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December 1986

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

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PREVIOUS DOCUMENTS

Previous Documents From Special Waste Form Lysimeters-Arid Program

A Field Lysimeter Facility for Evaluating the Performance of Commercial Solidified Low-Level Waste. 1984. M. B. Walter, M. J. Graham and G. W. Gee. PNL-5253, Pacific Northwest Laboratory, Richland, Washington.

"Evaluation of the Performance of Solidified Commercial Low-Level Wastes in an Arid Climate." 1984. M. J. Graham and M. B. Walter. In Proceedings of the Sixth Annual Participants' Information Meeting, DOE Low-Level Waste Managment Program, Denver, Colorado.

"Special Waste Form Lysimeters-Arid Annual Report 1985." M. B. Walter and M. J. Graham. 1985. In Proceedings of the Seventh Annual Participants' Information Meeting, DOE Low-Level Waste Management Program, Las Vegas, Nevada.

Organic Analyses of Commercial Nuclear Wastes from Nuclear Power Reactors. 1985. A. P. Toste. PNL Letter Report, Pacific Northwest Laboratory, Richland, Washington.

Summary of Thermochemical Data for Inorganic Cobalt Species. 1984. L. E. Eary, and S. R. Peterson. PNL Letter Report, Pacific Northwest Laboratory, Richland, Washington.

Special Waste Form Lysimeter-Arid Acquisition and Analysis of Radioactive Waste Forms and Waste Streams From a Pressurized Water Reactor. 1983. P. Colombo et al. BNL Letter Report, Brookhaven National Laboratory, Upton, New York.

Special Waste Form Lysimeter-Arid, Source Term Analysis and Leach Testing of Power Reactor Wastes. 1984. P. Colombo et al. BNL Letter Report, Brookhaven National Laboratory, Upton, New York.

Special Waste Form-Arid Program Waste Form Acquisition and Laboratory Leaching Studies. 1985. P. Colombo et al. BNL Informal Report BNL-37620, Brookhaven National Laboratory, Upton, New York.

ABSTRACT

Laboratory and field leaching experiments are being conducted by Pacific Northwest Laboratory (PNL) to investigate the performance of solidified low-level nuclear waste in a typical, arid, near-surface disposal site. Under PNL's Special Waste Form Lysimeters-Arid Program, a field test facility was constructed to monitor the leaching of commercial solidified waste. Laboratory experiments were conducted to investigate the leaching and adsorption characteristics of the waste forms in contact with soil.

Liquid radioactive wastes solidified in cement, vinyl ester-styrene, and bitumen were obtained from commercial boiling water and pressurized water reactors, and buried in a field leaching facility on the Hanford site in southeastern Washington State.

Batch leaching, soil column adsorption, and soil/waste form column experiments were conducted in the laboratory, using small-scale cement waste forms and Hanford site ground water. The purpose of these experiments is to evaluate the ability of laboratory leaching tests to predict leaching under actual field conditions and to determine which mechanisms (i.e., diffusion, solubility, adsorption) actually control the concentration of radionuclides in the soil surrounding the waste form.

Chemical and radionuclide analyses performed on samples collected from the field and laboratory experiments indicate strong adsorption of $^{134,137}Cs$ and ^{85}Sr onto the Hanford site sediment. Small amounts of ^{60}Co are leached from the waste forms as very mobile species. Some ^{60}Co migrated through the soil at the same rate as water. Chemical constituents present in the reactor waste streams also found at elevated levels in the field and laboratory leachates include sodium, sulfate, magnesium, and nitrate. Plausible solid phases that could be controlling some of the chemical and radionuclide concentrations in the leachate were identified using the MINTEQ geochemical computer code.

EXECUTIVE SUMMARY

Laboratory and field leaching experiments are being conducted by Pacific Northwest Laboratory (PNL) to investigate the performance of solidified low-level nuclear waste in a typical, arid, near-surface disposal site. A similar investigation is being conducted at Savannah River near Barnwell, South Carolina to determine the performance of low-level wastes in a humid climate. This information is needed to determine if currently proposed available waste forms will provide enhanced containment of commercial reactor waste materials at arid disposal sites versus containment at humid sites. Under PNL's Special Waste Form Lysimeters-Arid Program, a field test facility was constructed to monitor the leaching of commercial solidified waste under conditions representative of alternative disposal methods (e.g., below-ground vaults, earth-mounded concrete bunkers, shaft disposal, etc.) where the water instrusion is possible and the waste form is in contact with soil. Laboratory experiments are conducted to investigate the leaching and adsorption characteristics of the waste forms in contact with soil.

Liquid radioactive wastes solidified in cement, vinyl ester-styrene, and bitumen were obtained from commercial boiling water reactors (BWR) and pressurized water reactors (PWR), and buried in a field leaching facility on the Hanford site in southeastern Washington State. This facility consists of ten 3-m-deep by 1.8-m-dia steel caissons surrounding a 4-m-deep by 4-m-dia central instrument caisson. Each of these lysimeters contains a 210-L barrel of solidified waste with casing removed. It is filled with sifted Hanford site sediment from the lysimeter construction site. Leachate is collected from drains in the bottom of the lysimeters, and chemical and radionuclide analyses are performed.

Batch leaching, soil column adsorption, and soil/waste form column experiments are conducted in the laboratory, using small-scale waste forms and Hanford site ground water. The purpose of these experiments is to evaluate the ability of laboratory leaching tests to predict leaching under actual field conditions and to determine which mechanisms (i.e., diffusion, solubility, adsorption) actually control the concentration of radionuclides in the soil

surrounding the waste form. To date, only Portland III cement waste forms containing BWR evaporator concentrate and ion-exchange resin waste have been tested in the laboratory. Diffusion, soil column adsorption, and geochemical models were used in the analysis of the laboratory data.

Radionuclide analyses performed on samples collected in laboratory experiments indicate that $^{134,137}Cs$ leaches readily from the waste forms, and there is strong adsorption of $^{134,137}Cs$ and ^{85}Sr onto the Hanford site sediment. Both laboratory and field results show that small amounts of ^{60}Co are leached from the waste forms but as very mobile species. Some ^{60}Co migrated through the soil at the same rate as water. The PERCOL (Routson and Serne 1972) soil column adsorption model predicted an average ^{60}Co distribution coefficient of <1.5 for the leaching of a solidified waste form in a soil column. Chemical constituents present in the reactor waste streams also found at elevated levels in the field and laboratory leachates include sodium, sulfate, magnesium, and nitrate. Plausible solid phases that could be controlling some of the chemical and radionuclide concentrations in the leachate were identified using the MINTEQ geochemical computer code. At higher pH (values above approximately 10), magnesium precipitated primarily as brucite [$Mg(OH)_2$], and calcium precipitated as calcium carbonate ($CaCO_3$). Cobalt hydroxide [$Co(OH)_2$] may act as a solubility control at the high pH values observed. At pH values less than approximately 10, where the soil is an active buffer, magnesium and strontium are precipitating as carbonates ($MgCO_3$ and $SrCO_3$), while calcium remains oversaturated with respect to calcite or forms a mixed carbonate with magnesium that has higher solubility than calcite. Carbonates are important because they influence the release of strontium, calcium, and magnesium. The fate of calcium can influence the release of ^{90}Sr and ^{60}Co because they may substitute for calcium in the cement matrix.

The results of the combined leach-adsorption test effectively predicted the breakthrough of ^{60}Co observed in the field lysimeter facility for the waste forms tested. Further tests are needed to identify the mobile ^{60}Co species and to investigate the factors affecting their stability.

ACKNOWLEDGMENTS

Support for the Special Waste Form Lysimeters-Arid program is sponsored by the National Low-Level Waste Management Program Office of the U.S. Department of Energy.

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INTRODUCTION

Low-level radioactive liquid waste generated by nuclear power plants is solidified before transport and burial in near-surface burial sites. This practice is designed to limit the release of radionuclides to the environment associated with alternative disposal methods (e.g., below-ground vaults, earth-mounded concrete bunkers, shaft disposal, etc.) by providing structural stability to the wastes and is required by federal regulation 10 CFR Part 61 (NRC 1982). Typical solidifying agents used to bind the radionuclides in a solid waste form are cement, bitumen, and vinyl ester-styrene (Dow® polymer). The ability of these waste forms to retain radionuclides is evaluated using leaching tests where sample waste forms are contacted with water over time. Although these tests measure radionuclide leach rates in water and allow relative comparison of leaching characteristics, they cannot be used directly to predict the release and migration of radionuclides in actual burial conditions.

Estimating the potential for radionuclide migration from near-surface disposal sites where water may intrude or where the waste form is in contact with soil requires knowledge of the contaminant concentration in the soil surrounding the waste form. This concentration, referred to as the source term, may be controlled by the concentration, leach rate, and/or solubility of radionuclides in the waste form; the rate of water flow in the soil surrounding the waste; and solubility and adsorption processes that occur in the soil.

Pacific Northwest Laboratory (PNL) is currently conducting research for the U.S. Department of Energy (DOE) Low-Level Waste Management Program to evaluate the performance of solidified low-level waste forms in an arid near-surface burial site. A similar investigation is being conducted at Savannah River near Barnwell, South Carolina to determine the performance of low-level wastes in a humid climate. This information is needed to determine if currently proposed available waste forms will provide enhanced containment of commercial reactor waste materials at arid disposal sites versus containment of

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commercial reactor waste materials at arid disposal sites versus containment of humid sites. Under PNL's Special Waste Form Lysimeters-Arid (SWLA) program, a field test facility was constructed to monitor the leaching of commercial solidified waste. Laboratory experiments, being conducted in support of the field facility, are designed to investigate leaching and adsorption characteristics of the waste forms in contact with soil.

The major objectives of the program are to 1) monitor radionuclide release from actual commercial waste forms under field conditions, 2) evaluate the ability of laboratory leaching tests to predict leaching under actual field conditions, and 3) determine which mechanisms (i.e., diffusion, solubility, adsorption) actually control the source term. Leach rates and source terms obtained will also be used to model the migration of radionuclides in the lysimeter facility.

This report describes the laboratory experiments, presents and discusses the results of both the laboratory and field data collected, and summarizes the effectiveness of the laboratory leaching and adsorption experiments in predicting the performance of solidified wastes under actual field conditions.

LABORATORY EXPERIMENTS

Laboratory soil-column leaching experiments are being conducted on waste forms that are identical, except in scale, to waste forms buried in the field leaching facility. The objective of the laboratory column research is to determine source terms and solubility controls associated with the release and transport of radionuclides from laboratory-scale waste forms in the Hanford site sediment. This information will be used to predict and interpret leach rates and adsorption at the field leaching site. The laboratory research began by studying a mix of Portland III cement with evaporator concentrate and ion-exchange resin from a boiling water reactor (BWR). This waste form was chosen from those obtained for the SWLA program (Table 1) because it has the highest radionuclide activity and contains chelating agents that may increase the

TABLE 1. Waste Forms Obtained for the Special Waste Form Lysimeters-Arid Program

Waste Stream	Reactor	Solidifying Agent
Boric acid concentrate waste	PWR	Masonry cement
Boric acid concentrate waste	PWR	Bitumen
Evaporator-concentrate (regenerative) waste	BWR	Portland Type III cement
Evaporator-concentrate (regenerative) waste and ion-exchange resin	BWR	Portland Type III cement
Evaporator-concentrate (regenerative) waste and ion-exchange resin	BWR	Dow® polymer (vinyl ester-styrene)

Note: PWR = pressurized water reactor.
BWR = boiling water reactor.

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mobility of some radionuclides. Recommendations for further experiments using the remaining waste forms will be based on the evaluation of these results.

The laboratory experiments were conducted in three parts:

1. batch leaching of solidified waste forms
2. column adsorption of the leachate produced in the first step
3. simultaneous leaching and adsorption of solidified waste forms in soil columns.

The first two parts of the experiment are designed so that the leaching and adsorption processes can be examined separately (Figure 1). The combined results of parts one and two (batch leaching and soil column adsorption) are compared with the results of part three (the simultaneous leaching and adsorption in soil columns). The information gained from this comparison will be used to evaluate how well the batch leaching and adsorption data, which can be generated easily, predict the performance of waste forms under field-leaching conditions.

The evaporator concentrate from the BWR contains Na_2SO_4 waste produced in the regeneration of ion-exchange resins used to purify process water in the reactor. Radionuclides and dissolved ions that cause corrosion are removed in ion-exchange columns or beds filled with synthetic organic resin beads. The resin beads are loaded with ions that exchange with ions of the same sign and charge that are present in the waste stream until the exchange sites of the resin are saturated. The ion-exchange resins are regenerated by rinsing them with acid solution (for cation resin) to remove the exchanged ions and replacing them with fresh counter ions. The regeneration process is repeated until the beads must be replaced. Liquid regeneration waste is evaporated to reduce volume, and both the retired resin beads and the evaporator concentrate waste are solidified.

The radionuclides found in the waste stream of a BWR may have originated in the reactor fuel elements and entered the cooling waters through openings in the cladding or may be the result of neutron activation of corrosion products, chemical additives, or hydrogen or oxygen isotopes in the primary coolant (Carter, Moghissi and Kahn 1979).

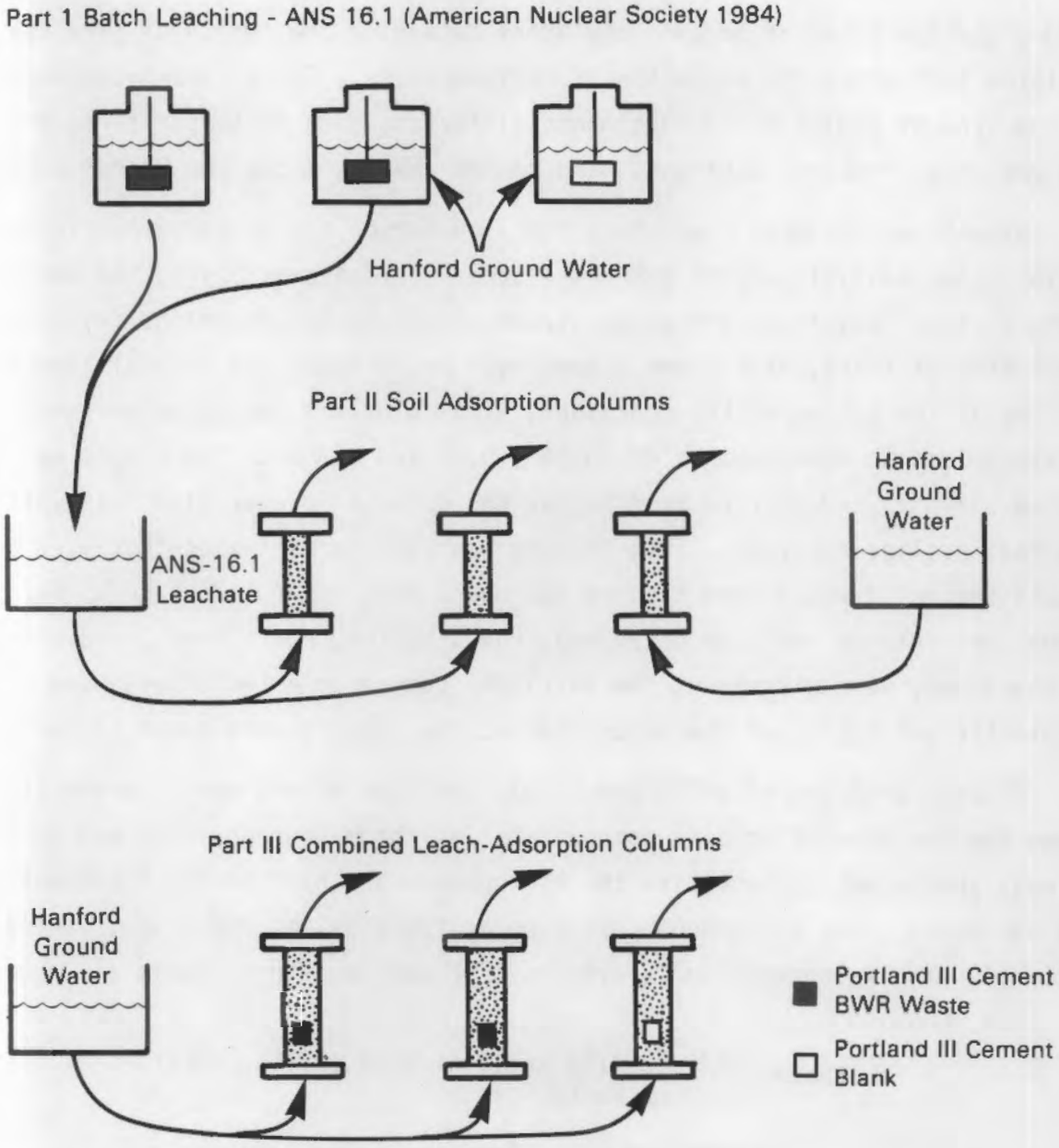

FIGURE 1. Special Waste Form Lysimeters-Arid Program Laboratory Column Experiments (BWR = Boiling Water Reactor)

Organic chelating agents [e.g., ethylenediamine tetraacetic acid (EDTA)] used in decontamination operations can also be found in the reactor waste stream. The ability of these chelating agents to form strong complexes with metals makes them useful for scavenging radionuclides from reactor process water; however, this same attribute can enhance leaching and transport of the radionuclides from the disposal site (Means and Alexander 1981).

Biodegradation rates of organic chelators determine the length of time the chelator influences the migration of radionuclides. These rates vary depending on the type of chelator and environmental factors such as temperature, pH, and the presence of water, nutrients, and toxins (Means, Kucak and Crerar 1980).

Brookhaven National Laboratory (BNL) performed the characterization and radionuclide analysis of the BWR waste stream before solidifying the sample waste forms. They found the waste stream sample to be 38% solids (by weight) consisting of thick, dark brown sludge with resin beads and crystallized salts settled at the bottom of the container. The colorless supernate was used to obtain pH and Eh measurements of 10.36 ± 0.02 and 260 mV. The sample was heated slightly and stirred to dissolve the salts in preparation for density and radionuclide analyses. This mixture was representative of that used to create the solid waste form samples and had a density of 1.27 g/cm^3. Before gamma spectroscopy could be performed, the organics, resin beads, and silicates in the slurry were dissolved. An intrinsic germanium detector was used to obtain the activities of the major radioactive constituents shown in Table 2.

Organic analyses of solid and liquid portions of the waste stream indicated the presence of organic compounds. Gas chromatography (GC) and combined GC/mass spectrometry identified the hydrophobic and hydrophilic fractions of the BWR waste. The hydrophobic or nonpolar fraction, at 165.3 ppm, is composed primarily of alkylphenols and alkylphenyl phosphate esters (Table 3).

TABLE 2. Radionuclide Activities in Boiling Water Reactor Waste Stream

Constituent	Activity (μCi/L)(a)
^{60}Co	$(1.58 \pm 0.24) \times 10^3$
^{137}Cs	$(2.34 \pm 0.35) \times 10^2$
^{134}Cs	$(3.60 \pm 0.54) \times 10^1$
^{54}Mn	$(8.72 \pm 1.31) \times 10^1$
^{144}Ce	$(4.05 \pm 1.26) \times 10^0$

(a) On date of solidification, September 27, 1983

TABLE 3. Hydrophobic Organic Compounds in Boiling Water Reactor Waste Stream

	Concentration (ppm)[a]	
	Liquid	Solid
Alkyl Phenols		
Cresol (methylphenol)	4.3	5.9
Dimethylphenols (3)[b]	0.7	16.2
Ethylphenol	1.7	9.5
C_2-phenols (6)	16.3	17.2
2,6(di-t-butyl)4-ethylphenol		0.5
Ethyl,nitrophenols (3)		1.6
Phosphate Esters		
Di(alkylphenyl)methyl-phosphates (3)	73.2	
Tri(alkylphenyl)phosphates (22)	11.1	2.9
Phthalate Esters		
Dimethylphthalates (2)	1.5	
Alkylphthalate	0.2	1.2
Benzene sulfonamide		0.8
Polyethylene glycol		0.5

(a) No entry indicates compound is below detection level (0.1 ppb).
(b) Number in parentheses indicates number of compounds identified.

These phenols and esters are typically used in industry as hydraulic fluids and plasticizers. Hydrophilic compounds were present at 71.4 ppm and include chelating agents commonly used in nuclear operations: citric acid, oxalic acid, and glycolic acid (Table 4). These compounds can solubilize and mobilize radionuclides (Means, Crerar and Duguid 1978). Other chelating agents such as EDTA were not found in the liquid or solid waste stream samples, but have been found in similar BWR waste streams (Walter and Graham 1985).

Portland cement is the most common hydraulic cement produced and has been used extensively for solidifying radioactive waste. It is composed mainly of silica, lime, alumina, and smaller quantities of magnesia, ferric oxide, and

TABLE 4. Hydrophilic Organic Compounds in Boiling Water Reactor Waste Stream

	Concentration (ppm)[a]	
	Liquid	Solid
Tricarboxylic Acids[b]		
Citric acid	0.4	
Dicarboxylic Acids[b]		
Oxalic acid	0.8	0.4
Propanedioic acid	0.7	
Maleic acid	0.4	
Butanedioic acid	4.8	0.2
Methylbutanedioic acid	1.7	
Hydroxybutanedioic acid	9.3	
2-ketoglutaric acid	3.9	
Hexanedioic acid	6.5	0.8
Nonanedioic acid	2.9	
Monocarboxylic Acids[b]		
2-methylpropanoic acid		0.8
Butanoic acid		0.4
2-butanoic acid		0.6
Octanoic acid		0.7
Nonanoic acid		1.1
Dodecanoic acid		0.9
Oxygenated Acids[b]		
Glycolic acid		0.6
Lactic acid	0.3	
2-hydroxypropanoic acid		1.2
3-hydroxybutanoic acid	18.3	3.4
4-methyl,2-oxopentanoic acid		0.6
4-oxopentanoic acid		1.1
Aromatic Acids[b]		
Benzoic acid	3.6	
Ketones		
3-methyl,3-hydroxy,2-butenone		0.3
4-methyoxybenzaldehyde		3.3
4-hydroxy,phenyl,1-ethanone	1.4	

(a) No entry indicates compound is below detection level (0.1 ppb).
(b) Methylated (BF_3/methanol); acids identified as methyl esters.

sulfur trioxide. Portland III cement differs from other Portland cements (I-V) because it has the highest percent of tricalcium silicate and the lowest percent of dicalcium silicate. The ratio of these constituents gives it shorter setting times, strength early in the curing process, and significant heat of hydration (Neilson 1983). Water in the waste combines chemically with the cement to form cement hydrate minerals in the solidification process. Water used in this way is limited to approximately 25% of the weight of the waste form (Colombo et al. 1975). Additional water is held in the pores of the cement by capillary pressure, while solids are physically held by the cement matrix (Neilson 1983).

Some radionuclides react with the cement to become part of the solid matrix. For example, ^{60}Co ions may exchange with calcium cations present as calcium silicates, aluminates, or aluminoferrites, to form corresponding cobalt compounds that will crystallize to become part of the hardened cement (Habayeb 1985). The high pH of cement facilitates the formation of cobalt hydroxide, which reacts with carbon dioxide to form insoluble cobalt carbonate (Weast 1984). These reactions result in reduced diffusion of ^{60}Co from the waste form. Chelating agents present in the waste can influence the solubility of cobalt by forming stable cobalt-organic complexes. These complexes are less likely to interact with the cement during solidification and can more easily diffuse than those held in the cement matrix.

The laboratory experiments were conducted using six laboratory-scale waste forms, fabricated by BNL, that measure 5 cm in height and 2.5 cm in diameter. Four of these waste forms contained evaporator concentrate and ion-exchange resin taken from the waste stream that was used to fabricate waste forms for burial in the field facility. Two waste forms were solidified as blanks using distilled water instead of waste. Portland III cement powder (16.5 g) was mixed with BWR waste (23.1 g) in a waste/binder ratio of 1.4. This ratio was selected based on an estimate of the waste/binder ratio provided by the power utility used in the solidification of the full-scale waste forms. The cement powder was weighed and placed in a 35-mL polyethylene vial that measured 7.6 cm in height and 2.5 cm in diameter. The waste was warmed to 50°C and mechanically mixed to disperse the solids. The solution was then drawn into a 50-mL

syringe, weighed, and placed in the vial with the powder. The mixture was stirred with a stainless steel spatula and covered for the curing interval (Colombo et al. 1986).

Four experiments are described here: a batch distribution coefficient (Kd) test, batch waste form leaching, soil column adsorption of leachate obtained in the batch leaching experiment, and a combined leach-adsorption test.

BATCH Kd EXPERIMENT

A batch distribution coefficient (Kd) test was conducted using waste form leachate, provided by BNL, to estimate distribution coefficients of radionuclides present in the waste form leachate. The Kd value was used to predict radionuclide breakthrough in the soil columns needed to design the soil column experiments. The Kd value is defined as the ratio of the equilibrium radionuclide concentration of the solid phase (µg/g) to the equilibrium concentration of the radionuclide (µg/mL) in solution at the conclusion of the test. It is calculated using the following equation:

$$Kd = \frac{BV - E(V+X)}{WE} \qquad (1)$$

where B = tracer activity in the influent blank, dpm/mL
V = volume of ground water with radioactive tracer added, mL
E = activity of tracer in the effluent solution, dpm/mL
X = excess solution volume left from the third rinse, mL
W = weight of solid aquifer material, g.

This equation is applicable when the tracer shows insignificant adsorption onto blank tube walls (Relyea, Serne and Rai 1980). One gram of sediment from the field lysimeter site was placed in each of three 50-mL centrifuge tubes. The sediments were rinsed using filtered Hanford site ground water (HGW) before being contacted with waste form leachate. When the rinsing cycles were completed, 30 mL of mixed ANS 16.1 leachates were placed in the centrifuge tubes and shaken at approximately 1 oscillation/s for 7 days. The tubes were then

centrifuged, and 15 mL of the supernate was removed and analyzed for radionuclide content. The batch Kd test that was conducted using BNL ANS 16.1 leachate estimated Kd values for ^{137}Cs and ^{60}Co at 3000 and 8 mL/g, respectively. Previous batch Kd analyses using Hanford site sediments and ground waters and these radionuclides yielded Kds of approximately 2000 mL/g for each (Ames and Rai 1978; Benson 1960; Hajek 1966; and Gee et al. 1981). The Kd of 8 for ^{60}Co and the presence of organic complexing agents in the raw waste stream suggest that some of the ^{60}Co in the waste form is combined with an organic material that increases its mobility.

BATCH LEACHING TEST

The batch leaching test used was developed by the American Nuclear Society (ANS) working group 16.1 (ANS 1984). The ANS 16.1 leach test consists of a full immersion water bath of a solidified waste form where the leachate is sampled and replaced at designated intervals.

Three waste forms were used in this experiment. Two of these waste forms were duplicates containing evaporator concentrate and ion-exchange resins from a BWR solidified with Portland III cement, and one was a blank containing only Portland III cement. All three waste forms were right cylinders measuring 2.5 cm in diameter and 5 cm in length.

Each waste form was suspended in 600 mL of HGW contained in a 1-L, wide-mouth polyethylene jar. The waste form remained suspended in the enclosed jar for a designated leaching interval.

At the end of each sampling interval the leachate was removed, filtered through a 0.45-μm filter, and analyzed for pH, Eh, and alkalinity (Greenberg, Trussell and Clesceri 1985). Leachate samples were also analyzed for anions (ion chromatography), cations (inductively coupled plasma spectrometry), and total organic and inorganic carbon (Persulfate-Ultraviolet Oxidation Method).

The radiological analysis was conducted using a sodium iodide detector. The radionuclides evaluated include ^{60}Co and $^{137,134}Cs$. At the end of the experiment, all of the available leachate was combined to be used as an influent solution for the soil column adsorption test.

By the end of the 35-day ANS 16.1 leach test, 79.9% of the ^{137}Cs and 51.9% of the ^{134}Cs present in the waste form had been leached (Appendix A). Only 0.5% of the ^{60}Co in the waste form was leached, even though the amount of ^{60}Co originally present in the waste form was ten times that of ^{137}Cs (Table 2). These results are comparable to those found in ANS 16.1 tests conducted on identical waste forms by BNL (Colombo et al. 1986, Appendix A). In both the PNL and BNL analyses, the rate of release of radionuclides was greatest in the first 5 days with much slower release for the remainder of the test (Figure 2). The BNL tests were conducted in deionized water, where no dissolved minerals are present to moderate the diffusion gradient between areas of high mineral concentration (cement waste form) and low mineral concentration (leachant). Although the rate of diffusion of radionuclides and other chemical components from the waste form was expected to be higher in deionized water than in HGW,

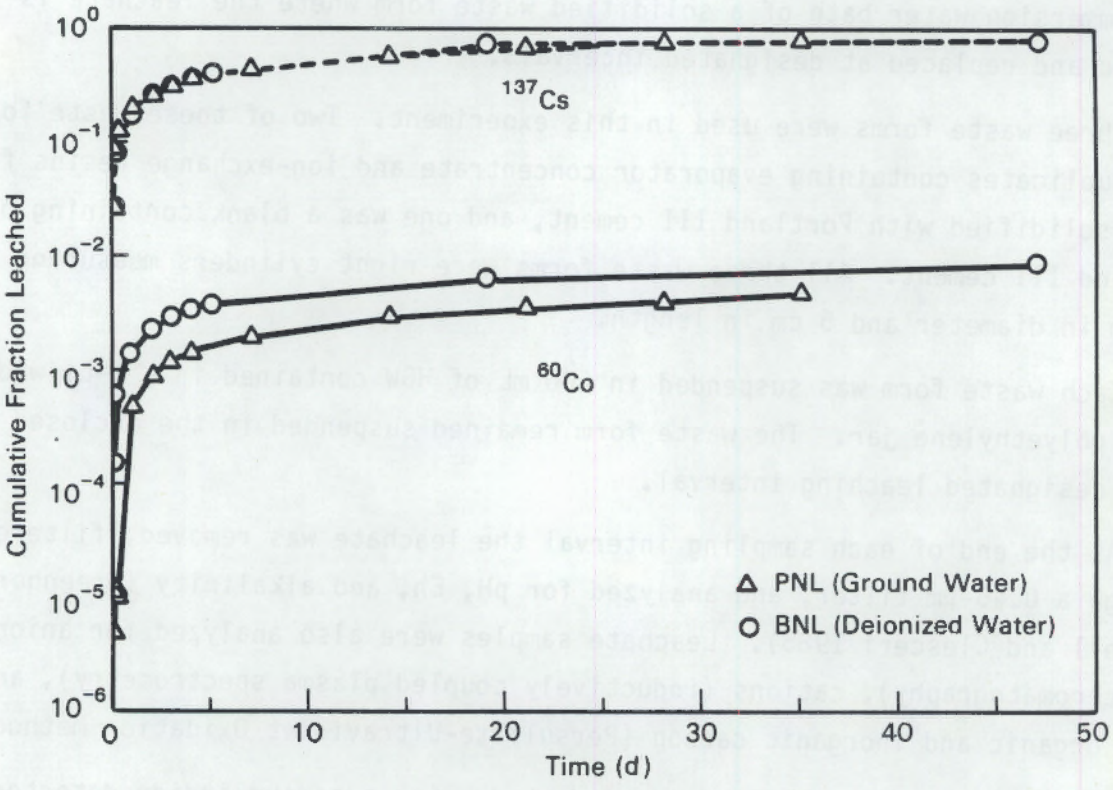

FIGURE 2. Comparison of Pacific Northwest Laboratory and Brookhaven National Laboratory ANS 16.1 Leaching Results for Cobalt-60 and Cesium-137

this effect was not observed. The dissolved minerals present in the HGW may have slowed the diffusion of ^{60}Co slightly in the PNL experiment relative to the BNL test, but had no observable effect on the movement of ^{137}Cs. There was also no difference in pH between the deionized and ground-water leaching experiments.

Two theoretical models were used in the analysis of data collected in the batch leaching experiment. The first used theoretically derived equations for simple diffusion to describe and quantify the release of radionuclides from the waste form. The second model used the MINTEQ geochemical computer code (Felmy, Girvin and Jenne 1984) to identify the chemical species controlling the chemical equilibrium of the system, thereby, influencing the solubility of the radionuclides.

In the diffusion model, the waste form is assumed to be a uniform, regularly shaped solid, and the leaching rate is assumed to be diffusion-controlled in the initial leaching phases (ANS 1984). Mass-transport equations can therefore be used to determine a cumulative "effective diffusivity" of the waste form using the equation:

$$D_e = \frac{\pi}{4} \left(\frac{\Sigma An}{Ao}\right)^2 \left(\frac{V}{S}\right)^2 \frac{1}{T} \qquad (2)$$

where D_e = effective diffusivity, cm^2/s
An = cumulative activity of the radionuclide release
Ao = total activity of the radionuclide at the beginning of the leach test
V = volume of specimen, cm^3
S = geometric surface area of the specimen as calculated from measured dimensions, cm^2
T = total leaching time, s.

This equation can be used if the isotopes are assumed to have long half-lives in relation to the length of the test and if less than 20% of the initial inventory of the species is leached from the waste form. When greater than 20% of the species is leached, the diffusion rate is calculated from a shape-specific solution of the mass-transport equations. In this case, a

dimensionless time factor (G) is selected for the cylinder based on the length/diameter ratio (ANS 1984) and included in an equation for effective diffusivity (D_e):

$$D_e = \frac{Gd^2}{T} \quad (3)$$

where d is the diameter of the cylinder (cm), and T is the elapsed leaching time in seconds since the beginning of the test. These equations are theoretically derived and their use requires five assumptions:

1. The concentration of the species being leached is zero at the surface of the waste form during leaching.
2. The leachant is continuously mixed, and its composition remains fairly unchanged (pH, etc).
3. The waste form is homogeneous and remains unchanged chemically or physically.
4. The surface is smooth and does not deteriorate with time.
5. The radionuclide of interest is present as only one chemical species.

The effective diffusivity and a leachability index (LI) calculated from cumulative diffusivities can be used as a basis for comparison of similar waste forms. The leachability index is defined as

$$L_I = \frac{1}{10} \sum_{n=1}^{10} [\log (\beta/Oi)]_n \quad (4)$$

where β is a defined constant (1 cm^2/s) and Di is the effective diffusivity of nuclide i calculated from the test data. Acceptable waste forms must have an LI $\geq$ 6, as specified by the U.S. Nuclear Regulatory Commission (NRC) in their "Technical Position on Waste Forms" (NRC 1983). Diffusion values and leachability indexes, determined in PNL and BNL ANS 16.1 leaching tests, are listed in Table 5.

