance Dose (man-rem/yr)	Occupational Dose (man-rem)
Unrestricted (Facility is Razed)	158	147	0	0.0 ²	10.5	0	326
Unrestricted (no Razing)	129	118	2.0	<10 ⁻⁶	10.5	0 ²	326
Conditional	110	100	2.2	<10 ⁻⁵	10.1	.3	305
Restricted Use	61	55	2.4	4.8	6.1	1.5	220
Restricted Non-Use	0	0	2.6	12.6	0	15.0	0

¹All costs are given of millions of 1979 dollars

²Negligibly low.

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Column 3 presents maintenance and surveillance costs if the entire facility is inactive. It is assumed that any future user of the facility will absorb the maintenance costs of their own project. The maintenance and surveillance cost is not significantly affected until after the facility is razed because of the high cost of heating and ventilating the buildings.

Column 4 shows the offsite risk due to the contamination remaining in the inactive facility after it has been decontaminated to the respective endpoint. The figures shown represent annualized risk and are only valid in the short-term because of the extreme uncertainties associated with long-term risk analysis. Column 5 shows the offsite risk which results from the work activities performed during the D&D project.

Column 6 lists the total annual radiation dose to maintenance and surveillance personnel after the facility has been decontaminated to the respective endpoints. Column 7 shows the total dose received by the D&D workers during the decontamination project.

The table illustrates how a greater decontamination effort increases D&D cost, D&D related offsite risk, and D&D occupational dose while decreasing annual maintenance and surveillance dose, annual maintenance and surveillance cost, and annual innate residual offsite risk. It should be noted that the increasing values are single (one time) values whereas the decreasing values are annual (recurring) values. Thus, although the annual values seem initially smaller, they accumulate annually and will eventually exceed the comparable single values.

The cost savings available from using optimum technology are almost the same for the conditional endpoint as for the unrestricted endpoint. This similarity occurs because these savings accrue primarily from the treatment of transuranic waste, and most of the transuranic waste has been generated by the time the conditional endpoint is achieved. Similarly the innate residual offsite risk becomes negligible at the conditional endpoint because most of the contamination has been removed from the facility.

2.4 Recommendations

1. Areas such as the laboratories and RADTU, which are not presently scheduled for deactivation, should remain operative as long as productive use can be made of the floor space because the building does not represent an unacceptable offsite hazard in the short-term.
2. Process areas presently scheduled for deactivation should be decontaminated as they become available. This will reduce the radiological hazard of Z-Plant and release the decontaminated areas for other uses while the rest of the building remains operational.
3. A transuranic waste processing facility should be installed in Z-Plant at the commencement of the D&D effort in order to minimize the cost of transuranic waste management.
4. Extensive D&D of the drain tunnels and of the ventilation systems on the duct level, second floor, and in Building 291-Z should not be initiated until the entire building has been committed exclusively to D&D and transuranic waste processing.
5. Z-Plant should be decontaminated at the end of this useful life in order to effectively eliminate the long-term radiological hazard associated with a plutonium contaminated facility. Ultimately the facility should be razed if absolute assurance is required for the complete removal of all transuranic contamination from the site.

3.0 DESCRIPTION OF D&D TECHNOLOGY

3.1 Introduction

Z-Plant is contaminated primarily with particle emitters. Gamma radiation is generally low level (except in Building 242-Z), and decontamination activities will seldom require shielding. The technological requirements for decontamination of transuranics can be grouped into four categories:

1. Methods of controlling contamination.
2. Removal of contaminated surfaces and fixtures from structures.
3. Transformation of grossly contaminated material and equipment from TRU to non-TRU waste status.
4. Measurement of the transuranic content of packaged waste.

3.2 Methods of Controlling Contamination

Alpha particles can be stopped by thin layers of material, but are quite harmful if ingested or inhaled. Three methods used to control contamination which may become airborne due to decontamination activities are:

1. If a cleanup activity causes an intolerable spread of contamination, a substitute activity should be sought.
2. When even the best available decontamination method creates very high levels of airborne activity, the entire operation must be enclosed.
3. In the presence of potential airborne contamination the worker is safeguarded with protective clothing and breathing apparatus.

The third method is essentially a health physics concern, and only methods No. 1 and No. 2 will be discussed herein.

3.2.1 Reducing Recontamination Caused By Cleanup Activities

Other than physical barriers, ventilation control is the principal method used to prevent the spread of contamination. In Z-Plant the

airflow is directed from those areas with a low potential for contamination through areas with higher potential for contamination before the air is filtered and discharged. To subdue airborne contamination, air is supplied near the ceiling and exhausted at floor level. Three other approaches are discussed below which aid contamination control during cleanup activities.

3.2.1.1 Affixing Contamination to a Surface

A contamination stabilization coating, such as a latex paint, can be used to cover the interior surfaces of a grossly contaminated glove box. The affixed contamination will not become dislodged during sectioning of the box. Heavier strippable coatings can be applied to structural surfaces to either bind the contamination, or to insure that a cleaned surface will remain clean while other cleanup activities proceed nearby.

3.2.1.2 Use of Less Disruptive Decontamination Techniques

Many decontamination techniques promote the spread of contamination, and efforts are underway to find substitutes. One likely candidate is a hydraulic pipe cutter which can cut pipes up to 2 inches in diameter. This substitute prevents the smoke and sparks which accompany the previously used mechanical sawing technique.

High pressure water lancing is being evaluated as a substitute for sand blasting to remove surfaces from floors, walls, and ceilings. However, water lancing may be an unacceptable technique if it generates sufficient water vapor to degrade the exhaust HEPA filter elements. Dry ice is also being investigated as an abrasive medium.

3.2.1.3 Vacuum Recovery

High localized airflow and filtering can be used to vacuum up and trap disturbed contamination before it can spread. The radioactive waste drum press and the abrasive blaster exemplify this technique. The radioactive waste drum press compacts combustible waste into 55 gallon drums, and uses a HEPA filtered exhaust ventilation system to process the

exhaust air. The abrasive blaster, while removing a thin surface layer from floors, walls or ceilings, incorporates vacuum recovery and cyclone separation systems to reduce dust and waste respectively.

3.2.2 Radiological Containments

A radiological containment is a plastic enclosure used to prevent the spread of airborne contamination. Containments range in size from as small as 1 ft³ to larger than 1000 ft³. One use of a small radiological containment is to enclose a pipe cutting operation where residual radioactive liquid may be encountered. A large containment tent could be used to enclose a glove box which is being sectioned. A large containment tent will have its own filtered ventilation exhaust system to suppress the spread of contamination by compelling the air to flow from the outside into the tent.

3.3 Removal of Contaminated Surfaces and Fixtures

Significant advances have been made recently in the design of equipment to remove contaminated surfaces and fixtures from structures. Those designs applicable solely to nuclear reactors will not be discussed. A list of some of the equipment expected to be used in the decontamination of Z-Plant is given in Table 3.4-1. Clarifying comments on certain items in the list are given below.

Plate Shear

A plate shear being tested will cut 6 feet per minute of the 1/4 inch stainless steel used in glove boxes. It will circumvent the problem that sparks could ignite a plastic containment if a mechanical saw is used to section a glove box.

Hydraulic Cutter

The hydraulic cutter can cut pipe up to 2 inches in diameter with a snipping motion. It does not create sparks and partially crimps the open pipe ends which inhibits leakage of residual liquid.

TABLE 3.4-1

DECONTAMINATION EQUIPMENT

EQUIPMENT	DESCRIPTION	ITEM APPLICATION
Vacuum cleaner with HEPA filter	The vacuum cleaner is adapted to either a 30 gallon or 55 gal. drum. Either solid or liquid debris is collected in the drum and the air is exhausted through a HEPA Filter after being dried by an impact filter.	Preliminary cleaning of surfaces. May be used to pick up liquids.
Plate Shear	Hand held electric shear.	Cut sheet metal and 1/4 inch steel plate.
Hydraulic Cutter	Hand-held hydraulic cutter which uses a crush of 35 tons for cutting.	Cut pipe and reinforcing steel bar.
Concrete Scabbler	Pneumatic scarifying tool.	Remove thin layer from surfaces.
Strippable Coating	Water-based hand strippable protective coating.	Protect cleaned surfaces from accidental recontamination.
Abrasive Blaster	Standard industrial abrasive blaster modified with vacuum recovery and cyclone separations systems.	Remove multiple layers of paint and etch the surface layer of walls, floors, etc.
Darda/Battelle Rock Splitter	Hydraulic concrete-splitting plug and mandrell assembly inserted into pre-drilled holes.	Splitting or spalling of concrete.
Radioactive Waste Drum Press	Hydraulic ram compacts combustible waste into 55 gal. drum. Air exhausted through HEPA filtered ventilation system.	Volume reduction of combustible waste.
Radioactive Acid Digestion Test Unit	In an acid digestion process combustible waste is treated in a mixture of sulphuric and nitric acid at 480°F to convert it to carbon dioxide, water and a small amount of noncombustible solid residue.	Reduce the volume of low-level combustible radioactive waste to less than two percent of original volume.

Concrete Scabbler

This rectangular array of many small bits can remove a very thin layer from a surface. It can be adjusted to remove the depth of surface to which contamination has penetrated.

Strippable Coating

Cleaned surfaces may be recontaminated by adjacent decontamination work. A strippable coating on a clean surface will prevent recontamination.

Abrasive Blaster

An industrial abrasive (sand) blaster generates large quantities of dust and waste. Vacuum recovery and cyclone separation systems reduce the dust and waste respectively.

Darda/Battelle Rock Splitter

The Rock Splitter resembles a jackhammer with a hollow cylinder in place of the blade. The lower end of the cylinder is split lengthwise. A wedge is mounted circumferentially, like a bracelet, near the bottom of the cylinder. The cylinder is inserted into a previously drilled hole and the two halves of the cylinder are forced apart. The wedge cracks the concrete horizontally about 2 inches below the surface and the concrete scales off. The 2 inch layer of surface removed is much less waste than would be generated by a jackhammer.

Radioactive Acid Digestion Test Unit (RADTU)

Some decontamination activities generate a volume of combustible solid waste (rags, protective clothing, etc.) which may exceed the volume of the material being decontaminated. The decontamination effort will be futile unless this volume of contaminated combustible solid waste can be reduced. The successful development of RADTU, with a volume reduction factor of 50 for combustible solid waste, would eliminate this problem.

3.4 Conversion of TRU Waste to Non-TRU Waste

Regulations have not been issued for the final disposal of TRU waste, but the cost of final disposition will probably be very high. Extraordinary savings could evolve from methods which reduce the transuranic

content of TRU waste to a level low enough to permit its classification as non-TRU waste. Two promising methods are presently being developed, vibratory finishing and electropolishing.¹

The vibratory finishing process consists of placing contaminated material in a bath of abrasive media and vibrating the bath vigorously. The abrasive media are small pieces of ceramic or metal. The abrasive media grates the contamination from the surface of the material, and a fluid flow washes the loosened contamination to the bottom of the tank for collection. Before processing, the contaminated material may have to be cut up either to expose contaminated surfaces to the abrasive media, or to make the pieces small enough to fit in the bath. This process can clean any type of grossly contaminated non-combustible material to below the TRU waste limit of 10 nCi/g, but it cannot clean below a surface contamination level of about 10,000 dpm/100 cm² α .

Electropolishing is actually reverse metal plating. The contaminated object must be an electrical conductor and acts as the anode in an electrolytic cell. An electric current causes anodic dissolution of the surface material. All radioactive contamination on the surface or trapped in surface imperfections is released to the electrolyte.

Vibratory finishing is preferred to electropolishing because it can decontaminate material to below the 10 nCi/g TRU waste limit at less cost. However, two conditions could exist which would favor electropolishing. First, portions of metal materials such as welds may not respond to vibratory finishing because the contamination is trapped within small crevices. Such materials can be cleaned by electropolishing. Second, if regulations ever limit surface contamination levels for non-TRU waste to below 10,000 dpm/100 cm² α , vibratory finishing will be inadequate and electropolishing will be necessary.

3.5 Measurement of the Transuranic Content of Packaged Waste

Waste which contains less than 10 nCi/g of transuranics can be classified as non-TRU waste. Estimates indicate that the packaging and disposal cost of TRU waste may be twelve times as high as for non-TRU

waste. The TRU waste disposal cost represents a significant portion of the total D&D cost, perhaps more than 30%, and a method which would reduce the quantity of TRU waste could effect significant savings. Methods of converting TRU waste to non-TRU waste were discussed in Section 3.4. Another means of minimizing the volume of TRU waste is to increase the detectability and accuracy of the instrumentation used to measure the 10 nCi/g limit.

