FIELD STUDY OF DISPOSED WASTES
FROM ADVANCED COAL PROCESSES

QUARTERLY TECHNICAL PROGRESS REPORT

May 1990 - July 1990

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1.0 OBJECTIVES

The Department of Energy/Morgantown Energy Technology Center (DOE/METC) has initiated research on the disposal of solid wastes from advanced coal processes. The objective of this research is to develop information to be used by private industry and government agencies for planning waste disposal practices associated with advanced coal processes. To accomplish this objective, DOE has contracted Radian Corporation and the North Dakota Energy & Environmental Research Center (EERC) to design, construct and monitor a limited number of field disposal tests with advanced coal process wastes. These field tests will be monitored over a three year period with the emphasis on collecting data on the field disposal of these wastes.

There has been considerable research on the characteristics and laboratory leaching behavior of coal wastes -- a lesser amount on wastes from advanced coal processes. However, very little information exists on the field disposal behavior of these wastes. Information on field disposal behavior is needed a) as input to predictive models being developed, b) as input to the development of rule of thumb design guidelines for the disposal of these wastes, and c) as evidence of the behavior of these wastes in the natural environment.

2.0 OBJECTIVES FOR THE CURRENT REPORTING PERIOD

The specific objectives for the current reporting period of May 1990 to July 1990 were as follows:

- Collect and characterize third quarter waste samples and water samples at the Colorado-Ute site;
- Collect quarterly core and groundwater samples at the Ohio Edison site;
- Fill and instrument the test cell at the Freeman United site;
- Finalize the selection of the fourth site; and

- Submit a revised Cost Proposal to DOE.

3.0 ACTIVITIES FOR THE REPORTING PERIOD

Colorado-Ute Site

The third set of quarterly waste cores samples was collected during this quarter and has been submitted for analysis at Radian and North Dakota EERC.

The results from previous quarterly sampling events at Colorado Ute were received from the analytical laboratories and are presented with a short discussion below.

Soil and Waste Properties

Core samples from the Colorado Ute test cell demonstrate that the FBC wastes have solidified into a coherent mass in the test cell. The results from detailed investigation of the mineralogy and physical properties of the soils and waste by North Dakota EERC are not presently available. These results will be used to confirm the identities of cementing phases suspected to be present based on the chemical analyses of the cored materials.

The analytical data on the composition of the fresh CFB ash is presented in Table 1 (ash was collected from the ash storage silo -- see November 1989 - January 1990 Quarterly Technical Progress Report). The ash composition is high in calcium and available lime, which reflects the amount of limestone added to absorb the sulfur from the feed coal. Concentrations of other major elements are typical of coal ash compositions from the combustion of western coal. Trace elements, including arsenic, barium, cadmium, chromium, copper, manganese, molybdenum, nickel, lead, selenium, strontium, and zinc are present in low to moderate amounts.

The concentrations of all elements considered in the Extraction Procedure (EP) test are also shown in Table 2. All EP elements are present at

TABLE 1
INITIAL CHARACTERIZATION OF COLORADO-UTE AFBC ASH.
mg/L except as noted

PARAMETER	Units	Location			
		Sample ID		Date Sampled	
		BOTTOM_ASH	FLY_ASH	BOTTOM_ASH	FLY_ASH
		Msr'd Val.	Det. Limit	Msr'd Val.	Det. Limit
Elements by AA					
Arsenic	mg/Kg	7.7	(1.2)	7.1	(1.2)
Cadmium	mg/Kg	2.2	(0.072)	1.7	(0.071)
Lead	mg/Kg	37.0	(4.8)	34.0	(4.8)
Selenium	mg/Kg	12.0	(1.2)	6.7	(1.2)
Elements by ICPES					
Aluminum	mg/Kg	94100.0	(20.0)	126000	(20.0)
Antimony	mg/Kg	ND	(48.0)	ND	(48.0)
Arsenic	mg/Kg	ND	(600.0)	ND	(600.0)
Barium	mg/Kg	280.0	(2.4)	100.0	(2.4)
Beryllium	mg/Kg	ND	(4.0)	6.2	(0.20)
Boron	mg/Kg	ND	(110.0)	ND	(120.0)
Cadmium	mg/Kg	ND	(10.0)	ND	(10.0)
Calcium	mg/Kg	105000	(100.0)	81100.0	(100.0)
Chromium	mg/Kg	32.0	(2.4)	26.0	(2.4)
Cobalt	mg/Kg	ND	(20.0)	ND	(20.0)
Copper	mg/Kg	36.0	(4.8)	23.0	(4.8)
Iron	mg/Kg	37900.0	(4.0)	21100.0	(4.0)
Lead	mg/Kg	185.0	(5.0)	226.0	(5.0)
Magnesium	mg/Kg	5660.0	(100.0)	4260.0	(100.0)
Manganese	mg/Kg	92.0	(2.4)	120.0	(2.4)
Molybdenum	mg/Kg	81.0	(12.0)	85.0	(12.0)
Nickel	mg/Kg	30.0	(4.8)	25.0	(4.8)
Potassium	mg/Kg	10500.0	(300.0)	7000.0	(300.0)
Selenium	mg/Kg	2370.0	(30.0)	1900.0	(30.0)

ND: Not detected at specified detection limit

NA: Not analyzed

SL: Sample lost

TABLE 1 (Continued)
INITIAL CHARACTERIZATION OF COLORADO-UTE AFBC ASH.
mg/L except as noted

PARAMETER	Units	Location			
		Msr'd Val.	Det. Limit	Msr'd Val.	Det. Limit
Silicon	mg/Kg	203000	(100.0)	216000	(100.0)
Silver	mg/Kg	ND	(2.4)	ND	(2.4)
Sodium	mg/Kg	3250.0	(100.0)	2450.0	(100.0)
Strontium	mg/Kg	210.0	(0.72)	210.0	(0.72)
Thallium	mg/Kg	ND	(200.0)	ND	(200.0)
Tin	mg/Kg	ND	(140.0)	ND	(140.0)
Titanium	mg/Kg	3600.0	(12.0)	1500.0	(12.0)
Vanadium	mg/Kg	ND	(2.0)	41.3	(2.0)
Zinc	mg/Kg	290.0	(4.8)	420.0	(4.8)
Forms of Sulfur					
Organic Sulfur	Wt %	0.0	()	0.0	()
Pyritic Sulfur	Wt %	0.0	()	0.0	()
Sulfate	Wt %	3.5	()	1.9	()
Heat of Hydration					
Heat of Hydration, temperature	degrees C	38.0	()	55.0	()
Heat of Hydration, time	minutes	4.0	()	40.0	()
Miscellaneous					
Alkalinity	mg HCO ₃ /L	200.0	(2.0)	150.0	(2.0)
Available Lime Index	Wt %	7.4	()	6.8	()
Carbonate, Water Soluble	mg/g	60.0	(2.5)	45.0	(2.5)
Chloride, Water Soluble	mg/g	ND	(0.10)	0.50	(0.10)
Fluoride, Water Soluble	mg/g	0.015	(0.0012)	0.32	(0.0012)
Loss on Ignition	%	1.2	(0.10)	8.7	(0.10)
Sulfate, Water Soluble	mg/g as S	14.5	(0.10)	16.0	(0.10)

ND: Not detected at specified detection limit

NA: Not analyzed

SL: Sample lost

October 10, 1990

TABLE 1 (Continued)
INITIAL CHARACTERIZATION OF COLORADO-UTE AFBC ASH.
mg/L except as noted

PARAMETER	Units	Location			
		Sample ID		Date Sampled	
		BOTTOM_ASH	FLY_ASH		
		BOTTOM_ASH	FLY_ASH		
Sulfur, Acid Soluble	mg/g as S	50.0	21.7	(0.25)	(0.25)
Total Chromatographable Organics	ug/g	3.3	3.6	()	()

ND: Not detected at specified detection limit
NA: Not analyzed
SL: Sample lost

TABLE 2
INITIAL EXTRACTION PROCEDURE (EP) TOXICITY OF COLORADO-UTE AFBC ASH.
mg/L except as noted

PARAMETER	Units	Location			
		BOTTOM_ASH	Sample ID	FLY_ASH	FLY_ASH
Water Quality Variables			Date Sampled		
pH	pH units	11.7		5.5	
Elements by AA					
Arsenic		ND (0.0050)		ND (0.0050)	
Cadmium		ND (0.00030)		ND (0.0011)	
Lead		ND (0.0020)		ND (0.0020)	
Mercury		ND (0.00020)		ND (0.00020)	
Selenium		ND (0.0050)		ND (0.0050)	
Elements by ICPE					
Barium		0.11 ()		0.082 ()	
Chromium		ND (0.010)		0.012 ()	
Silver		ND (0.010)		ND (0.010)	

ND: Not detected at specified detection limit

NA: Not analyzed

SL: Sample lost

or near the analytical detection limits except for barium. The concentrations of all EP elements are well below regulatory limits.

Initial chemical data on the soils and shallow bed rock in the vicinity of the test cell are presented in Tables 3 through 5. The locations, sampling depths, and brief descriptions of each soil sample are presented in Table 6 and Figure 1. The results in Tables 3 through 5 reflect the chemistry of the sandstones and mudstones underlying the thin soil horizon and the weathering processes in a semi-arid climate. Digestions of the soils show they are dominantly siliceous consisting of alumino-silicates of calcium, magnesium, potassium, and sodium. Variable amounts of iron oxides and calcium sulfate are present as cements. Organic carbon occurs mainly as woody fragments, and constitutes between 0.3 and 6.2% of the soils. Cation exchange capacities are moderate, ranging from about 10 to 22 meq/100 g soil.

Leachate and Groundwater Quality

Analytical data from the ASTM leaching test for the CFB ash are presented in Tables 7 through 10. Table 7 presents the results from the leaching of waste sampled from the storage silos prior to conditioning with water. Tables 8 through 10 present the results from leaching of samples cored from the ash in the test cell in September and December 1989 and in March of 1990.

Several differences between ASTM leachates of the fresh waste and of the landfilled material are apparent in the tables. The pH of the leachates of the fresh ash are somewhat higher than for other samples (pH of 12.2 for the fresh ash versus a median pH of 10.2 for the landfilled ash). Concentrations of potassium and zinc in the ASTM extracts of the fresh waste are also higher than for later samples, while the concentrations of aluminum and silicon in these samples are lower than average or not detected.

