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FERNALD SILO ANALYTICAL INFORMATION (DOCUMENTATION IS PART OF INDEPENDENT ASSESSMENT)

01/24/97

DOE-0423-97
DOE-FEMP ENERGY FUELS NU
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LETTER

Department of Energy

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JAN 24 1997

DOE-0423-97

Michelle Rehmann, Environmental Manager
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1515 Arapaho Street
Suite 900
Denver, Colorado 80202

Dear Ms. Rehmann:

FERNALD SILO ANALYTICAL INFORMATION

Enclosed are the appendices consolidating the Fernald Silo Contents Analytical Results you requested.

We will be awaiting your response. If you have any questions or problems, please contact David Rast at (513) 648-3138.

Sincerely,

Nina K. Akgunduz
OU4 Team Leader

FEMP:Rast

Enclosure: As Stated

cc w/o enc:

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Recycled and Recyclable

APPENDIX A

OPERABLE UNIT 4 REMEDIAL INVESTIGATION DATA SUMMARY

APPENDIX A

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A.1.0 INTRODUCTION

A.1.1 Purpose

Appendix A summarizes and presents data from the Remedial Investigation (RI) Report for Operable Unit 4. All data presented in this appendix were reported and discussed in detail in the RI Report for Operable Unit 4. The primary objective of data collection conducted for the RI Report for Operable Unit 4 was development of a detailed understanding of the nature of the wastes stored in Operable Unit 4, their impacts on the surrounding environment, and the threat posed to human health and the environment by Operable Unit 4. This detailed understanding was successfully developed to the degree necessary to: (1) support the decision on whether remedial action for Operable Unit 4 is warranted; and (2) support the evaluation of available remedial action alternatives in the Feasibility Study (FS).

A.1.2 Description of Summary Tables

The data presented here are summarized and arranged according to the appropriate subunits which are defined in Chapter 1 of this FS Report. Summary statistics were performed on the extremely large volume of RI data collected and reported in the RI Report for Operable Unit 4 to simplify presentation for this FS report. These summaries indicate the frequency of detection along with the number of rejected data points for each analyte. Also presented for each analyte are the mean concentrations, the upper 95 percent confidence intervals (CIs) on the mean, and the ranges of detection. Appendix A presents only that data from the RI which was determined through the data validation process and data useability assessment (both of which are described in detail in the RI Report for Operable Unit 4) to be useable for the purpose described in Section A.1.1. Subsequently, data validation qualifiers are not presented with this data, since qualifiers are only descriptive of and applicable to the discrete analytical results from which the data presented in this appendix are derived. Where appropriate, the summary data tables presented here contain descriptive notes which provide additional explanations to assist understanding of this information.

APPENDIX A.1

FEASIBILITY STUDY SUBUNIT A
(SILOS 1 AND 2 CONTENTS AND DECANT SUMP TANK SLUDGE)

OPERABLE UNIT 4 SILOS 1 AND 2 CONTENTS
SUMMARY OF RADIOLOGICAL ANALYSES

TABLE A.1-1

SUMMARY OF RADIONUCLIDE ANALYSES FOR SILOS 1 AND 2 RESIDUES

Analyte[a]	Frequency of Detection[b]	Rejected	Arithmetic Mean[c] (pCi/g)[d]	Upper 95% CI on Mean[c] (pCi/g)[d]	Range of Detects[c] (pCi/g)[d]
SILO 1					
Actinium-227	13/20	0	5960	7670	4320-17390
Lead-210	20/20	0	165000	202000	48980-381400
Polonium-210	13/13	0	242000	281000	144000-434000
Radium-226	20/20	0	391000	477000	89280-890700
Thorium-228	2/20	0	422	2280	835-2280
Thorium-230	24/24	0	60000	68900	10569-105372
Thorium-232	8/20	0	424	1110	661-1106
Uranium-234	21/21	0	800	932	326-1548
Uranium-235/236	14/20	0	38	54	19.1-105
Uranium-238	20/20	0	642	693	387-920
SILO 2					
Actinium-227	11/14	0	5100	6640	2905-10450
Lead-210	14/14	0	145000	190000	58160-399200
Polonium-210	8/8	0	139000	231000	55300-241000
Protactinium-231	1/14	0	2350	4040	4041-4041
Radium-226	14/14	0	195000	263000	657-481000
Thorium-228	5/14	0	645	7360	411-7360
Thorium-230	15/15	0	48400	76200	8365-132800
Thorium-232	3/14	0	402	985	851-985
Uranium-234	13/13	0	961	1160	121-1465
Uranium-235/236	11/13	0	73	94	35.6-172
Uranium-238	14/14	0	912	1120	46-1925

[a]Sample numbers used in this data set include: (Silo 1) 99728, 99743, 99870, 99885, 99909, 99930, 99939, 99948, 99966, 99975, 100004, 100025, 100039, 100108 through 100114; and (Silo 2) 99359, 99710, 99774, 99802, 99811, 99831, 99846, 99861, and 100115 through 100120.
[b]Rejected data not included in total number of samples.
[c]Values qualified with an R are excluded. The mean and upper 95% confidence interval (CI) on mean have been rounded to show three significant figures. The mean is calculated using one-half the Sample Quantitation Limit (SQL) for nondetects.
[d]Values expressed in picoCuries per gram (pCi/g).