TABLE 5. Comparison of Cumulative Diffusion Coefficients for Pacific Northwest Laboratory and Brookhaven National Laboratory ANS 16.1 Leaching Tests (cm^2/s)

	Diffusion Coefficient (D_e)			
	PNL (ground water)		BNL (deionized water)	
Time (d)	Cs-137	Co-60	Cs-137	Co-60
0.0833	2.16E-07	2.88E-15	1.77E-08	6.98E-13
0.25	1.59E-07	1.33E-15		
0.29			5.02E-08	3.01E-12
1.0	9.19E-08	5.85E-13	6.53E-08	4.78E-12
2.0	8.38E-08	9.70E-13	7.27E-08	6.28E-12
3.0	7.64E-08	1.15E-12	8.20E-08	6.59E-12
4.0	7.57E-08	1.23E-12	8.63E-08	6.57E-12
5.0			8.78E-08	6.56E-12
7.0	5.54E-08	1.20E-12		
14.0	7.31E-08	1.45E-12		
19.0			7.20E-08	5.13E-12
21.0	7.72E-08	1.44E-12		
28.0	7.92E-08	1.34E-12		
35.0	8.06E-08	1.57E-12		
47.0			6.20E-8	3.70E-12
90.0			4.14E-08	2.30E-12
Average LI	7.14	11.3	7.23	11.4

Diffusion coefficients determined in the PNL and BNL ANS 16.1 leaching tests are within the range of other reported values for leaching of BWR waste solidified in cement. A D_e value of approximately 3.0E-8 cm^2/s was reported for ^{137}Cs in simulated BWR resin waste solidified in Portland I cement (Dayal, Schweitzer and Davis 1983). Arora and Dayal (1984) reported a range of D_e values for the leaching of ^{137}Cs from BWR resin waste (Portland I cement) of 1.7E-8 to 3.7E-9 cm^2/s. In the same study, ^{60}Co leached from pressurized water reactor waste solidified in Portland III cement with a D_e range of 1.6E-11 to 1.8E-13 cm^2/s. Leachability indexes of 6.5 and 11.3 for ^{137}Cs and

^{60}Co, respectively, were reported by Kalb and Colombo (1984) for the leaching of BWR waste with ion-exchange resin solidified in Portland III cement.

Chemical analysis of the ANS 16.1 leachate revealed elevated levels of sodium and sulfate, which were present in high concentrations in the raw-waste stream. Potassium and phosphorous were both found in concentrations greater than those found in HGW, while calcium and magnesium concentrations decreased sharply as a result of precipitation as the leaching test progressed (Appendix A). Release of organic fractions, present in the waste stream, was indicated by increased total organic carbon (TOC) in the leachate. The leachate generated from the blank waste form remained near HGW concentrations except for elevated levels of potassium and decreased levels of calcium.

The MINTEQ geochemical computer code (Felmy, Girvin and Jenne 1984) performs the calculations necessary to simulate the contact of low-level waste leachate with sediment or the interaction between ground water and solidified low-level wastes. The code performs calculations of ion speciation, adsorption, oxidation-reduction, gas phase equilibria, and the precipitation/dissolution of solid phases. The MINTEQ code was used on data from laboratory experiments to identify compounds that are possibly controlling or affecting the concentrations of ions in the leachates. The speciation portion of the model computes the activities of complexed and uncomplexed cationic and anionic species, neutral ion pairs, and the activities of cationic and anionic redox species found in the leachate from the batch and column tests. The solubility portion of the code uses this information to calculate ion activity products (AP) for solids and minerals and compares them to the solubility products (K) of minerals and solids stored in the thermodynamic data base of MINTEQ. A saturation or disequilibrium index [log (AP/K)] is developed that indicates the degree of under or oversaturation of the leachate relative to solids and minerals of interest [i.e., $CaCO_3$, $SrCO_3$, $MgCO_3$, $Mg(OH)_2$, and $Co(OH)_2$]. If the leachate is over-saturated with respect to a certain mineral ($\log(AP/K)>0$), then some mineralogical factor or kinetics hindrance is considered responsible for the failure of the mineral to precipitate. If undersaturation is indicated ($\log(AP/K)<0$), either 1) a less soluble solid is controlling the dissolved solids concentration, 2) adsorption or another mechanism is controlling the

concentration below its solubility product, or 3) the concentration of the constituent in the source is low (below considered solid phase controls). Consideration of these saturation indices of the batch leaching and column effluents provides information as to solids, minerals, and mechanisms that are controlling the concentration of selected radionuclides and major constituents in the source term.

Chemical interaction between the solid waste form and the HGW were influenced by high pH. Because the raw BWR waste stream had a pH of 10.35 and cement is rich in unreacted $Ca(OH)_2$, the leachate also had high pH. Hydrated lime dissolving from the cement waste forms was responsible for raising the pH of the leachate to as high as 12.1 in the ANS 16.1 test (Figure 3).

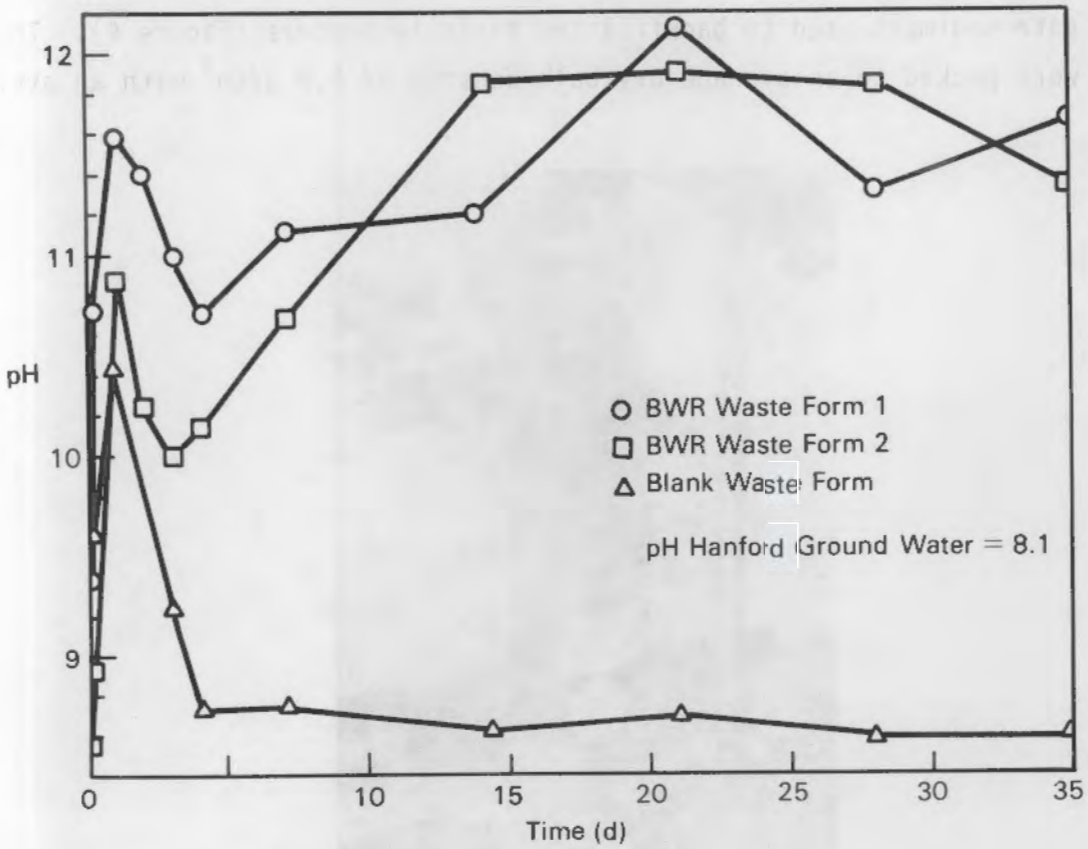

FIGURE 3. pH of Leachant in ANS 16.1 Experiment (BWR = Boiling Water Reactor.)

The results of the MINTEQ analysis of ANS 16.1 leachate predicted that, at pH values above 10, magnesium in the leachate precipitates primarily as brucite ($Mg(OH)_2$) and calcium precipitates as carbonate ($CaCO_3$). The carbonates are an important part of the chemical system controlling the release of strontium, calcium, and at pH values less than 10, Magnesium. The fate of calcium can influence the release of ^{90}Sr and ^{60}Co because they can exchange with calcium ions in the cement matrix. In addition, the metal hydroxide $Co(OH)_2$ may act as a solubility control at the high pH values observed.

SOIL COLUMN ADSORPTION TEST

In the soil column adsorption test, three columns were constructed from acrylic tubes measuring 8.7 cm in length with an ID of 2.1 cm, filled with the Hanford site sediment used to backfill the field lysimeters (Figure 4). The columns were packed to an average dry bulk density of 1.9 g/cm^3 with an average

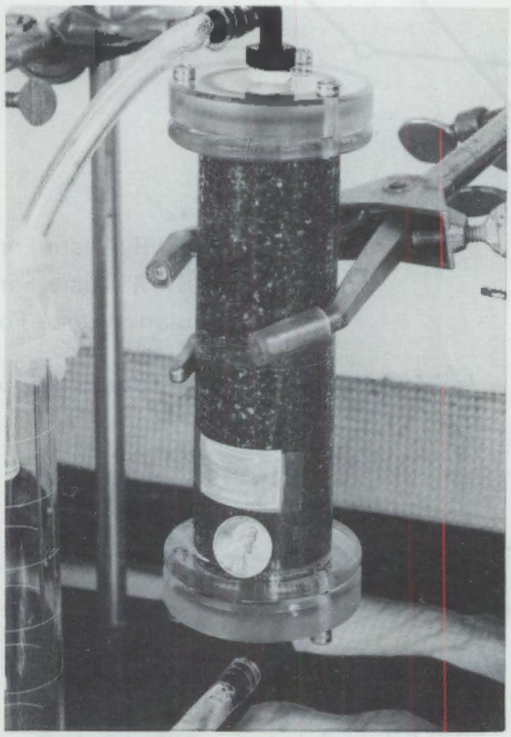

FIGURE 4. Close View of Leach-Adsorption Column Used in Laboratory Column Experiments (Adsorption column is similar.)

weight of soil equal to 58.21 g. The column geometry (length, diameter, and ratio of the two) was chosen to minimize dispersion and kinetic effects (Appendix B).

ANS 16.1 leachates from the two waste forms containing BWR waste were combined and totaled 10 L containing 0.445 μCi/L ^{137}Cs and 0.0266 μCi/L ^{60}Co. This solution was spiked with 0.325 μCi/L ^{85}Sr to facilitate analysis of ^{90}Sr present in the waste. The solution was then pumped into two of the columns at a constant flow rate of 7 mL/h, which is approximately 15 pore volumes (PV)/day. This represents an accelerated flow rate when compared to the field lysimeters, which drained 2 to 3 PV in 2 years of monitoring. The third soil column received filtered HGW pumped at the same rate. The direction of the flow was from the bottom to the top of the column to remove trapped air and maintain saturation.

The sample effluent was collected and analyzed daily until little change in its composition was observed. The sampling period was then extended to several days. The same chemical and radiological analyses that were performed for the ANS 16.1 tests were also performed on the soil adsorption column effluent (Appendix B).

Even at the end of approximately 430 PV, the ^{137}Cs and ^{85}Sr remained completely adsorbed onto the soil. Cobalt-60 appeared in the effluent before 18 PV of leachate had moved though the column. The effluent curves, shown in Figures 5a and 5b have a saw-tooth shape and appear to represent adsorption and desorption of variably complexed ^{60}Co on the soil. The expected breakthrough curve for adsorption in a soil column, in which the influent concentration is constant (such as in the soil column experiments), would show a steadily increasing concentration of radionuclides in the effluent until the soil could no longer adsorb the radionuclides borne in the influent. The curve would then become level at near influent concentrations. The interactions occurring in the soil column producing the experimental effluent curve shown in Figures 5a and 5b are not fully understood, given the available data. The variation in breakthrough might be best explained by fluctuation of the ^{60}Co in the soil column between species that do not adsorb and those that adsorb more strongly.

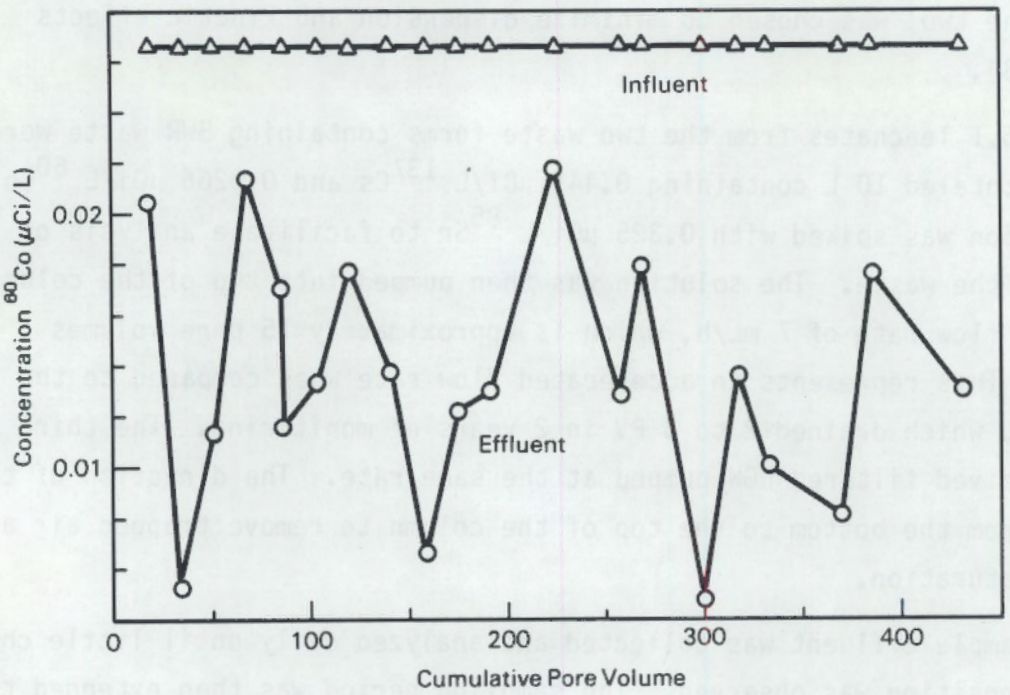

FIGURE 5a. Breakthrough Curve of Cobalt-60 in Soil Adsorption Column Number 1

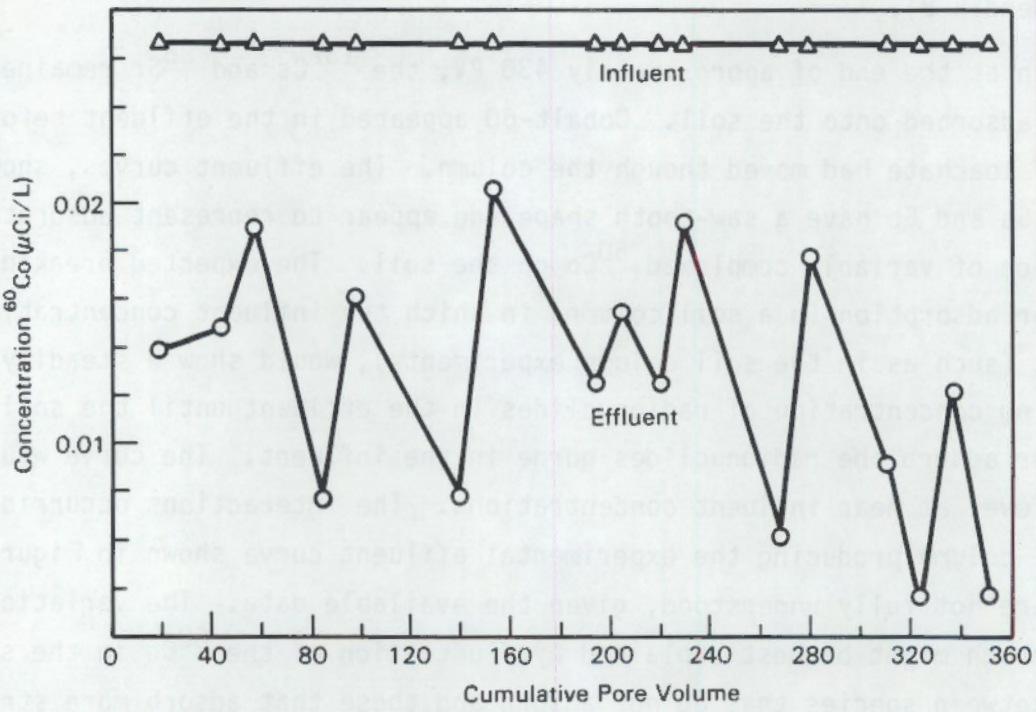

FIGURE 5b. Breakthrough Curve of Cobalt-60 in Soil Adsorption Column Number 2

Further tests would be required to identify the source of the variation and to evaluate the effects column geometry, flow rate, or colloidal particles have on the effluent curves.

Additional radiological analyses were performed on soil samples from both the soil adsorption and the combined leach/adsorption column experiments to determine the extent of adsorption of radionuclides onto sediment in contact with waste form leachate. At the end of the experiment, each of the columns was divided into sections and a representative 1-g sample was taken from each section. This sample was mixed with 4 g of cellulose and 15 g of a radionuclide-free sand in a scintillation vial and pressed into a wafer at 50,000 psi (345 MPa) to yield a wafer 2 1/4 in. (5.7 cm) in diameter and 1/8 in. (0.32 cm) thick. The solid samples were counted on intrinsic and coaxial germanium detectors.

In the soil adsorption columns, the majority of the ^{137}Cs, ^{134}Cs, and ^{85}Sr was bound in the first layer of soil nearest the influent with lesser amounts downgradient in the column, while ^{60}Co, present in the influent at only 0.0266 μCi/L, was not detected in the sectioned soil column (Figure 6).

The chemical analyses of the soil column effluent indicates that the chemical reactions in the soil column depend on the changes in pH in the column over time. The high pH of the ANS 16.1 leachate was neutralized in the soil columns until the buffering capacity of the soil was exceeded. The pH of the effluent then rose to between 9.4 and 10 and remained there until dropping slightly near the end of the column test (Figure 7). The drop in pH after approximately 225 PV cannot be explained by chemical reactions in the column and may have resulted from slight but prolonged exposure of the ANS 16.1 solution to air (absorption of CO_2). The MINTEQ analysis performed on the soil column effluent suggests that at pH 7 and 8, magnesium and strontium precipitate as carbonates ($MgCO_3$, $SrCO_3$) but that calcium remains in an oversaturated condition with respect to calcite or is at equilibrium with a mixed (calcium, magnesium) carbonate with a slightly higher solubility than calcite. At higher pH (10+), the chemical system is similar to that found in the ANS 16.1 test where magnesium precipitated as brucite and calcium as carbonate.

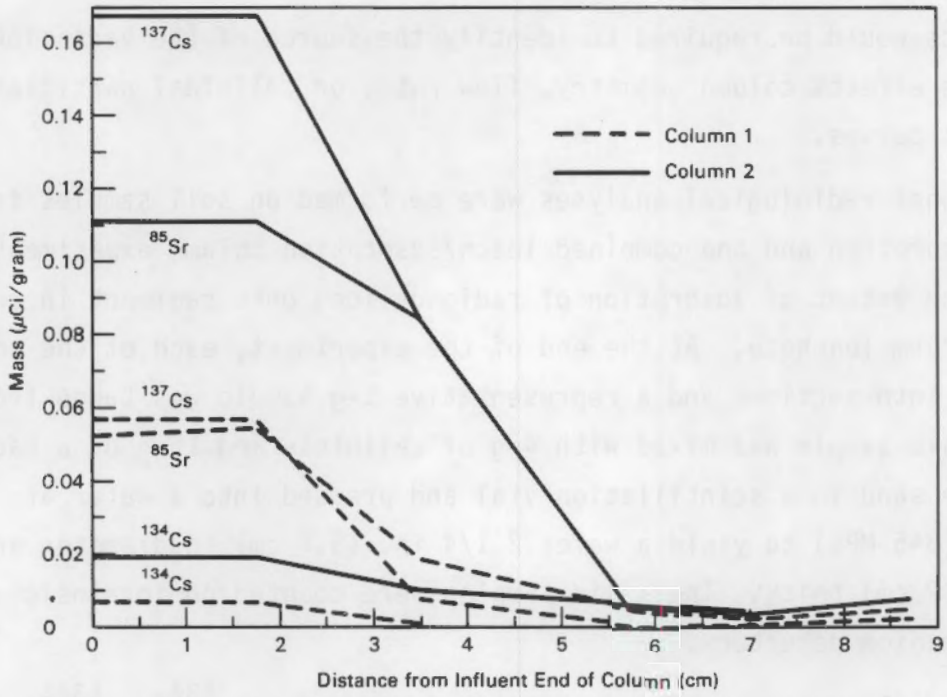

FIGURE 6. Distribution of Cesium-137,134 and Strontium-85 in Soil Adsorption Column

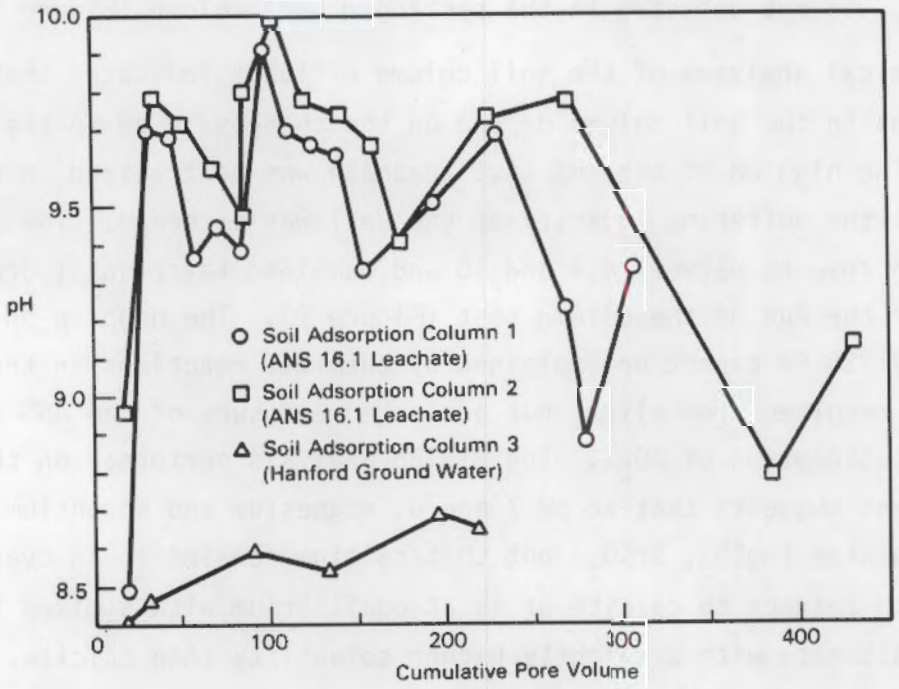

FIGURE 7. pH of Effluent from Soil Adsorption Columns (ANS = American Nuclear Society)

COMBINED LEACH ADSORPTION TEST

The combined leach-adsorption test was conducted in columns similar in design to those described in the soil column adsorption test, however, they were larger to accommodate the waste form, measuring 6 in. (15.24 cm) in length with an ID of 1.5 in. (3.81 cm).

Two duplicate waste forms and one blank Portland III cement waste form identical in composition and size as those described in the ANS 16.1 leach test were placed vertically into each column at the inlet end and centered on top of 1/2 in. (1.27 cm) of Hanford site lysimeter soil. The remaining space in the column was then packed with Hanford site lysimeter soil to a dry bulk density of 1.54 g/cm^3 (Figure 8).

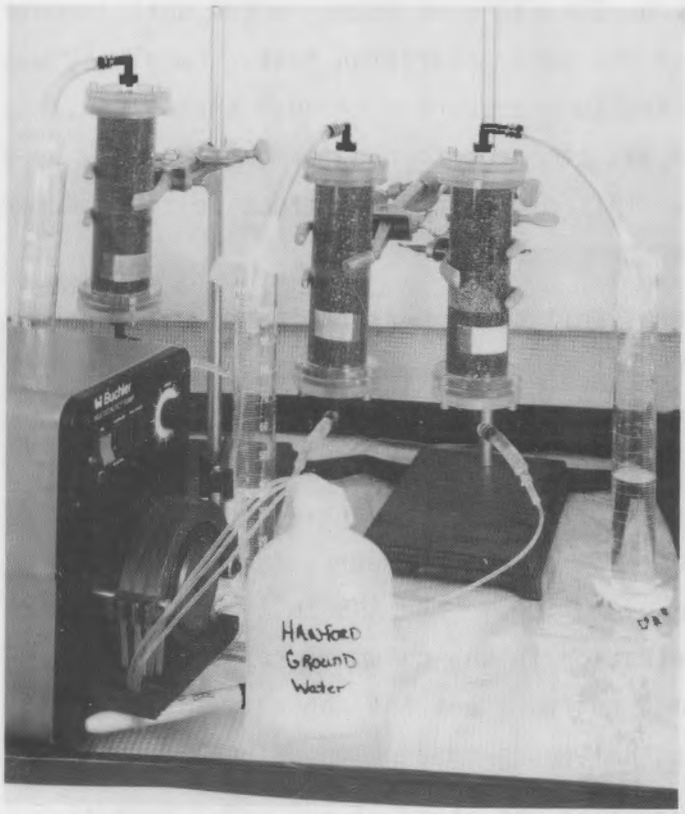

FIGURE 8. Combined Leach-Adsorption Columns for Laboratory Column Experiments

The columns were then saturated with HGW and allowed to sit for 16 h. The ground water was pumped up through the columns at a flow rate of 3 mL/h (0.8 PV/day) for 115 days. Effluent samples were collected in sealed 250-mL polyethylene bottles and the radionuclide, cation, anion, and carbon content of the effluents were determined as discussed for the ANS 16.1 leachates and the soil adsorption column effluent (Appendix C).

Cobalt-60 was present in the column effluent after only 1 PV of HGW had moved through the soil/waste form column, suggesting that some ^{60}Co was present in a complexed form with a Kd of zero. These combined leach-adsorption column effluent curves show decreasing concentration of ^{60}Co in the effluent as a result of the decreasing concentration of ^{60}Co leaching from the waste form (Figure 9a and 9b). At the end of the test, the waste form was removed from the column and the soil segments analyzed to determine the distribution of radionuclides. Cesium-134,137 were bound in the soil immediately surrounding the waste form as in the soil adsorption test. Cobalt-60 was detected in small amounts in several sections dispersed through the column. Sediment in contact with the waste form was cemented to the form most likely by precipitation of carbonate minerals. This may have some effect on the leach rate of radionuclides from the waste form.

A one-dimensional soil column adsorption code was used in the analysis of the combined leach-adsorption effluent data. The PERCOL code (Routson and Serne 1972) was used to estimate the Kd of ^{60}Co leaching from the sample waste form in the soil column. The computer model calculates the flow and adsorption of radionuclides in a soil column when given the soil characteristics, influent concentration, flow rate, column geometry, and Kd. The mass of ^{60}Co leached from the waste form over time in the ANS 16.1 batch leaching tests was used as the influent concentration in the column adsorption model. This influent concentration is assumed to represent the concentration of ^{60}Co leaching from the waste form in the actual leach-adsorption column.

The Kd (and therefore the shape of the model breakthrough curve) was varied until the best curve fit was obtained between the soil/waste form effluent curves and the model predictions. A curve was selected, through trial

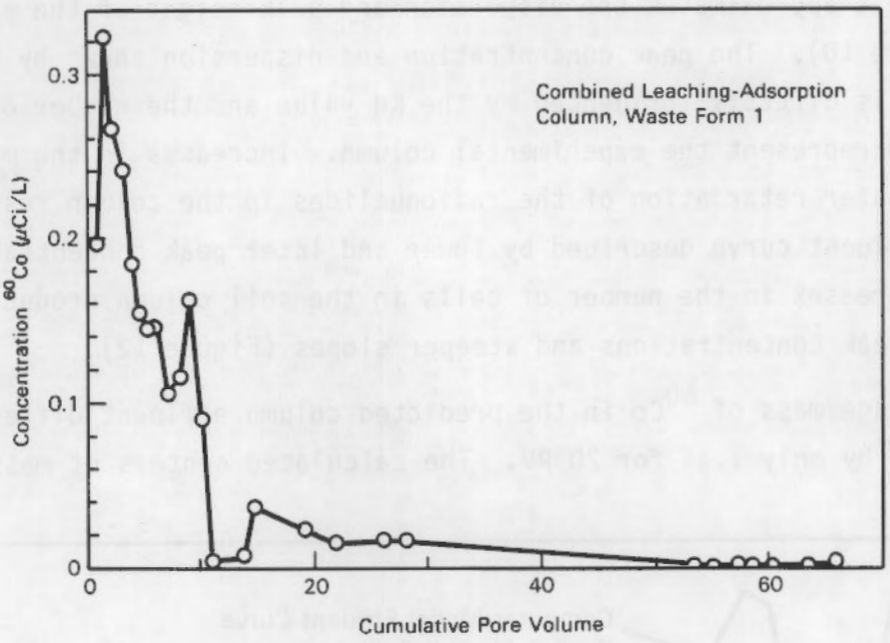

FIGURE 9a. Breakthrough Curve of Cobalt-60 in Combined Leach-Adsorption Column 1

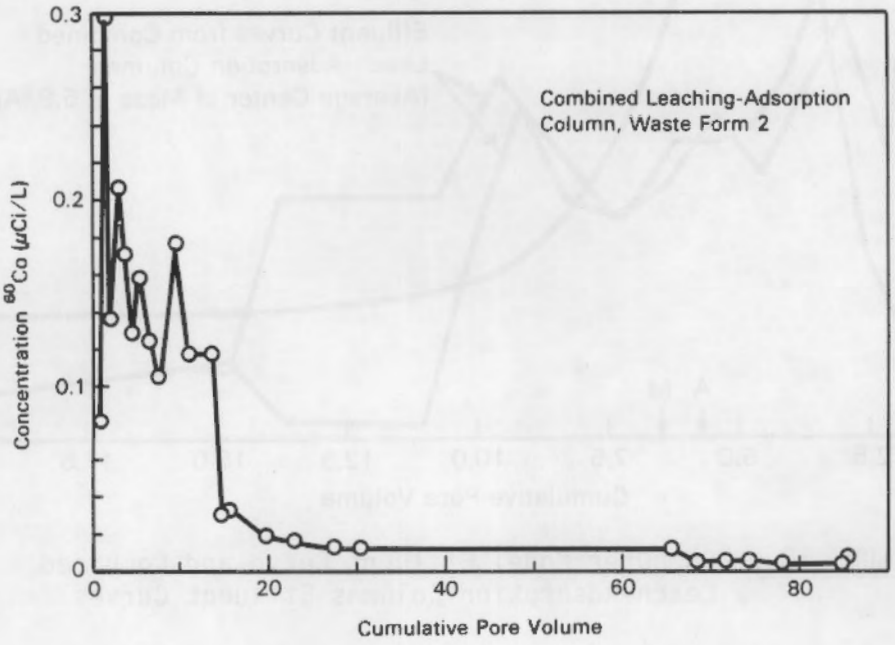

FIGURE 9b. Breakthrough Curve of Cobalt-60 in Combined Leach-Adsorption Column 2

and error, that approximates the dispersion and peak height of the experimental curves (Figure 10). The peak concentration and dispersion shown by the predicted curve is directly influenced by the Kd value and the number of soil cells used to represent the experimental column. Increases in the model's Kd represent greater retardation of the radionuclides in the column resulting in a predicted effluent curve described by lower and later peak concentrations (Figure 11). Increases in the number of cells in the soil column produce a curve with higher peak concentrations and steeper slopes (Figure 12).