The composition of the leachates of material cored from the test cell in the three quarterly sampling events shows a considerable range of variation, especially in material from the March quarter. For example, leachate from samples taken in March one foot apart at three and four feet of

TABLE 3
INITIAL CHARACTERIZATION OF UPGRADIENT SOILS AT THE TEST CELL.
mg/L except as noted

PARAMETER	Units	Location					
		Sample ID		Date Sampled		Date Sampled	
		Sample ID	Date Sampled	Sample ID	Date Sampled	Sample ID	Date Sampled
Elements by ICPE							
Aluminum	mg/Kg	41400.0	(20.0)	46700.0	(20.0)	45800.0	(20.0)
Antimony	mg/Kg	ND	(20.0)	ND	(20.0)	ND	(20.0)
Arsenic	mg/Kg	ND	(30.0)	ND	(30.0)	ND	(30.0)
Barium	mg/Kg	484.0	(1.0)	577.0	(1.0)	579.0	(1.0)
Beryllium	mg/Kg	ND	(0.20)	ND	(0.20)	ND	(0.20)
Boron	mg/Kg	ND	(60.0)	ND	(60.0)	ND	(60.0)
Cadmium	mg/Kg	ND	(0.50)	ND	(0.50)	ND	(0.50)
Calcium	mg/Kg	69600.0	(100.0)	107000	(100.0)	103000	(100.0)
Chromium	mg/Kg	39.7	(3.0)	45.1	(3.0)	41.1	(3.0)
Cobalt	mg/Kg	ND	(1.0)	ND	(1.0)	ND	(1.0)
Copper	mg/Kg	74.1	(2.0)	ND	(2.0)	ND	(2.0)
Iron	mg/Kg	24200.0	(4.0)	19900.0	(4.0)	19100.0	(4.0)
Lead	mg/Kg	ND	(5.0)	99.6	(5.0)	ND	(5.0)
Magnesium	mg/Kg	6550.0	(100.0)	7840.0	(100.0)	7700.0	(100.0)
Manganese	mg/Kg	280.0	(1.0)	256.0	(1.0)	222.0	(1.0)
Molybdenum	mg/Kg	237.0	(5.0)	246.0	(5.0)	234.0	(5.0)
Nickel	mg/Kg	55.5	(2.0)	ND	(2.0)	39.0	(2.0)
Potassium	mg/Kg	9950.0	(300.0)	10400.0	(300.0)	10000.0	(300.0)
Selenium	mg/Kg	2270.0	(30.0)	2570.0	(30.0)	2200.0	(30.0)
Silicon	mg/Kg	249000	(100.0)	262000	(100.0)	209000	(100.0)
Silver	mg/Kg	ND	(3.0)	ND	(3.0)	ND	(3.0)
Sodium	mg/Kg	5470.0	(100.0)	5310.0	(100.0)	4630.0	(100.0)
Strontium	mg/Kg	226.7	(0.30)	308.0	(0.30)	304.9	(0.30)
Thallium	mg/Kg	ND	(10.0)	ND	(10.0)	ND	(10.0)
Vanadium	mg/Kg	ND	(2.0)	ND	(2.0)	ND	(2.0)

ND: Not detected at specified detection limit
NA: Not analyzed
SL: Sample lost

TABLE 3 (Continued)
INITIAL CHARACTERIZATION OF UPGRADE SOILS AT THE TEST CELL.
mg/L except as noted

PARAMETER	Units	Location					
		Sample ID		Date Sampled		Det. Limit	
		COLY01-001	COLY01-002	COLY01-002	COLY01-002_DUP	COLY01-004	COLY01-004
		COLY01-001	COLY01-002	COLY01-002	COLY01-002_DUP	COLY01-004	COLY01-004
		15-Sep-89	15-Sep-89	15-Sep-89	15-Sep-89	15-Sep-89	15-Sep-89
		Msr'd Val.	Msr'd Val.	Msr'd Val.	Msr'd Val.	Msr'd Val.	Msr'd Val.
		Det. Limit	Det. Limit	Det. Limit	Det. Limit	Det. Limit	Det. Limit
		(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)
Zinc	mg/Kg	178.0	96.5	ND	ND	192.0	(2.0)
Miscellaneous							
Cation exchange capacity	meq/100g	15.0	16.0	()	16.0	13.0	()
Chloride, Water Soluble		0.24	0.0070	(0.089)	NA	0.11	(0.089)
Sulfate, Acid Soluble		11.6	18.3	(0.10)	NA	22.2	(0.10)
Sulfate, Water Soluble (as S)	mg/g	1.7	1.5	(0.050)	NA	3.6	(0.050)
Organics							
Total organic carbon	%	0.89	0.77	()	0.80	0.69	()
Sodium Carbonate Fusion, ICPEs							
Boron		ND	ND	(0.60)	NA	ND	(0.60)

ND: Not detected at specified detection limit

NA: Not analyzed

SL: Sample lost

TABLE 3
INITIAL CHARACTERIZATION OF UPGRADE SOILS AT THE TEST CELL.
mg/L except as noted

PARAMETER	Units	Location				Date Sampled			
		Sample ID		Date Sampled		Sample ID		Date Sampled	
		COLY01-006	COLY01-010	COLY01-014	COLY01-010	COLY01-010	COLY01-014	COLY01-010	COLY01-014
		15-Sep-89		15-Sep-89		15-Sep-89		15-Sep-89	
PARAMETER	Units	Msr'd Val.	Det. Limit	Msr'd Val.	Det. Limit	Msr'd Val.	Det. Limit	Msr'd Val.	Det. Limit
Elements by ICPEs									
Aluminum	mg/Kg	42000.0	(20.0)	90000.0	(20.0)	47000.0	(20.0)	47000.0	(20.0)
Antimony	mg/Kg	ND	(20.0)	ND	(20.0)	ND	(20.0)	ND	(20.0)
Arsenic	mg/Kg	ND	(30.0)	ND	(30.0)	ND	(30.0)	ND	(30.0)
Barium	mg/Kg	528.0	(1.0)	178.0	(1.0)	128.0	(1.0)	128.0	(1.0)
Beryllium	mg/Kg	ND	(0.20)	ND	(0.20)	ND	(0.20)	ND	(0.20)
Boron	mg/Kg	ND	(60.0)	ND	(60.0)	ND	(60.0)	ND	(60.0)
Cadmium	mg/Kg	ND	(0.50)	ND	(0.50)	ND	(0.50)	ND	(0.50)
Calcium	mg/Kg	92000.0	(100.0)	7160.0	(100.0)	3170.0	(100.0)	3170.0	(100.0)
Chromium	mg/Kg	36.0	(3.0)	54.7	(3.0)	ND	(3.0)	ND	(3.0)
Cobalt	mg/Kg	ND	(1.0)	ND	(1.0)	ND	(1.0)	ND	(1.0)
Copper	mg/Kg	ND	(2.0)	ND	(2.0)	ND	(2.0)	ND	(2.0)
Iron	mg/Kg	16600.0	(4.0)	35500.0	(4.0)	5860.0	(4.0)	5860.0	(4.0)
Lead	mg/Kg	127.0	(5.0)	499.0	(5.0)	121.0	(5.0)	121.0	(5.0)
Magnesium	mg/Kg	6750.0	(100.0)	5800.0	(100.0)	2000.0	(100.0)	2000.0	(100.0)
Manganese	mg/Kg	133.0	(1.0)	22.5	(1.0)	ND	(1.0)	ND	(1.0)
Molybdenum	mg/Kg	188.0	(5.0)	238.0	(5.0)	219.0	(5.0)	219.0	(5.0)
Nickel	mg/Kg	ND	(2.0)	ND	(2.0)	ND	(2.0)	ND	(2.0)
Potassium	mg/Kg	7780.0	(300.0)	16800.0	(300.0)	7430.0	(300.0)	7430.0	(300.0)
Selenium	mg/Kg	1980.0	(30.0)	1950.0	(30.0)	2250.0	(30.0)	2250.0	(30.0)
Silicon	mg/Kg	43300.0	(100.0)	21400.0	(100.0)	361000	(100.0)	361000	(100.0)
Silver	mg/Kg	ND	(3.0)	ND	(3.0)	ND	(3.0)	ND	(3.0)
Sodium	mg/Kg	6090.0	(100.0)	6210.0	(100.0)	4510.0	(100.0)	4510.0	(100.0)
Strontium	mg/Kg	353.4	(0.30)	258.3	(0.30)	81.0	(0.30)	81.0	(0.30)
Thallium	mg/Kg	ND	(10.0)	ND	(10.0)	ND	(10.0)	ND	(10.0)
Vanadium	mg/Kg	ND	(2.0)	ND	(2.0)	ND	(2.0)	ND	(2.0)

ND: Not detected at specified detection limit

NA: Not analyzed

SL: Sample lost

TABLE 3 (Continued)
INITIAL CHARACTERIZATION OF UPGRADEMENT SOILS AT THE TEST CELL -
mg/L except as noted

PARAMETER	Units	Location			
		Sample ID		Date Sampled	
		COLY01-006	COLY01-010	COLY01-014	COLY01-014
		15-Sep-89	15-Sep-89	15-Sep-89	15-Sep-89
		Msr'd Val.	Det. Limit	Msr'd Val.	Det. Limit
		228.0	(2.0)	142.0	(2.0)
Zinc	mg/Kg				
Miscellaneous					
Cation exchange capacity	meq/100g	14.0	()	16.0	()
Chloride, Water Soluble		0.68	(0.089)	0.56	(0.089)
Sulfate, Acid Soluble		29.1	(0.10)	7.9	(0.10)
Sulfate, Water Soluble (as S)	mg/g	4.5	(0.050)	1.3	(0.050)
Organics					
Total organic carbon	%	0.59	()	0.99	()
Sodium Carbonate Fusion, ICPE					
Boron		ND	(0.60)	ND	(0.60)

ND: Not detected at specified detection limit

NA: Not analyzed

SL: Sample lost

TABLE 4
INITIAL CHARACTERIZATION OF DOWNGRADENT SOILS AT THE TEST CELL.
mg/L except as noted