If it cannot be confirmed that plutonium contaminated waste is non-TRU, the waste must be treated as TRU waste. Consequently, it is imperative that the boundary between TRU waste and non-TRU waste be accurately detectable. Presently the accuracy of this measurement depends upon whether it is low density or high density waste.

Low density combustible waste can be accurately measured for transuranic content with a Multi-Energy Gamma Assay System (MEGAS). In a recent telephone conversation, Dr. C. J. Umbarger discussed the savings made possible by MEGAS during processing of 6000 ft³ of transuranic waste over a 5 year period at Los Alamos.

Prior to the development of MEGAS all transuranic contaminated waste had to be treated as TRU waste. The MEGAS system was able to establish that only 8% of the analyzed waste was TRU, while 10% was contaminated with transuranics below the 10 nCi/g limit, and 82% contained no detectable transuranic contamination. Estimating waste handling costs at \$50 per ft³ for TRU and \$5 per ft³ for non-TRU, the MEGAS system permitted a waste handling cost saving of \$248,400 over 5 years. This compares with a capital cost of \$50,000 and an annual operating cost of \$20,000.²

Most contaminated material is very dense. No existing equipment can accurately assess the transuranic content of packaged dense material. However, a "Barrel Counter", now being considered by Los Alamos and Rockwell Hanford, could perform an active and passive neutron activation assay on cut-up, drummed, dense waste. The cost of TRU waste disposal will probably be so high that the development of some system which can measure the transuranic content of drummed dense waste is a prerequisite to economically accomplishing any major transuranic decontamination effort.

4.0 DECONTAMINATION ENDPOINT ALTERNATIVES AND STUDY APPROACH

4.1 Decontamination Endpoint Alternatives

The decontamination and decommissioning of a plutonium contaminated structure comparable in size and complexity to Z-Plant is without precedent. The approach taken in this study was to designate as criteria several residual contamination limits, or endpoints, and then analyze the effects of achieving these endpoints. To facilitate a thorough analysis four different endpoints have been investigated, each of which represents a different level of residual contamination and a different permissible future building use. This approach permits examination of decontaminating different rooms to different endpoints. The four endpoints are defined in Table 4.1-1.

4.1.1 Definition of and Rationale for the Unrestricted Endpoint

The criteria which define the unrestricted endpoint are shown in Table 4.1-1. This endpoint describes a facility which is entirely free of radiological constraints and qualifies under ANSI Standard N328 as releasable for uncontrolled use. Typical uses of such a facility are also shown in Table 4.1-1.

All endpoints require both the removal of all contamination above the specified maximum limit and a means to verify the removal. However, plutonium contamination may exist in inaccessible areas. For this reason a distinction must be made between an "unrestricted room" and an "unrestricted site." A room will be considered unrestricted when its surfaces are free of detectable contamination above the criteria. This includes the removal of painted over contamination and contaminated concrete surfaces. It also includes the removal of contamination contained internally in piping, ductwork, or glove boxes. The site, however, can only qualify as unrestricted when the buildings have been razed because only thus can the absence of undetectable contamination be assured.

4.1.2 Definition of and Rationale for the Conditional Endpoint

The criteria which define the conditional endpoint are shown in Table 4.1-1. Under Section 420 of RHO-MA-220, "Rockwell Hanford

TABLE 4.1-1
 ALTERNATIVE ENDPOINTS FOR D&D EFFORTS
 UPPER LIMITS FOR VARIOUS CASES

	TYPICAL PERMISSIBLE USE	FIXED	REMOVABLE
UNRESTRICTED	Office Space	200 dpm/100 cm ² α	20 dpm/100 cm ² α
	Storage Space	.02 mrem/hr*	200 dpm/100 cm ² βγ
CONDITIONAL	Analytical Lab	2000 dpm/100 cm ² α	20 dpm/100 cm ² α
	Storage of Contained Radioactive Material	.1 mrem/hr*	200 dpm/100 cm ² βγ
RESTRICTED USE	Low Level Decontamination Facility	20,000 dpm/100 cm ² α	20 dpm/100 cm ² α
	Packaging of Low Level Radioactive Waste	.2 mrem/hr*	200 dpm/100 cm ² βγ
RESTRICTED NON-USE	No Permissible Use		
	The Facility Is Isolated	Deactivated Facility - No D&D	

*Contact Reading

Operations, Radiation Protection Standards and Control," the conditional endpoint constitutes a "Surface Contamination Area" which is subject to radiation monitoring on a scheduled basis.

The conditional endpoint will provide maximum future utilization of the structure if the unrestricted endpoint requires dismantlement or is otherwise economically unfeasible. Although restricted to a nuclear oriented use, the conditional endpoint provides the widest choice of options

within this constraint. Decontamination to the conditional endpoint is less costly than to the unrestricted endpoint primarily because scheduled radiation monitoring eliminates the need for absolute assurance that all contamination has been removed.

4.1.3 Definition of and Rationale for the Restricted Use Endpoint

The restricted use endpoint provides usable space at a moderate cost. The allowable uses are limited because of the higher residual contamination level. Nevertheless, if housing is needed for activities which are authorized for this endpoint, the decontamination of Z-Plant to this level may be the most economic way to provide this housing.

4.1.4 Definition of and Rationale for the Restricted Non-Use Endpoint

There are no residual contamination limits for the restricted non-use endpoint. This endpoint is defined as the condition of the facility upon completion of deactivation. When the facility is deactivated certain systems such as ventilation, lighting and fire protection must remain operational, and routine radiation monitoring is still required.

The restricted non-use endpoint is included to permit a comparison with the other three endpoints. Restricted non-use is not a gratis option. Although the only usable portions of the facility are the previously uncontaminated areas, substantial maintenance and surveillance costs will accrue annually.

4.2 Technical Approach

4.2.1 Decision Criteria

A typical cost/benefit study compares cost in dollars to income in dollars. A project will be initiated if the present value of the future income exceeds the cost by a sufficient margin to offset the risk of

undertaking the project. But no net economic benefit will accrue from the D&D of Z-Plant since the value of its use is exceeded by the D&D cost. The significant benefit is the reduction of both the occupational exposure to Z-Plant personnel and the potential offsite radiation hazard to the public.

Occupational exposure is the sum of the dose received by decontamination workers and the dose received by all other personnel whose routine duties require that they regularly occupy contaminated areas. Potential offsite radiation hazard to the public is the summation over all possible events of the total dose to the public from each event times the probability that the event will occur.

Since benefit is measured in man-rem units and cost is measured in dollar units, the two values must be subjectively compared by assigning a dollar value to a man-rem. This study is designed to facilitate this decision by providing separate data on costs, onsite dose, and offsite hazard for every case.

4.2.2 The Computer Program

A computer program was developed for use in this study. The logic flow diagram is shown in Figure 4.2-1. Each of the subroutines in the model is briefly discussed below.

Facilities Data

The Facilities Data file is an information storage and retrieval file. More than 100,000 data entries were needed to characterize the almost 400 rooms in Z-Plant. There are two categories of facilities data: radiological and non-radiological. The data stored in this file is used by all of the subroutines. The input to the Facilities Data file is discussed in detail in Chapter 5, "Characterization of Z-Plant."

Offsite Dose

The Offsite Dose Model calculates the radiation hazard to the public associated with each endpoint. The hazard from one postulated event such as an earthquake is the product of three parameters: the probability

FIGURE 4.2-1
Z-PLANT D&D COMPUTER PROGRAM
LOGIC FLOW DIAGRAM

of the event, the amount of contamination released by the event, and the dose to the public per unit of contamination released. The total hazard for each endpoint is the summation of the doses from all possible events. The Offsite Dose Model is discussed more fully in Chapter 9, "Offsite Radiological Risk of Alternative Plans."

D&D Tasks

Six Generic D&D Tasks were created to organize and standardize all of the diverse physical work activities which are required in the decontamination of Z-Plant. For instance, as many as 19 distinct work activities might be required to remove a contaminated glove box. These 19 work activities were combined as subtasks to create the generic task "Glove Box and Hood Cleanup or Removal." The six generic tasks are discussed in Chapter 6, "Decontamination Activities."

The D&D Tasks subroutine includes all six generic tasks. Based on facilities data, the appropriate tasks and subtasks needed to accomplish the work are chosen. The length of time that each subtask must be performed is calculated and the cost determined. The subroutine also calculates the dose to decontamination personnel, and the volume and disposal cost of the contaminated waste generated.

Utility Model

The Utility Model calculates the salvage value of the facility for a given endpoint. Parameters which affect the salvage value are maintenance and surveillance cost, reuse value, and the cost to raze the facility, if appropriate. Since this subroutine is oriented toward future activities in the facility, it is also used to calculate the anticipated occupational exposure of maintenance and surveillance personnel after the D&D project is completed.

5.0 CHARACTERIZATION OF Z-PLANT

5.1 General Description of Z-Plant

This study includes all of the buildings within the Z-Plant exclusion area except Building 2736-Z, the plutonium storage vault. All tanks and piping located within the buildings are included in the study. Underground facilities and piping which are not contained within a building are excluded from the study. Table 5.1-1 describes the buildings included in this study.

The 234-5-Z building houses several activities on the first floor. They include production process areas, office space, the Analytical Laboratory, the Chemical Technology Laboratory, and the Radioactive Acid Digestion Test Unit.

The "Duct Level" on the second floor of the building provides space for ventilation ducting, process piping and electrical conduit. The third level, which is called the "second floor", is divided into a front side and a back side. The front side includes offices, the ventilation supply fans and some building maintenance and support activities. The back side contains the building primary filters and ducts, and nine main exhaust filter rooms.

Most of the Z-Plant is radiologically controlled. The only uncontrolled areas are about 16,000 ft² of office space on the first floor, and the front (north) sides of the duct level (second level) and the second floor (third level). Figures 5.1-1, 5.1-2 and 5.1-3 are plan views of the three principle levels in Z-Plant.

5.2 Partitioning Z-Plant Into Areas

Z-Plant's size and heterogeneity make it desirable to divide Z-Plant into definite areas for the purpose of this study. Eighteen areas were chosen on the basis of structural divisions or use of the area. The areas and the primary activity of each are listed in Table 5.2-1. The areas are shown in Figures 5.2-1, 5.2-2 and 5.2-3.

TABLE 5.1-1

A DESCRIPTION OF THE BUILDINGS INCLUDED
IN THE Z-PLANT COST/RISK/BENEFIT ANALYSIS

Building Number	Building Name	Normal Use	Approximate Floor Space
232-Z	Waste Incinerator Building	Formerly used for reduction of combustible waste by incineration. Presently inactive.	2,400 ft ²
234-ZB	Waste Material Storage Building	Storage of non-contaminated waste material.	1,000 ft ²
234-ZC	Storage Building	General Storage.	144 ft ²
234-5-Z	Plutonium Processing Facility	Plutonium Processing and Actinide Laboratories	200,000 ft ²
236-Z	Plutonium Reclamation Facility	Plutonium Reclamation and Short Term Plutonium Storage.	22,000 ft ²
242-Z	Waste Treatment Facility	Separation of Americium from Plutonium Waste Stream. Presently inactive.	1,500 ft ²
291-Z	Exhaust Fan Building and Stack	Houses ventilation exhaust fans, vacuum system, vacuum pumps, and includes the area exhaust gas stack.	10,000 ft ²
2727-Z	Supplies Storage Building	Storage of non-nuclear supplies.	400 ft ²
2731-Z	Storage Building	Storage of non-nuclear supplies.	700 ft ²

Figure 5.1-1 Z-Plant First Floor Room Plan (First Level in Z-Plant)

Figure 5.1-2 Z-Plant Duct Level Room Plan (Second Level in Z-Plant)

RHO-CD-761

234-5
BLDG.

Figure 5.1-3 Z-Plant Second Floor Room Plan (Third Level in Z-Plant)

TABLE 5.2-1

PARTITIONING THE Z-PLANT COMPLEX INTO
18 AREAS OF HOMOGENEOUS ACTIVITY

Area Number	Area Description	Primary Area Activity
1	232-Z Incinerator Building	Reduction of contaminated combustible waste by incineration.
2	234-5-Z Process Areas	Plutonium processing.
3	236-Z Plutonium Reclamation Facility	Plutonium reclamation and short term plutonium storage.
4	242-Z Waste Treatment Facility	Separation of americium from plutonium waste stream.
5	Analytical labs on first level of 234-5-Z	Analytical laboratory support for some Hanford Operations.
6	Change rooms and main corridor of first level of 234-5-Z	The main east-west corridor and change rooms on the first level of 234-5-Z.
7	First floor offices	Offices and maintenance area which support Z-Plant.
8	Non-Destructive Analysis Area on first level of 234-5-Z	Packages are tested for trans-uranic content without physically altering the package.
9	South central portion of first level of 234-5-Z	Maintenance of instruments, supervision of Radiation Monitors and receiving of Plutonium Product into the 234-5-Z Building.
10	Chemical Technology Laboratories at southwest corner of first level of 234-5-Z	Development of chemical technology to support Rockwell Hanford Operations.
11	Radioactive Acid Digestion Test Unit at northwest corner of first level of 234-5-Z	Development of methods to reduce contaminated combustible waste by acid digestion.

