OPTIONS FOR THE DISPOSITION OF CURRENT INVENTORY OF ROCKY FLATS PLANT RESIDUES

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1.0 STATEMENT OF WORK

With the end of the Cold War, much concern has been directed towards the accumulation of special nuclear material resulting from the dismantlement of a large number of nuclear weapons. This concern has opened up a debate over the final disposition of the large inventory of weapons-capable plutonium. Technologies for the conversion of plutonium into acceptable forms will need to be assessed and evaluated. Candidate strategies for interim and final disposition include a variety of immobilization techniques (vitrification in glass, ceramic, or metal), conversion to reactor fuel, or direct discard as waste. The selected disposition strategy will be chosen based upon a range of decision metrics such as expected conversion costs, equipment requirements, and waste generation.

To this end, a systems analysis approach is necessary for the evaluation and comparison of the different disposition strategies. Current data on inventory of plutonium, such as that at the Rocky Flats Plant (RFP), may be useful for the evaluation and selection of candidate disposition technologies.

A preliminary analysis of the residues of scrap at Rocky Flats was performed to establish a foundation for comparison of candidate strategies. About 3 metric tons of plutonium and 270 metric tons of other wastes remain in the inventory at Rocky Flats. Estimates on the equipment, facility, manpower, and cost requirements to process this inventory over a proposed 10-year cleanup campaign will provide a benchmark for comparison and assessment of proposed disposition technologies.

2.0 METHODOLOGY

An integrated computer simulation model was used to obtain estimates of equipment requirements, costs, and wastes generation. The model is based on the process simulation program ProMoS (Process Modeling System), the Complex 21 (version 2.2.0) baseline database of process operations, and QuickSim, a spreadsheet model developed for estimation of facility sizing based on plutonium throughput.

A 10-year cleanup campaign is projected for current inventory of Rocky Flats plutonium residues to be processed through a facility. Cost estimates are based upon the assumption of a 13 year construction time for a new facility.

3.0 DATA

The summary of the Rocky Flats inventory of plutonium-contaminated residues was taken from the RF IDC list. Wastes were sorted and grouped based upon recommended processing streams, and grouped into categories of:

1) Burn/Cepod/Nitrate,
2) Crush/Cepod/Nitrate
3) Cepod/Nitrate
4) Crush/Burn/Cepod/Nitrate

5) Crush/Leach/Nitrate
6) Burn/Leach/Nitrate
7) Leach/Drum
8) Leach/Nitrate
9) ER/Chloride
10) MSE/Chloride
11) Crush/Burn
12) Burn/Grout
13) Crush/Grout
14) Grout/Drum

In general, the categories may be further grouped as

1) dissolver recoverable materials (nitrate recoverable materials),
2) *salts (chloride recoverable materials),*
3) burnable wastes, and
4) materials for direct discard (grouted and drummed).

The categorization of wastes and their accompanying IDC codes are tabulated in Table 1.

For a first estimate, the database for the Complex 21 baseline version 2.2.0 was adopted. Material is assumed to be processed through the Complex 21 defined processes for nitrate and chloride residue recoveries, and solid and liquid waste treatment. The ProMoS version 2.2.0 database was used for mass balance data, processing times, batch sizes, manpower requirements, and material flow. For the analysis of the Rocky Flats inventory, the materials from the IDC list were categorized and introduced into the appropriate aqueous recovery or waste processing feed operation. With some exception, material was processed along the streams according to the baseline flow diagram. The injection points are indicated in Table 1; the accompanying flowsheets detail the routing of the feed streams and refer to the processing codes summarized in Table 1.

A comparison was made between direct discard of all material versus processing and recovery of plutonium. In Case 1, all wastes are introduced into the facility simultaneously and processed concurrently. Case 1 makes the assumption of uniform plutonium loading in the feed streams and may be taken as an optimistic estimate of waste generation.

Case 2 represents a more conservative approach. In case 2, the residues that make up the individual categories (dissolver recoverable materials, salts, burnable wastes, and wastes for direct discard) are grouped, and each category of residue is introduced separately into the facility and processed individually. These values may give a more realistic estimate of facility operations as higher demands are made on facility due to non-uniform and non-optimal loading. Waste generation is expected to be higher for case 2 due to the non-uniform waste aggregation.

Case 3 makes the assumption of no processing of material, and the plutonium-contaminated residues are directly discarded. Combustibles are burned, as appropriate, and wastes are grouted and drummed directly.

4.0 RESULTS

Comparison of the three cases may be viewed in Tables 2, 3 and 4 and the accompanying graphs and charts. Table 2 compares the estimated waste generation among the three cases studies. Table 3 details the facility and operating parameters. Table 4 shows the individual contributions from the recommended processing categories referenced in Table 1.

In general, the following observations are significant:

1) Waste generation:

Direct discard of the IDC list of Rocky Flats inventory would generate nearly a 7-fold increase in the number transuranic (TRU) waste drums over processing of residues due to plutonium discard limits. Low-level wastes (LLW) under the direct discard option, however, show a significant decrease over the process option since the aqueous lines will not be required.

Under the processing option, dissolver recoverable materials are the largest contributor to the total TRU waste drums. Salts are the largest contributor to LLW waste. Clearly, additional processing/discard alternatives need to be explored.

Processing of all wastes categories together should give a lower bound on waste generation estimates due to the uniform loading of plutonium over the process centers.

2) Costs

Despite the lower facility, equipment and total capital costs under direct discard, total discounted cost for direct discard is estimated to be 33% higher than if residues are processed. The higher overall cost can be attributed to the higher TRU waste generated under the direct discard option. While capital costs are fixed, the costs for wastes are factored in on an annual basis, thereby increasing the overall discounted cost total.

Discounted costs for the 3 cases may be seen in Table 3 and Figure 9. The discounted cost increases from case 1 to case 2 due to the higher annual waste generation when wastes are the individual categories are processed independently.

3) Facility Size

As expected, projected facility size is smaller for the direct discard option over the aqueous processing option. Higher capital expenditures are expected if residue processing is chosen over direct discard.

