**Idaho
National
Engineering
Laboratory**

*Managed
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Department
of Energy*

**EGG-WTD-9594 Vol. VIII
January 1992**

APR 27 1992

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INFORMAL REPORT

**Preliminary Systems Design Study
Assessment Report
Volume VIII: Appendixes**

**J. L. Mayberry
F. Feizollahi
J. C. Del Signore**

*Work performed under
DOE Contract
No. DE-AC07-76ID01570*

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EGG-WTD-9594 Vol. VIII

EGG-WTD--9594-Vol.8

DE92 012537

PRELIMINARY SYSTEMS DESIGN STUDY ASSESSMENT REPORT

**Volume VIII
APPENDIXES**

**J. L. Mayberry
F. Feizollahi
J. C. Del Signore**

Published January 1992

**Idaho National Engineering Laboratory
EG&G Idaho, Inc.
Idaho Falls, Idaho 83415**

**Prepared for the
U.S. Department of Energy
Office of Environmental Restoration and Waste Management
Under DOE Idaho Field Office
Contract DE-AC07-76ID01570**

MASTER

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PRELIMINARY SYSTEMS DESIGN STUDY
ASSESSMENT REPORT
EGG-WTD-9594
Volume VIII

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ABSTRACT

The System Design Study (SDS), part of the Waste Technology Development Department at the Idaho National Engineering Laboratory (INEL), examined techniques available for the remediation of hazardous and transuranic waste stored at the Radioactive Waste Management Complex's Subsurface Disposal Area at the INEL. Using specific technologies, system concepts for treating the buried waste and the surrounding contaminated soil were evaluated. Evaluation included implementability, effectiveness, and cost. The SDS resulted in the development of technology requirements including demonstration, testing, and evaluation activities needed for implementing each concept.

The SDS results are published in eight volumes. Volume I contains an executive summary. The SDS summary and analysis of results are presented in Volume II. Volumes III through VII contain detailed descriptions of twelve system and four subsystem concepts. Volume VIII contains the appendixes.

ACKNOWLEDGMENTS

The authors would like to acknowledge the efforts of those that contributed to this report.

EG&G Idaho, Inc., Bechtel National, Inc., Ebasco Environmental, and IT Corp. for providing the assessments and functional and operational requirements for the 12 system and 4 subsystem concepts. Specifically, C. Klassy, K. Sherick and D. Haifner of EG&G Idaho, Inc., R. Schlueter, M. Pong, D. Harris, M. Beathard and P. Yen of Bechtel National, Inc., D. Prinzing, J. Bjorkstam, R. Vankateswar and S. Peck of Ebasco Environmental, J. Plum, J. Valdez, D. Vetter, M. Chavez, S. Djordevic, M. Swientoniewski, John McFee of IT Corp., and H. Kresny of Solmont Corporation.

Karen Grant and Janalee Nelson of EG&G Idaho, and Debra Iniquez of Bechtel National, Inc., for the extra effort required in editing this report.

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VOLUME VIII APPENDIXES

1. INTRODUCTION

This volume of the Systems Design Study contain four Appendixes that were part of the study. Appendix A is an EG&G Idaho, Inc., report that represents a review and compilation of previous reports describing the wastes and quantities disposed in the Subsurface Disposal Area of the Idaho National Engineering Laboratory. Appendix B contains the process flowsheets considered in this study, but not selected for detailed analysis. Appendix C is a historical tabulation of radioactive waste incinerators. Appendix D lists Department of Energy facilities where cementation stabilization systems have been used.

APPENDIX A

A BRIEF ANALYSIS AND DESCRIPTION OF TRANSURANIC WASTES IN THE SUBSURFACE DISPOSAL AREA OF THE RADIOACTIVE WASTE MANAGEMENT COMPLEX AT INEL

EGG-WTD-9438

A BRIEF ANALYSIS AND DESCRIPTION OF TRANSURANIC WASTES
IN THE SUBSURFACE DISPOSAL AREA
OF THE RADIOACTIVE WASTE MANAGEMENT COMPLEX
AT INEL

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Published February 1991

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Prepared for the
U.S. Department of Energy
Idaho Operations Office
Under DOE Contract No. DE-AC07-76ID01570

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EGG-WTD-9438

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ABSTRACT

This document presents a brief summary of the wastes and waste types disposed of in the transuranic contaminated portions of the Subsurface Disposal Area during the period 1954 through 1970. Wastes included in this summary are organics, inorganics, metals, radionuclides, and special-case wastes. In addition to summarizing amounts of wastes disposed and describing the wastes, the document also provides information on disposal pit and trench dimensions and contaminated soil volumes. The report also points out discrepancies that exist in available documentation regarding waste and soil volumes and makes recommendations for future efforts at waste characterization.

SUMMARY

This document presents a brief summary of the wastes and waste types disposed of in the Subsurface Disposal Area (SDA) at the Radioactive Waste Management Complex. The information presented in this report was compiled through the review of existing documents and is limited to the transuranic contaminated portions of the SDA, Pits 1 through 6, 9, and 10 and trenches 1 through 10. In addition to describing the wastes and disposal locations, several discrepancies between currently available documents are pointed out, and recommendations for future efforts aimed at characterizing the wastes are made.

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A BRIEF ANALYSIS AND DESCRIPTION OF TRANSURANIC WASTES
IN THE SUBSURFACE DISPOSAL AREA
OF THE RADIOACTIVE WASTE MANAGEMENT COMPLEX AT INEL

PURPOSE

The purpose of this report is to provide a brief overview and summary of the waste forms, types, and amounts buried in the Subsurface Disposal Area (SDA) at the Radioactive Waste Management Complex (RWMC) from 1952 to 1970. This document was prepared for use as necessary by programs within the EG&G Waste Technology Development Department, other EG&G organizations, and outside organizations interested in demonstrating potential remedial technologies at the SDA.

HISTORY

The RWMC was established in 1952 for the disposal of wastes generated at the National Reactor Testing Station (NRTS, now known as Idaho National Engineering Laboratory); wastes were later reviewed from a variety of sources, including government agencies, universities, and research laboratories. From 1952 to 1970 wastes consisting of solid wastes, transuranic (TRU) contaminated wastes (Barnes, 1989)^a, and low level wastes (LLW) were buried in a series of pits and trenches located in the area now known as the SDA.

Originally, these wastes were not segregated at the time of disposal; however, TRU wastes were generally placed in the pits, while LLWs were generally placed in the trenches. In 1970, above ground storage of TRU contaminated waste was initiated at the Transuranic Storage Area (TSA) at the RWMC. Currently, pit disposal at the SDA is utilized for LLWs only; trenches are no longer used for waste disposal.

a. For the purpose of this report TRU wastes are considered to be those wastes that are contaminated with alpha-emitting radionuclides that are heavier than uranium (atomic weight 92), have half-lives longer than 20 years, and are in concentrations greater than 10 nanocuries per gram.

DESCRIPTION

TRU wastes were disposed at the SDA in Pits 1 through 6, 9, 10, 11, and 12 and in Trenches 1 through 10 (refer to Figure 1 for details) and in limited amounts in Trenches 16 through 54 (Horton, 1988). During earlier retrieval efforts (circa 1978) the drummed wastes in pits 11 and 12 were removed (McKinley and McKinney, 1978); however, some wastes contained in boxes were left in the pits due to the deteriorated condition of the boxes (Horton, 1988). Pits 7 and 8 were used for the disposal of non-TRU wastes only (Card, 1977). Trenches were generally excavated to bedrock (basalt), approximately 10 ft down and averaged about 7 ft wide and up to 1800 ft long. Pits were excavated to bedrock and generally backfilled with 2 to 5 ft of soil to provide a level floor (Guay, 1989). Surface areas and volumes of the pits varied widely.

Following excavation, wastes were deposited into the pits and trenches. From 1952 until 1963, the waste containers (mainly steel drums and wooden and cardboard boxes) were stacked to optimize disposal space. From 1963 until 1969, the wastes were randomly dumped into the pits and trenches in order to limit worker radiation exposure. Beginning in 1969, the wastes containers were stacked in order to optimize disposal volume. Following emplacement of the wastes, the pits and trenches were backfilled and covered with at least 3 ft of the silty clay soil (Guay, 1989).

Excavated volumes of the pits and trenches are given in Table 1 (Guay, 1989). This table also includes the estimated volumes of soils placed in the pits and trenches as intermediate cover during placement of the wastes, backfilling of the pits and trenches, overburden placed after closure, and, in the case of the pits, underburden beneath the pits. Volumes of wastes disposed in the pits and trenches are also given. Excavation details of the individual pits and trenches are given in Tables 2 and 3.

The soils at the RWMC consist mainly of silty clays and sands. Details of the characteristics of INEL soils are presented in Tables 4 through 8.

Figure 1. Map of SDA and RWMC at INEL.

- PIT RAD WASTE
10 N C / GWH
- PIT RAD WASTE
BETA GAMMA
- PAD STORAGE
10 N C / GWH
- FIRE HYDRANT
- SUMP
- SHALLOW SOIL CIZ
- WASTE/CON/CANAL BONE
ENCOUNTERED DURING EXCAVATION
- UNRECORDED WASTE

- INFORMATION ON UNRECORDED WASTE
1. HIT WASTE AT 10' BELOW SURFACE DURING DRILLING OPERATIONS OF SVR 16 37' WEST OF EAST MONUMENT 3-14-83
 2. HIT WASTE AT APPROX 6' BELOW SURFACE DURING DRILLING OPERATIONS OF SVR 11 331', 333' & 343' WEST OF EAST MONUMENT 2-20-84
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 8. ENCOUNTERED WASTE DURING DRILLING OF SVR 12 CLOSED VAULT NOV 7-83
 9. ENCOUNTERED WASTE DURING SVR

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The soils at the RWMC consist mainly of silty clays and sands. Details of the characteristics of INEL soils are presented in Tables 4 through 8.