TABLE A.1-2

INVENTORY OF K-65 RADIOLOGICAL CONSTITUENTS

	Silo 1[a]		Silo 2[b]	
Analyte	Mean Inventory[c] (Ci)	UCL Inventory[c] (Ci)	Mean Inventory[c] (Ci)	UCL Inventory[c] (Ci)
Actinium-227	40	52	30	39
Lead-210	1110	1360	844	110
Polonium-210	1630	1890	809	1340
Protactinium-231	ND[d]	ND[d]	14	24
Radium-226	2630	3210	1140	1530
Thorium-228	2.8	15.3	3.8	43
Thorium-230	403	463	282	444
Thorium-232	2.9	7.5	2.3	5.7
Uranium-234	5.4	6.3	5.6	6.8
Uranium-235/236	0.26	0.36	0.43	0.55
Uranium-238	4.3	4.7	5.3	6.5
Total Uranium[e]	12.9	14.1	15.9	19.5

[a]Based on a volume of 3280 cubic meters (m^3) and a dry mass density of 2.050 grams per cubic centimeter (gm/cm^3).
[b]Based on a volume of 2840 m^3 and a dry mass density of 2.050 gm/cm^3.
[c]Values for mean and Upper Confidence Limit (UCL) calculated using value taken from Table 4-2 of the Remedial Investigation Report for Operable Unit 4 (RI Report for OU4).
[d]ND - Analyte was not detected.
[e]Total uranium mass values in metric tons (MT). Calculated from the isotopic distribution of uranium.

OPERABLE UNIT 4 SILOS 1 AND 2 CONTENTS AND DECANT SUMP TANK SLUDGE SUMMARY OF RADIOLOGICAL AND CHEMICAL ANALYSES

TABLE A.1-3

TCLP RADIOLOGICAL ANALYSES FOR SILOS 1 AND 2

Radiological Parameters	Silo 1[a] (pCi/L)									Silo 2[b] (pCi/L)								
	Zone A[c]			Zone B[c]			Zone C[c]			Zone A[c]			Zone B[c]			Zone C[c]		
Ac-227	7302	±	1648	7343	±	2111	5014	±	1371	4258	±	1220	2620	±	620	3400	±	780
Gross Alpha	N/A			N/A			227,000	±	54,000	NA			NA			NA		
Gross Beta	1,950,000	±	200,000	953,000	±	96,000	795,000	±	102,000	51,600	±	5400	1,180,000	±	120,000	1,060,000	±	110,000
Pb-210	1,670,000	±	170,000	997,000	±	103,000	509,000	±	54,000	104,000	±	13,400	220,000	±	25,000	119,000	±	15,000
Po-210	208,000	±	29,100	134,000	±	19,900	71,200	±	17,100	19,900	±	9000	36,200	±	7300	18,100	±	4930
Pa-231	<2800			<3100			<2900			<2000			<3300			<3300		
Ra-226	40,150	±	6050	66,370	±	9811	44,080	±	6609	24,410	±	3773	81,840	±	12,060	79,430	±	11,700
Ra-228	N/A			N/A			N/A			N/A			11	±	2.1	19.7	±	3.7
Th-228	14.9	±	5.3	40	±	14.6	49.8	±	16.4	24.7	±	10	204	±	67	113	±	46
Th-230	455	±	105	307	±	91	394	±	110	72.8	±	24	110	±	42	293	±	84
Th-232	5.65	±	2.72	6.53	±	3.86	8.42	±	4.34	1.87	±	1.94	<50			<50		
U-234	320	±	49	238	±	36	2480	±	460	417	±	67	2330	±	370	3860	±	640
U-235/236	14.1	±	3.5	9.74	±	2.69	133	±	81	19.2	±	4.8	95.6	±	28.3	158	±	44
U-238	332	±	51	246	±	37	2350	±	440	421	±	68	2400	±	380	4000	±	670

N/A - Data not available.
[a]Data from samples 100050 (11/12/92), 100051 (11/12/92), and 100052 (11/12/92).
[b]Data from samples 100065 (11/12/92), 100066 (11/12/92), and 100067 (11/12/92).
[c]The physical characteristics of the "Zones" are provided in Section 3.0 of the RI Report for OU4.

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TABLE A.1-4

K-65 DECANT SUMP TANK RADIOLOGICAL RESULTS FOR SLUDGE SAMPLE

Analyte	Results (pCi/L)	2 Sigma
Actinium-227	5.8×10^3	603
Lead-210	1.2×10^5	1.2×10^4
Protactinium-231	<855	N/A[a]
Radium-224	<41	N/A[a]
Radium-226	1.3×10^5	6.4×10^3
Radium-228	<140	N/A[a]
Thorium-230	5.2×10^4	7.6×10^3
Total Uranium	<1255[b]	N/A[a]

[a]Value expressed in micrograms per liter (μg/L).
[b]N/A - Not Applicable.