TABLE 1: RFP Residue Feed Stream Summary

Feed Candidate IDCs								
Processing Category		Recommended Processing	Injection point/ processing flow	IDC Code	ROCKY FLATS RESIDUE:	PU, KG	TOT MASS, KG	TOT MASS w/o Pu, KG
DISSOLVER RECOVERABLE MATERIALS	1	BURN/CEPOD/NITRATE	R-2, R-1, R-4, etc.	422	Soot	11.7	666.1	654.4
				338	Combustibles, Wet	33.4	6931	6897.6
				330	Combustibles, Dry	22.9	4589	4566.1
				338	Filter Media	93.8	2133	2039.2
				331	Filter, non Inc.	32.1	3202	3169.9
				310	Graph Scarf/Fines	76.5	944	867.5
				480	Light Metal	14.9	4034.4	4019.5
						285.3	22499.6	22214.2
	2	CRUSH/CEPOD/NITRATE	R-2, R-4, etc.	370	Leco Crucibles	137	8056	7919
						137	8056	7919
	3	CEPOD/NITRATE	R-2, R-4, etc.	159	Screenings from Oxide	137.8	320.8	183
				378	Firebrick Putt/Fines	13.7	291.4	277.7
				420	Ash, Pull Inc.	695.5	9957.2	9261.7
				421	Ash Heel	270.3	8904.9	8634.6
				290	Filter Sludge	14.6	379	364.4
				299	Misc. Sludge	6.5	87	80.5
				340	Sludge (Size Reduct)	4.1	120	115.9
						1142.5	20060.3	18917.8
	4	CRUSH/BURN/CEPOD/NITRATE	R-2, R-1, R-4, etc.	312	Graphite course	98.2	2129	2030.8
				301	Class Graph Shapes	9.3	6975	6965.7
				300	Graphite Molds	11.6	9420	9408.2
						119.3	18524	18404.7
	5	CRUSH/LEACH/NITRATE	R-2, R-3, R-7, etc.	377	Firebrick, Course	14.7	1586	1571.3
				377	Firebrick, Course	4.6	1717	1712.4
						19.3	3303	3283.7
	6	BURN/LEACH/NITRATE	R-2, R-1, R-3, R-7, etc.	337	Plastics	5.1	1262	1256.9
						5.1	1262	1256.9
	7	LEACH/DRUM	R-3, R-7, W-21, etc.	341	Leaded Drybox Gloves	3.5	6499	6495.5
				339	Lead Glov Non-Acid	1.6	7261	7259.4
				341	Leaded Drybox Gloves	1.3	398	396.7
				339	Lead Glov Non-Acid	0.2	104	103.8
						6.6	16262	16255.4
	8	LEACH/NITRATE	R-3, R-7, etc.	320	Heavy NON SS Metal	17.8	2098	2080.2
				371	Firebrick	8	1133	1125
				440	Class	6.9	897.4	890.5
						32.7	4128.4	4095.7
SALTS	9	ER/CHLORIDE	R-16, etc.	392	Unpul Sand, Slag & Cruc	57.5	1562	1504.5
				391	Unpul Sand & Cruc	28.4	744	715.6
				418	Molt Salt-Pack LANL	16.6	80.8	64.2
				393	Sand Slag, Cruc Heel	13.9	2439.9	2426
				411	ER	498.5	7159.3	6660.8
				413	ER	85.3	618.9	533.6
				414	DOR	46.3	936.2	889.9
				398	Pul Sand, Slag & Cruc	27.3	534	506.7
				385	Salt - Bad DOR Run	25.7	32	6.3
				473	ER Salt for LANL	15.1	203	187.9
				394	Sand from BBO	8.1	66.9	58.8
				415	Pu Chloride Mixed Salt	7.1	122.6	115.5
				414	DOR	6.9	3570.4	3563.5
				654	ER Salt from PU/NP	6.7	54	47.3
				368	MgO	44.8	1708	1663.2
						888.2	19832	18943.8
	10	MSE/CHLORIDE	R-15, etc	429	Scrub Alloy Salt	9.3	434.4	425.1
				409	MSE	241.3	1398.2	1156.9
				427	MSE spent Dic Salt	63.3	277.8	214.5
				405	MSE	32.1	1451	1418.9
				407	MSE	16.5	466	449.5
				410	MSE	6.6	29.3	22.7
				429	Scrub Alloy Salt	5.2	1300.6	1295.4
				406	Molt Salt-Ukn % Pulv	5.1	24.3	19.2
				408	MSE	4.8	210	205.2
						384.2	5591.6	5207.4
BURN/GROUT	11	CRUSH/BURN/GROUT	W-21, W-22, W-25, W-26, etc.	301	Class Graph Shapes	0.3	2621	2620.7
				312	Graphite course	0.3	378	377.7
						0.6	2999	2998.4
	12	BURN/GROUT	W-21, W-23, etc.	485	Scrap D38 shapes-class	0.1	975	974.9

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Feed Candidate IDCs								
Processing Category		Recommended Processing	Injection point/ processing flow	IDC Code	ROCKY FLATS RESIDUE	PU, KG	TOT MASS, KG	TOT MASS w/o Pu, KG
				435	CE/Ca Alloyw salt	0.2	7.7	7.5
				431	Resin, Leached	1.4	210.3	208.9
				431	Resin, Leached	0.3	1220.7	1220.4
				430	Resin, Unleached	0.1	1	0.9
				430	Resin, Unleached	0	115	115
				423	Soot Heels	0.6	32.6	32
				434	Free Calcium w/Salt	2.2	38	35.8
				333	Calcium Metal	0.4	3.8	3.4
				330	Combustibles, Dry	0.5	4731	4730.5
				336	Combustibles, Wet	0.2	1731	1730.8
				376	Processed Filter Media	2.9	2543	2540.1
				335	Drybox Filt, N-Acid	2.7	275	272.3
				342	Abs Drybox Filters	2.1	2097	2094.9
				335	Drybox Filt, N-Acid	1.7	2547	2545.3
				342	Abs Drybox Filters	1.7	191	189.3
				338	Filter Media	1.3	899	897.7
				376	Processed Filter Media	0.6	56	55.4
				331	Filter, non Inc.	0.1	910	909.9
				328	Ful-Flo Filters	0.1	211	210.9
				302	Benelex/Plexiglass	0.1	173	172.9
				303	Scarf Graph Chunks	0.5	6	5.5
				303	Scarf Graph Chunks	0.2	360.1	359.9
				310	Graph Scarf/Fines	0	1.9	1.9
				490	HEPA Filters	1.2	1263	1261.8
				491	Plenum pre-filters	0.1	1635	1634.9
				490	HEPA Filters	0.3	45	44.7
				480	Light Metal	2.4	36698.6	36696.2
				416	Zinc-Magn Alloy Met	0.4	4.8	4.4
				375	Oil Dry	0.1	186	185.9
				332	Oily Sludge	0.1	2.6	2.5
				337	Plastics	0.24	681	680.76
				487	Plastic shapes-class	0.1	937	936.9
						24.94	62989.1	62964.16
GROUT/DRUM	13	CRUSH/GROUT	W-21, W-22, W-28, etc.	489	BE scrap metal-class	0.1	1832	1831.9
				489	BE scrap metal-class	0.3	144	143.7
				486	Class Tool-Disposal	0.1	1	0.9
				486	Class Tool-Disposal	0	2939	2939
						0.5	4916	4915.5
	14	DRUM	W-26, etc.	438	Insulation	0.7	2933	2932.3
				373	Firebrick Heel	1.9	136	134.1
				855	ER Ceram from PU/NP	1.3	42	40.7
				360	Al Oxide Ceramic Cruc	0.1	40.9	40.8
				360	Al Oxide Ceramic Cruc	0.1	5.7	5.6
				334	Blanket, Fire	0.1	59.6	59.5
				440	Glass	0.9	6387.6	6386.7
				374	Blacktop, concr, dirt	0	3409	3409
				374	Blacktop, concr, dirt	0.1	15	14.9
				300	Graphite Molds	0.8	4123	4122.2
				321	Lead	0.1	15366	15365.9
				488	GB Parts w/Lead	0	365	365
				320	Heavy NON SS Metal	2.8	3077	3074.2
				481	Lgt SS Mtl-to leach	0.1	294	293.9
				484	Non-NM Metal	0.1	59	58.9
						9.1	36312.8	36303.7
	15	GROUT	W-25, etc.	442	Leach Raschig Rings	1.4	16227.8	16226.4
				442	Leach Raschig Rings	1.2	330.2	329
				441	Unleach Raschig Rings	1.1	47.2	46.1
				391	Unpul Sand & Cruc	0.4	265	264.6
				395	Unpulv Slag & Cruc	0.4	24	23.6
				372	Grit	0.2	1032.3	1032.1
				370	Leco Crucibles	0.3	238	237.7
				441	Unleach Raschig Rings	0.3	1370.8	1370.5
				433	Scrub Alloy spnt Dices Salt	0.3	22	21.7
				392	Unpul Sand, Slag & Cruc	0.1	104	103.9
				393	Sand Slag, Cruc Heel	0.1	25.1	25
				394	Sand from BBO	0.1	18.1	18
				372	Grit	0.1	8	7.9
				396	Pulver Slag	0.1	0.9	0.8
				376	Firebrick Pult/Fines	0	70.1	70.1
				428	Ash select for MMEC	2.5	33.9	31.4
				425	Fluid Bed Ash	0	6409	6409
				419	Unpul Inc. Ash	1.9	30.3	28.4
				292	Incinerator Sludge	1.3	5129.1	5127.8
				426	Reburned 413	0.9	19.2	18.3
				292	Incinerator Sludge	0.7	22	21.3