Figure 1. Map of SDA and RWMC at INEL.

Table 1. Summary of volumes of pits, trenches, wastes, and associated soils in selected pits and trenches at the SDA (Guay, 1989).

Location	Waste				Overburden Volume ft ³	Subsidence Volume ft ³	Underburden Volume ft ³
	Excavated Volume ft ³	Container Volume ft ³	Soil Volume ft ³				
T 1	81243	16897	64346		30563	0	NA
T 2	86932	6801	80131		26544	0	NA
T 3	90658	12375	78284		26664	689	NA
T 4	93828	17788	76040		26808	750	NA
T 5	112362	17905	94457		29245	0	NA
T 6	91982	15475	76507		26856	1800	NA
T 7	87278	10729	76549		29093	0	NA
T 8	97752	14143	83610		26880	156	NA
T 9	83633	13237	70396		28891	0	NA
T 10	91474	9107	82368		25904	923	NA
P 1	379135	81819	297316		107884	0	169532
P 2	1020359	418357	602002		425975	455	544852
P 3	368394	102059	266335		236150	0	70845
P 4	955309	388494	566815		787343	0	367427
P 5	796729	286612	510117		368236	18	100428
P 6	447515	223898	223617		409313	0	191013
P 9	342416	150690	191726		256812	353	149807
P 10	1052941	538865	514076		784084	0	526471
TOTAL	6279940	2325251	3954692		3654245	5144	2120375

a. Total volume of pits and trenches = 6,279,940 ft³
 Total volume of waste contained = 2,325,251 ft³
 Total volume of contaminated soil = 9,734,456 ft³
 Total volume of contaminated wastes and soils = 12,059,707 ft³

Does not include wastes retrieved during early and interim waste retrieval projects.

Table 2. Excavation details for selected pits at the SDA (Guay, 1989)

Pit #	Mean Surface Elevation (ft)	Mean Basal Surface Elevation (ft)	Average Estimated Overburden (ft)	Estimated Excavated Depth (ft)	Estimated Width (ft)	Estimated Length (ft)	Surface Area (ft ²)	Excavated Volume (ft ³)
1	5016.3	4995	3.5 (5.5) ^a	12.0	68	455	30,824	379,135
2	5014.1	4994	4.3 (5.5) ^a	10.3	87	1150	99,064	1,020,359
3	5014.3	5000	5.0 (1.5) ^a	7.8	100	472	47,230	368,394
4	5013.1	4993	7.5 (3.5) ^a	9.1	104	1000	104,979	955,309
5	5011.9	4993	5.5 (1.5) ^a	11.9	150	450	66,952	796,729
6	5012.2	4993	7.5 (3.5) ^a	8.2	120	455	54,575	447,515
9	5010.5	4993	6.0 (3.5) ^a	8.0	130	330	43,802	342,416
10	5104.1	4993	7.0 (4.7) ^a	9.4	120	940	112,015	1,052,941

a. The value in brackets is the depth of the soil left in place over the basalt when the pits were excavated.

Table 3. Excavation details for selected trenches at the SDA (Guay, 1989)

Trench #	Mean Surface Elevation (ft)	Mean Basalt Surface Elevation (ft)	Average Estimated Overburden (ft)	Estimated Excavated Depth ^a (ft)	Estimated Width (ft)	Estimated Length (ft)	Surface Area (ft ²)	Excavated Volume (ft ³)
1	5,012.9	4,997	3.8	10.1	7	1149	8,043	81,243
2	5,012.1	4,993	4.0	13.1	6	1106	6,636	86,932
3	5,012.6	4,993	4.0	13.6	6	1111	6,666	90,658
4	5,013.0	4,993	4.0	14.0	6	1117	6,702	93,828
5	5,013.6	4,997	3.8	14.6	6.6	1166	7,696	112,362
6	5,012.7	4,993	4.0	13.7	6	1119	6,714	91,982
7	5,014.2	4,997	3.8	11.4	6.6	1161	7,656	87,278
8	5,013.1	4,993	4.0	14.1	6	1120	6,720	97,752
9	5,013.8	4,997	3.8	11.0	6.6	1152	7,603	83,633
10	5,012.6	4,993	4.0	13.6	6	1121	6,726	91,474

a. The excavated depth was calculated by taking the difference between the surface elevation and the basalt elevation. From this value the estimated overburden was subtracted out. Finally, an additional 2 ft (1 ft for basalt overburden, 1 ft for depth of buried waste from original surface elevation) were subtracted out.

Table 4. Various Physical Characteristics of Soil and Sediment Samples from the RWMC Wells (EG&G Idaho 1989).

Well No.	Depth Interval		Specific Gravity	Bulk Density (g/cm ³)	Porosity (percent)	Moisture Content (percent)	Vertical Hydraulic Conduct. (m/day)
	Top (ft in.)	Bottom (ft in.)					
92	2 6	5	2.65	1.87	34.3	12.9	5.5 x 10 ⁻⁴
94	6 6	8 3	2.67	2.02	30.5	16.4	2.7 x 10 ⁻⁴
95	10	12 6	2.66	1.70	41.0	13.2	7.9 x 10 ⁻³

Table 5. Properties of soil and sediment samples from the RWMC wells (EG&G Idaho, 1989)

Well No.	Depth Interval		Particle Size Distribution(%) ^a			Clay Minerals (%)			Moisture Content (%)	Cation Exchange Capacity (meg/100 g)
	Top (ft in.)	Bottom (ft in.)	Clay	Silt	Sand	Kaolin-ite	Illite	Montmor-illonite		
92	2 6	5	21.2	48.8	30.1	2	5	5		14
94	6 6	8 3	38.7	56.5	4.8	3	9	4		23
95	10	12 6	38.5	55.6	5.9	1	4	3		17
Median ^b			35.9	56.0	7.3	2	7	6		21

- a. Clay <0.004 mm
 Silt 0.004 - 0.062 mm
 Sand 0.062 - <2.00 mm.
- b. Median of eight samples.

Table 6. Particle size distribution for subpit samples (in percent of analyzed sample^a (EG&G Idaho, 1989)

Sample ^b Number	Depth (in meters)	Clay <0.004 mm	Silt 0.004- 0.0625 mm	Sand Very Fine 0.0625- 0.125 mm	Sand Fine 0.125- 0.25 mm	Sand Medium 0.25- 0.5 mm	Sand Coarse ^c 0.5-1mm
EWR-1-4	0.91	53.3	38.5	4.8	2.3	0.9	0.1
EWR-1-3	1.22	41.0	30.1	11.0	17.7	0.2	0
EWR-1-2	1.52	54.7	40.1	4.1	0.7	0.2	0.1
EWR-1-1	1.83	23.5	69.8	6.0	0.6	0	0.1

a. Analyzed by the USGS Hydrologic Laboratory, Denver, Colorado.

b. All samples from surficial deposits.

c. No particles coarser than 1 mm observed.

Table 7. Mineralogy for subpit samples (in percent of analyzed sample)^a (EG&G Idaho, 1989)

Sample ^b Number	Depth (in meters)	Quartz	Potassium Feldspar	Plagioclase	Calcite	Pryoxene Dioxide	Clay Minerals	Total Percent
EWR-1-4	0.91	27	≤5	11	1	4	70	113+ ^c
EWR-1-3	1.22	29	≤6	10	0	9	55	103+
EWR-1-2	1.52	15	≤3	6	41	≤9	25	87+
EWR-1-1	1.83	29	5	12	13	≤9	40	99+

a. Analyzed by the USGS Hydrologic Laboratory, Denver, Colorado.

b. All samples from surficial deposits.

c. Due to high percentage of clay minerals.

Table 8. Clay mineralogy of selected surficial sediment samples (in percent of total clay minerals/percent of original bulk samples)^a (EG&G Idaho, 1989)

Sample	Depth (in meters)	Chlorite	Illite	Mixed Layer Clays (Illite/ Smectite)	Smectite	Kaolinite	Cation Exchange Capacity ^b	Carbonate Content (CaCO ₃) Percent
EWR-1-4	0.91	0/03	6/25	45/32	13/9	6/4	27	0
EWR-1-3	1.22	0/03	0/16	48/26	15/9	6/3	27	2.3
EWR-1-2	1.52	0/03	6/9	31/8	24/6	9/2	11	36.1
EWR-1-1	1.83	0/03	2/12	30/12	26/10	12/5	11	10.8

- a. Analyzed by the USGS Hydrologic Laboratory, Denver, Colorado.
b. In milliequivalents per 100 g.

WASTES DISPOSED

During the period 1954 to 1970 a wide variety of wastes and waste types were shipped to the SDA for disposal from on- and off-site generators. Table 9 presents a summary description of the makeup of the wastes buried at the SDA. Wastes of concern disposed of at the SDA include organics, inorganics, toxic metals, and radionuclides. Table 10 presents a listing of typical waste contaminants found at the SDA. A summary of the waste types buried at the SDA, giving weights and volumes, is presented in Table 11.

A variety of containers were utilized for the shipment of wastes to the SDA. These containers included steel drums (30, 40, and 55-gal), cardboard cartons, and wooden boxes (up to 105 in. x 105 in. x 214 in.). Larger individual items were disposed separately as loose trash. In addition, large amounts of plastic were used to line the containers and to wrap some of the boxes and most of the larger individual items. These plastics included polyethylene sheet plastic and drum liners, polyvinyl chloride sheets and liners, and plastic jugs and other containers of unknown composition. Tables 12 and 13 present a breakdown of the number of containers disposed of in the pits and trenches, respectively, at the SDA during the period 1954 to 1970. Waste items that may present a particular challenge for remedial technologies are summarized by pit in Table 14.

