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FIELD STUDY OF DISPOSED WASTES FROM ADVANCED COAL PROCESSES

DE-AC21-86MC22118 DOE Quarterly Technical Progress Report

October to December 1993

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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 SUMMARY OF PREVIOUS WORK

This study is organized into four major Tasks. Tasks 1 and 2 were devoted to planning the Task 3 field study. Task 4 uses the results of the field testing to produce an Engineering Design Manual for the utilities and industrial users who manage wastes from advanced coal combustion technologies.

Task 1 identified and rated test design options. A Test Design Manual was prepared and submitted to METC in 1988. Specific test procedures suitable for each design option were identified under Task 2. These test methods were documented in a

Test Procedures Manual, submitted to METC in 1988. Also under Task 2, test sites were selected and site access was negotiated. Sites in Illinois and North Dakota were delayed at this stage, and the North Dakota site was dropped from consideration. Task 2 was completed and Final Test Plans were submitted to METC for three sites in 1988.

Task 3 progress for each of the test sites is summarized below:

2.1 Colorado

The test cell was constructed in June, 1989 with CFBC ash from a low sulfur western coal. The ash has low lime and sulfate content. Core samples were collected in June and December 1989, in March, June and December of 1990, in June 1991, and most recently in June 1992. No groundwater or porewater samples have been recovered; one surface runoff sample was collected. At this time the three year monitoring period at the Colorado site is completed. The DOE plans further field monitoring at this site on an annual basis. A draft site assessment report, based on the initial three years of monitoring, was completed in December, 1992.

The strength of core samples from the Colorado site is low to moderate (200 psi to 900 psi), with permeabilities of 2×10^{-3} to 3×10^{-4} . Laboratory leachates show moderate concentrations of calcium, sulfate, and other common ions. Trace element concentrations in test leachates are low compared to regulatory limits. No leachate has been generated from the test cell at this site.

A site report has been prepared and submitted. Following receipt of comments from the DOE, the site report will be finalized.

Two test cells were constructed, in February and April of 1989, using LIMB ash from an Ohio coal with 2.4% sulfur. The ash has a high lime and sulfate content. Test case 1 (north cell) was constructed with 25% moisture; test case 2 (south cell) was constructed with 38% moisture to optimize compaction. The wastes expanded, heaved, and fractured during the first year, particularly in the south cell. Mineralogical changes in the wastes with hydration and weathering are the primary cause. Core strength is low to moderate (< 100 psi to 2000 psi) and highly variable because of fracturing. Field measurements of permeability vary from 3×10^{-3} to 5×10^{-5} cm/sec. Permeabilities are lowest in the north cell.

Large amounts of water were bound in the wastes in the first year as the waste saturated and hydrated. Starting in the second year, leachate appears to have migrated out of the south cell into one downgradient well. The leachate at the bottom of the test cell contains up to several thousand mg/L of sulfate, chloride, potassium, and sodium, with somewhat lower concentrations of calcium and silicon. Trace metal concentrations are generally low compared to regulatory limits, but a few samples contain arsenic at concentrations of up to 0.35 mg/L.

Core samples were first collected in June, 1989, and quarterly and annual core sampling events have taken place according to schedule since that time. Water samples have been collected on a quarterly basis since October, 1989. Final core sampling for the three year monitoring period took place in August, 1992.

A final report is in preparation for the Ohio LIMB site. Further monitoring, on an annual basis, is planned by the DOE.

2.3

Illinois

The first Illinois test cell was completed in April, 1991, with BFBC ash from an Illinois coal with 3.1% sulfur. A large excess of limestone is used in the combustor; the ash is high in lime relative to most FBC wastes, containing up to 30% CaO. The ash also contains abundant sulfate, but has relatively low concentrations of typical coal ash constituents compared to other wastes included in this study. The two test cells constructed for the second Illinois test case will evaluate the effects of added coal ash on cementitious reactions in the waste. Laboratory studies to define the optimum mix of FBC waste and coal fly ash were conducted and two mixes were selected. Both mixes contained equal amounts of fly ash and FBC ash by weight; one was wetted for compaction in place and the other was placed as a pumpable slurry. Cell construction, planned for late fall of 1992, was completed in June of 1993 due to permit complications.

The first test cell was instrumented and sampled in June 1991. Water samples and additional cores were collected in August and November, 1991, and on a nominal quarterly basis since then. No expansion has been noted at the site. The wastes are solidified with unconfined compressive strength between approximately 150 and 550 psi, although some fracture zones may be present in the waste and may reduce overall strength. The permeability measured on cores recovered from the test cell ranges from 1×10^{-6} to 2×10^{-4} ; field permeability measurements range from a high of 3×10^{-3} near the surface to a low of 2×10^{-5} at depth in the test cell. Two years of sampling has been completed at the site.

The lysimeters installed in the two new test cells--the compacted and pumpable-mix cells--were sampled for the first time during the most recent sampling event. The analytical results for these samples are discussed in this report.

3.0 OBJECTIVES FOR THE CURRENT REPORTING PERIOD

The specific objectives for the reporting period of April, 1993 to June, 1993 were as follows:

- Completion of the Ohio site report;
- Finalizing of Year 4 funding and contract modifications; and
- Starting Year 4 sampling and analysis.

4.0 ACTIVITIES FOR THE REPORTING PERIOD

4.1 Colorado Ute Site

Year 4 sampling and analysis will be started following approval of the revised cost proposal by the DOE. The draft Final Site Report will be completed as a final document and data delivered in electronic format pending receipt of comments on the draft document from the DOE.

4.2 Ohio Site

Year 4 sampling and analysis are pending approval of the revised cost proposal by the DOE. The draft Final Site Report is undergoing some final changes following internal review.

4.3 Illinois Site

The tenth set of quarterly water samples was collected in November, 1993. The analytical results for these water samples are shown in Table 1.

4.3.1 Groundwater Chemistry

Major element concentrations in groundwater samples from monitoring wells upgradient and downgradient of the test cells at the Illinois site are illustrated in Figures 1 through 3. Chemical data for these wells are given in Table 1.