TABLE A.1-5

CHEMICAL ANALYSES FOR SILOS 1 AND 2 RESIDUES

Analyte[a]	Frequency of Detection[b]	Rejected	Arithemetic Mean[c] (mg/kg)[d]	Upper 95% CI on Mean[c] (mg/kg)[d]	Range of Detection (mg/kg)[d]
SILO 1					
General Chemistry					
Ammonia	4/7	0	1.19	8.9	1.1-8.9
Chloride	7/7	0	637	1340	269-1349
Fluoride	2/7	0	1	394	15-394
Nitrate	5/5	2	2930	4764	2216-4764
Oil and grease	7/8	0	3650	27000	11.7-27000
Phosphorus	8/8	0	1130	3290	0.4-3290
Sulfate	6/6	1	1300	3460	444-3460
Total Kjeldahl nitrogen	7/7	0	479	676	51.6-782.5
Total organic carbon	8/8	0	19200	26200	5166-34800
Total organic nitrogen	8/8	0	448	623	51.6-782
Metals					
Aluminum	13/19	0	1050	1320	450-2460
Antimony	11/12	7	21	26	13.3-46.2
Arsenic	18/19	0	22	55	3.1-68.4
Barium	19/19	0	11600	14200	1970-22100
Beryllium	17/19	0	1	1	0.59-2.8
Boron	12/12	0	46	50	23.8-61.7
Cadmium	11/18	1	2	4	0.56-8
Calcium	19/19	0	2960	3650	799-5700
Chromium	19/19	0	42	55	19.7-165
Cobalt	19/19	0	936	1100	349-1870
Copper	19/19	0	285	331	122-475
Cyanide	19/19	0	2	3	0.52-4.4
Iron	19/19	0	14700	21100	4280-75100
Lead	19/19	0	81700	95500	17400-133000
Magnesium	19/19	0	2880	3380	1500-6020
Manganese	19/19	0	72	97	25.6-257
Mercury	18/19	0	0.6	0.9	0.15-2.8

TABLE A.1-5
(Continued)

Analyte[a]	Frequency of Detection[b]	Rejected	Arithemetic Mean[c] (mg/kg)[d]	Upper 95% CI on Mean[c] (mg/kg)[d]	Range of Detection (mg/kg)[d]
Molybdenum	12/12	0	4850	6290	968-8600
Nickel	19/19	0	1790	2290	629-3380
Potassium	19/19	0	429	493	158-715
Selenium	19/19	0	287	340	58.5-2810
Silicon	12/12	0	723	853	359-1290
Silver	19/19	0	11	13	5-23.3
Sodium	19/19	0	8670	10700	360-16700
Thallium	8/18	1	0.3	1.4	0.09-1.4
Vanadium	19/19	0	136	161	63.1-293
Zinc	14/19	0	28	37	7.7-212
SILO 2					
General Chemistry					
Chloride	6/6	0	65	141	28-141
Nitrate	5/5	1	5430	8900	3490-8900
Oil and grease	4/4	0	301	541	207-541
Phosphorus	5/5	0	1130	1400	623-1400
Sulfate	6/6	0	8610	19300	2590-19300
Total Kjeldahl nitrogen	3/3	0	204	220	176-220
Total organic carbon	5/5	0	6090	24400	148-24400
Total organic nitrogen	4/4	1	232	289	176-289
Metals					
Aluminum	8/14	0	845	1110	363-2250
Antimony	7/8	6	26	44	14.4-77.4
Arsenic	14/14	0	432	1550	57.5-1960
Barium	14/14	0	6970	19900	89.2-19900
Beryllium	14/14	0	2	3	0.59-6
Boron	5/8	0	38	51	18.4-81.2
Cadmium	13/14	0	5	7	2-19.1
Calcium	14/14	0	33300	301000	64-301000
Chromium	14/14	0	40	51	0.207-83.1
Cobalt	14/14	0	984	2430	6.2-2430
Copper	13/13	1	531	818	220-1790

TABLE A.1-5
(Continued)

Analyte[a]	Frequency of Detection[b]	Rejected	Arithemetic Mean[c] (mg/kg)[d]	Upper 95% CI on Mean[c] (mg/kg)[d]	Range of Detection (mg/kg)[d]
Cyanide	13/13	1	3	5	0.9-7.1
Iron	13/13	1	16500	28900	4010-40000
Lead	14/14	0	48200	299000	153-299000
Magnesium	14/14	0	3800	6410	805-8740
Manganese	14/14	0	163	259	40.6-403
Mercury	13/13	1	0.9	1.2	0.18-2.3
Molybdenum	8/8	0	291	440	148-479
Nickel	14/14	0	1380	1720	14.6-2640
Potassium	14/14	0	217	337	37.8-653
Selenium	13/13	1	110	124	49.6-155
Silicon	8/8	0	851	1148	507-1780
Silver	13/13	1	17	22	7.4-34.9
Sodium	14/14	0	2430	3200	226-4940
Thallium	9/12	1	1	2	0.33-5.7
Vanadium	14/14	0	237	298	21.9-535
Zinc	14/14	0	54	91	11.2-159

[a]Sample numbers used in this data set include: 99359, 99704-99806, 99711-99713, 99715, 99718, 99769-99771, 99775-99778, 99781, 99723-99725, 99729-99732, 99735, 99738-99740, 99745-99747, 99750, 99806-99808, 99812-99815, 99818, 99826-99828, 99832-99834, 99837, 99839, 99841-99843, 99847-99850, 99853, 94856-99858, 99865-99867, 99871-99874, 99877, 99880-99882, 99886-99889, 99904-99906, 99910-99913, 99916, 99925-99927, 99934-99936, 99940-99943, 99946, 99963-99965, 99980-99984, 99986, 99987, 99999, 100000, 100001, 100026-100029, 100032, 100034-100036, and 100115-100120.