TABLE 1: RFP Residue Feed Stream Summary

Feed Candidate IDCs								
Processing Category		Recommended Processing	Injection point/ Processing flow	IDC Code	ROCKY FLATS RESIDUE	PU, KG	TOT MASS, KG	TOT MASS w/o Pu, KG
				420	Ash, Pull Inc.	0.2	167.3	167.1
				421	Ash Heel	0	0.1	0.1
				387	Reburned SS&C Sweep	1.6	3.6	2
				404	MSE	1.9	404	402.1
				412	MSE	1.2	240.2	239
				409	MSE	0.6	130.8	130.2
				405	MSE	0.1	88	87.9
				404	MSE	0	112	112
				412	MSE	0	57.8	57.8
				407	MSE	0	1	1
				410	MSE	0	0.1	0.1
				411	ER	1.4	511	509.6
				363	ER Salt - First Use	0.1	1.7	1.6
				364	ER Salt - Second Use	0.1	1.5	1.4
				413	ER	0	1.1	1.1
				484	Non-NM Metal	0.2	5243	5242.8
				368	MgO	2.8	2570.3	2567.5
				415	Pu Chloride Mixed Salt	0	3.7	3.7
				299	Misc. Sludge	0.1	74	73.9
				340	Sludge (Size Reduct)	0	15	15
				390	Unpul Slag	0	0.2	0.2
				395	Unpulv Slag & Cruc	0	4	4
				398	Pul Sand, Slag & Cruc	0	3	3
				427	MSE spent Dic Salt	0	0.2	0.2
				428	Ash select for MMEC	0	0.1	0.1
				390	Unpul Slag	3	20.6	17.6
						26.7	*42081.3*	*42054.6*
					TOTAL	*3082.04*	*268817*	*265734.96*

TABLE 2: Estimated Waste Generation

	CASE 1: ALL WASTES PROCESSED SIMUL-TANEOUSLY	CASE 2: SUM OF WASTES PROCESSED INDIVIDUALLY	CASE 3: DISCARD ALL WASTES DIRECTLY W/O PROCESSING
TRU GROUTED WASTE (MT per year)	26	39	0
TRU SOLID WASTE (MT per year)	90	171	2020
TOTAL TRU DRUMS (Drums/year)	861	1252	8392
LLW GROUTED WASTE (MT per year)	387	404	0
LLW SOLID WASTE (MT per year)	17	17	16
TOTAL LLW DRUMS (Drums/year)	805	854	56
LIQUID EFFLUENTS (MT/year)	54	58	0
GASEOUS EFFLUENTS (MT/year)	15	16	1

TABLE 3: *Operating Requirements -- Process Wastes vs. Direct Discard*

	CASE 1: ALL WASTES PROCESSED SIMUL-TANEOUSLY	CASE 2: SUM OF WASTES PROCESSED INDIVIDUALLY	CASE 3: DISCARD ALL WASTES DIRECTLY W/O PROCESSING
FACILITY PARAMETERS			
FACILITY SIZE (Sq. ft.)	122800	122800	80100
GLOVEBOXES			
- PROCESSING	42	42	5
- WASTE	24	24	46
- ANALYTICAL LABORATORY	44	44	44
COST			
- FACILITY ($M)	234	234	179
- EQUIPMENT ($M)	148	148	108
- TOTAL CAPITAL ($M)	382	382	287
OPERATING PARAMETERS			
STAFF			
- OPERATING	83	110	31
- SUPPORT	493	662	183
- TOTAL	576	773	214
ANNUAL COSTS			
- WASTES ($M)	11	16	99
- OTHER OPERATING COSTS ($M)	50	61	24
DISCOUNTED COST TOTAL ($M)	1184	1309	1600

TABLE 4: Operating requirements if wastes categories are processed individually

	PERIODIC WASTES	DISSOLVER RECOVERABLE MATERIALS (w/o periodic waste)	MATERIALS PROCESSED DIRECTLY TO BURN/GROUT (w/o periodic waste)	MATERIALS PROCESSED DIRECTLY TO GROUT/DRUM (w/o periodic waste)	SALTS (w/o periodic waste)	SUM OF WASTES PROCESSED INDIVIDUALLY
WASTE						
TRU GROUTED WASTE (MT per year)	0	17.3	0	0	22	39
TRU SOLID WASTE (MT per year)	2.8	85.1	17.6	56.4	8.8	171
TOTAL TRU DRUMS (Drums/year)	12	847	71	201	121	1252
LLW GROUTED WASTE (MT per year)	5.7	115.1	0	0	282.7	404
LLW SOLID WASTE (MT per year)	16.9	0	0	0	0	17
TOTAL LLW DRUMS (Drums/year)	61.6	234.8	0	0	557.8	854
LIQUID EFFLUENTS (MT/year)	0.7	18.3	0	0	39.2	58
GASEOUS EFFLUENTS (MT/year)	0.9	7.6	0	0	7.1	16
OPERATING PARAMETERS						
NUMBER OF GLOVEBOXES						
- PROCESSING	10	18	0	0	39	67
- WASTE	16	12	1	1	14	44
- ANALYTICAL LABORATORY	44	0	0	0	0	44
STAFF						
-OPERATING	4	47	7	7	45	110
-SUPPORT	24	280	43	44	271	662
-TOTAL	28	327	50	51	317	773

