Hanford Grout Technology Program

Leach and EP Toxicity Tests on Grouted Waste From Tank 106-AN

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September 1989

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Pacific Northwest Laboratory
Richland, Washington 99352

SUMMARY

Pacific Northwest Laboratory is conducting laboratory experiments to produce leach rate data for various waste species that will be contained in grout at Hanford. In the work reported here, grout made from Tank 106-AN liquid waste was used to produce empirical leach rate data for several radionuclides (^{60}Co, ^{90}Sr, ^{99}Tc, ^{129}I, ^{137}Cs, and ^{241}Am), stable major components (NO_3^-, NO_2^-, F, Cl, and Na), and trace metals (Cr, Mo, and Ni). Two types of tests were used to produce leach rate data: an intermittent replacement leach test (ANS 16.1 leach test) and a static leach test. Measured effective diffusivities of key species are as follows: 4 to 6×10^{-8} cm^2/sec for ^{99}Tc, 3 to 7×10^{-8} cm^2/sec for ^{129}I, 4 to 6×10^{-9} cm^2/sec for nitrate, and 6 to 7×10^{-9} cm^2/sec for nitrite. The leach indices of all species studied are above (more favorable than) the waste form criteria. The leach indices for ^{99}Tc and ^{129}I are 7.4 ± 1.2 and 7.6 ± 0.4, respectively, and are being further investigated in continuing studies of double-shell slurry feed grouts. An Extraction Procedure (EP) toxicity test was also conducted and the grouted waste is considered nontoxic per this test protocol.

ACKNOWLEDGMENTS

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We wish to thank W. G. Richmond (WHC) for obtaining the Tank 106-AN liquid waste and results of various measurements, and the following PNL staff for analytical support: C. W. Thomas (wet chemical separations and radionuclide counting); and F. T. Hara, D. E. Rinehart, D. L. Widrig and L. M. Padilla (chemical analysis of leachates by ICP and IC). We wish to thank E. A. Fairweather for typing the original manuscript.

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1.0 INTRODUCTION

A U.S. Department of Energy (DOE) program is under way to construct and operate a Grout Treatment Facility (GTF) at the Hanford Site near Richland, Washington, for disposing of the low-level fraction of liquid double-shell tank wastes. The wastes will be immobilized and disposed as solidified grout. This program is funded through DOE and is managed by Westinghouse Hanford Company (WHC), with technical support from Oak Ridge National Laboratory (ORNL) and Pacific Northwest Laboratory (PNL).[a] The GTF produced grout containing phosphate-sulfate waste (PSW) during 1988/1989.

At the GTF, low-level liquid wastes are mixed with blends of grout-forming solids (Portland cement, fly ash, clays, and other components) to produce a slurry. This slurry is pumped to near-surface disposal sites (engineered vaults), where the grout will harden and cure to form large, solid monoliths of immobilized waste. As part of the program to demonstrate the acceptability of grout as a final disposal method, performance assessment studies are being conducted. These studies yield computer-generated predictions that are used to assess the impact of the grout disposal method on long-term public health and safety.

An assessment of the long-term performance of the grout disposal system requires data on the effective diffusivity of species within the grout. This document reports progress on laboratory experiments that are producing empirical diffusion data for a particular grouted waste stream (i.e., grouted waste from Tank 106-AN). Empirical leach rates are being produced for several radionuclides (^{14}C, ^{60}Co, ^{63}Ni, ^{90}Sr, ^{99}Tc, ^{129}I, ^{137}Cs, and ^{241}Am), stable major components (NO_3^-, NO_2^-, F, Cl, and Na), and trace metals (Cr, Mo, and Ni). The effective diffusivities are direct inputs to the performance assessment models used to forecast potential environmental impacts. In addition, the report presents results from an extraction procedure (EP) toxicity test, which is a regulatory test used for waste classification.

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This report is divided into sections that discuss materials used in leaching tests, test methods, and laboratory test results and conclusions. Appendices A through E contain the raw data used to support the analyses.

2.0 MATERIALS

Details on the Tank 106-AN waste, grout production, and Hanford groundwater chemistry are described in this section.

2.1 TANK 106-AN LIQUID WASTE

Westinghouse Hanford Company provided four lead-shielded pigs that contained plastic bottles of liquid waste. To create a composite sample of waste, a beaker was placed on a stirrer/hot plate and the contents of the bottle from one pig were poured into the beaker. Visual inspection showed a yellowish, clear fluid with no suspended solids. No residual precipitate was present in the bottle. Once the solution in the beaker reached >35°C, a second pig was opened and the contents of its bottle were added to the beaker. The procedure was repeated for the remaining bottles. At no time did the mixture show signs of precipitation or cloudiness. Because the liquid waste in each bottle was radioactive, contents were added to the beaker without measuring volumes. However, WHC indicated that each bottle contained about the same volume (i.e., 60 ± 10 mL). All sampling of the composite liquid waste sample was performed at temperatures of 50°C to 60°C. Chemical and radionuclide analyses were performed using the same procedures that were used to analyze grout leachates (see Section 3.0). The ion chromatography (IC) measurements were performed on a solution consisting of 1-part waste to 25-parts distilled water on October 29, 1987. The inductively coupled plasma (ICP) measurements were performed on a 1-part waste to 10-parts acid dilution on November 9, 1987. The radionuclide determinations were performed on a 1-part waste to 10-parts acid dilution over the period December 1 to 15, 1987.

Tables 2.1 and 2.2 compare the PNL measurements with results provided by WHC. The PNL and WHC composite samples were prepared separately and do not represent duplicate samples.

TABLE 2.1. Comparison Between PNL and WHC Chemical Analyses of Composite Samples of Tank 106-AN Waste

Waste Constituents	Chemical Results (mg/L) PNL	WHC
Al	10,800	12,465
B	28.6	18.2
Ca	70	85
Cr	662	832
Cu	---	1.5
K	31	32
Na	93,800	121,600
Ni	27	(5)[a]
Si	55	28
P	4,400	6,260
F^-	150 to 187	34
Cl^-	2,438	3,474
NO_2^-	38,250	36,754
NO_3^-	88,500	90,024
PO_4^{3-}	15,225	18,430
SO_4^{2-}	2,650	2,592
CO_3^{2-}	---	22,920
OH^-	---	23,000
TOC	---	0.441[b]

(a) Average of two samples with values reported; not an actual measurement of the composite.
(b) Molar (not mg/L).

TABLE 2.2. Comparison Between PNL and WHC Radionuclide Analyses of Composite Samples of Tank 106-AN Waste

Waste Constituents	Radionuclide Results (μCi/L) PNL	WHC
^{3}H	0.57	6.85
^{14}C	<5.41	0.65[a]
^{55}Fe	11.90	---
^{59}Ni	0.60	---
^{63}Ni	90.5	---
^{60}Co	32.7	---
^{79}Se	---	0.52
^{90}Sr	4,160	4,360
^{99}Tc	6.94	96.25[b]
^{129}I	0.03	<0.2
^{137}Cs	2.47×10^{5}	2.58×10^{5}
^{238}Pu	0.017	0.21
$^{239,240}Pu$	0.054	0.44
^{241}Am	0.5	1.45
^{244}Cm	0.0143	---
^{237}Np	---	0.16
Gross Beta	3.32×10^{5}	5.19×10^{5}
Gross Alpha	0.984	---

(a) Calculated average, not actual measurement; range of individual samples used to create the composite shown.
(b) Analyses by Westinghouse Hanford Company. Range of WHC values on individual samples used to create the composite shown.

2.2 GROUT PRODUCTION

Grout containing waste from Tank 106-AN was prepared by mixing 1080 g of dry blend with 1 L of liquid waste (9 lb/gal). The dry blend is a mixture of 47.5 wt% ground blast furnace slag; 47.5 wt% class F fly ash from Centralia, Washington; and 5 wt% type I/II Portland cement.

A small-volume mixing apparatus was built using a plastic 250-mL separatory funnel as the mixing chamber. A schematic of the apparatus is shown in Figure 2.1. In this design, a stainless steel ball valve replaces the original stopcock at the bottom of the funnel, which allows more effective discharge of the grout. A paddle was constructed of a 1/4-in. stainless steel shaft and a metal stir bar. The shaft is attached to the stir bar with a hinge pin. The pin allows the bar to fold to the shaft for insertion into the funnel. The bottom portion of the shaft fits into the opening of the ball valve to minimize "dead space" and to prevent wobbling during mixing. The paddle was rotated with a variable speed motor. During mixing, the stir bar

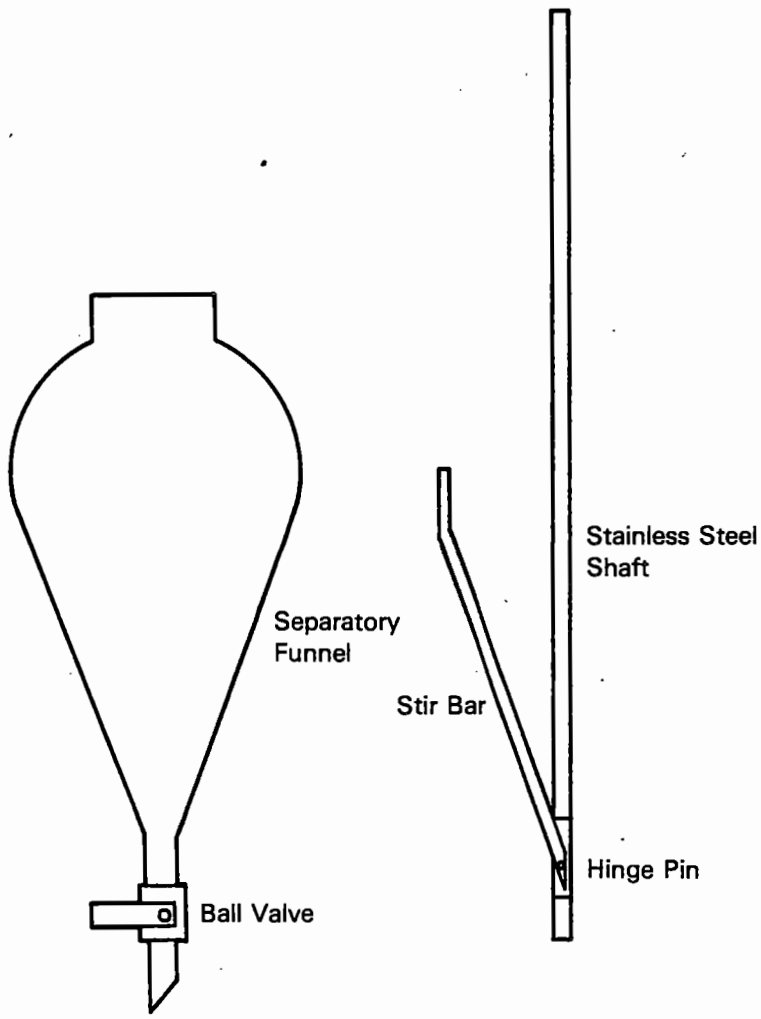

FIGURE 2.1. System Used to Mix Small Batches of Radioactive Grout

swings out to the walls of the funnel. The mixing shaft extends above the separatory funnel and through a powder funnel used to add grout solids.

This mixing apparatus was previously developed for use in producing grouts made from phosphate/sulfate waste (PSW). This system was chosen to reduce the potential for shearing of the PSW grout during mixing. To test the application of this mixing apparatus in producing grout from Tank 106-AN waste, grouts were prepared in the usual manner in a Hobart mixer. A second batch was prepared in the separatory funnel mixer. Rheological properties of the Hobart-mixed grouts were tested using both Fann and Haake viscometers. The funnel-mixed grouts were tested in the Haake viscometer. Based on the test results, mixing for 2.5 minute at 400 rpm in the separatory funnel mixer produced grouts with rheological properties that were comparable to those of grouts produced by conventional methods in the Hobart mixer.

Several hours prior to making the grout, the composite sample of 106-AN liquid waste was heated above 50°C and thoroughly mixed. A 50-mL sample was cooled to 50°C during transfer to the separatory funnel mixer. A pre-measured packet of dry solids blend was added over a 15-second period and mixed for 2.5 minutes at 400 rpm. The resulting sample of slurry was used for rheological measurements. The process was repeated twice more, the first time using 150 mL of liquid waste and the second time using 140 mL.

Rheological measurements of the slurry were conducted using a Haake RV-100 viscometer. The slurry was tested to a shear rate of 468 sec^{-1} over a 5-minute period. The critical flow rate (through a 2-in.-dia. pipe at a Reynolds number of 2100) was 17 gpm. The 10-minute gel strength was measured at 0.7 Pa. Figure 2.2 shows the rheogram in both the increasing and decreasing shear rate direction.

Grouts were placed in polyethylene vials with tight-fitting lids and cured in an oven at 42±2°C. Seven 30-mL grout specimens and one 55-mL specimen were prepared on October 28, 1987. After 40 days of curing, the grouts had ~7% by volume drainable liquid. The volume of liquid was too small to perform complete radiological or chemical analysis and was not further characterized. On December 7, 1987, four of the 30-mL samples were removed from

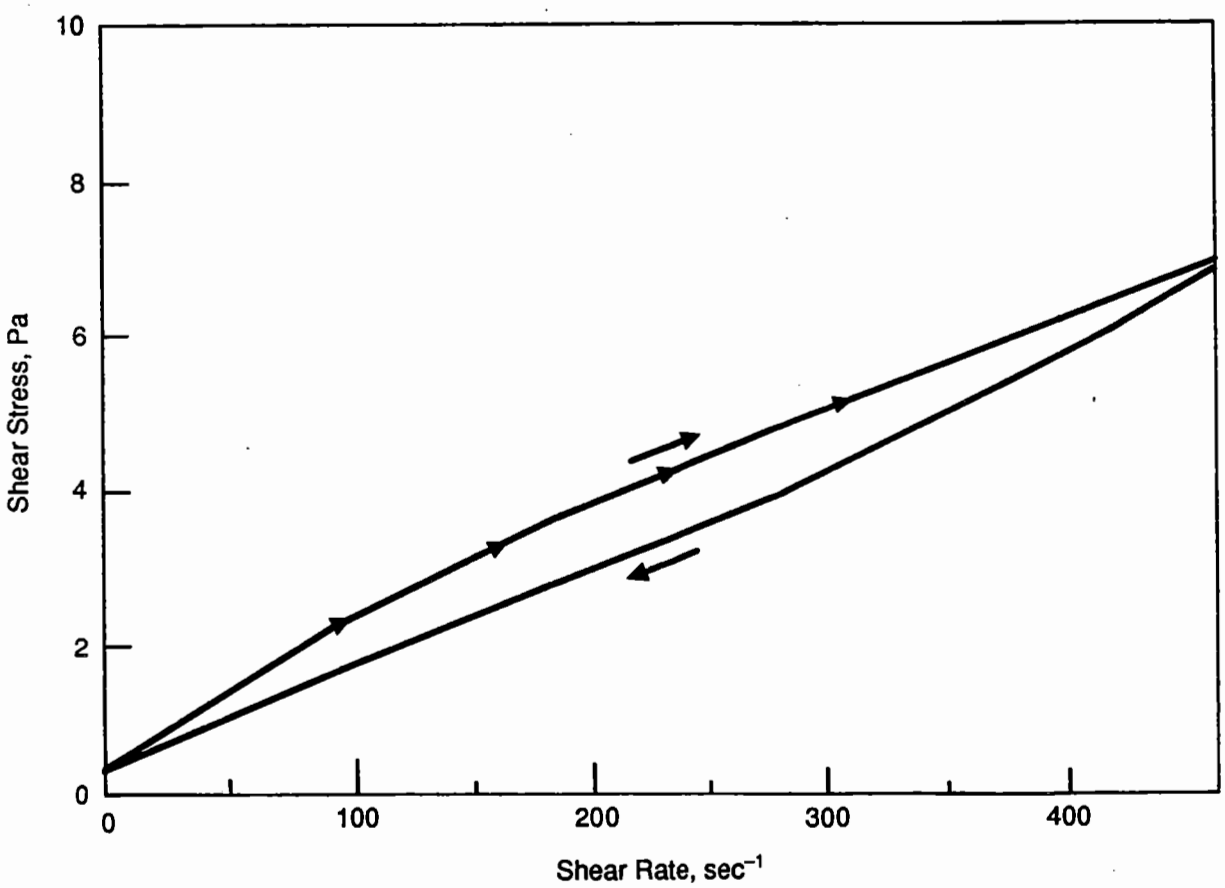

FIGURE 2.2. Rheogram for Tank 106-AN Grout

the oven and the ANS 16.1 and static leach tests were started in duplicate. The four leach tests were conducted on intact right cylinders (see Table 3.2 for the cylinder dimensions).