The average mass of ^{60}Co in the predicted column effluent differs from that observed by only 1.4% for 20 PV. The calculated centers of mass, shown as

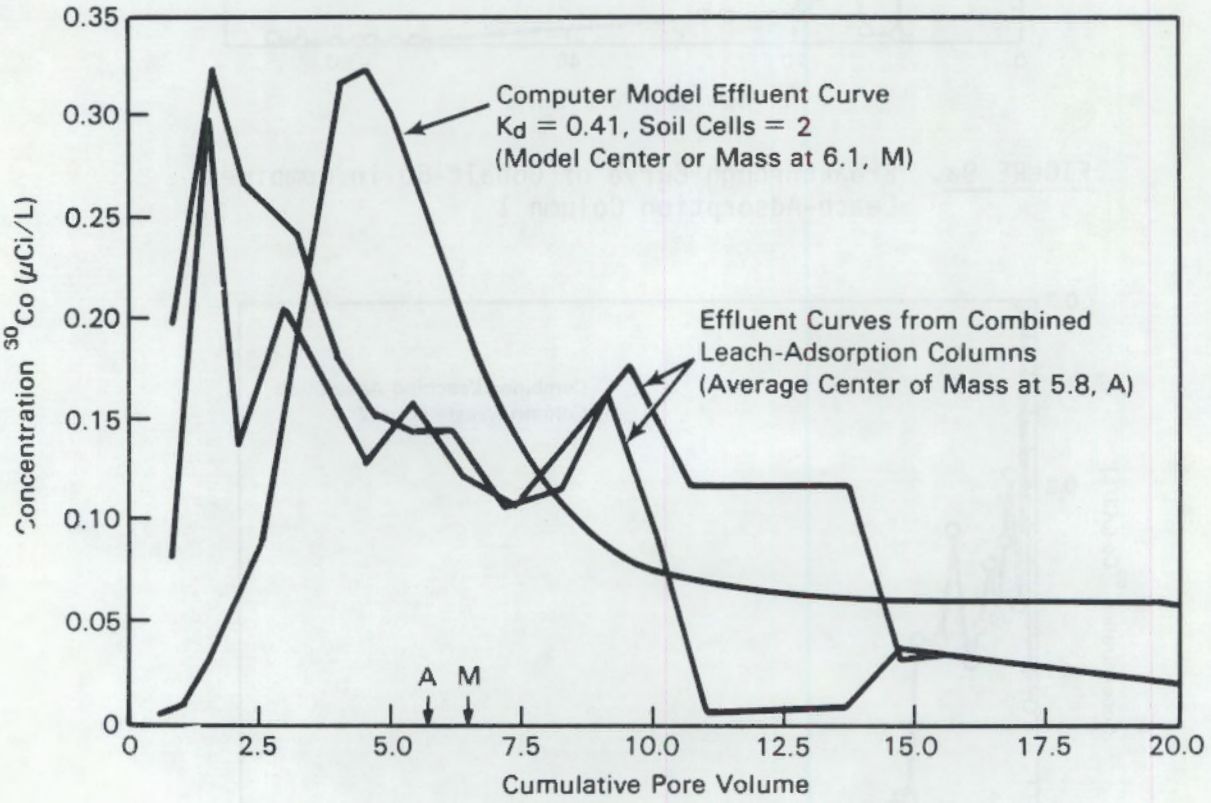

FIGURE 10 . Computer Model Effluent Curve and Combined Leach-Adsorption Columns Effluent Curves

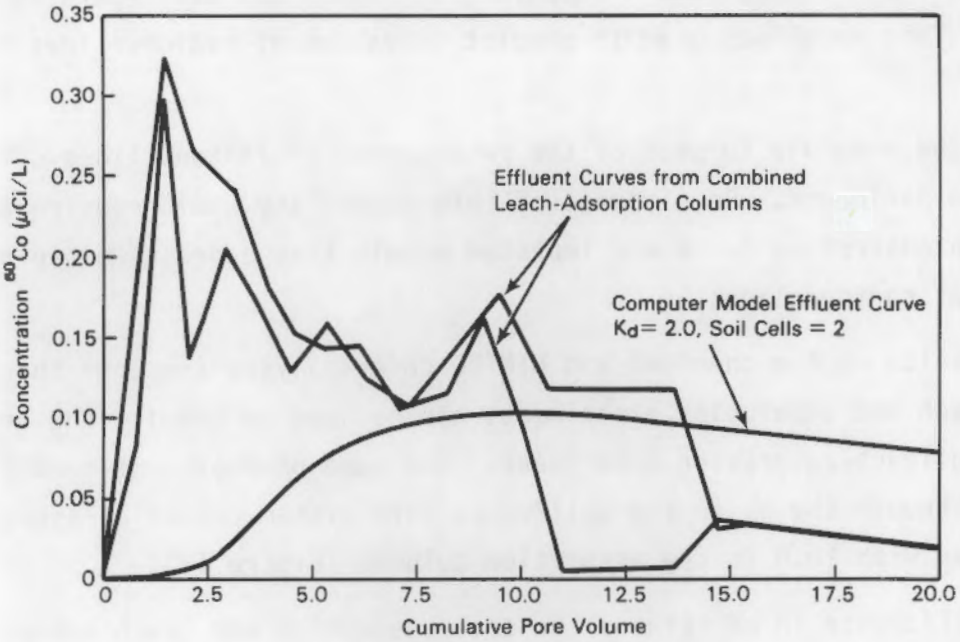

FIGURE 11. Computer Model Effluent Curve at kd = 2.0, Soil Cells = 2, and Combined Leach Adsorption Columns Effluent Curves

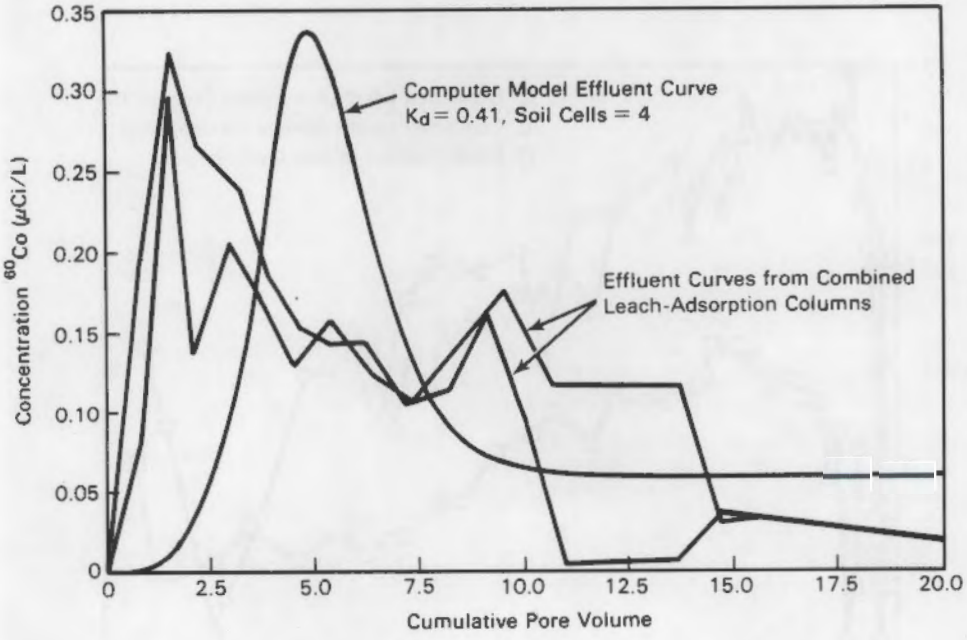

FIGURE 12. Computer Model Effluent Curve at kd = 0.41, Soil Cells = 4, and Combined Leach Adsorption Columns Effluent Curves

A (average of two columns) and M (modeled) in Figure 10, are separated by less than 1 PV. This model was used to predict Kd values of radionuclides in a soil column.

It may be possible to predict the retardation of radionuclides using laboratory experiments. Development of this capability would require additional leach-adsorption tests and improved models that address multiple speciation of radionuclides.

The results of the chemical and MINTEQ code analyses indicate that the separate leach and adsorption experiments can be used to predict the results of the combined leach-adsorption experiment. The same pH-dependent reactions occurred, although the pH in the soil/waste form system peaked at approximately 12.5 compared with 10.0 in the adsorption columns (Figure 13).

This difference in pH between the soil adsorption and leach-adsorption columns did not appear to affect the leachability or transport of radionuclides. The radionuclides behaved similarly in both experiments with ^{60}Co moving quite readily, while ^{85}Sr and $^{134,137}Cs$ were bound in the soil.

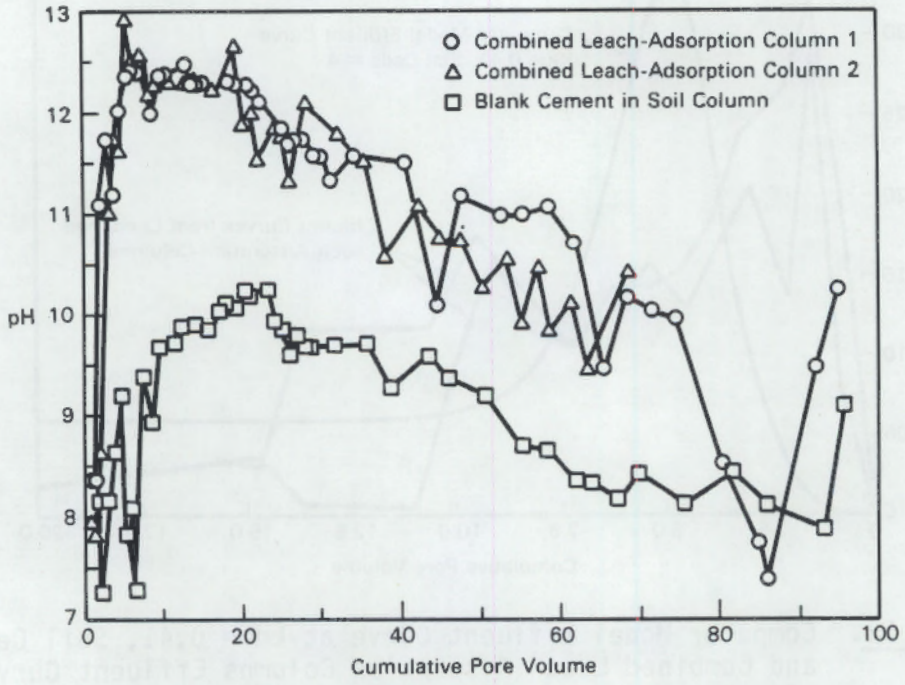

FIGURE 13. pH of Effluent from Combined Leach-Adsorption Columns Boiling Water Reactor Waste

FIELD INVESTIGATIONS

The field leaching facility is designed to monitor the release of radionuclides from commercial waste under actual field conditions. The laboratory experiments discussed previously provide information needed to interpret the field facility data.

The solidified waste forms used were obtained from commercial boiling water and pressurized water reactors, and buried in a field-scale leaching facility on the Hanford site in southeastern Washington State (Figure 14). The field-leaching facility, constructed in FY 1984, consists of ten 3-m-deep by 1.8-m-dia steel caissons surrounding a 4-m-deep by 4-m-dia central instrument caisson (Figure 15). One 210-L barrel of solidified waste (with casing removed) is centered in each lysimeter and surrounded by sifted sediment excavated from the lysimeter construction site. The waste types and solidifying agents represented are listed in Table 1. Chemical and radiological analyses are performed quarterly on leachate that drains from each lysimeter to the central caisson. Soil moisture, soil temperature, micrometeorological, and drainage data are also collected (Walter, Graham and Gee 1984).

The release and subsequent transport of radionuclides from waste forms contained in the SWLA caissons is controlled in part by the rate and quantity of water moving past the waste. This flux of soil water can be identified through a study of the lysimeter water balance.

A water balance calculation is an attempt to account for all of the water entering and leaving the lysimeter. Water entering the bare surface SWLA caissons can leave through evaporation or drainage, or remain in the soil as stored water. Water is stored in the soil profile only temporarily; and during this storage time, it is generally moving. It can move either upward toward the soil surface to be evaporated or downward to the bottom of the soil profile to exit as drainage. As the water moves downward through the lysimeter, it can dissolve radionuclides being released from the waste and transport the contaminant away from the burial zone.

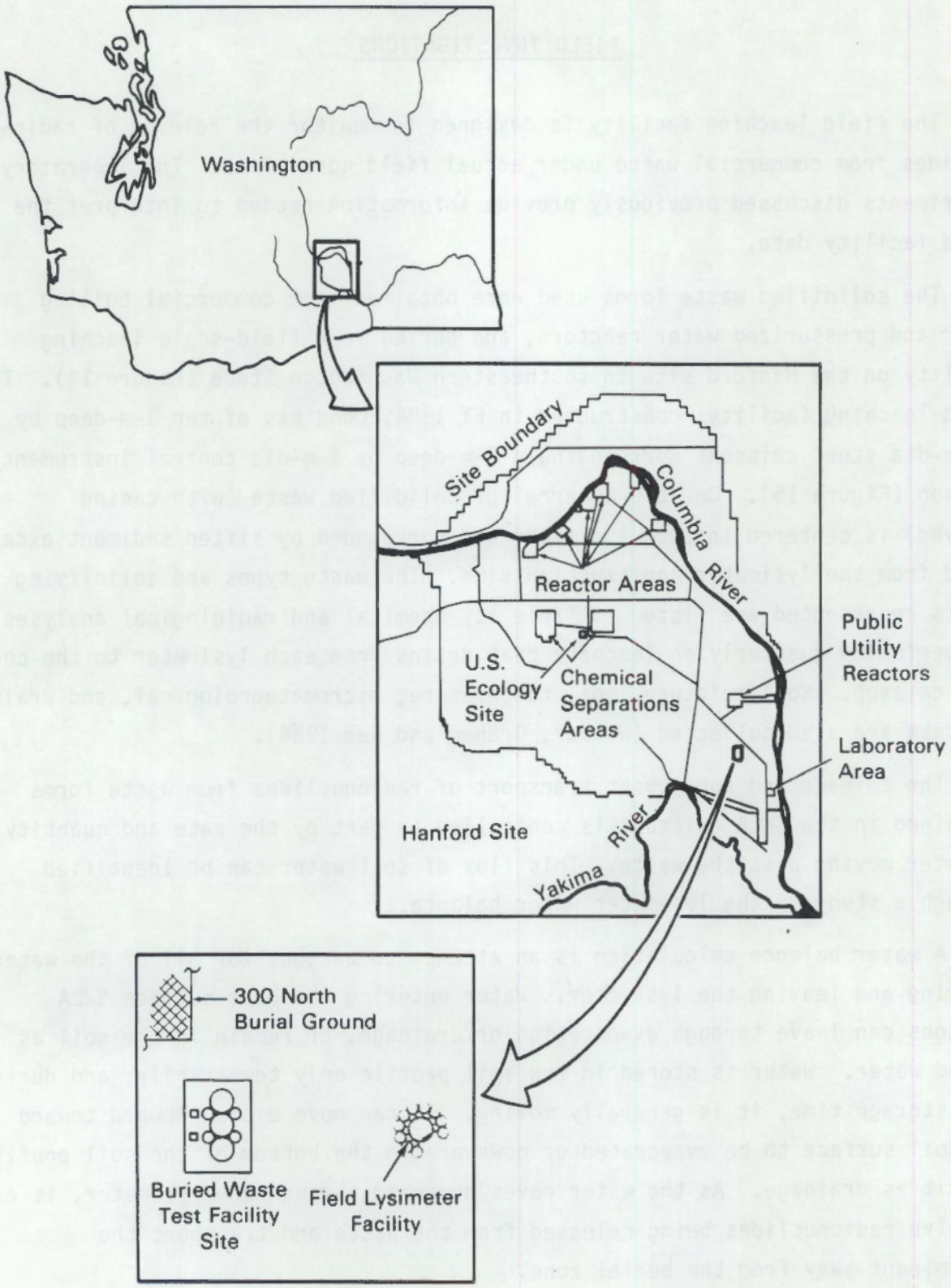

FIGURE 14. Location of Field Lysimeter Facility Within the Hanford Site

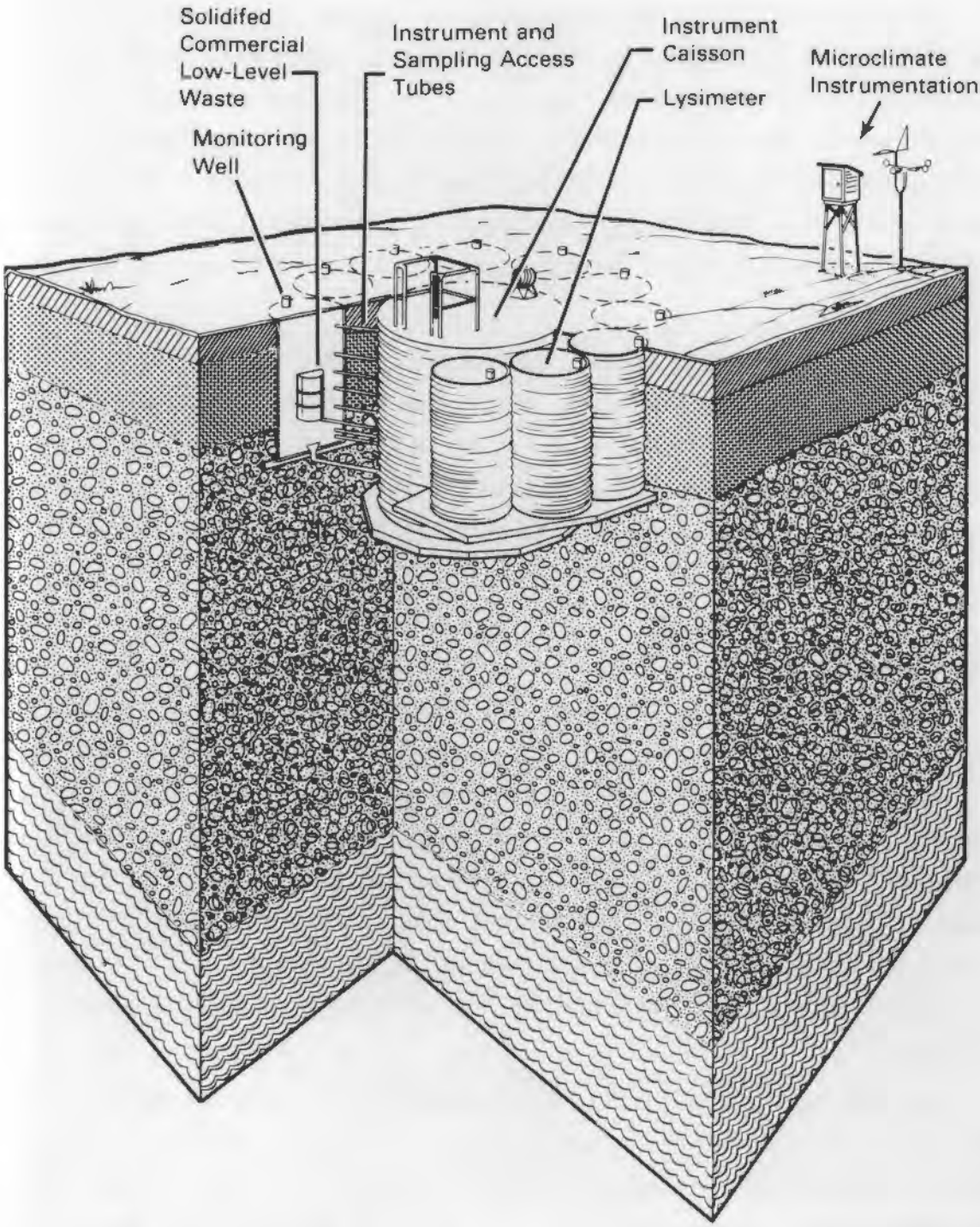

FIGURE 15. Conceptual Drawing of the Field Lysimeter Facility for the Special Waste Form Lysimeters-Arid Program

For this report, the water balance analysis was performed on two lysimeters at the SWLA facility. These lysimeters contain the same waste form type as used in the column leaching experiment. Stored water is calculated from monthly neutron probe measurements. Precipitation is taken from meteorological records, and drainage water is measured water that collects in the gravel layer at the bottom of the caissons. Evaporation is not measured directly but is calculated as the difference between precipitation and the sum of storage and drainage.

Storage and drainage are the two water balance components most directly related to leaching and transport. The water storage value describes the water content in the soil affecting dissolution and diffusion of contaminants. The drainage rate determines the convective flux of contaminants away from the burial zone. The water balance is controlled by hydraulic characteristics of the lysimeter soil.

SOIL CHARACTERISTICS

The soil used in the SWLA caissons is a composite of material found in the top 8 m of the site before construction began. In 1978 the site was excavated to a depth of 8 m to allow construction of the Buried Waste Test Facility (BWTF) (Phillips et al. 1979). This material was reexcavated for construction of the SWLA facility in 1983 (Walter, Graham and Gee 1984). Therefore, the material is essentially the same as that found in the BWTF, which is referred to as L-soil. The following comparison of SWLA soil and L-soil is used to show the soil characteristics important in the analysis of water storage and drainage.

The preconstruction soil profile consisted of approximately 30 cm of fine sand deposited mainly through wind action. This topsoil has never been officially classified but is thought to belong either to the Winchester or Quincy sand soil series. These soils are taxonomically classified as typical torripsament (i.e., a poorly developed, sandy soil found in a hot, dry climate). Below this thin topsoil were coarse sands and gravels deposited by catastrophic flooding of the area approximately 10,000 years ago. A transition zone of about 15 cm separated the two zones, with the flood deposits extending down

20 m to the water table. The mixture resulting from excavation is heavily weighted to the coarse flood sands but does contain some fines from the shallow surface material. The particle size for both the L-soil and the SWLA soil is shown in Table 6. Gravel found in the deep deposits was removed during back-filling; therefore, the sand fraction in both soil materials is relatively gravel free.

The soil water characteristic curve for L-soil and SWLA soil is shown in Figure 16. This figure is a plot of soil water content (m^3/m^3) versus soil matric potential (J/kg). The data points in Figure 16 represent average values of measurements taken on samples from the SWLA caissons (Walter, Graham and Gee 1984). The solid line represents data from samples of L-soil (Cass, Campbell and Jones 1981). Slight differences in the two curves may be explained by the different bulk densities used in making the measurements. The characteristic curve provides a measure of how tightly the soil can hold onto water, which in turn determines to what extent a soil will freely drain. A sandy soil will normally drain rapidly to approximately -10 J/kg. Drainage can continue beyond this point but will do so slowly. This potential generally corresponds to the bend or elbow in the soil water characteristic curve. If the soil drains to -10 J/kg, it will have a volumetric water content of less than 10%, which is why sandy soils are often described as having a "low water-holding capacity."

The saturated conductivity of 2×10^{-3} cm/s reported by Walter, Graham and Gee (1984) is also compatible with that reported for L-soil by Cass, Campbell and Jones (1981). This is a very high value of saturated conductivity and results from the coarse sand fraction. A phenomena that accompanies high

TABLE 6. Comparison of Particle-Size Distribution for Soil from Special Waste Form Lysimeter-Arid Field Facility and Buried Waste Test Facility

Soil	% Sand	% Silt	% Clay
SWLA	92	6	2
BWTF	91	7	2

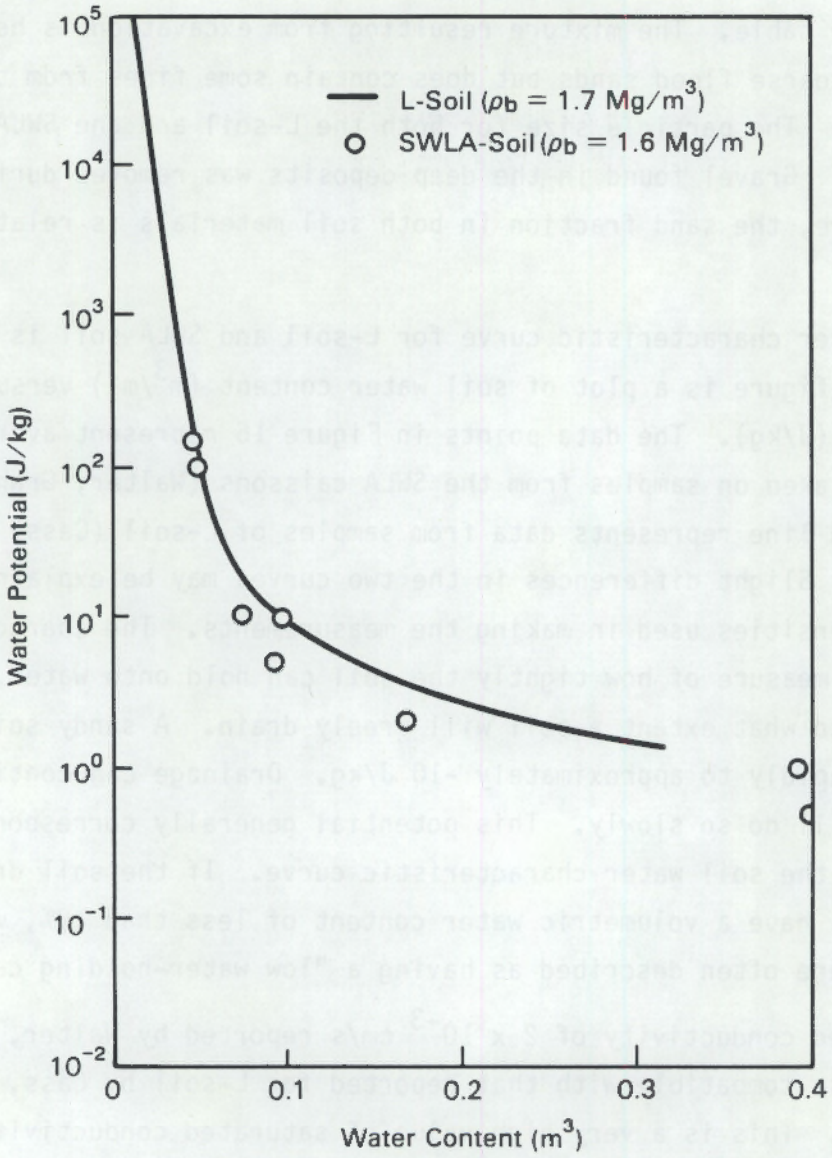

FIGURE 16. A Comparison of the Soil-Water Characteristic Curve for the Soil Material Found in the Buried Waste Test Facility (L-Soil) and the Special Waste Form Lysimeter Soil (SWLA-Soil)

saturated conductivity is a rapid reduction in conductivity as desaturation occurs. For example, the hydraulic conductivity is likely to be reduced by several orders of magnitude by the time the potential of -10 J/kg is reached.

The soil particle size, water characteristic curve, and conductivity data suggest that the SWLA soil has identical characteristics to those of the L-soil; therefore, the extensive soil characterization results found for L-soil

in Cass, Campbell and Jones (1981, 1984) will apply to the SWLA soil as well. These soil characteristics, which include low water-holding capacity, highly saturated conductivity, and low unsaturated conductivity, are significant in determining the soil water balance. Soil that is wet above the -10 J/kg value will tend to drain quickly and propagate the pulse of water deeper into the profile. However, in the absence of plant root extraction, the soil will not drain much below the -10 J/kg value, because of the rapid reduction in hydraulic conductivity. Therefore, it is expected that the SWLA caissons should exhibit a narrow range of water contents with all but the surface zone ranging between 6 to 12% volumetric water content.

LYSIMETER STORAGE AND DRAINAGE

Precipitation at the SWLA facility is typical of temperate-zone climates where the bulk of the water comes during winter months and a large percentage comes as snow. The precipitation rate can also vary significantly from year to year. The cumulative precipitation received from the time of burial of the waste forms in mid-March 1984 to April 1986 is shown in Figure 17. Note that 1984 was somewhat unusual because significant rains came in the spring and essentially no rain came in the fall. However, the expected precipitation occurred in January and February 1985. During the rapid melt of the February snow pack, lysimeters 8, 9, and 10 were temporarily flooded. During the second year, the facility received the usual distribution of winter precipitation with little water coming during the summer months.

Figure 18 shows the water storage record for lysimeters 3 and 9. These lysimeters contain BWR waste with ion-exchange resins solidified in Portland III cement. Three features from this data should be noted. First, although approximately 10 cm of precipitation came during the spring of 1984, none of that water shows up as storage detectable by the neutron probe. Some of this water must have been stored at least temporarily, but the neutron probe measurements are not sensitive to storage changes near the surface. Apparently, this water was reevaporated before being redistributed deeper into the caisson. In contrast, essentially all of the 10-cm precipitation during the

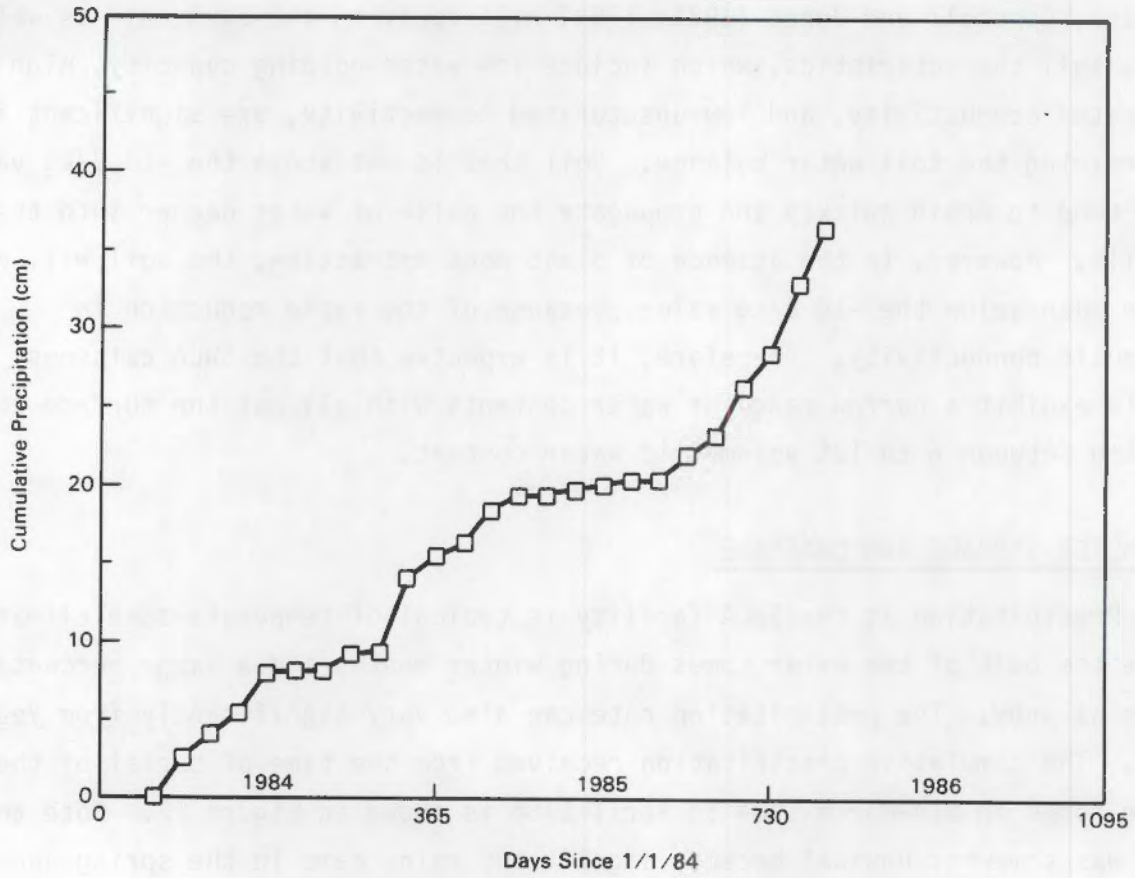

FIGURE 17 . Cumulative Precipitation at the Hanford Site Meteorological Station March 1984 Through April 1986

winter of 1985 was measured as a storage increase. This difference illustrates the response soils can have to summer and winter precipitation.

Figure 18 also shows the response of lysimeter 9 to flooding. Before flooding in February 1985, the storage characteristics of lysimeters 3 and 9 were essentially identical. During the flooding, lysimeter 9 shows a substantial jump in storage. The storage increase corresponds to an increase in average water content of 7 to nearly 12% volumetric water content. During the same time period, lysimeter 3 showed an increase to only 10% volumetric water content. However, the water content of lysimeter 9 returned very quickly to levels equal to those found in lysimeter 3. Within 2 weeks of flooding, the

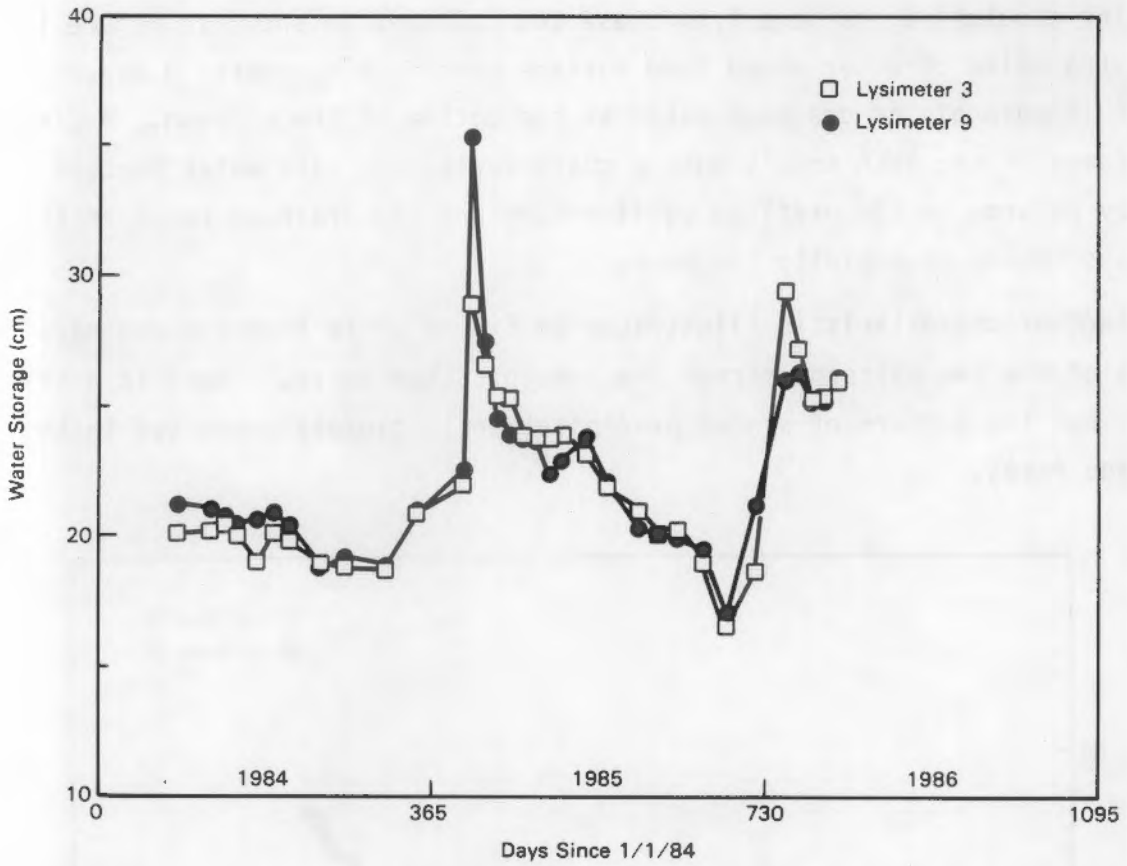

FIGURE 18. Comparison of Total Water Storage in Lysimeters 3 and 9 at the Special Waste Form Lysimeter-Arid Field Facility

water storage in both caissons was the same again. This quick response to added water may be explained by the correlation between the degree of soil saturation and hydraulic conductivity as discussed in the section on soil characteristics.

The pattern of storage changes throughout the rest of 1985 and early 1986 simply reflect the profiles' response to winter rain. Rapid storage increases occurred from November through February, followed by water losses by evaporation and drainage through the spring and summer. With the exception of periods of flooding, the fluctuations in storage correspond to a range in volumetric water content from 7 to 10%. Surface soils will cycle through wider ranges than these average subsurface moisture profile values.

The cumulative drainage from these two caissons is shown in Figure 19. The extra pulse of water added from surface runoff in lysimeter 9 appears almost immediately as drainage water at the bottom of the caisson. Again, this is because of the SWLA soil's unique characteristics. The water content quickly returns to its preflood equilibrium, and the drainage rates of the two caissons become essentially the same.

Another characteristic illustrated by Figure 19 is that the drainage curves of the two caissons mirror the precipitation curve. There is a phase shift, but the pattern of winter precipitation is closely preserved in the drainage rates.