TABLE 5.2-1 (Continued)

PARTITIONING THE Z-PLANT COMPLEX INTO
18 AREAS OF HOMOGENEOUS ACTIVITY

Area Number	Area Description	Primary Area Activity
12	291-Z Exhaust Fan Building and Stack	Houses ventilation exhaust fans, vacuum system, vacuum pumps, and includes the area exhaust gas stack.
13	Buildings 2727-Z, 2731-Z, 234-ZB and 234-ZC	Storage buildings for non-nuclear material.
14	South side of the second floor (third level) of 234-5-Z	Includes the primary filters and ducts of the 234-5-Z ventilation system.
15	Northeast quarter of second floor (third level) of 234-5-Z	Offices, maintenance area and lunchroom.
16	Northwest quarter of second floor (third level) of 234-5-Z	Control room and supply fans for the Z-Plant ventilation system.
17	Duct (second level) of 234-5-Z	Duct work, piping and conduit for 234-5-Z.
18	The basement level of 234-5-Z	Contains the large drain lines for 234-5-Z.

Figure 5.2-1 Z-Plant First Floor Area Plan (First Level in Z-Plant.)

Figure 5.2-2 Z-Plant Duct Level Area Plan (Second Level in Z-Plant)

Figure 5.2-3 Z-Plant Second Floor Area Plan (Third Level in Z-Plant)

The breakdown by area provides preliminary insight into the schedule of decontamination work. The size and heterogeneous nature of Z-Plant may make it advisable to schedule the decontamination work by individual area. A variety of sequences are feasible due to the independence of several of the areas. Furthermore, useful comparisons can be made between areas in Z-Plant and similar areas in other facilities.

5.3 Room by Room Characterization

There are two possible approaches to characterizing Z-Plant: by system or by room. The four ventilation systems and the eight drainage systems connect many different parts of the complex. The cost of decontaminating such systems can be calculated based on decontaminating the system in its entirety, or by allocating the decontamination cost on a room by room basis.

Since it will be desirable to know the cost of decontaminating different areas at different times to possibly different endpoints, the buildings were characterized solely on a room by room basis. Some data, such as contamination levels, is particularly amenable to recording in this manner. Using this characterization method, the cost, dose, and waste associated with decontamination can be calculated for any room or combination of rooms. A room by room breakdown of Area 2, a typical area in Z-Plant, is included to demonstrate the cost and dose associated with single rooms. The rooms in Area 2 are shown in Figure 5.3-1.

5.4 Non-Radiological Characterization

Non-radiological characterization is the accumulation of all necessary data except that which is related to contamination levels. The nature of Z-Plant encourages a breakdown of non-radiological data into these categories: hoods and glove boxes; miscellaneous equipment; piping; conduit; ductwork; and the structure itself.

Hoods and glove boxes comprise a category because both contain a high percentage of the total contamination in the complex. This category also includes process equipment located in hoods and glove boxes. Hoods must be removed from any area which is to be relatively free of radiological

Figure 5.3-1 Room Plan of Area 2

constraints. Generally, hoods must be classified as retrievable TRU waste unless subjected to processing by advanced decontamination technology such as vibratory finishing or electropolishing.

Miscellaneous equipment is a separate characterization category due to its extreme diversity. This characterization category is a catchall category. The miscellaneous equipment ranges from desks, chairs and fire hoses to radiation detection instruments and large electrical panels. This type of equipment varies in contamination level and has been included in a single category because most of it will be handled in a similar manner.

Piping and ductwork comprise two separate categories because of the vast amounts of each located throughout the facility. The piping and ductwork may be internally contaminated, externally contaminated, or non-contaminated.

Conduit is either externally contaminated or non-contaminated. Cable trays, which are included in the conduit category, can contain inaccessible non-detectable contamination and are assumed to be contaminated if they occupy areas of potential contamination.

The structural category includes the building shell and interior walls, floors, and ceilings. Although only a small portion of the initial contamination in the complex is associated with the structure, this contamination is attached to the building itself and can only be removed by special decontamination techniques.

Structural information is accumulated on six data sheets to facilitate characterization of each room, one data sheet for each structural surface (i.e., wall, ceiling, or floor). Characterization data for the other categories (hoods, miscellaneous equipment, piping, ductwork and conduit) are accumulated on one data sheet per category. Blank copies of all of the non-radiological characterization data sheets are included in Appendix B.

5.5 Radiological Characterization

Radiological characterization is the accumulation of data on the amount and distribution of radioactive contamination in Z-Plant. The objective of the radiological characterization of Z-Plant is to obtain data representative of the conditions that will exist in the facility at the outset of D&D.

The startup and operation of the plutonium recovery facility (236-Z) and the "A" oxide line, and the Terminal Cleanout of process areas will impact the facility's radiological condition between now and the initiation of D&D. Terminal Cleanout will remove all economically recoverable plutonium and leave the facility in a safe, stable condition. The quantity of plutonium in glove boxes and other process equipment will be significantly reduced and plutonium bearing liquids will be removed, but no significant dismantling of equipment or decontamination of surfaces outside of process equipment will be included. Therefore, the plutonium inventories which will exist inside process equipment at the start of D&D have been computed based on the endpoints specified in the Terminal Cleanout Scoping Study. On the other hand, the levels of contamination which now exist outside of process equipment are considered representative of what will be present at the start of D&D.

Some difficulties exist in ascertaining the current levels of contamination outside of process equipment. First, the existing data were collected by Radiation Monitoring primarily to identify radiation hazards and lack much of the detail necessary to make the calculations in this study on a room by room basis. On the other hand, gathering this data in the desired detail was not warranted because it would have consumed an estimated 60% of the FY-1979 funding for this project. Secondly, where plutonium has been painted over or has penetrated concrete surfaces, actual readings can only be obtained by removal of the paint or concrete. Performing this analysis on a plant-wide basis would also have been prohibitively expensive.

To overcome these difficulties, existing Radiation Monitoring data were used where applicable and representative interpolations were made to provide additional detail. The log books which record all "incidents" were reviewed to estimate the location of spills which have since been painted over. A limited number of new readings were taken when data was needed which would have a significant impact on the study.

6.0 DECONTAMINATION ACTIVITIES

6.1 Introduction

There has been considerable experience in the decontamination and decommissioning of plutonium contaminated facilities. However, there is very little cost information available on this subject. Relevant projects where cost information is currently being developed include the 233-S Dismantling Project underway at Rockwell Hanford Operations, the Decontamination and Restoration of the 231-Z Facility by Pacific Northwest Laboratories (PNL), the development of the Radioactive Acid Digestion Test Unit by Hanford Engineering Development Laboratory, and the volume reduction and vibratory finishing experimental work being conducted by PNL.

A typical costing calculation performed in this study is the analysis of decontaminating a room. The results include: (1) the cost of decontamination; (2) the volume and type of waste generated; (3) the dose to decontamination personnel; and (4) the reduction of offsite hazard to the public. Table 6.1-1 describes some of the information needed to calculate the cost and waste results, and includes comments on some of the dilemmas attendant to obtaining the information.

6.2 Generic D&D Tasks and Subtasks

A method was devised to overcome the lack of useful data and offset the complexity inherent in the diversity of activity and structure within Z-Plant. This method consisted of developing six generic D&D tasks to be included as subroutines in the computer program.

The following six generic D&D tasks include all of the physical activities which must be accomplished to decontaminate Z-Plant:

1. Glove Box and Hood Cleanup or Removal
2. Miscellaneous Equipment Removal
3. Piping Decontamination or Removal
4. Conduit Decontamination or Removal

TABLE 6.1-1
SOURCES OF COSTING DATA

<u>Typical Information Required</u>	<u>Data Availability</u>
1. The level of contamination on a wall	<ul style="list-style-type: none"> o Few records exist on contamination levels on the Z-Plant walls. o A complete new survey would be unreliable because contamination would remain undetected on those surfaces where it has been painted over.
2. Contamination level data accurate to the unrestricted endpoint level of 200 dpm/100cm ² α fixed and 20 dpm/100cm ² α smearable.	<ul style="list-style-type: none"> o The radiation monitoring equipment presently used in Z-Plant has a minimum sensitivity of 500 dpm/100cm² α.
3. The amount of decontamination work which must be performed on a concrete wall to clean it to a stipulated residual contamination level.	<ul style="list-style-type: none"> o Since radiation monitoring equipment cannot detect the depth to which contamination has penetrated in a porous surface, the amount of material which must be removed to clean the surface cannot be calculated.
4. What decontamination method should be used to remove a contaminated concrete surface.	<ul style="list-style-type: none"> o Certain decontamination methods remove a thin, even layer of surface while others remove a much greater but uneven depth per pass. The former generates less waste, which will yield a lower waste disposal cost, but only at a higher cost per square foot of area cleaned. It is difficult to choose the proper removal method because of the uncertainties attendant to waste disposal costs.
5. Cost of Waste Disposal	<ul style="list-style-type: none"> o Since methods for the retrieval and final disposal of transuranic waste have not yet been determined, it is impossible to predict what the cost will be.

5. Ventilation Decontamination or Removal

6. Structural Decontamination

Each of the generic D&D tasks was further divided into subtasks. A list of the 19 subtasks which comprise the "Glove Box and Hood Cleanup or Removal" generic task are shown in Table 6.2-1. A complete list of subtasks for each generic task is included in Appendix A.

The subtasks listed in Table 6.2-1 include all of the physical activities which might be required to prepare a grossly contaminated hood for shipment to either a burial ground or a decontamination center. All of the subtasks need not be performed on every hood. The decision to perform a subtask is determined from information provided on the "Glove Boxes and Open Hoods General Characterization" data sheet exhibited in Figure 6.2-1. A blank copy of each of the data sheets used to characterize Z-Plant is included in Appendix B.

The "Glove Boxes and Open Hoods General Characterization" data sheet combined with the 19 "Glove Box and Hood Cleanup or Removal" subtasks permits accurate assessment of the disposal cost of hoods with widely varying characteristics. Some hoods are very large complexes formed by welding a large number of smaller hoods together. The four access glove boxes to the 236-Z Building canyon each measure 2 ft x 9 1/2 ft x 60 ft. To be removed, such a hood must be cut into small manageable sections, and subtask No. 17, "Cut Partitions", would be operative. On the other hand, a small hood measuring 4 ft x 5 ft x 6 ft would be packaged intact and subtask No. 17 would not be required.

The hood characteristics also dictate the length of time during which a subtask must be performed. For instance, the basic measurement unit for the hood cleaning subtask "Decontaminate Outside" is manhours per square foot of outside surface. The total time required to perform this task is merely the product of the basic measurement unit (man-hour per square foot) times the surface area of the hood.

TABLE 6.2-1
 SUBTASKS WHICH COMPRISE THE GENERIC D&D TASK
 "GLOVE BOX AND HOOD CLEANUP OR REMOVAL"

1. Radiation Survey	11. Bagout Shielding
2. Erect Containment	12. Remove Structural Supports
3. Install Temporary Ventilation System	13. Seal Glove Ports
4. Decontaminate Interior	14. Seal Viewing Windows
5. Apply Fixative	15. Seal Glass
6. Remove External Connections	16. Unbolt Partitions
7. Cut Loadout Ports	17. Cut Partitions
8. Seal Openings	18. Decontaminate Outside
9. Disconnect Internal Connections	19. Remove Waste
10. Bagout Equipment	

6.3 Task Specific Parameters

Each subtask is affected by as many as 29 parameters. The subtask specific parameters have a different value for each subtask, while other parameters have the same value for every subtask. There are three essential subtask specific parameters: the manhours per unit required to perform the subtask; the amount of airborne contamination generated by performing a unit amount of the subtask; and the volume of waste (TRU and non-TRU) generated per unit amount of the subtask.