With the exception of chloride and sodium, the major element chemistry of groundwater downgradient of Test Cell 1 has not changed significantly. Concentrations of chloride and sodium in the shallow downgradient well, ILMW-3, continue the upward trend that was first noted in the last quarterly report. While concentrations of the major elements in the two deeper downgradient wells have been consistent over time, they have been highly variable in samples from ILMW-3. The concentration trends of the major elements suggests that some samples from wells ILMW-1 and ILMW-3 were mislabeled in sampling events 7 and 10. Field documents from the most recent sampling event confirmed that the labels for ILMW-1 and ILMW-3 were switched during sampling, and the data has been corrected. It is not possible to confirm that the same error occurred during seventh quarter sampling.

There have been no significant changes in the major element chemistry of groundwater upgradient from the test cells. Calcium, magnesium, and sulfate are higher in the shallowest upgradient well, ILMW-6, than in the mid-level and deeper wells-- ILMW-5 and -4, respectively. For all other major elements, the upgradient groundwater chemistry is very consistent with time and depth. The concentrations of the major elements in ILMW-6 are comparable to those in the mid-level downgradient well (ILMW-2) with the exception of sodium and alkalinity, which are slightly lower and higher, respectively, in ILMW-6. Concentrations of the major analytes in the two deepest upgradient wells are comparable to concentrations in the deepest downgradient well.

Major element concentrations in groundwater samples from monitoring wells downgradient of the compacted and pumpable-mix test cells, Test Cells 2 and 3,

LMW-1 LMW-2 LMW-3
 480' 490' 500'
 ■ ◆ ☆

LMW-4 LMW-5 LMW-6
 490' 500' 510'
 ■ ◆ ☆

Figure 1. Major cation concentrations in groundwater from Test Cell 1 at the Illinois site. Upgradient concentrations are shown for comparison. The numbers shown in the legends indicate the approximate elevation at the bottom of the screened interval in each well in feet above mean sea level.

Downgradient

Chloride, mg/L

Sulfate, mg/L

Total alkalinity, mg/L as HCO₃

LMW-1 LMW-2 LMW-3

480' 490' 500'

Upgradient

Chloride, mg/L

Sulfate, mg/L

Total alkalinity, mg/L as HCO₃

LMW-4 LMW-5 LMW-6

490' 500' 510'

Figure 2. Major anion concentrations in groundwater downgradient from the Test Cell 1 at the Illinois site. Upgradient concentrations are shown for comparison. The numbers shown in the legends indicate the approximate elevation at the bottom of the screened interval in each well in feet above mean sea level.

Figure 3. Major cation concentrations in groundwater downgradient from Test Cells 2 and 3 at the Illinois site. The numbers shown in the legends indicate the approximate elevation at the bottom of the screened interval in each well in feet above mean sea level.

respectively, are illustrated in Figure 3. The data indicate no departure from patterns described in previous quarterly reports. Sulfate, calcium, and magnesium are the major species in the wells downgradient of Test Cells 2 and 3. Concentrations of these analytes generally decrease with the depth of the well. Concentrations of sodium and chloride are highest in the deep well, ILMW-7. The concentration of chloride shows little variation between the mid-depth well, ILMW-8, and the shallow well, ILMW-9. The concentration of sodium, as with calcium, follows the same trend in the shallow and mid-depth well, with slightly higher concentrations in the shallow well.

4.3.2 Porewater Chemistry

Lysimeter samples were collected from all three test cells. A total of eleven lysimeters in Test Cell 1 yielded enough water for sampling. Six of these samples were submitted for complete testing; field analytes (pH, conductivity, temperature, and Eh) are reported for the remaining five. Four lysimeters from each of the other two test cells--the compacted and pumpable-mix--were also sampled for chemical analysis. Porewater chemistry data for the three test cells are shown in Tables 2 through 4.

Figure 4 shows a significant decrease in the concentration of sulfate in near-surface porewaters in Test Cell 1 during the tenth quarter. Concentrations of other major elements, which had been generally declining since the first quarter, appear to be stabilizing at relatively low levels. These trends are consistent with the leaching of soluble constituents from the surface of the test cell. Figure 5 shows the variation in major element chemistry with depth for tenth quarter porewater samples from Test Cell 1. All depths are relative to the top of the ash, which is presently covered by two feet of vegetated soil. The trends of the major elements in porewaters from Test Cell 1 indicate the presence of a leaching front from approximately four to six feet. The sample from the 10.5 and eleven-foot intervals are from within the underlying soil and, with the exception of calcium, contain low concentrations of the major analytes.

Figure 4. Major species concentrations in near-surface porewater from the first Illinois test cell. Concentrations shown are from the one-foot depth.

Test Cell #1 Lysimeters

Figure 5. Depth trends in 10th quarter pore composition. Values shown represent concentrations in individual lysimeters except for the 7.5 foot interval where two results were averaged.

Newly installed lysimeters in the compacted cell (Test Cell 2) and pumpable-mix cell (Test Cell 3) were sampled during the tenth quarter. Figures 6 and 7 show the variation with depth for porewater in the two new test cells. The deepest porewater sample in each cell was collected from within the underlying soils. The major analytes are present at significantly higher concentrations in the compacted cell than in the pumpable-mix cell. In general, the major element chemistry in both cells is highly variable with depth, and probably reflects the initial spatial variability of material in the test cells. The pumpable-mix test cell appears to be more homogeneous than the compacted test cell.

4.3.3 Surface Water

The chemical composition of an initial surface water sample collected from the compacted test cell during sampling event 10 is given in Table 5. Concentrations of most elements in the surface water sample were below the given reporting limit. Calcium, sodium, and potassium were the most abundant constituents, with concentrations of 71, 21, and 15 mg/L, respectively. Concentrations of magnesium, chloride, silicon, and boron ranged from 1 to 10 mg/L.

4.3.4 Groundwater Levels

Figure 8 shows the results of up- and downgradient groundwater level monitoring at the Illinois site from August of 1991 to June of 1993. Water level data will be used to estimate the saturated hydraulic conductivity of the shallow aquifer. The sudden downward trends seen periodically in the water levels are due to the purging of the wells being monitored prior to quarterly sampling. Water level recovery after purging is relatively rapid. Greater variability in the groundwater level can be seen in the downgradient well, probably as a result of runoff ponding in the nearby drainage. Groundwater levels peak in the winter and spring and are lowest in late summer or fall. 1993 was an exceptionally wet year in the midwest, and this is reflected by the most current groundwater data.