PARAMETER	Units	Location													
		Sample ID				Date Sampled				Sample ID					
		COLY07-001	COLY07-002	COLY07-004	COLY07-006	COLY07-001	COLY07-002	COLY07-004	COLY07-006	COLY07-001	COLY07-002	COLY07-004	COLY07-006		
		Msr'd Val.	Det. Limit	Msr'd Val.	Det. Limit	Msr'd Val.	Det. Limit	Msr'd Val.	Det. Limit	Msr'd Val.	Det. Limit	Msr'd Val.	Det. Limit	Msr'd Val.	Det. Limit
Elements by ICP'S															
Aluminum	mg/Kg	41600.0	(20.0)	48600.0	(20.0)	45000.0	(20.0)	48100.0	(20.0)						
Antimony	mg/Kg	ND	(20.0)	ND	(20.0)	ND	(20.0)	ND	(20.0)						
Arsenic	mg/Kg	ND	(30.0)	ND	(30.0)	ND	(30.0)	ND	(30.0)						
Barium	mg/Kg	440.0	(1.0)	614.0	(1.0)	463.0	(1.0)	136.0	(1.0)						
Beryllium	mg/Kg	ND	(0.20)	ND	(0.20)	ND	(0.20)	ND	(0.20)						
Boron	mg/Kg	ND	(60.0)	ND	(60.0)	ND	(60.0)	ND	(60.0)						
Cadmium	mg/Kg	ND	(0.50)	ND	(0.50)	ND	(0.50)	ND	(0.50)						
Calcium	mg/Kg	43300.0	(100.0)	72500.0	(100.0)	46100.0	(100.0)	ND	(100.0)						
Chromium	mg/Kg	41.6	(3.0)	39.5	(3.0)	38.4	(3.0)	29.7	(3.0)						
Cobalt	mg/Kg	141.0	(1.0)	ND	(1.0)	ND	(1.0)	ND	(1.0)						
Copper	mg/Kg	ND	(2.0)	ND	(2.0)	ND	(2.0)	ND	(2.0)						
Iron	mg/Kg	23700.0	(4.0)	19600.0	(4.0)	20300.0	(4.0)	7960.0	(4.0)						
Lead	mg/Kg	ND	(5.0)	ND	(5.0)	134.0	(5.0)	390.0	(5.0)						
Magnesium	mg/Kg	6350.0	(100.0)	7250.0	(100.0)	6780.0	(100.0)	2620.0	(100.0)						
Manganese	mg/Kg	348.0	(1.0)	251.0	(1.0)	353.0	(1.0)	ND	(1.0)						
Molybdenum	mg/Kg	230.0	(5.0)	173.0	(5.0)	230.0	(5.0)	202.0	(5.0)						
Nickel	mg/Kg	92.4	(2.0)	58.9	(2.0)	37.6	(2.0)	ND	(2.0)						
Potassium	mg/Kg	12700.0	(300.0)	11400.0	(300.0)	13000.0	(300.0)	8200.0	(300.0)						
Selenium	mg/Kg	2190.0	(30.0)	1690.0	(30.0)	2400.0	(30.0)	1990.0	(30.0)						
Silicon	mg/Kg	284000	(100.0)	284000	(100.0)	277000	(100.0)	317000	(100.0)						
Silver	mg/Kg	ND	(3.0)	ND	(3.0)	ND	(3.0)	ND	(3.0)						
Sodium	mg/Kg	6250.0	(100.0)	5290.0	(100.0)	5610.0	(100.0)	3900.0	(100.0)						
Strontium	mg/Kg	168.3	(0.30)	279.7	(0.30)	182.6	(0.30)	68.3	(0.30)						
Thallium	mg/Kg	ND	(10.0)	ND	(10.0)	ND	(10.0)	ND	(10.0)						
Vanadium	mg/Kg	ND	(2.0)	ND	(2.0)	ND	(2.0)	ND	(2.0)						

ND: Not detected at specified detection limit

NA: Not analyzed

SL: Sample lost

September 14, 1993

TABLE 4 (Continued)
INITIAL CHARACTERIZATION OF DOWNGRADE SOILS AT THE TEST CELL.
mg/L except as noted

PARAMETER	Units	Location					
		Sample ID		Date Sampled		Det. Limit	
Zinc	mg/Kg	COLY07-001	COLY07-002	COLY07-004	COLY07-006	MSr'd Val.	Det. Limit
		MSr'd Val.	MSr'd Val.	MSr'd Val.	MSr'd Val.	MSr'd Val.	Det. Limit
		71.9	88.4	64.0	62.7		(2.0)
Miscellaneous							
Cation exchange capacity	meq/100g						
Chloride, Water Soluble		14.0	15.0	17.0	15.0		()
Sulfate, Acid Soluble		0.27	0.44	0.43	1.0		(0.089)
Sulfate, Water Soluble (as S)		1.7	1.7	16.8	1.4		(0.10)
		0.10	0.28	2.6	0.14		(0.050)
Organics							
Total organic carbon	%	1.8	5.81	2.1	2.6		()
Sodium Carbonate Fusion, ICPEs							
Boron		ND	ND	ND	ND		(0.60)

ND: Not detected at specified detection limit
NA: Not analyzed
SL: Sample lost

TABLE 4
INITIAL CHARACTERIZATION OF DOWNGRADIENT SOILS AT THE TEST CELL.
mg/L except as noted

PARAMETER	Units	Location			
		Sample ID		Date Sampled	
		COLY07-009	COLY07-012	COLY07-014	COLY07-019
		COLY07-009	COLY07-012	COLY07-014	COLY07-019
		15-Sep-89	15-Sep-89	15-Sep-89	15-Sep-89
		Msr'd Val. Det. Limit	Msr'd Val. Det. Limit	Msr'd Val. Det. Limit	Msr'd Val. Det. Limit
Elements by ICPEs					
Aluminum	mg/Kg	55700.0 (20.0)	53100.0 (20.0)	69400.0 (20.0)	81500.0 (20.0)
Antimony	mg/Kg	ND (20.0)	ND (20.0)	ND (20.0)	ND (20.0)
Arsenic	mg/Kg	ND (30.0)	ND (30.0)	ND (30.0)	ND (30.0)
Barium	mg/Kg	181.0 (1.0)	156.0 (1.0)	400.0 (1.0)	187.0 (1.0)
Beryllium	mg/Kg	ND (0.20)	ND (0.20)	ND (0.20)	ND (0.20)
Boron	mg/Kg	ND (60.0)	ND (60.0)	ND (60.0)	ND (60.0)
Cadmium	mg/Kg	ND (0.50)	ND (0.50)	ND (0.50)	38.2 (0.50)
Calcium	mg/Kg	4360.0 (100.0)	3690.0 (100.0)	4780.0 (100.0)	4880.0 (100.0)
Chromium	mg/Kg	34.6 (3.0)	73.7 (3.0)	40.6 (3.0)	28.3 (3.0)
Cobalt	mg/Kg	88.2 (1.0)	186000 (1.0)	ND (1.0)	ND (1.0)
Copper	mg/Kg	42.6 (2.0)	ND (2.0)	ND (2.0)	50.3 (2.0)
Iron	mg/Kg	43000.0 (4.0)	35500.0 (4.0)	36200.0 (4.0)	19100.0 (4.0)
Lead	mg/Kg	173.0 (5.0)	ND (5.0)	176.0 (5.0)	162.0 (5.0)
Magnesium	mg/Kg	2800.0 (100.0)	3640.0 (100.0)	5090.0 (100.0)	7730.0 (100.0)
Manganese	mg/Kg	56.2 (1.0)	60.4 (1.0)	49.8 (1.0)	36.2 (1.0)
Molybdenum	mg/Kg	225.0 (5.0)	255.0 (5.0)	234.0 (5.0)	234.0 (5.0)
Nickel	mg/Kg	ND (2.0)	6480.0 (2.0)	43.7 (2.0)	ND (2.0)
Potassium	mg/Kg	9100.0 (300.0)	9590.0 (300.0)	14800.0 (300.0)	21900.0 (300.0)
Selenium	mg/Kg	2410.0 (30.0)	2680.0 (30.0)	2230.0 (30.0)	1680.0 (30.0)
Silicon	mg/Kg	322000 (100.0)	303000 (100.0)	301000 (100.0)	298000 (100.0)
Silver	mg/Kg	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)
Sodium	mg/Kg	6400.0 (100.0)	4820.0 (100.0)	5530.0 (100.0)	4900.0 (100.0)
Strontium	mg/Kg	198.6 (0.30)	90.5 (0.30)	274.7 (0.30)	141.1 (0.30)
Thallium	mg/Kg	ND (10.0)	255.0 (10.0)	ND (10.0)	ND (10.0)
Vanadium	mg/Kg	ND (2.0)	ND (2.0)	ND (2.0)	ND (2.0)

ND: Not detected at specified detection limit

NA: Not analyzed

SL: Sample lost

September 14, 1990

TABLE 4 (Continued)
INITIAL CHARACTERIZATION OF DOWNGRADIENT SOILS AT THE TEST CELL.
mg/L except as noted

PARAMETER	Units	Location					
		Sample ID		Date Sampled		Det. Limit	
Zinc	mg/Kg	COLY07-009	COLY07-012	COLY07-014	COLY07-019	Msr'd Val.	Det. Limit
		15-Sep-89	15-Sep-89	15-Sep-89	15-Sep-89	216.0	(2.0)
		109.0	290.0	61.5	216.0		
Miscellaneous							
Cation exchange capacity	meq/100g	22.0	14.0	18.0	10.0		
Chloride, Water Soluble		0.45	0.32	0.28	0.35		
Sulfate, Acid Soluble		2.0	4.3	5.4	16.7		
Sulfate, Water Soluble (as S)	mg/g	0.35	0.72	0.91	2.8		
Organics							
Total organic carbon	%	6.2	1.9	1.6	0.30		
Sodium Carbonate Fusion, ICPEs							
Boron		ND	ND	ND	ND		

ND: Not detected at specified detection limit

NA: Not analyzed

SL: Sample lost

TABLE 5
INITIAL CHARACTERIZATION OF SOILS AT BASE OF TEST CELL.

mg/L except as noted

PARAMETER	Units	Location					
		Sample ID		Date Sampled			
		COSS01	COSS03	COSS03	COSS03_DUP		
Water Quality Variables		15-Sep-89		15-Sep-89			
Electrical Conductivity	Msr'd Val.	Det. Limit	Msr'd Val.	Det. Limit	Msr'd Val.	Det. Limit	
pH	unhos/cm	1875.0	()	2400.0	()	NA	NA
	pH units	4.2	()	8.6	()	NA	NA
Elements by ICPEs							
Aluminum	mg/Kg	85956.0	(20.0)	50700.0	(20.0)	49000.0	(20.0)
Antimony	mg/Kg	-2.0	(400.0)	ND	(20.0)	ND	(20.0)
Arsenic	mg/Kg	-107.0	(600.0)	ND	(30.0)	ND	(30.0)
Barium	mg/Kg	537.0	(20.0)	478.0	(1.0)	477.0	(1.0)
Beryllium	mg/Kg	5.0	(4.0)	ND	(0.20)	ND	(0.20)
Boron	mg/Kg			ND	(60.0)	ND	(60.0)
Cadmium	mg/Kg	253.5	(9.9)	9.7	(0.50)	ND	(0.50)
Calcium	mg/Kg	31700.0	(2000.0)	52300.0	(100.0)	51400.0	(100.0)
Chromium	mg/Kg	59.2	(20.0)	31.9	(3.0)	39.2	(3.0)
Cobalt	mg/Kg	43.6	(20.0)	ND	(1.0)	ND	(1.0)
Copper	mg/Kg	57.0	(40.0)	ND	(2.0)	ND	(2.0)
Iron	mg/Kg	24951.0	(79.0)	23400.0	(4.0)	21200.0	(4.0)
Lead	mg/Kg	46.0	(99.0)	208.0	(5.0)	ND	(5.0)
Magnesium	mg/Kg	11747.0	(2000.0)	8640.0	(100.0)	8650.0	(100.0)
Manganese	mg/Kg	482.9	(20.0)	285.0	(1.0)	315.0	(1.0)
Molybdenum	mg/Kg	14.0	(99.0)	280.0	(5.0)	283.0	(5.0)
Nickel	mg/Kg	86.0	(40.0)	ND	(2.0)	47.0	(2.0)
Potassium	mg/Kg	16761.0	(6000.0)	10600.0	(300.0)	9470.0	(300.0)
Selenium	mg/Kg	335.0	(600.0)	2050.0	(30.0)	2060.0	(30.0)
Silicon	mg/Kg	308970	(2000.0)	267000	(100.0)	285000	(100.0)
Silver	mg/Kg	-1.1	(20.0)	ND	(3.0)	ND	(3.0)
Sodium	mg/Kg	7355.0	(2000.0)	5380.0	(100.0)	5190.0	(100.0)