[b]Rejected data not included in total number of samples.

[c]Values qualified with an R are excluded. The mean and upper 95% CI on mean has been rounded to show three significant figures. The mean is calculated using one-half the SQL for nondetects.

[d]Values expressed in milligrams per kilogram (mg/kg).

TABLE A.1-6

ORGANICS ANALYSES FOR SILO 1 RESIDUES

Analyte[a]	Frequency of Detection[b]	Rejected	Arithmetic Mean[c] (mg/kg)[d]	Upper 95% CI on Mean[c] (mg/kg)[d]	Range of Detection[c] (mg/kg)[d]
PCBs and Pesticides					
4,4'-DDT	2/19	0	0.21	0.07	0.014-0.068
4,4'-DDE	2/19	0	0.22	0.12	0.029-0.12
Aldrin	1/19	0	0.09	0.056[e]	e
Aroclor-1248	3/17	2	1.2	2	1.7-10
Aroclor-1254	17/17	2	7.4	10	1.1-20
Aroclor-1260	2/19	0	2.6	3.5	1.3-3.5
Dieldrin	1/19	0	0.21	0.093[e]	e
Endosulfan-I	2/19	0	0.1	0.092	0.011-0.092
Endosulfan II	2/19	0	0.22	0.26	0.082-0.26
Endrin	1/19	0	0.2	0.089[e]	e
Heptachlor epoxide	2/19	0	0.11	0.2	0.022-0.2
Semivolatile Organics					
Benzoic acid	4/12	7	0.53	0.12	0.075-0.12
Bis(2-Ethylhexyl)phthalate	12/16	3	0.7	1.5	0.07-6
Di-n-butylphthalate	2/19	0	0.21	0.057	0.046-0.057
Di-n-octylphthalate	8/19	0	0.3	0.97	0.045-0.97
Dimethyl phthalate	5/12	7	0.16	0.16	0.068-0.16
N-nitroso-di-n-propylamine	1/12	7	0.24	0.059[e]	e
Phenol	1/12	7	0.28	0.4[e]	e
Tributyl phosphate	9/9	2	15	51	0.2-51
Volatile Organics					
2-Butanone	4/11	7	0.007	0.022	0.002-0.022
2-Hexanone	6/11	7	0.007	0.017	0.002-0.017
4-Methyl-2-pentanone	3/11	7	0.005	0.003	0.002-0.003
Acetone	6/11	7	0.05	0.15	0.064-0.15
Methylene chloride	2/11	7	0.02	0.19	0.0380-0.19
Toluene	4/11	7	0.02	0.05	0.002-0.19

[a]Sample numbers used in this data set include: 99733, 99875, 99914, 99931, 99944, 99722, 99733, 99737, 99748, 99864, 99875, 99879, 99890, 99903, 99914, 99924, 99931, 99933, 99944, 99958, 99959, 99977, 99979, 99890, 100009, 100019, 100030, 100033, 100040, and 100108 through 100114.
[b]Rejected data not included in total number of samples.
[c]Values qualified with an R are excluded. The mean and upper 95% CI on mean has been rounded to show three significant figures. The mean is calculated using one-half the SQL for nondetects.
[d]Values expressed in milligrams per kilogram (mg/kg).
[e]Analyte was detected in a single sample.

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TABLE A.1-7

SUMMARY OF ORGANICS
ANALYSES FOR SILO 2 RESIDUES

Analyte[a]	Frequency of Detection[b]	Rejected	Arithmetic Mean[c] (mg/kg)[d]	Upper 95% CI on Mean[c] (mg/kg)[d]	Range of Detection[c] (mg/kg)[d]
PCBs and Pesticides					
Aroclor-1254	8/8	6	6.6	15	0.42-15
Aroclor-1260	1/14	0	1.4	0.034[e]	e
Semivolatile Organics					
Benzoic acid	3/9	4	0.57	0.39	0.076-0.39
Bis(2-ethylhexyl)phthalate	8/8	5	0.55	1.2	0.19-1.9
Diethyl phthalate	1/7	6	0.24	0.41[e]	e
Fluoranthene	1/13	0	0.18	0.064[e]	e
N-nitroso-di-n-propylamine	3/7	6	0.17	0.26	0.083-0.26
Pyrene	1/13	0	0.17	0.047[e]	e
Tributyl phosphate	5/5	1	29	73	7.5-73
Volatile Organics					
2-Butanone	1/7	7	0.007	0.01[e]	e
Acetone	3/7	7	0.02	0.07	0.033-0.072
Carbon tetrachloride	1/8	6	0.005	0.17[e]	e
Methylene chloride	2/8	6	0.013	0.047	0.015-0.047
Tetrachloroethene	1/8	6	0.005	0.14[e]	e
Toluene	1/8	6	0.008	0.01[e]	e
Total xylenes	1/7	7	0.006	0.003[e]	e

[a]Sample numbers used in this data set include: 99359, 99701, 99702, 99768, 99779, 99796, 99803, 99805, 99816, 99825, 99835, 99840, 99851, 99855, 99862, and 100115-100120.
[b]Rejected data not included in total number of samples.
[c]Values qualified with an R are excluded. The mean and upper 95% CI on mean has been rounded to show three significant figures. The mean is calculated using one-half the SQL for nondetects.
[d]Values expressed in milligrams per kilogram (mg/kg).
[e]Analyte detected in a single sample.