Compacted Cell Lysimeters

Figure 6. Depth Trends in Initial Porewater Composition for Test Cell 2---the Compacted Cell

Pumpable-Mix Cell Lysimeters

Figure 7. Depth Trends in Initial Porewater Composition for Test Cell 3---the Pumpable-Mix Cell

Figure 8. Trends in Groundwater Level at the Illinois Site

5.0**ACTIVITIES PLANNED FOR THE NEXT QUARTER**

The following activities are planned for the period of January, 1994 through March, 1994:

- Completion of the Ohio site report;
- Finalizing of Year 4 funding and contract modifications; and
- Starting Year 4 sampling and analysis.

Table 1

Chemical Characteristics of Illinois Groundwater, Event 10

Parameter	Units	IL5 / ILMW01		IL5 / ILMW02		IL5 / ILMW03	
		IL234		IL235		IL236	
		11/20/93		11/20/93		11/20/93	

Anions							
Chloride	mg/L	21.7	(0.100)	16.1	(0.100)	307	(0.100)
Fluoride	mg/L	0.238	(0.0500)	0.171	(0.0500)	0.171	(0.0500)
Sulfate	mg/L	475	(2.50)	1610	(2.50)	1330	(2.50)
Elements by ICPEs or AA							
Aluminum	mg/L	NR	(0.200)	NR	(0.200)	NR	(0.200)
Arsenic	mg/L	ND	(0.00400)	ND	(0.00400)	ND	(0.00400)
Barium	mg/L	0.0222	(0.0100)	NR	(0.0100)	0.0315	(0.0100)
Beryllium	mg/L	ND	(0.00200)	< DL	(0.00200)	< DL	(0.00200)
Boron	mg/L	1.16	(0.600)	NR	(0.600)	NR	(0.600)
Cadmium	mg/L	ND	(0.00100)	< DL	(0.00100)	ND	(0.00100)
Calcium	mg/L	168	(1.00)	414	(1.00)	277	(1.00)
Chromium	mg/L	< DL	(0.0100)	ND	(0.0100)	ND	(0.0100)
Cobalt	mg/L	< DL	(0.0100)	ND	(0.0100)	ND	(0.0100)
Copper	mg/L	< DL	(0.0200)	< DL	(0.0200)	NR	(0.0200)
Iron	mg/L	0.917	(0.0500)	ND	(0.0500)	NR	(0.0500)
Lead	mg/L	< DL	(0.00300)	NR	(0.00300)	ND	(0.00300)
Magnesium	mg/L	90.8	(1.00)	214	(1.00)	23.7	(1.00)
Manganese	mg/L	1.06	(0.0100)	3.22	(0.0100)	0.201	(0.0100)
Mercury	mg/L	ND	(0.00020)	ND	(0.00020)	ND	(0.00020)
Molybdenum	mg/L	< DL	(0.0500)	< DL	(0.0500)	0.223	(0.0500)
Nickel	mg/L	NR	(0.0200)	0.0215	(0.0200)	NR	(0.0200)
Potassium	mg/L	6.54	(3.00)	3.35	(3.00)	105	(3.00)
Selenium	mg/L	ND	(0.00500)	< DL	(0.00500)	NR	(0.00500)
Silicon	mg/L	6.18	(1.00)	6.56	(1.00)	3.49	(1.00)
Silver	mg/L	< DL	(0.0100)	ND	(0.0100)	< DL	(0.0100)
Sodium	mg/L	104	(1.00)	71.3	(1.00)	475	(1.00)
Strontium	mg/L	1.42	(0.00300)	0.944	(0.00300)	1.64	(0.00300)
Tin	mg/L	ND	(0.600)	ND	(0.600)	ND	(0.600)

() = Reporting Limit

C1-1

Table 1

(Continued)

Parameter	Units	IL5 / ILMW01		IL5 / ILMW02		IL5 / ILMW03	
		IL234		IL235		IL236	
		11/20/93		11/20/93		11/20/93	
<hr/>							
Elements by ICPEs or AA, cont.							
Vanadium	mg/L	NR	(0.0200)	< DL	(0.0200)	< DL	(0.0200)
Zinc	mg/L	NR	(0.0200)	NR	(0.0200)	NR	(0.0200)
Field measurements							
Conductivity	umhos/cm	2380	(5)	3680	(5)	3880	(5)
Redox (Eh)	mV	8.5	()	16.9	()	-23.2	()
Temperature	deg. C	12.8	()	12.9	()	11.3	()
Total Alkalinity	meq/L	1.2	(.03)	9.04	(.03)	11.4	(.03)
Total Dissolved Solids	mg/L	2142	(1)	2695	(1)	1069	(1)
pH	pH units	6.60	()	6.43	()	7.18	()

() = Reporting Limit

C1-2

Table 1
(Continued)