FIGURE 1: Number of Waste Drums vs Processing Category

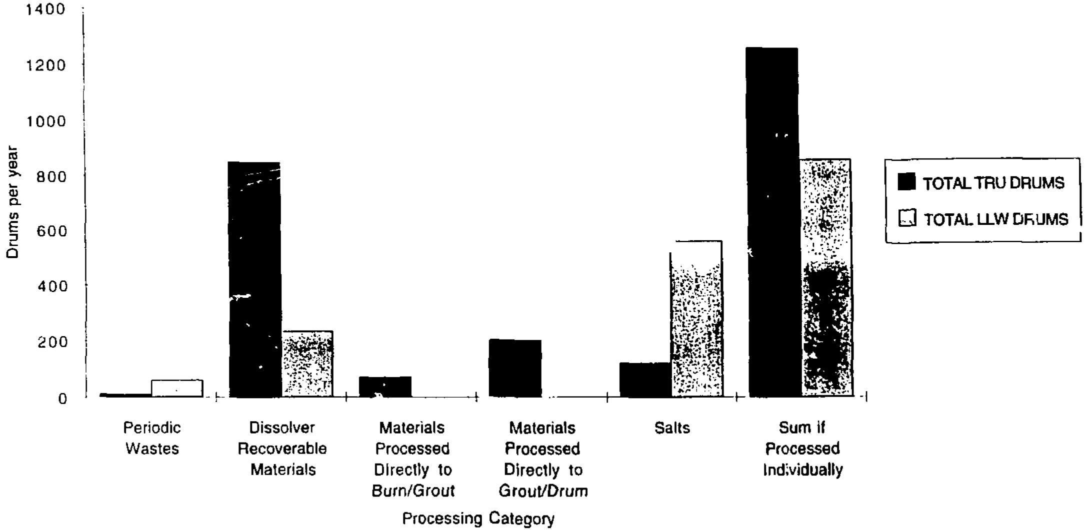


FIGURE 2: Number of LLW Drums vs Processing Category

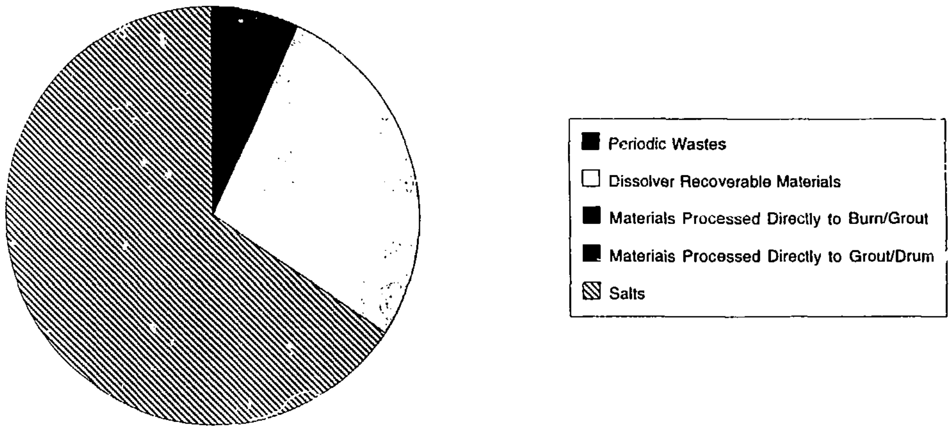


FIGURE 3: Number of TRU Drums vs Processing Category

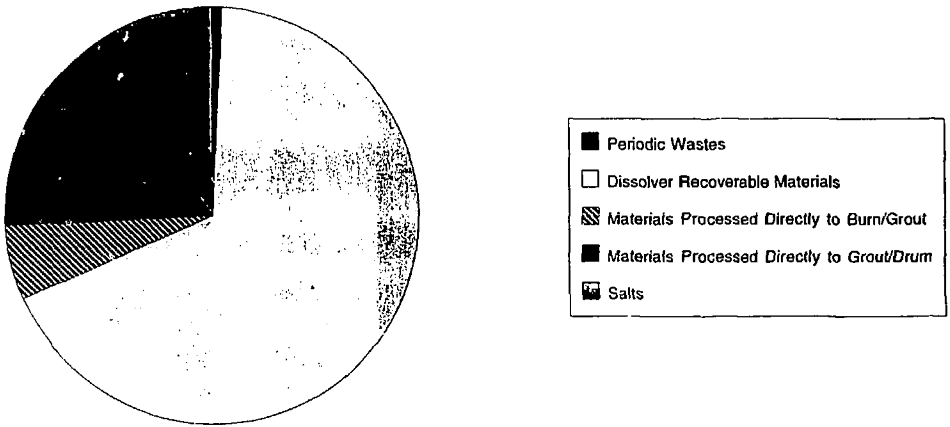


FIGURE 4: No. of Drums -- Process or Discard Directly

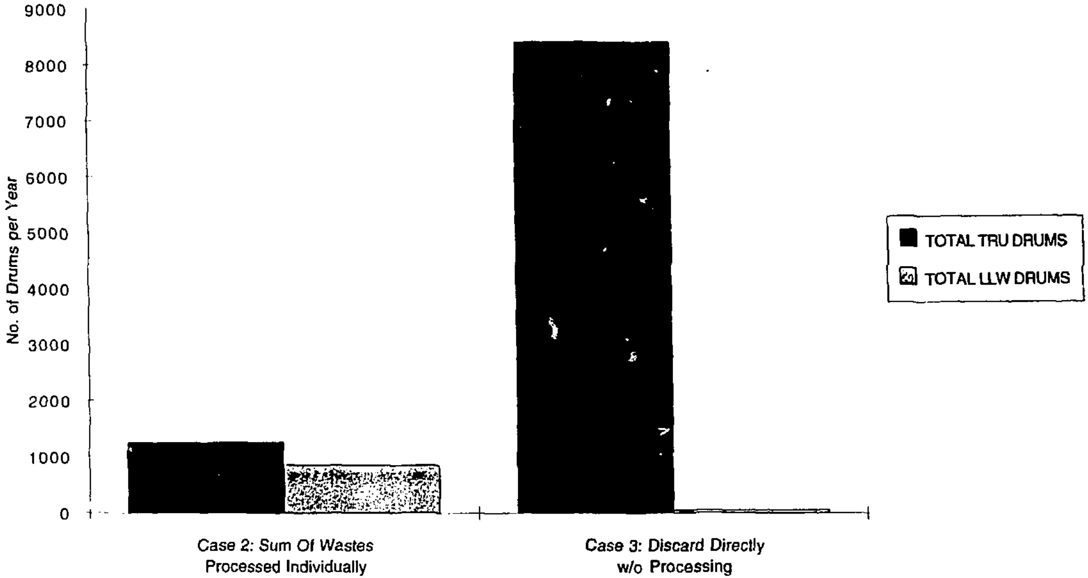


FIGURE 5: No. of Drums - Process Together or Process Individually