Nonradiological wastes of concern include primarily hazardous organics and various metals. Much of the organics were shipped to the SDA from off-site sources, particularly the Rocky Flats Plant (RFP). An estimate of the amounts of various organic compounds shipped from RFP to the SDA is given in Table 15. Estimates of the amount of organics generated at INEL and disposed in the SDA are not available. Estimates of the amounts of metal disposed at the SDA have generally included only nontoxic metals. These metals are of concern due to the large amounts present in the pits and trenches at the SDA and the difficulties that they may present during remediation of the wastes contained at the SDA. Estimated metal content is presented by pit/trench in Table 16.

Table 9. Summary listing of makeup of waste buried in the SDA at RWMC (McKinley, 1978)^a

Construction and Material	Lumber, wallboard, concrete blocks, steel plate, demolition and shapes, ducting, electrical wires, fuse boxes, roofing material, floor tile, insulation, lead sheet and bricks, asphalt paving material, soil, sand, gravel, steel stairways, and ladders.
Laboratory Equipment and Materials	Hoods, laboratory benches, desks, chairs, cabinets, glassware, plastic tubing, plastic and glass bottles, solutions stabilized in concrete or plaster, and vermiculite.
Process Equipment	Tanks, heat exchangers, tube bundles, condensers, pumps, piping, flanges, valves, organic wastes, ion exchange resins, zirconium plate, zirconium turnings, sawdust, and HEPA filters.
Maintenance Equipment	Hand tools, metal-working machines, cranes, hoists, welders, oils and grease, metal filings, abrasive wheels, and sheet.
Decontamination Materials	Paper, rags, plastic bags and sheet, floor sweepings, brooms, and steel wool.
Miscellaneous	Sewer sludge, garbage, animal remains and excreta, jet engines, vehicles, Test Reactor Area fuel, and boxes.

a. This listing is for the entire Subsurface Disposal Area (SDA). For the purpose of this document it is considered to be representative of the makeup of the TRU-contaminated waste.

Table 10. Typical waste contaminants at the SDA

1.	Organic Contaminated Sludge
	Trichloroethane
	1,1,1-Trichloroethane
	Carbon tetrachloride
	Trichloroethylene
	Tetrachloroethylene
	Perchloroethylene
	Methyl isobutyl ketone
	Methyl ethyl ketone
	Methylene bis (phenylisocyanate)
	n-Butanol
	Toluene diisocyanate
	Tributylphosphate
	Dichloromethane
	Freon 113
	Organophosphates
	Nitrobenzene
	Benzene
	Ether
	Xylene
	Toluene
	Ethylene glycol
	Texaco Regal Oil (gearbox, spindle, and hydraulic oils)
	PCB's (above 500 ppm in oil, quantities unknown)
	Ethylenediaminetetraacetic acid (EDTA)
	Kerosene
	Gasoline
	Asphalt
	Santo wax
2.	TRU-Organic Contaminated Waste
	Carbon tetrachloride
	Trichloroethane
	Texaco Regal Oil

Table 10. Continued

3. Hazardous Waste Sludge

Asbestos
Acids (hydrofluoric acid, hydrochloric acid)
Sodium, sodium compounds (sodium nitrate)
Potassium, potassium compounds (potassium nitrate)
Caustics (sodium hydroxide)
Ammonia bottles
Sulfur dioxide

4. Toxic Metals

Arsenic
Barium
Beryllium
Cadmium
Chromium
Lead
Lithium
Mercury
Selenium
Silver
Thallium oxide
Zirconium

5. General Radioactive Contaminants

Americium-241
Cesium-137
Cobalt-60
Neptunium
Plutonium (various)
Uranium (various)
Tritium

Table 10. Continued

6. General Wastes Contaminated with Wastes Listed Above

Aluminum

Carbon steel

Iron

Stainless steel

Glass

Portland cement

Graphite

Dirt, sand, and gravel

Table 11. Weight and volume fractions of wastes stored at the RWMC (Edinburgh, 1990)

CATEGORY	CODES	WEIGHT FRACTION ^a	VOLUME FRACTION ^a	DENSITY (lb/ft ³)
Combustibles	40	0.201	0.42	17.73
Sludge	36	0.327	0.18	67.22
Unknown/unclassifiable	21	0.097	0.15	24.87
Metals	15	0.222	0.086	95.87
Mixed waste	22	0.0389	0.073	19.86
Concrete, brick, particulates	38	0.0791	0.045	65.70
Nonmetals and glass	18	0.0284	0.041	25.95
Low level	7	0.00389	0.005	31.81
Remote handled	2	0.000961	0.001	25.31
NonTRU	1	0.00133	0.001	47.87
Salts	11	0.000691	0.0007	39.37

a. Weight and volume fractions of the buried TRU wastes are assumed to be same as that given for the stored TRU wastes.

Table 12. Waste container types, numbers, and total volumes for selected pits at the SDA (Guay, 1989)

<u>Pit #</u>	<u>Container Type</u>	<u>No. of Containers</u>	<u>Volume of Containers(ft³)</u>
1	Drums	8,285	60,917
	Wooden Boxes	152	8,001
	Cardboard Boxes	2,173	12,869
	Other	2	32
		<u>10,612</u>	<u>81,819</u>
2	Drums	34,480	252,077
	Wooden Boxes	1,048	75,728
	Cardboard Boxes	3,547	17,960
	Others	443	72,592
		<u>39,518</u>	<u>418,357</u>
3	Drums	6,684	48,961
	Wooden Boxes	201	10,565
	Cardboard Boxes	3,309	30,774
	Other	62	11,759
		<u>10,256</u>	<u>102,059</u>
4	Drums	31,467	231,330
	Wooden Boxes	624	68,060
	Cardboard Boxes	2,020	16,617
	Other	268	72,487
		<u>34,379</u>	<u>388,494</u>
5	Drums	19,652	144,355
	Wooden Boxes	919	110,831
	Cardboard Boxes	970	7,773
	Other	102	23,653
		<u>21,643</u>	<u>286,612</u>
6	Drums	13,912	102,272
	Wooden Boxes	590	73,918
	Cardboard Boxes	3,523	41,242
	Other	36	6,466
		<u>18,061</u>	<u>223,898</u>
9	Drums	3,937	28,942
	Wooden Boxes	520	72,735
	Cardboard Boxes	1,932	29,571
	Other	72	19,442
		<u>6,461</u>	<u>150,690</u>
10	Drums	27,101	189,857
	Wooden Boxes	2,311	274,048
	Cardboard Boxes	914	11,830
	Other	295	63,130
		<u>30,621</u>	<u>538,865</u>

Table 13. Waste container types, numbers, and total volumes for selected trenches at the SDA (Guay, 1989)

<u>Trench #^a</u>	<u>Container Type</u>	<u>No. of Containers</u>	<u>Volume of Containers(ft³)</u>
1	Drums	3,376	16,747
	Other	1	150
		<u>3,377</u>	<u>16,897</u>
2	Drums	1,045	6,761
	Wooden Boxes	4	40
		<u>1,049</u>	<u>6,801</u>
3	Drums	1,242	8,655
	Wooden Boxes	6	162
	Cardboard Boxes	1,423	7,115
		<u>2,671</u>	<u>15,932</u>
4	Drums	2,416	17,761
	Wooden Boxes	1	27
		<u>2,417</u>	<u>17,788</u>
5	Drums	2,541	18,176
		<u>2,541</u>	<u>18,176</u>
6	Drums	2,283	15,462
	Wooden boxes	1	13
		<u>2,284</u>	<u>15,475</u>
7	Drums	1,497	10,729
		<u>1,497</u>	<u>10,729</u>
8	Drums	1,654	12,160
	Cardboard boxes	793	3,965
		<u>2,447</u>	<u>16,125</u>
9	Drums	1,769	13,008
	Wooden boxes	1	224
	Cardboard box	2	10
		<u>1,772</u>	<u>13,242</u>
10	Steel drums	1,236	9,089
	Cardboard boxes	7	35
		<u>1,243</u>	<u>9,124</u>

- a. The stored waste in Trenches 1-10 consisted mainly of cardboard boxes from the INEL on-site generators. Intermixed with the on-site boxes were steel drums, wooden boxes, plastic bags, and loose waste. Some Rocky Flats waste is also intermixed. Values reflect the retrieved waste removed.

Table 14. Special waste considerations buried in pits at the SDA (Card, 1977)

Pit No.	Comments
1	Pit reopened in October, 1961, for disposal of some waste from the SL-1 reactor incident. Waste contained approximately 120 Curies of MFP. Highest radiation reading recorded was 10 R/h at contact. This waste is probably limited to the western end of the pit.
2	Large amounts of beta-gamma contaminated waste disposed with the TRU drums and boxes. This waste includes reactor shielding (36,000 lb), an aluminum heat exchanger (20,000 lb), drums with various contents, large (150 ft ³) concrete blocks contaminated with MFP, and other items. Also this pit contains contaminated material from the cleanup of the SL-1 incident. This pit was flooded in 1962, prior to closure.
3	NonTRU boxes from various on-site sources buried in this pit. These boxes apparently contain MFP. Six boxes (12,000 to 14,000 lb each) of intermediate-level waste (55-gal drum centered in a box, and the box was then filled with concrete shielding) buried at unknown locations in pit. SL-1 incident cleanup waste also buried in this pit.
4	MFP wastes intermixed with TRU wastes; locations are not clearly recorded (probably randomly dumped into the pit). Non-TRU waste (containers, scrap lumber, concrete, miscellaneous equipment, scrap metal, valves, and piping) generally confined to the westernmost 91 m of the pit.
5	No indication of non-TRU waste disposal; however, burial location for some of the wastes may be in error. A good possibility exists that some of the wastes may actually be outside of recorded pit boundaries.
6	No records of non-TRU waste disposal. Drums and boxes were not segregated during burial. A large number of boxes containing contaminated empty drums are buried in this pit.
9	No records of non-TRU waste disposal. Drums and boxes were not segregated. A large number of boxes containing contaminated empty drums are buried in pit.
10	No evidence of non-TRU waste disposal. Contains large number of boxes of contaminated empty drums, but the number of drums per box is not known. This pit was flooded in the spring of 1969, before it was closed.