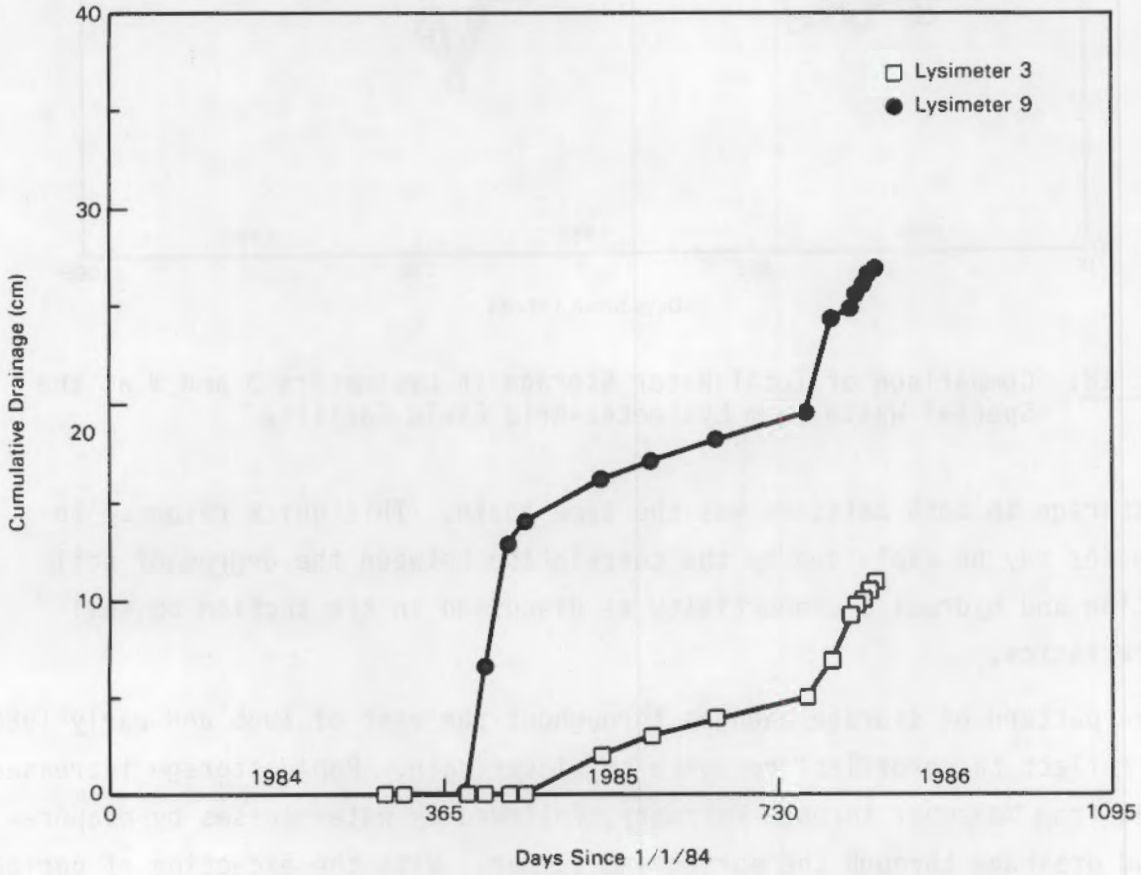

FIGURE 19. Comparison of Cumulative Drainage from Lysimeters 3 and 9 at the Special Waste Form Lysimeter-Arid Field Facility

WATER BALANCE AND LEACHING

Two characteristics of the caisson water balance that can have a direct effect on leaching and transport of the waste are the seasonal fluctuations in drainage rates and the relatively low (7 to 10% volumetric) water contents found year-around. The seasonal nature of the drainage results in high flow rates during the late winter and early spring. These high rates may tend to reduce solution concentrations of solutes that are released slowly from waste. On the other hand, these winter fluxes may remove solutes quickly enough to inhibit slow adsorption and precipitation reactions and thereby increase solution concentrations. Contaminants in solution during either drainage period will be moved rapidly to deeper parts of the profile if adsorption onto the soil is low.

During the late spring and summer, the flow of water past the waste form will be significantly reduced. During this period, solutes may diffuse away from the waste form as well as be carried away by the moving water. However, the low water content will severely reduce the diffusion of soluble species. The solution concentration around the waste form may build up all summer through dissolution and diffusion. Then these solutes will be swept away during winter drainage, leaving the process to begin again the following spring.

Finally, the highly dynamic and seasonal nature of drainage exhibited by these caissons is entirely dependent on the soil material used. This material is consistent with that found in many burial grounds at the Hanford site but may not be similar to other sites. If a finer-textured soil were used, the prominent seasonal fluctuations in these caissons would be damped out.

FIELD LYSIMETERS MONITORING

Since the waste forms were initially emplaced in March 1984, 8 of the 10 lysimeters have shown measurable breakthrough of ^{60}Co, while the other major constituents of the waste, $^{134,137}Cs$, ^{90}Sr, and ^{54}Mn have not reached the column bottom at detectable levels. The first sustained breakthrough of ^{60}Co in the lysimeter leachate occurred in L-9 at less than 1.5 lysimeter pore volumes (assuming drainage at 15% of saturation or 6 to 9% volumetric water

content). This early breakthrough was predicted by the results of the combined column leaching-adsorption experiments where ^{60}Co was present in the effluent at 0.83 PV.

Duplicate lysimeter pairs (3, 9), (2, 8) and (4, 10) show detectable levels of ^{60}Co in at least 3 and up to 7 samples (Table 7). All six lysimeters contain waste forms made from BWR wastes. Two of the boric acid waste lysimeters show no detectable radionuclides, while two others have small concentrations beginning to appear. The largest mass of ^{60}Co eluted to date came from lysimeter pair 3 and 9, which contain evaporator concentrate and resin beads solidified in Portland III cement (Figure 20). Brookhaven National Laboratory reported that these waste forms each contained about 2×10^5 μCi of ^{60}Co. The next largest mass of ^{60}Co eluted to date comes from lysimeter pair 2 and 8,

TABLE 7. Concentration of Cobalt-60 in Field Lysimeter Leachate ($\mu Ci/L \times 10^{-7}$)

Lysimeter	Waste Form	Cobalt-60 Concentration ($\mu Ci/L \times 10^{-7}$)								
		1/85	2/85	3/85	6/85	10/85	1/86	4/86	6/86	7/86
1	BA/MC	-	-	-	-	-	-	-	-	-
2	EVP/PC	-	-	-	-	242	6.4	419	589	1320
3	EVP + R/PC	-	-	-	-	17.0	866	891	1690	1950
4	EVP + R/VES	-	-	5.5	38	3.5	549	280	247	233
5	BA/Bit	-	-	-	-	-	-	-	2.9	-
6	BA/Bit	-	-	-	-	-	-	-	-	-
7	BA/MC	-	-	-	-	-	-	-	2.9	3.3
8	EVP/PC	-	-	5.5	23.6	195	444	523	940	1200
9	EVP + R/PC	-	16.7	23.3	-	1200	1880	1020	1730	3330
10	EVP + R/VES	4.1	5.5	-	-	-	-	1.4	19.9	14.4

BA/MC = Boric acid waste in masonry cement.
EVP/PC = Evaporator concentrate in Portland III cement.
EVP + R/PC = Evaporator concentrate and ion-exchange resins in Portland III cement.
EVP + R/VES = Evaporator concentrate and ion-exchange resins in vinyl ester-styrene.
BA/Bit = Boric acid waste in bitumen.

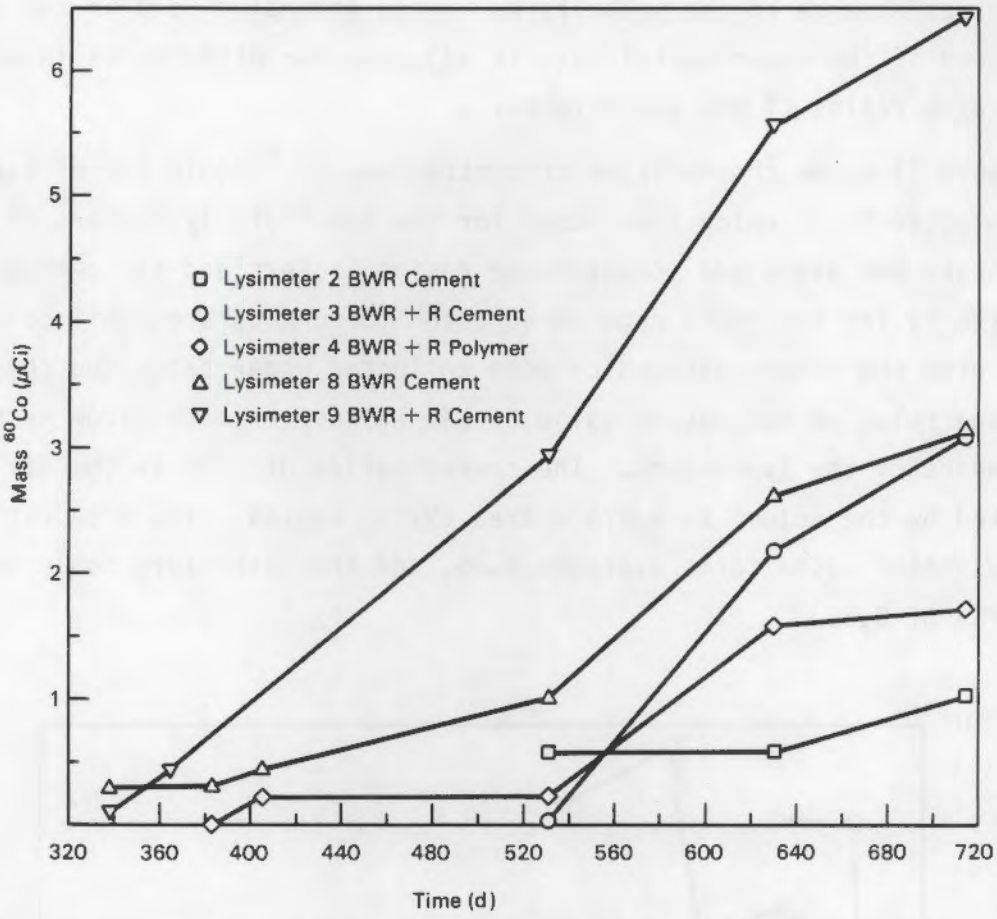

FIGURE 20. Cumulative Cobalt-60 Release in Field Lysimeters (BWR = Boiling Water Reactor)

which contain only evaporator concentrate (4.5×10^3 μCi of ^{60}Co) solidified in Portland cement. The third lysimeter pair, 4 and 10, contain BWR evaporator concentrate and resin wastes solidified in vinyl ester-styrene. Brookhaven National Laboratory reported the total inventory of ^{60}Co in these two polymer waste forms to be 4 to 5×10^4 μCi.

The four lysimeters that show slower or no radionuclide release to date contain two different PWR boric acid waste. Lysimeter pair 1 and 7 contain masonry cement with a total inventory of 5×10^2 μCi of ^{60}Co and lysimeter pair 5 and 6 contain bitumen with a total inventory of 1.2×10^3 μCi of ^{60}Co per barrel.

The performance of the waste forms in the laboratory and in the field can be compared if the experimental data is adjusted for differences in volume-to-surface-area ratios of the waste forms.

Figure 21 shows the relative concentrations of ^{60}Co in the effluent and the cumulative PV at which they occur for the two field lysimeters (3 and 9) that contain BWR waste and ion-exchange resins in Portland III cement. The cumulative PV for the field data is adjusted for unsaturated soil conditions to compare with the column data which were collected under saturated conditions. An average relative saturation value of 15% was approximated from neutron probe measurements of the lysimeters. The concentration of ^{60}Co in the effluent is multiplied by the volume to surface area (V/SA) ratios. The V/SA ratio of the field lysimeter waste forms averages 4.35, and the laboratory scale waste forms had a V/SA of 0.5.

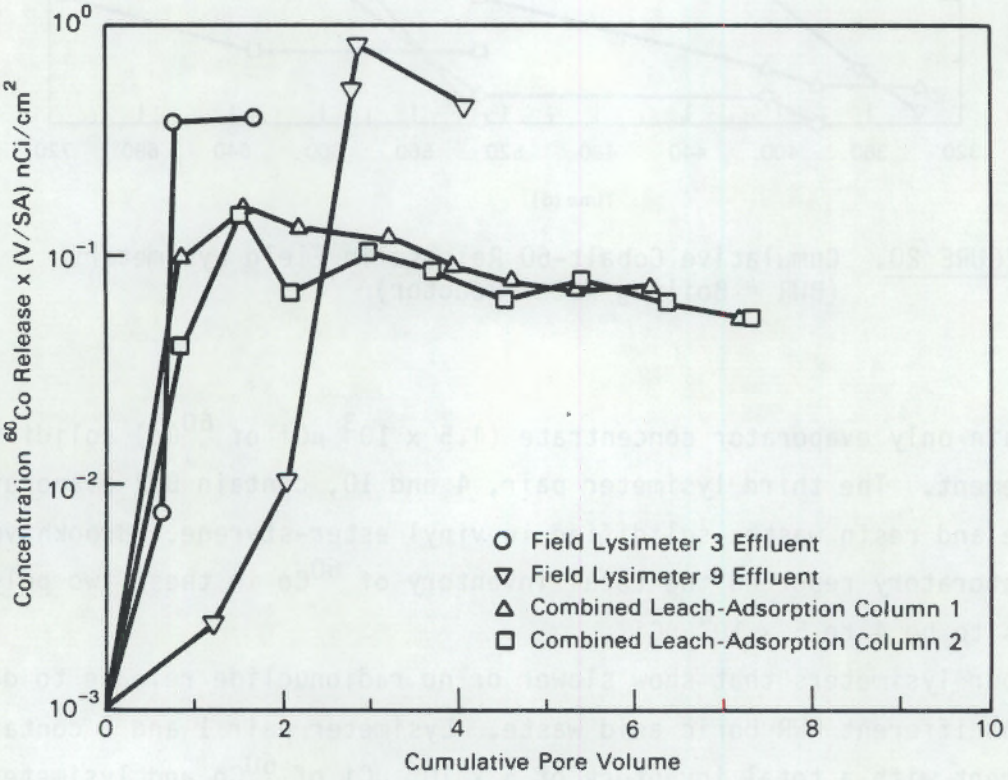

FIGURE 21. Concentration Cobalt-60 Leached Normalized to Surface Area Versus Pore Volume

Varied flow rates may be responsible for the differences in the effluent curves in Figure 21. Lysimeter 9, which was flooded, may have experienced a higher flow rate than lysimeter 3, producing both higher cumulative pore volume and peak concentration in the effluent. Differences between the field lysimeter curves and the leach-adsorption column curves could be attributed to seasonal fluctuations in lysimeter flow rates or by changes in saturation values between soil moisture measurements.

Continued field lysimeter monitoring will provide additional data to compare with the laboratory ^{60}Co-released data that will aid in the evaluation of the use of laboratory leach-adsorption tests to predict the performance of solidified waste forms under actual burial conditions.

Subsamples of the leachate collected at the bottom of the 10 lysimeters were submitted for total chemical analysis (Appendix D). Table 8 shows that the leachates in all the lysimeters remain near the ambient pH of 8.1 ± 0.3. All of the first samples appear to have elevated concentrations of total organic carbon and fluoride. Except perhaps for sample 4/86 of lysimeter 4, no other samples taken at later time periods clearly show elevated total organic carbon (TOC) contents. No other samples show elevated fluoride contents. The original TOC measurements were performed by an inexperienced operator on an instrument that was later found to be inefficiently sparging inorganic carbon from the samples. Thus, the analyses of TOC actually were biased high by inclusion of inorganic carbon. No explanation is offered for the apparent high fluoride content in the first sample from each lysimeter.

With continued sampling, significant increases in sulfate, magnesium, sodium and nitrate were observed in six lysimeters (2, 3, 4, 8, 9, and 10). The other four lysimeters showed significant increases in nitrate and moderate to no increase in sulfate, magnesium, and sodium.

The laboratory columns, where waste forms are packed in sediment, also show elevated levels of these constituents in the effluents. The tests using blank cement waste forms packed in soil with ground water percolating through the soil do not show elevated leachate concentrations of the constituents

TABLE 8. Lysimeter Leachate Chemical Analysis

Lysimeter	Date of Sampling	pH	TOC, ppm	Fluoride, mg/L	Magnesium, mg/L	Sulfate, mg/L	Sodium, mg/L	Nitrate, mg/L
1	10/84	8.34	124.4	9.20	11.02	60.3	127.0	0.3
	3/85	8.27		<1.00	22.20	95.0	31.2	246.0
	10/85	8.24		<1.00	23.70	68.0	37.0	296.0
	1/86	8.16		<1.00	31.50	65.0	33.0	435.0
	4/86	8.29	7.2	<1.00	18.50	39.0	17.0	32.0
2	10/84	8.25	242.4	12.10	9.92	45.3	168.0	0.3
	3/85	8.30		<1.00	11.50	81.0	64.1	136.0
	6/85	8.34		<1.00	20.80	90.0	25.1	179.0
	10/85	8.32		<1.00	66.00	960.0	131.0	128.0
	1/86	8.22		1.00	91.00	1400.0	240.0	167.0
	4/86	8.20	32.5	<1.00	70.70	1100.0	241.0	23.0
3	10/84	8.05	130.6	14.30	7.67	111.0	106.0	0.3
	3/85	8.14		<1.00	11.30	74.0	32.4	109.0
	6/85	8.33		<1.00	16.30	70.0	22.0	101.0
	10/85	8.12		<1.00	70.00	1060.0	120.0	35.0
	1/86	8.23		<1.00	92.00	1530.0	245.0	84.0
	4/86	8.06	53.2		94.00	1900.0	405.0	22.0
4	10/84	8.12	343.4	25.40	18.61	90.7	266.0	0.3
	3/85	8.26		4.10	44.90	108.8	105.0	108.0
	6/85	8.39		<1.00	42.80	104.0	34.0	104.0
	10/85	8.00		<1.00	61.50	690.0	99.0	52.0
	1/86	8.15		1.30	135.00	2230.0	430.0	128.0
	4/86	8.06	195.0	<1.00	45.00	740.0	261.0	14.0
5	10/85	7.93		<1.00	10.50	79.0	53.0	73.0
	1/86	8.23		<1.00	16.00	104.0	38.0	170.0
	4/86	8.05	6.1	<1.00	14.20	29.0	20.0	15.0
6	10/84	7.64	14.7	<1.00	20.72	69.0	71.4	52.3
	10/85	8.21		<1.00	21.00	56.0	40.0	118.0
	1/86	8.10		<1.00	20.00	61.0	34.0	158.0
	4/86	8.04	6.4	<1.00	18.20	34.0	19.0	25.0
7	10/84	8.19	186.9	17.20	16.21	216.0	130.0	0.3
	3/85	8.08		<1.00	15.70	132.0	65.8	181.0
	6/85	8.46		<1.00	21.10	90.0	29.7	184.0
	10/85	8.02		<1.00	21.00	65.0	32.0	240.0
	1/86	8.07		<1.00	22.00	64.0	31.0	260.0
	4/86	8.07	9.6	<1.00	13.20	36.0	18.0	19.0
8	10/84	7.73	181.9	13.10	16.04	181.0	153.0	0.2
	3/85	7.78		<1.00	21.40	195.0	21.8	88.0
	6/85	8.37		<1.00	21.10	187.0	21.3	57.0
	10/85	8.19		<1.00	61.00	955.0	113.0	9.0
	1/86	8.21		<1.00	81.00	1300.0	193.0	49.0
	4/86	8.00	33.3	<1.00	72.00	1100.0	207.0	14.0
9	10/84	7.93	212.0	24.50	19.62	261.0	110.0	0.3
	3/85	8.01		<1.00	16.40	95.0	17.8	112.0
	6/85	8.32		<1.00	20.30	171.0	21.9	71.0
	10/85	8.22		<1.00	57.00	915.0	196.0	50.0
	1/86	8.36		<1.00	88.00	1360.0	253.0	123.0
	4/86	8.26	74.2	<1.00	96.50	1800.0	486.0	11.0
10	3/85	8.24		<1.00	10.40	20.0	10.6	28.0
	10/85	8.24		<1.00	13.40	80.0	36.0	<5.00
	1/86	8.26		<1.00	16.80	148.0	35.0	6.5
	4/86	8.18	5.1	<1.00	20.30	160.0	32.0	5.4
Hanford Site Ground Water		8.1	1.0	<1.00	14.4	86	25	0.1

TOC = Total organic carbon.

listed above. Thus, the source of these elevated concentrations must be the liquid wastes that are solidified into the various waste forms.

An unexplainable factor, requiring further study, is that the combined leach-adsorption laboratory experiments (using BWR-evaporator concentrate and resin bead waste solidified in Portland cement) do not show the elevated NO_3 levels in the effluent solutions that are found in the field lysimeters. As the columns contain less soil per surface area or volume of waste form, trends in the field lysimeters are expected to be intensified in the laboratory columns.

The laboratory effluent data show that waste form leaching can push the pore water pH to high alkaline values. The field lysimeter leachates' pH values remain near ambient, probably because the ratio of soil volume to the surface area or the volume of the waste forms is much higher than that in the laboratory tests. This could prove to be an important factor considering the role pH played in precipitation of minerals in the column experiments.

The lysimeter leachates sampled recently on April 25, 1986, suggest that the concentrations of nitrate, sodium, sulfate, and magnesium are dropping. Further investigations will identify if this is a seasonal event tied to the volume of water reaching the bottom of the lysimeter or whether we have observed the early peak release that occurs in the laboratory columns. Lysimeters 5 and 6 also show higher-than-ambient boron values in the last sample analyzed. Monitoring will continue to see if boron can act as a good indicator of mobile constituent migration from solidified boric acid wastes.

CONCLUSIONS AND RECOMMENDATIONS

This research was conducted to evaluate the performance (release and migration of contaminants) of solidified low-level waste in an arid near-surface disposal site. Laboratory experiments performed on small-scale waste forms provided the information needed to interpret the data collected from the field leaching facility and demonstrated the ability of laboratory experiments to predict the performance of waste forms under field conditions. These experiments also enabled us to take the first steps toward understanding the mechanisms controlling the release and migration of radionuclides from solidified waste forms.

The results of the batch leaching experiment indicate $^{134,137}Cs$ were readily released from the cement waste forms. A much smaller but more mobile fraction (1%) of the available ^{60}Co was also leached. Waste forms contacted with HGW released ^{137}Cs and ^{60}Co at nearly the same rate as those leached in deionized water at BNL. The difference in leaching rates of readily leachable radionuclides, such as ^{137}Cs, between ground water and deionized water may be negligible.

The soil column adsorption experiment provided a soil adsorption profile for $^{134,137}Cs$ and ^{85}Sr that shows strong binding of these radionuclides to the Hanford site sediment and little or no adsorption of ^{60}Co. The sawtooth effluent curves generated in this test may indicate identifiable adsorption/desorption characteristics of ^{60}Co associated with species changes of complexed ^{60}Co in contact with soil. Further tests are necessary to confirm these results.

The results of the combined leach/adsorption test effectively predicted the breakthrough of ^{60}Co observed in the field lysimeter facility for those waste forms tested. This laboratory test showed that the leached ^{60}Co had a small distribution coefficient (Kd) with some fraction of the ^{60}Co moving at the same rate as water. The soil column model predicted a Kd of 0.5, which appears to correspond with the laboratory results and field observations. This low Kd value suggests that the ^{60}Co is complexed with organic compounds that have increased its mobility. Organic analysis of the leachate would be

required to identify the specific form(s) of the complexed ^{60}Co. Identification of these forms could lead to greater understanding of the release and transport of other radionuclides under actual burial conditions.

All three of the laboratory experiments show that the release and transport of radionuclides peaked shortly after being contacted with water and then dropped to much lower levels. Continued monitoring of the field lysimeters will tell us if this is true under actual burial conditions. This could be important when determining what source term concentrations should be used to project the future release of radionuclides to the environment.

Using the MINTEQ geochemical computer code, we identified plausible solid phases that could be controlling some of the chemical and radionuclide concentrations in the leachate. At higher pH (values above approximately 10), magnesium precipitated primarily as brucite [$Mg(OH)_2$] and calcium precipitated as calcium carbonate ($CaCO_3$). Cobalt hydroxide [$Co(OH)_2$] may act as a solubility control at the high pH values observed. At pH values less than approximately 10, where the soil is an active buffer, magnesium and strontium are precipitating as carbonates ($MgCO_3$ and $SrCO_3$), while calcium remains oversaturated with respect to calcite or is forming a mixed carbonate with magnesium that has higher solubility than calcite. Carbonates are important because they influence the release of strontium, calcium, and magnesium. The fate of calcium can influence the release of ^{90}Sr and ^{60}Co because they may substitute for calcium in the cement matrix. These results demonstrate the importance of pH in precipitation processes and, therefore, in the release and transport of ^{60}Co and ^{90}Sr. The concentration of ^{60}Co in the field lysimeter leachate, collected to date, is higher than what was predicted from the effluent concentrations observed in the leach-adsorption experiment (Figure 21). This may be attributed to the effect of the lower pH found in the field lysimeters.

Several conclusions may be drawn from the data collected from the field lysimeters, even though fewer than five pore volumes of leachate have been collected to date. The first breakthrough of ^{60}Co occurred in the six lysimeters containing BWR waste, with the earliest breakthrough and highest concentrations of ^{60}Co occurring in the lysimeters containing the greatest concentration of

^{60}Co. Waste forms containing smaller inventories released smaller concentrations of ^{60}Co, with breakthrough occurring later.

The immediate breakthrough of a small portion of ^{60}Co in the laboratory experiments (both column adsorption using ANS 16.1 leachates and the combined waste form-sediment column contacted with HGW) will require further study. Past studies with ^{60}Co tracer suggest that cobalt is readily adsorbed. Other studies have shown that ^{60}Co complexed to organic chelating agents can be quite mobile and exhibit little adsorption tendencies. Thus, ^{60}Co speciation is extremely important to determine its migration potential. This project should attempt to identify the ^{60}Co species that is mobile. From this knowledge, we should estimate what other radionuclides present in low-level waste might form similar mobile species.

More laboratory experiments should be performed to study the stability of the mobile species in ground water percolating through soils and to identify what variables affect the stability of the mobile species. Adsorption tests should be developed to study multiple species adsorption because the batch Kd method averages all species and treats the results as a gross average. Breakthrough curves predicted from Kd theory do not satisfactorily predict actual soil column effluents. Some effort should be spent to develop more sophisticated codes that consider multiple species with different adsorption tendencies.

Finally, the field lysimeter tests should be carefully monitored to identify whether the concentrations in the effluents have peaked or are still rising. The lysimeter facility should continue to be monitored for several years to study whether seasonal changes dramatically change migration when compared to the more controlled and stable laboratory tests.

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APPENDIX A

BATCH LEACHING CHEMICAL AND RADIONUCLIDE RESULTS

APPENDIX A

BATCH LEACHING CHEMICAL AND RADIONUCLIDE RESULTS

This appendix contains ANS 16.1 Chemistry Data, ANS 16.1 Radionuclide Data, and BNL 16.1 Radionuclide Data tables. All units in the chemistry tables are in mg/L unless otherwise noted. Diffusivity is in cm^2/s. Eh is in mV. TC = Total Carbon; TOC = Total Organic Carbon; and C/CO = concentration/initial concentration.

ANS 16.1 CHEMISTRY DATA--WASTE FORM 1

Sample Number	Time (days)	pH	Eh	ALKALINITY AS CO3	TC	TOC	Al
1	0.00035	8.81	283	97.20	36.9	1.7	<.03
2	0.08330	9.40	336	142.56	31.5	14.8	<.03
3	0.25000	10.72	361	132.84	31.0	10.5	<.03
4	1.00000	11.59	350	165.24	33.4	17.1	<.03
5	2.00000	11.40	332	165.24	36.4	15.6	<.03
6	3.00000	10.98	336	139.32	31.5	10.9	<.03
7	4.00000	10.69	359	126.36	32.6	9.5	<.03
8	7.00000	11.11	259	223.56	45.9	23.4	<.03
9	14.00000	11.19	263	401.76	70.7	47.9	<.03
10	21.00000	12.13	300	352.80	105.8	37.7	<.03
11	28.00000	11.31	383	277.20	53.0	33.1	<.03
12	35.00000	11.67	336	207.90	68.9	44.4	<.03

Sample Number	As	B	Ba	Be	Ca	Cd	Ce
1	0.0219	0.1574	0.0559	0.003	58.8480	<.05	<.06
2	<.02	0.0938	0.0284	<.002	35.8260	<.05	<.06
3	<.02	0.0787	0.0336	<.002	38.0260	<.05	<.06
4	<.02	0.0776	0.0139	<.002	15.0860	<.05	<.06
5	<.02	0.1173	0.0119	<.002	13.2170	<.05	<.06
6	<.02	0.0857	0.0167	<.002	18.8010	<.05	<.06
7	<.02	0.0821	0.0193	<.002	18.4060	<.05	<.06
8	<.02	0.0577	0.0082	<.002	7.6922	<.05	<.06
9	<.02	0.0933	0.0070	<.002	4.6637	<.05	<.06
10	<.02	0.0803	0.0104	<.002	6.9144	<.05	<.06
11	<.02	0.0814	0.0046	<.002	2.9139	<.05	0.0801
12	<.02	0.0572	0.0057	<.002	6.4507	<.05	<.06

Sample Number	Cr	Cu	Dy	Fe	Gd	K	La
1	0.0588	<.005	<.005	<.005	<.03	8.0927	<.005
2	<.015	<.005	<.005	<.005	<.03	21.3450	<.005
3	<.015	<.005	<.005	<.005	<.03	19.5550	<.005
4	<.015	<.005	<.005	<.005	<.03	26.6250	<.005
5	0.0206	<.005	<.005	<.005	<.03	25.7930	<.005
6	<.015	<.005	<.005	0.0109	<.03	20.4420	<.005
7	<.015	<.005	<.005	<.005	<.03	18.4150	<.005
8	<.015	<.005	<.005	<.005	<.03	31.6880	<.005
9	0.0166	<.005	<.005	<.005	<.03	48.7780	<.005
10	<.015	<.005	<.005	<.005	<.03	36.0790	<.005
11	<.015	<.005	<.005	<.005	<.03	28.8730	0.0055
12	<.015	<.005	<.005	0.0070	<.03	21.5010	<.005

ANS 16.1 CHEMISTRY DATA--WASTE FORM 1

Sample Number	Li	Mg	Mn	Mo	Na	Nd	Ni
1	0.0104	14.86400	<.005	0.2950	33.673	<.06	<.02
2	0.0204	7.81780	<.005	0.1268	139.390	<.06	<.02
3	0.0198	7.81780	<.005	0.1091	121.990	<.06	<.02
4	0.0250	4.52700	<.005	0.1141	187.720	<.06	<.02
5	0.0296	4.94420	<.005	<.01	181.740	<.06	<.02
6	0.0206	8.06220	<.005	0.0584	136.750	<.06	<.02
7	0.0185	10.83400	<.005	0.1419	121.710	<.06	<.02
8	0.0329	1.62180	<.005	0.0209	225.380	<.06	<.02
9	0.0669	0.00000	<.005	0.0326	384.780	<.06	<.02
10	0.0630	0.02910	<.005	0.0266	299.040	<.06	<.02
11	0.0643	0.01587	<.005	0.0198	266.170	<.06	<.02
12	0.0583	0.26190	<.005	0.0190	228.940	<.06	<.02

Sample Number	P	Pb	Ru	S	Sb	Se	Si
1	<.1	<.05	<.05	32.391	<.01	<.2	16.7540
2	1.5125	<.05	<.05	57.076	<.01	<.2	14.4580
3	1.1138	<.05	<.05	49.636	<.01	<.2	14.2180
4	1.4657	<.05	<.05	57.506	<.01	<.2	12.4880
5	1.2339	<.05	<.05	58.489	<.01	<.2	12.8580
6	0.7850	<.05	<.05	47.573	<.01	<.2	14.2380
7	0.7327	<.05	<.05	44.687	<.01	<.2	15.2380
8	1.6883	<.05	<.05	53.568	<.01	<.2	10.6660
9	3.4021	<.05	<.05	78.590	<.01	<.2	9.5029
10	2.5611	<.05	<.05	56.070	<.01	<.2	8.9185
11	2.4718	<.05	<.05	49.253	<.01	0.2386	8.9329
12	3.1999	<.05	<.05	49.664	<.01	<.2	8.3160

Sample Number	Sm	Sn	Sr	Te	Ti	V	Zn
1	<.05	<.05	0.26570	<.15	0.0085	0.0207	0.1882
2	<.05	<.05	0.26270	<.15	<.005	<.005	<.005
3	<.05	<.05	0.26700	<.15	<.005	<.005	<.005
4	<.05	<.05	0.16640	<.15	<.005	<.005	<.005
5	<.05	<.05	0.15550	<.15	<.005	<.005	<.005
6	<.05	<.05	0.15630	<.15	<.005	<.005	<.005
7	<.05	<.05	0.01541	<.15	<.005	<.005	<.005
8	<.05	<.05	0.15230	<.15	<.005	<.005	<.005
9	<.05	<.05	0.27870	<.15	<.005	<.005	<.005
10	<.05	<.05	0.27610	<.15	<.005	<.005	0.0169
11	0.0526	<.05	0.20230	<.15	<.005	0.0062	<.005
12	<.05	<.05	0.22390	<.15	<.005	<.005	0.0000

ANS 16.1 CHEMISTRY DATA--WASTE FORM 1

Sample Number	Zr	F-	Cl-	NO3-	SO4--	NO2-
1	0.0275	<1.1	24.9	<.3	81	<.1
2	<.01	<1.1	24.9	<.3	153	<.1
3	<.01	<1.1	24.9	<.3	128	<.1
4	<.01	<1.1	24.9	<.3	153	<.1
5	0.0140	<1.1	24.9	<.3	153	<.1
6	<.01	<1.1	24.9	<.3	128	<.1
7	<.01	<1.1	23.5	<.3	115	<.1
8	<.01	<1.3	28.0	<1	216	<.4
9	0.0125	<1.3	27.3	<1	243	<.4
10	0.0148	<5	20.9	<10	175	<3
11	<.01	<3	14.0	<1	104	<.4
12	<.01	<3	13.6	<1	107	<.4

ANS 16.1 CHEMISTRY DATA--WASTE FORM 2

SAMPLE NUMBER	TIME (DAYS)	pH	Eh	ALKALINITY AS CO3	TC	TOC	Al
1	0.00035	8.73	342	97.20	31.4	1.0	<.03
2	0.08330	8.53	347	155.52	31.8	15.1	<.03
3	0.25000	8.93	363	90.72	28.0	8.5	<.03
4	1.00000	10.88	354	97.64	36.8	19.8	<.03
5	2.00000	10.25	342	181.44	38.8	16.0	<.03
6	3.00000	10.00	363	149.04	31.9	10.4	<.03
7	4.00000	10.14	358	136.08	32.8	8.8	<.03
8	7.00000	10.68	224	230.04	46.2	21.5	<.03
9	11.40000	11.85	263	486.00	74.9	46.7	<.03
10	21.00000	11.90	306	352.80	160.3	36.6	<.03
11	28.00000	11.84	324	308.70	87.1	63.8	<.03
12	35.00000	11.32	342	201.60	89.9	61.5	<.03

SAMPLE NUMBER	As	B	Ba	Be	Ca	Cd	Ce
1	<.02	0.0880	0.0557	<.002	58.1730	<.005	<.06
2	<.02	0.0718	0.0393	<.002	44.5670	<.005	<.06
3	<.02	0.0660	0.0380	<.002	40.4590	<.005	<.06
4	<.02	0.0660	0.0241	<.002	24.4090	<.005	<.06
5	<.02	0.0657	0.0181	<.002	19.3390	<.005	<.06
6	<.02	0.0622	0.0205	<.002	23.7750	<.005	<.06
7	<.02	0.0610	0.0196	<.002	22.5310	<.005	<.06
8	<.02	0.0612	0.0076	<.002	7.6110	<.005	<.06
9	0.0264	0.0841	0.0027	<.002	1.7688	<.005	<.06
10	<.02	0.0722	0.0053	<.002	2.4977	<.005	<.06
11	<.02	0.0697	0.0040	<.002	4.4731	<.005	<.06
12	<.02	0.0572	0.0078	<.002	7.2347	<.005	<.06