000020

TABLE A.1-8

SUMMARY OF EP TOXICITY RESULTS FOR SILOS 1 AND 2 RESIDUES - 1989[a]

Analyte[b]	Frequency of Detection	Mean (mg/L)	Standard Deviation (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Maximum Concentration of Contaminants[c] (mg/L)
Silo 1						
Arsenic	6/7	0.312	0.144	ND[d]	0.484	5.0
Barium	7/7	4.362	4.399	0.079	14.5	100.0
Cadmium	6/7	0.027	0.031	ND	0.1	1.0
Chromium	7/7	0.333	0.277	0.02	0.964	5.0
Lead	7/7	561	278	0.159	904	5.0
Mercury	0/7	ND	ND	ND	ND	0.2
Selenium	7/7	0.535	0.238	0.217	0.997	1.0
Silver	6/7	0.074	0.040	ND	0.121	5.0
Silo 2						
Arsenic	6/6	0.389	0.137	0.163	0.592	5.0
Barium	6/6	1.087	0.755	0.095	2.62	100.0
Cadmium	6/6	0.102	0.091	0.017	0.278	1.0
Chromium	4/6	0.380	0.365	ND	1.02	5.0
Lead	6/6	322	266	0.155	714	5.0
Mercury	0/6	ND	ND	ND	ND	0.2
Selenium	6/6	0.705	0.488	0.24	1.56	1.0
Silver	4/6	0.087	0.076	ND	0.213	5.0

[a]The data presented in table have not been validated.
[b]The sample numbers used in this data set include: (Silo 1) MM3336 through MM3343; (Silo 2) MM3340 through MM3348.
[c]Data obtained from 40 CFR 261.24.
[d]ND - Not detected

000021

TABLE A.1-9

SUMMARY OF TCLP METALS ANALYSES FOR SILO 1 RESIDUES - 1990/1991

Analyte[a]	Frequency of Detection[b]	Rejected	Mean[c] (mg/L)[d]	Standard Deviation[c] (mg/L)[d]	Range[c] (mg/L)[d]	Maximum Allowable Concentration
Aluminum	12/12	0	0.314	0.067	0.228-0.441	g
Antimony	12/12	0	0.093	0.019	0.067-0.129	g
Arsenic	1/11	1	0.002	e	e	5.0
Barium	12/12	0	0.868	0.402	0.348-1.83	100.0
Beryllium	6/12	0	0.002	0.0004	0.002-0.003	g
Boron	11/12	0	0.255	0.070	0.168-0.384	g
Cadmium	12/12	0	0.003	0.001	0.002-0.005	1.0
Calcium	12/12	0	55.4	33.6	17.6-108	g
Chromium	12/12	0	0.059	0.012	0.045-0.081	5.0
Cobalt	12/12	0	1.82	0.89	0.72-3.06	g
Copper	12/12	0	0.208	0.097	0.068-0.404	g
Iron	10/12	0	0.046	0.022	0.018-0.1	g
Lead	8/9	3	614	221	229-841	5.0
Magnesium	12/12	0	8.96	2.00	6.12-13.8	g
Manganese	12/12	0	0.163	0.070	0.067-0.308	g
Mercury	1/12	0	0.0002	e	e	0.2
Molybdenum	12/12	0	0.072	0.026	0.036-0.108	g
Nickel	12/12	0	3.18	1.39	1.32-5.57	g
Potassium	12/12	0	10.3	5.32	2.95-18.3	g
Selenium	11/11	1	0.135	0.088	0.015-0.306	1.0
Silicon	12/12	0	31.9	8.2	13.5-42.1	g
Silver	12/12	0	0.034	0.008	0.023-0.048	5.0
Thallium	9/12	0	0.005	0.003	0.002-0.009	g
Vanadium	12/12	0	0.023	0.005	0.017-0.032	g
Zinc	12/12	0	0.128	0.079	0.02-0.323	g

[a]The sample numbers used in this data set include: 99727,99742,99869,99884,99908, 99929,99938, 99967, 99985, 100003, 100024, and 100038.

[b]Rejected data not included in total number of samples.

[c]Values qualified with an R, U, or UJ are excluded. The mean and standard deviation have been rounded to show no more than three significant figures.

[d]Values expressed in milligrams per liter (mg/L).

[e]Analyte was detected in a single sample.

[f]Data obtained from 40 CFR 261.24.

[g]No standard Maximum Allowable Concentrations (MAC) specified in 40 CFR 261.24.

TABLE A.1-10

SUMMARY OF TCLP ORGANICS ANALYSES FOR SILO 1 RESIDUES - 1990/1991

Analyte[a]	Frequency of Detection[b]	Rejected	Mean[c] (mg/L)[d]	Standard Deviation[c] (mg/L)[d]	Range[c] (mg/L)[d]	Maximum Allowable Consentration[f]
PCBs and Pesticides						
None detected						
Semivolatile Organics						
4-Chloro-3-methylphenol	1/10	1	0.004	e	e	g
4-Nitrophenol	1/11	0	0.008	e	e	g
Benzoic acid	4/10	1	0.049	0.048	0.006-0.1	g
Bis(2-Ethylhexyl)phthalate	2/10	1	0.052	0.065	0.006-0.098	g
Di-n-octylphthalate	4/10	1	0.021	0.002	0.005-0.05	g
N-Nitroso-di-n-propylamine	4/10	1	0.127	0.116	0.018-0.28	g
Volatile Organics						
2-Butanone	7/9	2	0.005	0.003	0.001-0.01	200.0
4-Methyl-2-pentanone	8/11	0	0.002	0.003	0.001-0.01	g
Acetone	9/10	1	0.223	0.153	0.069-0.49	g
Methylene chloride	9/11	0	0.018	0.010	0.009-0.038	g
Tetrachloroethene	1/5	6	0.001	e	e	0.7
Toluene	5/11	0	0.002	0.002	0.001-0.005	g