Table 15. Volumes of organic wastes shipped from RFP to INEL (Kudera, 1987)

Year	RWMC Status	Number of Drums	(VOLUMES IN GALLONS)		
			Texaco Regal Oil	Carbon Tetrachloride	Other Organic ^a
1966	Buried	267	2,000 ^b	800 ^b	No Record
1967	Buried	5,518	22,247	14,832	4,255
1968	Buried	2,391	10,771	7,181	18,313
1969	Buried	<u>533</u>	<u>4,000^b</u>	<u>1,600^b</u>	<u>2,400^b</u>
Total	Buried	8,709	39,018	24,413	24,968
1970	Stored	1,092	2,528	1,685	35,135
1971	Stored	825	8,911	5,940	16,564
1972	Stored	953	11,322	7,548	10,771
1973	Stored	596	8,794	5,862	6,846
1974	Stored	572	9,158	6,106	5,356
1975	Stored	539	6,456	4,304	5,371
1976	Stored	361	4,548	3,032	4,179
1977	Stored	334	3,796	2,531	4,743
1978	Stored	471	3,388	2,259	12,431
1979	Stored	384	4,396	2,930	6,398
1980	Stored	422	5,095	3,396	7,925
1981	Stored	674	8,557	5,705	10,127
1982	Stored	480	6,736	4,491	7,670
1983	Stored	387	10,189	6,792	9,240
1984	Stored	276	8,646	5,764	120
1985	Stored	300	8,852	5,902	----- ^c
1986	Stored	463	8,617	5,744	----- ^c
1987 ^d	Stored	<u>155</u>	<u>4,853</u>	<u>3,235</u>	----- ^c
Total	Stored	9,284	124,842	83,226	142,876

a. Mostly 1,1,1-trichloroethane, trichloroethylene, perchloroethylene, and used oil.

b. Data estimated.

c. In 1984, this category of organic wastes were processed separately and shipped to the Nevada Test Site as low-level wastes.

d. January to June 1987.

Table 16. Estimates of metal content in selected pits and trenches at the SDA
(Garcia et al, 1989)

Waste Location	Total Weight of Waste (kg)	Maximum Metal Weight (kg)	Minimum Metal Weight (kg)
PIT 1	337,300	269,840	16,865
PIT 2	7,264,000	5,811,200	363,200
PIT 3	823,500	658,800	41,175
PIT 4	5,539,000	4,431,200	276,950
PIT 5	2,968,000	2,374,400	148,400
PIT 6	2,672,000	2,137,600	133,600
PIT 9	1,357,707	1,086,166	67,885
PIT 10	6,148,000	4,918,400	307,400
TRENCH 1	274,500	219,600	13,725
TRENCH 2	123,700	98,960	6,185
TRENCH 3	196,500	157,200	9,825
TRENCH 4	267,600	214,080	13,380
TRENCH 5	347,200	277,760	17,360
TRENCH 6	305,000	244,000	15,250
TRENCH 7	198,800	159,040	9,940
TRENCH 8	208,000	166,400	10,400
TRENCH 9	179,300	143,440	8,965
TRENCH 10	110,500	88,400	5,525
TOTAL:	27,962,900	22,370,320	1,398,145

Radiological wastes of primary concern at the SDA include TRU wastes and LLW, which include mixed-fission products (MFP) and mixed activation products (MAP). In addition, some high radiation level wastes were disposed of in trenches at the SDA (Vigil, 1989). Currently, the TRU wastes are felt to be of most concern as a threat to human health and the environment. The amount of TRU nuclides originating from RFP buried in the SDA from 1954 to 1970 is 381.3 kg, corresponding to 241,531 Curies (Lee, 1971) (Garcia and Knight, 1989). In addition, 203,322.5 kg (74.7 Curies) of various uranium isotopes were also shipped from RFP to the SDA (Lee, 1971) (Garcia and Knight, 1989). Following the retrieval efforts in Pits 11 and 12, approximately 116 boxes of TRU wastes remain in these pits (Horton, 1988). Assuming an average size of 4 x 4 x 7 ft for boxes received from RFP, the corresponding TRU waste volume equals 17,359 ft³. According to Horton (1988), Trenches 16 through 54 contain a total of 4,367 ft³ of TRU wastes (potentially mixed with MFP) received from on-site waste generators. For LLW, a total of 583,000 Curies (which includes mixed fission and activation products) were buried in the SDA with the TRU wastes (Vigil, 1989); it is not clear, however, if this amount includes only INEL-generated wastes or both INEL and off-site generated LLW. (In addition, because TRU and LLW wastes were not completely segregated prior to 1970, TRU wastes may also be present in Trenches 11 through 15; this cannot, however, be substantiated without a review of the shipping records for these trenches.)

The disposal records include a variety of sludges having been disposed in the SDA. These sludges include process sludges from RFP (74 series sludges), sewage sludge, and miscellaneous other sludges. The greatest volume of sludges were those received from RFP (Vigil, 1989) and included the following.

- 741 sludge is a wet sludge produced from treating aqueous process wastes, such as ion-exchange column effluents, distillates, and caustic scrub solutions. The caustic scrub solutions contain ferric sulfate, calcium chloride, magnesium sulfate, and flocculating agents. These chemicals form a precipitate of the

hydrated oxides of iron, magnesium, aluminum, silicon, plutonium, and americium and may contain low concentrations of beryllium.

- 742 sludge is a wet sludge produced from the treatment of all other plant radioactive and/or chemical contaminated wastes and further treatment of 741 sludge. This type of sludge may also contain mercury, lithium batteries, and small amounts of contaminated mercury in pint bottles. The same treatment chemicals were used as in the 741 sludge and the same precipitates formed.
- 743 sludge was produced from treatment of liquid organic wastes. The sludge waste consists of such materials as degreasing agents (mostly trichloroethane), lathe coolant (60% Texaco Regal Oil and 40% carbon tetrachloride), and hydraulic oils. Other organic wastes included trichloroethylene, tetrachloroethylene, gearbox and spindle oils, and trace amounts of miscellaneous organic laboratory wastes (e.g., organophosphates and nitrobenzene). There are also some unknown volumes of oil containing PCBs that were processed with this type of sludge.
- 744 sludge resulted from processing liquid waste not compatible with the 741 and 742 processes due to their plutonium complex nature. The complex chemicals included some alcohols, organic acids, and VERSENES (trade name for chelating agents containing ethylenediaminetetraacetic acid). These were added to Portland cement to solidify the wastes.
- 745 sludge is a salt waste originating from evaporation of liquid waste impounded in solar evaporation ponds at the RFP. The salt is estimated to consist of 60% sodium nitrate, 30% potassium nitrate, and 10% miscellaneous material.

MIGRATION OF WASTES

In recent years, data has been gathered documenting the migration of some waste constituents away from the SDA (EG&G Idaho, 1989). In particular, several organic compounds (including carbon tetrachloride, chloroform, tetrachloroethylene, 1,1,1-trichloroethylene, and trichloroethylene) have been detected at elevated levels in the sedimentary interbeds beneath the RWMC and in wells near the SDA (Hodge et al, 1989). Radionuclides (including Pu-238, Pu-239, Pu-240, Am-241, Cs-137, and Sr-90) have been detected in the soils and in sedimentary interbeds to a depth of 240 ft beneath the RWMC (Hodge et al, 1989). Table 17 describes the migration of contaminants from the SDA into the surrounding media. Figures 2 and 3 present diagrams of the migration pathways for radionuclides and hazardous contaminants and for volatile organic chemical contaminants, respectively.

ASSUMPTIONS

In order to compile the summary information presented in this document, the following assumptions were made.

- All of the soils in the pits and trenches considered were assumed to be TRU contaminated. Earlier retrieval efforts (Thompson, 1972) (McKinley and McKinney, 1978) (Bischoff and Hudson, 1979) discovered a large number of breached drums and decayed cardboard and wooden boxes. Because it has been 12 years since these efforts took place and because the wastes had been in place for less than 10 years at the time of these retrieval efforts, the majority of the waste containers are now assumed to have been breached or otherwise decayed. The contaminants are assumed to have leaked or migrated out into the surrounding soils.
- Because of the above assumption, all underburden associated with Pits 1 - 6, 9, and 10 and Trenches 1 - 10 are assumed to be TRU contaminated. As a result of discoveries made during the earlier retrieval operations (McKinley and McKinney, 1978)

Table 17. Summary of Contaminants and Environmental Media of Concern (Hodge et al, 1989).

ENVIRONMENTAL MEDIUM	PRESENCE OF		
	ORGANICS	INORGANICS	RADIONUCLIDES
Air	X	X	
Surface water			a
Soil	X	a	X
Bedrock	a	a	a
Interbeds	a	X	X
Groundwater	X	X	X

a. Sampling results detected contaminant presence at levels below environmental concern, but worthy of note.