SAMPLE NUMBER	Cr	Cu	Dy	Fe	Gd	K	La
1	<.015	<.005	<.005	<.005	<.03	8.0776	<.005
2	<.015	<.005	<.005	0.0097	<.03	20.6830	<.005
3	<.015	<.005	<.005	<.005	<.03	18.1710	<.005
4	<.015	<.005	<.005	<.005	<.03	28.4750	<.005
5	<.015	<.005	<.005	<.005	<.03	26.4020	<.005
6	<.015	<.005	<.005	<.005	<.03	20.5340	<.005
7	<.015	<.005	<.005	<.005	<.03	18.6130	<.005
8	<.015	<.005	<.005	<.005	<.03	31.5810	<.005
9	0.0182	<.005	<.005	<.005	<.03	48.7630	<.005
10	0.0171	<.005	<.005	<.005	<.03	37.1880	<.005
11	0.0175	<.005	<.005	<.005	<.03	30.5730	<.005
12	<.015	<.005	<.005	<.005	<.03	20.0890	<.005

ANS 16.1 CHEMISTRY DATA--WASTE FORM 2

SAMPLE NUMBER	Li	Mg	Mn	Mo	Na	Nd
1	0.0068	14.9400	<.005	0.1121	32.468	<.06
2	0.0188	9.5531	<.005	0.1150	133.610	<.06
3	0.0172	9.3384	<.005	0.1082	115.240	<.06
4	0.0277	5.1712	<.005	0.1170	206.590	<.06
5	0.0254	6.2243	<.005	0.1661	189.060	<.06
6	0.0174	7.7628	<.005	0.1651	140.060	<.06
7	0.0159	9.0781	<.005	0.1721	124.290	<.06
8	0.0324	3.6565	<.005	0.0193	225.620	<.06
9	0.0659	0.0500	<.005	0.0318	389.780	<.06
10	0.0665	0.1571	<.005	0.0324	314.310	<.06
11	0.0709	0.5215	0.8674	<.01	306.730	<.06
12	0.0623	3.1849	<.005	0.0141	222.970	<.06

SAMPLE NUMBER	Ni	P	Pb	Ru	S	Sb	Se	Si
1	<.06	0.1367	<.05	<.05	31.345	<.1	<.2	16.6470
2	<.06	1.5724	<.05	<.05	56.517	<.1	<.2	15.0990
3	<.06	1.0446	<.05	<.05	48.589	<.1	<.2	14.7780
4	<.06	1.7128	<.05	<.05	66.049	<.1	<.2	13.7370
5	<.06	1.3185	<.05	<.05	60.489	<.1	<.2	13.7510
6	<.06	0.8756	<.05	<.05	46.809	<.1	<.2	16.9400
7	<.06	0.7045	<.05	<.05	43.710	<.1	<.2	14.4540
8	<.06	1.6005	<.05	<.05	51.228	<.1	<.2	12.2350
9	<.06	3.2859	<.05	<.05	80.722	<.1	<.2	9.7923
10	0.0024	2.4389	<.05	<.05	60.195	<.1	<.2	9.4938
11	<.06	4.8248	<.05	<.05	74.877	<.1	<.2	9.8935
12	<.06	5.2673	<.05	<.05	61.295	<.1	<.2	10.0520

SAMPLE NUMBER	Sm	Sn	Sr	Te	Ti	V	Zn	Zr
1	<.05	<.05	0.25960	<.15	<.005	<.005	<.005	<.01
2	<.05	<.05	0.28750	<.15	<.005	<.005	<.005	<.01
3	<.05	<.05	0.25560	<.15	<.005	<.005	<.005	<.01
4	<.05	<.05	0.02086	<.15	<.005	<.005	<.005	<.01
5	<.05	<.05	0.17990	<.15	<.005	<.005	<.005	<.01
6	<.05	<.05	0.16680	<.15	<.005	<.005	<.005	<.01
7	<.05	<.05	0.15590	<.15	<.005	<.005	<.005	<.01
8	<.05	<.05	0.14660	<.15	<.005	<.005	<.005	<.01
9	<.05	<.05	0.22740	<.15	<.005	<.005	<.005	<.01
10	<.05	<.05	0.19110	<.15	<.005	<.005	0.0167	<.01
11	<.05	<.05	0.29140	<.15	<.005	<.005	<.005	<.01
12	<.05	<.05	0.23080	<.15	<.005	<.005	<.005	<.01

ANS 16.1 CHEMISTRY DATA--WASTE FORM 2

SAMPLE NUMBER	F-	Cl-	NO3-	SO4--	NO2-
1	<1.1	24.9	<.3	83	<.1
2	<1.1	26.4	<.3	160	<.1
3	<1.1	27.9	<.3	134	<.1
4	<1.1	26.4	<.3	192	<.1
5	<1.1	26.4	<.3	134	<.1
6	<1.1	24.9	<.3	128	<.1
7	<1.1	24.9	<.3	115	<.1
8	<1.3	27.1	<1	194	<.4
9	<1.3	27.1	<1	250	<.4
10	<5	23.8	<10	210	<3
11	<3	14.3	<1	160	<.4
12	<3	14.0	<1	140	<.4

ANS 16.1 CHEMISTRY DATA--BLANK WASTE FORM

SAMPLE NUMBER	TIME (DAYS)	pH	Eh	ALKALINITY AS CO3	TC	TOC	Al
1	0.00035	8.75	333	93.96	27.7	0.9	<.03
2	0.08330	10.07	346	97.20	13.4	0.6	<.03
3	0.25000	9.62	365	61.56	13.9	0.7	<.03
4	1.00000	10.46	358	77.76	12.2	0.7	<.03
5	2.00000	9.78	357	77.76	21.0	0.5	<.03
6	3.00000	9.25	368	68.04	25.3	0.7	<.03
7	4.00000	8.73	373	74.52	29.0	0.7	<.03
8	7.00000	8.75	323	74.52	28.5	0.8	<.03
9	11.40000	8.60	285	71.28	27.9	0.6	<.03
10	21.00000	8.69	327	75.60	28.3	0.4	<.03
11	28.00000	8.58	345	75.60	29.6	0.7	<.03
12	35.00000	8.58	363	88.20	24.4	0.4	<.03

SAMPLE NUMBER	As	B	Ba	Be	Ca	Cd
1	0.0315	0.1343	0.0572	0.0024	57.602	<.005
2	<.02	0.0880	0.0386	<.002	41.378	<.005
3	0.0254	0.0833	0.0409	<.002	41.739	<.005
4	0.0222	0.0822	0.0216	<.002	17.030	<.005
5	<.02	0.0845	0.0279	<.002	23.285	<.005
6	<.02	0.0798	0.0332	<.002	26.513	<.005
7	<.02	0.0751	0.0450	<.002	37.406	<.005
8	0.0203	0.0750	0.0407	<.002	28.764	<.005
9	0.0230	0.1347	0.0466	0.0027	28.367	<.005
10	0.0487	0.1013	0.0605	<.002	40.856	0.0051
11	<.02	0.1000	0.0569	<.002	45.092	<.005
12	<.02	0.0807	0.0591	<.002	48.588	<.005

SAMPLE NUMBER	Ce	Cr	Cu	Dy	Fe	Gd	K
1	<.06	0.0349	<.005	<.005	<.005	<.03	10.274
2	<.06	<.015	<.005	<.005	<.005	<.03	35.951
3	<.06	<.015	<.005	<.005	<.005	<.03	24.639
4	<.06	<.015	<.005	<.005	<.005	<.03	48.360
5	<.06	<.015	<.005	0.0084	<.005	<.03	43.902
6	<.06	<.015	<.005	<.005	<.005	<.03	31.220
7	<.06	<.015	<.005	<.005	<.005	<.03	21.235
8	<.06	<.015	<.005	<.005	0.0088	<.03	30.652
9	<.06	0.0187	<.005	<.005	<.005	<.03	30.162
10	0.0724	<.015	0.0086	0.0052	<.005	<.03	15.851
11	<.06	<.015	<.005	<.005	<.005	<.03	11.696
12	<.06	<.015	<.005	0.0057	<.005	<.03	10.518

ANS 16.1 CHEMISTRY DATA--BLANK WASTE FORM

SAMPLE NUMBER	La	Li	Mg	Mn	Mo	Na
1	<.005	0.0125	14.748	<.005	0.2517	26.500
2	<.005	0.0423	11.619	<.005	0.1180	32.622
3	<.005	0.0287	13.030	<.005	0.1082	29.994
4	<.005	0.0532	11.376	<.005	0.1082	34.508
5	0.0084	0.0550	13.083	<.005	0.1369	33.762
6	<.005	0.0417	13.464	<.005	0.1238	31.059
7	<.005	0.0243	14.110	<.005	0.1258	28.801
8	<.005	0.0334	14.476	<.005	0.0201	29.502
9	<.005	0.0372	14.165	<.005	0.0774	29.474
10	0.0068	0.0260	14.532	<.005	0.0308	25.763
11	<.005	0.0172	14.671	<.005	0.0222	24.980
12	0.0094	0.0139	14.716	<.005	0.0268	26.518

SAMPLE NUMBER	Nd	Ni	P	Pb	Ru	S	Sb	Se
1	<.06	<.02	<.1	<.05	<.05	29.352	<.1	<.2
2	<.06	<.02	<.1	<.05	<.05	26.929	<.1	<.2
3	<.06	<.02	<.1	<.05	<.05	26.327	<.1	<.2
4	<.06	<.02	<.1	<.05	<.05	23.876	<.1	<.2
5	<.06	<.02	<.1	<.05	<.05	27.924	<.1	<.2
6	<.06	<.02	<.1	<.05	<.05	28.565	<.1	<.2
7	<.06	<.02	<.1	<.05	<.05	29.130	<.1	<.2
8	<.06	<.02	0.1030	<.05	<.05	25.036	<.1	<.2
9	<.06	<.02	<.1	<.05	<.05	28.262	<.1	<.2
10	<.06	<.02	0.2011	<.05	<.05	29.487	<.1	0.2650
11	0.0636	<.02	0.1455	<.05	<.05	29.114	<.1	0.2086
12	0.0681	<.02	0.1416	<.05	<.05	30.384	<.1	<.2

SAMPLE NUMBER	Si	Sm	Sn	Sr	Te	Ti	V
1	16.594	<.05	<.05	0.2596	<.15	0.0085	0.0143
2	14.351	<.05	<.05	0.5435	<.15	<.005	<.005
3	14.859	<.05	<.05	0.5091	<.15	<.005	<.005
4	14.004	<.05	<.05	0.4090	<.15	<.005	<.005
5	15.698	<.05	<.05	0.2486	<.15	<.005	<.005
6	15.806	<.05	<.05	0.2798	<.15	<.005	<.005
7	15.860	<.05	<.05	0.2847	<.15	<.005	<.005
8	16.023	<.05	<.05	0.2722	<.15	<.005	<.005
9	16.093	<.05	<.05	0.3068	<.15	<.005	0.0083
10	16.639	0.0517	<.05	0.2710	0.2117	<.005	0.0077
11	15.858	<.05	<.05	0.2587	<.15	<.005	0.0056
12	15.914	<.05	<.05	0.2557	<.15	<.005	<.005

ANS 16.1 CHEMISTRY DATA--BLANK WASTE FORM

SAMPLE NUMBER	Zn	Zr	F-	Cl-	NO3-	SO4--	NO2-
1	<.005	0.0444	<1.1	23.5	<.3	68	<.1
2	<.005	0.0242	<1.1	22.3	<.3	65	<.1
3	<.005	<.01	<1.1	22.0	<.3	63	<.1
4	<.005	<.01	<1.1	20.7	<.3	58	<.1
5	<.005	0.0192	<1.1	22.0	<.3	67	<.1
6	<.005	0.0111	<1.1	22.1	<.3	70	<.1
7	<.005	<.01	<1.1	23.5	<.3	70	<.1
8	<.005	<.01	<1.3	27.1	<1	94	<.4
9	<.005	0.0721	<1.3	24.7	<1	89	<.4
10	0.0244	0.0199	<3	19.8	<10	84	<3
11	<.005	<.01	<3	13.0	<1	63	<.4
12	<.005	<.01	<3	13.3	<1	66	<.4

ANS 16.1 Cs-137 DATA--WASTE FORM 1

TIME (DAYS)	INCREMENTAL FRACTION	CUMULATIVE FRACTION	CUMULATIVE DIFFUSIVITY
0.00035	0.0390	0.039	9.86e-06
0.08330	0.0628	0.102	2.82e-07
0.25000	0.0451	0.147	1.96e-07
1.00000	0.0649	0.212	1.05e-07
2.00000	0.0596	0.271	9.08e-08
3.00000	0.0424	0.314	8.2e-08
4.00000	0.0363	0.350	8.07e-08
7.00000	0.0807	0.431	4.44e-08
14.00000	0.1400	0.571	7.49e-08
21.00000	0.0993	0.670	7.72e-08
28.00000	0.0781	0.748	8.11e-08
35.00000	0.0512	0.799	8.06e-08

ANS 16.1 Cs-134--WASTE FORM 1

TIME (DAYS)	INCREMENTAL FRACTION	CUMULATIVE FRACTION	CUMULATIVE DIFFUSIVITY
0.00035	0.00691	0.00691	3.1e-07
0.08330	0.02760	0.03450	3.25e-08
0.25000	0.03550	0.07000	4.45e-08
1.00000	0.05670	0.12700	3.65e-08
2.00000	0.06290	0.19000	4.08e-08
3.00000	0.03820	0.22800	2.35e-08
4.00000	0.03480	0.26300	2.68e-08
7.00000	0.05610	0.31900	3.09e-08
14.00000	0.11400	0.43200	3.43e-08
21.00000	0.00964	0.44200	4.44e-11
28.00000	0.06860	0.51100	5.76e-11
35.00000	0.00530	0.51600	5.08e-11

ANS 16.1 CO-60--WASTE FORM 1

TIME (DAYS)	INCREMENTAL FRACTION	CUMULATIVE FRACTION	CUMULATIVE DIFFUSIVITY
0.00035	0.000005	0.000005	1.49e-13
0.08330	0.000005	0.000010	2.88e-15
0.25000	0.000002	0.000012	1.33e-15
1.00000	0.000495	0.000507	5.85e-13
2.00000	0.000511	0.001020	1.18e-12
3.00000	0.000158	0.001180	1.05e-12
4.00000	0.000166	0.001340	1.02e-12
7.00000	0.000455	0.001800	1.05e-12
14.00000	0.001070	0.002860	1.33e-12
21.00000	0.000688	0.003550	1.37e-12
28.00000	0.000421	0.003970	1.28e-12
35.00000	0.000857	0.004830	1.51e-12

ANS 16.1 Cs-137--WASTE FORM 2

TIME (DAYS)	INCREMENTAL FRACTION	CUMULATIVE FRACTION	CUMULATIVE DIFFUSIVITY
0.00035	0.0143	0.0143	0.000001
0.08330	0.0596	0.0739	1.49e-07
0.25000	0.0413	0.1150	1.21e-07
1.00000	0.0710	0.1860	7.88e-08
2.00000	0.0627	0.2490	7.67e-08
3.00000	0.0439	0.2930	7.07e-08
4.00000	0.0382	0.3310	7.07e-08
7.00000	0.0807	0.4120	6.64e-08
14.00000	0.1480	0.5600	7.13e-08
21.00000	0.1140	0.6740	7.72e-08
28.00000	0.0838	0.7570	8.47e-08
35.00000	0.0425	0.8000	8.06e-08

ANS 16.1 Cs-134--WASTE FORM 2

TIME (DAYS)	INCREMENTAL FRACTION	CUMULATIVE FRACTION	CUMULATIVE DIFFUSIVITY
0.00035	0.03790	0.0379	0.000009
0.08330	0.03170	0.0696	1.32e-07
0.25000	0.03190	0.1020	9.37e-08
1.00000	0.06550	0.1670	6.34e-08
2.00000	0.02590	0.1930	4.23e-08
3.00000	0.04370	0.2370	2.72e-08
4.00000	0.02990	0.2660	3.09e-08
7.00000	0.06870	0.3350	3.73e-08
14.00000	0.13900	0.4740	8.11e-08
21.00000	0.00316	0.4770	5.85e-11
28.00000	0.00302	0.4800	6.36e-11
35.00000	0.04120	0.5220	5.08e-11

ANS 16.1 Co-60--WASTE FORM 2

TIME (DAYS)	INCREMENTAL FRACTION	CUMULATIVE FRACTION	CUMULATIVE DIFFUSIVITY
0.00035	0.000005	0.000005	1.49e-13
0.08330	0.000005	0.000010	2.88e-15
0.25000	0.000002	0.000012	1.33e-15
1.00000	0.000495	0.000507	5.85e-13
2.00000	0.000310	0.000818	7.6e-13
3.00000	0.000468	0.001290	1.25e-12
4.00000	0.000292	0.001580	1.41e-12
7.00000	0.000463	0.002040	1.35e-12
14.00000	0.001060	0.003110	1.57e-12
21.00000	0.000630	0.003740	1.51e-12
28.00000	0.000421	0.004160	1.4e-12
35.00000	0.000857	0.005010	1.63e-12

BNL ANS 16.1 Cs-137--WASTE FORM 1

TIME (DAYS)	INCREMENTAL FRACTION	CUMULATIVE FRACTION	pH	ALKALINITY AS CaCO3
0.08	0.020	0.020	11.7	530
0.29	0.047	0.067	11.8	700
1.00	0.082	0.149	12.0	750
2.00	0.077	0.226	12.0	930
3.00	0.058	0.284	11.9	580
4.00	0.047	0.331	11.7	330
5.00	0.042	0.373	11.8	380
19.00	0.244	0.617	12.5	1750
47.00	0.180	0.807	12.3	1350
90.00	0.067	0.874	10.3	630

BNL ANS 16.1 Cs-134--WASTE FORM 1

TIME (DAYS)	INCREMENTAL FRACTION	CUMULATIVE FRACTION	pH	ALKALINITY AS CaCO3
0.08	0.022	0.022	11.7	530
0.29	0.050	0.072	11.8	700
1.00	0.084	0.156	12.0	750
2.00	0.082	0.238	12.0	930
3.00	0.081	0.299	11.9	580
4.00	0.050	0.349	11.7	330
5.00	0.044	0.393	11.8	380
19.00	0.256	0.649	12.5	1750
47.00	0.194	0.843	12.3	1350
90.00	0.068	0.909	10.3	630

BNL ANS 16.1 Co-60--WASTE FORM 1

TIME (DAYS)	INCREMENTAL FRACTION	CUMULATIVE FRACTION	pH	ALKALINITY AS CaCO3
0.08	0.00011	0.00011	11.7	530
0.29	0.00033	0.00044	11.8	700
1.00	0.00056	0.00100	12.0	750
2.00	0.00070	0.00170	12.0	930
3.00	0.00050	0.00220	11.9	580
4.00	0.00040	0.00260	11.7	330
5.00	0.00030	0.00290	11.8	380
19.00	0.00260	0.00550	12.5	1750
47.00	0.00240	0.00790	12.3	1350
90.00	0.00120	0.00910	10.3	630

BNL ANS 16.1 Cs-137--WASTE FORM 2

TIME (DAYS)	INCREMENTAL FRACTION	CUMULATIVE FRACTION	pH	ALKALINITY AS CaCO3
0.08	0.031	0.031	11.8	500
0.29	0.052	0.093	11.9	630
1.00	0.097	0.190	12.0	780
2.00	0.090	0.280	12.1	950
3.00	0.060	0.340	12.0	400
4.00	0.049	0.388	11.8	380
5.00	0.042	0.431	11.8	1730
19.00	0.217	0.648	12.5	1750
47.00	0.157	0.805	12.4	1180
90.00	0.051	0.856	11.5	490

BNL ANS 16.1 Cs-134--WASTE FORM 2

TIME (DAYS)	INCREMENTAL FRACTION	CUMULATIVE FRACTION	pH	ALKALINITY AS CaCO3
0.08	0.033	0.033	11.8	500
0.29	0.067	0.100	11.9	630
1.00	0.100	0.200	12.0	780
2.00	0.090	0.290	12.1	950
3.00	0.070	0.360	12.0	400
4.00	0.050	0.410	11.8	380
5.00	0.045	0.455	11.8	1730
19.00	0.198	0.653	12.5	1750
47.00	0.160	0.813	12.4	1180
90.00	0.049	0.862	11.5	490

BNL ANS 16.1 Co-60--WASTE FORM 2

TIME (DAYS)	INCREMENTAL FRACTION	CUMULATIVE FRACTION	pH	ALKALINITY AS CaCO3
0.08	0.0002	0.0002	11.8	500
0.29	0.0005	0.0008	11.9	630
1.00	0.0011	0.0019	12.0	780
2.00	0.0011	0.0030	12.1	950
3.00	0.0007	0.0037	12.0	400
4.00	0.0005	0.0042	11.8	380
5.00	0.0005	0.0047	11.8	1730
19.00	0.0029	0.0076	12.5	1750
47.00	0.0020	0.0096	12.4	1180
90.00	0.0004	0.0100	11.5	490

APPENDIX B

SOIL COLUMN ADSORPTION CHEMICAL AND RADIONUCLIDE RESULTS; SOIL COLUMN GEOMETRY CONSIDERATIONS

APPENDIX B

SOIL COLUMN ADSORPTION CHEMICAL AND RADIONUCLIDE RESULTS; SOIL COLUMN GEOMETRY CONSIDERATIONS

Several guidelines were observed in the column design (Relyea, Serne and Rai 1980):

1. Column diameter should be >30 to 40 times the particle size to avoid velocity effects (channeling, etc.).
2. Column length should be >4 times the column diameter to minimize the effects of velocity on the effective pore volume.
3. Flow velocity should be >80 times the column diameter divided by the column length in centimeters to reduce dispersion (cm/sec).
4. Flow velocity should be > the value 1.6X10-3 divided by the column length in centimeters to reduce diffusion (cm/sec).

This appendix contains soil adsorption column chemistry data and radionuclide data. All units in the chemistry tables are in mg/L unless otherwise noted. Eh is in mV. TC = Total Carbon; TOC = Total Organic Carbon; and C/CO = concentration/initial concentration.

SOIL ADSORPTION COLUMN CHEMISTRY--WASTE FORM 1

SAMPLE NUMBER	CUMULATIVE PV (mL)	pH	Eh	ALKALINITY AS CO3	TC	TOC	Al
1	18.82	8.49	389	84	43.2	5.3	<.03
2	31.01	9.70	399		54.9	7.4	<.03
3	43.82	9.68	403		60.1	8.6	<.03
4	57.08	9.36	404	144	63.8	5.6	<.03
5	70.52	9.45	407		72.8	8.2	<.03
6	84.32	9.38	405				<.03
7	97.22	9.91	402	150			0.0659
8	109.41	9.69	398				<.03
9	124.82	9.66	388				<.03
10	138.80	9.63	398	162	75.7	8.0	<.03
11	152.60	9.33	376				<.03
12	193.10	9.51	408	141			0.1175
13	228.31	9.69	390	165			0.1002
14	267.28	9.23	381	168	76.6	9.1	0.0727
15	280.36	8.88	332	168			<.03
16	307.42	9.34	392	180	78.8	9.0	<.03

SAMPLE NUMBER	As	B	Ba	Be	Ca	Cd	Ce
1	<.02	0.0779	0.0269	<.002	29.5780	<.005	<.06
2	<.02	0.0658	0.0052	<.002	10.2940	<.005	<.06
3	<.02	0.0604	0.0031	<.002	8.9050	<.005	<.06
4	<.02	0.0604	0.0042	<.002	8.4148	<.005	<.06
5	<.02	0.0551	0.0050	<.002	8.5619	<.005	<.06
6	<.02	0.0927	0.0097	<.002	6.3115	<.005	<.06
7	<.02	0.0752	0.0065	<.002	7.3509	<.005	<.06
8	<.02	0.0645	0.0081	<.002	7.5159	<.005	<.06
9	<.02	0.0658	0.0089	<.002	7.3917	<.005	<.06
10	<.02	0.0658	0.0104	<.002	6.9766	<.005	<.06
11	<.02	0.0591	0.0102	<.002	6.5043	<.005	<.06
12	0.0408	0.1000	0.0116	<.002	4.3772	<.005	<.06
13	<.02	0.0779	0.0111	<.002	4.3665	<.005	<.06
14	<.02	0.0753	0.0131	<.002	4.4062	<.005	<.06
15	0.0394	0.0639	0.0158	<.002	4.4783	<.005	<.06
16	<.02	0.0508	0.0119	<.002	4.2964	<.005	<.06

SOIL ADSORPTION COLUMN CHEMISTRY--WASTE FORM 1

SAMPLE NUMBER	Cr	Cu	Dy	Fe	Gd	K	La
1	<.015	<.005	<.005	<.005	<.03	4.5201	<.005
2	<.015	<.005	<.005	<.005	<.03	2.7635	<.005
3	<.015	<.005	<.005	0.0079	<.03	2.4850	<.005
4	<.015	<.005	<.005	<.005	<.03	2.5921	<.005
5	<.015	<.005	<.005	<.005	<.03	4.1560	<.005
6	<.015	<.005	<.005	0.0142	<.03	6.8123	<.005
7	<.015	<.005	<.005	0.0157	<.03	10.3680	<.005
8	<.015	<.005	<.005	0.0073	<.03	14.8670	<.005
9	<.015	<.005	<.005	0.0121	<.03	19.4090	<.005
10	<.015	<.005	<.005	<.005	<.03	22.0870	<.005
11	<.015	<.005	<.005	<.005	<.03	24.1220	<.005
12	<.15	<.002	<.005	0.0330	<.03	23.8980	<.005
13	<.015	<.005	<.005	0.0255	<.03	25.6140	<.005
14	<.015	<.005	<.005	0.0110	<.03	27.9240	<.005
15	<.015	<.005	<.005	0.0187	<.03	32.7160	<.005
16	<.015	<.005	<.005	0.0080	<.03	30.5710	<.005

SAMPLE NUMBER	Li	Mg	Mn	Mo	Na	Nd	Ni
1	<.005	5.8478	<.005	0.0168	110.06	<.06	<.02
2	<.005	1.3680	<.005	0.0144	165.66	<.06	<.02
3	0.0115	0.9923	0.3533	<.01	177.26	<.06	<.02
4	0.0214	0.8767	0.3156	<.01	183.90	<.06	<.02
5	0.0272	0.9249	0.0153	<.01	200.53	<.06	<.02
6	0.0230	0.6936	<.005	0.0168	175.97	<.06	<.02
7	0.0222	0.7322	<.005	0.0144	189.39	<.06	<.02
8	0.0288	0.6840	<.005	<.01	195.24	<.06	<.02
9	0.0329	0.7322	<.005	<.01	200.53	<.06	<.02
10	0.0329	0.7225	<.005	<.01	199.91	<.06	<.02
11	0.0321	0.7033	<.005	<.01	203.33	<.06	<.02
12	0.0333	0.5519	<.005	0.0465	178.58	<.06	<.02
13	0.0365	0.5332	<.005	0.0317	193.26	<.06	<.02
14	0.0382	0.5893	<.005	0.0125	201.94	<.06	<.02
15	0.0360	0.5803	<.005	0.0207	209.49	<.06	<.02
16	0.0305	0.4901	<.005	0.0160	208.06	<.06	<.02

SOIL ADSORPTION COLUMN CHEMISTRY--WASTE FORM 1

SAMPLE NUMBER	P	Pb	Ru	S	Sb	Se	Si
1	1.31740	<.05	<.05	56.268	<.1	<.2	27.907
2	1.45030	<.05	<.05	58.021	<.1	<.2	23.047
3	1.42040	<.05	<.05	58.065	<.1	<.2	18.716
4	1.32010	<.05	<.05	57.870	<.1	<.2	14.846
5	1.39880	<.05	<.05	60.208	<.1	<.2	12.892
6	1.45570	<.05	<.05	58.303	1.9410	<.2	16.350
7	1.41770	<.05	<.05	58.779	<.1	<.2	15.417
8	1.41500	<.05	<.05	59.515	<.1	<.2	12.268
9	1.42590	<.05	<.05	60.857	<.1	<.2	11.096
10	1.45840	<.05	<.05	61.420	<.1	<.2	10.730
11	1.49090	<.05	<.05	61.572	<.1	<.2	10.384
12	1.57200	<.05	<.05	57.910	<.1	0.2973	12.463
13	1.48721	<.05	<.05	58.287	<.1	<.2	10.398
14	1.49710	<.05	<.05	60.904	<.1	<.2	10.013
15	1.73870	<.05	<.05	64.635	0.5090	<.2	11.683
16	1.59530	<.05	<.05	62.590	0.2284	<.2	10.920

SAMPLE NUMBER	Sm	Sn	Sr	Te	Ti	V	Zn
1	<.05	<.05	0.1087	<.15	<.005	0.0282	<.005
2	<.05	<.05	0.0325	<.15	<.005	0.0137	<.005
3	<.05	<.05	0.0265	<.15	<.005	0.0072	<.005
4	<.05	<.05	0.0250	<.15	<.005	0.0072	<.005
5	<.05	<.05	0.0262	<.15	<.005	<.005	0.0734
6	<.05	<.05	0.0215	<.15	<.005	0.0072	0.0060
7	<.05	<.05	0.0228	<.15	<.005	0.0064	<.005
8	<.05	<.05	0.0240	<.15	<.005	<.005	<.005
9	<.05	<.05	0.0246	<.15	<.005	<.005	<.005
10	<.05	<.05	0.0250	<.15	<.005	<.005	<.005
11	<.05	<.05	0.0250	<.15	<.005	<.005	<.005
12	<.05	<.05	0.0195	<.15	0.0067	0.0093	0.0057
13	<.05	<.05	0.0188	<.15	0.0054	0.0062	<.005
14	<.05	<.05	0.0198	<.15	<.005	0.0054	0.0067
15	<.05	<.05	0.0215	<.15	<.005	<.005	<.005
16	<.05	<.05	0.0187	<.15	<.005	<.005	<.005

SOIL ADSORPTION COLUMN CHEMISTRY--WASTE FORM 1

SAMPLE NUMBER	Zr	F-	Cl-	NO3-	SO4--	NO2-
1	0.0175	<3	19.8	<10	162	<2
2	0.0297	<3	18.9	<10	162	<2
3	0.0198	<3	19.4	<10	162	<2
4	0.0190	<3	19.8	<10	164	<2
5	0.0137	<3	20.7	<10	168	<2
6	<.01	<3	20.2	<10	166	<2
7	<.01	<3	19.8	<10	168	<2
8	<.01	<3	19.4	<10	162	<2
9	<.01	<3	20.7	<10	166	<2
10	<.01	<3	20.2	<10	166	<2
11	<.01	<3	21.1	<10	170	<2
12	0.0209	<1	25.0	<.7	172	0.3
13	0.0366	<1	25.0	1.6	176	<.3
14	0.0157	<1	26.0	1.3	160	<.3
15	0.0108	<3	22.4	<10	183	<2
16	0.0114	<3	21.1	<10	173	<2

SOIL ADSORPTION COLUMN CHEMISTRY--WASTE FORM 2

SAMPLE NUMBER	CUMULATIVE PV (mL)	pH	Eh	ALKALINITY AS CO3	TC	TOC	Al
1	17.92	8.96	398	102	47.7	7.5	<.03
2	33.86	9.79	398		56.6	8.1	<.03
3	50.53	9.72	401		62.9	7.3	<.03
4	67.65	9.60	402	144	66.5	7.3	<.03
5	84.76	9.48	404		72.5	6.8	<.03
6	85.66	9.80	402				0.0647
7	103.58	9.99	393	144			0.0472
8	119.89	9.78	398				0.0372
9	140.50	9.74	393				0.0858
10	158.42	9.66	399	168	74.9	7.7	0.0380
11	174.55	9.41	375				<.03
12	224.19	9.73	397	168			0.1353
13	238.17				69.0	8.1	
14	268.99	9.78	389	168			0.1104
15	317.02		381	168	77.8	8.1	0.0819
16	384.67	8.79	345	168			<.03
17	417.02				80.3	8.9	
18	430.28	9.14	390	192			<.03

SAMPLE NUMBER	As	B	Ba	Be	Ca	Cd	Ce
1	<.02	0.0776	0.0218	<.002	26.3890	<.005	<.06
2	<.02	0.0593	0.0050	<.002	9.6453	<.005	<.06
3	<.02	0.0508	0.0039	<.002	8.2121	<.005	<.06
4	<.02	0.0522	0.0045	<.002	7.3750	<.005	<.06
5	<.02	0.0451	0.0068	<.002	7.5222	<.005	<.06
6	<.02	0.1160	0.0064	0.0035	5.5332	<.005	<.06
7	<.02	0.0713	0.0064	<.002	6.0499	<.005	<.06
8	<.02	0.0587	0.0082	<.002	6.3413	<.005	<.06
9	<.02	0.0615	0.0098	<.002	6.2493	<.005	<.06
10	<.02	0.0531	0.0108	<.002	5.7482	<.005	<.06
11	<.02	0.0531	0.0108	<.002	5.3078	<.005	<.06
12	<.02	0.0883	0.0106	<.002	3.8481	<.005	<.06
13							
14	<.02	0.0779	0.0111	<.002	4.0845	<.005	<.06
15	<.02	0.0753	0.0131	<.002	4.1531	<.005	<.06
16	<.02	0.0627	0.0163	<.002	4.2593	<.005	<.06
17							
18	<.02	0.0438	0.0175	<.002	5.2044	<.005	<.06

SOIL ADSORPTION COLUMN CHEMISTRY--WASTE FORM 2

SAMPLE NUMBER	Cr	Cu	Dy	Fe	Gd	K	La
1	<.015	<.005	<.005	0.0062	<.03	4.1880	<.005
2	<.015	<.005	<.005	<.005	<.03	2.7564	<.005
3	<.015	<.005	<.005	<.005	<.03	3.0769	<.005
4	<.015	<.005	<.005	<.005	<.03	5.2564	<.005
5	<.015	<.005	<.005	0.1925	<.03	10.6200	<.005
6	0.0313	<.005	<.005	0.0077	<.03	11.9940	<.005
7	<.015	<.005	<.005	<.005	<.03	13.9540	<.005
8	<.015	<.005	<.005	<.005	<.03	17.4960	<.005
9	<.015	<.005	<.005	<.005	<.03	21.7120	<.005
10	<.015	<.005	<.005	<.005	<.03	24.4520	<.005
11	<.015	<.005	<.005	<.005	<.03	26.2440	<.005
12	<.015	<.005	<.005	0.0485	<.03	25.2120	<.005
13							
14	<.015	<.005	<.005	0.0460	<.03	27.3310	<.005
15	<.015	<.005	<.005	0.0165	<.03	28.7500	<.005
16	<.015	<.005	<.005	0.0312	<.03	33.3490	<.005
17							
18	<.015	<.005	<.005	0.0076	<.03	33.7040	<.005