Parameter	Units	IL4 / ILMW04		IL4 / ILMW05		IL4 / ILMW05		IL4 / ILMW06	
		IL237		IL238		IL244 Dup of IL238		IL239	
		11/20/93		11/20/93		11/20/93		11/20/93	
Anions									
Chloride	mg/L	15.7	(0.100)	16.6	(0.100)	16.7	(0.100)	22.0	(0.100)
Fluoride	mg/L	0.252	(0.0500)	0.243	(0.0500)	NR	(0.0500)	0.139	(0.0500)
Sulfate	mg/L	441	(2.50)	485	(2.50)	501	(2.50)	1590	(2.50)
Elements by ICPES or AA									
Aluminum	mg/L	NR	(0.200)	< DL	(0.200)	< DL	(0.200)	NR	(0.200)
Arsenic	mg/L	ND	(0.00400)	ND	(0.00400)	ND	(0.00400)	< DL	(0.00400)
Barium	mg/L	0.0148	(0.0100)	0.0121	(0.0100)	0.0140	(0.0100)	0.0137	(0.0100)
Beryllium	mg/L	ND	(0.00200)	ND	(0.00200)	< DL	(0.00200)	ND	(0.00200)
Boron	mg/L	1.19	(0.600)	1.13	(0.600)	1.32	(0.600)	1.20	(0.600)
Cadmium	mg/L	ND	(0.00100)	ND	(0.00100)	ND	(0.00100)	ND	(0.00100)
Calcium	mg/L	156	(1.00)	153	(1.00)	180	(1.00)	367	(1.00)
Chromium	mg/L	NR	(0.0100)	ND	(0.0100)	ND	(0.0100)	< DL	(0.0100)
Cobalt	mg/L	< DL	(0.0100)	ND	(0.0100)	NR	(0.0100)	< DL	(0.0100)
Copper	mg/L	< DL	(0.0200)	ND	(0.0200)	NR	(0.0200)	< DL	(0.0200)
Iron	mg/L	0.754	(0.0500)	0.710	(0.0500)	0.754	(0.0500)	ND	(0.0500)
Lead	mg/L	< DL	(0.00300)	< DL	(0.00300)	< DL	(0.00300)	< DL	(0.00300)
Magnesium	mg/L	84.8	(1.00)	83.7	(1.00)	99.6	(1.00)	230	(1.00)
Manganese	mg/L	0.347	(0.0100)	0.345	(0.0100)	0.409	(0.0100)	1.13	(0.0100)
Molybdenum	mg/L	ND	(0.0500)	< DL	(0.0500)	ND	(0.0500)	< DL	(0.0500)
Nickel	mg/L	< DL	(0.0200)	0.0208	(0.0200)	NR	(0.0200)	0.0550	(0.0200)
Potassium	mg/L	6.66	(3.00)	5.38	(3.00)	7.05	(3.00)	14.0	(3.00)
Selenium	mg/L	ND	(0.00500)	ND	(0.00500)	ND	(0.00500)	ND	(0.00500)
Silicon	mg/L	6.61	(1.00)	6.19	(1.00)	7.19	(1.00)	6.30	(1.00)
Silver	mg/L	NR	(0.0100)	ND	(0.0100)	NR	(0.0100)	NR	(0.0100)
Sodium	mg/L	137	(1.00)	133	(1.00)	156	(1.00)	154	(1.00)
Strontium	mg/L	1.58	(0.00300)	1.55	(0.00300)	1.87	(0.00300)	2.85	(0.00300)
Tin	mg/L	ND	(0.600)	ND	(0.600)	ND	(0.600)	ND	(0.600)
Vanadium	mg/L	NR	(0.0200)	ND	(0.0200)	ND	(0.0200)	NR	(0.0200)

() = Reporting Limit

CI-1

Table 1

(Continued)

Parameter	Units	IL4 / ILMW04		IL4 / ILMW05		IL4 / ILMW05		IL4 / ILMW06	
		IL237		IL238		IL244 Dup of IL238		IL239	
		11/20/93		11/20/93		11/20/93		11/20/93	
<hr/>									
Elements by ICPEs or AA, cont.									
Zinc	mg/L	NR	(0.0200)	NR	(0.0200)	0.0206	(0.0200)	NR	(0.0200)
Field measurements									
Conductivity	umhos/cm	2390	(5)	2450	(5)	2450	(5)	3580	(5)
Redox (Eh)	mV	9.1	()	8.1	()	8.8	()	21.3	()
Temperature	deg. C	12.1	()	12.4	()	12.1	()	12.0	()
Total Alkalinity	meq/L	12.84	(.03)	13.04	(.03)	10.08	(.03)	14.12	(.03)
Total Dissolved Solids	mg/L	1216	(1)	1355	(1)	1466	(1)	3199	(1)
pH	pH units	6.53	()	6.60	()	6.63	()	6.35	()

() = Reporting Limit

C1-2

Table 1

(Continued)

Parameter	Units	IL6 / ILMW07		IL6 / ILMW08		IL6 / ILMW09	
		IL240		IL241		IL242	
		11/20/93		11/20/93		11/20/93	
<hr/>							
Anions							
Chloride	mg/L	37.9	(0.100)	11.8	(0.100)	15.7	(0.100)
Fluoride	mg/L	0.376	(0.0500)	0.199	(0.0500)	NR	(0.0500)
Sulfate	mg/L	225	(2.50)	1360	(2.50)	2550	(2.50)
<hr/>							
Elements by ICPEs or AA							
Aluminum	mg/L	NR	(0.200)	NR	(0.200)	ND	(0.200)
Arsenic	mg/L	ND	(0.00400)	ND	(0.00400)	ND	(0.00400)
Barium	mg/L	0.0264	(0.0100)	0.0129	(0.0100)	0.0131	(0.0100)
Beryllium	mg/L	NR	(0.00200)	< DL	(0.00200)	< DL	(0.00200)
Boron	mg/L	1.52	(0.600)	NR	(0.600)	0.654	(0.600)
Cadmium	mg/L	< DL	(0.00100)	ND	(0.00100)	< DL	(0.00100)
Calcium	mg/L	104	(1.00)	336	(1.00)	435	(1.00)
Chromium	mg/L	ND	(0.0100)	ND	(0.0100)	ND	(0.0100)
Cobalt	mg/L	ND	(0.0100)	ND	(0.0100)	NR	(0.0100)
Copper	mg/L	NR	(0.0200)	< DL	(0.0200)	ND	(0.0200)
Iron	mg/L	1.36	(0.0500)	ND	(0.0500)	ND	(0.0500)
Lead	mg/L	< DL	(0.00300)	NR	(0.00300)	< DL	(0.00300)
Magnesium	mg/L	58.1	(1.00)	223	(1.00)	486	(1.00)
Manganese	mg/L	0.288	(0.0100)	0.547	(0.0100)	6.71	(0.0100)
Mercury	mg/L	< DL	(0.00020)	ND	(0.00020)	ND	(0.00020)
Molybdenum	mg/L	NR	(0.0500)	ND	(0.0500)	ND	(0.0500)
Nickel	mg/L	< DL	(0.0200)	NR	(0.0200)	0.0412	(0.0200)
Potassium	mg/L	5.09	(3.00)	NR	(3.00)	5.97	(3.00)
Selenium	mg/L	ND	(0.00500)	ND	(0.00500)	ND	(0.00500)
Silicon	mg/L	6.78	(1.00)	6.96	(1.00)	5.86	(1.00)
Silver	mg/L	ND	(0.0100)	ND	(0.0100)	< DL	(0.0100)
Sodium	mg/L	137	(1.00)	44.8	(1.00)	73.1	(1.00)
Strontium	mg/L	1.14	(0.00300)	0.433	(0.00300)	1.34	(0.00300)
Tin	mg/L	ND	(0.600)	ND	(0.600)	ND	(0.600)