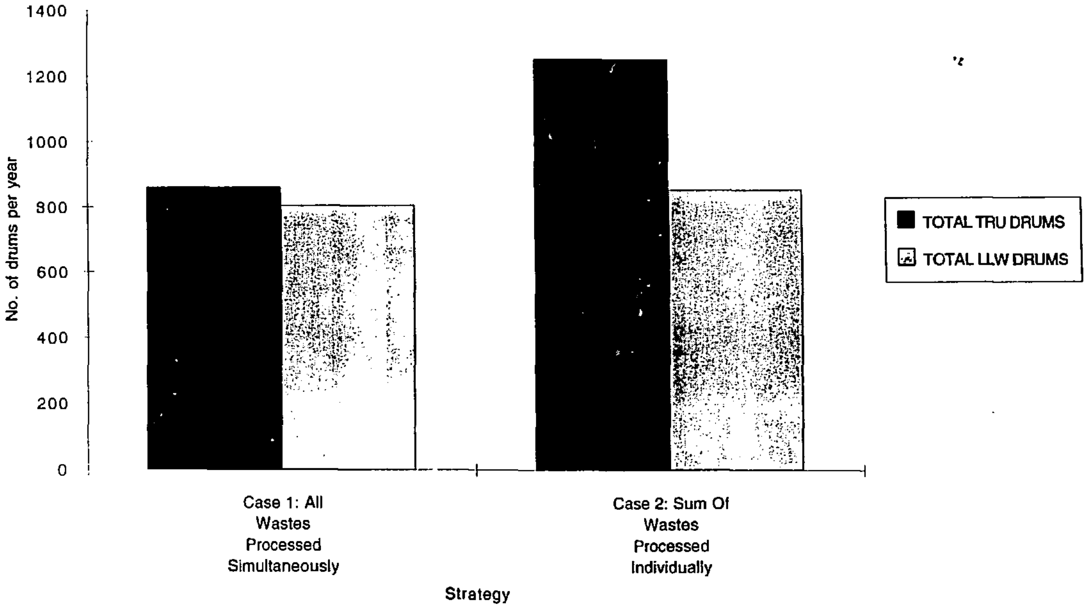


FIGURE 6: Staffing Requirements

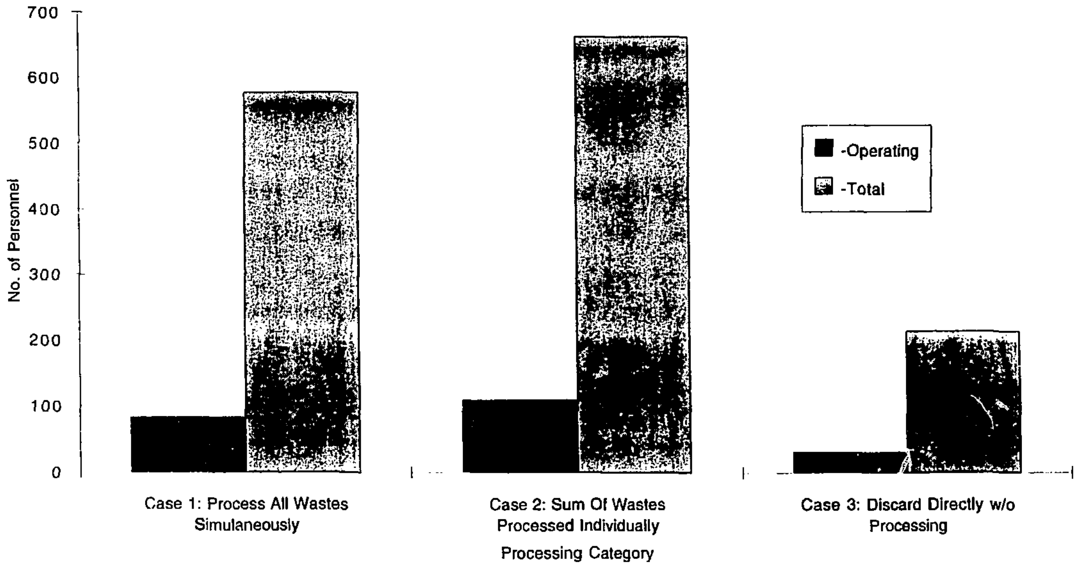


FIGURE 7: No. of Gloveboxes vs. Processing Category

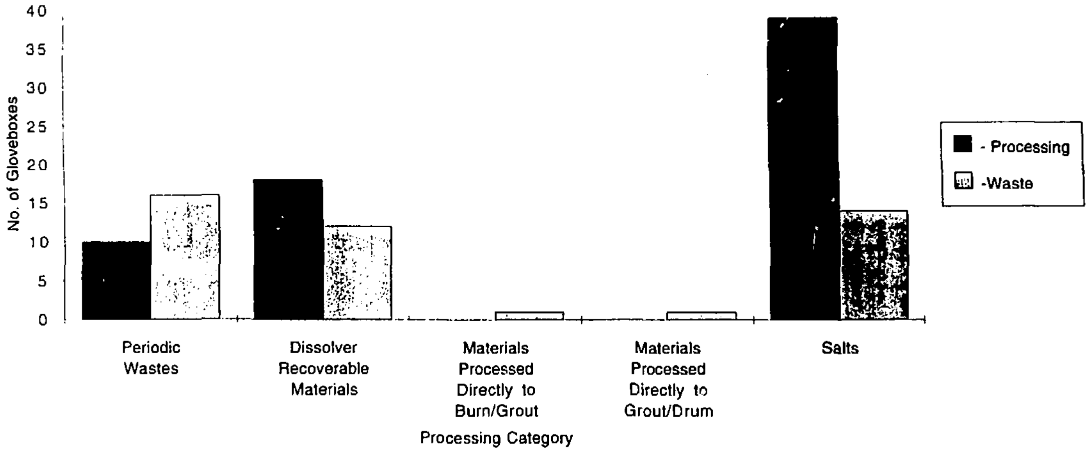


FIGURE 8: Number of Gloveboxes vs. Strategy

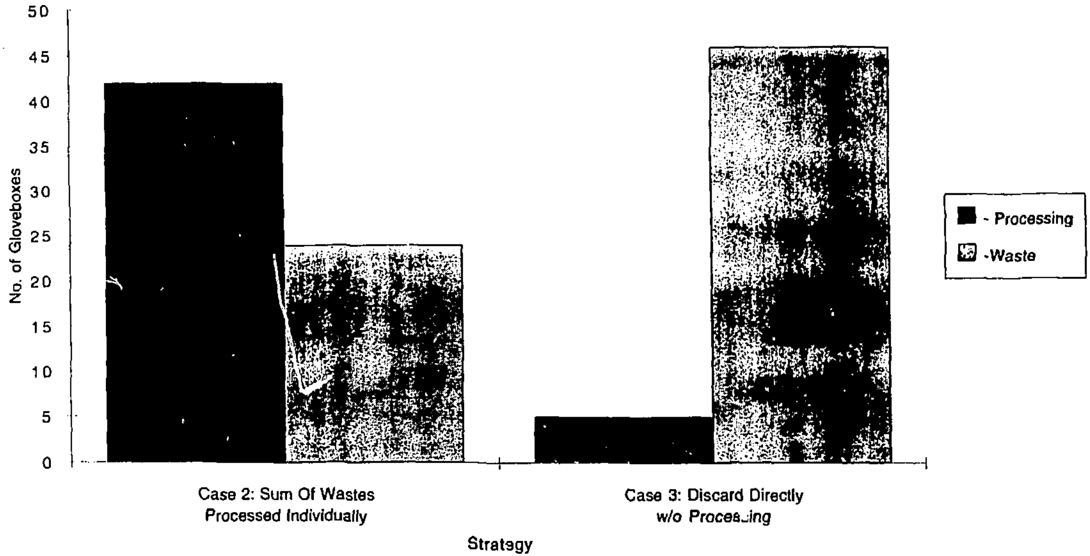


FIGURE 9: Costs - Process Wastes vs. Discard Directly

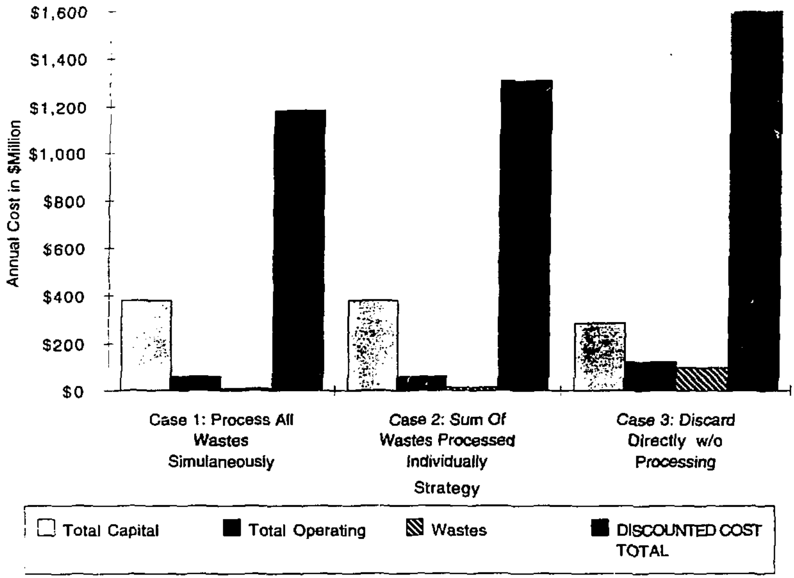
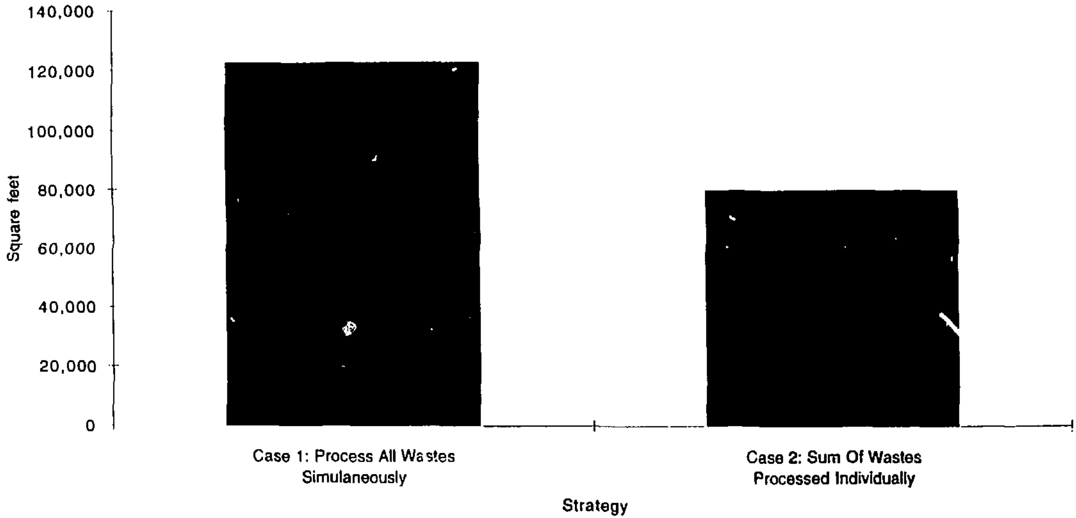