SAMPLE NUMBER	Li	Mg	Mn	Mo	Na	Nd	Ni
1	0.0065	5.1368	0.0453	0.0334	120.16	<.06	<.02
2	0.0114	1.1651	<.005	0.0283	168.95	<.06	<.02
3	0.0188	0.8511	0.4930	<.01	179.93	<.06	<.02
4	0.0245	0.7497	0.0309	0.0154	188.53	<.06	<.02
5	0.0302	0.7903	<.005	0.0206	200.69	<.06	<.02
6	0.0259	0.5988	0.2301	0.1798	173.98	<.06	<.02
7	0.0243	0.5689	<.005	0.0603	188.82	<.06	<.02
8	0.0299	0.5788	0.5466	<.01	194.20	<.06	<.02
9	0.0332	0.6387	<.005	0.0201	196.08	<.06	<.02
10	0.0356	0.5988	<.005	0.0264	198.11	<.06	<.02
11	0.0340	0.5689	0.4930	<.01	201.41	<.06	<.02
12	0.0333	0.5332	<.005	0.0204	181.02	<.06	<.02
13							
14	0.0365	0.4864	<.005	0.0170	197.62	<.06	<.02
15	0.0398	0.5800	<.005	0.0170	201.99	<.06	<.02
16	0.0360	0.5915	0.5344	<.01	209.42	<.06	<.02
17							
18	0.0360	0.8000	0.0120	0.0136	225.26	<.06	<.02

SOIL ADSORPTION COLUMN CHEMISTRY--WASTE FORM 2

SAMPLE NUMBER	P	Pb	Ru	S	Sb	Se	Si	Sm
1	1.4924	<.05	<.05	57.367	<.1	<.2	26.080	<.05
2	1.5162	<.05	<.05	59.251	8.6805	<.2	21.684	<.05
3	1.4239	<.05	<.05	59.251	<.1	<.2	17.102	<.05
4	1.4001	<.05	<.05	60.009	<.1	<.2	14.309	<.05
5	1.4209	<.05	<.05	61.824	<.1	<.2	12.436	<.05
6	1.2546	<.05	<.05	58.031	<.1	<.2	15.870	<.05
7	1.2661	<.05	<.05	58.480	<.1	<.2	14.466	<.05
8	1.3547	<.05	<.05	58.973	7.0813	<.2	11.613	<.05
9	1.4061	<.05	<.05	61.283	<.1	<.2	10.554	<.05
10	1.4204	<.05	<.05	61.888	<.1	<.2	10.291	<.05
11	1.4033	<.05	<.05	62.628	5.2634	<.2	10.207	<.05
12	1.4817	<.05	<.05	59.341	9.3867	<.2	12.352	<.05
13								
14	1.5037	<.05	<.05	60.038	<.1	<.2	10.405	<.05
15	1.5830	<.05	<.05	61.770	<.1	<.2	10.027	<.05
16	1.5247	<.05	<.05	64.784	0.1827	<.2	11.923	<.05
17								
18	1.5912	<.05	<.05	66.928	<.1	<.2	10.855	<.05

SAMPLE NUMBER	Sn	Sr	Te	Ti	V	Zn	Zr
1	<.05	0.0953	<.15	<.005	0.0310	0.0218	0.0248
2	<.05	0.0292	<.15	<.005	0.0172	<.005	0.0313
3	<.05	0.0243	<.15	<.005	0.0095	<.005	0.0264
4	<.05	0.0230	<.15	<.005	0.0052	<.005	0.0216
5	<.05	0.0250	<.15	<.005	<.005	<.005	<.01
6	<.05	0.0219	<.15	0.0129	0.0135	<.005	0.0282
7	<.05	0.0197	<.15	<.005	<.005	<.005	0.0173
8	<.05	0.0206	<.15	<.005	<.005	<.005	0.0157
9	<.05	0.0216	<.15	<.005	<.005	<.005	0.0149
10	<.05	0.0219	<.15	<.005	<.005	<.005	0.0102
11	<.05	0.0206	<.15	<.005	<.005	<.005	<.01
12	<.05	0.0173	<.15	<.005	0.0077	<.005	0.0262
13							
14	<.05	0.0176	<.15	<.005	0.0054	<.005	0.0344
15	<.05	0.0195	<.15	<.005	0.0062	<.005	0.0262
16	<.05	0.0219	<.15	<.005	<.005	<.005	0.0170
17							
18	<.05	0.0273	<.15	<.005	<.005	<.005	<.01

SOIL ADSORPTION COLUMN CHEMISTRY--WASTE FORM 2

SAMPLE NUMBER	F-	Cl-	NO3-	SO4--	NO2-
1	<3	26.6	<10	174	<2
2	<3	26.6	<10	182	<2
3	<3	26.0	<10	174	<2
4	<3	26.6	<10	187	<2
5	<3	26.6	<10	182	<2
6	<3	25.4	<10	174	<2
7	<3	26.0	<10	174	<2
8	<3	26.0	<10	178	<2
9	<3	26.6	<10	182	<2
10	<3	27.7	<10	186	<2
11	<3	27.1	<10	186	<2
12	<1	25.0	<.7	172	0.3
13					
14	<1	25.0	1.1	176	0.3
15	<1	26.0	0.9	160	<.3
16	<3	30.1	<10	200	<2
17					
18	<3	30.7	<10	204	<2

SOIL ADSORPTION COLUMN CHEMISTRY--BLANK

SAMPLE NUMBER	CUMULATIVE PV (mL)	pH	Eh	ALKALINITY AS CO3	TC	TOC	Al
1	16.58	8.40	392	90	35.9	1.7	0.0611
2	31.10	8.46	382		34.1	1.1	
3	46.33				34.5	1.0	
4	89.79	8.59	387	75	34.4	0.5	0.0725
5	102.02				35.1	0.6	
6	132.44	8.54	366	87			0.0614
7	195.34	8.69	350		34.0	0.3	<.03
8	207.17						
9	217.03	8.65	401	102	33.6	0.6	<.03

SAMPLE NUMBER	As	B	Ba	Be	Ca	Cd	Ce
1	<.02	0.1065	0.0600	<.002	63.499	<.005	<.06
2							
3							
4	<.02	0.0883	0.0557	<.002	58.498	<.005	<.06
5							
6	<.02	0.0844	0.0542	<.002	57.812	<.005	0.0743
7	0.0821	0.0757	0.0600	<.002	56.409	<.005	<.06
8							
9	<.02	0.0686	0.0545	<.002	56.195	<.005	<.06

SAMPLE NUMBER	Cr	Cu	Dy	Fe	Gd	K	La
1	<.015	<.005	0.0059	0.0185	<.03	6.7373	0.0073
2							
3							
4	<.015	<.005	0.0059	0.0220	<.03	7.1186	0.0063
5							
6	<.015	<.005	0.0059	0.0120	<.03	7.3093	0.0062
7	<.015	0.0079	<.005	0.0638	<.03	7.7006	<.005
8							
9	<.015	<.005	<.005	0.0180	<.03	7.7315	<.005

SAMPLE NUMBER	Li	Mg	Mn	Mo	Na	Nd	Ni
1	0.0073	14.097	<.005	0.0306	21.244	<.06	<.02
2							
3							
4	0.0106	14.415	<.005	0.0193	24.408	<.06	<.02
5							
6	0.0114	15.005	<.005	0.0159	24.373	<.06	<.02
7	0.0083	14.535	0.1475	0.0189	23.706	<.06	<.02
8							
9	0.0061	14.575	<.005	0.0195	24.210	<.06	<.03

SOIL ADSORPTION COLUMN CHEMISTRY--BLANK

SAMPLE NUMBER	P	Pb	Ru	S	Sb	Se	Si
1	<.1	<.05	<.05	29.710	<.1	<.2	20.870
2							
3							
4	<.1	<.05	<.05	29.748	<.1	<.2	17.833
5							
6	<.1	<.05	<.05	29.710	<.1	<.2	17.124
7	0.6315	<.05	<.05	27.585	0.8026	0.3496	16.674
8							
9	0.1226	<.05	<.05	29.779	0.4111	<.2	16.695

SAMPLE NUMBER	Sm	Sn	Sr	Te	Ti	V	Zn
1	<.05	<.05	0.2375	<.15	<.005	0.0216	0.0101
2							
3							
4	<.05	<.05	0.2273	<.15	<.005	0.0116	0.0071
5							
6	<.05	<.05	0.2354	<.15	<.005	0.0093	0.0054
7	<.05	<.05	0.2434	0.4242	<.005	<.005	0.0062
8							
9	<.05	<.05	0.2474	<.15	<.005	<.005	<.005

SAMPLE NUMBER	Zr	F-	Cl-	NO3-	SO4--	NO2-
1	0.0276	<1	22.0	<.7	86	<.3
2						
3						
4	0.0321	<1	22.0	<.7	86	<.3
5						
6	0.0262	<1	22.0	<.7	86	<.3
7	<.01	<1	24.8	<.7	90	<.3
8						
9	0.0191	<1	25.4	<.7	90	<.3

SOIL ADSORPTION COLUMN COBALT-60--WASTE FORM 1

SAMPLE NUMBER	CUMULATIVE PV (mL)	MICROCURIES PER LITER	C/Co
1	18.8	0.01380	0.518
2	43.8	0.01470	0.554
3	57.1	0.01900	0.713
4	84.3	0.00749	0.282
5	97.2	0.01610	0.604
6	139.0	0.00767	0.288
7	153.0	0.02050	0.770
8	193.0	0.01240	0.466
9	204.0	0.01540	0.580
10	219.0	0.01240	0.466
11	228.0	0.01920	0.722
12	267.0	0.00608	0.228
13	279.0	0.01760	0.661
14	310.0	0.00899	0.338
15	323.0	0.00363	0.136
16	337.0	0.01210	0.455
17	351.0	0.00363	0.136

SOIL ADSORPTION COLUMN COBALT-60--WASTE FORM 2

SAMPLE NUMBER	CUMULATIVE PV (mL)	MICROCURIES PER LITER	C/Co
1	17.9	0.02050	0.771
2	33.9	0.00527	0.198
3	50.5	0.01140	0.427
4	67.7	0.02140	0.803
5	84.8	0.01700	0.639
6	85.7	0.01160	0.434
7	104.0	0.01130	0.501
8	120.0	0.01770	0.666
9	141.0	0.01370	0.516
10	158.0	0.00656	0.247
11	175.0	0.01220	0.457
12	191.0	0.01300	0.488
13	224.0	0.02180	0.818
14	257.0	0.01280	0.482
15	269.0	0.01790	0.673
16	299.0	0.00476	0.179
17	317.0	0.01360	0.509
18	331.0	0.01000	0.377
19	369.0	0.00802	0.301
20	385.0	0.01760	0.663
21	430.0	0.01300	0.489

APPENDIX C

COMBINED LEACH-ADSORPTION CHEMICAL AND RADIONUCLIDE RESULTS

APPENDIX C

COMBINED LEACH-ADSORPTION CHEMICAL AND RADIONUCLIDE RESULTS

This appendix contains Combined Soil/Waste Form Column Chemistry and Cobalt-60 data tables. All units in the chemistry tables are in mg/L unless otherwise noted. Eh is in mV. TC = Total Carbon and TOC = Total Organic Carbon.

COMBINED SOIL/WASTE FORM COLUMN CHEMISTRY--WASTE FORM 1

SAMPLE NUMBER	CUMULATIVE PV (mL)	pH	Eh	ALKALINITY AS CO3	TC	TOC
1	0.82	8.31	339	100.44	117.20	68.40
2	1.51	8.36	352	210.66	331.20	263.00
3	2.09	11.09	331	272.16	369.70	327.10
4	2.97	11.74	309	575.12	304.50	255.20
5	3.70	11.18	331	382.32	265.80	227.40
6	4.52	12.02	299	648.00	197.60	156.80
7	5.40	12.35	313	882.00	281.20	157.40
8	6.33	12.42	326	963.90	337.10	125.00
9	7.31	12.39	327	982.80	228.00	111.50
10	8.61	11.99	289		298.90	142.70
11	9.54	12.35	320	995.40	372.40	171.00
12	10.65	12.39	350	1083.60	276.10	162.60
13	12.75	12.48	314	1058.40	205.20	137.30
14	13.66	12.29	302	919.80	199.70	88.10
15	14.66	12.28	264	781.20	200.50	71.40
16	15.66	12.33	329	693.00	196.60	67.00
17	17.01	12.29	324		95.10	66.70
18	18.61	12.31	322	541.80	90.40	68.80
19	19.58	12.26	319	504.00	101.40	62.70
20	20.79	12.26	318	480.00	151.60	59.50
21	21.79	12.19	307	432.00	80.00	56.00
22	22.72	12.09	280	420.00	76.60	55.60
23	25.00	11.84	334	372.00	88.00	49.20
24	26.02	11.68	329	336.00	160.10	36.50
25	27.21	11.76	338		64.80	36.70
26	28.18	11.75	325		66.00	34.10
27	29.09	11.58	322	264.00	122.10	29.30
28	30.28	11.58	322		105.00	26.90
29	31.03	11.31	322		107.80	24.70
30	34.21	11.59	341	192.00		
31	40.49	11.52	332	36.00		
32	44.46	10.09	345	168.00	60.50	16.50
33	47.52	11.18	325	144.00	72.90	19.40
34	52.44	10.98	354	99.00	38.90	13.20
35	55.14	11.00	320	90.00	25.70	12.80
36	58.37	11.07	337			
37	61.46	10.73	291	69.00		
38	65.40	9.47	365	60.00	33.40	13.10
39	68.21	10.19	354	51.00	29.00	16.10
40	71.65	10.03	354	48.00	32.14	14.22
41	74.40	9.95	350	41.40	25.50	14.80
42	80.30	8.51	365	34.80	28.50	15.20
43	84.94	7.73	353	33.60	27.35	13.59
44	85.92	7.38	375	37.80		
45	94.85	10.26	368	34.80	12.63	8.80

COMBINED SOIL/WASTE FORM COLUMN CHEMISTRY--WASTE FORM 1

SAMPLE NUMBER	Al	As	B	Ba	Be	Ca
1	<.03	0.0922	0.1114	0.2180	0.0054	181.9820
2	<.03	0.1386	0.1066	0.3936	<.002	242.1000
3	0.1004	0.1320	0.1044	0.1182	<.002	89.8860
4	1.1042	0.1254	0.0974	0.0464	<.002	43.0460
5	0.2298	0.1188	0.1020	0.0480	<.002	43.4080
6	6.4970	0.0387	0.0749	0.0075	<.002	5.1035
7	4.4368	0.0351	0.0827	0.0073	<.002	8.0192
8	5.8970	0.0352	0.0667	0.0047	<.002	5.7063
9	6.4970	0.0387	0.0749	0.0075	<.002	5.1035
10	5.4675	0.0211	0.0716	0.0037	<.002	4.4799
11	5.4578	0.0645	0.1066	0.0063	<.002	4.1858
12	5.5273	0.0354	0.0885	<.002	<.002	3.2293
13	7.3973	0.0257	0.0726	<.002	<.002	1.9030
14	7.5410	0.0603	0.0715	0.0109	<.002	3.0175
15	6.3823	<.02	0.0598	0.0033	<.002	1.6290
16	5.3698	0.0230	0.0620	0.0025	<.002	2.1263
17	5.3980	<.02	0.0737	<.002	<.002	1.9991
18	5.1228	<.02	0.0748	<.002	<.002	1.8652
19	5.1862	<.02	0.0737	0.0033	<.002	1.7492
20	5.1370	<.02	0.0772	<.002	<.002	1.6879
21	4.8191	<.02	0.0854	0.0025	<.002	1.7169
22	4.8547	<.02	0.0784	<.002	<.002	1.6756
23	4.9036	0.0215	0.0676	<.002	<.002	1.3169
24	5.0558	0.0388	0.0676	<.002	<.002	1.4402
25	4.1149	0.0443	0.0778	<.002	<.002	1.2614
26	3.8542	<.02	0.0751	<.002	<.002	1.2682
27	3.5750	<.02	0.0710	<.002	<.002	1.2174
28	3.4114	<.02	0.0927	<.002	<.002	1.1897
29	3.2214	<.02	0.0846	<.002	<.002	1.2355
30						
31	<.03	<.02	0.0709	<.002	<.002	1.3505
32	2.4462	<.02	0.1406	0.0037	<.002	1.4365
33	2.1592	0.0308	0.1192	<.002	<.002	1.2238
34	1.6648	<.02	0.0678	<.002	<.002	1.4859
35	1.5496	<.02	0.1073	<.002	<.002	1.6793
36						
37	1.0402	0.0308	0.1037	0.0023	<.002	2.0091
38	0.7819	<.02	0.0965	0.0045	<.002	4.3624
39	0.5383	<.02	0.0527	0.0060	<.002	6.1361
40	0.4167	<.02	0.0408	0.0059	<.002	7.2933
41	0.3580	<.02	0.0829	0.0065	<.002	9.1015
42	0.2130	<.02	0.0992	0.0062	0.0041	10.2330
43	0.3478	0.0519	0.0634	0.0154	<.002	12.9140
44	0.1738	<.02	0.1261	0.0103	<.002	12.3580
45	0.1562	<.02	0.0711	0.0165	<.002	26.6690

COMBINED SOIL/WASTE FORM COLUMN CHEMISTRY--WASTE FORM 1

SAMPLE NUMBER	Cd	Ce	Cr	Cu	Dy	Fe	Gd
1	<.005	<.06	0.1228	0.0348	<.005	0.0792	<.03
2	<.005	<.06	0.1682	0.0288	<.005	<.005	<.03
3	<.005	<.06	0.1154	0.0476	<.005	<.005	<.03
4	<.005	<.06	0.0878	0.0562	<.005	<.005	<.03
5	<.005	<.06	0.0772	0.0382	<.005	<.005	<.03
6	<.005	<.06	0.0356	0.0410	<.005	0.0445	<.03
7	<.005	<.06	0.0504	0.0560	<.005	0.0111	<.03
8	<.005	<.06	0.0387	0.0423	<.005	0.0209	<.03
9	<.005	<.06	0.0356	0.0410	<.005	0.0445	<.03
10	<.005	<.06	0.0426	0.0340	<.005	0.0223	<.03
11	<.005	<.06	0.0513	0.0725	<.005	0.0092	<.03
12	<.005	<.06	0.0513	0.0725	<.005	0.0092	<.03
13	<.005	<.06	0.0424	0.0331	<.005	<.005	<.03
14	<.005	<.06	0.0303	0.0311	<.005	0.0714	<.03
15	<.005	<.06	0.0260	0.0195	<.005	0.2053	<.03
16	<.005	<.06	0.0218	0.0112	<.005	0.0724	<.03
17	<.005	<.06	0.0182	<.005	<.005	0.0373	<.03
18	<.005	<.06	0.0197	<.005	<.005	0.0404	<.03
19	<.005	<.06	0.0172	<.005	<.005	0.0425	<.03
20	<.005	<.06	0.0162	<.005	<.005	0.0400	<.03
21	<.005	<.06	0.0177	<.005	<.005	0.0888	<.03
22	<.005	<.06	<.015	<.005	<.005	0.0512	<.03
23	<.005	<.06	0.0248	<.005	<.005	0.0520	<.03
24	<.005	<.06	<.015	<.005	<.005	0.0612	<.03
25	<.005	<.06	<.015	0.0072	<.005	0.0439	<.03
26	<.005	<.06	<.015	<.005	<.005	0.0471	<.03
27	<.005	<.06	<.015	<.005	<.005	0.0455	<.03
28	<.005	<.06	<.015	<.005	<.005	0.0288	<.03
29	<.005	<.06	<.015	<.005	<.005	0.0540	<.03
30							
31	<.005	<.06	<.015	<.005	<.005	0.0448	<.03
32	<.005	<.06	<.015	<.005	<.005	0.0351	<.03
33	<.005	<.06	<.015	<.005	<.005	0.0140	<.03
34	<.005	<.06	<.015	<.005	<.005	0.0272	<.03
35	<.005	<.06	<.015	<.005	<.005	0.0152	<.03
36							
37	<.005	<.06	<.015	<.005	<.005	0.0116	<.03
38	<.005	<.06	<.015	<.005	<.005	0.0060	<.03
39	<.005	<.06	<.015	<.005	<.005	<.005	<.03
40	<.005	<.06	<.015	<.005	<.005	<.005	<.03
41	<.005	<.06	<.015	<.005	<.005	<.005	<.03
42	<.005	<.06	0.0322	<.005	<.005	0.0178	<.03
43	0.0042	<.06	<.015	0.0064	<.005	0.0328	<.03
44	<.005	<.06	0.0159	<.005	<.005	0.0145	<.03
45	<.005	<.06	<.015	<.005	<.005	<.005	<.03

COMBINED SOIL/WASTE FORM COLUMN CHEMISTRY--WASTE FORM 1

SAMPLE NUMBER	K	La	Li	Mg	Mn	Mo
1	10.6300	<.005	<.005	30.6960	<.005	0.1950
2	15.6268	<.005	<.005	39.8700	<.005	0.1434
3	10.0242	<.005	<.005	2.4646	<.005	0.1176
4	7.3592	<.005	<.005	0.1180	<.005	0.0984
5	7.1774	<.005	<.005	0.3420	<.005	0.0854
6	11.0410	<.005	<.005	<.1	<.005	0.0393
7	5.0485	<.005	<.005	<.1	<.005	0.0425
8	7.3139	<.005	<.005	<.1	<.005	0.0354
9	11.0410	<.005	<.005	<.1	<.005	0.0393
10	15.5660	<.005	<.005	<.1	<.005	0.0319
11	19.7050	<.005	<.005	<.1	<.005	0.0466
12	19.7050	<.005	<.005	<.1	<.005	0.0562
13	28.2790	<.005	<.005	<.1	<.005	0.0690
14	27.5050	<.005	<.005	0.2500	<.005	0.0141
15	23.7970	<.005	<.005	<.1	<.005	0.0958
16	21.8790	<.005	<.005	<.1	<.005	0.0208
17	21.7870	<.005	<.005	<.1	0.0383	0.0167
18	19.9110	<.005	<.005	<.1	<.005	0.0178
19	17.9120	<.005	<.005	<.1	0.0780	0.0226
20	16.8050	<.005	<.005	<.1	<.005	0.0178
21	15.0060	<.005	<.005	0.1586	0.0960	0.0280
22	14.6830	<.005	<.005	<.1	<.005	0.0280
23	14.1950	<.005	<.005	<.1	<.005	<.01
24	14.4740	<.005	<.005	<.1	<.005	<.01
25	12.6170	<.005	<.005	<.1	0.0239	0.0147
26	12.9790	<.005	<.005	<.1	0.0322	0.0111
27	12.9150	<.005	<.005	<.1	0.0343	<.01
28	13.2180	<.005	<.005	<.1	0.0153	0.0336
29	13.5600	<.005	<.005	<.1	<.005	0.0372
30						
31	20.4010	<.005	0.0139	<.1	<.005	0.0302
32	20.2190	<.005	0.0065	<.1	<.005	<.01
33	18.1850	<.005	0.0079	<.1	<.005	<.01
34	19.1730	<.005	0.0173	<.1	0.1679	0.0315
35	26.6970	<.005	0.0194	<.1	<.005	<.01
36						
37	30.8370	<.005	0.0254	<.1	<.005	<.01
38	30.6340	<.005	0.0296	<.1	<.005	<.01
39	29.1400	<.005	0.0281	<.1	<.005	0.0250
40	28.1140	<.005	0.0235	<.1	<.005	0.0178
41	27.9440	<.005	0.0252	<.1	<.005	0.0922
42	24.7400	<.005	0.0224	<.1	<.005	0.2316
43	30.7730	<.005	0.0185	0.1827	<.005	<.01
44	28.9970	<.005	0.0201	<.1	<.005	0.0375
45	33.4550	<.005	0.0147	<.1	<.005	0.0125

COMBINED SOIL/WASTE FORM COLUMN CHEMISTRY--WASTE FORM 1

SAMPLE NUMBER	Na	Nd	Ni	P	Pb	Ru	S
1	525.560	<.06	<.02	13.937B	<.05	<.05	447.180
2	979.160	<.06	<.02	28.8080	<.05	<.05	831.760
3	1119.940	<.06	<.02	22.3220	<.05	<.05	639.820
4	1029.640	<.06	<.02	16.6280	<.05	<.05	476.600
5	808.100	<.06	<.02	14.8996	<.05	<.05	406.260
6	924.880	<.06	<.02	8.0400	<.05	<.05	162.670
7	983.670	<.06	<.02	12.2220	<.05	<.05	252.590
8	1000.800	<.06	<.02	10.1940	<.05	<.05	203.640
9	924.880	<.06	<.02	8.0400	<.05	<.05	162.670
10	936.300	<.06	<.02	11.2720	<.05	<.05	194.660
11	940.510	<.06	<.02	12.3530	<.05	<.05	205.500
12	1009.700	<.06	<.02	11.4680	<.05	<.05	172.010
13	973.370	<.06	<.02	9.7170	<.05	<.05	135.440
14	839.840	<.06	<.02	6.3998	<.05	<.05	94.108
15	703.000	<.06	<.02	5.2722	<.05	<.05	77.291
16	568.860	<.06	<.02	4.9054	<.05	<.05	68.549
17	542.150	<.06	<.02	5.0177	<.05	<.05	67.958
18	491.000	<.06	<.02	5.4377	<.05	<.05	66.056
19	449.710	<.06	<.02	4.6983	<.05	<.05	58.578
20	416.580	<.06	<.02	4.5860	<.05	<.05	54.151
21	375.870	<.06	<.02	4.0438	<.05	<.05	49.310
22	367.440	<.06	<.02	4.1660	<.05	<.05	48.591
23	363.600	<.06	<.02	3.8516	<.05	<.05	46.380
24	351.750	<.06	<.02	3.6490	<.05	<.05	45.379
25	268.730	<.06	<.02	2.5000	<.05	<.05	35.653
26	253.960	<.06	<.02	2.3038	<.05	<.05	34.239
27	238.200	<.06	<.02	1.9937	<.05	<.05	33.157
28	229.750	<.06	<.02	2.1117	<.05	<.05	34.986
29	216.950	<.06	<.02	2.0710	<.05	<.05	34.185
30							
31	150.620	<.06	<.02	1.9900	<.05	<.05	30.934
32	174.880	<.06	<.02	1.4768	<.05	<.05	31.354
33	156.550	<.06	<.02	1.4137	<.05	<.05	30.106
34	113.350	<.06	<.02	1.0528	<.05	<.05	27.929
35	109.140	<.06	<.02	1.0186	<.05	<.05	29.513
36							
37	87.482	<.06	<.02	0.9814	<.05	<.05	28.969
38	78.727	<.06	<.02	1.0668	<.05	<.05	29.129
39	71.430	<.06	<.02	1.3203	<.05	<.05	29.097
40	65.907	<.06	<.02	1.2726	<.05	<.05	29.342
41	57.800	<.06	<.02	1.2506	<.05	<.05	27.587
42	47.716	<.06	<.02	1.2294	<.05	<.05	23.764
43	47.000	<.06	0.0243	1.4195	0.082	<.05	27.241
44	48.095	<.06	<.02	2.7804	<.05	<.05	25.913
45	30.083	<.06	<.02	0.5923	<.05	<.05	27.250

COMBINED SOIL/WASTE FORM COLUMN CHEMISTRY--WASTE FORM 1

SAMPLE NUMBER	Sb	Se	Si	Sm	Sn	Sr	Te
1	<.1	<.2	73.740	<.05	0.0732	0.74840	0.7920
2	<.1	<.2	89.088	<.05	<.05	1.03840	<.15
3	<.1	<.2	148.370	<.05	<.05	0.04076	<.15
4	<.1	<.2	166.712	<.05	<.05	0.19100	<.15
5	<.1	<.2	143.640	<.05	<.05	0.17720	<.15
6	<.1	<.2	185.750	<.05	<.05	0.02180	<.15
7	<.1	<.2	206.980	<.05	<.05	0.03530	<.15
8	<.1	<.2	204.430	<.05	<.05	0.02570	<.15
9	<.1	<.2	185.750	<.05	<.05	0.02180	<.15
10	<.1	<.2	182.060	<.05	<.05	0.01200	<.15
11	<.1	<.2	199.150	<.05	<.05	0.02020	<.15
12	<.1	<.2	232.640	<.05	<.05	0.01210	<.15
13	<.1	<.2	198.700	<.05	<.05	0.00840	<.15
14	0.1251	<.2	169.740	<.05	<.05	0.01690	<.15
15	<.1	<.2	148.510	<.05	<.05	0.00680	0.1939
16	<.1	<.2	135.020	<.05	<.05	0.00990	<.15
17	<.1	<.2	133.830	<.05	<.05	0.00860	<.15
18	<.1	<.2	124.300	<.05	<.05	0.00760	<.15
19	<.1	<.2	112.960	<.05	<.05	0.00700	<.15
20	<.1	<.2	104.870	<.05	<.05	0.00650	<.15
21	<.1	<.2	95.017	<.05	<.05	0.00670	<.15
22	<.1	<.2	91.546	<.05	<.05	0.00590	<.15
23	<.1	<.2	82.848	<.05	<.05	0.00420	<.15
24	<.1	<.2	80.770	<.05	<.05	0.00440	<.15
25	0.1014	<.2	66.849	<.05	<.05	0.00500	<.15
26	<.1	<.2	63.610	<.05	<.05	0.00410	<.15
27	<.1	<.2	59.183	<.05	<.05	0.00380	<.15
28	<.1	<.2	55.866	<.05	<.05	0.00470	<.15
29	<.1	<.2	52.627	<.05	<.05	0.00410	<.15
30							
31	<.1	<.2	41.910	<.05	<.05	0.00460	<.15
32	0.4053	<.2	42.601	<.05	<.05	0.00410	0.2594
33	0.1916	<.2	37.706	<.05	<.05	0.00390	<.15
34	<.1	<.2	26.071	<.05	<.05	0.00500	<.15
35	<.1	<.2	23.043	<.05	<.05	0.00510	<.15
36							
37	8.7178	<.2	17.091	<.05	<.05	0.00700	<.15
38	<.1	<.2	14.500	<.05	<.05	0.01590	<.15
39	<.1	<.2	13.112	<.05	<.05	0.02360	<.15
40	6.1713	<.2	12.119	<.05	<.05	0.02780	<.15
41	<.1	<.2	11.823	<.05	<.05	0.03420	<.15
42	<.1	<.2	11.725	<.05	<.05	0.04210	<.15
43	0.1017	<.2	12.000	<.05	<.05	0.05020	<.15
44	<.1	<.2	14.160	<.05	<.05	0.05220	<.15
45	<.1	<.2	16.091	<.05	<.05	0.15780	<.15

COMBINED SOIL/WASTE FORM COLUMN CHEMISTRY--WASTE FORM 1

SAMPLE NUMBER	Ti	V	Zn	Zr	F-	Cl-	NO3-
1	0.0138	0.1584	0.9884	0.2578	<5	43.0	11
2	<.005	0.3110	0.9164	0.1172	<5	58.0	<2
3	<.005	0.2974	0.5612	0.0458	<5	45.0	<2
4	<.005	0.2488	0.0442	0.0122	<5	38.0	<2
5	<.005	0.3052	0.0190	0.0264	<5	34.0	<2
6	<.005	0.0744	0.0261	<.01	<5	29.0	<2
7	<.005	0.1297	0.0490	<.01			
8	<.005	0.0925	0.1043	<.01			
9	<.005	0.0744	0.0261	<.01	<5	24.4	<10
10	<.005	0.0510	0.0289	<.01			
11	<.005	0.1205	0.0128	<.01	<5	28.8	<10
12	<.005	0.0874	0.0062	<.01	<5	26.5	<10
13	<.005	0.0667	0.0217	0.0385	<5	29.2	<10
14	<.005	0.0394	0.1328	<.01	<3	24.0	<2
15	<.005	0.0252	0.0360	0.0319	<3	23.4	<2
16	0.0057	0.0243	0.0087	0.0100	<3	21.9	<2
17	<.005	0.0222	0.0056	<.01	<3	21.9	<2
18	<.005	0.0253	0.0049	<.01	<3	21.6	<2
19	<.005	0.0227	0.0059	<.01	<3	21.0	<2
20	<.005	0.0206	0.0059	<.01	<3	20.1	<2
21	0.0087	0.0227	0.0129	0.0320	<3	20.4	<2
22	<.005	0.0196	0.0097	<.01	<3	19.5	<2
23	<.005	0.0142	0.0068	<.01	<3	19.5	<2
24	<.005	0.0129	0.0073	<.01	<3	19.5	<2
25	0.0061	0.0180	0.0063	<.01	<3	19.2	<2
26	0.0061	0.0180	<.005	<.01	<3	19.2	<2
27	0.0051	0.0156	<.005	<.01	<3	19.8	<2
28	0.0065	0.0177	<.005	<.01	<3	19.2	<2
29	0.0079	0.0177	0.0053	0.0282	<3	19.2	<2
30					<5	22.0	<.7
31	<.005	0.0135	<.005	<.01	<3	12.2	<2
32	<.005	<.005	0.0496	<.01	<3	18.9	<2
33	<.005	0.0052	0.0066	<.01	<3	18.0	<2
34	<.005	0.0067	<.005	<.01	<3	17.7	<2
35	<.005	<.005	<.005	<.01	<3	17.7	<2
36							
37	<.005	<.005	<.005	<.01	<3	17.8	<1.5
38	<.005	<.005	<.005	<.01	<3	18.1	<1.5
39	<.005	<.005	<.005	0.0279	<3	14.9	<1
40	<.005	<.005	<.005	0.0161	<3	15.1	<1
41	<.005	0.0061	<.005	0.0344	<3	15.1	<1
42	0.0064	0.0155	<.005	<.01	<5	18.7	<5
43	<.005	<.005	0.0106	0.0177	<5	22.2	<5
44	<.005	0.0169	<.005	<.01	<5	21.8	<10
45	<.005	<.005	<.005	<.01	<10	27.6	<10

COMBINED SOIL/WASTE FORM COLUMN CHEMISTRY--WASTE FORM 1

SAMPLE NUMBER	SO4--	NO2-	PO4-
1	140.0	<1	7
2	260.0	<1	8
3	210.0	<1	<8
4	150.0	<1	<8
5	130.0	<1	<8
6	75.0	<1	<8
7			
8			
9	500.0	<3	<25
10			
11	660.0	<3	<25
12	550.0	<3	<25
13	430.0	<3	<25
14	259.0	<.3	<2
15	224.0	<.3	<2
16	209.0	<.3	<2
17	198.0	<.3	<2
18	196.0	<.3	<2
19	172.0	<.3	<2
20	158.0	<.3	<2
21	150.0	<.3	<2
22	141.0	<.3	<2
23	127.0	<.3	<2
24	118.0	<.3	<2
25	110.0	<.3	<2
26	105.0	<.3	<2
27	108.0	<.3	<2
28	98.0	<.3	<2
29	98.0	<.3	<2
30	95.0	<.3	<2
31	91.0	<.3	<2
32	86.0	<.3	<2
33	86.0	<.3	<2
34	81.0	<.3	<2
35		<.3	<2
36			
37	86.0	<1.5	<25
38	86.0	<1.5	<25
39	74.0	<.5	<2
40	76.0	<.5	<2
41	74.0	<.5	<2
42	66.0	<2	<10
43	74.0	<2	<10
44	66.9	<5	<10
45	90.0	<5	<10