On December 7, 1987, the 55-mL grout sample was removed from the oven and further cured at room temperature until February 17, 1988, when the EP toxicity test was performed. On February 17, the sample had no drainable liquid.

2.3 HANFORD GROUND WATER

Using data from the Hanford Ground-Water Monitoring Program, a well (#6-S3-25) has been identified on the Hanford Site that is free of contamination and provides water representative of natural waters in the unconfined aquifer underlying Hanford. Periodically, large volumes of water are pumped

from the well into prerinsed plastic containers. The well water is then filtered through a 0.22-μm membrane and stored for use in various laboratory experiments. A complete chemical analysis of the water is made on each new batch.

No significant changes in the water composition from batch-to-batch and during storage in the laboratory have been observed. The chemical composition of the batch used for the leach tests reported here is shown in Table 2.3.

TABLE 2.3. Chemical Composition of Water from a Hanford Well[a]

Analysis	Units	Result
pH	---	8.47
Eh	mV	385
Al	mg/L	0.064
B	mg/L	0.089
as H_3BO_3	mg/L	0.52
Ba	mg/L	0.043
Ca	mg/L	58.8
Cd	mg/L	<0.004
Cr	mg/L	<0.02
Cu	mg/L	<0.004
Fe	mg/L	0.019
K	mg/L	7.4
Mg	mg/L	14.0
Mn	mg/L	0.16
Na	mg/L	24.8
P	mg/L	0.17
as PO_4	mg/L	0.51
Pb	mg/L	<0.06
Si	mg/L	15.5
Sr	mg/L	0.238
Zn	mg/L	<0.02
F^-	mg/L	0.57
Cl^-	mg/L	22.5
NO_2^-	mg/L	<0.3
NO_3^-	mg/L	<0.5
SO_4^{2-}	mg/L	70.5
PO_4^{3-}	mg/L	<1.0
HCO_3^-	mg/L	174
CO_3^{2-}	mg/L	0.0
Total Alk (as CO_3^{2-})	mg/L	85.68
OH^-	mg/L	0.0
TOC	mg/L	0.84
Inorganic carbon	mg/L	33.0
Cations	meq/L	5.36
Anions	meq/L	5.00

(a) This batch sampled on November 11, 1987.

3.0 METHODS

This section describes the procedures used to leach the 106-AN grout. Two types of leach tests were used: an intermittent replacement leach test (ANS 16.1 leach test) and a static leach test. An EP toxicity test was also conducted on the 106-AN grout. Table 3.1 shows the sampling schedule for the ANS 16.1 leach test and the static leach test.

All the leach tests involving 106-AN grout used intact right cylinders. Table 3.2 identifies the tests that were conducted and describes the size of the cylinders that were used. The leach tests were conducted at room temperature. The leachant was Hanford ground water taken from well 6-S3-25. Prior to use, the ground water was filtered through a 0.22-μm membrane. Ground water was used as the leachant rather than distilled water, which is commonly used, because the leach data will be used primarily for performance assessment calculations. These calculations will simulate the release of contaminants from grout buried in unsaturated sediments, and any water reaching the grout will have a chemical nature more like ground water than distilled water. Thus, we believe our data are more representative of actual leach rates.

TABLE 3.1. Sampling Schedule for ANS 16.1 Leach Test and Static Leach Test

Sample #	ANS 16.1 Leach Test (cumulative time)	Sample #	Static Leach Test (cumulative time)
1	2 hours	1	4 days
2	7 hours	2	19 days
3	1 day	2	46 days
4	2 days	4	92 days
5	3 days		
6	4 days		
7	19 days		
8	46 days		
9	92 days		

TABLE 3.2. Tests Conducted on 106-AN Grout Specimens and Dimensions of Right Cylinders

Tests	Specimen	Diameter (cm)	Length (cm)	Surface Area (cm^2)	Volume (cm^3)	Wet Weight (g)
Static	S-1	3.2	3.7	53.3	29.8	54.29
Static	S-2	3.2	3.9	55.3	31.4	56.95
ANS 16.1	ANS-3	3.1	3.3	47.2	24.9	47.97
ANS 16.1	ANS-4	3.1	3.95	53.6	29.8	58.61
EP Tox.	EP-1	3.1	7.3	86.2	55.1	107.41

3.1 ANS 16.1 LEACH TESTS

The ANS 16.1 intermittent replacement leach test consists of a procedure whereby the leachate is sampled and replaced at specific intervals (ANSI/ANS 1986). To initiate the tests, a volume of ground water (in cm^3) equal to about 10 times the specimen's geometric surface area (in cm^2) was added to wide-mouth polyethylene jars. Using unwaxed dental floss, the grout specimens were anchored securely to the lids of each jar and then suspended in the leachant. The ANS 16.1 leach tests were performed in duplicate.

At each sampling interval the leachate was removed, filtered through a 0.22-μm Millex-GS Millipore® filter, and analyzed. The pH, Eh, and alkalinity were measured as quickly as possible. The pH was measured using a Corning Model 130® pH meter and combination electrode. The alkalinity, reported as mg/L carbonate, was measured by standard methods using a Mettler DL40® memotitrator and a micro-combination pH electrode [Method #403 from American Public Health Association (1981)]. The remaining samples were used for the following analyses:

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1. Approximately 20 mL were provided for IC anion analyses.
2. Approximately 20 mL were provided for ICP emission spectrometry. The samples were acidified with Ultrex® HCl to a pH of <2.
3. The remaining volume (~300 mL) was given to a radiochemist, who performed the wet chemical separations and individual radionuclide counting.

Unlike previous leaching tests performed by PNL, total carbon (TC) and total organic carbon (TOC) analyses were not performed because the leachates contained significant amounts of radioactivity, above allowable limits for analyses on our carbon analyzers. In addition, the radionuclide and chemical plateout on containers at each sampling interval was not monitored.

The cations in solution were measured using an ICP spectrophotometer (Applied Research Laboratories Model #3580®). The instrument can simultaneously measure over 30 elements, although we report data for only the following: Al, B, Ba, Ca, Cd, Cr, Cu, Fe, K, Li, Mg, Mn, Mo, Na, Ni, Pb, Si, Sr, and Zn. Most other elements are not present in the grout leachates at measurable concentrations.

The anions in solution were measured using a Dionex model #2310® ion chromatograph. The constituents measured were F^-, Cl^-, NO_2^-, NO_3^-, SO_4^{2-}, and PO_4^{3-}.

3.2 STATIC LEACH TESTS

Two right cylinders of grout were suspended in separate, wide-mouthed polyethylene jars filled with Hanford ground water at a volume (in cm^3) equal to about 10 times the geometric surface area (in cm^2) of the grout sample. At the prescribed times, 50 mL of leachate were removed from the container

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and filtered through a 0.22-μm membrane. The effluents were analyzed for the same constituents and treated exactly as described for the ANS 16.1 leach tests. To replenish the leachate removed for analysis, 50 mL of fresh Hanford ground water were added and the experiment was continued. Because only 50 mL of leachate was removed, radiocounting consumed the available sample. This sample was analyzed for radionuclides after measuring its pH; therefore, chemical analyses were not obtained on this one sample. The duplicate static leach test provided the sample used for chemical analyses.

3.3 EXTRACTION PROCEDURE TOXICITY TESTS

The EP toxicity test was performed on an intact grout sample produced with waste from Tank 106-AN. This test is an Environmental Protection Agency test method (U.S. EPA 1982) that is intended to determine whether a waste exhibits the characteristics of EP toxicity. A 107-g sample was placed in a 2-L container, along with distilled water equal to 16 times the sample weight. During the test the sample container was tumbled at 30 rpm, and the pH was measured periodically and adjusted to 5 ± 0.2 using a 0.5 N acetic acid solution. The pH adjustment continued for 6 hours. After 24 hours, the pH was measured and additional acid was added to reduce the pH to 5. Agitation continued for an additional 4 hours. During the EP toxicity test, the grout sample chipped and several small pieces were present along with the large sample. At the end of the test, distilled water was added to bring the total solution weight equal to 20 times the sample weight. An aliquot of the solution was then filtered through a 0.45-μm filter and submitted for ICP analysis of specific metals. The level of mercury in the leachate was determined using a flameless atomic absorption method.

The Structural Integrity Test (SIT) was performed on a simulated Tank 106-AN waste solidified in grout. This grout sample remained intact following the integrity test; therefore, it was assumed that the grouts produced using actual liquid waste would also remain intact.

4.0 RESULTS AND DISCUSSION

The results of the ANS 16.1 leach tests, static leach tests, and EP toxicity leach tests are presented in this section, along with an interpretation of the results. Measured chemical data from the ANS 16.1 and static leach tests are provided in Appendix A. Appendix B lists the radionuclide counting data (corrected for decay to the start of the leach tests) and effective diffusion coefficient (D_e) calculations for all constituents that leached. Appendix C contains mass balance calculations for selected chemicals. Appendix D contains the raw counting data for radionuclides, and Appendix E contains initial inventory (A_0) calculations for selected species.

4.1 LEACHATE CHEMISTRY FOR ANS 16.1 AND STATIC LEACH TESTS

For both tests, Figure 4.1 and Tables A.1 through A.4 show an immediate rise in solution pH from the ambient ground-water value of 8.47 upon contact

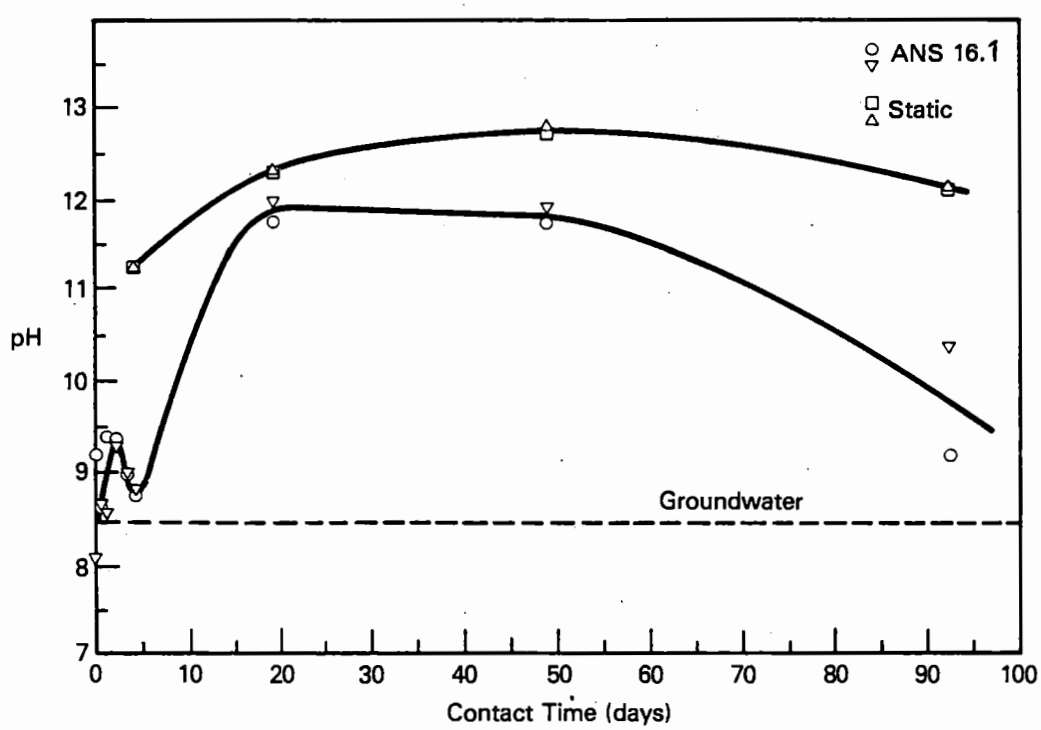

FIGURE 4.1. pH Values for ANS 16.1 and Static Leachates from Intact Grout Cylinders

with the grout. For the ANS 16.1 test leachates, the pH values for the 2-hour through 2-day samples were between 8.1 and 9.4. At 19 days and 46 days, the leachate pH peaked at values of 11.8 to 12.0, then dropped to about 9.5 at 92 days. In contrast, the pH values from the static leach tests rose to 11.25 after 4 days, then remained above 12 for the remainder of the test. The difference in pH values was caused by the intermittent changes of leachant during the ANS 16.1 test, which replenished the bicarbonate (HCO_3^-) content of the leach water. Continually replenishing the HCO_3^- with fresh ground water during the ANS 16.1 test removed hydroxide and calcium ions from the solution through precipitation of calcium carbonate. In the static leach tests, after the HCO_3^- content was depleted, the pH continued to rise because no additional bicarbonate was added to neutralize the excess OH^- that was released.