[a]The sample numbers used in this data set include: 99726, 99734, 99741, 99749, 99868, 99876, 99883, 99891, 99907, 99915, 99928, 99932, 99937, 99945, 99960, 99962, 99976, 100010, 100023, 100031, 100037, and 100041.
[b]Rejected data not included in total number of samples.
[c]Values qualified with an R, U, or UJ are excluded. The mean and standard deviation have been rounded to show no more than three significant figures. The range has been rounded to the nearest thousandth, unless a fourth decimal place is required to show a value.
[d]Values expressed in milligrams per liter (mg/L).
[e]Analyte detected in a single sample.
[f]Data obtained from 40 CFR 261.24.
[g]No standard MAC specified in 40 CFR 261.24.

TABL ..1-11

SUMMARY OF TCLP METALS ANALYSES FOR SILO 2 RESIDUES - 1990/1991

Analyte[a]	Frequency of Detection[b]	Rejected	Mean[c] (mg/L)[d]	Standard Deviation[c] (mg/L)[d]	Range[c] (mg/L)[d]	Maximum Allowable Concentration[e]
Aluminum	7/7	0	1.29	0.763	0.462-2.75	f
Antimony	6/6	1	0.096	0.018	0.079-0.123	f
Arsenic	8/8	0	0.064	0.110	0.003-0.32	5.0
Barium	8/8	0	2.96	3.30	0.157-8.47	100.0
Beryllium	7/7	0	0.005	0.0007	0.003-0.006	f
Boron	4/4	0	0.69	0.58	0.24-1.5	f
Cadmium	7/7	1	0.047	0.028	0.010-0.077	1.0
Calcium	7/7	0	483	276	163-975	f
Chromium	8/8	0	0.129	0.036	0.086-0.207	5.0
Cobalt	7/7	0	3.02	2.11	1.18-6.16	f
Copper	7/7	0	1.41	1.41	0.274-3.86	f
Iron	7/7	0	0.076	0.012	0.053-0.090	f
Lead	7/7	1	516	348	117-1072	5.0
Magnesium	7/7	0	15.4	8.84	7.39-29.6	f
Manganese	7/7	0	0.776	0.466	0.409-1.62	f
Molybdenum	7/7	0	0.058	0.027	0.034-0.099	f
Nickel	7/7	0	3.48	1.45	2.04-5.77	f
Potassium	5/7	0	4.032	1.18	2.64-5.31	f
Selenium	8/8	0	0.114	0.184	0.026-0.568	1.0
Silicon	5/5	1	16.3	5.2	12.1-24.3	f
Silver	8/8	0	0.093	0.032	0.053-0.164	5.0
Thallium	6/7	0	0.009	0.011	0.0022-0.0288	f
Vanadium	5/5	1	0.053	0.006	0.046-0.060	f
Zinc	6/6	1	0.339	0.184	0.141-0.563	f

[a]The sample numbers used in this data set include: 99355, 99709, 99773, 99801, 99810, 99830, 99845, and 99860.
[b]Rejected data not included in total number of samples.
[c]Values qualified with an R, U, or UJ are excluded. The mean and standard deviation have been rounded to show no more than three significant figures. The range has been rounded to the nearest thousandth, unless a fourth decimal place is required to show a value.
[d]Values expressed in milligrams per liter (mg/L).
[e]Data obtained from 40 CFR 261.24.
[f]No standard MAC specified in 40 CFR 261.24.

TABLE A.1-12

SUMMARY OF TCLP ORGANICS ANALYSES FOR SILO 2 RESIDUES - 1990/1991

Analyte[a]	Frequency of Detection[b]	Rejected	Mean[c] (mg/L)[d]	Standard Deviation[c] (mg/L)[d]	Range[c] (mg/L)[d]	Maximum Allowable Concentration[f] (mg/L)
PCBs and Pesticides						
alpha-BHC	1/6	1	0.0002	e	e	g
beta-BHC	3/6	1	0.0004	0.0002	0.0002-0.0006	g
Semivolatile Organics						
N-Nitroso-di-n-propylamine	1/7	0	0.005	e	e	g
Pentachlorophenol	1/7	0	0.018	e	e	100.0
Tributyl Phosphate	1/1	0	0.66	e	e	g
Volatile Organics						
2-Butanone	3/7	1	0.002	0.002	0.002-0.002	200.0
4-Methyl-2-pentanone	1/8	0	0.001	e	e	g
Acetone	2/8	0	0.0535	0.054	0.015-0.092	g
Carbon disulfide	1/8	0	0.004	e	e	g
Methylene chloride	2/8	0	0.03	0.023	0.014-0.046	g

[a]The sample numbers used in this data set include: 99707, 99708, 99772, 99780, 99800, 99804, 99809, 99817, 99829, 99836, 99844, 99852, 99859, and 99863.
[b]Rejected data not included in total number of samples.
[c]Values qualified with an R, U, or UJ are excluded. The mean and standard deviation have been rounded to show no more than three significant figures. The range has been rounded to the nearest thousandth, unless a fourth decimal place is required to show a value.
[d]Values expressed in milligrams per liter (mg/L).
[e]Analyte was detected in a single sample.
[f]Data obtained from 40 CFR 261.24.
[g]No standard MAC specified in 40 CFR 261.24.