FIGURE 10: Facility Size - Process Wastes vs Discard Directly

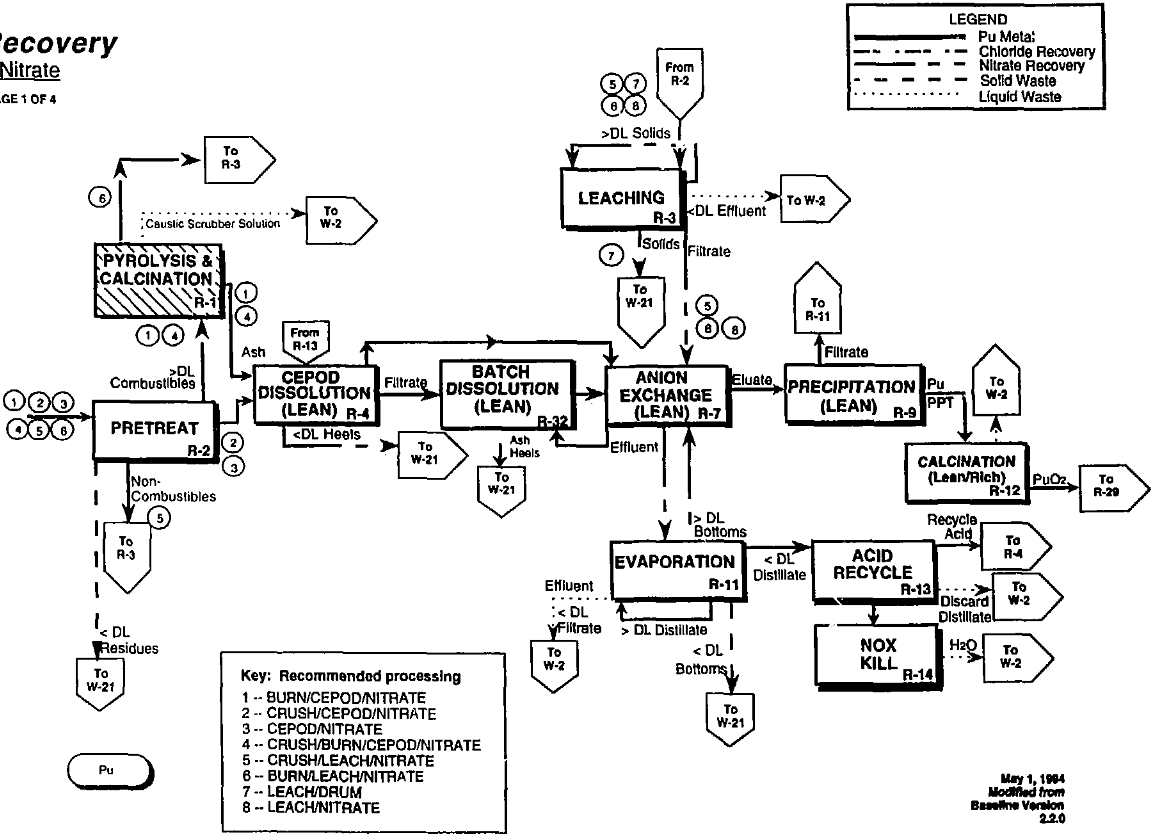


ROCKY FLATS -- Process Residues

Pre-Decisional Draft

Recovery

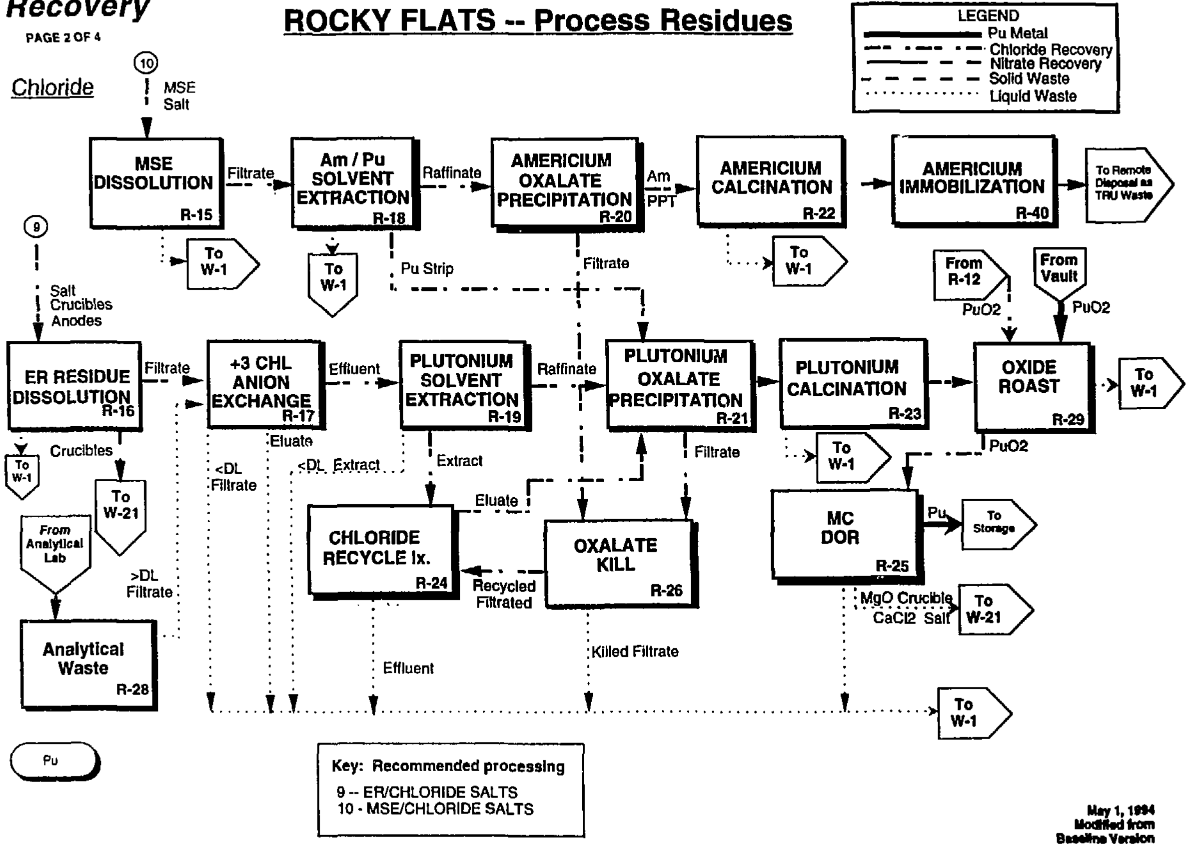
Nitrate



May 1, 1994
Modified from
Baseline Version
2.2.0

ROCKY FLATS -- Process Residues

Pre-Decisional Draft

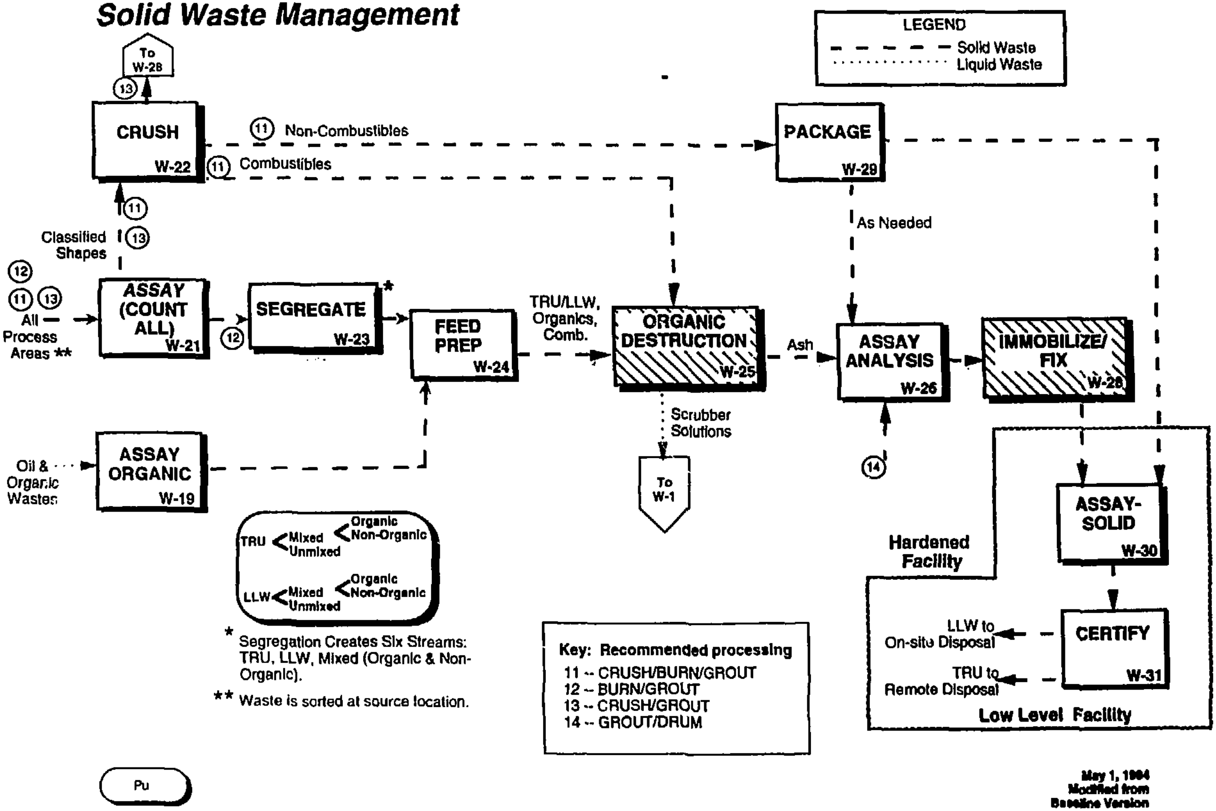


May 1, 1994
Modified from
Baseline Version
2.2.0