6.4 Non-Task Specific Parameters

Non-task specific parameters are used to segregate certain roughly defined values which greatly affect decontamination costs. Two such parameters are the cost of TRU waste disposal and the cost of vibratory

**PROJECT B-244
D&D OF Z-PLANT
GENERAL CHARACTERIZATION
GLOVE BOXES AND OPEN HOODS**

Preparer's Name: _____

Date: _____

Building No.: _____ Room No.: _____

Equipment Identification: _____

Isotope Mixture: _____

Type: glove box; open hood (size of opening _____ linear feet)

Number of External Connections:

Elect. _____ Inst. Air _____ Chemical _____ Drains _____ Vacuum _____ Exhaust _____ Proc. _____

Is a Temporary E4 Connection Required? Yes; No

Items to be Bagged Out:

Number Of Items	Description	Size (ft)			Number of Connections To Be Cut	Bagout Port Size Adequate?	
		L	W	H		Yes	No

DIAGRAM

Separable Sections

Section Number	Dimensions (ft)			Shielding			Separation Method			Glove Ports		Viewing Windows			Extrem. Dose mR/hr	Proxim. Dose mR/hr	Surface Contam. DPM/100 CM ²	
	L	W	H	L(ft)	W(ft)	T(in)	Unbolt	Cut	Linear Ft.	No.	Size	No.	Size	Area ft ²			Fixed	Smear

Figure 6.2-1 Glove Boxes and Hoods General Characterization Data Sheet

finishing. The former is essentially unknown since the technology has not been defined. The latter is an established commercial technology, but modification of the process to safely handle fissile material is not yet complete.

These parameters are segregated for two reasons. First, the program can be quickly and easily updated as better information becomes available. Second, different program runs can be made which include or exclude the use of individual advanced processes such as vibratory finishing. By comparing these runs, the savings attributable to vibratory finishing can be estimated and the value of a vibratory finishing facility ascertained.

6.5 Computer Program Versatility

Subtasks, subtask specific parameters, and non-subtask specific parameters imbue the computer program with versatility. The cost, dose and waste calculations can be performed for any room or combination of rooms. Tasks, subtasks and parameters can be added, refined or deleted. Finally, the computer program is not limited to the D&D of Z-Plant; it can be applied to any structure which is contaminated predominately by transuranics.

7.0 COST ESTIMATES OF ALTERNATIVE PLANS

7.1 Derivation of Costs

The cost of each alternative endpoint was determined by the computer program using cost estimates from RHO-N-336, "Cost and Dose Calculations for Z-Plant D&D."(3) An overview of the program logic is given below.

7.1.1 The Subtask as the Elemental Cost Unit

The generic tasks and sub-tasks were discussed in Chapter 6. Each generic task is composed of from 4 to 19 subtasks. Each subtask results in a fundamental cost element. The manhours required to perform a unit amount of each subtask have been estimated.(3) Using the facilities data, the program calculates how many unit amounts of each subtask must be performed. The cost of each subtask is the product of the number of units to be performed, the manhours required per unit, and the labor cost of a manhour.

For example, consider subtask No. 10 of the generic task Glove Box or Hood Cleanup or Removal. All internal equipment must be removed from a glove box before the glove box itself can be moved. Therefore, subtask No. 10, "Bag Out Equipment," is performed on any glove box which contains internal equipment. Items of internal equipment in glove boxes are listed on the Glove Box and Hood General Characterization data sheet for each glove box, and this information is stored in the Facilities Data file.

When the program is instructed to calculate the cost of decontaminating a room it will search the Facilities Data file to discover if there is a glove box in the room. If it finds glove box data, it will use the data to decide whether or not to activate each subtask. For instance, if internal equipment is listed for the hood the computer will activate the "Bag Out Equipment" subtask and calculate its cost. The program will sum the cost of each activated subtask to determine the total cost of cleaning or removing the hood.

7.1.2 Cost Load Factors

It is expected that most of the decontamination work will be performed by a team of four: two decontamination workers, a decontamination supervisor, and a radiation monitor. It is assumed that only one of the decontamination workers can work directly on the subtask while the other 3 team members provide support. The amount of time for the one worker to perform a unit amount of the subtask was estimated, and this value was multiplied by various load factors to account for the conditions listed below:

1. A four man team
2. Workers must wear protective clothing and face masks
3. Additional security requirements in Z-Plant
4. Support by engineering and other functions
5. Overhead.

An appropriate factor is also included to account for the cost of consumables such as protective clothing and cleaning materials.

7.1.3 Deciding on an Endpoint

To calculate the cost to achieve an endpoint, the permissible residual contamination limits for that endpoint are put into the program. The computer searches the Facilities Data file to identify any surface, whether on equipment or structure, where these limits are exceeded. The program then activates the subtasks which are needed to bring the contamination levels down to the specified permissible limit.

Excessive contamination levels are treated in two ways. First, certain overriding decision criteria have been specified for each endpoint. For instance, even though they may be acceptably clean on the outside, all gloveboxes and internally contaminated pipe and ductwork will be removed from a room when the unrestricted endpoint is stipulated. Second, there is a decontamination factor for each subtask. Lacking any overriding decision criteria, the computer will search out the subtask

which has a sufficiently high decontamination factor to clean the surface to the specified permissible level. For instance, assume that a painted concrete wall is contaminated. If the contamination level on the wall is only twice the permissible level the computer will choose the subtask "Manual Wash" which has a decontamination factor of 2. If the contamination level on the wall is 50 times the permissible limit, manual washing is not an acceptable subtask. In this case the computer will opt for subtask "Abrasive Blast" with a decontamination factor of 100.

7.3 Estimated Decontamination Costs in 1979 Dollars

This section presents the estimated costs to decontaminate the entire Z-Plant complex, each area of Z-Plant, and each room in Area 2. These estimates are given for each endpoint and include all waste handling costs. The cost reductions attainable through use of advanced technology are also provided.

7.3.1 Decontamination Costs

Table 7.3-1 shows the estimated cost in 1979 dollars to decontaminate Z-Plant to each of the four designated endpoints using current burial practices and technology. Current burial practice is to package waste and bury it without further processing. Non-TRU waste is sent to shallow land burial. TRU waste is sent to 20 year retrievable storage whence it will be recovered and sent to deep geological storage. The constraint of current technology signifies that only equipment and technology which is currently available was considered for use in the study.

TABLE 7.3-1

THE COST IN MILLIONS OF 1979 DOLLARS TO DECONTAMINATE Z-PLANT
TO THE FOUR DESIGNATED ENDPOINTS USING CURRENT BURIAL
PRACTICES AND TECHNOLOGY

	ENDPOINTS			
	Unrestricted	Conditional	Restricted Use	Restricted Non-Use
Decontamination Cost	128.8	110.3	60.7	0.0
Annual Main- tenance and Surveillance Cost	2.0	2.2	2.4	2.6

- NOTES:
1. All costs include the packaging, storing, retrieval and final disposition of TRU waste where applicable.
 2. At the unrestricted endpoint surfaces have been cleaned to the unrestricted contamination limits, but razing of the facility is not included and undetectable hidden contamination may remain.

One assumption made in the study is a significant exception from current burial practice. In order to provide realistic cost estimates it has been assumed that the 10 nCi/g boundary between TRU and non-TRU waste can be accurately measured. In reality, there is no nondestructive assay equipment available that can measure the transuranic activity in packaged dense waste such as glove boxes. Z-Plant presently generates only very small amounts of dense transuranic waste, and due to the lack of any alternative, treats it all as TRU waste. Clearly this will be an unacceptable method of handling sizeable volumes of transuranic contaminated waste.

Table 7.3-2 gives the estimated cost to decontaminate each Area to endpoints 1, 2 and 3 using current burial practices and technology. These estimates include the same assumptions that were used to develop Table 7.3-1. A room-by-room cost breakdown for Area 2 is shown in Table 7.3-3. A room-by-room cost breakdown for any combination of rooms can be provided as needed.

7.4 Cost Reduction from Advanced Technology

Advanced Technology refers to waste reduction processes which have been demonstrated to be feasible on a laboratory scale, but where at least one significant development aspect (usually criticality prevention) is not complete.⁽³⁾ The cost estimates used for the advanced technologies are based on information derived from visits to the demonstration facilities, discussions with the respective program managers, and experimental work presently being performed for the 233-S Dismantling Project.⁽¹⁾ Engineering factors are included to allow for the uncertainties associated with the unresolved technical problems.

Only those processes which will significantly reduce the cost of decontaminating Z-Plant are discussed. In all cases the savings derive from either the reduction of waste volume or the conversion of TRU waste to non-TRU waste. Table 7.4-1 shows the estimated cost reductions which are possible for each endpoint through the use of advanced technology if the entire Z-Plant complex is decontaminated. All estimates include the assumption that the 10 nCi/g TRU waste boundary can be accurately measured.

Cost figures are given for each process or combination of processes which can be used. Compaction and acid digestion are alternative methods of treating combustible waste and only one would be used. Size reduction is a preliminary step in the vibratory finishing process, and both processes are prerequisites to electropolishing.

The table indicates that electropolishing reduces savings. This occurs when the sole requirement is to decontaminate waste below the 10 nCi/g limit because vibratory finishing performs this task faster and cheaper than electropolishing. However, electropolishing will be

TABLE 7.3-2

THE COST IN 1979 DOLLARS TO DECONTAMINATE EACH AREA OF
Z-PLANT TO THE RESPECTIVE ENDPOINTS USING
CURRENT BURIAL PRACTICES AND TECHNOLOGY

Area	Endpoint		
	Unrestricted	Conditional	Restricted Use
1	2,437,000	2,200,000	1,840,000
2	19,398,000	18,063,000	15,955,000
3	26,433,000	24,159,000	20,891,000
4	1,254,000	1,097,000	871,000
5	5,629,000	4,657,000	3,226,000
6	1,427,000	1,181,000	737,000
7	0	0	0
8	1,268,000	1,030,000	638,000
9	3,864,000	3,209,000	2,240,000
10	4,885,000	4,173,000	3,062,000
11	4,026,000	3,404,000	2,478,000
12	5,409,000	4,329,000	2,803,000
13	697,000	584,000	366,000
14	14,481,000	11,534,000	2,094,000
15	0	0	0
16	0	0	0
17	36,014,000	29,275,000	3,450,000
18	1,564,000	1,488,000	84,000
TOTAL	128,796,000	110,343,000	60,735,000

TABLE 7.3-3

THE COST IN 1979 DOLLARS TO DECONTAMINATE EACH ROOM IN
AREA 2 OF Z-PLANT TO THE RESPECTIVE ENDPOINTS USING
CURRENT BURIAL PRACTICES AND TECHNOLOGY

Room	Endpoint		
	Unrestricted	Conditional	Restricted Use
192A	263,000	226,000	151,000
192B	105,000	89,000	56,000
192C	82,000	69,000	44,000
227	1,337,000	1,298,000	1,239,000
228	2,567,000	2,424,000	2,214,000
229	223,000	189,000	121,000
230	3,737,000	3,496,000	3,127,000
231	1,755,000	1,692,000	1,597,000
232	380,000	323,000	203,000
232A	1,180,000	1,121,000	1,129,000
233	276,000	231,000	146,000
234	355,000	322,000	253,000
235A	1,146,000	1,078,000	986,000
235B	4,109,000	3,814,000	3,368,000
236	1,196,000	1,082,000	862,000
237	333,000	299,000	238,000
238	27,000	22,000	16,000
245	145,000	132,000	103,000
C19	80,000	70,000	48,000
C239A	51,000	43,000	27,000
C239B	51,000	43,000	27,000
TOTAL	19,398,000	18,063,000	15,955,000

TABLE 7.4-1

THE COST REDUCTIONS POSSIBLE IN Z-PLANT
FOR EACH ENDPOINT BY USE OF ADVANCED
WASTE REDUCTION TECHNOLOGY*

Advanced Waste Reduction Technology	Unrestricted Endpoint	Conditional Endpoint	Restricted Use Endpoint
1. Compaction	310,000	225,000	164,000
2. Acid Digestion	737,000	667,000	423,000
3. Size Reduction	5,983,000	6,982,000	3,479,000
4. Size Reduction and Vibratory Finishing	10,099,000	10,099,000	5,872,000
5. Size Reduction, Vibratory Finishing and Electropolishing	9,763,000	9,763,000	5,677,000
6. Compaction and Size Reduction	6,293,000	6,208,000	3,643,000
7. Compaction, Size Reduction and Vibratory Finishing	10,409,000	10,326,000	6,036,000
8. Compaction, Size Reduction, Vibratory Finishing and Electropolishing	10,073,000	9,988,000	5,941,000
9. Acid Digestion and Size Reduction	6,720,000	6,640,000	3,902,000
10. Acid Digestion, Size, Reduction and Vibratory Finishing	10,836,000	10,756,000	6,295,000
11. Acid Digestion, Size Reduction, Vibratory Finishing and Electropolishing	10,810,000	10,730,000	6,100,000

* The cost reductions shown are gross savings in 1979 dollars
and do not include the cost of the "Advanced" equipment.

necessary if surface contamination levels for non-TRU waste are ever restricted to significantly below the 10,000 dpm/100 cm² α level. In this case, no savings will be available from vibratory finishing because the process will be incapable of converting TRU waste to non-TRU waste.