TABLE A.1-13

ESTIMATED INVENTORY OF K-65 SILOS METALS

	Silo 1[a]		Silo 2[b]	
Analyte	Mean Inventory[c] (MT)[d]	UCL Inventory[c] (MT)[d]	Mean Inventory[c] (MT)[d]	UCL Inventory[c] (MT)[d]
Aluminum	7.06	8.88	4.92	6.46
Antimony	0.14	0.17	0.16	0.27
Arsenic	0.15	0.37	2.52	9.02
Barium	78.0	95.5	40.6	116
Beryllium	0.007	0.007	0.01	0.02
Boron	0.31	0.35	0.22	0.30
Cadmium	0.013	0.027	0.029	0.04
Calcium	19.9	24.5	194	1750
Chromium	0.28	0.37	0.23	0.30
Cobalt	6.29	7.40	5.73	14.1
Copper	1.92	2.23	3.09	4.76
Cyanide	0.013	0.020	0.02	0.03
Iron	98.8	142	96.1	168
Lead	549	642	281	1740
Magnesium	19.4	22.7	22.1	37.3
Manganese	0.48	0.65	0.95	1.51
Mecury	0.004	0.006	0.005	0.007
Molybdenum	32.6	42.3	1.69	2.56
Nickel	12.0	15.4	8.03	10.0
Potassium	2.88	3.31	1.26	1.96
Selenium	1.92	2.29	0.64	0.72
Silicon	4.86	5.74	4.95	6.68
Silver	0.07	0.09	0.10	0.13
Sodium	58.3	71.9	14.1	18.6
Thallium	0.002	0.009	0.006	0.012
Vanadium	0.91	1.08	1.38	1.73
Zinc	0.17	0.25	0.31	0.53

[a]Based on a volume of 3280 m^3 and a dry mass density of 2.050 gm/cm^3.
[b]Based on a volume of 2840 m^3 and a dry mass density of 2.050 gm/cm^3.
[c]Values for mean and UCI concentrations taken from Table 4-4 of the RI Report for OU4.
[d]Units are in metric tons (MT).

APPENDIX A.2

FEASIBILITY STUDY SUBUNIT B
(SILO 3 CONTENTS)

OPERABLE UNIT 4 SILO 3 CONTENTS
SUMMARY OF SILO 3 RADIOLOGICAL ANALYSES

TABLE A.2-1

SUMMARY OF RADIONUCLIDE CONCENTRATIONS IN SILO 3 RESIDUES

Analyte [a]	Frequency of Detection[b]	Rejected	Arithmetic Mean[c] (pCi/g)[d]	Upper 95% CI on Mean[c] (pCi/g)[d]	Range of Detection[c] (pCi/g)[d]
SILO 3					
Actinium-227	9/9	2	618	925	234-1363
Lead-210	11/11	0	2620	3480	454-6427
Protactinium-231	9/11	0	487	627	266-931
Radium-224	11/11	0	290	367	64-453
Radium-226	11/11	0	2970	3870	467-6435
Radium-228	9/11	0	297	406	82-559
Thorium-228	7/11	0	590	747	459-996
Thorium-230	11/11	0	51200	60200	21010-71650
Thorium-232	8/11	0	656	842	411-1451
Uranium-234	11/11	0	1480	1730	348-1935
Uranium-235/236	10/11	0	93.6	117	42-158
Uranium-238	11/11	0	1500	1780	320-2043

[a]Sample numbers used in this data set include: 100097 - 100107.
[b]Rejected data not included in total number of samples.
[c]Values qualified with an R are excluded. The mean and upper 95% CI on mean have been rounded to show three significant figures. The mean is calculated using one-half the SQL for nondetects.
[d]Values expressed in picoCuries per gram (pCi/g).

TABLE A.2-2

INVENTORY OF SILO 3 RADIOLOGICAL CONSTITUENTS

Analyte	Silo 3[a] Mean Inventory[b] (Ci)[c]	Silo 3[a] UCL Inventory[b] (Ci)[c]
Actinium-227	5.4	8.2
Protactinium-231	4.3	5.5
Lead-210	23.2	30.8
Radium-224	2.6	3.2
Radium-226	26.3	34.2
Radium-228	2.6	3.6
Thorium-228	5.2	6.60
Thorium-230	453	532
Thorium-232	5.8	7.4
Uranium-234	13.1	15.3
Uranium-235/236	0.83	1.04
Uranium-238	13.3	15.7
Total Uranium	39.9[d]	47.2[d]

[a]Based on a volume of 3900 m^3 and a dry mass density of 2.267 gm/cm^3.
[b]Values for mean and UCI concentrations taken from Table 4-19 of the RI Report for OU4.
[c]Values expressed in Curies.
[d]Total uranium mass values in MT. Calculated from isotopic distribution of uranium.