Figure 2. Conceptual model of radionuclide and hazardous contaminant migration at the SDA (EG&G Idaho, 1989).

Figure 3. Conceptual model of volatile-organic chemical contaminant migration at the SDA (EG&G Idaho, 1989).

9-1300

the top 18 in. of overburden over the pits and trenches are assumed to be uncontaminated.

- Because these wastes were disposed during the period 1952 - 1970, the corresponding definition of TRU wastes was used. The current definition is for these wastes to have a concentration greater than 100 nanocuries per gram.
- Although no records exist for waste shipments to the SDA originating from INEL (earlier known as the National Reactor Testing Station - NRTS) sources, because of the activities being performed at the different facilities (particularly RFP and INEL) the vast majority of the TRU wastes are assumed to have originated off-site. The majority of LLW is assumed to have come from on-site generators. The pits generally contain more RFP TRU waste than INEL LLW waste; the opposite is true for trenches (Vigil, 1989).
- TRU wastes were limited to the pits and trenches considered in this document; these pits and trenches are the only areas at the SDA requiring remediation. However, a few containers of waste may be located outside of established pit/trench boundaries.
- Waste volumes given do not, with the exception of Pit 9 metal contents, include the volume of container/packaging materials. The volumes of metal drums, wood, and plastics may be considerable (wood was often used to shore bulky waste items in the wooden boxes during shipment to prevent movement, and most items were wrapped in at least a single layer of plastic prior to disposal). It is unclear if the volumes of wastes included materials (e.g., lead sheeting) used for shielding in the waste containers and whether these volumes are significant.
- Mixed wastes were not considered separately from the other organic and TRU wastes.

- The description and quantities of wastes disposed at the SDA will not change significantly from those presented in this document following a more detailed review of the available literature and shipping records. This review is pending.

DISCREPANCIES

Although widespread belief regarding the combined volume of wastes and contaminated soils at the SDA range from 7.7 million ft³ (Plessinger, 1988) to 8.0 million ft³ (Humphrey and Bischoff, 1980), the degree of detail and method of estimating this volume provided by Guay (1989) lends greater credence to the estimate quoted in this document (e.g., 12.1 million ft³). The estimate of 8.2 million ft³ quoted by Plessinger (1988) appears to be in error. In addition, Plessinger's estimate does not include underburden volume; although Humphrey and Bischoff's estimates do include underburden, their calculations are not sufficiently documented to permit comparison. Guay's estimate includes not only overburden and underburden, but also presents a breakdown of volumes by pit and trench based on individual basalt and soil surface elevations and takes into account subsidence and compaction of waste containers in trenches. A large portion of these discrepancies may be due to additional overburden placed during subsequent SDA regrading operations.

Guay (1989) cites a number of references that give a total waste volume (from RFP, other off-site generators, and NRTS/INEL generators) buried at the SDA from 1952 through 1970 as 4.16 million ft³. In his calculations of waste container volume buried in the TRU contaminated portions of the SDA, Guay gives a total of 2.32 million ft³. Other estimates of total waste volume include: 2.67 million ft³ (Humphrey and Bischoff, 1980) (Vigil, 1989), 2.34 million ft³ (Garcia et al, 1989), 2.7 million ft³ (as both TRU and beta-gamma wastes) (Hinckley, 1981), and 2.3 million ft³ (McKinley, 1978). It is assumed that these numbers also represent wastes buried in the TRU contaminated portions of the SDA. Although some of these numbers may have since been discredited in subsequent efforts, they are provided to demonstrate the wide discrepancies that exist in estimates of waste amounts buried at the SDA. Obviously, further work is necessary to refine these numbers and explore this discrepancy.

Differences also exist in the estimated amounts of TRU radionuclides present at the SDA. ORNL (1989) presents a total mass of TRU nuclides (of DOE/defense origin) of 357 kg (as of 1988). Barnes et al (1989) cites the

Pu²³⁹ content of the buried wastes as being 338 kg. Lee (1971) claims that 381.3 kg of TRU nuclides were shipped from the RFP to the SDA during the period 1954 to 1970; of this amount, 343.3 kg were Pu²³⁹. It is not clear whether the numbers cited by ORNL and Barnes et al include TRU nuclides generated on the INEL Site or by off-site generators other than RFP. The reduction in TRU nuclides resulting from decay during the intervening period (1970 to 1988/1989) may not account for the entire discrepancy, particularly if TRU wastes from generators other than the RFP were received at the SDA. Again, further work is necessitated to determine the amount of TRU nuclides present in buried wastes at the SDA. Lee (1971) has been cited in this report because it is not only the more conservative number, but also because this number was supplied directly from RFP, the major generator of TRU wastes.

This report was developed through the review of a large number of existing documents that present a great deal of information on the waste types, quantities, and locations. The information selected for inclusion in this report, however, was chosen because it appeared to be the most valid and defensible of the information contained in the reports reviewed in the time allowed. An example of this is Card (1977), which contains a series of diagrams of the TRU-containing pits showing general waste disposal locations; these diagrams were not included in this report. This is because the source of the information used to develop these drawings is not felt to be entirely accurate. Thus, this report represents what is felt to be the best available information at the time of release. As more information becomes known, and as more validity is afforded to the existing information not included in this report, this report will be revised.

PROPOSED FUTURE ACTIONS

In light of the questions arising from the assumptions made and discrepancies identified during preparation of this document, several additional efforts to reduce the uncertainties regarding buried wastes (including locations, contaminants, conditions, and quantities) are proposed to be conducted by the staff of the Technology Demonstration group at EG&G Idaho.

- Identify and obtain existing site characterization documents and reports from earlier retrieval efforts. This has, to a large extent, already been accomplished, and files containing this information have been set up.
- Identify current site characterization efforts within other organizations, such as Waste Area Group-7 (WAG-7). Although the extent of current site characterization efforts has not been determined, initial contacts with personnel involved with identified efforts have been made. In these cases, agreement has been reached regarding the need for a coordinated site characterization effort, such as that currently proposed.
- Review existing information to identify primary information sources, determine data quality, ensure consistency, and establish a valid foundation for future efforts.
- Compile waste amounts, waste types, and identification of waste disposal locations from the existing documents reviewed above.
- Review existing shipping records dating from the period of burial of RFP wastes at the SDA to determine types, dates, and volumes of wastes shipped from RFP to INEL. This effort is currently being performed by WAG-7; however, no coordination in this effort is apparent and the time frame for completion does not coincide with Waste Technology Development Department milestones. We propose that these records be reviewed by personnel having strong

technical backgrounds with the purpose of updating the existing Radioactive Waste Management Information System database and validating existing information on waste volumes and disposal locations.

- Emphasize attempts to verify the locations of "special case" wastes and to establish a confidence level with relation to the existing information sources. The intent will be to utilize current, state-of-the-art geophysical techniques, in addition to the existing waste disposal records, to determine the locations of these special case wastes and to define the boundaries of the pits and trenches.
- Reconstruct, to the degree attainable, shipping records for on-site generators of wastes buried at the SDA. These records were destroyed during previous "housekeeping" efforts, but can be reconstructed to a limited extent from knowledge of the work processes and research activities generating the wastes. This effort has been begun by members of the Risk Assessment unit under Bob Nitschke, but is currently on hold pending budget allocations and anticipated workload.
- Estimate current radionuclide inventories in buried wastes at the SDA by applying rate of decay algorithms to the reviewed and verified radionuclide estimates resulting from the proposed effort.

REFERENCES

Note: Some of the references listed below may contain sensitive information and may not be available to the public.

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APPENDIX B

PROCESS FUNCTIONAL DIAGRAM FOR
15 CONCEPTS NOT CONSIDERED
IN THE DETAILED
CONCEPT DEVELOPMENT PHASE

PROCESS		STORAGE/ DISPOSAL						
<pre> graph LR A[CRYOGENIC FREEZING] --> B[ONGOING REFRIGERATION AND MONITORING] </pre>								
<p>PROCESS: CRYOGENIC FREEZING</p> <p>LLW/TRU: N/A</p> <p>FINAL WASTE FORM #1: PROCESS IN PLACE AND LEAVE IN PLACE</p>		<p>EG&G SYSTEM DESIGN STUDY</p> <p>PROCESS FLOW DIAGRAM</p> <table border="1"> <tr> <td rowspan="2">EBASCO ENVIRONMENTAL</td> <td>PFD No.</td> <td></td> </tr> <tr> <td>1-EB-3</td> <td>1/18/91</td> </tr> </table>		EBASCO ENVIRONMENTAL	PFD No.		1-EB-3	1/18/91
EBASCO ENVIRONMENTAL	PFD No.							
	1-EB-3	1/18/91

DESCRIPTION:

- RETRIEVAL SUBSYSTEM IS USED TO RETRIEVE WASTE.
- BARRIERS ON DISPOSAL SITE ARE PREPARED AND WASTE IS REPLACED ON SITE.
- SITE IS CAPPED AND MARKED.

APPENDIX B
PROCESS FUNCTIONAL DIAGRAM FOR 15 CONCEPTS NOT CONSIDERED
IN THE DETAILED CONCEPT DEVELOPMENT PHASE
(CONTINUED)

EGG1103

PROCESS

STORAGE/
DISPOSAL

CAP

MONITOR

- TOPSOIL
- LOW PERMEABLE MEMBRANE
- MULTI LAYER
- CONCRETE
- ASPHALT

PROCESS:
CREATE NEW TRENCHES, THEN
REBURY ALL WASTES

LLW/TRU: N/A

FINAL WASTE FORM #1:
PROCESS IN PLACE AND LEAVE IN PLACE

EG&G SYSTEM DESIGN STUDY

PROCESS FLOW DIAGRAM

EBASCO
ENVIRONMENTAL

PFD No.