Tables 7.4-2, -3 and -4 show the cost reductions possible in each area from using advanced technology to achieve each endpoint. Tables 7.4-5, -6 and -7 provide the same information for a room-by-room breakdown of Area 2. Any endpoint residual contamination level can be specified, and information similar to that shown in Table 7.4-5 can be calculated for any combination of rooms. This information will indicate whether the savings potential of advanced technology warrants investing in these waste reduction processes if only certain parts of Z-Plant are decontaminated. The program can easily be modified to perform these calculations for any advanced technological process.

7.5 Utility of the Facility

Table 7.5-1 provides information related to the future use of the facility. Column 1 shows the annual maintenance and surveillance cost for the decontaminated facility. This value is included in Table 2.3-1 to account for an estimated 20 year future life of the facility.

Column 2 gives the cost to raze the facility if it is first decontaminated to the unrestricted endpoint. The workers are assumed to wear one set of protective clothing for precautionary purposes. The razing cost is not included on previous cost tables unless explicitly mentioned. There is no annual maintenance and surveillance cost for a razed facility.

The interior of the structure will be somewhat impaired by decontamination work. Consequently, some restoration will be required if the building is to be reused following decontamination. The net reuse value of the facility, which is shown in Column 3 of Table 7.5-1, is the value of the restored facility minus the restoration cost. A small portion of the facility, such as the office space in Area 7, will be reusable for any activity without restoration because it already meets the unrestricted criteria.

TABLE 7.4-2

COST REDUCTIONS POSSIBLE IN EACH AREA THROUGH UTILIZATION
OF ADVANCED WASTE REDUCTION TECHNOLOGY TO ACHIEVE
THE UNRESTRICTED ENDPOINT*

	1	2	3	4	5
Area	Compaction (\$ x 1000)	Acid Digestion (\$ x 1000)	Size Reduction (\$ x 1000)	Size Reduction and Vibratory Finishing (\$ x 1000)	Size Reduction, Vibratory Finishing, and Electropolishing (\$ x 1000)
1	4	16	139	234	226
2	25	134	1,297	2,191	2,116
3	38	190	1,746	2,947	2,849
4	3	7	55	94	90
5	16	16	83	140	136
6	2	1	0	0	0
7	0	0	0	0	0
8	2	1	0	0	0
9	11	11	58	99	95
10	13	18	117	197	191
11	10	16	107	181	175
12	16	11	28	47	45
13	1	1	0	0	0
14	50	81	576	972	940
15	0	0	0	0	0
16	0	0	0	0	0
17	106	221	1,712	2,890	2,794
18	13	13	65	110	107

*. How to use this table: Columns 1 and 2 are applicable to combustible waste only and are alternatives. Columns 3, 4 and 5 are applicable to noncombustible waste and are alternatives. Total cost reduction in 1979 dollars is the sum of one of the first two columns and one of the last three columns.

TABLE 7.4-3

COST REDUCTIONS POSSIBLE IN EACH AREA THROUGH UTILIZATION OF
ADVANCED WASTE REDUCTION TECHNOLOGY TO ACHIEVE
THE CONDITIONAL ENDPOINT*

	1	2	3	4	5
Area	Compaction (\$ x 1000)	Acid Digestion (\$ x 1000)	Size Reduction (\$ x 1000)	Size Reduction and Vibratory Finishing (\$ x 1000)	Size Reduction, Vibratory Finishing, and Electropolishing (\$ x 1000)
1	4	16	139	234	226
2	21	130	1,297	2,191	2,116
3	30	183	1,746	2,947	2,849
4	3	7	55	94	90
5	12	12	83	140	136
6	2	1	0	0	0
7	0	0	0	0	0
8	2	1	0	0	0
9	8	9	58	99	95
10	9	14	117	197	191
11	7	13	107	181	175
12	12	8	28	47	45
13	1	1	0	0	0
14	36	67	576	972	940
15	0	0	0	0	0
16	0	0	0	0	0
17	67	184	1,712	2,890	2,794
18	11	11	65	110	107

* How to use this table: Columns 1 and 2 are applicable to combustible waste only and are alternatives. Columns 3, 4 and 5 are applicable to noncombustible waste and are alternatives. Total cost reduction in 1979 dollars is the sum of one of the first two columns and one of the last three columns.

TABLE 7.4-4

COST REDUCTIONS POSSIBLE IN EACH AREA THROUGH UTILIZATION
OF ADVANCED WASTE REDUCTION TECHNOLOGY TO ACHIEVE THE
RESTRICTED USE ENDPOINT*

	1	2	3	4	5
Area	Compaction (\$ x 1000)	Acid Digestion (\$ x 1000)	Size Reduction (\$ x 1000)	Size Reduction and Vibratory Finishing (\$ x 1000)	Size Reduction, Vibratory Finishing, and Electropolishing (\$ x 1000)
1	3	14	81	137	132
2	16	111	744	1,257	1,214
3	23	153	1,016	1,715	1,660
4	3	7	37	62	60
5	8	10	51	86	83
6	2	1	0	0	0
7	0	0	0	0	0
8	2	1	0	0	0
9	7	9	36	61	59
10	6	13	71	120	116
11	5	12	68	115	111
12	9	7	18	30	29
13	1	0	0	0	0
14	25	27	331	559	540
15	0	0	0	0	0
16	0	0	0	0	0
17	46	47	983	1,659	1,604
18	8	10	42	71	69

* How to use this table: Columns 1 and 2 are applicable to combustible waste only and are alternatives. Columns 3, 4 and 5 are applicable to noncombustible waste and are alternatives. Total cost reduction in 1979 dollars is the sum of one of the first two columns and one of the last three columns.

TABLE 7.4-5

COST REDUCTIONS POSSIBLE IN AREA 2 OF Z-PLANT THROUGH
UTILIZATION OF ADVANCED WASTE REDUCTION TECHNOLOGY TO
ACHIEVE THE UNRESTRICTED ENDPOINT*

	1	2	3	4	5
Area	Compaction \$	Acid Digestion \$	Size Reduction \$	Size Reduction and Vibratory Finishing \$	Size Reduction, Vibratory Finishing, and Electropolishing \$
192A	779	686	0	0	0
192B	743	371	0	0	0
192C	583	292	0	0	0
227	814	13,307	131,497	221,954	214,585
228	1,920	21,911	213,565	360,477	348,509
229	653	326	0	0	0
230	3,698	26,151	285,414	481,750	465,757
231	1,543	17,022	165,597	279,511	270,231
232	633	316	0	0	0
232A	1,834	9,037	101,464	171,262	165,576
233	1,000	500	0	0	0
234	633	317	0	0	0
235A	1,568	10,195	95,938	161,934	156,558
235B	3,854	31,195	298,345	503,577	486,858
236	1,905	1,484	5,422	9,152	8,848
237	573	286	0	0	0
238	437	219	0	0	0
245	458	229	0	0	0
C19	407	229	0	0	0
C239A	241	120	0	0	0
C239B	241	120	0	0	0

* How to use this table: Columns 1 and 2 are applicable to combustible waste only and are alternatives. Columns 3, 4 and 5 are applicable to noncombustible waste and are alternatives. Total cost reduction in 1979 dollars is the sum of one of the first two columns and one of the last three columns.

TABLE 7.4-6

COST REDUCTIONS POSSIBLE IN AREA 2 OF Z-PLANT THROUGH
UTILIZATION OF ADVANCED WASTE REDUCTION TECHNOLOGY TO
ACHIEVE THE CONDITIONAL ENDPOINT*

	1	2	3	4	5
Area	Compaction \$	Acid Digestion \$	Size Reduction \$	Size Reduction and Vibratory Finishing \$	Size Reduction, Vibratory Finishing, and Electropolishing \$
192A	668	686	0	0	0
192B	636	371	0	0	0
192C	494	292	0	0	0
227	695	13,307	131,497	221,954	214,585
228	1,641	21,004	213,565	360,477	348,509
229	550	326	0	0	0
230	3,131	25,218	285,414	481,750	465,757
231	1,309	16,355	165,597	279,511	270,231
232	538	316	0	0	0
232A	1,559	8,651	101,464	171,262	165,576
233	843	500	0	0	0
234	548	317	0	0	0
235A	1,337	9,894	95,938	161,934	156,558
235B	3,277	30,268	298,345	503,577	486,858
236	1,623	1,484	5,422	9,152	8,848
237	492	286	0	0	0
238	386	219	0	0	0
245	399	229	0	0	0
C19	366	229	0	0	0
C239A	204	120	0	0	0
C239B	204	120	0	0	0

* How to use this table: Columns 1 and 2 are applicable to combustible waste only and are alternatives. Columns 3, 4 and 5 are applicable to noncombustible waste and are alternatives. Total cost reduction in 1979 dollars is the sum of one of the first two columns and one of the last three columns.

TABLE 7.4-7

COST REDUCTIONS POSSIBLE IN AREA 2 OF Z-PLANT THROUGH
UTILIZATION OF ADVANCED WASTE REDUCTION TECHNOLOGY TO
ACHIEVE THE RESTRICTED USE ENDPOINT*

	1	2	3	4	5
Area	Compaction \$	Acid Digestion \$	Size Reduction \$	Size Reduction and Vibratory Finishing \$	Size Reduction, Vibratory Finishing, and Electropolishing \$
192A	511	608	0	0	0
192B	504	319	0	0	0
192C	371	238	0	0	0
227	527	11,502	77,431	130,696	126,357
228	1,256	17,980	118,508	200,030	193,389
229	463	281	0	0	0
230	2,319	21,581	157,381	265,643	256,824
231	988	13,958	98,742	166,667	161,133
232	406	263	0	0	0
232A	1,173	7,346	59,783	100,908	97,558
233	635	378	0	0	0
234	414	244	0	0	0
235A	1,009	8,463	56,633	95,591	92,417
235B	2,490	25,791	172,270	290,774	281,121
236	1,238	1,162	3,617	6,105	5,902
237	406	263	0	0	0
238	271	177	0	0	0
245	284	184	0	0	0
C19	269	184	0	0	0
C239A	149	96	0	0	0
C239B	149	96	0	0	0

* How to use this table: Columns 1 and 2 are applicable to combustible waste only and are alternatives. Columns 3, 4 and 5 are applicable to noncombustible waste and are alternatives. Total cost reduction in 1979 dollars is the sum of one of the first two columns and one of the last three columns.

TABLE 7.5-1
UTILITY OF THE FACILITY

Endpoint	Annual Cost of Maintenance and Surveillance (1979 \$ x 106)	Cost to Raze the Facility (1979 \$ x 106)	Net Reuse Value (1979 \$ x 106)
Unrestricted	2.02	28.9	24.7
Conditional	2.17	--	20.0
Restricted Use	2.37	--	17.2
Restricted Non-Use	2.58	--	9.5

8.0 OCCUPATIONAL DOSE IN Z-PLANT

The Z-Plant occupational dose is the dose received by personnel employed in the facility. Decontamination influences two components of occupational dose: the dose to maintenance and surveillance personnel and the dose to the decontamination work force. These components tend to offset one another because decontamination will lower the subsequent maintenance and surveillance exposure.

8.1 Maintenance and Surveillance Dose

The maintenance and surveillance dose is computed in the Utility Model subroutine as an annual whole body dose rate. First, a residual contamination endpoint level is stipulated from which an average dose rate (man-rem/hour) in the facility can be calculated. Next, the number of hours per year that maintenance and surveillance personnel must spend in the facility for that endpoint is determined. The annual dose rate (man-rem/year) is the product of the average dose rate (man-rem/hour) and the average annual maintenance and surveillance exposure time (hours/year).

8.2 The Dose to Decontamination Personnel

The decontamination worker dose is calculated for each subtask by the D&D generic task subroutines. Both a whole body dose and an inhalation dose are computed. Each dose is the product of the number of man-hours required to perform the subtask times the respective exposure rates (whole body and inhalation) which exist while the work is being done.