ROCKY FLATS -- Process Residues

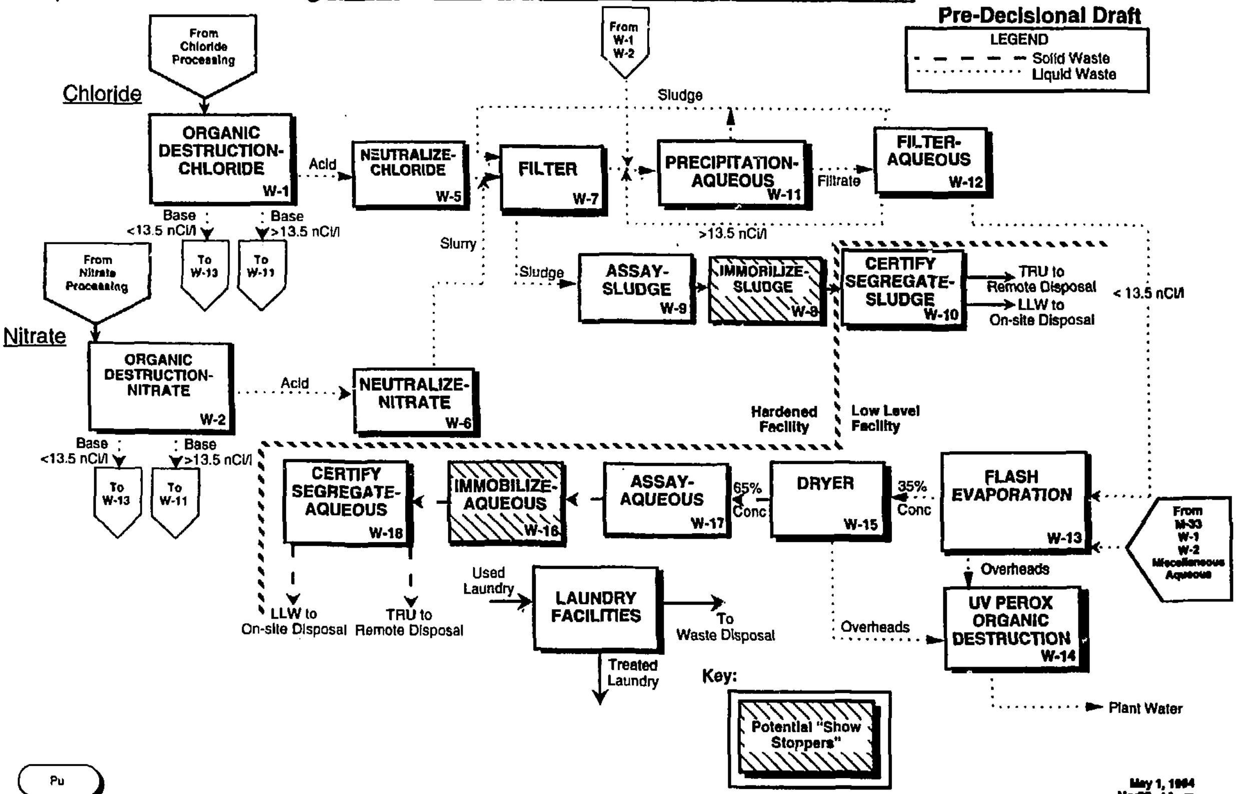
Pre-Decisional Draft

Solid Waste Management



May 1, 1994
Modified from
Baseline Version
2.2.0

Aqueous Waste Management ROCKY FLATS -- Process Residues



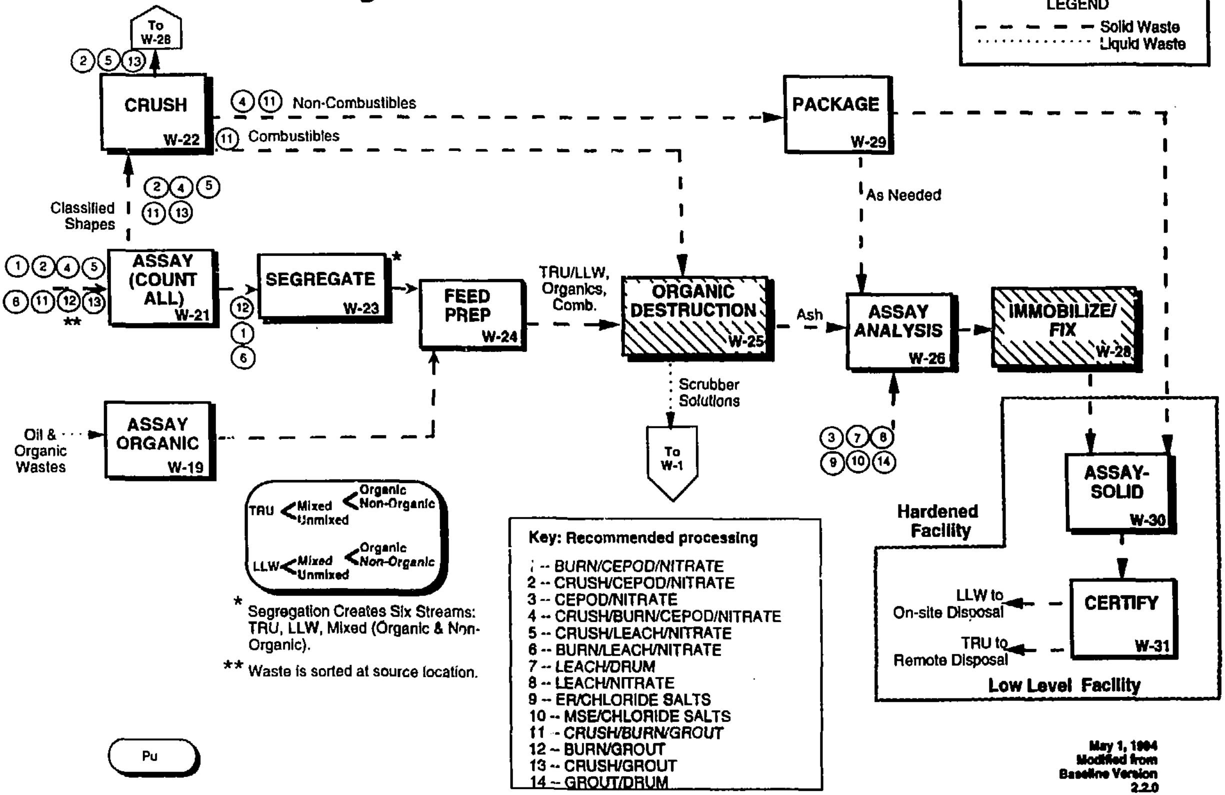
Note: Organic Liquid wastes from all process areas are routed to Solid Waste Management.

May 1, 1994
Modified from
Baseline Version
2.2.0