ND: Not detected at specified detection limit

NA: Not analyzed

SL: Sample lost

TABLE 5 (Continued)
INITIAL CHARACTERIZATION OF SOILS AT BASE OF TEST CELL.
mg/L except as noted

PARAMETER	Units	Location			
		Sample ID		Date Sampled	
		COSS01	COSS03	COSS03	COSS03_DUP
		COSS01	COSS03	COSS03	COSS03_DUP
		15-Sep-89	15-Sep-89	15-Sep-89	15-Sep-89
		Msr'd Val.	Det. Limit	Msr'd Val.	Det. Limit
Strontium	mg/Kg	325.2	(6.0)	591.5	(0.30)
Thallium	mg/Kg	40.0	(200.0)	ND	(10.0)
Titanium	mg/Kg	4308.0	(99.0)	NA	NA
Vanadium	mg/Kg	77.5	(40.0)	ND	(2.0)
Zinc	mg/Kg	152.4	(40.0)	228.0	(2.0)
Miscellaneous					
Cation exchange capacity	meq/100g	18.0	()	13.0	()
Chloride, Water Soluble		0.19	(0.089)	0.18	(0.089)
Sulfate, Acid Soluble		10.9	(0.10)	90.9	(0.10)
Sulfate, Water Soluble (as S)	mg/g	1.1	(0.050)	15.1	(0.050)
Organics					
Total organic carbon	%	0.54	()	0.33	()
Sodium Carbonate Fusion, ICPE					
Boron		ND	(0.60)	ND	(0.60)
					NA

ND: Not detected at specified detection limit

NA: Not analyzed

SL: Sample lost

TABLE 6. BACKGROUND SOIL SAMPLES AND QUARTERLY WASTE CORES FOR CHEMICAL ANALYSIS - COLORADO UTE SITE

Date	Sample #	Depth (ft.)	Material	Comments	Sample Analyzed (Y/N)
<u>Test Cell Chemical Core (NW Corner of SE Quadrant)</u>					
9/15/89	COLY16-1	0-1'	Core Ash		Y
9/15/89	COLY16-2	1-2'	Core Ash		Y
9/15/89	COLY16-3	2-3'	Core Ash		Y
9/15/89	COLY16-4	3-4'	Core Ash		Y
9/15/89	COLY16-5	4-5'	Core Ash		N
9/15/89	COLY16-6	5-6'	Core Ash		Y
9/15/89	COLY16-7	6-7'	Core Ash		Y
9/15/89	COLY16-8	7-8'	Core Ash/Soil		Y
9/15/89	COLY13-9	8-9'	Core Soil	(Near CO-LY-16-8)	Y
<u>Upgradient Soil</u>					
9/15/89	COLY1-1	0-1'	Soil		Y
9/15/89	COLY1-2	1-2'	Soil		Y
9/15/89	COLY1-3	2-3'	Soil		N
9/15/89	COLY1-4	3-4'	Cuttings	Poor Core Recovery	Y
9/15/89	COLY1-5	4-5'	Soil	Loose Material	N
9/15/89	COLY1-6	5-6'	Soil		Y
9/15/89	COLY1-7	6-7'	Soil		N
9/15/89	COLY1-8	7-8'	Soil		N
9/15/89	COLY1-9	8-9'	Soil		N
9/15/89	COLY1-10	9-10'	Soil	Good Core Recovery	Y
9/15/89	COLY1-11	10-11'	Core		N
9/15/89	COLY1-12	11-12'	Soil		N
9/15/89	COLY1-13	12-13'	Soil		N
9/15/89	COLY1-14	13-14'	Soil		Y
<u>Downgradient Soil</u>					
9/15/89	COLY7-1	0-1'	Soil		Y
9/15/89	COLY7-2	1-2'	Soil		Y
9/15/89	COLY7-3	2-3'	Soil	Poor Core Recovery	N
9/15/89	COLY7-4	3-4'	Cuttings	Loose Material	Y
9/15/89	COLY7-5	4-5'	Soil		N
9/15/89	COLY7-6	5-6'	Soil		Y
9/15/89	COLY7-7	6-7'	No Sample		N
9/15/89	COLY7-8	7-8'	No Sample		N
9/15/89	COLY7-9	8-9'	Soil	Good Core Recovery	Y
9/15/89	COLY7-10	9-10'	Core		N
9/15/89	COLY7-11	10-11'	Soil		N
9/15/89	COLY7-12	11-12'	Soil		Y
9/15/89	COLY7-13	12-13'	Soil		N
9/15/89	COLY7-14	13-14'	Soil		Y
9/15/89	COLY7-15	14-15'	Soil	Poor Core Recovery	N
9/15/89	COLY7-16	15-16'	Cuttings	Loose Material	N
9/15/89	COLY7-17	16-17'	Soil		N
9/15/89	COLY7-18	17-18'	Soil		N
9/15/89	COLY7-19	18-19'	Soil		Y
<u>Soil-Base of Cell (Four Corners)</u>					
6/15/89	COSS-1	Base of Cell 8'	Soil	Shovel Samples	Y
6/15/89	COSS-2	Base of Cell 8'	Soil		N
6/15/89	COSS-3	Base of Cell 8'	Soil		Y
6/15/89	COSS-4	Base of Cell 8'	Soil		N

FIGURE 1.

COLORADO-UTE SITE

SAMPLING LOCATIONS FOR CHEMICAL ANALYSIS

- ▼ Waste Cores - Test Cell Ash
- Soil Cores/Samples - Base of Test Cells
- Soil Cores/Samples - Upgradient and Downgradient Monitor Well Sites (MW7, MW1, MW4)

SAMPLE DESIGNATIONS

C O L Y 8 - 1

Site I.D. Sample Number

OH = Ohio
CO = Colorado
IL = Illinois

Hole Number

Ly = Lysimeter Hole
NT = Neutron Tube Hole
MW = Monitor Well Hole
SS = Other Soil Sample (i.e., shovel)

HOLE I.D.

TABLE 7
INITIAL ASTM WATER EXTRACTS OF COLORADO-UTE AFBC ASH.
mg/L except as noted

PARAMETER	Units	Location			
		Sample ID		Date Sampled	
		BOTTOM_ASH	FLY_ASH	BOTTOM_ASH	FLY_ASH
Water Quality Variables					
Conductivity	umhos/cm	5800.0	()	5400.0	()
pH	pH units	12.2	()	12.2	()
Elements by AA					
Arsenic		ND	(0.0050)	ND	(0.0050)
Cadmium		ND	(0.00030)	ND	(0.00030)
Lead		ND	(0.0020)	0.0022	(0.0020)
Selenium		ND	(0.0050)	0.0072	(0.0050)
Elements by ICPE					
Aluminum		ND	(0.20)	ND	(0.20)
Barium		ND	(0.10)	0.10	(0.10)
Beryllium		ND	(0.0020)	ND	(0.0020)
Boron		ND	(0.60)	0.67	(0.60)
Calcium		850.0	(1.0)	1100.0	(1.0)
Chromium		ND	(0.010)	0.028	(0.010)
Cobalt		ND	(0.010)	ND	(0.010)
Copper		0.035	(0.020)	ND	(0.020)
Iron		ND	(0.040)	ND	(0.040)
Magnesium		ND	(1.0)	ND	(1.0)
Manganese		ND	(0.010)	ND	(0.010)
Molybdenum		0.089	(0.050)	0.32	(0.050)
Nickel		ND	(0.020)	ND	(0.020)
Potassium		4.0	(3.0)	6.0	(3.0)
Silicon		NA		NA	
Silver		ND	(0.010)	ND	(0.010)

ND: Not detected at specified detection limit

NA: Not analyzed

SL: Sample lost

TABLE 7 (Continued)
INITIAL ASTM WATER EXTRACTS OF COLORADO-UTE AFBC ASH.
mg/L except as noted

PARAMETER	Units	Location			
		Sample ID		Date Sampled	
		BOTTOM_ASH	FLY_ASH	BOTTOM_ASH	FLY_ASH
		Msr'd Val.	Det. Limit	Msr'd Val.	Det. Limit
Strontium		1.9	(0.0030)	4.2	(0.0030)
Tin		ND	(0.060)	ND	(0.60)
Vanadium		ND	(0.020)	ND	(0.020)
Zinc		2.3	(0.020)	4.9	(0.020)
Miscellaneous					
Ammonia		ND	(0.20)	ND	(0.20)
Chloride		0.98	(0.20)	34.0	(0.20)
Nitrate		ND	(0.15)	ND	(0.30)
Sulfate		630.0	(0.50)	1300.0	(0.50)
Sulfide		ND	(1.0)	ND	(1.0)
Sulfite		3.4	(2.0)	0.0	(2.0)
Total Cyanide		ND	(0.010)	0.023	(0.010)
Radionuclides					
Ac-228	picoCuries/L	ND	(29.0)	ND	(18.0)
Bi-214	picoCuries/L	ND	(17.0)	15.0	()
K-40	picoCuries/L	ND	(75.0)	ND	(44.0)
Pb-211	picoCuries/L	ND	(204.0)	ND	(135.0)
Pb-212	picoCuries/L	ND	(14.0)	ND	(10.0)
Pb-214	picoCuries/L	ND	(17.0)	ND	(12.0)
Ra-226	picoCuries/L	ND	(111.0)	ND	(81.0)
U-235	picoCuries/L	ND	(42.0)	ND	(32.0)