TABLE A.2-3

TCLP RADIOLOGICAL ANALYSES FOR SILO 3 RESIDUES

Radiological Parameters[a]	Concentration (pCi/L)[b]
Actinium-227	5.54 ± 1.94
Gross alpha	3150 ± 830
Gross beta	670 ± 340
Lead-210	87.1 ± 9.2
Polonium-210	245 ± 110
Protactinium-231	< 647
Radium-226	2455 ± 558
Radium-228	< 110
Thorium-228	3.17 ± 1.42
Thorium-230	10.4 ± 2.8
Thorium-232	< 1
Uranium-234	92.2 ± 13.8
Uranium-235/236	5.09 ± 1.59
Uranium-238	86 ± 13

[a]Data from sample 100074 (11/12/92).
[b]Values for concentration taken from Table 4-22 of the RI Report for OU4, expressed in picoCuries per liter (pCi/L).

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OPERABLE UNIT 4 SILO 3 CONTENTS
SUMMARY OF CHEMICAL ANALYSES

TABLE A.2-4

INVENTORY OF SILO 3 METALS

Analyte	Silo 3[a] Mean Inventory[b] (MT)[c]	Silo 3[a] UCL Inventory[b] (MT)[c]
Aluminum	152	175
Arsenic	17.2	28.0
Barium	1.92	2.46
Beryllium	0.21	0.26
Cadmium	0.53	0.83
Calcium	260	295
Chromium	2.55	3.49
Cobalt	18.6	25.6
Copper	22.5	29.5
Iron	334	462
Lead	15.3	21.0
Magnesium	518	609
Manganese	38.7	45.6
Mercury	0.004	0.006
Nickel	27.9	37.9
Potassium	64.2	124
Selenium	1.54	2.02
Silver	0.14	0.16
Sodium	319	361
Thallium	0.19	0.50
Vanadium	16.1	30.9
Zinc	3.98	4.73

[a]Based on a volume of 3900 cubic meters (m^3) and a dry mass density of 2.267 gm/cm^3.
[b]Values for mean and UCI concentrations taken from Table 4-20 of the RI Report for OU4.
[c]Units are expressed in metric tons (MT).

TABLE A.2-5

EP TOXICITY RESULTS FOR SILO 3 RESIDUES - 1989[a]

Analyte[b]	Frequency of Detection	Mean (mg/L)[d]	Standard Deviation (mg/L)[d]	Minimum (mg/L)[d]	Maximum (mg/L)[d]	Maximum Allowable Concentration[c] (mg/L)[d]
Silo 3						
Arsenic	9/11	9.481	12.393	ND[e]	41.5	5.0
Barium	11/11	0.080	0.046	0.02	0.156	100.0
Cadmium	11/11	0.847	1.740	0.108	6.32	1.0
Chromium	11/11	5.05	3.22	0.336	11.9	5.0
Lead	7/11	0.239	0.327	ND[e]	1.01	5.0
Mercury	2/11	0.0005	0.0009	ND[e]	0.003	0.2
Selenium	11/11	2.65	3.00	0.92	11.7	1.0
Silver	1/11	0.007	0.008	ND[e]	0.032	5.0

[a]The data presented in table have not been validated.
[b]The sample numbers used in this data set include: MM3325 through MM3335.
[c]Data obtained from 40 CFR 261.24.
[d]Values expressed in milligrams per liter (mg/L).
[e]ND - Not Detected.

TABLE A.2-6

SUMMARY OF INORGANIC ANALYSES FOR SILO 3 RESIDUES

Analyte[a]	Frequency of Detection[b]	Rejected	Arithmetic Mean[c] (mg/kg)[d]	Upper 95% CI on Mean[c] (mg/kg)[d]	Range of Detection[c] (mg/kg)[d]
Metals					
Aluminum	11/11	0	17200	19800	10800-23700
Antimony	1/1	10	5.5[e]	e	e
Arsenic	11/11	0	1950	3170	532-6380
Barium	11/11	0	217	278	118-332
Beryllium	11/11	0	24.2	29.1	10-39.9
Cadmium	11/11	0	60	94	21.5-204
Calcium	11/11	0	29400	33400	21300-39900
Chromium	11/11	0	288	395	139-560
Cobalt	10/10	1	2100	2890	1100-3520
Copper	11/11	0	2550	3340	1610-7060
Iron	11/11	0	37800	52200	13900-67600
Lead	11/11	0	1730	2380	646-4430
Magnesium	11/11	0	58600	68900	38200-80900
Manganese	11/11	0	4380	5160	2420-6500
Mercury	3/3	8	0.4	0.7	0.3-0.69
Nickel	10/10	1	3150	4290	1760-6170
Potassium	11/11	0	7260	14000	1300-22800
Selenium	11/11	0	174	229	101-349
Silver	11/11	0	16	18	9.2-23.8
Sodium	11/11	0	36100	40800	22900-51700
Thallium	10/10	1	21	56	4-73.9
Vanadium	11/11	0	1820	3490	418-4550
Zinc	11/11	0	450	535	301-672

[a]Sample numbers used in this data set include: 100097 through 100107.
[b]Rejected data not included in total number of samples.
[c]Values qualified with an R are excluded. The mean and upper 95% CI on mean has been rounded to show three significant figures.
[d]Values expressed in milligrams per kilogram (mg/kg).
[e]Analyte detected in a single sample.

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