() = Reporting Limit

C1-1

Table 1

(Continued)

Parameter	Units	IL6 / ILMW07		IL6 / ILMW08		IL6 / ILMW09	
		IL240		IL241		IL242	
		11/20/93		11/20/93		11/20/93	

Elements by ICPES or AA, cont.							
Vanadium	mg/L	< DL	(0.0200)	NR	(0.0200)	NR	(0.0200)
Zinc	mg/L	NR	(0.0200)	NR	(0.0200)	0.0374	(0.0200)
Field measurements							
Conductivity	umhos/cm	1860	(5)	3360	(5)	4180	(5)
Redox (Eh)	mV	4.9	()	13.7	()	19.5	()
Temperature	deg. C	13.7	()	13.5	()	13.7	()
Total Alkalinity	meq/L	11.52	(.03)	10.04	(.03)	10.08	(.03)
Total Dissolved Solids	mg/L	1020	(1)	2784	(1)	4355	(1)
pH	pH units	6.15	()	6.47	()	6.40	()

() = Reporting Limit

C1-2

Table 2

Chemical Characteristics of Porewater from Illinois Test Cell 1, Event 10

Parameter	Units	IL1 / ILLY01		IL1 / ILLY05		IL1 / ILLY12		IL1 / ILLY13	
		IL245		IL247		IL250		IL251	
		11/21/93		11/21/93		11/21/93		11/21/93	
Anions									
Chloride	mg/L	14.2	(0.100)	NA		115	(0.100)	669	(0.100)
Fluoride	mg/L	NR	(0.0500)	NA		0.153	(0.0500)	0.134	(0.0500)
Sulfate	mg/L	448	(2.50)	NA		1060	(2.50)	4970	(2.50)
Elements by ICPEs or AA									
Aluminum	mg/L	< DL	(0.200)	NA		NR	(0.200)	1.33	(0.200)
Arsenic	mg/L	ND	(0.00400)	NA		ND	(0.00400)	ND	(0.00400)
Barium	mg/L	0.0247	(0.0100)	NA		0.0143	(0.0100)	0.0134	(0.0100)
Beryllium	mg/L	< DL	(0.00200)	NA		ND	(0.00200)	< DL	(0.00200)
Boron	mg/L	NR	(0.600)	NA		NR	(0.600)	NR	(0.600)
Cadmium	mg/L	ND	(0.00100)	NA		ND	(0.00100)	0.00138	(0.00100)
Calcium	mg/L	20.4	(1.00)	NA		126	(1.00)	1.12	(1.00)
Chromium	mg/L	0.0487	(0.0100)	NA		< DL	(0.0100)	ND	(0.0100)
Cobalt	mg/L	ND	(0.0100)	NA		ND	(0.0100)	ND	(0.0100)
Copper	mg/L	< DL	(0.0200)	NA		NR	(0.0200)	NR	(0.0200)
Iron	mg/L	NR	(0.0500)	NA		NR	(0.0500)	NR	(0.0500)
Lead	mg/L	NR	(0.00300)	NA		NR	(0.00300)	0.0654	(0.00300)
Magnesium	mg/L	NR	(1.00)	NA		NR	(1.00)	NR	(1.00)
Manganese	mg/L	< DL	(0.0100)	NA		NR	(0.0100)	NR	(0.0100)
Molybdenum	mg/L	0.0864	(0.0500)	NA		0.263	(0.0500)	1.29	(0.0500)
Nickel	mg/L	NR	(0.0200)	NA		NR	(0.0200)	< DL	(0.0200)
Potassium	mg/L	391	(3.00)	NA		178	(3.00)	3220	(3.00)
Selenium	mg/L	ND	(0.00500)	NA		ND	(0.00500)	ND	(0.00500)
Silicon	mg/L	200	(1.00)	NA		122	(1.00)	545	(1.00)
Silver	mg/L	< DL	(0.0100)	NA		NR	(0.0100)	< DL	(0.0100)
Sodium	mg/L	112	(1.00)	NA		471	(1.00)	2560	(1.00)
Strontium	mg/L	5.33	(0.00300)	NA		4.76	(0.00300)	3.99	(0.00300)
Tin	mg/L	ND	(0.600)	NA		< DL	(0.600)	< DL	(0.600)
Vanadium	mg/L	NR	(0.0200)	NA		NR	(0.0200)	NR	(0.0200)

() = Reporting Limit

C1-1

Table 2
(Continued)

Parameter -----	Units -----	IL1 / ILLY01 IL245 11/21/93 -----		IL1 / ILLY05 IL247 11/21/93 -----		IL1 / ILLY12 IL250 11/21/93 -----		IL1 / ILLY13 IL251 11/21/93 -----	
Elements by ICPEs or AA, cont.									
Zinc	mg/L	NR	(0.0200)	NA		< DL	(0.0200)	NR	(0.0200)
Field measurements									
Conductivity	umhos/cm	270	(5)	660	(5)	2130	(5)	19300	(5)
Redox (Eh)	mV	-205	()	-213.3	()	-267.5	()	-341.5	()
Temperature	deg. C	12.6	()	13.2	()	16.0	()	16.1	()
Total Alkalinity	meq/L	6.68	(.03)	NA		7.08	(.03)	85.4	(.03)
Total Dissolved Solids	mg/L	866	(1)	NA		2542	(1)	15347	(1)
pH	pH units	10.05	()	10.39	()	11.30	()	12.56	()

25

Table 2

(Continued)

Parameter	Units	IL1 / ILLY14		IL1 / ILLY17		IL1 / ILLY22		IL1 / ILLY23	
		IL252		IL254		IL258		IL259	
		11/21/93		11/21/93		11/21/93		11/21/93	