ND: Not detected at specified detection limit

NA: Not analyzed

SL: Sample lost

TABLE 8
ASTM WATER EXTRACTS OF LANDFILLED AFBC ASH.
mg/L except as noted

PARAMETER	Units	Location			
		Sample ID		Date Sampled	
		MSr'd Val.	Det. Limit	MSr'd Val.	Det. Limit
Water Quality Variables					
Electrical Conductivity	umhos/cm	1725.0	()	2000.0	()
pH	pH units	9.2	()	9.8	()
Elements by AA					
Arsenic		0.0065	(0.0050)	0.0079	(0.0050)
Cadmium		ND	(0.0010)	ND	(0.0010)
Lead		0.0047	(0.0020)	ND	(0.0020)
Selenium		12.6	(0.0050)	9.5	(0.0050)
Elements by ICPEs					
Aluminum		3.8	(0.20)	2.0	(0.20)
Barium		ND	(0.010)	ND	(0.010)
Beryllium		ND	(0.0020)	ND	(0.0020)
Boron		ND	(0.60)	0.75	(0.60)
Calcium		440.0	(1.0)	500.0	(1.0)
Chromium		0.017	(0.010)	0.019	(0.010)
Cobalt		ND	(0.010)	ND	(0.010)
Copper		ND	(0.020)	ND	(0.020)
Iron		ND	(0.040)	ND	(0.040)
Magnesium		1.7	(1.0)	2.5	(1.0)
Manganese		ND	(0.010)	ND	(0.010)
Molybdenum		ND	(0.050)	0.083	(0.050)
Nickel		ND	(0.020)	ND	(0.020)
Potassium		24.0	(3.0)	31.0	(3.0)
Silicon		ND	(1.0)	ND	(1.0)
Silver		ND	(0.010)	ND	(0.010)
Water Quality Variables					
Electrical Conductivity	umhos/cm	1725.0	()	2000.0	()
pH	pH units	9.2	()	9.8	()
Elements by AA					
Arsenic		0.0065	(0.0050)	0.0079	(0.0050)
Cadmium		ND	(0.0010)	ND	(0.0010)
Lead		0.0047	(0.0020)	ND	(0.0020)
Selenium		12.6	(0.0050)	9.5	(0.0050)
Elements by ICPEs					
Aluminum		3.8	(0.20)	2.0	(0.20)
Barium		ND	(0.010)	ND	(0.010)
Beryllium		ND	(0.0020)	ND	(0.0020)
Boron		ND	(0.60)	0.75	(0.60)
Calcium		440.0	(1.0)	500.0	(1.0)
Chromium		0.017	(0.010)	0.019	(0.010)
Cobalt		ND	(0.010)	ND	(0.010)
Copper		ND	(0.020)	ND	(0.020)
Iron		ND	(0.040)	ND	(0.040)
Magnesium		1.7	(1.0)	2.5	(1.0)
Manganese		ND	(0.010)	ND	(0.010)
Molybdenum		ND	(0.050)	0.083	(0.050)
Nickel		ND	(0.020)	ND	(0.020)
Potassium		24.0	(3.0)	31.0	(3.0)
Silicon		ND	(1.0)	ND	(1.0)
Silver		ND	(0.010)	ND	(0.010)

ND: Not detected at specified detection limit

NA: Not analyzed

SL: Sample lost

September 13, 1990

TABLE 8 (Continued)
ASTM WATER EXTRACTS OF LANDFILLED AFBC ASH.
mg/L except as noted

PARAMETER	Units	Location					
		Sample ID		Date Sampled		Det. Limit	
		COLY16-001	COLY16-002	COLY16-003	COLY16-004	COLY16-004	COLY16-004
		15-Sep-89	15-Sep-89	15-Sep-89	15-Sep-89	15-Sep-89	15-Sep-89
		Msr'd Val.	Msr'd Val.	Msr'd Val.	Msr'd Val.	Msr'd Val.	Msr'd Val.
		Det. Limit	Det. Limit	Det. Limit	Det. Limit	Det. Limit	Det. Limit
Sodium		NA	NA	NA	NA	NA	NA
Strontium		1.6	2.0	1.8	1.7	1.7	1.7
Tin		ND	ND	ND	ND	ND	ND
Vanadium		0.050	0.075	0.088	0.097	0.097	0.097
Zinc		ND	ND	ND	ND	ND	ND
Miscellaneous							
Chloride		41.0	43.0	27.0	37.0	37.0	37.0
Nitrate		ND	ND	ND	ND	ND	ND
Sulfate		1100.0	1200.0	1000.0	1000.0	1000.0	1000.0
Sulfite		3.2	11.2	8.0	10.4	10.4	10.4

ND: Not detected at specified detection limit

NA: Not analyzed

SL: Sample lost

TABLE 8

ASTM WATER EXTRACTS OF LANDFILLED AFBC ASH.

mg/L except as noted

PARAMETER	Units		Location			
			Sample ID		Date Sampled	
Water Quality Variables						
Electrical Conductivity	umhos/cm		COLY16-006	COLY16-007	COLY16-008	COLY16-008
pH	pH units		COLY16-006	COLY16-007	COLY16-008	COLY16-008
Elements by AA						
Arsenic	ND		MSR'd Val.	Det. Limit	MSR'd Val.	Det. Limit
Cadmium	ND		MSR'd Val.	Det. Limit	MSR'd Val.	Det. Limit
Lead	ND		MSR'd Val.	Det. Limit	MSR'd Val.	Det. Limit
Selenium	ND		MSR'd Val.	Det. Limit	MSR'd Val.	Det. Limit
Elements by ICPE						
Aluminum	ND		MSR'd Val.	Det. Limit	MSR'd Val.	Det. Limit
Barium	0.036		MSR'd Val.	Det. Limit	MSR'd Val.	Det. Limit
Beryllium	ND		MSR'd Val.	Det. Limit	MSR'd Val.	Det. Limit
Boron	ND		MSR'd Val.	Det. Limit	MSR'd Val.	Det. Limit
Calcium	420.0		MSR'd Val.	Det. Limit	MSR'd Val.	Det. Limit
Chromium	0.012		MSR'd Val.	Det. Limit	MSR'd Val.	Det. Limit
Cobalt	ND		MSR'd Val.	Det. Limit	MSR'd Val.	Det. Limit
Copper	ND		MSR'd Val.	Det. Limit	MSR'd Val.	Det. Limit
Iron	ND		MSR'd Val.	Det. Limit	MSR'd Val.	Det. Limit
Magnesium	ND		MSR'd Val.	Det. Limit	MSR'd Val.	Det. Limit
Manganese	ND		MSR'd Val.	Det. Limit	MSR'd Val.	Det. Limit
Molybdenum	0.16		MSR'd Val.	Det. Limit	MSR'd Val.	Det. Limit
Nickel	ND		MSR'd Val.	Det. Limit	MSR'd Val.	Det. Limit
Potassium	43.0		MSR'd Val.	Det. Limit	MSR'd Val.	Det. Limit
Silicon	6.2		MSR'd Val.	Det. Limit	MSR'd Val.	Det. Limit
Silver	ND		MSR'd Val.	Det. Limit	MSR'd Val.	Det. Limit

ND: Not detected at specified detection limit

NA: Not analyzed

SL: Sample lost

TABLE 8 (Continued)
ASTM WATER EXTRACTS OF LANDFILLED AFBC ASH.
mg/L except as noted

PARAMETER	Units	Msr'd Val.	Det. Limit	Msr'd Val.	Det. Limit	Msr'd Val.	Det. Limit
Location							
Sample ID							
Date Sampled							
COLY16-006							
COLY16-007							
15-Sep-89							
COLY16-008							
COLY16-008							
15-Sep-89							
Sodium		NA		NA		NA	
Strontium		3.0	(0.0030)	2.2	(0.0030)	5.8	(0.0030)
Tin		ND	(0.60)	ND	(0.60)	ND	(0.60)
Vanadium		ND	(0.020)	0.11	(0.020)	ND	(0.020)
Zinc		ND	(0.020)	ND	(0.020)	ND	(0.020)
Miscellaneous							
Chloride		22.0	(0.040)	27.0	(0.10)	7.0	(0.020)
Nitrate		ND	(0.030)	ND	(0.030)	ND	(0.030)
Sulfate		990.0	(1.0)	1000.0	(1.0)	1500.0	(2.5)
Sulfite		20.0	(0.40)	9.6	(0.40)	13.6	(0.40)

ND: Not detected at specified detection limit

NA: Not analyzed

SL: Sample lost

September 13, 1990

TABLE 9
ASTM WATER EXTRACTS OF LANDFILLED AFBC ASH:
mg/L except as noted

PARAMETER	Units	Location			
		Sample ID		Date Sampled	
		DECC002-001	DECC002-002	DECC002-003	DECC002-004
		17-Dec-89	17-Dec-89	17-Dec-89	17-Dec-89
		Msr'd Val.	Det. Limit	Msr'd Val.	Det. Limit
		Msr'd Val.	Det. Limit	Msr'd Val.	Det. Limit
Water Quality Variables					
Conductivity	umhos/cm	1480.0	()	1430.0	()
pH	pH units	10.1	()	10.1	()
Elements by AA					
Arsenic		ND	(0.0050)	0.0056	(0.0050)
Cadmium		ND	(0.0010)	ND	(0.0010)
Lead		0.0090	(0.0030)	0.028	(0.0030)
Selenium		ND	(0.0050)	ND	(0.0050)
Elements by ICPEs					
Aluminum		2.2	(0.20)	2.4	(0.20)
Barium		0.014	(0.010)	0.015	(0.010)
Beryllium		ND	(0.0020)	ND	(0.0020)
Boron		ND	(0.60)	ND	(0.60)
Calcium		420.0	(1.0)	400.0	(1.0)
Chromium		0.023	(0.010)	0.011	(0.010)
Cobalt		ND	(0.010)	ND	(0.010)
Copper		ND	(0.020)	ND	(0.020)
Iron		ND	(0.040)	ND	(0.040)
Magnesium		1.1	(1.0)	1.2	(1.0)
Manganese		ND	(0.010)	ND	(0.010)
Molybdenum		0.056	(0.050)	0.055	(0.050)
Nickel		ND	(0.020)	ND	(0.020)
Potassium		28.0	(3.0)	22.0	(3.0)
Silicon		1.9	(1.0)	1.8	(1.0)
Silver		ND	(0.010)	0.011	(0.010)
Water Quality Variables					
Conductivity	umhos/cm	1480.0	()	1430.0	()
pH	pH units	10.1	()	10.1	()
Elements by AA					
Arsenic		ND	(0.0050)	0.0056	(0.0050)
Cadmium		ND	(0.0010)	ND	(0.0010)
Lead		0.0090	(0.0030)	0.028	(0.0030)
Selenium		ND	(0.0050)	ND	(0.0050)
Elements by ICPEs					
Aluminum		2.2	(0.20)	2.4	(0.20)
Barium		0.014	(0.010)	0.015	(0.010)
Beryllium		ND	(0.0020)	ND	(0.0020)
Boron		ND	(0.60)	ND	(0.60)
Calcium		420.0	(1.0)	400.0	(1.0)
Chromium		0.023	(0.010)	0.011	(0.010)
Cobalt		ND	(0.010)	ND	(0.010)
Copper		ND	(0.020)	ND	(0.020)
Iron		ND	(0.040)	ND	(0.040)
Magnesium		1.1	(1.0)	1.2	(1.0)
Manganese		ND	(0.010)	ND	(0.010)
Molybdenum		0.056	(0.050)	0.055	(0.050)
Nickel		ND	(0.020)	ND	(0.020)
Potassium		28.0	(3.0)	22.0	(3.0)
Silicon		1.9	(1.0)	1.8	(1.0)
Silver		ND	(0.010)	0.011	(0.010)

ND: Not detected at specified detection limit

NA: Not analyzed

SL: Sample lost

TABLE 9 (Continued)

ASTM WATER EXTRACTS OF LANDFILLED AFBC ASH.