Figure 4.2 shows the Ca concentrations measured in the leachates. In each test there was a net decrease in Ca concentrations compared to the

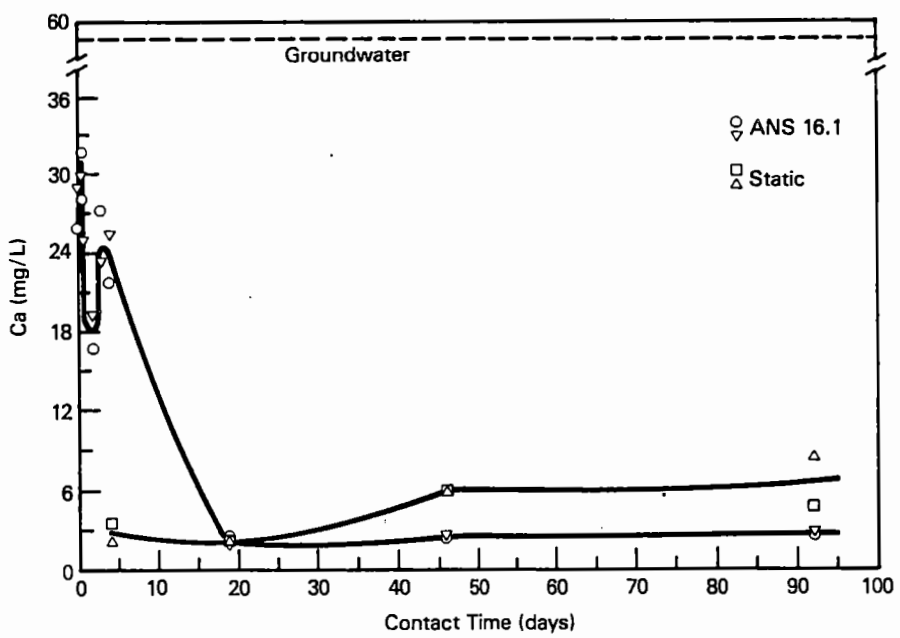

FIGURE 4.2. Ca Concentration for ANS 16.1 and Static Leachates from Intact Grout Cylinders

ground-water concentrations. The replicate samples of the ANS 16.1 and static leach tests showed good reproducibility. The decrease in Ca and carbonate concentrations (see Appendix A) suggests that $CaCO_3$ precipitated. Although the ANS 16.1 leachates exhibited higher concentrations of Ca than the leachates from the static leach tests, the actual mass precipitated was larger. This difference occurred because the entire inventory of ANS 16.1 leachate solution was changed at each sampling time (470 to 540 mL), whereas in the static leach test, only 50 mL of solution was changed in the leach vessels at each sampling time. After 92 days, the ANS 16.1 leach test samples showed a net precipitation of at least 221 mg of calcium, whereas the static leach tests showed a net precipitation of only 39.6 mg of calcium. These calculated precipitation values account only for losses from the original leachant and do not account for the Ca mass that leaches from the grout and reprecipitates.

The chemical compositions of the leachates from the 92-day static leach test and the 2-hour, 7-hour, 19-day, and 92-day ANS 16.1 leach tests were input to the geochemical code MINTEQ (Felmy, Girvin and Jenne 1984 and Peterson et al. 1987). The solutions were speciated and ion activity products calculated for common minerals. The ion activity products were compared to mineral solubility products to evaluate whether specific minerals were in equilibrium, oversaturated, or undersaturated with respect to the leachate.

The computer analyses suggested that the leachates from the ANS 16.1 and static leach test at 19 through 92 days were in equilibrium with carbonate minerals such as calcite, aragonite, and/or magnesite. The early ANS 16.1 test leachates (2 and 7 hour) were oversaturated, suggesting that the carbonates were still forming and had not completely precipitated to a condition of equilibrium. Appendix C contains estimates of the masses of constituents either leached or precipitated in all of the leach tests.

There were also distinct differences in the Mg, Na, and K leachate concentrations between the two tests. Figures 4.3, 4.4, and 4.5 show the leachate concentrations for Mg, Na, and K, respectively. In the ANS 16.1 tests, the Mg concentrations dipped slightly from 14 to 8 to 11.7 mg/L between 2 hours and 4 days. At the longer times (19 and 92 days), the Mg

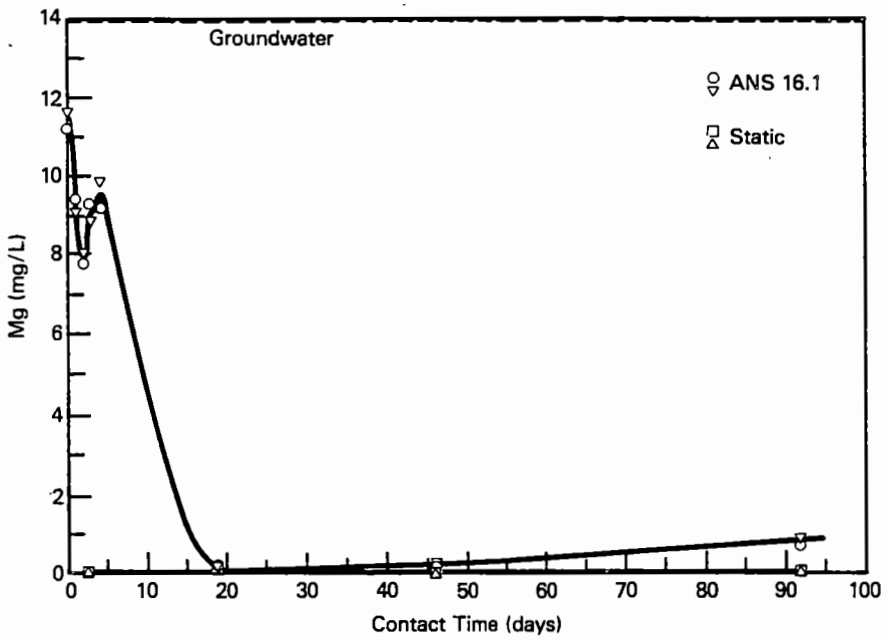

FIGURE 4.3. Mg Concentration for ANS 16.1 and Static Leachates from Intact Grout Cylinders

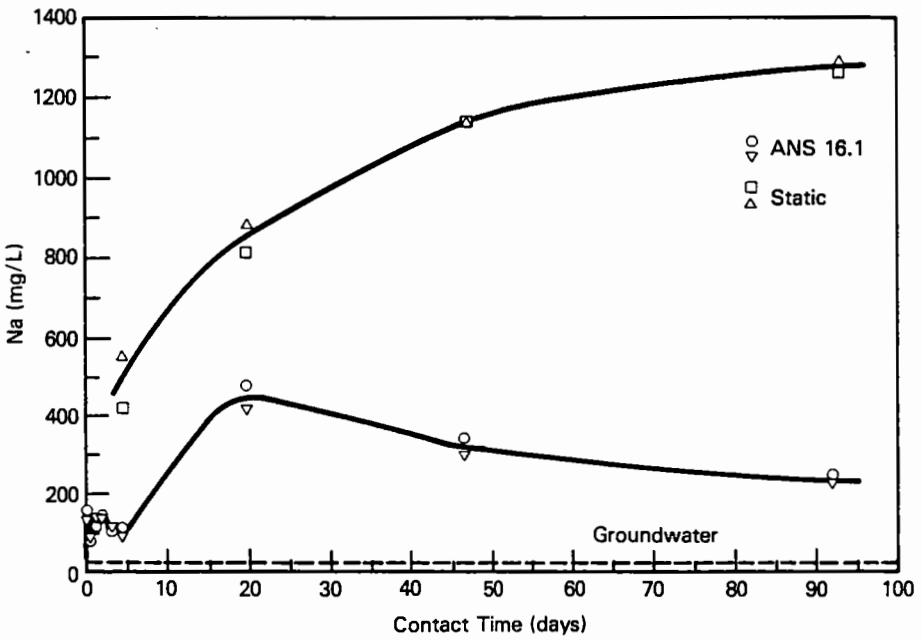

FIGURE 4.4. Na Concentration for ANS 16.1 and Static Leachates from Intact Grout Cylinders

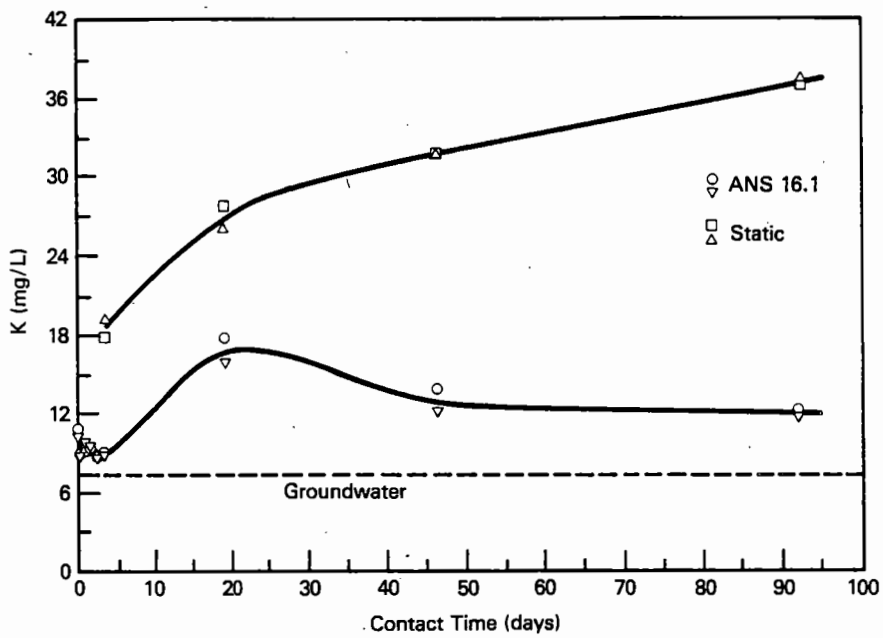

FIGURE 4.5. K Concentration for ANS 16.1 and Static Leachates from Intact Grout Cylinders

concentrations dropped to values below 1 mg/L. In contrast, the Mg concentration of the leachate from the static leach test rapidly decreased after 4 days of contact and remained below the detection limit. MINTEQ code predictions suggested that the rapid decrease in magnesium concentrations in the static leach tests was caused by the precipitation of brucite [$Mg(OH)_2$]. MINTEQ predicted that neither brucite nor $MgCO_3$ controlled the observed Mg solution concentrations in ANS 16.1 test leachates. A mixed Ca, Mg carbonate mineral may be the controlling solid.

At a minimum, 40 mg of Mg precipitated in the ANS 16.1 leach tests and at least 10.5 mg of Mg has precipitated in the static leach tests. MINTEQ predicts that portlandite dissolving in distilled water with a very low CO_2 content would reach a steady-state pH value of 12.42. Perhaps other species that are present could lower the pH to the observed value of 12.1. Whatever the cause, grout contacting Hanford ground water under stagnant flow conditions will generate a leachate with a pH value of about 12 that is in equilibrium with brucite [$Mg(OH)_2$].

The ANS 16.1 leach tests showed a net release of Na and K from the grout. The ambient Na concentration of Hanford ground water is about 25 mg/L, whereas most of the leachates showed concentrations over 200 mg/L. Mass balance calculations suggested that at least 860 mg of Na leached from the grout after 92 days of ANS 16.1 leaching. This range amounts to 35% to 40% of the total Na present in the liquid waste encapsulated in the grout. In the static leach test, the Na concentration steadily increased with time and, after 92 days of leaching, showed a value of 1250 mg/L. Mass balance calculations suggested that at least 860 mg of Na leached from the grout after 92 days of static testing, a value identical to that for the ANS 16.1 tests.

The K concentrations from the two leach tests showed the same patterns as the Na concentrations. In the ANS 16.1 leach test, the K concentrations in the leachates rose to values of 9 to 16 mg/L versus the ambient ground-water value of 7.4 mg/L. The concentrations in later samples stabilized in the range of 12 to 13 mg/L. Mass balance calculations for the ANS 16.1 leach tests showed about 18 to 20 mg of K released from the grout. In the static leach tests, K concentrations slowly increased and, after 92 days, were near 37 mg/L. Mass balance calculations for the static leach test showed a release of 20.5 mg of K, similar to the mass calculated for the ANS 16.1 leach test. The total K released to date is greater than 70% of the K in the liquid waste. Much of the K that has leached comes from the materials in the solid blend. Previous leach studies on grouts made with liquids that contained very low concentrations of K show similar masses of K leached.

After CaO, the two largest components of the grout are generally Al_2O_3 and SiO_2. In the ANS 16.1 leach test, Al concentrations were consistently below 2 mg/L and Si concentrations were consistently between 12.4 to 19 mg/L, which is very close to the ambient ground-water value of 15 mg/L. In the static leach test, the Al concentration in the leachates slowly increased to 15 mg/L. The Si concentrations showed a slight release above the ambient ground-water value of 15 mg/L. The increase in Al concentrations in the leachates from the static leach test can be explained by the rise in pH to values near 12. Solution concentrations of Al are often larger in natural systems when pH values exceed 10.

MINTEQ predictions suggested that the Al concentrations in the static leach test leachates were slightly oversaturated with respect to diaspore [AlO(OH)] and undersaturated with respect to gibbsite [$Al(OH)_3$] and boehmite [γ-AlO(OH)]. All of the leachates from the ANS 16.1 leach test were in equilibrium with gibbsite or boehmite when pH values were below 10.5, and with diaspore when pH values were larger than 10.5. It appears that in high pH environments diaspore may control the solution concentrations of Al, while at pH values less than 10.5 boehmite or gibbsite may control.

The observed Si concentrations in the leachates with pH values over 10 were undersaturated with respect to SiO_2 (am), chalcedony, or sepiolite, three minerals that have appeared to be controls in other grouts. At lower pH values, the leachates may be in equilibrium with chalcedony, a cryptocrystalline form of quartz.

The leachates showed moderate levels of sulfate and a trace of phosphate, but no common sulfate- or phosphate-bearing minerals appeared to be in equilibrium. All the sulfate minerals considered (gypsum, calcium monosulfate, and ettringite) were undersaturated, and all the common phosphate-bearing minerals would control phosphate concentrations at values below our detection limits.

The liquid waste contained large concentrations of nitrate and nitrite. Figures 4.6 and 4.7 show the effluent concentrations of nitrate and nitrite, respectively. The nitrate and nitrite levels in the ANS 16.1 leach test leachates peaked at 19 days before slowly dropping to values above 200 mg/L and 80 mg/L, respectively. The total mass leached in 92 days for both tests was similar: ~810 mg of NO_3^- and 375 mg of NO_2^-. This amount represents 37 ± 2% of the nitrate and nitrite originally present in the liquid waste. Some fluoride, chloride, and sulfate also leached from the grouts, as shown in Appendix A.

Leachates from both tests generally showed no detectable releases of the trace metals (Cd, Cr, Cu, Mn, Pb, and Zn). However, there appeared to be a measurable release of Mo and Ni. More quantitative discussions appear in the next section, where leach rates from grout are discussed.