Anions									
Chloride	mg/L	31.4	(0.100)	986	(0.100)	NA		NA	
Fluoride	mg/L	0.287	(0.0500)	0.115	(0.0500)	NA		NA	
Sulfate	mg/L	2220	(2.50)	6590	(2.50)	NA		NA	
Elements by ICPEs or AA									
Aluminum	mg/L	< DL	(0.200)	1.90	(0.200)	NA		NA	
Arsenic	mg/L	ND	(0.00400)	ND	(0.00400)	NA		NA	
Barium	mg/L	0.0198	(0.0100)	0.0207	(0.0100)	NA		NA	
Beryllium	mg/L	ND	(0.00200)	ND	(0.00200)	NA		NA	
Boron	mg/L	NR	(0.600)	NR	(0.600)	NA		NA	
Cadmium	mg/L	ND	(0.00100)	NR	(0.00100)	NA		NA	
Calcium	mg/L	490	(1.00)	5.78	(1.00)	NA		NA	
Chromium	mg/L	ND	(0.0100)	< DL	(0.0100)	NA		NA	
Cobalt	mg/L	ND	(0.0100)	ND	(0.0100)	NA		NA	
Copper	mg/L	ND	(0.0200)	NR	(0.0200)	NA		NA	
Iron	mg/L	ND	(0.0500)	NR	(0.0500)	NA		NA	
Lead	mg/L	NR	(0.00300)	< DL	(0.00300)	NA		NA	
Magnesium	mg/L	162	(1.00)	NR	(1.00)	NA		NA	
Manganese	mg/L	0.255	(0.0100)	NR	(0.0100)	NA		NA	
Molybdenum	mg/L	NR	(0.0500)	1.53	(0.0500)	NA		NA	
Nickel	mg/L	NR	(0.0200)	< DL	(0.0200)	NA		NA	
Potassium	mg/L	4.53	(3.00)	3750	(3.00)	NA		NA	
Selenium	mg/L	ND	(0.00500)	< DL	(0.00500)	NA		NA	
Silicon	mg/L	36.5	(1.00)	475	(1.00)	NA		NA	
Silver	mg/L	< DL	(0.0100)	< DL	(0.0100)	NA		NA	
Sodium	mg/L	264	(1.00)	3100	(1.00)	NA		NA	
Strontium	mg/L	1.06	(0.00300)	12.5	(0.00300)	NA		NA	
Tin	mg/L	ND	(0.600)	< DL	(0.600)	NA		NA	
Vanadium	mg/L	< DL	(0.0200)	NR	(0.0200)	NA		NA	

() = Reporting Limit

C1-3

Table 2

(Continued)

Parameter	Units	IL1 / ILLY14		IL1 / ILLY17		IL1 / ILLY22		IL1 / ILLY23	
		IL252		IL254		IL258		IL259	
		11/21/93		11/21/93		11/21/93		11/21/93	
Elements by ICPEs or AA, cont.									
Zinc	mg/L	NR	(0.0200)	NR	(0.0200)	NA		NA	
Field measurements									
Conductivity	umhos/cm	2260	(5)	22300	(5)	6500	(5)	5828	(5)
Redox (Eh)	mV	-73.7	()	-343.5	()	-326.8	()	-312.1	()
Temperature	deg. C	16.8	()	16.5	()	16.3	()	16.6	()
Total Alkalinity	meq/L	2.56	(.03)	88.68	(.03)	NA		NA	
Total Dissolved Solids	mg/L	3844	(1)	18642	(1)	NA		NA	
pH	pH units	8.03	()	12.61	()	12.26	()	12.07	()

() = Reporting Limit

C1-4

Table 2
(Continued)

Parameter	Units	IL1 / ILLY25	IL1 / ILLY26		IL1 / ILLY27
		IL261	IL262		IL263
		11/21/93	11/21/93		11/21/93
<hr/>					
Anions					
Chloride	mg/L	NA	161	(0.100)	NA
Fluoride	mg/L	NA	0.124	(0.0500)	NA
Sulfate	mg/L	NA	1150	(2.50)	NA
Elements by ICPEs or AA					
Aluminum	mg/L	NA	ND	(0.200)	NA
Arsenic	mg/L	NA	ND	(0.00400)	NA
Barium	mg/L	NA	NR	(0.0100)	NA
Beryllium	mg/L	NA	ND	(0.00200)	NA
Boron	mg/L	NA	NR	(0.600)	NA
Cadmium	mg/L	NA	ND	(0.00100)	NA
Calcium	mg/L	NA	7.87	(1.00)	NA
Chromium	mg/L	NA	0.0101	(0.0100)	NA
Cobalt	mg/L	NA	< DL	(0.0100)	NA
Copper	mg/L	NA	NR	(0.0200)	NA
Iron	mg/L	NA	NR	(0.0500)	NA
Lead	mg/L	NA	< DL	(0.00300)	NA
Magnesium	mg/L	NA	< DL	(1.00)	NA
Manganese	mg/L	NA	ND	(0.0100)	NA
Molybdenum	mg/L	NA	0.246	(0.0500)	NA
Nickel	mg/L	NA	< DL	(0.0200)	NA
Potassium	mg/L	NA	572	(3.00)	NA
Selenium	mg/L	NA	< DL	(0.00500)	NA
Silicon	mg/L	NA	265	(1.00)	NA
Silver	mg/L	NA	< DL	(0.0100)	NA
Sodium	mg/L	NA	575	(1.00)	NA
Strontium	mg/L	NA	10.6	(0.00300)	NA
Tin	mg/L	NA	< DL	(0.600)	NA
Vanadium	mg/L	NA	NR	(0.0200)	NA

() = Reporting Limit

Table 2

(Continued)

Parameter	Units	IL1 / ILLY25		IL1 / ILLY26		IL1 / ILLY27	
		IL261		IL262		IL263	
		11/21/93		11/21/93		11/21/93	
<hr/>							
Elements by ICPEs or AA, cont.							
Zinc	mg/L	NA		NR	(0.0200)	NA	
Field measurements							
Conductivity	umhos/cm	3440	(5)	NA		17400	(5)
Redox (Eh)	mV	-295.0	()	NA		-337.0	()
Temperature	deg. C	15.5	()	NA		17.6	()
Total Alkalinity	meq/L	NA		19.52	(.03)	NA	
Total Dissolved Solids	mg/L	NA		3859	(1)	NA	
pH	pH units	11.77	()	NA		12.44	()