COMBINED SOIL/WASTE FORM COLUMN CHEMISTRY--WASTE FORM 2

SAMPLE NUMBER	CUMULATIVE PV (mL)	pH	Eh	ALKALINITY AS CO3	TC	TOC	Al
1	0.83	7.96	368	123.12	47.7	7.5	<.03
2	1.56	7.81	366	155.52	56.6	8.1	<.03
3	2.18	8.61	350	181.44	62.9	7.3	<.03
4	3.20	11.01	348	524.88	66.5	7.3	0.0340
5	3.93	11.72	330	1296.00	72.5	6.8	1.5686
6	4.59	11.62	338	1425.60			3.1228
7	5.34	12.92	337	1425.60			4.3693
8	6.17	12.48	307	1360.80			5.4160
9	7.15	12.55	306	1285.20			6.1240
10	8.28	12.17	358	1064.70	74.9	7.7	5.3619
11	10.11	12.39	350	1039.50			8.2501
12	10.99	12.31	329	1014.30			6.7350
13	12.76	12.31	327	945.00			8.5206
14	13.74	12.27	256	945.00	69.0	8.1	9.9926
15	14.68	12.34	280	819.00			9.4316
16	16.56	12.25	311	718.20			8.6466
17	18.05	12.32	302	642.60			8.0870
18	19.05	12.65	323	554.40			7.9807
19	20.16	11.88	317	491.40	77.8	8.1	7.6834
20	21.10	12.01	327	466.20			7.2091
21	21.95	11.54	293	396.00			7.3578
22	24.21	11.82	352	384.00			7.1949
23	25.13	11.77	352	384.00			6.9075
24	26.07	11.33	353		80.3	8.9	5.0452
25	28.06	12.08	342	450.00			6.5349
26	35.48	11.52	329	198.00			4.2164
27	38.23	10.58	341	144.00			3.6221
28	42.24	11.07	342	123.00			2.5636
29	44.96	10.77	329	108.00			2.3815
30	50.17	10.28	313	78.00			1.7144
31	53.30	10.55	364	72.00			1.3917
32	54.99	9.91	356	69.00			1.1376
33	57.25	10.47	358				0.8858
34	58.49	9.85	356	57.60			0.7568
35	61.24	10.11	351	63.00			0.5564
36	63.29	9.44	343				0.6319

COMBINED SOIL/WASTE FORM COLUMN CHEMISTRY--WASTE FORM 2

SAMPLE NUMBER	As	B	Ba	Be	Ca	Cd
1	0.0883	0.1426	0.5073	0.0030	490.3600	<.002
2	0.1980	0.1276	0.5234	0.0042	267.7800	<.002
3	0.2444	0.1344	0.2104	<.002	114.4700	<.002
4	0.1188	0.1228	0.0620	<.002	40.4000	<.002
5	0.1320	0.1182	0.0150	<.002	9.5624	<.002
6	0.1850	0.1182	0.0086	<.002	5.7424	<.002
7	0.0703	0.0765	0.0069	<.002	4.1644	<.002
8	0.0562	0.0716	0.0064	<.002	3.6366	<.002
9	0.0281	0.0568	0.0025	<.002	3.0127	<.002
10	0.0449	0.1214	0.0056	0.0020	2.8772	<.002
11	0.0321	0.0976	<.002	<.002	1.8399	<.002
12	0.0451	0.1021	0.0033	<.002	2.5639	<.002
13	0.0257	0.0896	<.002	<.002	1.1912	<.002
14	0.0301	0.0885	0.0023	<.002	1.6290	<.002
15	0.0593	0.0814	0.0329	<.002	1.7446	<.002
16	<.02	0.0709	<.002	<.002	1.2848	<.002
17	<.02	0.0767	<.002	<.002	1.2649	<.002
18	0.0330	0.0767	<.002	<.002	1.2571	<.002
19	<.02	0.0686	<.002	<.002	1.1949	<.002
20	<.02	0.0628	<.002	<.002	1.3048	<.002
21	<.02	0.0628	<.002	<.002	1.2571	<.002
22	<.02	0.0781	<.002	<.002	1.1753	<.002
23	<.02	0.0663	0.0023	<.002	1.3063	<.002
24	0.0754	0.0846	<.002	<.002	1.5565	<.002
25	<.02	0.1026	<.002	<.002	1.1114	<.002
26	<.02	0.1251	<.002	0.0031	1.5750	<.002
27	0.0268	0.0977	<.002	<.002	1.1881	<.002
28	<.02	0.0558	<.002	<.002	1.6846	<.002
29	<.02	0.0798	<.002	<.002	1.6579	<.002
30	0.0231	0.0751	<.002	<.002	1.8021	<.002
31	<.02	0.0655	<.002	<.002	1.9178	<.002
32	<.02	0.0408	0.0037	<.002	2.8862	<.002
33	<.02	0.0382	0.0048	<.002	5.2189	<.002
34	<.02	0.1010	0.0054	0.0025	7.1119	<.002
35	<.02	0.0613	0.0057	<.002	9.1402	<.002
36	0.0519	0.0582	0.0146	<.002	11.9360	0.0046

COMBINED SOIL/WASTE FORM COLUMN CHEMISTRY--WASTE FORM 2

SAMPLE NUMBER	Ce	Cr	Cu	Dy	Fe	Gd	K
1	<.06	0.1862	0.0730	0.0087	0.0113	<.03	19.3370
2	<.06	0.1798	0.1038	<.005	<.005	<.03	17.5954
3	<.06	0.1238	0.1026	<.005	0.0066	<.03	11.7808
4	<.06	0.0826	0.1314	<.005	<.005	<.03	7.2986
5	<.06	0.0794	0.1922	<.005	<.005	<.03	6.0570
6	<.06	0.0604	0.1160	<.005	<.005	<.03	5.5118
7	<.06	0.0532	0.0809	<.005	0.0407	<.03	5.0971
8	<.06	0.0532	0.0809	<.005	0.0407	<.03	5.0971
9	<.06	0.0308	0.0329	<.005	0.0275	<.03	4.4822
10	<.06	0.0607	0.0414	<.005	0.0301	<.03	4.1667
11	<.06	0.0492	0.0291	<.005	0.0291	<.03	4.2870
12	<.06	0.0570	0.0384	<.005	0.0285	<.03	4.5277
13	<.06	0.0466	0.0235	<.005	0.0308	<.03	3.9260
14	<.06	0.0424	0.0192	<.005	0.0669	<.03	4.2506
15	<.06	0.0331	0.0106	<.005	0.1261	<.03	3.5364
16	<.06	0.0225	<.005	<.005	0.0606	<.03	3.5824
17	<.06	0.0215	<.005	<.005	0.0571	<.03	3.7508
18	<.06	0.0195	<.005	<.005	0.0822	<.03	3.9804
19	<.06	0.0190	<.005	<.005	0.0784	<.03	4.0416
20	<.06	<.015	<.005	<.005	0.1404	<.03	4.5468
21	<.06	<.015	<.005	<.005	0.0530	<.03	5.2664
22	<.06	<.015	<.005	<.005	0.0700	<.03	5.4761
23	<.06	<.015	<.005	<.005	0.1189	<.03	6.7172
24	<.06	0.0181	0.0102	<.005	0.1228	<.03	9.7447
25	<.06	0.0160	<.005	<.005	0.0220	<.03	14.7250
26	<.06	0.0252	<.005	<.005	0.0562	<.03	17.5610
27	<.06	<.015	<.005	<.005	0.0227	<.03	20.5390
28	<.06	<.015	<.005	<.005	0.0780	<.03	26.3630
29	<.06	<.015	<.005	<.005	0.0271	<.03	35.3540
30	<.06	<.015	<.005	<.005	0.0271	<.03	35.3540
31	<.06	<.015	<.005	<.005	0.0112	<.03	49.5310
32	<.06	<.015	<.005	<.005	0.0527	<.03	48.1350
33	<.06	<.015	<.005	<.005	0.0098	<.03	47.9450
34	<.06	0.0373	<.005	<.005	0.0095	<.03	46.9620
35	<.06	<.015	<.005	<.005	0.0228	<.03	40.6750
36	<.06	<.015	0.0070	<.005	0.0337	<.03	46.9700

COMBINED SOIL/WASTE FORM COLUMN CHEMISTRY--WASTE FORM 2

SAMPLE NUMBER	La	Li	Mg	Mn	Mo	Na
1	0.0196	0.0122	102.1200	0.0321	0.21270	403.960
2	<.005	0.0060	50.4000	<.005	0.17560	897.860
3	<.005	<.005	18.8798	<.005	0.10960	781.060
4	<.005	<.005	4.0802	<.005	0.07100	902.060
5	<.005	<.005	<.1	<.005	0.08540	1368.980
6	<.005	<.005	<.1	<.005	0.05800	1383.020
7	<.005	<.005	<.1	<.005	0.04430	1336.100
8	<.005	<.005	<.1	<.005	0.03360	1314.900
9	<.005	<.005	<.1	<.005	0.02740	1141.400
10	<.005	<.005	<.1	<.005	0.17980	923.430
11	<.005	<.005	<.1	<.005	0.10920	941.380
12	<.005	<.005	<.1	<.005	0.05060	957.910
13	<.005	<.005	<.1	<.005	0.06580	880.890
14	<.005	<.005	<.1	<.005	0.07400	852.410
15	<.005	<.005	<.1	0.3056	0.06820	701.570
16	<.005	<.005	<.1	<.005	0.02860	599.500
17	<.005	<.005	<.1	<.005	0.02450	511.770
18	<.005	<.005	<.1	0.0815	0.02450	465.380
19	<.005	<.005	<.1	<.005	0.02330	427.120
20	<.005	<.005	<.1	<.005	0.01630	395.420
21	<.005	<.005	<.1	0.0329	<.01	392.360
22	<.005	<.005	<.1	<.005	0.01900	372.820
23	<.005	<.005	<.1	<.005	0.01480	342.350
24	<.005	<.005	<.1	0.0228	0.03560	319.610
25	<.005	<.005	<.1	<.005	0.09740	370.000
26	<.005	0.0065	<.1	<.005	0.18620	199.500
27	<.005	0.0092	<.1	<.005	0.05670	175.360
28	<.005	0.0161	<.1	<.005	<.01	126.650
29	<.005	0.0217	<.1	<.005	0.02030	117.710
30	<.005	0.0240	<.1	<.005	0.01400	93.805
31	<.005	0.0250	<.1	<.005	<.01	82.543
32	<.005	0.0230	<.1	<.005	0.01350	76.354
33	<.005	0.0215	<.1	<.005	0.01000	69.451
34	<.005	0.0263	<.1	<.005	0.03015	61.299
35	<.005	0.0177	<.1	<.005	0.02640	52.693
36	<.005	0.0185	0.1157	<.005	0.01710	51.536

COMBINED SOIL/WASTE FORM COLUMN CHEMISTRY--WASTE FORM 2

SAMPLE NUMBER	Nd	Ni	P	Pb	Ru	S
1	0.151	0.0237	28.7210	0.1045	<.05	623.750
2	<.06	<.02	33.1200	<.05	<.05	845.540
3	<.06	<.02	23.3900	<.05	<.05	582.140
4	<.06	<.02	19.0786	<.05	<.05	406.860
5	<.06	<.02	17.0886	<.05	<.05	342.600
6	<.06	<.02	14.4426	<.05	<.05	278.640
7	<.06	<.02	13.0860	<.05	<.05	239.890
8	<.06	<.02	12.5170	<.05	<.05	215.880
9	<.06	<.02	9.4135	<.05	<.05	159.020
10	<.06	<.02	9.3985	<.05	<.05	141.570
11	<.06	<.02	10.1420	<.05	<.05	146.770
12	<.06	<.02	10.8670	<.05	<.05	155.300
13	<.06	<.02	9.2747	<.05	<.05	118.680
14	<.06	<.02	8.1865	<.05	<.05	98.873
15	<.06	<.02	6.2021	<.05	<.05	74.613
16	<.06	<.02	5.8475	<.05	<.05	68.748
17	<.06	<.02	5.6507	<.05	<.05	62.189
18	<.06	<.02	4.7305	<.05	<.05	54.143
19	<.06	<.02	4.3615	<.05	<.05	50.079
20	<.06	<.02	4.1873	<.05	<.05	47.056
21	<.06	<.02	4.0459	<.05	<.05	46.081
22	<.06	<.02	3.6929	<.05	<.05	42.557
23	<.06	<.02	3.2902	<.05	<.05	39.714
24	<.06	<.02	4.9175	<.05	<.05	40.004
25	<.06	<.02	1.0604	<.05	<.05	32.308
26	<.06	<.02	0.9184	<.05	<.05	29.609
27	<.06	<.02	1.0705	<.05	<.05	29.609
28	<.06	<.02	1.0883	<.05	<.05	28.371
29	<.06	<.02	0.9165	<.05	<.05	29.561
30	<.06	<.02	1.0649	<.05	<.05	29.401
31	<.06	<.02	1.0056	<.05	<.05	29.353
32	<.06	<.02	1.5186	<.05	<.05	28.566
33	<.06	<.02	1.5412	<.05	<.05	28.423
34	<.06	<.02	1.8873	<.05	<.05	25.738
35	<.06	<.02	2.0015	<.05	<.05	20.458
36	<.06	<.02	2.4719	0.0923	<.05	24.301

COMBINED SOIL/WASTE FORM COLUMN CHEMISTRY--WASTE FORM 2

SAMPLE NUMBER	Sb	Se	Si	Sm	Sn	Sr
1	<.1	<.2	39.367	<.05	0.0814	2.0064
2	<.1	<.2	61.654	<.05	0.0644	1.1580
3	<.1	<.2	95.446	<.05	<.05	0.4940
4	<.1	<.2	273.340	<.05	<.05	0.1688
5	<.1	<.2	434.900	<.05	<.05	0.0482
6	<.1	<.2	365.160	<.05	<.05	0.0294
7	<.1	<.2	346.310	<.05	<.05	0.0226
8	<.1	<.2	316.570	<.05	<.05	0.0193
9	<.1	<.2	263.050	<.05	<.05	0.0151
10	<.1	<.2	240.830	<.05	<.05	0.0156
11	<.1	<.2	208.360	<.05	<.05	0.0086
12	<.1	<.2	221.020	<.05	<.05	0.0124
13	<.1	<.2	194.410	<.05	<.05	0.0048
14	<.1	<.2	164.970	<.05	<.05	0.0080
15	0.8894	0.3698	139.690	<.05	<.05	0.0680
16	<.1	0.2163	125.090	<.05	<.05	0.0043
17	<.1	<.2	111.530	<.05	<.05	0.0042
18	<.1	<.2	99.887	<.05	<.05	0.0051
19	<.1	<.2	92.164	<.05	<.05	0.0046
20	<.1	<.2	84.072	<.05	<.05	0.0044
21	<.1	<.2	82.320	<.05	<.05	0.0033
22	<.1	<.2	74.204	<.05	<.05	0.0035
23	<.1	<.2	67.874	<.05	<.05	0.0037
24	0.3605	<.2	77.394	<.05	<.05	0.0047
25	<.1	<.2	91.438	<.05	<.05	0.0056
26	<.1	<.2	41.186	<.05	<.05	0.0068
27	<.1	<.2	37.202	<.05	<.05	0.0046
28	<.1	<.2	27.173	<.05	<.05	0.0037
29	<.1	<.2	24.411	<.05	<.05	0.0057
30	<.1	<.2	20.307	<.05	<.05	0.0063
31	<.1	<.2	18.843	<.05	<.05	0.0074
32	<.1	<.2	18.558	<.05	<.05	0.0109
33	<.1	<.2	17.982	<.05	<.05	0.0202
34	<.1	<.2	18.239	<.05	<.05	0.0307
35	<.1	<.2	18.655	<.05	<.05	0.0331
36	0.1017	<.2	18.833	<.05	<.05	0.0464

COMBINED SOIL/WASTE FORM COLUMN CHEMISTRY--WASTE FORM 2

SAMPLE NUMBER	Te	Ti	V	Zn	Zr	F-	Cl-
1	<.15	0.0135	0.0520	0.6569	0.0897	<1.1	54.0
2	<.15	0.0094	0.3790	0.3466	0.1060	<1.1	54.0
3	<.15	<.005	0.5306	0.1014	0.0886	<1.1	41.0
4	<.15	<.005	0.3878	0.0284	0.0520	<1.1	35.0
5	<.15	<.005	0.2178	0.0396	<.01	<1.1	31.0
6	<.15	<.005	0.1574	0.0500	<.01	<1.1	28.0
7	<.15	<.005	0.1154	0.0590	<.01		
8	<.15	<.005	0.0971	0.0198	<.01		
9	<.15	<.005	0.0630	0.0560	<.01		
10	<.15	0.0103	0.0955	0.0124	0.0112	<5	26.7
11	<.15	<.005	0.0499	<.005	0.0106	<5	26.5
12	<.15	0.0050	0.0850	0.0075	0.0162	<5	31.1
13	<.15	<.005	0.0499	0.0073	0.0182	<5	28.8
14	<.15	0.0061	0.0375	0.0097	0.0122	<3	18.6
15	0.3132	0.0124	0.0303	0.0105	0.0526	<3	17.0
16	<.15	0.0076	0.0226	<.005	<.01	<3	16.7
17	<.15	0.0072	0.0277	<.005	<.01	<3	16.4
18	<.15	0.0106	0.0257	0.0073	0.0296	<3	16.4
19	<.15	0.0106	0.0246	0.0052	0.0332	<3	16.1
20	<.15	0.0098	0.0200	0.0070	0.0102	<3	15.5
21	<.15	<.005	0.0185	0.0052	<.01	<3	15.8
22	<.15	<.005	0.0135	0.0078	<.01	<3	16.4
23	<.15	0.0061	0.0129	0.0078	<.01	<3	18.3
24	0.2309	0.0145	0.0475	0.0056	<.01	<3	16.4
25	<.15	0.0099	0.0325	0.0054	0.0262	<2	23.0
26	<.15	0.0148	0.0160	<.005	<.01	<3	15.5
27	<.15	<.005	0.0103	0.0097	<.01	<3	15.5
28	<.15	<.005	<.005	0.0056	<.01		15.8
29	<.15	<.005	<.005	<.005	<.01	<3	16.4
30	<.15	<.005	<.005	<.005	0.0179	<3	16.8
31	<.15	<.005	<.005	<.005	<.01		
32	<.15	<.005	<.005	<.005	<.01	<3	14.2
33	<.15	<.005	<.005	<.005	<.01	<3	14.4
34	<.15	0.0107	0.0165	<.005	0.0285	<3	14.2
35	<.15	<.005	<.005	<.005	<.01	<5	16.5
36	0.1775	<.005	0.0080	0.1152	0.0177	<5	21.3

COMBINED SOIL/WASTE FORM COLUMN CHEMISTRY--WASTE FORM 2

SAMPLE NUMBER	NO3-	SO4--	NO2-
1	<.3	245	8
2	<.3	255	30
3	4	180	26
4	<2	130	<8
5	<2	110	<8
6	<2	105	<8
7			
8			
9			
10	<10	470	<3
11	<10	470	<3
12	<10	500	<3
13	<10	380	<3
14	<5	230	<1
15	<5	180	<1
16	<5	165	<1
17	<5	151	<1
18	<5	135	<1
19	<5	125	<1
20	<5	115	<1
21	<5	112	<1
22	<5	107	<1
23	<5	107	<1
24	<5	107	<1
25	<3	95	<1
26	<5	74	<1
27	<5	74	<1
28	<3	77	<5
29	<5	80	<1
30		80	<1.5
31			
32	<1	72	<.5
33	<1	72	<.5
34	<1	69	<.5
35	<5	54	<2
36	<5	66	<2

COMBINED SOIL/WASTE FORM CHEMISTRY--BLANK

SAMPLE NUMBER	CUMULATIVE PV (mL)	pH	Eh	ALKALINITY AS CO3	TC	TOC
1	0.88	8.29	364	58.32	35.90	1.70
2	1.65	8.16	379		34.10	1.10
3	2.28	7.26	351		34.50	1.00
4	3.24	8.16	349	38.88	34.40	0.50
5	4.11	8.65	348	44.71	35.10	0.60
6	4.88	9.20	333	46.66		
7	5.46	7.82	339	37.80		
8	5.97	8.09	334	76.60		
9	6.53	7.28	347	52.53		
10	7.62	9.38	340	69.00	34.00	33.70
11	8.55	8.94	378	75.00		
12	9.72	9.69	349	96.00	33.60	32.90
13	11.53	9.73	311	71.40		
14	12.38	9.88	326	75.60		
15	14.30	9.92	330	67.20		
16	15.63	9.86	324	67.20		
17	17.20	10.05	328	71.40		
18	18.16	10.13	333			
19	19.32	10.10	333			
20	20.30	10.24	343			
21	21.20	10.18	292	58.80		
22	23.14	10.23	341			
23	24.13	9.93	340			
24	25.29	9.84	335			
25	26.22	9.61	329	42.00		
26	27.10	9.80	337			
27	28.26	9.69	336			
28	28.98	9.70	345	42.00		
29	31.83	9.70	354	24.00		
30	38.75	9.27	403			
31	43.27	9.59	355	30.00		
32	50.62	9.20	365	30.00		
33	58.30	8.66	323	31.80		
34	62.00	8.37	382	31.80		
35	63.86	8.33	374	33.00	11.60	0.51
36	67.23	8.19	381	32.40	11.73	0.76
37	69.81	8.44	361	32.40	12.60	0.80
38	75.55	8.12	373	33.00	12.50	0.90
39	81.54	8.45	352	33.00	12.19	0.47
40	84.90				12.85	0.69
41	85.92	8.12	404	33.00	10.38	1.07
42	95.79	9.10	387	32.40	10.98	8.80

COMBINED SOIL/WASTE FORM CHEMISTRY--BLANK

SAMPLE NUMBER	Al	As	B	Ba	Be	Ca
1	<.03	0.0330	0.1252	0.0579	<.002	58.8410
2	<.03	0.0231	0.0754	0.0299	<.002	32.0170
3	<.03	<.02	0.0580	0.0184	<.002	22.8120
4	<.03	<.02	0.0626	0.0136	<.002	17.3620
5	<.03	<.02	0.0603	0.0091	<.002	12.4090
6	<.03	<.02	0.0603	0.0070	<.002	9.6721
7	<.03	0.0264	0.0630	0.00B1	<.002	7.8532
8	<.03	<.02	0.0617	0.0039	<.002	6.4180
9	<.03	<.02	0.0469	0.0020	<.002	5.0740
10	<.03	<.02	0.0617	0.0044	<.002	4.6565
11	<.03	<.02	0.0640	0.0042	<.002	5.0045
12	<.03	<.02	0.0547	0.0057	<.002	5.8896
13	<.03	<.02	0.0559	0.0112	<.002	8.0518
14	0.0330	<.02	0.0585	0.0175	<.002	9.1104
15	<.03	<.02	0.0585	0.0162	<.002	8.8844
16	0.0345	<.02	0.0643	0.0170	<.002	9.11B7
17	0.0345	<.02	0.0632	0.0175	<.002	9.3753
18	0.0346	<.02	0.0678	0.0185	<.002	10.0450
19	0.0463	<.02	0.0737	0.0202	<.002	10.8590
20	0.0410	<.02	0.0678	0.0198	<.002	11.8180
21	0.0805	<.02	0.0702	0.0220	<.002	12.6220
22	0.0419	<.02	0.0546	0.0239	<.002	14.3480
23	0.0504	<.02	0.0572	0.0255	<.002	15.5960
24	0.0748	<.02	0.0839	0.0258	<.002	16.0860
25	0.0473	<.02	0.0769	0.0245	<.002	16.7280
26	0.0473	<.02	0.0671	0.0240	<.002	17.2480
27	0.0370	<.02	0.0629	0.0240	<.002	17.9070
28	0.0568	<.02	0.0643	0.0250	<.002	18.2890
29	0.1222	0.0325	0.1039	0.0318	<.002	20.0780
30	<.03	<.02	0.1112	0.0278	0.0036	21.4160
31	<.03	<.02	0.2002	0.0156	<.002	22.4380
32	<.03	<.02	0.0760	0.0279	<.002	25.2280
33	<.03	<.02	0.2205	0.0278	<.002	27.0930
34	<.03	<.02	0.1907	0.0288	<.002	28.0920
35	<.03	<.02	0.0817	0.0295	0.0023	28.1080
36	<.03	<.02	0.0659	0.0298	<.002	29.1170
37	<.03	<.02	0.0868	0.0284	<.002	29.9080
38	<.03	<.02	0.0907	0.0244	<.002	26.8600
39	0.1316	0.0603	0.0892	0.0354	<.002	30.8870
40	<.03	<.02	0.1019	0.0313	<.002	33.0440
41	<.03	<.02	0.1214	0.0263	<.002	26.8320
42	<.03	<.02	0.0808	0.0283	<.002	30.4040

COMBINED SOIL/WASTE FORM CHEMISTRY--BLANK

SAMPLE NUMBER	Cd	Ce	Cr	Cu	Dy	Fe
1	<.005	<.06	<.015	<.005	<.005	0.0223
2	<.005	<.06	<.015	<.005	<.005	0.0060
3	<.005	<.06	<.015	<.005	<.005	<.005
4	<.005	<.06	<.015	<.005	<.005	<.005
5	<.005	<.06	<.015	<.005	<.005	<.005
6	<.005	<.06	<.015	<.005	<.005	<.005
7	<.005	<.06	<.015	<.005	<.005	0.0244
8	<.005	0.2900	<.015	<.005	0.0160	<.005
9	<.005	0.0980	<.015	<.005	<.005	<.005
10	<.005	<.06	<.015	<.005	<.005	0.0173
11	<.005	<.06	<.015	<.005	<.005	0.0065
12	<.005	<.06	<.015	<.005	<.005	<.005
13	<.005	<.06	<.015	<.005	<.005	<.005
14	<.005	<.06	<.015	<.005	<.005	0.0956
15	<.005	<.06	<.015	<.005	<.005	<.005
16	<.005	<.06	<.015	<.005	<.005	<.005
17	<.005	<.06	<.015	<.005	<.005	<.005
18	<.005	<.06	<.015	<.005	<.005	<.005
19	<.005	<.06	<.015	<.005	<.005	<.005
20	<.005	<.06	<.015	<.005	<.005	<.005
21	<.005	<.06	<.015	<.005	<.005	<.005
22	<.005	<.06	<.015	<.005	<.005	0.0057
23	<.005	<.06	<.015	<.005	<.005	0.0088
24	<.005	<.06	<.015	<.005	<.005	<.005
25	<.005	<.06	<.015	<.005	<.005	<.005
26	<.005	<.06	<.015	<.005	<.005	<.005
27	<.005	<.06	<.015	<.005	<.005	<.005
28	<.005	<.06	<.015	<.005	<.005	<.005
29	0.0066	0.1042	<.015	0.0085	0.0071	0.0355
30	<.005	<.06	0.0484	<.005	<.005	0.0062
31	<.005	<.06	<.015	<.005	<.005	<.005
32	<.005	<.06	<.015	<.005	<.005	0.0090
33	<.005	<.06	<.015	<.005	<.005	0.0052
34	<.005	<.06	<.015	<.005	<.005	<.005
35	<.005	<.06	0.0213	<.005	<.005	0.0250
36	<.005	<.06	<.015	<.005	<.005	<.005
37	<.005	0.0686	<.015	<.005	<.005	<.005
38	<.005	<.06	<.015	<.005	<.005	0.0087
39	0.0057	0.0969	<.015	0.0091	0.0059	0.0162
40	<.005	<.06	<.015	<.005	<.005	<.005
41	<.005	<.06	<.015	<.005	<.005	<.005
42	<.005	<.06	<.015	<.005	<.005	<.005

COMBINED SOIL/WASTE FORM CHEMISTRY--BLANK

SAMPLE NUMBER	Gd	K	La	Li	Mg	Mn
1	<.03	6.3901	<.005	<.005	13.0130	<.005
2	<.03	4.8153	<.005	<.005	7.0165	<.005
3	<.03	4.0581	<.005	<.005	5.0177	<.005
4	<.03	3.6342	<.005	<.005	3.5613	<.005
5	<.03	3.1496	<.005	<.005	2.3172	<.005
6	<.03	2.7559	<.005	<.005	1.6568	<.005
7	<.03	2.5728	<.005	<.005	1.2407	<.005
8	0.032	2.5890	<.005	<.005	0.9429	<.005
9	<.03	2.2650	<.005	<.005	0.7506	<.005
10	<.03	2.4164	<.005	<.005	0.5526	<.005
11	<.03	4.2249	<.005	<.005	0.4654	<.005
12	<.03	12.0060	<.005	<.005	0.3316	<.005
13	<.03	31.7630	<.005	0.0120	0.2501	<.005
14	<.03	60.6720	<.005	0.0319	0.1845	<.005
15	<.03	68.2200	<.005	0.0458	0.1076	<.005
16	<.03	70.0800	<.005	0.0491	<.1	<.005
17	<.03	69.6960	<.005	0.0530	<.1	<.005
18	<.03	69.5770	<.005	0.0541	<.1	<.005
19	<.03	69.6030	<.005	0.0586	<.1	<.005
20	<.03	69.3270	<.005	0.0569	<.1	0.0670
21	<.03	67.4510	<.005	0.0608	<.1	<.005
22	<.03	64.5970	<.005	0.0573	<.1	<.005
23	<.03	63.4330	<.005	0.0573	0.1072	<.005
24	<.03	58.3050	<.005	0.0574	0.1098	0.0657
25	<.03	57.2300	<.005	0.0574	0.1297	0.0485
26	<.03	54.7430	<.005	0.0550	0.1297	<.005
27	<.03	53.6260	<.005	0.0534	0.1497	0.5552
28	<.03	54.7010	<.005	0.0550	0.1697	<.005
29	<.03	47.5420	0.0080	0.0569	0.2432	<.005
30	<.03	42.0520	<.005	0.0510	0.1521	<.005
31	<.03	38.0270	<.005	0.0430	0.2682	<.005
32	<.03	31.4420	0.0056	0.0402	0.7078	0.0596
33	<.03	27.3360	<.005	0.0342	1.1952	<.005
34	<.03	25.6800	<.005	0.0337	1.4693	<.005
35	<.03	24.1860	<.005	0.0343	1.6823	<.005
36	<.03	22.0400	<.005	0.0317	1.9485	<.005
37	<.03	20.9150	<.005	0.0308	2.1279	<.005
38	<.03	16.6910	<.005	0.0266	2.2107	<.005
39	<.03	16.6970	0.0098	0.0278	2.9712	<.005
40	<.03	15.4430	<.005	0.0272	3.3206	<.005
41	<.03	13.8320	<.005	0.0266	2.2999	<.005
42	<.03	12.1740	<.005	0.0231	3.5770	<.005

COMBINED SOIL/WASTE FORM CHEMISTRY--BLANK

SAMPLE NUMBER	Mo	Na	Nd	Ni	P	Pb	Ru
1	0.0169	9.5414	<.06	<.02	0.5288	<.05	<.05
2	0.0161	10.4500	<.06	<.02	0.2746	<.05	<.05
3	<.01	19.6420	<.06	<.02	0.2948	<.05	<.05
4	<.01	33.2220	<.06	<.02	0.3169	<.05	<.05
5	0.0121	47.3930	<.06	<.02	0.2856	<.05	<.05
6	0.0145	56.7430	<.06	<.02	0.2911	<.05	<.05
7	0.0248	59.9250	<.06	<.02	0.4979	<.05	<.05
8	0.0151	62.8230	<.06	<.02	0.3017	<.05	<.05
9	<.01	68.4640	<.06	<.02	0.2342	<.05	<.05
10	0.0183	70.5440	<.06	<.02	0.4292	<.05	<.05
11	0.0216	100.2600	<.06	<.02	0.2101	<.05	<.05
12	0.0200	79.3540	<.06	<.02	0.1329	<.05	<.05
13	0.0208	71.7070	<.06	<.02	0.1149	<.05	<.05
14	<.01	61.5760	<.06	<.02	0.1928	0.0583	<.05
15	0.0107	49.3580	<.06	<.02	<.1	<.05	<.05
16	0.0113	47.1910	<.06	<.02	<.1	<.05	<.05
17	0.0131	43.5660	<.06	<.02	<.1	<.05	<.05
18	0.0143	40.5710	<.06	<.02	<.1	<.05	<.05
19	0.0173	39.4290	<.06	<.02	<.1	<.05	<.05
20	0.0208	36.5920	<.06	<.02	<.1	<.05	<.05
21	0.0226	36.4740	<.06	<.02	4.1660	<.05	<.05
22	<.01	36.6300	<.06	<.02	<.1	<.05	<.05
23	<.01	34.6700	<.06	<.02	<.1	<.05	<.05
24	0.0251	30.4110	<.06	<.02	<.1	0.0510	<.05
25	<.01	29.3450	<.06	<.02	<.1	<.05	<.05
26	0.0239	28.0240	<.06	<.02	<.1	<.05	<.05
27	<.01	27.9230	<.06	<.02	<.1	<.05	<.05
28	0.0176	27.1610	<.06	<.02	<.1	<.05	<.05
29	0.0204	26.4700	<.06	<.02	0.1783	0.0790	<.05
30	0.3099	25.1010	<.06	<.02	<.1	<.05	<.05
31	0.1008	26.8360	<.06	<.02	<.1	<.05	<.05
32	0.0333	25.2440	<.06	<.02	<.1	<.05	<.05
33	<.01	26.6860	<.06	<.02	<.1	<.05	<.05
34	<.01	26.8360	<.06	<.02	<.1	<.05	<.05
35	0.1968	26.8350	<.06	<.02	0.1205	<.05	<.05
36	0.0542	26.6510	<.06	<.02	<.1	<.05	<.05
37	0.0511	25.7360	<.06	<.02	<.1	<.05	<.05
38	0.0997	24.5290	<.06	<.02	<.1	<.05	<.05
39	0.0520	26.0580	0.0617	<.02	0.1615	0.1126	<.05
40	0.0564	27.6140	<.06	<.02	<.1	<.05	<.05
41	0.0188	24.2240	<.06	<.02	<.1	<.05	<.05
42	0.0118	27.3570	<.06	<.02	<.1	<.05	<.05