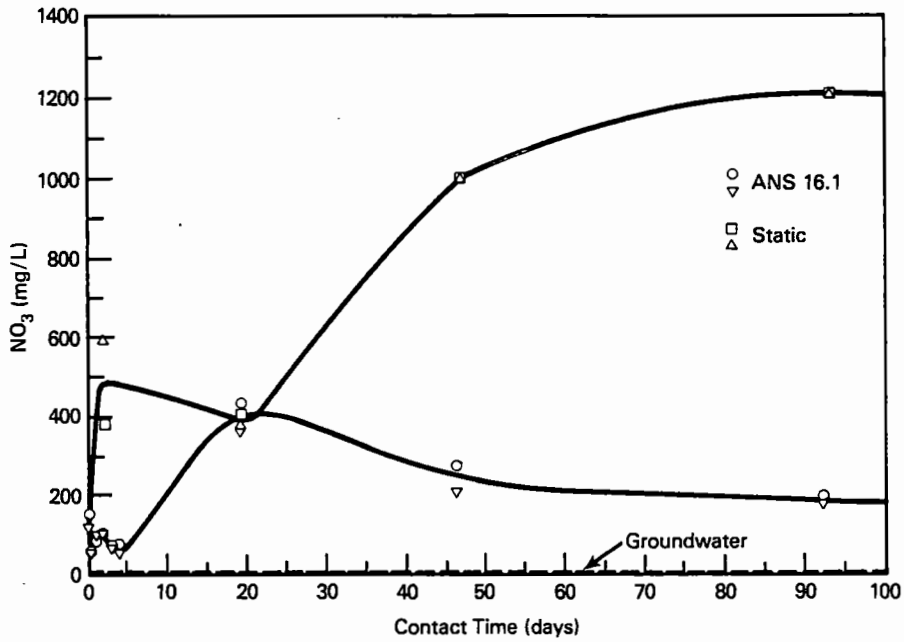

FIGURE 4.6. NO_3 Concentration in ANS 16.1 and Static Leachates from Intact Grout Cylinders

4.2 LEACH RATES OF SELECTED SPECIES

The leach data for selected trace metals, major chemical species, and radionuclides using the semi-infinite-solid mass transport diffusion model are described here. The data on mass or radioactivity found in the leachates, after correction for radioactive decay to the start of the experiments, are shown in Appendix B. For the ANS 16.1 leach test, the cumulative fraction leached and incremental fraction leached at each sampling interval are also provided in Appendix B.

In previous work (Serne et al. 1987), we concluded that the semi-infinite solid diffusion leach model was appropriate. This type of diffusion model is the most popular release model used to describe the leaching of grouts and other cement waste forms. This model is used by researchers at Brookhaven National Laboratory (Kalb and Columbo 1984; Arora and Dayal 1984; Dayal, Schweitzer and Davis 1984; Dayal, Arora and Morcos 1983); at ORNL (Moore, Godbee and Kibbey 1977; Godbee, Anders and Nielson 1980; Clark 1977);

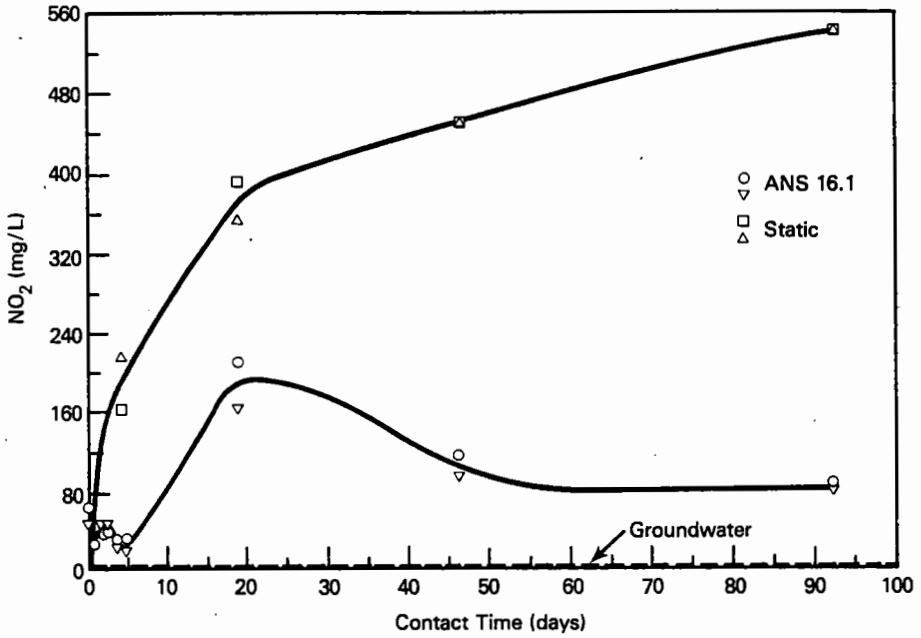

FIGURE 4.7. NO_2 Concentration in ANS 16.1 and Static Leachates from Intact Grout Cylinders

at the Japan Atomic Energy Research Institute (Matsuzuru and Moriyama 1982; Moriyama, Dojiri and Matsuzuru 1977); and at the United Kingdom Atomic Energy Authority, Harwell (Sambell, Smitton and Elsden 1982). The model is used to analyze laboratory leach data on cylindrical blocks of cement or grout waste forms in which nuclear wastes are incorporated, and is endorsed by the American Nuclear Society (ANS). In addition, the model is the basis for the recommended leach test ANSI/ANS-16.1, "Measurement of the Leachability of Solidified Low-Level Radioactive Wastes by a Short-Term Test Procedure" (ANSI/ANS 1986).

Equations for the calculation of D_e follow:

$$D_e = \frac{\pi}{4}\left(\frac{\sum_{n=1}^{N} a_n}{A_o}\right)^2 \left(\frac{V}{S}\right)^2 \frac{1}{t} \qquad (1)$$

$$D_e = \pi \left(\frac{a_n}{A_o}\right)^2 \left(\frac{V}{S}\right)^2 \frac{T}{(\Delta t_n)^2} \qquad (2)$$

where D_e = effective diffusion coefficient (cm^2/s)

a_n = amount of species of interest leached during the leach interval (e.g., g or μCi)

A_o = total amount of species in solid waste form (e.g., g or μCi)

V = volume of solid waste form (cm^3)

S = geometric surface area of waste form (cm^2)

t = total elapsed time since start of leaching (s) = $\Sigma(\Delta t)_n = t_n$

$T = [\frac{1}{2}(\sqrt{t_n} + \sqrt{t_{n-1}})]^2$

(Δt_n) = time duration of interval n (s)

n = subscript number for each time interval

N = total number of time intervals = Σn.

The first equation is used to calculate the cumulative diffusion coefficient for species "i," and the second equation is used to calculate the instantaneous or incremental diffusion coefficient for species "i" at each leach interval "n." The effective cumulative diffusion coefficients, D_e, are listed in Table 4.1 for the constituents for both the ANS 16.1 and static leach tests in which Hanford ground water was the leachant. Appendix B also lists values of the incremental D_e obtained by separately evaluating each ANS 16.1 leach test interval. These values are a useful check to see if any one data point is an outlier. The cumulative approach would propagate the effect of the outlier through all further calculations.

If leaching were accurately described by the semi-infinite-solid diffusion model, the D_e values should be constant with time. It can be seen in Table 4.1 and Appendix B that the cumulative D_e values for the ANS 16.1 data decrease with time. Appendix B also shows that the incremental D_e values generally decrease with time, although certain samples show fluctuations.

The species with the highest leach rates ($>5x10^{-9}$ cm^2/s cumulative effective diffusion coefficients) include ^{99}Tc, ^{129}I, Cl^-, NO_2^-, NO_3^- and Na. Under static test conditions, Mo showed effective diffusion coefficients above $5x10^{-9}$ cm^2/s. Nickel and ^{137}Cs showed effective diffusion coefficients in

TABLE 4.1. Cumulative D_e Values for Species Leaching From Tank 106-AN Grout (cm^2/s)

Constituent	(days)	ANS 16.1 Leach Test	Static Leach Test
NO_3^-	4	$1.2\pm0.1\times10^{-8}$	$1.1\pm0.4\times10^{-8}$
	19	$1.0\pm0.1\times10^{-8}$	$2.1\pm0.2\times10^{-9}$
	46	$7.0\pm0.4\times10^{-9}$	$7.0\pm0.4\times10^{-9}$
	92	$4.6\pm0.7\times10^{-9}$	$6.2\pm0.5\times10^{-9}$
NO_2^-	4	$1.6\pm0.5\times10^{-8}$	$1.1\pm0.4\times10^{-8}$
	19	$1.2\pm0.2\times10^{-8}$	$1.1\pm0.3\times10^{-8}$
	46	$8.1\pm0.4\times10^{-9}$	$8.1\pm0.4\times10^{-9}$
	92	$5.8\pm1.0\times10^{-9}$	$6.9\pm0.6\times10^{-9}$
Cl^-	4	$3.5\pm1.1\times10^{-8}$	$3.0\pm0.7\times10^{-9}$
	19	$2.3\pm0.3\times10^{-8}$	$8.3\pm1.1\times10^{-9}$
	46	$1.4\pm0.1\times10^{-8}$	$6.5\pm0.3\times10^{-9}$
	92	$8.9\pm1.0\times10^{-9}$	$6.9\pm0.6\times10^{-9}$
F^-	4	$6.7\pm5.2\times10^{-10}$	$1.1\pm0.5\times10^{-9}$
	19	$1.4\pm0.2\times10^{-9}$	$1.3\pm0.6\times10^{-9}$
	46	$1.1\pm0.1\times10^{-9}$	$7.2\pm0.4\times10^{-10}$
	92	$4.1\pm0.5\times10^{-10}$	$4.9\pm0.4\times10^{-10}$
Na	4	$1.4\pm0.5\times10^{-8}$	$1.1\pm0.3\times10^{-8}$
	19	$1.1\pm0.3\times10^{-9}$	$9.0\pm2.1\times10^{-9}$
	46	$7.6\pm1.1\times10^{-9}$	$7.8\pm0.1\times10^{-9}$
	92	$5.7\pm1.2\times10^{-9}$	$6.2\pm0.5\times10^{-9}$
Mo	4	$<1\times10^{-9}$	$1.3\pm0.7\times10^{-8}$
	19	$<3\times10^{-9}$	$1.0\pm0.3\times10^{-8}$
	46	$<4\times10^{-9}$	$7.6\pm1.1\times10^{-9}$
	92	$<3\times10^{-9}$	$9.4\pm1.0\times10^{-9}$
Ni	4	$<6\times10^{-9}$	$3.6\pm3.6\times1^{-10}$
	19	$<2\times10^{-9}$	$3.3\pm1.8\times10^{-10}$
	46	$<9\times10^{-10}$	$3.7\pm0.2\times10^{-10}$
	92	$<5\times10^{-10}$	$4.3\pm0.2\times10^{-10}$

TABLE 4.1. (contd)

Constituent	(days)	ANS 16.1 Leach Test	Static Leach Test
Cr	4	$<1.3\times10^{-11}$	$<4\times10^{-13}$
	19	$<4.5\times10^{-12}$	$<1\times10^{-13}$
	46	$<2\times10^{-12}$	$<5\times10^{-13}$
	92	$<1\times10^{-12}$	$3.0\pm0.2\times10^{-14}$
^{241}Am	4	1.2×10^{-11}	-----
	19	3.8×10^{-12}	-----
	46	2.1×10^{-12}	9.3 to 12.8×10^{-13}
	92	-----	-----
^{137}Cs	4	1.1×10^{-9}	-----
	19	5.0×10^{-10}	-----
	46	3.0×10^{-10}	2.0 to 2.8×10^{-10}
	92	-----	-----
^{129}I	4	3.4×10^{-8}	-----
	19	4.2×10^{-8}	-----
	46	3.1×10^{-8}	4.5 to 7.3×10^{-8}
	92	-----	-----
^{90}Sr	4	5.8×10^{-15}	-----
	19	3.1×10^{-15}	-----
	46	2.1×10^{-15}	3.0 to 4.1×10^{-16}
	92	-----	-----
^{99}Tc	4	3.9×10^{-8}	-----
	19	2.5×10^{-8}	-----
	46	4.3×10^{-8}	4.3 to 6.4×10^{-8}
	92	-----	-----
^{60}Co	4	$<8.9\times10^{-11}$	-----
	19	$<3.2\times10^{-11}$	-----
	46	$<1.7\times10^{-11}$	<2.1 to 2.9×10^{-12}
	92	-----	-----

the range 1 to $5x10^{-10}$ cm^2/s, while ^{241}Am and ^{90}Sr showed low diffusion coefficients ($<5x10^{-12}$ cm^2/s). There are very few differences in the leach rates of the anions (TcO_4^-, I^-, Cl^-, NO_2^-, NO_3^-, and F^-) and the cation Na between the two tests. Molybdenum appears to leach faster under static conditions, while Am and Sr leach slower under static conditions.

As was found for PSW grout (Serne et al. 1987, 1989) and cladding removal waste (CRW) grout (to be reported), iodine, technetium, nitrite, nitrate, and sodium are leached more rapidly than other species. The effective diffusivities for the 106-AN grouts are larger than those measured on PSW and CRW grouts. The cause could be that 106-AN liquid waste is chemically more difficult to encapsulate or that the physical structure of the 106-AN grout is more porous to water leaching than previously studied grouts. Also, the 40-day curing time is the shortest used in any of the grout leach tests, and the ending at 92 days of contact is the shortest time studied. Both facts also lead to larger effective diffusivities. That is, for periods of time up to at least 1 year, longer curing times generally result in lower leach rates, and as leach experiments are continued for periods up to 3 years, we find that the cumulative effective diffusivities continue to slowly decrease, especially for the ANS 16.1 tests.

It appears that high pH leaching environments will reduce the Am and Sr leaching, probably because of solubility considerations.

Tallent et al. (1988) at ORNL has performed ANS 16.1 leach tests on simulated 106-AN waste that was grouted with the ratio 8 lb/gal (versus our 9 lb/gal) solid blend to liquid waste. The ORNL grout dry blend was 47% ground blast furnace slag, 47% Class F fly ash, and 6% type I-II Portland cement by weight, which differs slightly from our 47.5%:47.5%:5% mixture.

Table 4.2 compares average, incremental effective diffusivities calculated at ORNL with the equivalent PNL data and cumulative effective diffusivities from static tests. The leach indices for the ANS 16.1 data are also shown in Table 4.2.