8.2.1 The Whole Body Dose

The whole body dose is calculated using two dose rates: a room dose rate and a proximity dose rate. The room dose rate, derived from radiation monitoring records, is the average whole body dose rate which exists throughout the room. The proximity dose rate, derived from the radioactive isotope inventory in each glove box, is the whole body dose rate which exists close to the glove boxes.

The whole body dose is the sum of the room dose and the proximity dose. The room dose is the product of the room dose rate times the total number of hours that the room is occupied. The proximity dose is the

product of the proximity dose rate times the total number of hours spent working near the glove boxes. Both dose rates are included in the Facilities Data file and are appropriately reduced as decontamination work progresses in order to account for the removal of part of the radiation source.

An extremity dose to the hands and arms while work is being performed in the glove boxes is calculated in a similar manner. An extremity dose rate is computed for each glove box based upon its radioisotopic inventory. Both the proximity and extremity dose rates are calculated based on the predicted inventories in the glove boxes after Terminal Cleanout.

8.2.2 Inhalation Dose

The inhalation dose is caused by the contamination released to the air in the work area by each subtask. The level of airborne contamination depends upon the concentration of the surface contamination which is disturbed, the fraction of the surface contamination which is released to the air by the disturbance, the volume of the room, and the number of air changes per hour. The inhalation dose depends upon the level of airborne contamination, its isotopic makeup, the breathing rate of the workers, the protection factor offered by their protective masks, and the total time of exposure.

8.3 The Occupational Dose Corresponding to Each Endpoint

Table 8.3-1 gives the occupational whole body dose in Z-Plant for each of the four designated endpoints. The maintenance and surveillance measurement, which is dose rate rather than accumulated dose, has been multiplied by a 20 year period to convert it to dose units for comparison purposes. A 20 year period was chosen as the estimated life of Z-Plant.

The apparent trade-off between maintenance and surveillance dose and the dose to decontamination workers is misleading. Pu-239, with a half-life of 24,360 years, is essentially stable. Since Z-Plant must eventually deteriorate, decontamination can be postponed but not avoided. The annual maintenance and surveillance dose might be considered the interest payment for postponing decontamination.

TABLE 8.3-1

THE D&D RELATED OCCUPATIONAL WHOLE BODY DOSE IN Z-PLANT
FOR THE FOUR DESIGNATED ENDPOINTS

ENDPOINT	WHOLE BODY DOSE		
	Maintenance and Surveillance Whole Body Dose Over 20 Years (Man-rem)	Decontamination Worker Whole Body Dose (Man-rem)	Total Whole Body Dose (Man-rem)
Unrestricted	Negligible	326	326
Conditional	6	326	332
Restricted Use	30	305	335
Restricted Non-Use	300	220	520

Table 8.3-2 shows the inhalation dose received by decontamination personnel in cleaning Z-Plant to each of the four endpoints. Inhalation dose results from airborne contamination, and is an abnormal condition created by decontamination activities. Consequently no significant inhalation dose is received by maintenance and surveillance personnel.

TABLE 8.3-2

THE D&D RELATED INHALATION DOSE IN Z-PLANT FOR THE
FOUR DESIGNATED ENDPOINTS

ENDPOINT	INHALATION DOSE (MAN-REM)				
	GI-LLI	Thyroid	Bone	Liver	Lung
Unrestricted	.0003	0	.070	.008	.112
Conditional	.0002	0	.060	.007	.096
Restricted Use	.0001	0	.033	.003	.053
Restricted Non-Use	0	0	0	0	0

Table 8.3-3 lists both the whole body and inhalation doses to D&D personnel from decontaminating each area of Z-Plant to the unrestricted endpoint. The corresponding reduction in the maintenance and surveillance dose has not been included since it has not been calculated on an area-by-area basis. Table 8.3-4 lists for a room-by-room breakdown of Area 2 the same type of information as given in Table 8.3-3.

TABLE 8.3-3

THE DOSE TO D&D PERSONNEL FROM
DECONTAMINATING EACH AREA OF Z-PLANT
TO THE UNRESTRICTED ENDPOINT

AREA	INHALATION DOSE (MAN-REM)					
	Whole Body Dose (man-rem)	GI-LLI	Thyroid	Bone	Liver	Lung
1	6.2	10^{-5}	0	10^{-3}	10^{-4}	10^{-3}
2	46.2	10^{-5}	0	10^{-2}	10^{-3}	10^{-3}
3	70.0	10^{-4}	0	10^{-2}	10^{-3}	10^{-2}
4	23.2	10^{-6}	0	10^{-4}	10^{-4}	10^{-3}
5	14.3	10^{-5}	0	10^{-3}	10^{-4}	10^{-3}
6	3.6	10^{-6}	0	10^{-3}	10^{-4}	10^{-3}
7	0	0	0	0	0	0
8	3.2	10^{-6}	0	10^{-3}	10^{-4}	10^{-3}
9	9.8	10^{-5}	0	10^{-3}	10^{-4}	10^{-3}
10	12.4	10^{-5}	0	10^{-3}	10^{-4}	10^{-3}
11	13.2	10^{-5}	0	10^{-3}	10^{-4}	10^{-3}
12	10.7	10^{-5}	0	10^{-3}	10^{-4}	10^{-3}
13	1.8	10^{-6}	0	10^{-4}	10^{-5}	10^{-4}
14	36.7	10^{-5}	0	10^{-2}	10^{-3}	10^{-2}
15	0	0	0	0	0	0
16	0	0	0	0	0	0
17	71.3	10^{-4}	0	10^{-2}	10^{-3}	10^{-2}
18	4.0	10^{-6}	0	10^{-3}	10^{-4}	10^{-3}

TABLE 8.3-4

THE DOSE TO D&D PERSONNEL FROM DECONTAMINATING
EACH ROOM IN AREA 2 TO THE UNRESTRICTED ENPOINT

ROOM NUMBER	INHALATION DOSE (MAN-REM)					
	Whole Body Dose (man-rem)	GI-LLI	Thyroid	Bone	Liver	Lung
192A	0.667	10^{-8}	0	10^{-4}	10^{-5}	10^{-4}
192B	0.266	10^{-7}	0	10^{-4}	10^{-5}	10^{-4}
192C	0.208	10^{-7}	0	10^{-5}	10^{-5}	10^{-4}
227	3.388	10^{-6}	0	10^{-3}	10^{-4}	10^{-3}
228	6.010	10^{-5}	0	10^{-3}	10^{-4}	10^{-3}
229	0.565	10^{-6}	0	10^{-4}	10^{-5}	10^{-4}
230	9.070	10^{-5}	0	10^{-3}	10^{-4}	10^{-3}
231	4.148	10^{-6}	0	10^{-3}	10^{-4}	10^{-3}
232	0.963	10^{-6}	0	10^{-4}	10^{-5}	10^{-4}
232A	2.990	10^{-6}	0	10^{-3}	10^{-4}	10^{-3}
233	0.699	10^{-6}	0	10^{-4}	10^{-5}	10^{-4}
234	.900	10^{-6}	0	10^{-4}	10^{-5}	10^{-4}
235A	2.904	10^{-6}	0	10^{-4}	10^{-4}	10^{-3}
235B	10.013	10^{-5}	0	10^{-3}	10^{-4}	10^{-3}
236	1.669	10^{-6}	0	10^{-3}	10^{-4}	10^{-3}
237	0.844	10^{-6}	0	10^{-4}	10^{-5}	10^{-4}
238	0.068	10^{-7}	0	10^{-5}	10^{-6}	10^{-5}
245	0.367	10^{-7}	0	10^{-4}	10^{-5}	10^{-4}
C19	0.203	10^{-7}	0	10^{-5}	10^{-6}	10^{-4}
C239A	0.129	10^{-7}	0	10^{-5}	10^{-6}	10^{-5}
C239B	0.129	10^{-7}	0	10^{-5}	10^{-6}	10^{-5}

9.0 OFFSITE RADIOLOGICAL RISK OF ALTERNATIVE PLANS

The various alternatives in the decontamination and decommissioning of Z-Plant can affect the radiological risk to the offsite population in several different ways. This study examines the effect on offsite risk of achieving the various alternatives. The base case is a deactivated contaminated facility.

9.1 Nature of Risk Analysis

Offsite risk is a quantified measure of the radiological hazard to the public from a particular operation or facility. The potential for an accident which would breach the structural containment and release radioactive contaminants to the environment represents the hazard to the public.

Decontamination operations reduce offsite risk by stabilizing the radioactive contaminants as buried waste. The total impact of D&D on offsite risk includes 1) the risk reduction because there is less contamination in the facility, 2) the added risk caused by the D&D operations, and 3) the risk associated with the buried waste. The risk from the inactive facility and the buried waste will be called "innate residual offsite risk." The risk from the D&D operations will be called "D&D related offsite risk."

Risk is the mathematical product of the probability of a given accident and the predicted consequences of that accident. Total risk is the sum of the risks associated with all dominant accidents. Therefore, risk analysis is primarily concerned with estimating probabilities and consequences of various accidents.

9.2 Approach to Risk Quantification

9.2.1 Available Literature

6. NUREG/DR-0129, Volume 1 and 2, Technology, Safety and Costs of Decommissioning a Reference Small Mixed Oxide Fuel Fabrication Plant, C. C. Jenkins, E. S. Murphy and K. J. Schneider, Pacific Northwest Laboratory.
7. NUREG-0278, Technology, Safety and Costs of Decommissioning a Reference Nuclear Fuel Reprocessing Plant, Pacific Northwest Laboratories.

9.2.2 Dominant Accidents

9.2.2.1 Accidents in the Inactive Structure

The nine dominant accidents associated with the facility were obtained from the Z-Plant SAR. The following discussion addresses the effect of D&D on the consequences of each of the nine accidents.

a. Earthquake with Fire

The probability of this externally caused accident is not affected by D&D. As decontamination proceeds, the consequences of this accident are reduced in proportion to the percentage of radionuclides removed from the facility. A recent earthquake analysis has demonstrated that the probability of a damaging earthquake is one in one hundred years rather than the one in eight hundred and forty years reported in the Z-Plant SAR.(5) There is a 10 percent probability that the earthquake will cause a fire. Thus, the probability of an earthquake with fire is 1×10^{-3} events per year.

b. Waste Drum Fire Outside of the Structure

This accident is caused by improper rinsing of nitrated rags. Such small quantities of this waste would be generated in an inactive facility that the probability of this accident is negligible.

c. Product Removal Can Spill

A spill of concentrated plutonium solution (250 g/l) is the smallest contributor to total Z-Plant risk of the nine accidents analyzed in the Z-Plant SAR. The consequence of this accident is four orders of magnitude smaller than an earthquake with fire. This accident can be ignored because all concentrated plutonium solutions will be removed from Z-Plant during terminal cleanout.

d. Criticality

After terminal cleanout the inactive facility will contain more than a critical mass of plutonium. However, the plutonium will be very highly dispersed, i.e., on walls and floors, and the probability of a criticality is negligible.

e. Waste Drum Fire - Ventilation Zone III

Ventilation Zone III is that portion of Z-Plant where plutonium product is contained by only one physical barrier such as a glove box. This accident was significant when certain areas of Z-Plant were maintained above atmospheric pressure and a fire could release unfiltered air carrying radionuclides to the environment. However, the ventilation system has been modified to maintain a negative pressure throughout the facility which will prevent any unfiltered release from this accident.

f. Roof Fire/Major Fire

The probability of a major fire in Z-Plant was estimated using nationwide fire data. The only available data is for active facilities, and the probability of a fire in an inactive facility is somewhat lower. The probability of this accident is estimated as 2×10^{-4} occurrences per year. D&D will reduce the amount of radionuclides available for release by a fire.

g. Plane Crash

The probability of a plane impacting Z-Plant is constant until all or part of the building is razed. The probability of a plane crash and subsequent fire is calculated in the Z-Plant SAR to be 3×10^{-6} occurrences per year. The amount of radionuclides available for release is reduced by decontamination.

h. Tornado

ERDA-1538(6) reports the likelihood of a tornado in the Hanford area as 6×10^{-6} occurrences per year. This probability is not affected by D&D, but the potential radionuclide release due to this accident is reduced by decontamination.

i. Explosions

All explosion mechanisms addressed in the Z-Plant SAR are related to operations. The small explosions which are possible in an inactive structure have such low probabilities and minor consequences that explosions in an inactive structure need not be considered.