mg/L except as noted

PARAMETER	Units	Location							
		Sample ID		Date Sampled		Sample ID		Date Sampled	
		Msr'd Val.	Det. Limit	Msr'd Val.	Det. Limit	Msr'd Val.	Det. Limit	Msr'd Val.	Det. Limit
Sodium		8.3	(1.0)	5.3	(1.0)	9.9	(1.0)	7.1	(1.0)
Strontium		1.8	(0.0030)	1.5	(0.0030)	2.2	(0.0030)	2.1	(0.0030)
Tin		ND	(0.60)	ND	(0.60)	ND	(0.60)	ND	(0.60)
Vanadium		ND	(0.020)	0.025	(0.020)	ND	(0.020)	0.041	(0.020)
Zinc		ND	(0.020)	ND	(0.020)	ND	(0.020)	ND	(0.020)
Miscellaneous									
Chloride		25.0	(0.040)	18.0	(0.040)	24.0	(0.040)	21.0	(0.040)
Nitrate		ND	(1.0)	ND	(1.0)	ND	(1.0)	0.030	(0.020)
Sulfate		1000.0	(1.0)	980.0	(1.0)	1200.0	(1.0)	1200.0	(1.0)
Sulfite		1.7	(0.40)	2.1	(0.40)	1.6	(0.40)	5.9	(0.40)

ND: Not detected at specified detection limit
NA: Not analyzed
SL: Sample lost

TABLE 9
ASTM WATER EXTRACTS OF LANDFILLED AFBC ASH.

mg/L except as noted

PARAMETER	Units	Location			
		Sample ID		Date Sampled	
Water Quality Variables					
	Conductivity				
	pH				
Elements by AA					
Elements by ICPIES					

ND: Not detected at specified detection limit

NA: Not analyzed

SL: Sample lost

TABLE 9 (Continued)
ASTM WATER EXTRACTS OF LANDFILLED AFBC ASH.
mg/L except as noted

PARAMETER	Units	Location			
		Sample ID		Date Sampled	
		Msr'd Val.	Det. Limit	Msr'd Val.	Det. Limit
Sodium		6.0	(1.0)	8.9	(1.0)
Strontium		2.1	(0.0030)	2.5	(0.0030)
Tin		ND	(0.60)	ND	(0.60)
Vanadium		0.036	(0.020)	0.022	(0.020)
Zinc		ND	(0.020)	ND	(0.020)
Miscellaneous					
Chloride		22.0	(0.040)	19.0	(0.040)
Nitrate		0.80	(0.020)	ND	(1.0)
Sulfate		1200.0	(1.0)	1400.0	(1.0)
Sulfite		ND	(0.40)	6.1	(0.40)

ND: Not detected at specified detection limit

NA: Not analyzed

SL: Sample lost

TABLE 10
ASTM WATER EXTRACTS OF LANDFILLED AFBC ASH.
mg/L except as noted

PARAMETER	Units	Location											
		Sample ID				Date Sampled							
		MARCO02-001	MARCO02-002	MARCO02-003	MARCO02-004	MARCO02-001	MARCO02-002	MARCO02-003	MARCO02-004				
		16-Mar-90	16-Mar-90	16-Mar-90	16-Mar-90	16-Mar-90	16-Mar-90	16-Mar-90	16-Mar-90				
		Msr'd Val.	Det. Limit	Msr'd Val.	Det. Limit	Msr'd Val.	Det. Limit	Msr'd Val.	Det. Limit	Msr'd Val.	Det. Limit	Msr'd Val.	Det. Limit
Water Quality Variables													
Conductivity	umhos/cm	1100.0	()	1600.0	()	1120.0	()	1180.0	()				
pH	pH units	10.1	()	10.1	()	10.0	()	11.9	()				
Elements by AA													
Arsenic		ND	(0.0050)	ND	(0.0050)	ND	(0.0050)	ND	(0.0050)	ND	(0.0050)	ND	(0.0050)
Cadmium		ND	(0.0010)	ND	(0.0010)	ND	(0.0010)	ND	(0.0010)	ND	(0.0010)	ND	(0.0010)
Lead		0.0097	(0.0030)	0.0037	(0.0030)	0.0052	(0.0030)	ND	(0.0030)	ND	(0.0030)	ND	(0.0030)
Selenium		0.0057	(0.0050)	ND	(0.0050)	ND	(0.0050)	ND	(0.0050)	ND	(0.0050)	ND	(0.0050)
Elements by ICPEs													
Aluminum		3.6	(0.20)	1.9	(0.20)	2.3	(0.20)	ND	(0.20)	ND	(0.20)	ND	(0.20)
Barium		0.015	(0.010)	0.018	(0.010)	0.013	(0.010)	0.067	(0.010)	0.067	(0.010)	0.067	(0.010)
Beryllium		ND	(0.0020)	ND	(0.0020)	ND	(0.0020)	ND	(0.0020)	ND	(0.0020)	ND	(0.0020)
Boron		ND	(0.60)	ND	(0.60)	ND	(0.60)	ND	(0.60)	ND	(0.60)	ND	(0.60)
Calcium		290.0	(1.0)	470.0	(1.0)	300.0	(1.0)	1200.0	(2.0)	1200.0	(2.0)	1200.0	(2.0)
Chromium		ND	(0.010)	ND	(0.010)	ND	(0.010)	ND	(0.010)	ND	(0.010)	ND	(0.010)
Cobalt		ND	(0.010)	ND	(0.010)	ND	(0.010)	ND	(0.010)	ND	(0.010)	ND	(0.010)
Copper		ND	(0.020)	ND	(0.020)	ND	(0.020)	ND	(0.020)	ND	(0.020)	ND	(0.020)
Iron		ND	(0.040)	ND	(0.040)	ND	(0.040)	ND	(0.040)	ND	(0.040)	ND	(0.040)
Magnesium		ND	(1.0)	1.3	(1.0)	ND	(1.0)	ND	(1.0)	ND	(1.0)	ND	(1.0)
Manganese		ND	(0.010)	ND	(0.010)	ND	(0.010)	ND	(0.010)	ND	(0.010)	ND	(0.010)
Molybdenum		ND	(0.050)	0.070	(0.050)	ND	(0.050)	0.096	(0.050)	0.096	(0.050)	0.096	(0.050)
Nickel		ND	(0.020)	ND	(0.020)	ND	(0.020)	ND	(0.020)	ND	(0.020)	ND	(0.020)
Potassium		18.0	(3.0)	26.0	(3.0)	15.0	(3.0)	23.0	(3.0)	23.0	(3.0)	23.0	(3.0)
Silicon		1.8	(1.0)	2.5	(1.0)	1.8	(1.0)	ND	(1.0)	ND	(1.0)	ND	(1.0)
Silver		ND	(0.010)	ND	(0.010)	ND	(0.010)	0.041	(0.010)	0.041	(0.010)	0.041	(0.010)

ND: Not detected at specified detection limit

NA: Not analyzed

SL: Sample lost

TABLE 10 (Continued)
ASTM WATER EXTRACTS OF LANDFILLED AFBC ASH.
mg/L except as noted

PARAMETER	Units	Location							
		Sample ID		Date Sampled		Msr'd Val.		Det. Limit	
		Msr'd Val.	Det. Limit	Msr'd Val.	Det. Limit	Msr'd Val.	Det. Limit	Msr'd Val.	Det. Limit
Sodium		4.6	(1.0)	5.9	(1.0)	2.9	(1.0)	3.3	(1.0)
Strontium		1.1	(0.0030)	1.9	(0.0030)	1.1	(0.0030)	2.6	(0.0030)
Tin		ND	(0.60)	ND	(0.60)	ND	(0.60)	ND	(0.60)
Vanadium		0.037	(0.020)	0.061	(0.020)	0.042	(0.020)	ND	(0.020)
Zinc		ND	(0.020)	ND	(0.020)	0.18	(0.020)	0.040	(0.020)
Miscellaneous									
Chloride		21.0	(0.10)	24.0	(0.040)	15.0	(0.040)	9.0	(0.020)
Nitrate		0.71	(0.20)	0.70	(0.20)	0.60	(0.20)	0.71	(0.20)
Sulfate		580.0	(0.50)	900.0	(1.0)	650.0	(0.50)	1500.0	(1.0)
Sulfite		3.5	(0.40)	5.6	(0.40)	2.3	(0.40)	11.1	(0.40)

ND: Not detected at specified detection limit

NA: Not analyzed

SL: Sample lost

TABLE 10
ASTM WATER EXTRACTS OF LANDFILLED AFBC ASH.
mg/L except as noted

PARAMETER	Units	Location			
		Sample ID		Date Sampled	
		MARCO02-005	MARCO02-006	MARCO02-007	MARCO02-008
		16-Mar-90	16-Mar-90	16-Mar-90	16-Mar-90
		Msr'd Val.	Det. Limit	Msr'd Val.	Det. Limit
		Msr'd Val.	Det. Limit	Msr'd Val.	Det. Limit
Water Quality Variables					
Conductivity	umhos/cm	1360.0	()	2700.0	()
pH	pH units	11.0	()	11.6	()
				6200.0	()
				12.0	()
				1210.0	()
				10.4	()
Elements by AA					
Arsenic		ND	(0.0050)	ND	(0.0050)
Cadmium		ND	(0.0010)	ND	(0.0010)
Lead		ND	(0.0030)	ND	(0.0030)
Selenium		ND	(0.0050)	ND	(0.0050)
Elements by ICPE					
Aluminum		0.34	(0.20)	ND	(0.20)
Barium		0.031	(0.010)	0.092	(0.010)
Beryllium		ND	(0.0020)	ND	(0.0020)
Boron		ND	(0.60)	ND	(0.60)
Calcium		430.0	(1.0)	1200.0	(1.0)
Chromium		0.012	(0.010)	0.011	(0.010)
Cobalt		ND	(0.010)	ND	(0.010)
Copper		ND	(0.020)	ND	(0.020)
Iron		ND	(0.040)	0.054	(0.040)
Magnesium		ND	(1.0)	ND	(1.0)
Manganese		ND	(0.010)	ND	(0.010)
Molybdenum		0.12	(0.050)	0.13	(0.050)
Nickel		ND	(0.020)	ND	(0.020)
Potassium		48.0	(3.0)	35.0	(3.0)
Silicon		10.7	(1.0)	ND	(1.0)
Silver		ND	(0.010)	0.032	(0.010)

ND: Not detected at specified detection limit

NA: Not analyzed

SL: Sample lost

September 13, 1990

TABLE 10 (Continued)
ASTM WATER EXTRACTS OF LANDFILLED AFBC ASH.
mg/L except as noted

PARAMETER	Units	Location					
		Sample ID		Date Sampled		Det. Limit	
		MARCO02-005	MARCO02-006	MARCO02-007	MARCO02-008	MARCO02-008	MARCO02-008
		16-Mar-90	16-Mar-90	16-Mar-90	16-Mar-90	16-Mar-90	16-Mar-90
		Msr'd Val.	Msr'd Val.	Msr'd Val.	Msr'd Val.	Msr'd Val.	Msr'd Val.
Sodium		7.9	7.1	4.8	6.1	6.1	(1.0)
Strontium		2.5	3.2	3.5	2.1	2.1	(0.0030)
Tin		ND	ND	ND	ND	ND	(0.60)
Vanadium		0.042	ND	ND	0.071	0.071	(0.020)
Zinc		0.028	ND	0.028	ND	ND	(0.020)
Miscellaneous							
Chloride		23.0	13.0	11.0	26.0	26.0	(0.10)
Nitrate		0.70	0.83	0.86	0.83	0.83	(0.20)
Sulfate		870.0	980.0	1600.0	1100.0	1100.0	(1.0)
Sulfite		ND	2.6	6.7	17.6	17.6	(0.40)

ND: Not detected at specified detection limit

NA: Not analyzed

SL: Sample lost

depth show a jump in sulfate concentrations from 650 mg/L to 1500 mg/L. The pH and the concentrations of aluminum, calcium, and silicon in the leachate also vary significantly within each core of the ash in the test cell. Since the ASTM leach procedure is based on a relatively small (500g) section of core rather than the larger volume sampled by a lysimeter or groundwater sample, this range of variation is not unusual. However, despite the short range compositional variations, the average composition of the leachates does not appear to have changed significantly in the course of the three sampling events.