TABLE 4.2. Comparison of ORNL and PNL Leach Data

Species	ANS 16.1 Leach Test D_e(incremental) ORNL	ANS 16.1 Leach Test D_e(incremental) PNL	Static Leach Test D_e(cumulative) PNL
^{99}Tc	1.3×10^{-9} [a]	$4.57 \pm 8.33 \times 10^{-7}$	4.3 to 6.4×10^{-8}
NO_3	1.3×10^{-8} [a]	$1.06 \pm 1.14 \times 10^{-8}$	$6.2 \pm 0.5 \times 10^{-9}$
NO_2	1.0×10^{-8} [b]	$1.29 \pm 1.27 \times 10^{-8}$	$6.9 \pm 0.6 \times 10^{-9}$
I	1.6×10^{-8} [b]	$3.40 \pm 3.80 \times 10^{-8}$	4.5 to 7.3×10^{-8}
Cl	2.0×10^{-8} [b]	$2.42 \pm 1.82 \times 10^{-8}$	$6.9 \pm 0.6 \times 10^{-9}$
	Leach Indices (ANS 16.1 Test)		
^{99}Tc	9.1 ± 0.0 [a]	7.4 ± 1.2	
NO_3	8.0 ± 0.1 [a]	8.2 ± 0.5	
NO_2	8.0 ± 0.1 [b]	8.1 ± 0.5	
I	7.8 ± 0.1 [b]	7.6 ± 0.4	
Cl	7.7 ± 0.2 [b]	7.9 ± 0.6	

(a) Tallent et al. 1988
(b) 1988 draft report, Oak Ridge National Laboratory

The agreement between the ORNL and PNL data for nitrate, nitrite, iodine, and chloride is excellent. The leach indices of these four anionic species hover around 8 ($D_e = 10^{-8}$ cm^2/s), which is one order-of-magnitude more favorable (leach resistant) than that required by the WHC grout formulation criteria.[a]

There is a distinct difference in the ORNL and PNL data for Tc. The Tc diffusivity is about 350 times greater in the PNL tests. Some of the difference is likely caused by the difficulty in measuring low levels of ^{99}Tc in actual leachate that has 10^5 more activity of such isotopes as ^{137}Cs. The original ^{99}Tc inventory in the 106-AN waste stream is relatively small, and ^{99}Tc concentrations in the leachates are within a factor of 10 of the

(a) Riddelle, J. G. 1987. Formulation Criterion for the Hanford Grout Disposal Program. Internal Report SD-WM-SS-004, Westinghouse Hanford Company, Richland, Washington.

background. On the other hand, ORNL spiked their simulated waste with an adequate amount of ^{99}Tc to allow adequate counting of leachates. It is not known whether the addition of excess ^{99}Tc could influence (bias) leach rate determination. Studies on the effects of varying ^{99}Tc inventories in double-shell slurry feed grouts are under way. Uncertainty in the Tc inventory has a large effect on the calculated effective diffusivity. If the Tc concentration in the waste samples measured by WHC (Table 2.2) is used in the calculations, the effective diffusivity would decrease by more than two orders of magnitude, and the Tc leach index would increase by two units. Thus, the values would be very near the ORNL values. At any rate, these preliminary studies suggest that ^{99}Tc leach rates may approach the minimum performance requirement and additional attention is warranted.

The static tests also suggest that iodine leach rates are greater under the chemical conditions observed for low flow conditions. Similar results were obtained on other leach tests using PSW (Serne et al. 1989) and CRW grouts (to be reported).

One might expect that the PNL grout at 9 lb/gal mix ratio would perform better than the ORNL grout at 8 lb/gal. Leach rates for nitrate, nitrite, and chloride do not suggest that the higher solids content in the PNL grout results in increased leach resistance. Perhaps the differences in curing (PNL at room temperature versus ORNL at 60°C) or the use of actual tank waste has confounded the expected improvement with a larger percentage of grout-forming solids in the grout mix.

4.3 RESULTS OF EXTRACTION PROCEDURE TOXICITY TEST

The results of the analysis of filtered leachate from the EP toxicity test are shown in Table 4.3. In most cases, the metal concentrations are below the analytical detection limit, and in all cases the observed concentrations are below the regulatory limits. Thus, based on testing one sample, it appears that Tank 106-AN grout is not toxic per the EP toxicity test protocol.

TABLE 4.3. Extraction Procedure Toxicity Results for Radioactive Tank 106-AN Grout

Element	Analyzed Concentration (mg/L)	Regulatory Limit (mg/L)
Ag	<0.01	5
As	<0.25	5
Ba	0.48	100
Cd	<0.01	1
Cr	0.07	5
Hg	0.0001	0.2
Pb	<0.10	5
Se	<0.25	1

5.0 REFERENCES

American Public Health Association. 1981. Standard Methods for the Examination of Water and Wastewater, eds. A. E. Greenberg, J. J. Connors, D. Jenkins, and M. H. Franson. Method #403. American Public Health Association, Washington, D.C.

ANSI/ANS. 1986. Measurement of the Leachability of Solidified Low-Level Radioactive Wastes by a Short-Term Test Procedure. ANS 16.1, American Nuclear Society, La Grange Park, Illinois.

Arora, H., and R. Dayal. 1984. Solidification and Leaching of Boric Acid and Resin LWR Wastes. NUREG/CR-3909, Nuclear Regulatory Commission, Washington, D.C.

Clark, W. E. 1977. "The Isolation of Radioiodine with Portland Cement Part 1: Scoping Leach Studies." Nuclear Technology 36:215-221.

Dayal, R., H. Arora and N. Morcos. 1983. Estimation of Cesium-137 Release from Waste/Cement Composites Using Data from Small-Scale Specimen. NUREG/CR-3382, Nuclear Regulatory Commission, Washington, D.C.

Dayal, R., D. C. Schweitzer and R. E. Davis. 1984. "Wet and Dry Cycle Leaching: Aspects of Research in the Unsaturated Zone." In NRC Nuclear Waste Geochemistry '83, eds., D. H. Alexander and G. F. Birchard, pp. 440-453. NUREG/CP-0052, Nuclear Regulatory Commission, Washington, D.C.

Felmy, A. R., D. C. Girvin and E. A. Jenne. 1984. MINTEQ: A Computer Program for Calculating Aqueous Geochemical Equilibria. NTIS PB 84-157148 (EPA-600/3-84-032), National Technical Information Service, Springfield, Virginia.

Godbee, H. W., O. U. Anders and R. M. Nielson, Jr. 1980. "Application of Mass Transport Theory to the Leaching of Radionuclides from Waste Solids." Nuclear and Chemical Waste Management 1:29-35.

Kalb, P. D., and P. Columbo. 1984. "Full-Scale Leaching Study of Commercial Reactor Waste Forms." In Waste Management '84, Vol. 2, ed. R. G. Post, pp. 189-194. The University of Arizona Press, Tempe, Arizona.

Matsuzuru, H., and N. Moriyama. 1982. "Leaching Radionuclides from a Cement Composite Incorporating Evaporatory Concentrates Generated at a Pressurized Water Reactor Nuclear Power Plant." Nuclear Science and Engineering 80:14-25.

Moore, J. G., H. W. Godbee and A. H. Kibbey. 1977. "Leach Behavior of Hydrofracture Grout Incorporating Radioactive Wastes." Nuclear Technology 32:39-59.

Moriyama, N., S. Dojiri and H. Matsuzuru. 1977. "Leaching of ^{137}Cs from the Ion Exchange Resin Incorporated in Polyethylene or Cement Composite." Health Physics 32:549-552.

Peterson, S. R., C. J. Hostetler, W. J. Deutsch and C. E. Cowan. 1987. MINTEQ User's Manual. NUREG/CR-4808, Nuclear Regulatory Commission, Washington, D.C.

Riddelle, J. G. 1987. Formulation Criteria for the Hanford Grout Disposal Program. SD-WM-SS-004, Westinghouse Hanford Company, Richland, Washington.

Sambell, R. A. J., C. Smitton and A. Elsden. 1982. "A Contribution Towards a Standard Leach Test for Immobilized Low and Medium Level Waste." Nuclear and Chemical Waste Management 3:125-129.

Serne, R. J., and W. J. Martin, S. B. McLaurine, S. P. Airhart, V. L. LeGore and R. L. Treat. 1987. Laboratory Leach Tests of Phosphate/Sulfate Waste Grout and Leachate Adsorption Tests Using Hanford Sediment. PNL-6019, Pacific Northwest Laboratory, Richland, Washington.

Serne, R. J., W. J. Martin, V. L. LeGore, C. L. Lindenmeier, S. B. McLaurine, P. F. C. Martin, and R. O. Lokken. 1989. Leach Tests on Grouts Made with Actual and Trace Metal-Spiked Synthetic Phosphate/Sulfate Waste. PNL-7121, Pacific Northwest Laboratory, Richland, Washington.

Tallent, O. K., E. W. McDaniel, G. D. Del Cul, K. E. Dodson and D. R. Trotter. 1988. "Immobilization of Technetium and Nitrate in Cement-Based Materials." Mat. Res. Soc. Symp. Proc. 12:23-32.

U.S. Environmental Protection Agency. 1982. "Test Methods for the Evaluation of Solid Waste." Physical and Chemical Properties. SW-846, Environmental Protection Agency, Washington, D.C.

APPENDIX A

CHEMICAL COMPOSITIONS OF LEACHATES

TABLE A.1. Chemical Composition of Leachates from Static Leach Test (S-1)

SAMPLE ID		HGW	S1-1	S1-2	S1-3	S1-4
DAYS			4	19	46	92
VOL mls			50	50	50	50
ANALYSIS	UNITS					
pH		8.470	11.250	12.340	12.790	12.080
EH		385.000	316.000	291.000	309.000	227.000
Al	mg/l	0.640	0.042	5.310	-	11.200
B	mg/l	0.089	0.904	1.870	-	2.920
as H3BO3	mg/l	0.509	5.169	10.693	-	16.697
Ba	mg/l	<0.002	0.006	<0.002	-	<0.002
Ca	mg/l	58.800	3.610	2.250	-	4.880
Cd	mg/l	<0.004	<0.004	<0.004	-	<0.004
Cr	mg/l	<0.020	<0.020	<0.020	-	0.021
Cu	mg/l	<0.004	<0.004	<0.004	-	<0.004
Fe	mg/l	0.019	<0.005	<0.005	-	0.030
K	mg/l	7.370	17.900	28.000	-	36.900
Li	mg/l	0.012	0.021	0.025	-	0.037
Mg	mg/l	14.000	<0.060	<0.060	-	<0.060
Mn	mg/l	0.162	<0.002	<0.002	-	<0.002
Mo	mg/l	<0.010	0.139	0.310	-	0.521
Na	mg/l	24.800	423.000	880.000	-	1262.000
Ni	mg/l	<0.022	0.035	0.080	-	0.133
P	mg/l	0.170	-	-	-	-
as PO4	mg/l	0.521	-	-	-	-
Pb	mg/l	<0.060	<0.060	<0.060	-	<0.060
Si	mg/l	15.500	10.600	14.500	-	19.700
Sr	mg/l	0.238	0.052	0.033	-	0.044
Zn	mg/l	<0.020	<0.020	<0.020	-	<0.020
F-	mg/l	0.572	0.780	1.180	-	1.260
Cl-	mg/l	22.500	28.200	44.000	-	58.000
NO2-	mg/l	<0.300	162.000	390.000	-	540.000
NO3-	mg/l	<0.500	382.000	400.000	-	1210.000
PO4	mg/l	<0.400	<0.400	2.150	-	6.300
SO4-	mg/l	70.500	119.000	235.000	-	312.000
HCO3-	mg/l	174.216	0.000	0.000	-	0.000
CO3-	mg/l	0.000	161.820	377.580	-	89.700
OH-	mg/l	0.000	45.849	30.566	-	285.396
T-ALK	mg/l	85.680	242.730	431.520	-	593.340
P-ALK	mg/l	0.000	161.820	242.730	-	548.490
TOC	mg/l	0.840	-	-	-	-
IC	mg/l	33.020	-	-	-	-
CATIONS	mg/l	5.359	19.030	39.090	-	56.058
ANIONS	mg/l	4.996	21.091	35.515	-	59.238

TABLE A.2. Chemical Composition of Leachates from Static Leach Test (S-2)

SAMPLE ID		HGW	S2-1	S2-2	S2-3	S2-4
DAYS			4	19	46	92
VOL mls			50	50	50	50
ANALYSIS	UNITS					
pH		8.470	11.210	12.360	12.720	12.090
EH		385.000	292.000	313.000	302.000	213.000
Al	mg/l	0.640	2.410	6.400	11.300	14.200
B	mg/l	0.089	1.260	1.720	2.460	3.150
as H3BO3	mg/l	0.509	7.205	9.835	14.066	18.012
Ba	mg/l	<0.002	0.006	<0.002	<0.002	<0.002
Ca	mg/l	58.800	2.090	2.260	5.990	8.350
Cd	mg/l	<0.004	<0.004	<0.004	<0.004	<0.004
Cr	mg/l	<0.020	<0.020	<0.020	<0.020	0.021
Cu	mg/l	<0.004	<0.004	<0.004	<0.004	<0.004
Fe	mg/l	0.019	2.120	<0.005	<0.005	0.028
K	mg/l	7.370	19.200	26.000	31.600	37.200
Li	mg/l	0.012	0.020	0.022	0.029	0.032
Mg	mg/l	14.000	<0.060	<0.060	<0.060	<0.060
Mn	mg/l	0.162	0.008	<0.002	<0.002	<0.002
Mo	mg/l	<0.010	0.211	0.270	0.390	0.516
Na	mg/l	24.800	548.000	810.000	1140.000	1285.000
Ni	mg/l	<0.020	0.055	0.060	0.100	0.143
P	mg/l	0.170	-	-	-	-
as PO4	mg/l	0.521	-	-	-	-
Pb	mg/l	<0.060	<0.060	<0.060	<0.060	<0.060
Si	mg/l	15.500	13.300	16.100	18.900	21.900
Sr	mg/l	0.238	0.040	0.033	0.044	0.055
Zn	mg/l	<0.020	<0.020	<0.020	<0.020	<0.020
F-	mg/l	0.572	0.890	1.170	1.230	1.340
Cl-	mg/l	22.500	29.600	42.500	49.900	57.000
NO2-	mg/l	<0.300	215.000	355.000	449.000	540.000
NO3-	mg/l	<0.500	505.000	370.000	1010.000	1210.000
PO4	mg/l	<0.400	3.000	2.100	1.890	6.800
SO4-	mg/l	70.500	474.000	199.000	268.000	307.000
HCO3-	mg/l	174.216	0.000	0.000	0.000	0.000
CO3-	mg/l	0.000	215.760	323.540	161.820	161.820
OH-	mg/l	0.000	45.849	76.443	213.962	244.528
T-ALK	mg/l	85.680	296.670	458.440	539.400	593.340
P-ALK	mg/l	0.000	188.790	296.670	458.490	512.430
TOC	mg/l	0.840	-	-	-	-
IC	mg/l	33.020	-	-	-	-
CATIONS	mg/l	5.359	24.422	35.996	50.673	57.239
ANIONS	mg/l	4.996	33.424	34.374	51.089	59.110

TABLE A.3. Chemical Composition of Leachates from ANS 16.1 Leach Test (A-3)