9.2.2.2 Accidents from D&D Operations

Decontamination operations are a potential source of accidents. Postulated decontamination accidents with the most severe consequences are discussed below.

a. Criticality

The inventory of plutonium isotopes in an inactive facility will be lower than in an active facility. Consequently, the severity of a criticality during D&D operations in an inactive facility is assumed to be less than for an operating facility because, on the average, less fissile material will be involved. The probability of a criticality during D&D operations is conservatively assumed to be 1×10^{-2} occurrences per year as calculated in the SAR for an operating facility.

b. Explosions

Explosions are a hazard during D&D operations. The consequences of an explosion depend upon the location and the amount of material involved. The assumed occurrence probability is the 1×10^{-3} /year as calculated in the Z-Plant SAR for the operating facility.

c. Filter Failure

An accidental rupture of the secondary HEPA filter during dismantling of the ventilation system could release plutonium to the environment. The probability of this accident is 1×10^{-2} events/year.

d. Other Possible Accidents

A number of minor accidents which could occur within the containment of the building during D&D would cause only negligible offsite exposure. Examples of such accidents are:

- Inadvertant cutting of contaminated metal
- Inadvertant dumping of contaminated solid waste
- Loss of local airborne contamination control
- Temporary loss of utility services
- Leaking radioactive liquids.

9.2.2.3 Transportation and Waste Handling Accidents

Transportation accidents involve either TRU waste or non-TRU waste.

TRU Waste

a. Waste Drum Fire

The dominant transportation accident is spontaneous ignition and fire in a waste drum while the waste drum is outside the building. The Z-Plant SAR gives the probability of this accident occurring either inside the building or during transit as 3×10^{-4} events per drum. Since the drum will be outside approximately 1/4 of the time during D&D operations, the probability of this event during outside handling and transport is $3/4 \times 10^{-4}$ events per drum.

b. Transport Accident

An accident during truck transportation of waste drums could cause a fire which would release radionuclides. Because of the short distance to the storage pad the probability of such a fire, as determined from data contained in ERDA-1538,(6) is 6×10^{-8} events per load.

Non-TRU Waste

a. Burial Trench Fire

The probability of a burial trench fire which could release mixed fission products and low level concentrations of plutonium is calculated in ERDA-1538. Approximately one burial trench fire will occur every 300 years. If it is assumed that 50 percent of the available radionuclides are released by the fire, the release probability for this accident is 2.8×10^{-6} curies released per curie buried.

b. Fire During Shipment to Burial Ground

The probability that a truck transporting waste will be involved in an accident which causes a fire is 6×10^{-8} events per truck load. Because of the low probability of this accident, its significance is inconsequential when compared to a burial trench fire.

9.2.2.4 Retrieval and Processing of TRU Waste

Waste generated during Z-Plant D&D will be sorted as TRU or non-TRU waste. Non-TRU waste will be permanently buried. TRU waste will be buried, but it must be retrieved within 20 years for processing and permanent disposition.

Methods for retrieval, processing, and final disposition of TRU waste are presently undefined and a detailed risk analysis is not feasible. However, this risk should be approximately the same order of magnitude as the risk associated with D&D and initial burial of the waste. Therefore,

this component of risk has been set equal to the D&D risk plus the transport risk for TRU waste. The risk of D&D and initial burial, and the risk of retrieval through final disposition are both one time risks borne twenty years apart.

9.2.2.5 Accidents Affecting Buried Waste

Buried radioactive waste is in a stable configuration. The risk of release during 20 year retrievable storage or permanent burial is orders of magnitude lower than for the same quantity of radionuclides contained in a structure, and is considered inconsequential for the purposes of this study.

9.2.3 Dose Conversion Factors

Two types of radioactivity can be accidentally released from Z-Plant: contamination and fission products. The dominant offsite dose from all of the described accidents except criticality is primarily due to Pu-238, Pu-239, Pu-240, Pu-241 and Am-241. A criticality promotes nuclear fission, and the offsite dose is dominated by fission products, i.e., the seven iodine isotopes.

A dose conversion factor is the computed value of the offsite dose in man-rem which results from the accidental release of one curie of a given isotope. The dose conversion factor depends upon both the radioactive isotope and the release mechanism. A dose conversion factor was calculated by Pacific Northwest Laboratories for every appropriate combination of accident and isotope. Factors were calculated for maximum individual exposure and total population exposure, and for a one year and a fifty year dose. Thus four dose conversion factors, for each of five isotopes (seven for the criticality), were calculated for each set of accident conditions.

The accidents fall into the following four categories based upon release height and meteorology:

a. Fire in Facility

Earthquake with fire, roof fire/major fire, plane crash and fire.

b. Very High Release

Tornado.

c. Outdoor Fire

Transport accident, burial trench fire.

d. Explosion

Explosion in the facility during decontamination.

9.2.4 Release from Normal D&D

In addition to accidental releases, there will be normal releases from D&D operations which will contribute to the public radiation exposure. NUREG-0278(7) predicts a release of 2.1×10^{-3} Ci from the normal D&D of a generic fuel reprocessing plant. About 80% of this release is from the plasma torch cutting of a liquid waste storage tank, an operation which will not occur in the D&D of Z-Plant.

The NUREG-0278 estimated release is based on an original inventory of 270,000 Ci of both transuranics and fission products, whereas the inventory of transuranics in Z-Plant at the start of D&D will be approximately 10,000 grams, or less than 20,000 Ci. Adjusting for the lower inventory and for not using torch cutting, the release from normal D&D of Z-Plant will not exceed 2×10^{-4} Ci. The SAR indicates that the release from normal operation of Z-Plant is 1.8×10^{-3} Ci/year. Since the release from normal D&D of the facility is only about one-tenth of the annual operational release, it does not contribute significantly to public radiation hazard and need not be considered in this study.

9.2.5 Long Term Risk

A structure which contains radionuclides represents an ongoing risk. The preceeding discussion quantifies that risk in the near term. Since Z-Plant is contaminated with long lived isotopes, significant decay of the radionuclides will not occur during the life of the buildings. Predicting risk beyond 50 years is impractical because the building will deteriorate, the local demography will change, and the meteorology may change. Therefore, this study does not attempt to quantify risk in the long term.

9.3 Results

Table 9.3-1 summarizes the risk calculations made in this study. The innate residual offsite risk is the annual risk associated with the facility and buried waste for each endpoint. The risk reduction achieved by decontaminating to endpoints 1, 2 and 3 is calculated by subtracting the innate residual offsite risk for each endpoint from the corresponding risk for alternative 4.

The D&D related offsite risk, which includes the risk of TRU retrieval and processing, is born only during the operational phases of the project. This risk can be considered the investment in risk reduction, and when divided by the annual risk reduction will yield the number of years required to "pay back" the investment.

Offsite risk reduction and D&D related offsite risk can be calculated for any combination of rooms in Z-Plant.

TABLE 9.3-1

OFFSITE RISK ASSOCIATED WITH ENDPOINT ALTERNATIVES USING CURRENT BURIAL PRACTICES AND TECHNOLOGY

Endpoint	Innate Residual Offsite Risk (man-rem/year)	Offsite Risk Reduction (man-rem/year)	D&D Related Offsite Risk (man-rem)
1. Unrestricted	<10 ⁻⁶	12.6	10.50
2. Conditional	<10 ⁻⁵	12.6	10.11
3. Restricted Use	4.8	7.8	6.19
4. Restricted Non-Use	12.6	0	0

10.0 A COMPARISON OF COST VERSUS RISK FOR EACH ENDPOINT

10.1 Introduction

Section 4.2.1, "Decision Criteria", discussed the difficulties inherent in equating cost measured in dollars to benefit measured in man-rem. A subjective decision on the dollar value of a man-rem is indispensable to this comparison. This chapter supplies the information needed to make this decision.

10.2 Cost, Risk and Waste Data Using Current Technology

Table 10.2-1 describes the cost, risk, and waste from decontaminating Z-Plant to each of the four endpoints using current burial practices and technology. The cost figures shown in Column 1 were taken from Table 7.3-1, and their derivation was explained in Section 7.3.

The radiation dose associated with each endpoint is shown in columns 2, 3 and 4. Chapter 9 elaborated on the innate residual offsite risk and the D&D related offsite risk. The former is the risk to the public that remains after the selected decontamination endpoint has been achieved. The latter is the risk to the public from accidents which could occur during the decontamination work.

The occupational dose was discussed in Chapter 8. It is the sum of the dose to the decontamination workers and the dose over a 20 year period to maintenance and surveillance personnel. The value given in column 4 is a summation of the whole body dose shown in Table 8.3-1 and the inhalation dose shown in Table 8.3-2.

TABLE 10.2-1

THE COST, RISK, AND WASTE FROM Z-PLANT D&D USING
CURRENT BURIAL PRACTICE AND TECHNOLOGY

	1	2	3	4	5	6
Endpoint	Cost (millions of 1979 dollars)	Innate Residual Offsite Risk (man-rem/yr)	D&D Related Offsite Risk (man-rem)	Occupational Dose (man-rem)	Volume of TRU Waste (ft ³)	Volume of Non- TRU Waste (ft ³)
1. Unrestricted	169.2	10 ⁻⁶	10.50	326.39	172,293	184,683
2. Conditional	153.7	10 ⁻⁵	10.11	304.71	172,293	133,914
3. Restricted Use	108.1	4.8	6.13	219.66	100,084	97,642
4. Restricted Non-Use	51.6	12.6	0	0	0	0

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The dollar amount given in column 1 is the cost to achieve the endpoint. The incremental cost to achieve any endpoint is determined by subtracting the cost of the restricted non-use endpoint from the cost of the subject endpoint. For instance, the incremental cost to achieve the unrestricted endpoint is the unrestricted endpoint cost (\$169,200,000) minus the restricted non-use endpoint cost (\$51,600,000).

The total dose associated with each endpoint is the sum of the numbers shown in columns 3 and 4. Column 2 is a dose rate and represents the annual offsite risk to the public because of the residual contamination in the plant. The incremental benefit, or dose reduction, of achieving an endpoint is the total dose associated with the restricted non-use endpoint minus the total dose of the subject endpoint. Thus, the man-rem reduction (benefit) of achieving the unrestricted endpoint is calculated by comparing the risk (column 2 and the sum of columns 3 and 4) associated with the unrestricted endpoint ($<10^{-6}$ man-rem/yr, 336.89 man-rem) with the total risk for the restricted non-use endpoint (12.6 man-rem/yr, 0 man-rem). As more decontamination is accomplished the values in columns 3 and 4 increase while the values in column 2 decrease. This is because the benefit consists of voluntarily undergoing the decontamination associated doses in order to reduce the innate residual offsite dose.

Columns 5 and 6 show the volumes of TRU and non-TRU waste respectively. These values are included because of the strong impact which waste handling has on total cost. Assumed waste handling costs are approximately \$70/ft³ for TRU waste and \$5.40/ft³ for non-TRU waste.

Tables 10.2-2 and 10.2-3 present the same type of information as given in Table 10.2-1 but on an area size and room size scale respectively. Similar tables can be generated for any room or combination of rooms.