Tables 11 through 13 present the results of ASTM leaches of soil samples collected beneath and around the test cell. The ASTM leachates of the soils are neutral to acidic, ranging from pH 7.4 to 4.6. The major ions in ASTM leachates of soil samples include calcium, magnesium, and sulfate, with lesser amounts of potassium, strontium, chloride, and nitrate.

Discussion

The initial composition of solid waste from the FBC process represents a mixture which is far from chemical equilibrium. The dissolution and hydration reactions of calcium oxide in the solid waste produce a high pH in the liquid phase, and also supply a source of calcium ions to the solution. The high pH liquid attacks other solids, especially glassy material on the surfaces of ash particles, bringing aluminum and silicon into solution. The dissolution of calcium sulfate, which is essentially pH independent, provides a source of sulfate ions. Leachate solutions from such material tend to be supersaturated with respect to a number of mineral phases, some of which are more likely to form than others.

The computer program MINTEQA1 was used to calculate the activities of all aqueous components detected in the ASTM leachate solutions. These activity values were then used in the solubility product expression for the formation of specific minerals from the components defined in the MINTEQ model. The solubility product, K_{sp} , is defined as:

September 14, 1990

TABLE 11
ASTM WATER EXTRACTS OF UPGRADEMENT SOILS AT THE TEST CELL.
mg/L except as noted

PARAMETER	Units	Location							
		Sample ID				Date Sampled			
		COLY01-001	COLY01-002	COLY01-004	COLY01-010	Msr'd Val.	Det. Limit	Msr'd Val.	Det. Limit
Water Quality Variables									
Electrical Conductivity	umhos/cm	1575.0	()	1750.0	()	2000.0	()	1150.0	()
pH	pH units	7.7	()	7.8	()	8.4	()	6.8	()
Elements by AA									
Arsenic		ND	(0.0050)	ND	(0.0050)	ND	(0.0050)	ND	(0.0050)
Cadmium		ND	(0.0010)	ND	(0.0010)	ND	(0.0010)	0.0011	(0.0010)
Lead		0.0029	(0.0020)	0.0064	(0.0020)	ND	(0.0020)	0.0095	(0.0020)
Selenium		ND	(0.0050)	ND	(0.0050)	ND	(0.0050)	ND	(0.0050)
Elements by ICPEs									
Aluminum		ND	(0.20)	0.32	(0.20)	ND	(0.20)	0.93	(0.20)
Barium		0.057	(0.010)	0.070	(0.010)	0.059	(0.010)	0.011	(0.010)
Beryllium		ND	(0.0020)	ND	(0.0020)	ND	(0.0020)	ND	(0.0020)
Boron		ND	(0.60)	ND	(0.60)	ND	(0.60)	ND	(0.60)
Calcium		350.0	(1.0)	280.0	(1.0)	430.0	(1.0)	90.0	(1.0)
Chromium		ND	(0.010)	ND	(0.010)	ND	(0.010)	ND	(0.010)
Cobalt		ND	(0.010)	ND	(0.010)	ND	(0.010)	ND	(0.010)
Copper		ND	(0.020)	ND	(0.020)	ND	(0.020)	ND	(0.020)
Iron		ND	(0.040)	0.21	(0.040)	0.062	(0.040)	0.72	(0.040)
Magnesium		34.0	(1.0)	34.0	(1.0)	54.0	(1.0)	49.0	(1.0)
Manganese		ND	(0.010)	ND	(0.010)	ND	(0.010)	0.013	(0.010)
Molybdenum		ND	(0.050)	ND	(0.050)	ND	(0.050)	ND	(0.050)
Nickel		ND	(0.020)	ND	(0.020)	0.026	(0.020)	0.022	(0.020)
Potassium		3.1	(3.0)	ND	(3.0)	ND	(3.0)	ND	(3.0)
Silicon		NA		NA		NA		NA	
Silver		ND	(0.010)	ND	(0.010)	ND	(0.010)	ND	(0.010)

ND: Not detected at specified detection limit

NA: Not analyzed

SL: Sample lost

TABLE 11 (Continued)
ASTM WATER EXTRACTS OF UPGRADEMENT SOILS AT THE TEST CELL.
mg/L except as noted

PARAMETER	Units	Location					
		Sample ID		Date Sampled		Det. Limit	
		COLY01-001	COLY01-002	COLY01-004	COLY01-010		
		COLY01-001	COLY01-002	COLY01-004	COLY01-010		
		15-Sep-89	15-Sep-89	15-Sep-89	15-Sep-89		
		Msr'd Val.	Msr'd Val.	Msr'd Val.	Msr'd Val.	Det. Limit	Det. Limit
Sodium		NA	NA	NA	NA		
Strontium		2.3	(0.0030)	2.3	(0.0030)	1.2	(0.0030)
Tin		ND	(0.60)	ND	(0.60)	ND	(0.60)
Vanadium		ND	(0.020)	ND	(0.020)	ND	(0.020)
Zinc		ND	(0.020)	ND	(0.020)	0.055	(0.020)
Miscellaneous							
Chloride		2.1	(0.020)	2.7	(0.020)	15.0	(0.10)
Nitrate		12.0	(0.030)	4.2	(0.030)	3.8	(0.030)
Sulfate		1000.0	(1.0)	830.0	(1.0)	1300.0	(1.0)
Sulfite		0.80	(0.40)	4.0	(0.40)	18.4	(0.40)

ND: Not detected at specified detection limit

NA: Not analyzed

SL: Sample lost

TABLE 11
ASTM WATER EXTRACTS OF UPGRADEMENT SOILS AT THE TEST CELL.
mg/L except as noted

PARAMETER	Units	Msr'd Val.	Det. Limit
Location			
Sample ID			
Date Sampled			
COLY01-014			
COLY01-014			
15-Sep-89			
Water Quality Variables			
Electrical Conductivity	umhos/cm	80.0	()
pH	pH units	5.3	()
Elements by AA			
Arsenic		ND	(0.0050)
Cadmium		ND	(0.0010)
Lead		0.025	(0.0020)
Selenium		ND	(0.0050)
Elements by ICPE			
Aluminum		1.4	(0.20)
Barium		ND	(0.010)
Beryllium		ND	(0.0020)
Boron		ND	(0.60)
Calcium		ND	(1.0)
Chromium		ND	(0.010)
Cobalt		ND	(0.010)
Copper		ND	(0.020)
Iron		0.26	(0.040)
Magnesium		ND	(1.0)
Manganese		ND	(0.010)
Molybdenum		ND	(0.050)
Nickel		0.030	(0.020)
Potassium		ND	(3.0)
Silicon		NA	
Silver		ND	(0.010)

ND: Not detected at specified detection limit

NA: Not analyzed

SL: Sample lost

TABLE 11 (Continued)
ASTM WATER EXTRACTS OF UPGRADEMENT SOILS AT THE TEST CELL.
mg/L except as noted

PARAMETER	Units	Msr'd Val.	Det. Limit	Location Sample ID Date Sampled
Sodium		NA		COLY01-014
Strontium		0.0060	(0.0030)	COLY01-014
Tin		ND	(0.60)	15-Sep-89
Vanadium		ND	(0.020)	
Zinc		0.038	(0.020)	
Miscellaneous				
Chloride		18.0	(0.020)	
Nitrate		1.9	(0.030)	
Sulfate		52.0	(0.25)	
Sulfite		0.70	(0.40)	

ND: Not detected at specified detection limit

NA: Not analyzed

SL: Sample lost

TABLE 12
ASTM WATER EXTRACTS OF DOWNGRADIENT SOILS AT THE TEST CELL.
mg/L except as noted

PARAMETER	Units	Location			
		Sample ID		Date Sampled	
		COLY07-001	COLY07-004	COLY07-006	COLY07-009
		COLY07-001	COLY07-004	COLY07-006	COLY07-009
		15-Sep-89	15-Sep-89	15-Sep-89	15-Sep-89
		Msr'd Val.	Det. Limit	Msr'd Val.	Det. Limit
		Msr'd Val.	Det. Limit	Msr'd Val.	Det. Limit
Water Quality Variables					
Electrical Conductivity	umhos/cm	350.0	()	2150.0	()
pH	pH units	7.4	()	7.2	()
Elements by AA					
Arsenic		0.0055	(0.0050)	ND	(0.0050)
Cadmium		ND	(0.0010)	ND	(0.0010)
Lead		0.0078	(0.0020)	0.074	(0.0040)
Selenium		ND	(0.0050)	ND	(0.0050)
Elements by ICPE					
Aluminum		ND	(0.20)	ND	(0.20)
Barium		0.22	(0.010)	0.10	(0.010)
Beryllium		ND	(0.0020)	ND	(0.0020)
Boron		ND	(0.60)	ND	(0.60)
Calcium		68.0	(1.0)	440.0	(1.0)
Chromium		ND	(0.010)	ND	(0.010)
Cobalt		ND	(0.010)	ND	(0.010)
Copper		ND	(0.020)	ND	(0.020)
Iron		0.088	(0.040)	ND	(0.040)
Magnesium		7.1	(1.0)	82.0	(1.0)
Manganese		ND	(0.010)	ND	(0.010)
Molybdenum		ND	(0.050)	ND	(0.050)
Nickel		ND	(0.020)	0.021	(0.020)
Potassium		6.6	(3.0)	8.4	(3.0)
Silicon		8.8	(1.0)	8.3	(1.0)
Silver		ND	(0.010)	ND	(0.010)

ND: Not detected at specified detection limit

NA: Not analyzed

SL: Sample lost

September 13, 1990

TABLE 12 (Continued)
ASTM WATER EXTRACTS OF DOWNGRADIENT SOILS AT THE TEST CELL.
mg/L except as noted