SAMPLE ID		HGW	A3-1	A3-2	A3-3	A3-4	A3-5	A3-6	A3-7	A3-8	A3-9
DAYS			0.083	0.292	1.000	2.000	3.000	4.000	19.000	46.000	92.000
VOL mls			470	470	470	470	470	470	470	470	470
ANALYSIS UNITS											
pH		8.470	9.230	8.640	9.400	9.390	9.000	8.740	11.760	11.750	9.170
EH		385.000	332.000	337.000	326.000	333.000	336.000	366.000	324.000	319.000	284.000
Al	mg/l	0.640	0.353	0.205	0.237	0.159	0.103	0.098	1.330	0.969	0.199
B	mg/l	0.089	0.354	0.249	0.310	0.318	0.248	0.193	0.920	0.570	0.476
as H3BO3	mg/l	0.509	2.024	1.424	1.773	1.818	1.418	1.104	5.261	3.259	2.722
Ba	mg/l	<0.002	0.036	0.037	0.030	0.025	0.028	0.031	<0.002	<0.002	<0.002
Ca	mg/l	58.800	29.100	30.500	25.200	19.600	23.400	25.600	1.960	2.670	2.910
Cd	mg/l	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Cr	mg/l	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Cu	mg/l	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Fe	mg/l	0.019	0.017	0.016	0.018	0.016	0.023	0.012	<0.005	<0.005	0.007
K	mg/l	7.370	10.400	8.800	10.000	9.800	9.100	8.900	16.000	12.000	11.800
Li	mg/l	0.012	<0.004	0.026	0.021	0.020	0.023	0.021	0.020	0.016	0.019
Mg	mg/l	14.000	11.700	11.200	9.170	8.120	8.810	9.870	<0.060	0.260	0.909
Mn	mg/l	0.162	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Mo	mg/l	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.160	<0.010	0.090
Na	mg/l	24.800	143.000	87.600	142.000	140.000	109.000	89.100	426.000	291.000	231.000
Ni	mg/l	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	0.040	<0.020	0.027
P	mg/l	0.170	-	-	-	-	-	-	-	-	-
as PO4	mg/l	0.521	-	-	-	-	-	-	-	-	-
Pb	mg/l	<0.060	<0.060	<0.060	<0.060	<0.060	<0.060	<0.060	<0.060	<0.060	<0.060
Si	mg/l	15.500	13.100	12.800	12.600	12.600	12.500	13.000	17.000	14.800	12.600
Sr	mg/l	0.238	0.169	0.171	0.141	0.118	0.135	0.155	0.033	0.028	0.034
Zn	mg/l	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
F-	mg/l	0.572	0.670	0.630	0.680	0.720	0.700	0.650	0.930	0.740	0.600
Cl-	mg/l	22.500	26.200	24.800	26.400	26.400	26.600	26.000	34.500	28.900	27.000
NO2-	mg/l	<0.300	54.000	27.300	51.000	51.000	32.900	25.900	168.000	96.000	80.800
NO3-	mg/l	<0.500	121.000	58.700	104.000	104.000	65.000	55.100	367.000	210.000	176.000
PO4	mg/l	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	10.400	2.050	<0.400	1.700
SO4-	mg/l	70.500	97.000	86.200	95.000	95.000	81.900	83.000	145.000	119.000	116.000
HCO3-	mg/l	174.216	131.618	153.537	164.517	164.517	164.517	230.316	0.000	0.000	0.061
CO3-	mg/l	0.000	0.000	0.000	0.000	0.000	0.000	0.000	113.260	97.100	64.700
OH-	mg/l	0.000	0.000	0.000	0.000	0.000	0.000	0.000	41.270	32.090	0.000
T-ALK	mg/l	85.680	64.730	75.510	80.910	80.910	80.910	113.270	186.090	153.730	64.730
P-ALK	mg/l	0.000	0.000	0.000	0.000	0.000	0.000	0.000	129.460	105.180	32.350
TOC	mg/l	0.840	-	-	-	-	-	-	-	-	-
IC	mg/l	33.020	-	-	-	-	-	-	-	-	-
CATIONS	mg/l	5.359	8.902	6.481	8.445	7.987	6.868	6.195	19.030	13.114	10.566
ANIONS	mg/l	4.996	8.079	6.555	8.244	8.246	6.955	7.725	19.819	13.933	9.964

TABLE A.4. Chemical Composition of Leachates from ANS 16.1 Leach Test (A-4)

SAMPLE ID		HGW	A4-1	A4-2	A4-3	A4-4	A4-5	A4-6	A4-7	A4-8	A4-9
DAYS			0.083	0.292	1.000	2.000	3.000	4.000	19.000	46.000	92.000
VOL mls			540	540	540	540	540	540	540	540	540
ANALYSIS UNITS											
pH		8.470	8.080	8.670	8.610	9.330	9.010	8.790	12.010	11.900	10.380
EH		385.000	333.000	329.000	336.000	332.000	349.000	366.000	299.000	315.000	279.000
Al	mg/l	0.640	0.370	0.151	0.165	0.203	0.161	0.089	2.290	1.460	0.206
B	mg/l	0.089	0.359	0.203	0.260	0.352	0.253	0.230	1.170	0.730	0.501
as H3BO3	mg/l	0.509	2.053	1.161	1.487	2.013	1.447	1.315	6.690	4.174	2.865
Ba	mg/l	<0.002	0.032	0.039	0.032	0.022	0.022	0.026	<0.002	<0.002	<0.002
Ca	mg/l	58.800	25.900	31.700	28.200	16.600	27.300	21.700	2.630	2.610	2.550
Cd	mg/l	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Cr	mg/l	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Cu	mg/l	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Fe	mg/l	0.019	0.017	0.014	0.014	0.020	0.012	0.200	<0.005	<0.005	0.047
K	mg/l	7.370	10.800	8.700	9.300	9.700	8.900	9.100	17.600	13.800	12.200
Li	mg/l	0.012	0.020	0.018	0.019	0.018	0.016	0.018	0.020	0.020	0.018
Mg	mg/l	14.000	11.400	11.400	9.410	7.730	9.270	9.170	<0.060	0.170	0.682
Mn	mg/l	0.162	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Mo	mg/l	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.180	0.120	0.085
Na	mg/l	24.800	158.000	81.900	117.000	138.000	98.000	98.600	480.000	339.000	243.000
Ni	mg/l	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	0.039	0.035	0.025
P	mg/l	0.170	-	-	-	-	-	-	-	-	-
as PO4	mg/l	0.521	-	-	-	-	-	-	-	-	-
Pb	mg/l	<0.060	<0.060	<0.060	<0.060	<0.060	<0.060	<0.060	<0.060	<0.080	<0.060
Si	mg/l	15.500	12.900	13.100	12.400	12.400	12.800	12.800	18.500	16.300	12.200
Sr	mg/l	0.238	0.159	0.176	0.148	0.106	0.147	0.139	0.040	0.028	0.032
Zn	mg/l	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
F-	mg/l	0.572	0.680	0.660	0.640	0.650	0.680	0.640	1.050	0.810	0.660
Cl-	mg/l	22.500	26.200	25.400	27.600	26.000	26.400	25.800	37.500	30.800	27.800
NO2-	mg/l	<0.300	65.000	24.500	40.300	48.000	31.800	32.500	213.000	122.000	86.700
NO3-	mg/l	<0.500	150.000	54.200	90.000	105.000	69.000	72.000	431.000	272.000	194.000
PO4	mg/l	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	2.260	1.070	1.800
SO4-	mg/l	70.500	103.000	77.700	76.400	92.000	82.000	96.000	191.000	136.000	120.000
HCO3-	mg/l	174.216	87.738	87.738	175.477	109.678	87.738	109.678	0.000	0.000	49.369
CO3-	mg/l	0.000	0.000	0.000	0.000	0.000	0.000	0.000	97.080	97.100	80.900
OH-	mg/l	0.000	0.000	0.000	0.000	0.000	0.000	0.000	50.439	32.090	0.000
T-ALK	mg/l	85.680	43.150	43.150	86.300	53.940	43.150	53.940	186.090	153.730	105.180
P-ALK	mg/l	0.000	0.000	0.000	0.000	0.000	0.000	0.000	137.550	105.180	40.450
TOC	mg/l	0.840	-	-	-	-	-	-	-	-	-
IC	mg/l	33.020	-	-	-	-	-	-	-	-	-
CATIONS	mg/l	5.359	9.380	6.308	7.510	7.715	6.617	6.360	21.452	15.237	11.061
ANIONS	mg/l	4.996	8.192	5.216	7.609	7.220	5.732	6.428	22.879	15.910	11.840

APPENDIX B

CUMULATIVE FRACTION LEACHED AND EFFECTIVE DIFFUSION COEFFICIENT DATA

TABLE B.1-1. Nitrate (NO_3) Fraction Leached from 106-AN Grout for Static Leach Test (106S-1)

SAMPLE	mg LEACHED	cum. An/Ao	TIME days	D cum. (<0.2)
106S-1	2.29E+02	1.10E-01	4.00E+00	8.58E-09
106S-2	2.59E+02	1.24E-01	1.90E+01	2.31E-09
106S-3	6.39E+02	3.06E-01	4.60E+01	7.27E-09
106S-4	8.15E+02	3.91E-01	9.20E+01	6.52E-09

TABLE B.1-2. Nitrite (NO_2) Fraction Leached from 106-AN Grout for Static Leach Test (106S-1)

SAMPLE	mg LEACHED	cum. An/Ao	TIME days	D cum. (<0.2)
106S-1	9.70E+01	1.08E-01	4.00E+00	8.25E-09
106S-2	2.42E+02	2.68E-01	1.90E+01	1.30E-08
106S-3	2.97E+02	3.30E-01	4.60E+01	8.37E-09
106S-4	3.74E+02	4.15E-01	9.20E+01	7.33E-09

TABLE B.1-3. Chloride (Cl) Fraction Leached from 106-AN Grout for Static Leach Test (106S-1)

SAMPLE	mg LEACHED	cum. An/Ao	TIME days	D cum. (<0.2)
106S-1	3.42E+00	5.95E-02	4.00E+00	2.52E-09
106S-2	1.32E+01	2.29E-01	1.90E+01	9.11E-09
106S-3	1.67E+01	2.90E-01	4.60E+01	6.26E-09
106S-4	2.39E+01	4.16E-01	9.20E+01	7.33E-09

TABLE B.1-4. Fluoride (F) Fraction Leached from 106-AN Grout for Static Leach Test (106S-1)

SAMPLE	mg LEACHED	cum. An/Ao	TIME days	D cum. (<0.2)
106S-1	1.25E-01	3.14E-02	4.00E+00	7.01E-10
106S-2	3.75E-01	9.43E-02	1.90E+01	1.33E-09
106S-3	4.36E-01	1.09E-01	4.60E+01	7.42E-10
106S-4	4.86E-01	1.22E-01	9.20E+01	4.63E-10

TABLE B.1-5. Sodium (Na) Fraction Leached from 106-AN Grout for Static Leach Test (106S-1)

SAMPLE	mg LEACHED	cum. An/Ao	TIME days	D cum. (<0.2)
106S-1	2.39E+02	1.08E-01	4.00E+00	8.32E-09
106S-2	5.33E+02	2.41E-01	1.90E+01	1.05E-08
106S-3	7.08E+02	3.20E-01	4.60E+01	7.83E-09
106S-4	8.59E+02	3.88E-01	9.20E+01	6.53E-09

TABLE B.1-6. Molybdenum (Mo) Fraction Leached from 106-AN Grout for Static Leach Test (106S-1)

SAMPLE	mg LEACHED	cum. An/Ao	TIME days	D cum. (<0.2)
106S-1	7.74E-02	1.06E-01	4.00E+00	8.01E-09
106S-2	1.86E-01	2.55E-01	1.90E+01	1.19E-08
106S-3	2.55E-01	3.50E-01	4.60E+01	6.75E-09
106S-4	3.48E-01	4.76E-01	9.20E+01	1.01E-08

TABLE B.1-7. Nickel (Ni) Fraction Leached from 106-AN Grout for Static Leach Test (106S-1)

SAMPLE	mg LEACHED	cum. An/Ao	TIME days	D cum. (<0.2)
106S-1	7.80E-03	1.22E-02	4.00E+00	1.06E-10
106S-2	3.54E-02	5.54E-02	1.90E+01	4.60E-10
106S-3	5.03E-02	7.87E-02	4.60E+01	3.84E-10
106S-4	7.41E-02	1.16E-01	9.20E+01	4.15E-10

TABLE B.1-8. Chromium (Cr) Fraction Leached from 106-AN Grout for Static Leach Test (106S-1)

SAMPLE	mg LEACHED	cum. An/Ao	TIME days	D cum. <0.2
106S-1	< 1.20E-02	7.69E-04	4.00E+00	< 4.21E-13
106S-2	< 1.30E-02	8.33E-04	1.90E+01	< 1.04E-13
106S-3	< 1.40E-02	8.97E-04	4.60E+01	< 4.98E-14
106S-4	1.56E-02	9.99E-04	9.20E+01	3.09E-14

TABLE B.2-1a. Am-241 Fraction Leached for Static Leach Test: Whole Grout in Hanford Ground Water (all < 1-3 values)

	SAMPLE ID	uCi LEACHED	TIME DAYS	cum An/Ao	D cum cm2/sec
106AN	1-1	0.0000E+00	4.00	0.00E+00	0.00E+00
106AN	1-2	0.0000E+00	19.00	0.00E+00	0.00E+00
106AN	1-3	4.5630E-05	46.00	3.87E-03	9.29E-13

TABLE B.2-1b. Am-241 Fraction Leached for Static Leach Test: Whole Grout in Hanford Ground Water (all = 1-3 values)

	SAMPLE ID	uCi LEACHED	TIME DAYS	cum An/Ao	D cum cm2/sec
106AN	1-1	4.5630E-05	4.00	3.87E-03	1.07E-11
106AN	1-2	4.9433E-05	19.00	4.19E-03	2.64E-12
106AN	1-3	5.3552E-05	46.00	4.54E-03	1.28E-12

TABLE B.2-2a. Cs-137 Fraction Leached for Static Leach Test: Whole Grout in Hanford Ground Water (all < 1-3 values)

	SAMPLE ID	uCi LEACHED	TIME DAYS	cum An/Ao	D cum cm2/sec
106AN	1-1	0.0000E+00	4.00	0.00E+00	0.00E+00
106AN	1-2	0.0000E+00	19.00	0.00E+00	0.00E+00
106AN	1-3	3.3480E+02	46.00	5.75E-02	2.05E-10

TABLE B.2-2b. Cs-137 Fraction Leached for Static Leach Test: Whole Grout in Hanford Ground Water (all = 1-3 values)

	SAMPLE ID	uCi LEACHED	TIME DAYS	cum An/Ao	D cum cm2/sec
106AN	1-1	3.3480E+02	4.00	5.75E-02	2.36E-09
106AN	1-2	3.6270E+02	19.00	6.23E-02	5.82E-10
106AN	1-3	3.9293E+02	46.00	6.75E-02	2.82E-10

TABLE B.2-3a. I-129 Fraction Leached for Static Leach Test: Whole Grout in Hanford Ground Water (all < 1-3 values)

	SAMPLE ID	uCi LEACHED	TIME DAYS	cum An/Ao	D cum cm2/sec
106AN	1-1	0.0000E+00	4.00	0.00E+00	0.00E+00
106AN	1-2	0.0000E+00	19.00	0.00E+00	0.00E+00
106AN	1-3	3.9150E-04	46.00	6.51E-01	4.51E-08