() = Reporting Limit

C1-6

Table 3

Chemical Characteristics of Initial Porewater from Illinois Test Cell 2---Compacted Cell

Parameter	Units	IL2 / IL2LY05		IL2 / IL2LY06		IL2 / IL2LY07		IL2 / IL2LY08	
		IL264		IL265		IL266		IL267	
		11/21/93		11/21/93		11/21/93		11/21/93	
<hr/>									
Anions									
Chloride	mg/L	509	(0.100)	276	(0.100)	595	(0.100)	201	(0.100)
Fluoride	mg/L	0.405	(0.0500)	0.116	(0.0500)	0.478	(0.0500)	0.353	(0.0500)
Sulfate	mg/L	4730	(2.50)	2490	(2.50)	4990	(2.50)	3300	(2.50)
 Elements by ICPEs or AA									
Aluminum	mg/L	ND	(0.200)	ND	(0.200)	NR	(0.200)	ND	(0.200)
Arsenic	mg/L	ND	(0.00400)	ND	(0.00400)	ND	(0.00400)	ND	(0.00400)
Barium	mg/L	0.0101	(0.0100)	0.0124	(0.0100)	0.0191	(0.0100)	0.0481	(0.0100)
Beryllium	mg/L	ND	(0.00200)	ND	(0.00200)	< DL	(0.00200)	ND	(0.00200)
Boron	mg/L	3.94	(0.600)	4.94	(0.600)	0.836	(0.600)	2.46	(0.600)
Cadmium	mg/L	NR	(0.00100)	< DL	(0.00100)	NR	(0.00100)	< DL	(0.00100)
Calcium	mg/L	9.26	(1.00)	65.5	(1.00)	6.48	(1.00)	432	(1.00)
Chromium	mg/L	ND	(0.0100)	ND	(0.0100)	< DL	(0.0100)	NR	(0.0100)
Cobalt	mg/L	ND	(0.0100)	< DL	(0.0100)	< DL	(0.0100)	< DL	(0.0100)
Copper	mg/L	< DL	(0.0200)	< DL	(0.0200)	NR	(0.0200)	NR	(0.0200)
Iron	mg/L	NR	(0.0500)	0.0860	(0.0500)	0.200	(0.0500)	ND	(0.0500)
Lead	mg/L	0.00308 S	(0.00300)	NR	(0.00300)	0.00652 S	(0.00300)	< DL	(0.00300)
Magnesium	mg/L	NR	(1.00)	ND	(1.00)	ND	(1.00)	85.0	(1.00)
Manganese	mg/L	ND	(0.0100)	ND	(0.0100)	NR	(0.0100)	0.190	(0.0100)
Molybdenum	mg/L	8.08	(0.0500)	4.18	(0.0500)	6.10	(0.0500)	0.730	(0.0500)
Nickel	mg/L	< DL	(0.0200)	ND	(0.0200)	< DL	(0.0200)	< DL	(0.0200)
Potassium	mg/L	825	(3.00)	640	(3.00)	629	(3.00)	49.0	(3.00)
Selenium	mg/L	NR	(0.00500)	NR	(0.00500)	NR	(0.00500)	NR	(0.00500)
Silicon	mg/L	884	(1.00)	167	(1.00)	6620	(1.00)	45.8	(1.00)
Silver	mg/L	< DL	(0.0100)	< DL	(0.0100)	< DL	(0.0100)	< DL	(0.0100)
Sodium	mg/L	2620	(1.00)	1170	(1.00)	3330	(1.00)	1060	(1.00)
Strontium	mg/L	1.25	(0.00300)	2.23	(0.00300)	0.607	(0.00300)	1.68	(0.00300)
Tin	mg/L	< DL	(0.600)	NR	(0.600)	ND	(0.600)	NR	(0.600)
Vanadium	mg/L	0.0441	(0.0200)	0.0210	(0.0200)	0.0778	(0.0200)	NR	(0.0200)

() = Reporting Limit

CI-1

Table 3

(Continued)

Parameter	Units	IL2 / IL2LY05		IL2 / IL2LY06		IL2 / IL2LY07		IL2 / IL2LY08	
		IL264		IL265		IL266		IL267	
		11/21/93		11/21/93		11/21/93		11/21/93	
<hr/>									
Elements by ICPEs or AA, cont.									
Zinc	mg/L	NR	(0.0200)	< DL	(0.0200)	NR	(0.0200)	NR	(0.0200)
Field measurements									
Conductivity	umhos/cm	7610	(5)	4500	(5)	10080	(5)	5900	(5)
Redox (Eh)	mV	-241.1	()	-286.3	()	-239.8	()	1.0	()
Temperature	deg. C	11.4	()	12.6	()	13.6	()	14	()
Total Alkalinity	meq/L	31.68	(.03)	13.16	(.03)	55.56	(.03)	3.44	(.03)
Total Dissolved Solids	mg/L	NA		6053	(1)	16472	(1)	5982	(1)
pH	pH units	11.19	()	12.3	()	11.1	()	6.39	()

() = Reporting Limit

C1-2

Table 4

Chemical Characteristics of Initial Porewater from Illinois Test Cell 3---Pumpable-Mix Cell