PARAMETER	Units	Location					
		Sample ID		Date Sampled		Det. Limit	
		COLY07-001	COLY07-004	COLY07-006	COLY07-009	Msr'd Val.	Det. Limit
		15-Sep-89	15-Sep-89	15-Sep-89	15-Sep-89		
Sodium		NA	NA	NA	NA		
Strontium		0.42	(0.0030)	0.0090	(0.0030)	0.17	(0.0030)
Tin		ND	(0.60)	ND	(0.60)	ND	(0.60)
Vanadium		ND	(0.020)	ND	(0.020)	ND	(0.020)
Zinc		0.050	(0.020)	0.022	(0.020)	ND	(0.020)
Miscellaneous							
Chloride		0.88	(0.020)	40.0	(0.10)	37.0	(0.10)
Nitrate		11.0	(0.030)	4.8	(0.030)	2.2	(0.030)
Sulfate		86.0	(0.50)	1500.0	(2.5)	230.0	(0.25)
Sulfite		0.65	(0.40)	1.6	(0.40)	1.1	(0.40)

ND: Not detected at specified detection limit

NA: Not analyzed

SL: Sample lost

TABLE 12
ASTM WATER EXTRACTS OF DOWNGRADIENT SOILS AT THE TEST CELL.
mg/L except as noted

PARAMETER	Units	Msr'd Val.	Det. Limit
Location			
Sample ID			
Date Sampled			
COLY07-012			
COLY07-012			
15-Sep-89			
Water Quality Variables			
Electrical Conductivity	umhos/cm	2050.0	()
pH	pH units	4.2	()
Elements by AA			
Arsenic		ND	(0.0050)
Cadmium		0.0040	(0.0010)
Lead		0.47	(0.040)
Selenium		ND	(0.0050)
Elements by ICPE:			
Aluminum		0.58	(0.20)
Barium		ND	(0.010)
Beryllium		ND	(0.0020)
Boron		ND	(0.60)
Calcium		450.0	(1.0)
Chromium		ND	(0.010)
Cobalt		0.013	(0.010)
Copper		ND	(0.020)
Iron		ND	(0.040)
Magnesium		78.0	(1.0)
Manganese		0.43	(0.010)
Molybdenum		ND	(0.050)
Nickel		0.050	(0.020)
Potassium		3.5	(3.0)
Silicon		3.5	(1.0)
Silver		ND	(0.010)

ND: Not detected at specified detection limit

NA: Not analyzed

SL: Sample lost

September 13, 1990

TABLE 12 (Continued)
ASTM WATER EXTRACTS OF DOWNGRADIENT SOILS AT THE TEST CELL.
mg/L except as noted

PARAMETER	Units	Msr'd Val.	Det. Limit
Location			
Sample ID			
Date Sampled			
COLY07-012			
COLY07-012			
15-Sep-89			
NA			
Sodium		1.6	(0.0030)
Strontium		ND	(0.60)
Tin		ND	(0.020)
Vanadium		2.6	(0.020)
Zinc			
Miscellaneous			
Chloride		23.0	(0.040)
Nitrate		ND	(0.030)
Sulfate		1500.0	(2.5)
Sulfite		0.36	(0.40)

ND: Not detected at specified detection limit

NA: Not analyzed

SL: Sample lost

TABLE 13
ASTM WATER EXTRACTS OF SOILS AT BASE OF TEST CELL.
mg/L except as noted

PARAMETER	Units	Location			
		Sample ID		Date Sampled	
		COSS01	COSS03	COSS01	COSS03
		15-Sep-89		15-Sep-89	
		Msr'd Val.	Det. Limit	Msr'd Val.	Det. Limit
Water Quality Variables					
Electrical Conductivity	umhos/cm	1875.0	()	2400.0	()
pH	pH units	8.5	()	8.6	()
Elements by AA					
Arsenic		ND	(0.0050)	ND	(0.0050)
Cadmium		ND	(0.0010)	ND	(0.0010)
Lead		0.0056	(0.0020)	ND	(0.0020)
Selenium		ND	(0.0050)	ND	(0.0050)
Elements by ICFES					
Aluminum		ND	(0.20)	ND	(0.20)
Barium		0.020	(0.010)	0.020	(0.010)
Beryllium		ND	(0.0020)	ND	(0.0020)
Boron		ND	(0.60)	0.75	(0.60)
Calcium		140.0	(1.0)	510.0	(1.0)
Chromium		ND	(0.010)	ND	(0.010)
Cobalt		ND	(0.010)	ND	(0.010)
Copper		ND	(0.020)	ND	(0.020)
Iron		ND	(0.040)	0.057	(0.040)
Magnesium		66.0	(1.0)	100.0	(1.0)
Manganese		ND	(0.010)	ND	(0.010)
Molybdenum		ND	(0.050)	0.069	(0.050)
Nickel		0.026	(0.020)	0.024	(0.020)
Potassium		ND	(3.0)	ND	(3.0)
Silicon		NA		NA	
Silver		ND	(0.010)	ND	(0.010)

ND: Not detected at specified detection limit

NA: Not analyzed

SL: Sample lost

TABLE 13 (Continued)
ASTM WATER EXTRACTS OF SOILS AT BASE OF TEST CELL.
mg/L except as noted

PARAMETER	Units	Location			
		Sample ID		Date Sampled	
		COSS01	COSS03	COSS01	COSS03
		15-Sep-89	15-Sep-89	15-Sep-89	15-Sep-89
		Msr'd Val.	Det. Limit	Msr'd Val.	Det. Limit
Sodium	NA	2.0	(0.0030)	7.4	(0.0030)
Strontium	ND	ND	(0.60)	ND	(0.60)
Tin	ND	ND	(0.020)	ND	(0.020)
Vanadium	ND	ND	(0.020)	ND	(0.020)
Zinc	ND	ND	(0.020)	ND	(0.020)
Miscellaneous					
Chloride	1.2	(0.020)		16.0	(0.020)
Nitrate	0.82	(0.030)		ND	(0.030)
Sulfate	660.0	(1.0)		1900.0	(2.5)
Sulfite	0.80	(0.40)		ND	(0.40)

ND: Not detected at specified detection limit

NA: Not analyzed

SL: Sample lost

$$K_{sp} = A^a \cdot B^b / C^c \cdot D^d$$

for the reaction:

In the presentations of solubility data shown here the base 10 log of all activities and solubility products is used in order to show linear correlations over wide activity ranges, and for ease of presentation with pH data since $pH = -\log H^+$ activity.

The activities of calcium and sulfate in leachates from the land-filled waste appear to be controlled by the solubility of gypsum ($CaSO_4 \cdot 2H_2O$), a reaction product of calcium and sulfur from the AFBC process. Figure 2 plots the calculated activities of calcium and sulfate. Most of the values cluster near the solubility limit of gypsum and along the line of equal calcium and sulfate activities, suggesting that gypsum dissolution is largely responsible for controlling the activities of these ions in solution. The three outlying points with higher calcium activities represent high pH solutions where calcium activity is influenced by calcium hydroxide dissolution.

In addition, pozzolanic reactions occurring in the landfilled solid waste require the equilibrium of calcium and sulfate ions in solution with the crystalline Ca-silicate, Ca-hydroxide, and Ca-aluminosulphate phases responsible for the cementation process. Reactions to form these cements link the concentrations of silicon and aluminum to the concentrations of calcium and sulfate in the leachates through the solubility product expression. Ettringite ($Ca_3Al_2O_6 \cdot 3CaSO_4 \cdot 31H_2O$) and calcium silicate hydrate ($Ca_3SiO_5 \cdot H_2O$) are two phases commonly occurring during the hydration of ordinary Portland cement which also appear to influence the composition of leachate from the AFBC waste. The formation of ettringite can be represented by the equation:

The solubility product for ettringite is thus given by the expression:

FIGURE 2

Colorado Ute ASTM Leachates

$$K_{\text{ett}} = a^{12}\text{H}^+ / (a^6\text{Ca}^{+2} * a^2\text{Al}^{3+} * a^3\text{SO}_4^{-2})$$

The activities of water and of solid ettringite are taken as unity, and are omitted in the solubility product expression. For purposes of presentation this expression can be reduced by taking the logarithm of both sides and converting the H^+ activity to pH to give the following:

$$\log K_{\text{ett}} = -12\text{pH} - 6 \log a\text{Ca}^{+2} - 2 \log a\text{Al}^{+3} - 3 \log a\text{SO}_4^{-2}$$

Figure 3 shows the compositions of the ASTM leachates plotted against the solubility product expression for ettringite.

As can be seen from this representation of ettringite solubility, pH is a major factor in determining the equilibrium phases in the system. In addition, pH affects the equilibrium of the system indirectly through the activities of components such as aluminum and silicon, which are largely present in solution as hydroxide complexes or weak acids.

Several aluminosilicate phases occur at or near saturation limits in the ASTM leachates of the AFBC waste. Figures 4, 5, and 6 show the leachate compositions plotted against the solubility product expressions for boehmite ($\gamma \text{AlO-OH}$), halloysite, $(\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4$ and $\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4 \cdot 2\text{H}_2\text{O}$), and leucite, $(\text{KAlSi}_2\text{O}_6)$, respectively. Boehmite, an aluminum hydroxide, and halloysite, a clay mineral with the same chemical composition as kaolinite, are most likely present as weathering products of the FBC waste, while leucite, a feldspathoid mineral found in silica-deficient volcanic rocks, is probably a constituent of the fresh ash.

Ohio Edison Site

Quarterly groundwater and waste core samples were received from the Ohio Edison site and have been submitted for analysis.

FIGURE 3
Colorado Ute ASTM Leachates

FIGURE 4
Colorado Ute ASTM Leachates

FIGURE 5
Colorado Ute ASTM Leachates

FIGURE 6
Colorado Ute ASTM Leachates

Freeman Illinois Site

Construction of the landfill test cells at the Freeman United site was delayed due to plant outages during July. Filling of the test cells is now scheduled to begin on August 6, 1990. EERC and Radian personnel will be on hand to supervise operations and to obtain preliminary samples of soils and waste materials. Records will also be maintained of the plant operating conditions during the construction of the test cells. It is expected that a period of 6 to 10 weeks will be required to fill both test cells if plant operations can be maintained.

North Dakota Site

Site access and permitting difficulties have stalled progress on the site selection process at Dakota Gasification. The selection of this site for the fourth study site is still under consideration.

Project Management

Radian has prepared a revised cost estimate to complete the project based on DOE response to the Cost Proposal submitted last quarter. The revised Cost Proposal will be submitted to the DOE in the near future.

4.0 PROBLEMS ENCOUNTERED

None.

5.0 ACTIVITIES PLANNED FOR THE NEXT QUARTER

The following activities are planned for the period of August 1990 through October 1990:

- Fourth quarter waste core samples will be collected and characterized at the Colorado Ute site;

- Annual soil core samples will be collected and characterized at the Colorado Ute site;
- Fourth quarter waste core and groundwater samples will be collected and characterized at the Ohio Edison site;
- Annual soil core samples will be collected and characterized at the Ohio Edison site;
- The Freeman United test cells will be filled and instrumented and preliminary waste and soil samples will be collected and characterized;
- The site selection process for a fourth site will be renewed;
- Start integrating EERC data on Radian database; and
- A revised Cost Proposal will be finalized with DOE.

- END -

DATE FILMED

01 / 29 / 91