TABLE B.2-3b. I-129 Fraction Leached for Static Leach Test: Whole Grout in Hanford Ground Water (all = 1-3 values)

	SAMPLE ID	uCi LEACHED	TIME DAYS	cum An/Ao	D cum cm2/sec
106AN	1-1	3.9150E-04	4.00	6.51E-01	5.19E-07
106AN	1-2	4.2412E-04	19.00	7.06E-01	1.42E-07
106AN	1-3	4.5947E-04	46.00	7.64E-01	7.27E-08

TABLE B.2-4a. Co-60 Fraction Leached for Static Leach Test: Whole Grout in Hanford Ground Water (all < 1-3 values)

	SAMPLE ID	uCi LEACHED	TIME DAYS	cum An/Ao	D cum cm2/sec
106AN	1-1	0.0000E+00	4.00	0.00E+00	0.00E+00
106AN	1-2	0.0000E+00	19.00	0.00E+00	0.00E+00
106AN	1-3	4.8330E-03	46.00	5.81E-03	2.09E-12

TABLE B.2-4b. Co-60 Fraction Leached for Static Leach Test: Whole Grout in Hanford Ground Water (all = 1-3 values)

	SAMPLE ID	uCi LEACHED	TIME DAYS	cum An/Ao	D cum cm2/sec
106AN	1-1	4.8330E-03	4.00	5.81E-03	2.40E-11
106AN	1-2	5.2357E-03	19.00	6.29E-03	5.94E-12
106AN	1-3	5.6721E-03	46.00	6.82E-03	2.86E-12

TABLE B.2-5a. Sr-90 Fraction Leached for Static Leach Test: Whole Grout in Hanford Ground Water (all < 1-3 values)

	SAMPLE ID	uCi LEACHED	TIME DAYS	cum An/Ao	D cum cm2/sec
106AN	1-1	0.0000E+00	4.00	0.00E+00	0.00E+00
106AN	1-2	0.0000E+00	19.00	0.00E+00	0.00E+00
106AN	1-3	6.7770E-03	46.00	6.91E-05	2.96E-16

TABLE B.2-5b. Sr-90 Fraction Leached for Static Leach Test: Whole Grout in Hanford Ground Water (all = 1-3 values)

	SAMPLE ID	uCi LEACHED	TIME DAYS	cum An/Ao	D cum cm2/sec
106AN	1-1	6.7770E-03	4.00	6.91E-05	3.40E-15
106AN	1-2	6.7770E-03	19.00	6.91E-05	7.16E-16
106AN	1-3	6.7770E-03	46.00	6.91E-05	2.96E-16

TABLE B.2-6a. Tc-99 Fraction Leached for Static Leach Test: Whole Grout in Hanford Ground Water (all < 1-3 values)

	SAMPLE ID	uCi LEACHED	TIME DAYS	cum An/Ao	D cum cm2/sec
106AN	1-1	0.0000E+00	4.00	0.00E+00	0.00E+00
106AN	1-2	0.0000E+00	19.00	0.00E+00	0.00E+00
106AN	1-3	1.0206E+00	46.00	6.24E+01	4.28E-08

TABLE B.2-6b. Tc-99 Fraction Leached for Static Leach Test: Whole Grout in Hanford Ground Water (all = 1-3 values)

	SAMPLE ID	uCi LEACHED	TIME DAYS	cum An/Ao	D cum cm2/sec
106AN	1-1	1.0206E+00	4.00	6.24E+00	4.92E-07
106AN	1-2	1.1056E+00	19.00	6.76E+00	1.25E-07
106AN	1-3	1.1976E+00	46.00	7.32E+00	6.39E-08

TABLE B.3-1. Nitrate (NO_3) Fraction Leached from 106-AN Grout for Static Leach Test (106S-2)

SAMPLE	mg LEACHED	cum. An/Ao	TIME days	D cum. (<0.2)
106S2-1	3.03E+02	1.38E-01	4.00E+00	1.36E-08
106S2-2	2.47E+02	1.13E-01	1.90E+01	1.91E-09
106S2-3	6.49E+02	2.97E-01	4.60E+01	6.75E-09
106S2-4	8.20E+02	3.75E-01	9.20E+01	5.80E-09

TABLE B.3-2. Nitrite (NO_2) Fraction Leached from 106-AN Grout for Static Leach Test (106S-2)

SAMPLE	mg LEACHED	cum. An/Ao	TIME days	D cum. (<0.2)
106S2-1	1.29E+02	1.36E-01	4.00E+00	1.32E-08
106S2-2	2.24E+02	2.36E-01	1.90E+01	9.11E-09
106S2-3	2.98E+02	3.15E-01	4.60E+01	7.83E-09
106S2-4	3.75E+02	3.96E-01	9.20E+01	6.52E-09

TABLE B.3-3. Chloride (Cl) Fraction Leached from 106-AN Grout for Static Leach Test (106S-2)

SAMPLE	mg LEACHED	cum. An/Ao	TIME days	D cum. (<0.2)
106S2-1	4.26E+00	7.07E-02	4.00E+00	3.56E-09
106S2-2	1.24E+01	2.05E-01	1.90E+01	7.49E-09
106S2-3	1.78E+01	2.95E-01	4.60E+01	6.75E-09
106S2-4	2.34E+01	3.89E-01	9.20E+01	6.53E-09

TABLE B.3-4. Fluoride (F) Fraction Leached from 106-AN Grout for Static Leach Test (106S-2)

SAMPLE	mg LEACHED	cum. An/Ao	TIME days	D cum. (<0.2)
106S2-1	1.91E-01	4.56E-02	4.00E+00	1.48E-09
106S2-2	3.75E-01	8.96E-02	1.90E+01	1.21E-09
106S2-3	4.41E-01	1.05E-01	4.60E+01	6.89E-10
106S2-4	5.40E-01	1.29E-01	9.20E+01	5.16E-10

TABLE B.3-5. Sodium (Na) Fraction Leached from 106-AN Grout for Static Leach Test (106S-2)

SAMPLE	mg LEACHED	cum. An/Ao	TIME days	D cum. (<0.2)
106S2-1	3.14E+02	1.35E-01	4.00E+00	1.31E-08
106S2-2	4.97E+02	2.14E-01	1.90E+01	7.49E-09
106S2-3	7.35E+02	3.17E-01	4.60E+01	7.83E-09
106S2-4	8.77E+02	3.78E-01	9.20E+01	5.80E-09

TABLE B.3-6. Molybdenum (Mo) Fraction Leached from 106-AN Grout for Static Leach Test (106S-2)

SAMPLE	mg LEACHED	cum. An/Ao	TIME days	D cum. (<0.2)
106S2-1	1.21E-01	1.57E-01	4.00E+00	1.75E-08
106S2-2	1.66E-01	2.16E-01	1.90E+01	8.30E-09
106S2-3	2.51E-01	3.26E-01	4.60E+01	8.37E-09
106S2-4	3.46E-01	4.49E-01	9.20E+01	8.66E-09

TABLE B.3-7. Nickel (Ni) Fraction Leached from 106-AN Grout for Static Leach Test (106S-2)

SAMPLE	mg LEACHED	cum. An/Ao	TIME days	D cum. (<0.2)
106S2-1	1.98E-02	2.96E-02	4.00E+00	6.22E-10
106S2-2	2.44E-02	3.65E-02	1.90E+01	2.00E-10
106S2-3	5.03E-02	7.51E-02	4.60E+01	3.50E-10
106S2-4	8.00E-02	1.19E-01	9.20E+01	4.42E-10

TABLE B.3-8. Chromium (Cr) Fraction Leached from 106-AN Grout for Static Leach Test (106S-2)

SAMPLE	mg LEACHED	cum. An/Ao	TIME days	D cum. <0.2
106S2-1	< 1.20E-02	7.33E-04	4.00E+00 <	3.83E-13
106S2-2	< 1.30E-02	7.94E-04	1.90E+01 <	9.46E-14
106S2-3	< 1.40E-02	8.55E-04	4.60E+01 <	4.53E-14
106S2-4	1.56E-02	9.53E-04	9.20E+01	2.81E-14

TABLE B.4-1. Nitrate (NO_3) Fraction Leached from 106-AN Grout for ANS 16.1 Leach Test (106AN-3)

SAMPLE	mg LEACHED	An/Ao	cum. An/Ao	TIME days	D Inc.	D cum <0.2
106AN 3-1	6.51E+01	3.53E-02	3.53E-02	8.33E-02	3.68E-08	3.68E-08
106AN 3-2	3.03E+01	1.65E-02	5.18E-02	2.90E-01	1.07E-08	2.27E-08
106AN 3-3	5.59E+01	3.03E-02	8.21E-02	1.00E+00	1.06E-08	1.66E-08
106AN 3-4	5.59E+01	3.03E-02	1.12E-01	2.00E+00	1.32E-08	1.55E-08
106AN 3-5	3.48E+01	1.89E-02	1.31E-01	3.00E+00	8.69E-09	1.41E-08
106AN 3-6	2.94E+01	1.60E-02	1.47E-01	4.00E+00	8.73E-09	1.33E-08
106AN 3-7	1.98E+02	1.07E-01	2.55E-01	1.90E+01	5.09E-09	1.09E-08
106AN 3-8	1.13E+02	6.14E-02	3.16E-01	4.60E+01	1.58E-09	7.27E-09
106AN 3-9	9.48E+01	5.14E-02	3.67E-01	9.20E+01	8.23E-10	5.11E-09

TABLE B.4-2. Nitrite (NO_2) Fraction Leached from 106-AN Grout for ANS 16.1 Leach Test (106AN-3)

SAMPLE	mg LEACHED	An/Ao	cum. An/Ao	TIME days	D Inc.	D cum <0.2
106AN 3-1	2.90E+01	3.64E-02	3.64E-02	8.33E-02	4.53E-08	4.53E-08
106AN 3-2	1.46E+01	1.83E-02	5.47E-02	2.90E-01	1.53E-08	2.94E-08
106AN 3-3	2.74E+01	3.44E-02	8.91E-02	1.00E+00	1.58E-08	2.26E-08
106AN 3-4	2.74E+01	3.44E-02	1.23E-01	2.00E+00	1.96E-08	2.17E-08
106AN 3-5	1.76E+01	2.21E-02	1.46E-01	3.00E+00	1.38E-08	2.01E-08
106AN 3-6	1.38E+01	1.74E-02	1.63E-01	4.00E+00	1.20E-08	1.89E-08
106AN 3-7	9.06E+01	1.14E-01	2.77E-01	1.90E+01	6.62E-09	1.40E-08
106AN 3-8	5.17E+01	6.49E-02	3.41E-01	4.60E+01	2.04E-09	8.37E-09
106AN 3-9	4.35E+01	5.46E-02	3.96E-01	9.20E+01	1.08E-09	6.52E-09

TABLE B.4-3. Chloride (Cl) Fraction Leached from 106-AN Grout for ANS 16.1 Leach Test (106AN-3)

SAMPLE	mg LEACHED	An/Ao	cum. An/Ao	TIME days	D Inc.	D cum <0.2
106AN 3-1	2.00E+00	3.93E-02	3.93E-02	8.33E-02	5.30E-08	5.30E-08
106AN 3-2	1.24E+00	2.45E-02	6.38E-02	2.90E-01	2.73E-08	4.00E-08
106AN 3-3	2.11E+00	4.15E-02	1.05E-01	1.00E+00	2.30E-08	3.16E-08
106AN 3-4	2.11E+00	4.15E-02	1.47E-01	2.00E+00	2.86E-08	3.07E-08
106AN 3-5	2.21E+00	4.36E-02	1.90E-01	3.00E+00	5.36E-08	3.44E-08
106AN 3-6	1.89E+00	3.72E-02	2.28E-01	4.00E+00	5.50E-08	4.33E-08
106AN 3-7	6.48E+00	1.28E-01	3.55E-01	1.90E+01	8.34E-09	2.48E-08
106AN 3-8	3.46E+00	6.81E-02	4.23E-01	4.60E+01	2.25E-09	1.47E-08
106AN 3-9	2.43E+00	4.79E-02	4.71E-01	9.20E+01	8.27E-10	9.62E-09

TABLE B.4-4. Fluoride (F) Fraction Leached from 106-AN Grout for ANS 16.1 Leach Test (106AN-3)

SAMPLE	mg LEACHED	An/Ao	cum. An/Ao	TIME days	D Inc.	D cum <0.2
106AN 3-1	5.29E-02	1.50E-02	1.50E-02	8.33E-02	6.67E-09	6.67E-09
106AN 3-2	3.13E-02	8.90E-03	2.39E-02	2.90E-01	3.12E-09	4.85E-09
106AN 3-3	5.83E-02	1.66E-02	4.05E-02	1.00E+00	3.17E-09	4.03E-09
106AN 3-4	7.99E-02	2.27E-02	6.32E-02	2.00E+00	7.39E-09	4.91E-09
106AN 3-5	6.91E-02	1.96E-02	8.28E-02	3.00E+00	9.38E-09	5.62E-09
106AN 3-6	4.21E-02	1.20E-02	9.48E-02	4.00E+00	4.90E-09	5.52E-09
106AN 3-7	1.93E-01	5.49E-02	1.50E-01	1.90E+01	1.33E-09	2.90E-09
106AN 3-8	9.07E-02	2.58E-02	1.76E-01	4.60E+01	2.78E-10	1.65E-09
106AN 3-9	1.51E-02	4.30E-03	1.80E-01	9.20E+01	5.75E-12	8.64E-10

TABLE B.4-5. Sodium (Na) Fraction Leached from 106-AN Grout for ANS 16.1 Leach Test (106AN-3)

SAMPLE	mg LEACHED	An/Ao	cum. An/Ao	TIME days	D Inc.	D cum <0.2
106AN 3-1	6.38E+01	3.27E-02	3.27E-02	8.33E-02	3.65E-08	3.65E-08
106AN 3-2	3.39E+01	1.74E-02	5.00E-02	2.90E-01	1.38E-08	2.46E-08
106AN 3-3	6.33E+01	3.24E-02	8.24E-02	1.00E+00	1.40E-08	1.94E-08
106AN 3-4	6.22E+01	3.18E-02	1.14E-01	2.00E+00	1.68E-08	1.86E-08
106AN 3-5	4.55E+01	2.33E-02	1.38E-01	3.00E+00	1.53E-08	1.80E-08
106AN 3-6	3.47E+01	1.78E-02	1.55E-01	4.00E+00	1.25E-08	1.72E-08
106AN 3-7	2.17E+02	1.11E-01	2.66E-01	1.90E+01	6.30E-09	1.30E-08
106AN 3-8	1.44E+02	7.36E-02	3.40E-01	4.60E+01	2.63E-09	8.37E-09
106AN 3-9	1.11E+02	5.70E-02	3.97E-01	9.20E+01	1.17E-09	6.52E-09

TABLE B.4-6. Molybdenum (Mo) Fraction Leached from 106-AN Grout for ANS 16.1 Leach Test (106AN-3)