Parameter	Units	IL3 / IL3LY01		IL3 / IL3LY02		IL3 / IL3LY03		IL3 / IL3LY04	
		IL270		IL271		IL272		IL273	
		11/21/93		11/21/93		11/21/93		11/21/93	
<hr/>									
Anions									
Chloride	mg/L	205	(0.100)	189	(0.100)	316	(0.100)	111	(0.100)
Fluoride	mg/L	0.912	(0.0500)	0.189	(0.0500)	0.186	(0.0500)	0.0707	(0.0500)
Sulfate	mg/L	1890	(2.50)	2890	(2.50)	2930	(2.50)	2860	(2.50)
Elements by ICPEs or AA									
Aluminum	mg/L	NR	(0.200)	NR	(0.200)	NR	(0.200)	NR	(0.200)
Arsenic	mg/L	0.0654	(0.00400)	ND	(0.00400)	ND	(0.00400)	ND	(0.00400)
Barium	mg/L	NR	(0.0100)	0.0303	(0.0100)	0.0200	(0.0100)	0.0213	(0.0100)
Beryllium	mg/L	ND	(0.00200)	ND	(0.00200)	ND	(0.00200)	ND	(0.00200)
Boron	mg/L	1.34	(0.600)	3.39	(0.600)	4.28	(0.600)	3.78	(0.600)
Cadmium	mg/L	< DL	(0.00100)	< DL	(0.00100)	NR	(0.00100)	< DL	(0.00100)
Calcium	mg/L	6.32	(1.00)	87.0	(1.00)	24.8	(1.00)	379	(1.00)
Chromium	mg/L	< DL	(0.0100)	ND	(0.0100)	ND	(0.0100)	ND	(0.0100)
Cobalt	mg/L	ND	(0.0100)	ND	(0.0100)	ND	(0.0100)	ND	(0.0100)
Copper	mg/L	NR	(0.0200)	< DL	(0.0200)	NR	(0.0200)	< DL	(0.0200)
Iron	mg/L	NR	(0.0500)	NR	(0.0500)	NR	(0.0500)	ND	(0.0500)
Lead	mg/L	NR	(0.00300)	0.00322 S	(0.00300)	0.00568 S	(0.00300)	< DL	(0.00300)
Magnesium	mg/L	NR	(1.00)	NR	(1.00)	NR	(1.00)	63.7	(1.00)
Manganese	mg/L	NR	(0.0100)	NR	(0.0100)	< DL	(0.0100)	NR	(0.0100)
Molybdenum	mg/L	3.72	(0.0500)	3.67	(0.0500)	4.50	(0.0500)	0.892	(0.0500)
Nickel	mg/L	< DL	(0.0200)	< DL	(0.0200)	0.0527	(0.0200)	NR	(0.0200)
Potassium	mg/L	217	(3.00)	403	(3.00)	530	(3.00)	226	(3.00)
Selenium	mg/L	0.0336 X	(0.00500)	NR	(0.00500)	0.0108	(0.00500)	NR	(0.00500)
Silicon	mg/L	268	(1.00)	192	(1.00)	367	(1.00)	14.5	(1.00)
Silver	mg/L	NR	(0.0100)	< DL	(0.0100)	< DL	(0.0100)	< DL	(0.0100)
Sodium	mg/L	1170	(1.00)	1480	(1.00)	1600	(1.00)	772	(1.00)
Strontium	mg/L	0.177	(0.00300)	2.64	(0.00300)	1.21	(0.00300)	2.20	(0.00300)
Tin	mg/L	ND	(0.600)	ND	(0.600)	< DL	(0.600)	< DL	(0.600)
Vanadium	mg/L	0.0700	(0.0200)	0.0295	(0.0200)	0.115	(0.0200)	NR	(0.0200)

() = Reporting Limit

C1-1

Table 4

(Continued)

Parameter	Units	IL3 / IL3LY01		IL3 / IL3LY02		IL3 / IL3LY03		IL3 / IL3LY04	
		IL270	11/21/93	IL271	11/21/93	IL272	11/21/93	IL273	11/21/93
Elements by ICPEs or AA, cont.									
Zinc	mg/L	NR	(0.0200)	NR	(0.0200)	NR	(0.0200)	NR	(0.0200)
Field measurements									
Conductivity	umhos/cm	3440	(5)	4280	(5)	5860	(5)	3860	(5)
Redox (Eh)	mV	-215.6	()	-211.6	()	-240.8	()	-160	()
Temperature	deg. C	19.3	()	13.6	()	17.0	()	17.0	()
Total Alkalinity	meq/L	12.8	(.03)	7.76	(.03)	15.64	(.03)	NA	()
Total Dissolved Solids	mg/L	NA		6320	(1)	7314	(1)	5082	(1)
pH	pH units	10.36	()	10.55	()	11.02	()	8.12	()

() = Reporting Limit

C1-2

Table 5

Chemical Characteristics of Initial Surface Water from Test Cell 2---Compacted Cell

		IL2 / IL2SW01	
		IL268	
		11/20/93	
Parameter	Units		

Anions			
Chloride	mg/L	6.56	(0.100)
Elements by ICPEs or AA			
Aluminum	mg/L	ND	(0.200)
Arsenic	mg/L	ND	(0.00400)
Barium	mg/L	NR	(0.0100)
Beryllium	mg/L	ND	(0.00200)
Boron	mg/L	1.34	(0.600)
Cadmium	mg/L	NR	(0.00100)
Calcium	mg/L	70.7	(1.00)
Chromium	mg/L	NR	(0.0100)
Cobalt	mg/L	< DL	(0.0100)
Copper	mg/L	NR	(0.0200)
Iron	mg/L	NR	(0.0500)
Lead	mg/L	NR	(0.00300)
Magnesium	mg/L	9.17	(1.00)
Manganese	mg/L	0.0140	(0.0100)
Mercury	mg/L	NR	(0.00020)
Molybdenum	mg/L	0.0636	(0.0500)
Nickel	mg/L	ND	(0.0200)
Potassium	mg/L	14.6	(3.00)
Selenium	mg/L	< DL	(0.00500)
Silicon	mg/L	1.73	(1.00)
Silver	mg/L	NR	(0.0100)
Sodium	mg/L	21.0	(1.00)
Strontium	mg/L	0.144	(0.00300)
Tin	mg/L	NR	(0.600)
Vanadium	mg/L	NR	(0.0200)
Zinc	mg/L	< DL	(0.0200)

() = Reporting Limit

Table 5

(Continued)

		IL2 / IL2SW01	
		IL268	
Parameter	Units	11/20/93	
-----	-----	-----	
Field measurements			
Conductivity	umhos/cm	1800	(5)
Redox (Eh)	mV	36.2	()
Temperature	deg. C	5.0	()
Total Alkalinity	meq/L	.67	(.03)
Total Dissolved Solids	mg/L	700	(1)
pH	pH units	5.95	()

() = Reporting Limit

DATE

FILMED

6/15/94

END