1-EB-4

1/18/91

FINAL WASTE FORM:
LEAVE WASTE IN PLACE AND MINIMIZE MIGRATION
OF RADIOACTIVE AND HAZARDOUS CONSTITUENTS.

DESCRIPTION:
EXTRACT AND INCINERATE VOLATILE ORGANICS
FROM WASTE SITE. INJECT GROUT INTO WASTE
TO FILL VOIDS.

NEXT ASSISTANT ENG	
PROJECT NO.	DATE
	DATE
DESIGN	DATE
CHECKED	DATE
DRAWN	DATE
RELEASE	DATE

EG&G INCORPORATED

EG&G SYSTEM DESIGN STUDY
PROCESS FLOW DIAGRAM

SCALE	NONE	DATE	2/91	1--EG-5
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438214 REV DATE 2/8/91

NOTES:

- ACID DIGESTION/GLASSIFICATION SYSTEM WITH TRU REDUCTION.
- SHADED BLOCKS ARE THOSE NECESSARY FOR CLASSIFIED WASTE FORM.

APPENDIX B
PROCESS FUNCTIONAL DIAGRAM FOR 15 CONCEPTS NOT CONSIDERED
IN THE DETAILED CONCEPT DEVELOPMENT PHASE
(CONTINUED)

0	3/11/91	ISSUED FOR REVIEW	J.P.	J.M.	J.V.	J.M.
NO.	DATE	REVISION	BY	CHKD.	ENGR.	APPR.
000000	3/8/91	J. MacFEE	TJO	DW Y	JOHN VALDEZ	

INTERNATIONAL TECHNOLOGY CORPORATION
ALBUQUERQUE, NEW MEXICO

EG & G IDAHO, INCORPORATED
SYSTEM DESIGN STUDY
IDAHO FALLS, IDAHO

PROCESS FLOW DIAGRAMS FOR
SYSTEM DESIGN STUDY

JOB NUMBER	DRAWING NUMBER	REVISION
501411	2 - 11 - 10	B

NOTES:

- ACID DIGESTION/GLASSIFICATION SYSTEM WITH TRU REDUCTION.
- SHADED BLOCKS ARE THOSE NECESSARY FOR CLASSIFIED WASTE FORM.

APPENDIX B
 PROCESS FUNCTIONAL DIAGRAM FOR 15 CONCEPTS NOT CONSIDERED
 IN THE DETAILED CONCEPT DEVELOPMENT PHASE
 (CONTINUED)

NOTES:

- THERMAL TREATMENT/GLASSIFICATION SYSTEM WITH LLW PRESORT.
(NO LIQUIDS CLEANUP)
- SHADED BLOCKS ARE THOSE NECESSARY FOR THE GLASSIFIED WASTE FORM.

APPENDIX B
PROCESS FUNCTIONAL DIAGRAM FOR 15 CONCEPTS NOT CONSIDERED
IN THE DETAILED CONCEPT DEVELOPMENT PHASE
(CONTINUED)

B	3/11/91	ISSUED FOR REVIEW	J.P.	J.M.	J.V.	7/7/91
NO.	DATE	REVISION	BY	CHKD.	ENGR.	APPR.
3/8/91	J. McFEE		TIG	JOHN VALDEZ

**INTERNATIONAL
TECHNOLOGY
CORPORATION**
ALBUQUERQUE, NEW MEXICO

EG & G IDAHO, INCORPORATED
SYSTEM DESIGN STUDY
IDAHO FALLS, IDAHO

PROCESS FLOW DIAGRAMS FOR
SYSTEM DESIGN STUDY

JOB NUMBER	DRAWING NUMBER	REVISION
301411	2 - 1 T - 8	8

APPENDIX B
PROCESS FUNCTIONAL DIAGRAM FOR 15 CONCEPTS NOT CONSIDERED
IN THE DETAILED CONCEPT DEVELOPMENT PHASE
(CONTINUED)

NOTES:

- THERMAL TREATMENT/GLASSIFICATION SYSTEM WITH LLW PRESORT.
- SHADED BLOCKS ARE THOSE NECESSARY FOR THE GLASSIFIED WASTE FORM.

APPENDIX B
PROCESS FUNCTIONAL DIAGRAM FOR 15 CONCEPTS NOT CONSIDERED
IN THE DETAILED CONCEPT DEVELOPMENT PHASE
(CONTINUED)

B	3/11/81	ISSUED FOR REVIEW	J.P.	J.M.	J.V.	STAV
NO.	DATE	REVISION	BY	CHKD.	ENGR.	APPR.
3/8/81	JUN/FEE	TJG	2/1/81	JOHN VALDEZ
INTERNATIONAL TECHNOLOGY CORPORATION ALBUQUERQUE, NEW MEXICO						
EG & G IDAHO, INCORPORATED SYSTEM DESIGN STUDY IDAHO FALLS, IDAHO						
PROCESS FLOW DIAGRAMS FOR SYSTEM DESIGN STUDY						
JOB NUMBER		DRAWING NUMBER		REVISION		
301411		2 - 1 T - 6		B

NOTES:

- THERMAL TREATMENT/GLASSIFICATION SYSTEM WITH LLW PRESORT.
- SHADED BLOCKS ARE THOSE NECESSARY FOR THE GLASSIFIED WASTE FORM.

APPENDIX B
PROCESS FUNCTIONAL DIAGRAM FOR 15 CONCEPTS NOT CONSIDERED
IN THE DETAILED CONCEPT DEVELOPMENT PHASE
(CONTINUED)

B		3/11/91		ISSUED FOR REVIEW		J.P.		J.W.		J.V.		J.H.V.	
NO.		DATE		REVISION		BY		CHKD.		ENGR.		APPR.	
3/8/91		J.MCFEE		T.J.G.		J.W.H.		J.H.		J.H.		JOHN VALDEZ
INTERNATIONAL TECHNOLOGY CORPORATION ALBUQUERQUE, NEW MEXICO													
EG & G IDAHO, INCORPORATED SYSTEM DESIGN STUDY IDAHO FALLS, IDAHO													
PROCESS FLOW DIAGRAMS FOR SYSTEM DESIGN STUDY													
JOB NUMBER				DRAWING NUMBER				REVISION					
301411				2 - I T - 5				B

DESCRIPTION:

- RETRIEVAL SUBSYSTEM IS USED TO RETRIEVE AND PRESORT WASTE.
- SOIL PROCESSING SUBSYSTEM IS USED TO PROCESS SOILS.
- METAL SIZING AND DECON SUBSYSTEM IS USED TO PROCESS BULK METALS.
- COMBUSTIBLE WASTE IS INCINERATED TO REDUCE VOLUME AND DESTROY ORGANIC CONTAMINANTS.
- NONCOMBUSTIBLE WASTE AND ASH FROM INCINERATOR ARE MELTED INTO A LEACH-RESISTANT, HIGH INTEGRITY STRUCTURE.
- SECONDARY WASTE STREAMS FROM OFFGAS TREATMENT ARE SOLIDIFIED.
- CONTAINERS ARE ASSAYED AND TRU IS SEPARATED FROM LLW FOLLOWING WASTE PROCESSING.

EGG1103

APPENDIX B
PROCESS FUNCTIONAL DIAGRAM FOR 15 CONCEPTS NOT CONSIDERED
IN THE DETAILED CONCEPT DEVELOPMENT PHASE

B-11

PROCESS:
SINTERING

LLW/TRU: POST SORT

FINAL WASTE FORM #2:
LEACH RESISTANT, HIGH INTEGRITY
STRUCTURE (GLASS, ROCK) OR LLW

EG&G SYSTEM DESIGN STUDY

PROCESS FLOW DIAGRAM

EBASCO
ENVIRONMENTAL

PFD No.

2-EB-2

2/12/91

APPENDIX B
 PROCESS FUNCTIONAL DIAGRAM FOR 15 CONCEPTS NOT CONSIDERED
 IN THE DETAILED CONCEPT DEVELOPMENT PHASE
 (CONTINUED)

ACID DIGESTION PROCESS IS A CHEMICAL OXIDATION PROCESS UTILIZING SULFURIC & NITRIC ACIDS. TESTS RUN AT HANFORD TO PROCESS RESIN, RAGS, WOOD, REACTIVE SCRAP & PLASTICS. ACIDS CAN BE RECYCLED AND PU RECOVERED.

CENTRIFUGE/DRYING STEP REQUIRED TO TREAT RESIDUE PERIODICALLY FOR SOLIDIFICATION. ACID VAPORS RETURNED TO DIGESTER OFFGAS SYSTEM FOR RECOVERY.

DESCRIPTION:

RETRIEVE, SORT, PACKAGE AND SEND TO TREATMENT FACILITY. SORT SOILS AND METALS AND TREAT SEPARATELY. TREAT REMAINING WASTE WITH ACID DIGESTION SYSTEM. RECOVER PLUTONIUM FROM DIGESTER SOLUTION.

FINAL WASTE FORM REQUIREMENT

CREATE WASTE FORM THAT MEETS THE LDR REQUIREMENTS AND RESTRICTS THE HYDROGEN GENERATION FROM METALS.