ROCKY FLATS - Direct Discard of All Residues

Pre-Decisional Draft

Solid Waste Management

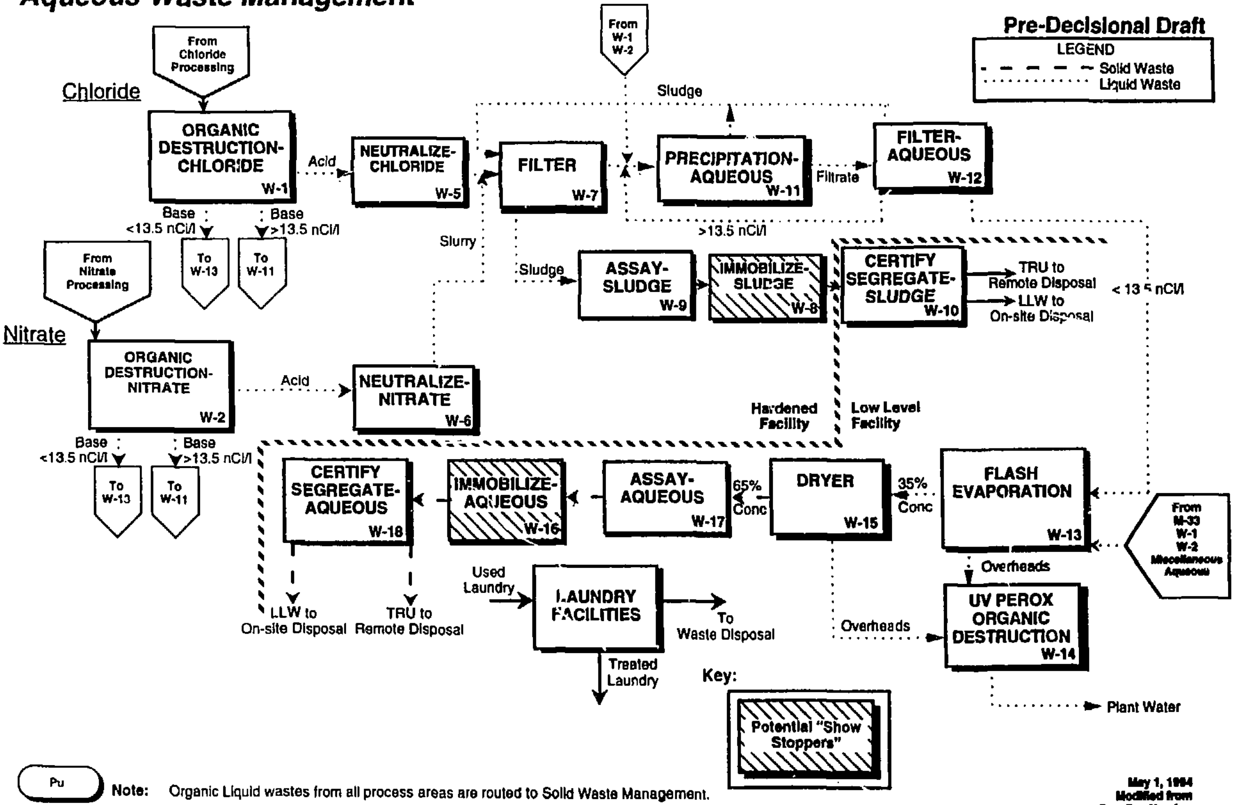


May 1, 1994
Modified from
Baseline Version
2.2.0

ROCKY FLATS - Direct Discard of All Residues

Aqueous Waste Management

Pre-Decisional Draft



Note: Organic Liquid wastes from all process areas are routed to Solid Waste Management.

May 1, 1994
Modified from Baseline Version 2.2.0