10.3 Cost, Risk and Waste Data Using Advanced Technology

Table 10.3-1 illustrates the cost, risk and waste from decontaminating Z-Plant to the unrestricted endpoint using advanced technology in conjunction with current practice. The costs shown in column 1 are taken

TABLE 10.2-2

THE COST, RISK AND WASTE FROM EACH AREA OF Z-PLANT BY
DECONTAMINATING TO THE UNRESTRICTED ENDPOINT
USING CURRENT BURIAL PRACTICES AND TECHNOLOGY

	Cost (millions of 1979 dollars)	Reduction in Innate Residual Offsite Risk (man-rem/yr)	O&D Related Offsite Risk (man-rem)	Occupational Dose (man-rem)	Volume of TRU Waste (ft ³)	Volume of Non- TRU Waste (ft ³)
Area 1	2.43	.27	.21	8.47	3,986	2,461
Area 2	19.39	2.52	1.17	34.09	37,473	14,733
Area 3	26.43	3.38	2.28	65.01	50,230	22,860
Area 4	1.25	1.24	.09	29.94	1,595	1,517
Area 5	5.62	.16	.47	12.32	2,392	9,345
Area 6	1.42	0	.12	2.51	0	1,179
Area 7	0	0	0	0	0	0
Area 8	1.26	<.01	.11	3.89	0	964
Area 9	3.86	.11	.33	5.64	1,680	6,438
Area 10	4.88	.21	.41	9.28	3,360	7,691
Area 11	4.02	.21	.34	13.30	3,080	6,244
Area 12	5.40	.05	.45	9.96	797	9,788
Area 13	.69	<.01	.06	2.69	0	550
Area 14	14.48	1.07	1.24	43.43	16,570	29,640
Area 15	0	0	0	0	0	0
Area 16	0	0	0	0	0	0
Area 17	36.01	3.22	3.08	82.00	49,250	63,419
Area 18	1.56	.11	.14	3.86	1,880	7,854

TABLE 10.2-3

THE COST, RISK AND WASTE FROM DECONTAMINATING
EACH ROOM IN AREA 2 OF Z-PLANT TO THE UNRESTRICTED
ENDPOINT USING CURRENT BURIAL PRACTICES AND TECHNOLOGY

Room	Cost (millions of 1979 dollars)	Innate Residual Offsite Risk Reduction (man-rem/yr)	D&D Related Offsite Risk (man-rem)	Occupational Dose (man-rem)	Volume of TRU Waste (ft ³)	Volume of Non- TRU Waste (ft ³)
192A	.263	0	.04	.39	87	465
192B	.105	0	.08	.24	0	444
192C	.082	0	.07	.24	0	354
227	1.337	.11	.09	1.39	3,783	486
228	2.567	.27	.11	4.91	6,144	1,146
229	.223	0	.04	.58	0	390
230	3.737	.27	.15	4.07	8,211	2,208
231	1.755	.54	.09	3.33	4,764	924
232	.380	.05	.05	.81	0	378
232A	1.180	.21	.05	3.71	2,919	1,095
233	.276	0	.06	.49	0	597
234	.355	0	.03	.37	0	378
235A	1.146	.80	.07	7.95	66	936
235B	4.109	.27	.08	4.32	2,760	2,301
236	1.196	0	.15	.57	8,583	1,137
237	.333	0	.03	.30	156	342
238	.027	0	.03	.05	0	261
245	.145	0	.02	.12	0	273
C19	.080	0	.02	.09	0	243
C239A	.051	0	.01	.08	0	144
C239B	.051	0	.02	.08	0	144

TABLE 10.3-1

THE COST, RISK, AND WASTE FROM THE DECONTAMINATION OF
Z-PLANT TO THE UNRESTRICTED ENDPOINT USING ADVANCED
TECHNOLOGY IN CONJUNCTION WITH CURRENT PRACTICE

	1	2	3	4	5	6
The Advanced Technology Which is Used in Conjunction With Current Practice	Cost (millions of 1979 dollars)	Innate Residual Offsite Risk (man-rem/yr)	O&D Related Offsite Risk (man-rem)	Occupational Dose (man-rem)	Volume of TRU Waste (ft ³)	Volume of Non- TRU Waste (ft ³)
1. Current Practice (CP) Only	128.8	<10 ⁻⁶	10.50	326.39	172,293	184,683
2. CP + Compaction	128.5	<10 ⁻⁶	10.50	326.39	172,293	110,810
3. CP + Acid Digestion	128.1	<10 ⁻⁶	10.50	326.39	163,678	96,035
4. CP + Volume Reduction	122.8	<10 ⁻⁶	10.50	326.39	74,086	184,683
5. CP + Volume Reduction and Vibratory Finishing	118.8	<10 ⁻⁶	10.50	326.39	16,799	184,683
6. CP + Volume Reduction, Vibratory Finishing, and Electropolishing	119.0	<10 ⁻⁶	10.50	326.39	10,588	184,683
7. CP + Compaction and Volume Reduction	122.5	<10 ⁻⁶	10.50	326.39	74,086	110,810
8. CP + Compaction, Volume Reduction and Vibratory Finishing	118.4	<10 ⁻⁶	10.50	326.39	16,799	110,810
9. CP + Compaction, Volume Reduction, Vibratory Finish- ing and Electropolishing	118.8	<10 ⁻⁶	10.50	326.39	10,588	110,810
10. CP + Acid Digestion and Volume Reduction	122.1	<10 ⁻⁶	10.50	326.39	65,471	96,035
11. CP + Acid Digestion, Volume Reduction and Vibratory Finishing	118.0	<10 ⁻⁶	10.50	326.39	8,184	96,035
12. CP + Acid Digestion, Volume Reduction, Vibratory Finishing and Electropolishing.	118.0	<10 ⁻⁶	10.50	326.39	1,973	96,035

from Table 7.4-1. The innate residual offsite risk and the occupational dose values are all taken from row 1 of Table 10.2-1, and are the same for every case.

The innate residual offsite risk is constant because it depends primarily upon the inventory of transuranic contamination remaining in the facility, and this is not affected by advanced technology. The D&D related offsite risk increases slightly above the value for "Current Practice" because more handling of the waste is required prior to burial. Finally, the occupational dose is constant because, in their preliminary work with transuranic contaminated waste in their vibratory finishing and electropolishing development programs, Pacific Northwest Laboratories has found no detectable whole body radiation exposure to participating personnel.

The cost reductions available from using advanced technology accrue solely from reduced waste handling costs, and this is reflected in columns 5 and 6. Waste handling costs can be lowered by reducing the volume of combustible waste through compaction or acid digestion, by reducing the volume of non-combustible waste through volume reduction, or by converting \$70/ft³ TRU waste to \$5.40/ft³ non-TRU waste by vibratory finishing or electropolishing.

REFERENCES

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2. This cost data which has not been published was supplied by:

C. John Umbarger, Ph.D
Program Manager
Waste Assay Instrumentation Program
Health Physics Group (505-843-6249)
University of California
Los Alamos Scientific Laboratory
Los Alamos, New Mexico 87545
6. ERDA-1538, "Final Environmental Statement, Waste Management Operations, Hanford Reservation," U.S. Energy Research and Development Administration, December, 1975.
7. NUREG-0278, "Technology, Safety, and Costs of Decommissioning a Reference Nuclear Reprocessing Plant," Battelle Pacific Northwest Laboratory, October, 1977.

APPENDIX A

GENERIC D&D TASKS
AND SUBTASKS

STRUCTURAL DECONTAMINATION

1. Manual wash
2. Dry vacuum
3. Foam and vacuum
4. Chemically strip
5. Abrasive blast
6. Manual spalling
7. Cement scarifying
8. Mechanical spalling
9. Plaster removal
10. Fix with paint
11. Radiation survey
12. Seal openings
13. Emplace and remove strippable coating
14. Remove waste
15. Remove false ceiling
16. Remove partition

VENTILATION DECONTAMINATION

1. Radiation survey
2. Surface cleaning
3. Disconnect joints
4. Mechanical cutting
5. Blank ends
6. Remove waste

CONDUIT DECONTAMINATION

1. Radiation survey
2. Manual decontamination
3. Disconnect from electrical systems
4. Section conduit
5. Remove and section cable
6. Install temporary supports
7. Cut cable tray supports
8. Section cable tray
9. Remove waste

MISCELLANEOUS EQUIPMENT

1. Radiation survey
2. Package
3. Remove

PIPE DECONTAMINATION

1. Radiation survey
2. Clean surface
3. Disconnect flanges
4. Hydraulic pipe cut contaminated pipe
5. Hydraulic pipe cut non-contaminated pipe
6. Mechanical cut
7. Cap open ends
8. Bag
9. Remove waste

GLOVEBOX AND HOOD CLEANUP OR REMOVAL

1. Radiation Survey
2. Erect containment
3. Install temporary ventilation system
4. Decontaminate interior
5. Apply fixture
6. Remove external connections
7. Cut loadout ports
8. Seal openings
9. Disconnect internal connections
10. Bagout equipment
11. Bagout shielding
12. Remove structural supports
13. Seal glove ports
14. Seal viewing windows
15. Seal glass
16. Unbolt partitions
17. Cut partitions
18. Decontaminate outside
19. Remove waste

RHO-CD-761

APPENDIX B

BLANK COPIES OF CHARACTERIZATION FORMS

RHO-CD-761

Preparer's Name: _____

Date: _____

PROJECT B-244
D&D OF Z-PLANT
GENERAL CHARACTERIZATION
COVER SHEET

Building No.: _____ Room No.: _____

Current Occupant: _____

Current Use: _____

Room Dose (mR/Hr): _____

Applicable Reference Drawings:

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
13. _____
14. _____
15. _____
16. _____
17. _____
18. _____
19. _____
20. _____
21. _____
22. _____
23. _____
24. _____
25. _____

Preparer's Name: _____

RHO-CD-761

Date: _____

PROJECT B-244
D&D OF Z-PLANT
GENERAL CHARACTERIZATION

Building No.: _____ Room No.: _____

Wall: N; E; S; W

Length _____ Height _____ Thickness _____ Area _____ ft²

Material: concrete; aluminum; block; other _____

Finish: plaster; tile; paint; other _____

Type of Wall: bearing; partition; other _____

Shared Wall With: _____

Remarks:

Unacceptable D&D Tasks:

Openings: (Doorway, Vent Register, Duct, Pipes, Conduit)

Type	Diameter	Width	Height	Material
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

Columns

Dimensions:

Material: reinforced concrete; other _____

Contamination Level:

Area (ft ²)	Fixed Count (dpm)	Smearable Count (dpm)
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

Preparer's Name: _____

RHO-CD-761

Date: _____

PROJECT B-244
D&D OF Z-PLANT
GENERAL CHARACTERIZATION

Building No.: _____ Room No.: _____

Ceiling:

Length _____ Width _____ Thickness _____ Area _____ ft²

Material: concrete; aluminum; steel; other _____

Finish: vinyl; asbestos; tile; other _____

Lights: recessed _____; suspended _____

Remarks:

Unacceptable D&D Tasks:

Openings: (Vent Register, Duct, Pipes, Conduit)

Type	Diameter	Width	Length	Material
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

Contamination Level:

Area (ft ²)	Fixed Count (dpm)	Smearable Count (dpm)
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

Preparer's Name: _____

RHO-CD-761

Date: _____

PROJECT B-244
D&D OF Z-PLANT
GENERAL CHARACTERIZATION

Building No.: _____ Room No.: _____

Floor: _____

Length _____ Width _____ Thickness _____ Area _____ ft²

Material: concrete; steel; other _____

Finish: asbestos; tile; vinyl; other _____

Remarks: _____

Unacceptable D&D Tasks: _____

Openings: (Drain, Vent Register, Duct, Pipes, Conduit, Grating, Sump)

Type	Diameter	Width	Height	Material
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

Columns

Dimensions: _____

Material: reinforced concrete; other _____

Contamination Level: _____

Area (ft ²)	Fixed Count (dpm)	Smearable Count (dpm)
_____	_____ _____	_____ _____
_____	_____ _____	_____ _____
_____	_____ _____	_____ _____
_____	_____ _____	_____ _____

Preparer's Name: _____

PROJECT B-244
D&D OF Z-PLANT
GENERAL CHARACTERIZATION

Building No.: _____ Room No.: _____

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PROJECT B-244
D&D OF Z-PLANT
GENERAL CHARACTERIZATION
CONDUIT

Preparer's Name: _____

Date: _____

Building No.: _____

Room No.: _____

TYPE	WIDTH	HEIGHT	DIAMETER	LENGTH
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

RHO-CD-76.1

Preparer's Name: _____

PROJECT 8-244
D&D OF Z-PLANT
GENERAL CHARACTERIZATION

Date: _____

VENTILATION AND VACUUM SYSTEMS

Building No.: _____

Room No. : _____

[illegible]

EQUIPMENT DESCRIPTION/NOTES	UNIT		TOTAL				MASK ? REMOVAL SEQUENCE BEFORE (1) DURING (2) AFTER (3) PIPES/ HOODS	EXIT ACCESS- SIBLE POS- SIBLE
	TYPICAL UNIT CU.FT @#/CU.FT	TABULATION	TIME TO FREE MNHRS EACH	NUMBER	REMOVAL TIME	VOLUME (FT ³)	WEIGHT (LBS)	
A. INSTRUMENTS								
(1) Radiation, Mobile	5 @ 10							
(2) Radiation, Mounted	2 40							
(3) Other Portable								
(4) Other Mounted								
(5) Alarms/Horns/Bells	1/2 10							
B. CONTROLS								
(1) Unit (e.g. pump etc.)	2-1/2 10							
(2) Breaker Panels	20							
(3) System (e.g. mtr. ctr.)	20							
(4) Power Dist. Panel	30							
C. OPERATING UNITS								
(1) Motors (squared dimensions)	125							
(2) Pumps "	60							
(3) Fans "	10							
(4) Filters	12							
(5) Other								
D. MISCELLANEOUS								
(1) Light Fixtures	1 20							
(2) Fire Extinguishers	1 25							
(3) Containers								
(4) Ladders/Chairs	5 5							
(5) Desks/Cabinets/Files	30 3							
(6) Lavatory Fixtures	2 25							
E. CONTINUATIONS (Identify by Line)								