EG&G SYSTEM DESIGN STUDY ACID DIGESTION AND PACKAGING SYSTEM FLOW DIAGRAM

JOB NO.
20996-005

FIGURE
3 - BE - 5

DATE
2/8/91

APPENDIX B
PROCESS FUNCTIONAL DIAGRAM FOR 15 CONCEPTS NOT CONSIDERED
IN THE DETAILED CONCEPT DEVELOPMENT PHASE
(CONTINUED)

DESCRIPTION:

- RETRIEVAL SUBSYSTEM IS USED TO RETRIEVE AND PRESORT WASTE.
- SOIL PROCESSING SUBSYSTEM IS USED TO PROCESS SOILS.
- METAL SIZING AND DECON SUBSYSTEM IS USED TO PROCESS BULK METALS.
- ALL REMAINING WASTE IS SOLIDIFIED TO IMMOBILIZE BOTH ORGANICS AND INORGANICS.
- CONTAINERS ARE ASSAYED AND TRU IS SEPARATED FROM LLW FOLLOWING WASTE PROCESSING.

EGG1103

PROCESS	PACKAGE FOR DISPOSAL	STORAGE/ DISPOSAL
		CLEAN STACK GAS
		CLEAN SOIL
		LLW SOIL
	<div style="display: flex; align-items: center; justify-content: center;"> <div style="border: 1px solid black; padding: 5px; margin: 0 10px;">PACKAGE</div> <div style="border: 1px solid black; padding: 5px; margin: 0 10px;">CONTAINER ASSAY</div> </div>	LLW TRU WASTE
		CLEAN WATER
		LLW METAL
APPENDIX B PROCESS FUNCTIONAL DIAGRAM FOR 15 CONCEPTS NOT CONSIDERED IN THE DETAILED CONCEPT DEVELOPMENT PHASE (CONTINUED)		

PROCESS:
SOLIDIFICATION

LLW/TRU: POST-SORT

FINAL WASTE FORM #3:
MEETS LDR REQUIREMENTS AND
RESTRICTS H₂ GENERATION

EG&G SYSTEM DESIGN STUDY

PROCESS FLOW DIAGRAM

EBASCO ENVIRONMENTAL	PFD No. 3-EB-2	2/12/91
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FINAL WASTE FORM:

MEET CURRENT MP-WAC AND TRAMPAC REQUIREMENTS.

DESCRIPTION:

RETRIEVE, SORT, DECON METALS, IMMOBILIZE SLUDGE AND FINES, PACKAGE REMAINING WASTE. SEPARATE TRU/LLW AFTER PROCESSING.

PROJECT NO.	DATE
DESIGN	DATE
CHECKED	DATE
APPROVED	DATE
DATE	12/90
RELEASE	DATE

<p>EG&G SYSTEM DESIGN STUDY PROCESS FLOW DIAGRAM</p>	
<p>DATE: 12/90</p> <p>BY: CHRBAUGH</p>	<p>DATE: 12/90</p> <p>BY: 4-EG-1</p>
<p>SCALE: NONE</p>	

437730 REV DATE 2/8/91

APPENDIX C

HISTORICAL TABULATION OF
RADIOACTIVE WASTE INCINERATORS

APPENDIX C
HISTORICAL TABULATION OF RADIOACTIVE WASTE INCINERATORS

INSTALLATION	LOCATION	BUILT(1)	STATUS(2)	TYPE	CAPACITY	TYPE(3)	TYPE(4)
<u>U.S. Low Activity Incinerators</u>							
Knolls Atomic Power Laboratory	NY	1949	N	EA			Wet Scrubber
Argonne National Laboratory	IL	1951	N	EA			Wet Scrubber
Los Alamos Scientific Laboratory	NM	1951	N	EA	90 kg/hr	C	Wet Scrubber
Battis Atomic Power Laboratory	PA	1953	N	EA			Wet Scrubber
Shippingport Atomic Power Station	PA		N	EA			Wet Scrubber
U.S. Nuclear Defense Laboratory	MD	1963	N	CA			
Douglas United Nuclear	WA	1967	N	EA		C, P, R	None
Yankee Atomic Electric Co.	MA	1968	N	EA		C	Wet Scrubber
Lawrence Livermore National Laboratory	CA	1978	O	CA	S 0.4 m ³ /hr L 110 l/hr		None
CECo - Byron Nuclear Station	IL	1983	AS	FB		C, P, R	Wet Scrubber
CECo - Braidwood Nuclear Station	IL		AS	FB		C, P, R	Wet Scrubber
Duke Power - Oconee Nuclear Station	SC	1983	In Test	FB		C, P, R	Wet Scrubber
Savannah River Plant (BGI)	SC	1983	Hold	CA	180 kg/hr	C, FCW, P, R	Dry
Idaho National Engineering Lab - WERF	ID	1984	O	CA	180 kg/hr	C, P, R	Dry
Georgia Power - Vogtle Nuclear Station	GA	1985	AS	FB		C, P, R	Wet Scrubber
Babcock and Wilcox	PA	1985	AS	CA			Wet Scrubber
Oak Ridge Gaseous Diffusion Plant (K-25)	TN	1987	O	RK	S 330 kg/hr L 680 l/hr 470 kg/hr	C, S, N	Wet Scrubber
Savannah River Plant (CIF)	SC	(1991)	UC	RK		C, FCW, P, R	Wet Scrubber
Los Alamos National Laboratory	NM	(1991)		CA			Wet Scrubber
Lawrence Livermore National Laboratory	CA	(1992)		RK			Wet Scrubber
Panlex	TX	(1994)		CA			Wet Scrubber

APPENDIX C
HISTORICAL TABULATION OF RADIOACTIVE WASTE INCINERATORS
(CONTINUED)

INSTALLATION	LOCATION	BUILT(1)	STATUS(2)	TYPE	CAPACITY	TYPE(3)	TYPE(4)
<u>Non-U.S. Low Activity Incinerators</u>							
Chalk River Nuclear Laboratory	Canada	1960	N	CA		C, P, R	Dry
Belgian Nuclear Center - Mol	Belgium	1960	N	CA		C, P, R	Wet Scrubber
Harwell Nuclear Research Center	U.K.	1962		CA		C, P, R	Dry
Nuclear Research Center - Karlsruhe	Germany	1963	N	EA		C, FCW, P, R	Dry
Berkeley Nuclear Laboratory	U.K.	1965		CA		C, P, R	Wet Scrubber
JAERI - Tokai Research Establish.	Japan	1966	N	EA		C, P, R	Wet Scrubber
CEBG - Bradwell Power Station	U.K.	1967		EA		C, P, R	Wet Scrubber
Hunterston "A" Station	U.K.	1967		EA		C, P, R	Wet Scrubber
Cadastre Nuclear Study Center	France		0	EA		C, FCW, P, R	
Fontenay-Aux-Roses Center	France	1967	0	EA		C, P, R	Dry
Grenoble Nuclear Study Center	France	1970	0	EA		C, P, R	Dry
National Center of Scientific Research - Strasbourg	France	1970	0	EA		C, P, R	Dry
Belgian Nuclear Center - Mol	Belgium	1970	0	Slag Pyr		C, P, R	Wet Scrubber
Nuclear Research Center - Karlsruhe	Germany	1971	0	EA		C, FCW, P, R	Dry
JAERI - Tokai Research Establish.	Japan	1972	N	EA			Dry
JAERI - Oarai Research Establish.	Japan	1973	0	CA		C, P	Wet Scrubber
Nuclear Research Center - Juelich (Pilot Plant)	Germany	1975	0	CP		C, FCW, P, R	Dry
Wuerenlingen Research Center	Switz.	1975	0	EA			Dry
Studsvik Research Facilities	Sweden	1976	0	EA		C, FCW, P, R	Wet Scrubber
JAERI - Oarai Research Establish.	Japan	1976	N	EA			Dry
PNC - Oarai Research Establish.	Japan	1976	0	EA		C, FCW, P, R	Wet Scrubber
Japan Atomic Power Co. - Tsuruga Plant	Japan	1977	0	EA		C, P, R	Dry
PNC - Tokai Research Establish.	Japan	1977	0	CA		C, P, R	Wet Scrubber
Bruce Nuclear Complex	Canada	1977	0	CP		C, P, R	Dry
Kansai Electric Power Co. - Mihama Plant	Japan	1978	0	EA		C, P, R	Dry
Saferdorf Research Center	Austria	1978	0	EA		C, FCW, P, R	Dry
CEBG - Hinkley Point Station	U.K.	1978	0	EA		C, P, R	Wet Scrubber
CEBG - Hinkley Point Station	U.K.	1978	0	EA		C, P, R	Dry
CEBG - Wylfa Power Station	U.K.	1978	0	EA		C, P, R	Wet Scrubber
JAERI - Tokai Research Establish.	U.K.		UC	EA		C, P, R	Dry
Chalk River Nuclear Laboratory	Japan	1979	0	EA		C, P, R	Dry
Chubu Electric Power Co. - Hamana Plant	Canada	1980	0	CP		C, P, R	Dry
Kyushu Electric Power Co. - Genkai Unit 1	Japan	1981	0	EA		C, P, R	Dry
Kansai Electric Power Co. - Ohi Plant	Japan	1981	0	EA		C, P, R	Dry
Kansai Elec. Power Co. - Takahama Plant	Japan	1982	0	EA		C, P, R	Dry
Tokyo Elec. Power Co. - Fukushima Plant	Japan	(1984)	UC	EA		C, P, R	Dry
Chugoku Elec. Power Co. - Shimane Plant	Japan	(1984)	UC	EA		C, P, R	Dry
Kyushu Elec. Power Co. - Sendai Plant	Japan	(1984)	UC	EA		C, P, R	Dry

APPENDIX C
HISTORICAL TABULATION OF RADIOACTIVE WASTE INCINERATORS
(CONTINUED)