COMBINED SOIL/WASTE FORM CHEMISTRY--BLANK

SAMPLE NUMBER	S	Sb	Se	Si	Sm	Sn
1	29.527	<.1	<.2	28.356	<.05	<.05
2	17.636	<.1	<.2	31.510	<.05	<.05
3	17.565	<.1	<.2	37.081	<.05	<.05
4	19.049	<.1	<.2	47.434	<.05	<.05
5	19.749	<.1	<.2	54.424	<.05	<.05
6	20.077	<.1	<.2	58.103	<.05	<.05
7	18.466	<.1	<.2	56.609	0.2770	0.0780
8	17.924	<.1	<.2	58.109	0.3710	<.05
9	18.575	<.1	<.2	61.026	<.05	0.0780
10	19.318	<.1	<.2	63.670	<.05	<.05
11	29.054	<.1	<.2	80.081	<.05	<.05
12	25.534	<.1	<.2	63.193	<.05	<.05
13	28.145	<.1	<.2	60.091	<.05	<.05
14	28.843	0.1112	<.2	52.145	<.05	<.05
15	27.514	<.1	<.2	44.121	<.05	<.05
16	27.322	<.1	<.2	42.255	<.05	<.05
17	27.018	2.5774	<.2	39.109	<.05	<.05
18	26.874	<.1	<.2	35.616	<.05	<.05
19	27.402	<.1	<.2	34.402	<.05	<.05
20	26.986	<.1	<.2	31.212	<.05	<.05
21	48.591	<.1	<.2	91.546	<.05	<.05
22	28.963	<.1	<.2	27.818	<.05	<.05
23	29.524	<.1	<.2	25.763	<.05	<.05
24	28.816	<.1	<.2	23.620	<.05	<.05
25	28.525	<.1	<.2	23.474	<.05	<.05
26	28.570	<.1	<.2	22.342	<.05	<.05
27	28.906	<.1	<.2	21.941	<.05	<.05
28	28.771	<.1	<.2	21.466	<.05	<.05
29	27.771	0.1678	0.2458	19.959	0.0804	0.0550
30	27.535	0.1370	<.2	18.199	<.05	<.05
31	27.933	10.3980	<.2	16.731	<.05	<.05
32	27.801	<.1	<.2	15.202	<.05	<.05
33	28.569	4.2373	<.2	14.212	<.05	<.05
34	29.905	<.1	<.2	14.092	<.05	<.05
35	29.138	0.1345	<.2	13.952	<.05	0.0593
36	29.403	<.1	<.2	13.424	<.05	<.05
37	27.867	<.1	<.2	13.491	<.05	<.05
38	24.376	<.1	<.2	13.378	<.05	<.05
39	27.804	0.1525	0.2156	13.399	0.0723	<.05
40	28.937	<.1	<.2	13.624	<.05	<.05
41	26.282	<.1	<.2	13.478	<.05	<.05
42	27.236	<.1	<.2	12.494	<.05	<.05

COMBINED SOIL/WASTE FORM CHEMISTRY--BLANK

SAMPLE NUMBER	Sr	Te	Ti	V	Zn	Zr	F-
1	0.2310	<.15	<.005	0.0326	0.1122	<.01	<5
2	0.1248	<.15	<.005	0.0179	0.0845	0.0321	<5
3	0.0921	<.15	<.005	0.0880	0.0428	0.0657	<5
4	0.0652	<.15	<.005	0.1001	0.0104	0.0138	<5
5	0.0457	<.15	<.005	0.0919	0.0070	0.0295	<5
6	0.0347	<.15	<.005	0.0850	0.0056	0.0219	<5
7	0.0290	<.15	<.005	0.0097	0.1013	0.0198	
8	0.0250	<.15	0.0100	0.1070	0.0266	0.0144	
9	0.0160	<.15	<.005	0.0760	0.0525	<.01	
10	0.0157	<.15	0.0060	0.0908	0.0053	<.01	<5
11	0.0177	<.15	<.005	0.0531	<.005	<.01	<5
12	0.0210	<.15	<.005	0.0512	<.005	<.01	<5
13	0.0317	<.15	<.005	0.0435	<.005	<.01	<3
14	0.0378	0.2493	<.005	0.0326	0.0452	<.01	<3
15	0.0378	<.15	<.005	0.0268	<.005	0.0105	<3
16	0.0387	<.15	<.005	0.0299	<.005	<.01	<3
17	0.0398	<.15	<.005	0.0299	<.005	0.0100	<3
18	0.0434	<.15	<.005	0.0237	<.005	0.0346	<3
19	0.0465	<.15	<.005	0.0248	<.005	0.0299	<3
20	0.0503	<.15	<.005	0.0191	<.005	0.0577	<3
21	0.0059	<.15	<.005	0.0196	0.0097	<.01	<3
22	0.0594	<.15	<.005	0.0123	<.005	<.01	<3
23	0.0639	<.15	<.005	0.0111	<.005	<.01	<3
24	0.0691	<.15	<.005	0.0135	<.005	<.01	<3
25	0.0717	<.15	<.005	0.0118	<.005	0.0314	<3
26	0.0729	<.15	<.005	0.0101	<.005	0.0314	<3
27	0.0771	<.15	<.005	0.0084	<.005	<.01	<3
28	0.0780	<.15	<.005	0.0109	<.005	0.0259	<3
29	0.0880	<.15	0.0072	0.0186	0.0097	0.0247	<1
30	0.1200	<.15	0.0191	0.0270	<.005	0.0480	<3
31	0.1442	<.15	<.005	<.005	<.005	<.01	<3
32	0.3395	<.15	<.005	0.0093	<.005	<.01	<3
33	0.5511	<.15	<.005	<.005	<.005	0.0113	<3
34	0.6461	<.15	<.005	<.005	<.005	0.0164	<3
35	0.7116	<.15	0.0115	0.0125	<.005	0.0499	<3
36	0.8011	<.15	<.005	0.0081	<.005	0.0510	<3
37	0.8432	<.15	<.005	0.0055	<.005	0.0510	<3
38	0.8674	<.15	<.005	<.005	<.005	0.0122	<5
39	1.0259	0.2071	<.005	0.0068	0.0092	0.0183	<5
40	1.1551	<.15	<.005	0.0073	<.005	<.01	<5
41	0.8977	<.15	<.005	0.0090	0.0075	<.01	<5
42	1.1848	<.15	<.005	<.005	<.005	<.01	<10

COMBINED SOIL/WASTE FORM CHEMISTRY--BLANK

SAMPLE NUMBER	Cl-	NO3-	SO4--	NO2-
1	17.0	<2	83.0	<1
2	13.0	<2	47.0	<1
3	14.0	8	47.0	<1
4	15.0	<2	48.0	<1
5	15.0	<2	49.0	<1
6	16.0	<2	49.0	<1
7				
8				
9				
10	14.4	<10	57.0	<3
11	22.3	<10	97.0	<3
12	19.4	<10	75.0	<3
13	21.9	<.9	97.0	<.3
14	19.7	<.9	90.0	<.3
15	19.7	<.9	90.0	<.3
16	19.5	<.9	85.0	<.3
17	18.4	<.9	83.0	<.3
18	18.3	<.9	80.0	<.3
19	17.8	<.9	78.0	<.3
20	18.6	<.9	80.0	<.3
21	17.3	<.9	78.0	<.3
22	17.6	<.9	78.0	<.3
23	17.3	<.9	78.0	<.3
24	17.6	<.9	78.0	<.3
25	17.3	<.9	78.0	<.3
26	17.0	<.9	76.0	<.3
27	16.7	<.9	76.0	<.3
28	17.3	<.9	78.0	<.3
29	21.0	<.7	83.0	<.3
30	16.7	<.9	76.0	<.3
31	16.2	<.9	74.0	<.3
32	17.6	<.9	78.0	<.3
33	18.1		90.0	<1.5
34	18.3		85.0	<1.5
35	14.2	<1	73.0	<.5
36	14.0	<1	74.0	<.5
37	14.2	<1	74.0	<.5
38	18.2	<5	66.0	<2
39	21.7	<5	81.0	<2
40	20.9	<2.5	78.0	<1
41	18.5	<10	64.3	<5
42	27.6	<10	90.0	<5

COMBINED SOIL/WASTE FORM COLUMN COBALT-60--WASTE FORM 1

SAMPLE NUMBER	CUMULATIVE PV (mL)	MICROCURIES PER LITER
1	0.82	0.0812
2	1.51	0.2970
3	2.09	0.1360
4	2.97	0.2060
5	3.70	0.1710
6	4.52	0.1280
7	5.40	0.1580
8	6.33	0.1240
9	7.31	0.1060
10	9.54	0.1770
11	10.70	0.1170
12	13.70	0.0000
13	14.70	0.0302
14	15.70	0.0330
15	19.60	0.0193
16	22.70	0.0158
17	27.20	0.0120
18	30.30	0.0000

COMBINED SOIL/WASTE FORM COLUMN COBALT-60--WASTE FORM 2

SAMPLE NUMBER	CUMULATIVE PV (mL)	MICROCURIES PER LITER
1	0.83	0.1960
2	1.56	0.3230
3	2.18	0.2670
4	3.20	0.2410
5	3.93	0.1850
6	4.59	0.1540
7	5.34	0.1440
8	6.17	0.1450
9	7.15	0.1060
10	8.28	0.1160
11	9.13	0.1620
12	10.10	0.0901
13	11.00	0.0405
14	13.70	0.0708
15	14.70	0.0364
16	19.10	0.0228
17	22.00	0.0148
18	26.10	0.0165
19	28.10	0.0000

APPENDIX D

FIELD LYSIMETER CHEMICAL AND RADIONUCLIDE RESULTS;
DRAINAGE DATA

APPENDIX D

FIELD LYSIMETER CHEMICAL AND RADIONUCLIDE RESULTS; DRAINAGE DATA

This appendix contains chemical analysis, radionuclide analysis, and drainage data tables. All units in the chemistry tables are in mg/L unless otherwise noted. All units in the radionuclide tables are in µg/L. Lysimeter drainage data tables are in liters. Eh is in millivolts. TC = Total Carbon and TOC = Total Organic Carbon.

CHEMICAL ANALYSIS LYSIMETER 1

0	1 24OCT84	2 20JUN85	3 24OCT85	4 30JAN86	5 25APR86
1 Eh	121.000	257.000	270.000	236.700	249.400
2 pH	8.340	8.270	8.240	8.160	8.290
3 ALKALINITY	343.800	50.000	90.000	68.180	
4 CONDUCTANCE	0.523	0.622	0.985	0.954	0.481
5 TC	229.000	42.200	40.910	30.260	23.100
6 TOC	124.400		10.160	7.350	7.200
7 F-	9.200	0.510	0.700	0.700	<1
8 Cl-	3.990	6.600	5.700	5.200	4.100
9 NO2-	<1	<1	<1	<1	<1
10 NO3-	0.300	246.000	296.000	435.000	32.000
11 SO4--	60.300	95.000	68.000	65.000	39.000
12 PO4-	<5	<5	<5.00	<5.00	<5
13 B	0.120	<.01	0.056	0.042	0.117
14 Ba	0.120	0.230	0.268	0.150	0.060
15 Ca	54.700	98.100	103.000	130.000	74.900
16 Cd	<.004	<.004	<.004	0.007	<.004
17 Cr	<.02	0.020	0.043	0.042	<.02
18 Cu	0.010	<.004	0.021	0.009	0.005
19 Fe	<.005	<.005	0.025	0.025	0.011
20 K	46.000	10.400	16.000	13.000	7.300
21 Li	<.04	<.04	0.073	0.084	0.080
22 Mg	11.020	22.200	23.700	31.500	18.500
23 Mn	0.150	<.002	0.005	0.003	<.002
24 Mo	<.01	<.01	0.020	<.01	<.01
25 Na	127.000	31.200	37.000	33.000	17.000
26 Ni	<.02	<.02	<.02	<.02	<.02
27 P	0.200	<.1	0.100	0.200	<.1
28 Si	23.500	14.100	17.600	15.700	18.800
29 Sr	0.320	0.460	0.511	0.578	0.320
30 Zn	0.510	0.150	0.057	0.110	0.100

CHEMICAL ANALYSIS LYSIMETER 2

0	1 24OCT84	2 29MAR85	3 20JUN85	4 24OCT85	5 30JAN86	6 25APR86
1 Eh	-57.000	296.000	282.000	310.200	240.400	270.400
2 pH	8.250	8.300	8.340	8.320	8.220	8.200
3 ALKALINITY	350.700	80.000	60.000	60.000	113.180	
4 CONDUCTANCE	0.658	0.775	0.568	1.840	2.360	1.750
5 TC	361.300	64.700	41.700	56.500	63.100	55.000
6 TOC	242.400			26.200	31.500	32.500
7 F-	12.100	0.500	0.580	0.800	1.000	<1
8 Cl-	2.490	7.800	9.500	30.000	48.000	20.000
9 NO2-	<1	<1	<1	<1	<1	<1
10 NO3-	0.300	136.000	179.000	128.000	167.000	23.000
11 SO4--	45.300	81.000	90.000	960.000	1400.000	1100.000
12 PO4-	<5	<5	<5	<5.00	<5.00	<5
13 B	0.200	<.01	<.01	0.054	0.046	0.044
14 Ba	0.130	0.250	0.240	0.078	0.098	0.500
15 Ca	47.100	41.100	93.900	295.000	386.000	263.000
16 Cd	<.004	<.004	<.004	0.009	<.004	<.004
17 Cr	<.02	0.020	<.02	0.025	<.02	<.02
18 Cu	0.004	0.020	<.004	0.230	0.016	0.160
19 Fe	<.005	<.005	<.005	0.030	0.029	0.028
20 K	77.000	78.700	6.900	18.000	20.000	7.400
21 Li	<.04	<.04	<.04	0.180	<.04	0.224
22 Mg	9.920	11.500	20.800	66.000	91.000	70.700
23 Mn	0.110	<.002	<.002	0.009	<.002	0.030
24 Mo	<.01	<.01	<.01	0.050	<.01	0.044
25 Na	168.000	64.100	25.100	131.000	240.000	241.000
26 Ni	<.02	<.02	<.02	0.020	<.02	<.02
27 P	0.200	<.1	<.1	0.350	0.500	<.1
28 Si	22.500	13.300	17.600	19.900	15.900	22.000
29 Sr	0.290	0.230	0.420	1.410	1.660	1.030
30 Zn	0.060	0.120	0.180	0.100	0.340	0.180

CHEMICAL ANALYSIS LYSIMETER 3

0	1 240CT84	2 29MAR85	3 20JUN85	4 240CT85	5 30JAN86	6 25APR86
1 Eh	-185.000	343.000	293.000	307.500	229.400	290.400
2 pH	8.050	8.140	8.330	8.120	8.230	8.060
3 ALKALINITY	209.000	60.000	60.000	70.000	90.960	
4 CONDUCTANCE	0.606	0.573	0.568	1.850	2.360	2.640
5 TC	196.500	43.700	46.100	58.980	54.650	79.300
6 TOC	130.600			24.460	30.020	53.200
7 F-	14.300	0.400	0.500	0.800	<1.00	<1
8 Cl-	14.300	5.800	5.400	40.000	54.000	30.000
9 NO2-	<1	<1	<1	<1	<1	<1
10 NO3-	0.300	109.000	101.000	35.000	84.000	22.000
11 SO4-	111.000	74.000	70.000	1060.000	1530.000	1900.000
12 PO4-	<5	<5	<5	<5.00	<5.00	<5
13 B	0.210	<.01	<.01	0.066	0.056	0.036
14 Ba	0.110	0.260	0.230	0.048	0.147	0.170
15 Ca	51.800	54.700	74.500	312.000	380.000	350.000
16 Cd	<.004	<.004	<.004	0.007	0.005	<.004
17 Cr	<.02	0.030	<.02	<.02	0.035	<.02
18 Cu	<.004	0.010	<.004	0.014	0.029	0.026
19 Fe	<.005	<.005	<.005	0.208	0.036	0.028
20 K	49.000	32.900	6.600	16.000	14.000	10.000
21 Li	<.04	<.04	<.04	0.080	0.050	0.280
22 Mg	7.670	11.300	16.300	70.000	92.000	94.000
23 Mn	0.100	<.002	<.002	0.003	0.015	0.062
24 Mo	<.01	<.01	<.01	0.063	0.015	0.080
25 Na	106.000	32.400	22.000	120.000	245.000	405.000
26 Ni	0.040	0.020	<.02	<.02	<.02	<.02
27 P	0.100	<.1	<.1	0.230	0.200	<.1
28 Si	44.400	19.600	20.400	23.500	19.100	24.000
29 Sr	0.390	0.310	0.330	1.450	1.520	1.430
30 Zn	0.690	0.090	0.350	0.210	0.170	0.550

CHEMICAL ANALYSIS LYSIMETER 4

0	1 240CT84	2 29MAR85	3 29JUN85	4 240CT85	5 30JAN86	6 25APR86
1 Eh	-208.000	319.000	293.000	314.100	254.200	315.100
2 pH	8.120	8.260	8.390	8.000	8.150	8.060
3 ALKALINITY	489.500	120.000	100.000	140.000	181.920	
4 CONDUCTANCE	1.164	1.587	1.025	1.410	3.190	1.209
5 TC	507.100	120.300	78.500	243.160	655.580	240.300
6 TOC	343.400			167.700	438.388	195.000
7 F-	25.400	4.100	0.490	0.700	1.300	<1
8 Cl-	5.490	72.000	49.000	65.000	65.000	17.000
9 NO2-	<1	3.000	6.000	5.600	<1	<1
10 NO3-	0.300	108.000	104.000	52.000	128.000	14.000
11 SO4-	90.700	108.000	104.000	690.000	2230.000	740.000
12 PO4-	<5	<5	<5	<5.00	<5.00	<5
13 B	0.420	<.01	<.01	0.076	0.123	0.100
14 Ba	0.180	0.350	0.310	0.400	0.180	0.140
15 Ca	62.000	148.000	190.000	271.000	525.000	187.000
16 Cd	<.004	<.004	<.004	0.008	0.009	<.004
17 Cr	<.02	0.010	<.02	0.020	<.02	<.02
18 Cu	<.004	0.050	<.004	0.014	0.041	0.014
I9 Fe	0.200	<.005	<.005	0.048	0.069	0.038
20 K	173.000	286.000	10.300	15.000	17.000	10.000
21 Li	<.04	<.04	<.04	0.090	0.060	0.194
22 Mg	18.610	44.900	42.800	61.500	135.000	45.000
23 Mn	0.220	<.002	0.080	0.046	0.017	0.006
24 Mo	<.01	<.01	<.01	0.035	0.017	0.036
25 Na	266.000	105.000	34.000	99.000	430.000	261.000
26 Ni	<.02	0.040	0.020	0.025	0.150	<.02
27 P	0.200	<.1	<.1	0.200	1.000	0.400
28 Si	33.200	13.300	14.000	17.700	14.000	17.000
29 Sr	0.420	0.830	0.880	1.330	2.170	0.780
30 Zn	0.170	0.300	1.820	0.310	0.070	0.600

CHEMICAL ANALYSIS LYSIMETER 5

0	1 240CT85	2 30JAN86	3 25APR86
1 Eh	319.800	263.300	333.400
2 pH	7.930	8.230	8.050
3 ALKALINITY	80.000	98.540	
4 CONDUCTANCE	0.580	0.618	0.364
5 TC	60.680	42.570	35.500
6 TOC	12.160	9.560	6.100
7 F-	0.400	<1.00	<1
8 Cl-	3.300	5.200	3.100
9 NO2-	<1	<1	<1
10 NO3-	73.000	170.000	15.000
11 SO4-	79.000	104.000	29.000
12 PO4-	<5.00	<5.00	<5
13 B	0.100	0.056	17.300
14 Ba	0.345	0.118	0.048
15 Ca	54.000	70.000	59.100
16 Cd	0.005	<.004	<.004
17 Cr	<.02	0.020	<.02
18 Cu	0.042	0.011	<.004
19 Fe	0.021	0.009	0.005
20 K	42.000	27.000	6.400
21 Li	<.04	<.04	0.073
22 Mg	10.500	16.000	14.200
23 Mn	0.004	0.003	<.002
24 Mo	<.01	<.01	<.01
25 Na	53.000	38.000	20.000
26 Ni	0.020	<.02	<.02
27 P	<.1	<.1	<.1
28 Si	15.600	13.500	17.800
29 Sr	0.260	0.337	0.274
30 Zn	0.200	0.150	<.02

CHEMICAL ANALYSIS LYSIMETER 6

0	1 24OCT84	2 24OCT85	3 30JAN86	4 25APR86
1 Eh	69.000	338.700	272.300	332.400
2 pH	7.640	8.210	8.100	8.040
3 ALKALINITY	297.000	110.000	144.020	
4 CONDUCTANCE	297.000	0.760	0.633	0.462
5 TC	95.900	69.520	52.990	31.400
6 TOC	14.700	10.570	8.210	6.400
7 F-	0.500	0.400	0.700	<1
8 Cl-	5.180	4.400	4.800	5.200
9 NO2-	27.100	<1	1.200	<1
10 NO3-	52.300	118.000	158.000	25.000
11 SO4-	69.000	56.000	61.000	34.000
12 PO4-	<5	<5.00	<5.00	<5
13 B	0.060	0.082	0.064	24.500
14 Ba	0.124	0.279	0.124	0.059
15 Ca	90.000	83.000	83.000	74.200
16 Cd	<.004	<.004	<.004	<.004
17 Cr	<.02	<.02	0.020	<.02
18 Cu	0.010	0.018	0.009	0.029
19 Fe	<.005	0.019	0.056	0.041
20 K	54.000	29.000	16.000	5.100
21 Li	<.04	0.084	0.056	0.080
22 Mg	20.720	21.000	20.000	18.200
23 Mn	0.020	0.005	0.008	<.002
24 Mo	<.01	0.020	0.088	<.01
25 Na	71.400	40.000	34.000	19.000
26 Ni	<.02	<.02	0.020	<.02
27 P	0.200	0.200	<.1	<.1
28 Si	20.000	14.900	13.900	18.800
29 Sr	0.520	0.459	0.428	0.320
30 Zn	0.870	0.230	0.220	0.160

CHEMICAL ANALYSIS LYSIMETER 7

0	1 24OCT84	2 29MAR85	3 20JUN85	4 24OCT85	5 30JAN86	6 25APR86
1 Eh	148.000	339.000	290.000	368.700	279.900	336.600
2 pH	8.190	8.080	8.460	8.020	8.070	8.070
3 ALKALINITY	255.800	70.000	80.000	70.000	98.540	
4 CONDUCTANCE	0.905	0.838	0.595	1.630	0.689	0.350
5 TC	281.700	52.700	50.400	40.890	38.710	27.600
6 TOC	186.900			9.830	8.330	9.600
7 F-	17.200	0.470	0.540	0.700	0.800	<1
8 Cl-	5.710	6.800	5.000	5.000	5.400	3.100
9 NO2-	<1	21.000	1.100	<1	<1	<1
10 NO3-	0.300	181.000	184.000	240.000	260.000	19.000
11 SO4-	216.000	132.000	90.000	65.000	64.000	36.000
12 PO4-	<5	<5	<5	<5.00	<5.00	<5
13 B	0.150	<.01	<.01	0.057	0.046	0.270
14 Ba	0.130	0.320	0.260	0.107	0.123	0.047
15 Ca	96.100	81.000	102.000	95.000	96.000	56.700
16 Cd	<.004	<.004	<.004	<.004	<.004	<.004
17 Cr	<.02	0.020	0.010	<.02	0.020	<.02
18 Cu	0.040	0.040	0.010	0.021	0.091	0.013
19 Fe	<.005	<.005	<.005	0.016	<.005	<.005
20 K	62.000	46.000	9.700	12.000	11.000	6.400
21 Li	<.04	<.04	<.04	0.087	0.080	0.071
22 Mg	16.210	15.700	21.100	21.000	22.000	13.200
23 Mn	0.120	<.002	0.020	0.003	<.002	<.002
24 Mo	<.01	<.01	<.01	0.018	<.01	<.01
25 Na	130.000	65.800	29.700	32.000	31.000	18.000
26 Ni	0.020	0.020	<.02	<.02	<.02	<.02
27 P	0.200	<.1	<.1	0.100	<.1	<.1
28 Si	31.800	13.900	14.700	17.000	14.600	17.500
29 Sr	0.600	0.210	0.820	0.444	0.436	0.251
30 Zn	1.240	0.210	0.290	0.060	0.100	0.070

CHEMICAL ANALYSIS LYSIMETER 8

0	1 24OCT84	2 29MAR85	3 20JUN85	4 24OCT85	5 30JAN86	6 25APR86
1 Eh	97.000	322.000	290.000	353.400	269.600	365.700
2 pH	7.730	7.780	8.370	8.190	8.210	8.000
3 ALKALINITY	332.800	40.000	50.000	70.000	106.120	
4 CONDUCTANCE	1.018	0.652	0.524	1.800	2.210	1.620
5 TC	284.200	25.700	41.000	61.140	33.960	59.300
6 TOC	181.900			24.600	7.790	33.300
7 F-	13.100	0.620	0.500	0.800	0.700	<1
8 Cl-	3.730	7.500	57.000	32.000	46.000	18.000
9 NO2-	<1	<1	1.500	<1	<1	<1
10 NO3-	0.200	88.000	57.000	9.000	49.000	14.000
11 SO4--	181.000	195.000	187.000	955.000	1300.000	1100.000
12 PO4-	<5	0.700	0.500	<5.00	<5.00	<5
13 B	0.180	<.01	<.01	0.065	0.049	0.038
14 Ba	0.130	0.250	0.260	0.214	0.137	0.180
15 Ca	76.000	91.800	94.100	256.000	331.000	252.000
16 Cd	<.004	<.004	<.004	<.004	0.006	<.004
17 Cr	0.020	0.030	<.02	<.02	0.035	<.02
18 Cu	0.020	0.020	0.010	0.017	0.045	0.046
19 Fe	<.005	<.005	<.005	0.064	0.035	0.020
20 K	88.000	5.200	7.400	18.000	17.000	7.400
21 Li	<.04	<.04	<.04	0.190	0.050	0.212
22 Mg	16.040	21.400	21.100	61.000	81.000	72.000
23 Mn	0.070	<.002	<.002	0.128	0.012	0.058
24 Mo	<.01	<.01	<.01	0.026	0.012	0.046
25 Na	153.000	21.800	21.300	113.000	193.000	207.000
26 Ni	0.020	<.02	<.02	0.020	0.110	0.046
27 P	0.200	0.300	<.1	0.200	0.400	<.1
28 Si	37.900	18.500	19.800	23.300	14.600	23.000
29 Sr	0.560	0.340	0.400	1.210	1.370	1.000
30 Zn	1.150	0.280	0.820	0.230	0.167	0.240

CHEMICAL ANALYSIS LYSIMETER 9

0	1 24OCT84	2 29MAR85	3 20JUN85	4 24OCT85	5 30JAN86	6 25APR86
1 Eh	185.000	352.000	299.000	336.000	266.700	281.800
2 pH	7.930	8.010	8.320	8.220	8.360	8.260
3 ALKALINITY	206.300	40.000	70.000	90.000	136.440	
4 CONDUCTANCE	0.738	0.508	0.507	0.460	2.310	2.420
5 TC	311.000	26.200	42.200	24.420	98.380	120.100
6 TOC	212.000			8.670	53.360	74.200
7 F-	24.500	0.650	0.690	0.700	<1.00	<1
8 Cl-	6.900	8.000	9.000	50.000	81.000	23.000
9 NO2-	<1	<1	2.400	<1	<1	<1
10 NO3-	0.300	112.000	71.000	50.000	123.000	11.000
11 SO4-	261.000	95.000	171.000	915.000	1360.000	18000.000
12 PO4-	<5	<5	<5	<5.00	<5.00	<5
13 B	0.110	<.01	<.01	0.067	0.043	0.042
14 Ba	0.120	0.240	0.260	0.156	0.129	0.220
15 Ca	141.500	70.100	92.100	245.000	370.000	272.000
16 Cd	<.004	<.004	<.004	0.008	0.006	<.004
17 Cr	<.02	0.020	<.02	0.025	0.044	<.02
18 Cu	1.000	0.170	0.040	0.070	0.170	0.070
19 Fe	<.005	<.005	<.005	0.033	0.038	0.042
20 K	87.000	6.500	8.200	22.000	26.000	15.000
21 Li	<.04	<.04	<.04	0.200	0.120	0.440
22 Mg	19.620	16.400	20.300	57.000	88.000	96.500
23 Mn	0.140	<.002	<.002	0.116	0.034	0.510
24 Mo	<.01	<.01	<.01	0.018	0.034	0.068
25 Na	110.000	17.800	21.900	196.000	253.000	486.000
26 Ni	0.030	<.02	<.02	0.026	0.140	0.040
27 P	0.100	<.1	<.1	1.100	1.600	2.000
28 Si	22.300	20.500	19.800	26.000	24.300	30.000
29 Sr	0.710	0.300	0.400	1.190	1.660	1.250
30 Zn	1.030	0.220	1.610	0.470	0.122	0.200

CHEMICAL ANALYSIS LYSIMETER 10

0		1 29MAR85	2 24OCT85	3 30JAN86	4 25APR86
1	Eh	335.000	358.600	271.600	373.400
2	pH	8.240	8.240	8.260	8.180
3	ALKALINITY	70.000	70.000	113.630	
4	CONDUCTANCE	0.286	0.680	0.532	0.483
5	TC	34.300	47.650	41.180	38.200
6	TOC		5.240	5.070	5.100
7	F-	0.480	0.600	0.500	<1
8	Cl-	1.500	4.400	6.700	6.900
9	NO2-	<1	<1	<1	<1
10	NO3-	28.000	<5.00	6.500	5.400
11	SO4-	20.000	80.000	148.000	160.000
12	PO4-	0.500	<5.00	<5.00	<5
13	B	<.01	0.065	0.045	0.089
14	Ba	0.040	0.117	0.102	0.080
15	Ca	41.100	58.000	71.000	85.300
16	Cd	<.004	<.004	<.004	<.004
17	Cr	<.02	<.02	<.02	<.02
18	Cu	0.020	0.014	0.009	0.010
19	Fe	<.005	0.016	0.014	0.008
20	K	3.800	5.600	4.400	4.000
21	Li	<.04	0.052	0.056	0.088
22	Mg	10.400	13.400	16.800	20.300
23	Mn	<.002	0.029	0.010	0.005
24	Mo	<.01	0.026	0.100	<.01
25	Na	10.600	36.000	35.000	32.000
26	Ni	<.02	<.02	<.02	<.02
27	P	0.100	0.200	0.100	<.1
28	Si	16.400	17.300	12.500	16.300
29	Sr	0.145	0.277	0.329	0.395
30	Zn	<.02	0.220	0.658	0.405

LYSIMETER RADIONUCLIDE ANALYSIS--COBALT-60 MICROGRAMS/mL

LYSIMETER NUMBER	24OCT84	24JAN85	14FEB85	11MAR85
1	*	*	*	*
2	*	*	*	*
3	*	*	*	*
4	*	*	*	*
5	*	*	*	*
6	*	*	*	*
7	*	*	*	*
8	*	*	0.000002	*
9	*	*	5.473e-07	0.000002
10	*	4.07e-07	*	*

LYSIMETER NUMBER	29MAR85	20JUN85	24OCT85	30JAN86
1	*	*	*	*
2	*	*	0.000024	6.43e-07
3	*	*	0.000002	0.000087
4	5.473e-07	0.000004	3.48e-07	0.000055
5	*	*	*	*
6	*	*	*	*
7	*	*	*	*
8	5.47e-07	0.000002	0.000020	0.000044
9	*	*	0.000120	0.000188
10	*	*	*	*

LYSIMETER NUMBER	25APR86	6JUN86
1	*	*
2	0.000042	0.000059
3	0.000089	0.000169
4	0.000028	0.000025
5	*	2.99e-07
6	*	*
7	*	2.95e-07
8	0.000052	0.000094
9	0.000102	0.000173
10	1.41e-07	0.000002

* = VALUE BELOW DETECTION LIMIT

LYSIMETER DRAINAGE TO JUNE 1984 (LITERS)

LYSIMETER NUMBER	26OCT84	16NOV84	24JAN85	13FEB85	11MAR85	29MAR85
1	1.085	0.170				
2	1.070	0.175	0.021			15.08
3	0.850	0.085	0.691			1.40
4	1.100	0.010	0.175			1.00
5			0.021			
6	0.950	0.090	0.146			
7	0.818		0.055			8.56
8	0.675		0.069	173.100	165.43	31.24
9	1.090	0.260	0.010	199.450	139.92	23.68
10			0.087	12.815		159.26

LYSIMETER NUMBER	20JUN85	14AUG85	24OCT85	31JAN86	28FEB86	21MAR86
1	50.14	27.62	24.18	28.46	50.75	58
2	56.70	29.35	23.68	17.12	40.50	62
3	50.14	30.96	19.90	24.68	39.00	57
4	57.70	28.42	27.46	24.68	105.00	40
5		0.03	0.50	3.00	94.25	38
6		1.00	3.00	11.45	143.00	44
7	67.15	27.32	24.68	32.24	126.00	32
8	55.81	23.68	29.35	36.02	126.00	12
9	48.25	26.52	20.85	13.90	136.00	4
10	97.52		46.36	9.56		51

LYSIMETER NUMBER	27MAR86	3APR86	10APR86	17APR86	25APR86	1MAY86
1	14	9.0	13	9.0	9.670	7.505
2	14	10.0	11	9.0	10.460	7.050
3	15	12.0	11	10.0	10.000	6.730
4	14	11.0	10	9.0	9.600	7.400
5	12	11.0	10	9.5	11.200	8.795
6	15	14.0	12	11.0	13.750	9.780
7	14	14.0	11	9.0	9.355	8.390
8	19	14.5	11	9.0	9.740	7.485
9	17	12.5	11	10.0	8.600	6.950
10	105			48.0	6.215	

LYSIMETER DRAINAGE TO JUNE 1984 (LITERS)

LYSIMETER NUMBER	8MAY86	15MAY86	22MAY86	29MAY86	6JUN86	12JUN86
1	9.490	9.800	7.360	7.965	9.350	5.555
2	9.200	8.735	7.435	7.490	8.215	5.540
3	7.145	9.850	6.950	8.755	8.405	5.040
4	8.425	9.250	7.220	7.790	7.990	5.555
5	8.605	9.160	7.410	7.265	7.430	5.450
6	10.505	10.000	8.420	7.525	7.725	6.695
7	7.480	9.000	7.665	6.480	9.050	5.620
8	8.260	8.680	7.225	7.325	10.375	5.900
9	7.345	7.430	6.210	6.830	8.000	5.445
10	22.000				32.225	

LYSIMETER NUMBER	19JUN86	TOTAL TO 19JUN86
1	6.74	358.840
2	6.98	360.801
3	7.36	342.941
4	6.75	399.525
5	6.00	249.616
6	6.88	336.916
7	6.62	436.483
8	7.72	779.584
9	6.84	728.080
10	8.50	598.542

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