INSTALLATION	LOCATION	BUILT(1)	STATUS(2)	TYPE	CAPACITY	TYPE(3)	TYPE(4)
<u>U.S. TRU Waste and U/Pu Recovery Incinerators</u>							
LANL Pu Recovery Incinerator	NM	1962	N	CA	0.5 kg/hr	C, FCW, P, R	Wet Scrubber
National Lead Co. of Ohio	OH	1964		CA	1000 kg/hr	C, FCW	None
Union Carbide - ORNL, Y-12	TN	1965			2 kg/hr	C, FCW	Wet Scrubber
Nuclear Fuel Services	TN			CA	270 kg/hr	C, FCW, P	Wet Scrubber
Roddy Flats Plant	CO	1969	O	Oxy Enrich	16 kg/hr	C, P	Wet Scrubber
United Nuclear Corporation	CT	1960	N		95 kg/hr	FCW	Dry
Metals and Controls	MA	1960	N		90 kg/hr	FCW	Dry
Pratt and Whitney Aircraft	CT	1960	N		270 kg/hr	FCW	None
GE Atomic Power Equipment Department	CA	1960	N	CA	45 kg/hr	C, FCW, P, R	Wet Scrubber
Gulf General Atomics	CA	1960	N	CA	10 bbl/day	P, FCW	Dry
ARHCO Pu Recovery Incinerator	WA	1961		CA	20 kg/hr	C, FCW, P	Wet Scrubber
United Nuclear Corporation	RI	1967	N		45 kg/hr	C, FCW, P, R	Wet Scrubber
B and W Nuclear Materials Division	PA	1969	N	EA	9 kg/hr	C, FCW, P	Wet Scrubber
Goodyear Atomic Corporation	OH	1971		CA	2300 kg/mo	C, FCW, P	None
Babcock and Wilcox	VA	1972		EA	80 kg/hr	C, FCW, P	Wet Scrubber
Mound Lab. - Pu Recovery Incinerator	OH	1972		CA	90 l/day	C	Wet Scrubber
Union Carbide, K-25	TN	1972		CA		FCW	None
GE Nuclear Fuel Plant	NC	1972	N	EA	1300 kg/hr	C, FCW, P, R	Wet Scrubber
Kerr-McGee Nuclear Corporation	OK	1972		EA	70 kg/hr	FCW	Dry
Westinghouse Nuclear Fuels Division	SC	1974	O	CA		C, FCW, P, R	Wet Scrubber

APPENDIX C
HISTORICAL TABULATION OF RADIOACTIVE WASTE INCINERATORS
(CONTINUED)

INSTALLATION	LOCATION	BUILT(1)	STATUS(2)	TYPE	CAPACITY	TYPE(3)	TYPE(4)
<u>U.S. TRU Waste and U/Pu Recovery Incinerators (Continued)</u>							
Mound Laboratory (Development)	OH	1975		Cyclone	1 drum	C, FCW, P	Wet Scrubber
Los Alamos National Laboratory	NM	1976	O	CA	45 kg/hr	C, FCW, P, R	Wet Scrubber
Rocky Flats Plant	CO	1978	Hold	FB	75 kg/hr	C, P, R	Dry
Rocky Flats Plant (Development)	CO	1980	N	Agit Hearth	70 kg/hr	C, FCW, P, R	Wet Scrubber
Rocky Flats Plant (Development)	CO	1980	N	Rotary Kiln	40 kg/hr	C, FCW, P, R	Wet Scrubber
Mound Laboratory	OH	1981	Existing, New Task	Glass Melt	23 kg/hr	C, FCW, P, R	Wet Scrubber
Idaho National Engineering Lab. (NWCF) GE Nuclear Fuel Plant Savannah River Plant (PWI)	ID	1982	O	FB		FCW	Wet Scrubber
	NC	(1983)		CA		C, FCW, P, R	Wet Scrubber
	SC	1985	N	CA	10 kg/hr	C, FCW, P, R	Dry
Idaho National Engineering Lab. (PREPP)	ID	1987	In Test	Rotary Kiln	2300 m ³ /yr	C, N, P, R, S	Wet Scrubber
Advanced Nuclear Fuels, Inc.	WA	1987	O	CA	90 kg/hr		Wet Scrubber
Savannah River Laboratory (PRI)	SC	1990	In Design	CA	0.57 kg/hr	C, FCW, P, R	Dry
Savannah River Laboratory (PRI) (Development)	SC	1990	In Design	CA	200 gm/batch	C, FCW, P, R	Dry
Los Alamos National Laboratory	NM	1991	Procure	CA			Wet Scrubber
Lawrence Livermore National Lab.	CA	1991	Procure	RK			
Oak Ridge National Laboratory (EURII)	TN	(1991)	Procure	CA	45 kg/hr	FCW	Dry

APPENDIX C
HISTORICAL TABULATION OF RADIOACTIVE WASTE INCINERATORS
(CONTINUED)

INSTALLATION	LOCATION	BUILT(1)	STATUS(2)	TYPE	CAPACITY	TYPE(3)	TYPE(4)
<u>Non-U.S. TRU Waste and U-Pu Recovery Incinerators</u>							
Windescale (Pilot Plant)	UK	1973		CP	5 kg/hr	C, FCW, P, R	Wet Scrubber
Center of Nuclear Studies - Grenoble	France	1961	N	CA	400 kg/yr	C, FCW, P, R	Wet Scrubber
Marcoule Center of Pu Production	France	1964		CA	90 kg/hr	C, FCW, P, R	Wet Scrubber
Marcoule Center (Pilot Plant)	France	1970		EA	1 kg/hr	C, FCW, P, R	Dry
PNC - Oharai Research Establish.	Japan	1963		EA		C, FCW, P, R	Wet Scrubber

- (1) Parenthesis around year built indicates actual construction not confirmed for this report.
 (2) Status: UC = Under Construction; O = Operational; N = No Longer Operating; AS = Awaiting Start-up.
 (3) Type: CA = Controlled Air; FB = Fluidized Bed; EA = Excess Air; CP = Controlled Pyrolysis.
 (4) Waste Type: C = Combustibles; FCW = Fuel Cycle Waste; N = Non-Combustibles; P = Plastic; R = Rubber; S = Sludges.

APPENDIX D

DOE FACILITY CEMENTATION SYSTEMS

APPENDIX D
DOE FACILITY CEMENTATION SYSTEMS

DOE FACILITY	TREATMENT	UNIT NAME	WASTE TREATMENT CAPACITY(1)	RCRA PERMIT STATUS	SOLIDN AGENT(S)
<u>TRU-Waste Treatment Systems</u>					
Los Alamos National Lab, NM	ID Solid'n.	TA-50 Vacuum Filter Operation	1500 l/d	None	Portland Cement/ Diatomaceous Earth Portland Cement Envirostone
	ID Solid'n.	Pretreatment Plant	1900 l/yr		
	ID Solid'n.	TA-65 Plutonium Facility	40 l/d		
Rocky Flats Plant, CO	ID Solid'n.	374 Vacuum Filter Operation	270 kg/hr	IS	Portland Cement/ Diatomaceous Earth
	ID Solid'n.	774 Vacuum Filter Operation	600 kg/d	IS	Portland Cement/ Diatomaceous Earth
	ID Solid'n.	774 OASIS System	450 l/shift	IS	Envirostone
	ID Solid'n.	774 Special Setups Operation	80 l/d	IS	Portland Cement/ RAMCOTE
<u>Low-Level Waste Treatment Systems</u>					
West Valley, NY	ID Solid'n.	Cement Solidification System	8860 l/d	None	Portland Cement plus Additives
Mound, OH	ID Solid'n.	Alpha-Contaminated Water Processing Facility	3800 l/mo	None	Portland Cement
	ID Solid'n.	Tritiated Water Solidification Facility	9500 l/mo	None	Portland Cement/ Clay
Idaho National Eng'g Lab, ID	ID Solid'n.	Waste Experimental Reduction Facility	450 kg/d	IS	Portland Cement
	ID Solid'n.	Waste Engineering Development Facility	450 kg/d	IS	Portland Cement
Savannah River Plant, SC	Solid'n.	Z Area Saltstone	600 l/min		Portland Cement/ Slag/Flyash
	ID Solid'n.	Naval Fuels Saltcrete	870 kg/d	None	Portland Cement

APPENDIX D
DOE FACILITY CEMENTATION SYSTEMS
(CONTINUED)

DOE FACILITY	TREATMENT	UNIT NAME	WASTE TREATMENT CAPACITY(1)	RCA PERMIT STATUS	SOLIDN AGENT(S)
Harford Operations, WA	Solid'n.	Grout Treatment Facility	160 l/min	IS	Portland Cement/ Flyash/Clay
Lawrence Livermore Natl Lab, CA	ID Solid'n.	Bldg. 513 Solidification Unit	950 l/d	IS	Various
Oak Ridge Gaseous Diffusion Plant, TN	Solid'n. Solid'n.	Hydrofracture Grout Facility Sludge Treatment Facility	NIO	IS	Portland Cement/ Flyash
Oak Ridge Gaseous Diffusion Plant, TN	Solid'n.	Concrete Fixation Facility		IS	Portland Cement/ Flyash/Slag
Rocky Flats Plant, CO	Solid'n. Solid'n.	788 Portland Cement Operation Bldg. 374 Salicic Acid Operation	20 kg/min 730 kg/hr	IS IS	Portland Cement Portland Cement

(1) Waste treatment capacity figures are rounded to the nearest 10.
ID = In drum; final product drummed.
NIO = Not in operation.
IS = Interim Status

End Date
6-05-92