SAMPLE	mg LEACHED	An/Ao	cum. An/Ao	TIME days	D Inc.	D cum <0.2
106AN 3-1	< 5.40E-03	8.31E-03	8.31E-03	8.33E-02	< 2.04E-09	< 2.04E-09
106AN 3-2	< 5.40E-03	8.31E-03	1.66E-02	2.90E-01	< 2.72E-09	< 2.34E-09
106AN 3-3	< 5.40E-03	8.31E-03	2.49E-02	1.00E+00	< 7.97E-10	< 1.53E-09
106AN 3-4	< 5.40E-03	8.31E-03	3.32E-02	2.00E+00	< 9.89E-10	< 1.36E-09
106AN 3-5	< 5.40E-03	8.31E-03	4.15E-02	3.00E+00	< 1.68E-09	< 1.41E-09
106AN 3-6	< 5.40E-03	8.31E-03	4.98E-02	4.00E+00	< 2.36E-09	< 1.53E-09
106AN 3-7	8.10E-02	1.25E-01	1.74E-01	1.90E+01	6.86E-09	< 3.94E-09
106AN 3-8	5.40E-03	8.31E-03	1.83E-01	4.60E+01	2.89E-11	< 1.78E-09
106AN 3-9	4.32E-02	6.65E-02	2.49E-01	9.20E+01	1.38E-09	< 1.61E-09

TABLE B.4-7. Nickel (Ni) Fraction Leached from 106-AN Grout for ANS 16.1 Leach Test (106AN-3)

SAMPLE	mg LEACHED	An/Ao	cum. An/Ao	TIME days	D Inc.	D cum <0.2
106AN 3-1	< 1.08E-02	1.93E-02	1.93E-02	8.33E-02	< 1.27E-08	< 1.27E-08
106AN 3-2	< 1.08E-02	1.93E-02	3.86E-02	2.90E-01	< 1.70E-08	< 1.46E-08
106AN 3-3	< 1.08E-02	1.93E-02	5.79E-02	1.00E+00	< 4.98E-09	< 9.54E-09
106AN 3-4	< 1.08E-02	1.93E-02	7.71E-02	2.00E+00	< 6.18E-09	< 8.48E-09
106AN 3-5	< 1.08E-02	1.93E-02	9.64E-02	3.00E+00	< 1.05E-08	< 8.84E-09
106AN 3-6	< 1.08E-02	1.93E-02	1.16E-01	4.00E+00	< 1.48E-08	< 9.54E-09
106AN 3-7	< 1.08E-02	1.93E-02	1.35E-01	1.90E+01	1.91E-10	< 2.73E-09
106AN 3-8	< 1.08E-02	1.93E-02	1.54E-01	4.60E+01	1.81E-10	< 1.48E-09
106AN 3-9	3.78E-03	6.75E-03	1.61E-01	9.20E+01	1.65E-11	< 8.04E-10

TABLE B.4-8. Chromium (Cr) Fraction Leached from 106-AN Grout for ANS 16.1 Leach Test (106AN-3)

SAMPLE	mg LEACHED	An/Ao	cum. An/Ao	TIME days	D Inc.	D cum <0.2
106AN 3-1	< 1.08E-02	7.83E-04	7.83E-04	8.33E-02	< 2.10E-11	< 2.10E-11
106AN 3-2	< 1.08E-02	7.83E-04	1.57E-03	2.90E-01	< 2.80E-11	< 2.41E-11
106AN 3-3	< 1.08E-02	7.83E-04	2.35E-03	1.00E+00	< 8.21E-12	< 1.57E-11
106AN 3-4	< 1.08E-02	7.83E-04	3.13E-03	2.00E+00	< 1.02E-11	< 1.40E-11
106AN 3-5	< 1.08E-02	7.83E-04	3.92E-03	3.00E+00	< 1.73E-11	< 1.46E-11
106AN 3-6	< 1.08E-02	7.83E-04	4.70E-03	4.00E+00	< 2.44E-11	< 1.57E-11
106AN 3-7	< 1.08E-02	7.83E-04	5.48E-03	1.90E+01	< 3.14E-13	< 4.51E-12
106AN 3-8	< 1.08E-02	7.83E-04	6.27E-03	4.60E+01	< 2.98E-13	< 2.43E-12
106AN 3-9	< 1.08E-02	7.83E-04	7.05E-03	9.20E+01	< 2.22E-13	< 1.54E-12

TABLE B.5-1. Nitrate (NO_3) Fraction Leached from 106-AN Grout for ANS 16.1 Leach Test (106AN-4)

SAMPLE	mg LEACHED	An/Ao	cum. An/Ao	TIME days	D inc.	D cum. (<0.2)
106AN 4-1	8.07E+01	3.58E-02	3.58E-02	8.33E-02	4.34E-08	4.34E-08
106AN 4-2	2.90E+01	1.29E-02	4.87E-02	2.90E-01	7.48E-09	2.30E-08
106AN 4-3	4.83E+01	2.15E-02	7.02E-02	1.00E+00	6.09E-09	1.39E-08
106AN 4-4	5.64E+01	2.51E-02	9.52E-02	2.00E+00	1.03E-08	1.28E-08
106AN 4-5	3.70E+01	1.64E-02	1.12E-01	3.00E+00	7.52E-09	1.17E-08
106AN 4-6	3.86E+01	1.71E-02	1.29E-01	4.00E+00	1.15E-08	1.17E-08
106AN 4-7	2.32E+02	1.03E-01	2.32E-01	1.90E+01	5.39E-09	9.11E-09
106AN 4-8	1.47E+02	6.51E-02	2.97E-01	4.60E+01	2.03E-09	6.75E-09
106AN 4-9	1.04E+02	4.64E-02	3.43E-01	9.20E+01	7.68E-10	4.19E-09

TABLE B.5-2. Nitrite (NO_2) Fraction Leached from 106-AN Grout for ANS 16.1 Leach Test (106AN-4)

SAMPLE	mg LEACHED	An/Ao	cum. An/Ao	TIME days	D inc.	D cum. (<0.2)
106AN 4-1	3.49E+01	3.59E-02	3.59E-02	8.33E-02	4.35E-08	4.35E-08
106AN 4-2	1.31E+01	1.34E-02	4.93E-02	2.90E-01	8.13E-09	2.36E-08
106AN 4-3	2.16E+01	2.22E-02	7.15E-02	1.00E+00	6.51E-09	1.44E-08
106AN 4-4	2.58E+01	2.65E-02	9.80E-02	2.00E+00	1.15E-08	1.35E-08
106AN 4-5	1.70E+01	1.75E-02	1.15E-01	3.00E+00	8.51E-09	1.25E-08
106AN 4-6	1.74E+01	1.79E-02	1.33E-01	4.00E+00	1.25E-08	1.25E-08
106AN 4-7	1.15E+02	1.18E-01	2.51E-01	1.90E+01	7.05E-09	1.09E-08
106AN 4-8	6.57E+01	6.75E-02	3.19E-01	4.60E+01	2.19E-09	7.83E-09
106AN 4-9	4.67E+01	4.79E-02	3.67E-01	9.20E+01	8.20E-10	5.11E-09

TABLE B.5-3. Chloride (Cl) Fraction Leached from 106-AN Grout for ANS 16.1 Leach Test (106AN-4)

SAMPLE	mg LEACHED	An/Ao	cum. An/Ao	TIME days	D inc.	D cum. (<0.2)
106AN 4-1	2.00E+00	3.22E-02	3.22E-02	8.33E-02	3.55E-08	3.55E-08
106AN 4-2	1.57E+00	2.52E-02	5.74E-02	2.90E-01	2.91E-08	3.24E-08
106AN 4-3	2.75E+00	4.44E-02	1.02E-01	1.00E+00	2.64E-08	2.96E-08
106AN 4-4	1.89E+00	3.05E-02	1.32E-01	2.00E+00	1.54E-08	2.49E-08
106AN 4-5	2.11E+00	3.39E-02	1.66E-01	3.00E+00	3.25E-08	2.63E-08
106AN 4-6	1.78E+00	2.87E-02	1.95E-01	4.00E+00	3.27E-08	2.71E-08
106AN 4-7	8.10E+00	1.31E-01	3.25E-01	1.90E+01	8.73E-09	2.03E-08
106AN 4-8	4.48E+00	7.22E-02	3.98E-01	4.60E+01	2.53E-09	1.30E-08
106AN 4-9	2.86E+00	4.61E-02	4.44E-01	9.20E+01	7.68E-10	8.19E-09

TABLE B.5-4. Fluoride (F) Fraction Leached from 106-AN Grout for ANS 16.1 Leach Test (106AN-4)

SAMPLE	mg LEACHED	An/Ao	cum. An/Ao	TIME days	D inc.	D cum <0.2
106AN 4-1	5.83E-02	1.36E-02	1.36E-02	8.33E-02	5.43E-09	5.43E-09
106AN 4-2	4.75E-02	1.11E-02	2.46E-02	2.90E-01	4.81E-09	5.14E-09
106AN 4-3	3.67E-02	8.54E-03	3.32E-02	1.00E+00	8.42E-10	2.70E-09
106AN 4-4	4.21E-02	9.80E-03	4.29E-02	2.00E+00	1.37E-09	2.27E-09
106AN 4-5	5.83E-02	1.36E-02	5.65E-02	3.00E+00	4.48E-09	2.62E-09
106AN 4-6	3.67E-02	8.54E-03	6.51E-02	4.00E+00	2.50E-09	2.60E-09
106AN 4-7	2.58E-01	6.00E-02	1.25E-01	1.90E+01	1.59E-09	2.02E-09
106AN 4-8	1.29E-01	2.99E-02	1.55E-01	4.60E+01	3.74E-10	1.28E-09
106AN 4-9	4.75E-02	1.11E-02	1.66E-01	9.20E+01	3.80E-11	7.36E-10

TABLE B.5-5. Sodium (Na) Fraction Leached from 106-AN Grout for ANS 16.1 Leach Test (106AN-4)

SAMPLE	mg LEACHED	An/Ao	cum. An/Ao	TIME days	D inc.	D cum <0.2
106AN 4-1	7.19E+01	3.01E-02	3.01E-02	8.33E-02	3.11E-08	3.11E-08
106AN 4-2	3.08E+01	1.29E-02	4.30E-02	2.90E-01	7.62E-09	1.82E-08
106AN 4-3	4.98E+01	2.09E-02	6.39E-02	1.00E+00	5.82E-09	1.16E-08
106AN 4-4	6.11E+01	2.56E-02	8.95E-02	2.00E+00	1.09E-08	1.14E-08
106AN 4-5	3.95E+01	1.66E-02	1.06E-01	3.00E+00	7.74E-09	1.07E-08
106AN 4-6	3.99E+01	1.67E-02	1.23E-01	4.00E+00	1.11E-08	1.07E-08
106AN 4-7	2.46E+02	1.03E-01	2.26E-01	1.90E+01	5.43E-09	9.11E-09
106AN 4-8	1.70E+02	7.11E-02	2.97E-01	4.60E+01	2.45E-09	6.75E-09
106AN 4-9	1.18E+02	4.94E-02	3.46E-01	9.20E+01	8.80E-10	4.79E-09

TABLE B.5-6. Molybdenum (Mo) Fraction Leached from 106-AN Grout for ANS 16.1 Leach Test (106AN-4)

SAMPLE	mg LEACHED	An/Ao	cum. An/Ao	TIME days	D inc.	D cum <0.2
106AN 4-1	< 5.40E-03	6.84E-03	6.84E-03	8.33E-02	< 1.38E-09	< 1.38E-09
106AN 4-2	< 5.40E-03	6.84E-03	1.37E-02	2.90E-01	< 1.84E-09	< 1.58E-09
106AN 4-3	< 5.40E-03	6.84E-03	2.05E-02	1.00E+00	< 5.39E-10	< 1.03E-09
106AN 4-4	< 5.40E-03	6.84E-03	2.73E-02	2.00E+00	< 6.69E-10	< 9.19E-10
106AN 4-5	< 5.40E-03	6.84E-03	3.42E-02	3.00E+00	< 1.14E-09	< 9.57E-10
106AN 4-6	< 5.40E-03	6.84E-03	4.10E-02	4.00E+00	< 1.60E-09	< 1.03E-09
106AN 4-7	9.18E-02	1.16E-01	1.57E-01	1.90E+01	5.96E-09	< 3.20E-09
106AN 4-8	5.94E-02	7.52E-02	2.32E-01	4.60E+01	2.37E-09	< 3.76E-09
106AN 4-9	4.05E-02	5.13E-02	2.84E-01	9.20E+01	8.19E-10	< 2.90E-09

TABLE B.5-7. Nickel (Ni) Fraction Leached from 106-AN Grout for ANS 16.1 Leach Test (106AN-4)

SAMPLE	mg LEACHED	An/Ao	cum. An/Ao	TIME days	D inc.	D cum <0.2
106AN 4-1	< 1.08E-02	1.57E-02	1.57E-02	8.33E-02	< 8.38E-09	< 8.38E-09
106AN 4-2	< 1.08E-02	1.57E-02	3.13E-02	2.90E-01	< 1.12E-08	< 9.63E-09
106AN 4-3	< 1.08E-02	1.57E-02	4.70E-02	1.00E+00	< 3.28E-09	< 6.29E-09
106AN 4-4	< 1.08E-02	1.57E-02	6.26E-02	2.00E+00	< 4.07E-09	< 5.59E-09
106AN 4-5	< 1.08E-02	1.57E-02	7.83E-02	3.00E+00	< 6.91E-09	< 5.82E-09
106AN 4-6	< 1.08E-02	1.57E-02	9.39E-02	4.00E+00	< 9.73E-09	< 6.29E-09
106AN 4-7	1.03E-02	1.49E-02	1.09E-01	1.90E+01	1.13E-10	< 1.78E-09
106AN 4-8	8.10E-03	1.17E-02	1.21E-01	4.60E+01	6.69E-11	< 9.00E-10
106AN 4-9	2.70E-03	3.91E-03	1.24E-01	9.20E+01	5.53E-12	< 4.80E-10

TABLE B.5-8. Chromium (Cr) Fraction Leached from 106-AN Grout for ANS 16.1 Leach Test (106AN-4)

SAMPLE	mg LEACHED	An/Ao	cum. An/Ao	TIME days	D inc.	D cum <0.2
106AN 4-1	< 1.08E-02	6.41E-04	6.41E-04	8.33E-02	< 1.41E-11	< 1.41E-11
106AN 4-2	< 1.08E-02	6.41E-04	1.28E-03	2.90E-01	< 1.88E-11	< 1.62E-11
106AN 4-3	< 1.08E-02	6.41E-04	1.92E-03	1.00E+00	< 5.50E-12	< 1.05E-11
106AN 4-4	< 1.08E-02	6.41E-04	2.56E-03	2.00E+00	< 6.83E-12	< 9.37E-12
106AN 4-5	< 1.08E-02	6.41E-04	3.20E-03	3.00E+00	< 1.16E-11	< 9.76E-12
106AN 4-6	< 1.08E-02	6.41E-04	3.85E-03	4.00E+00	< 1.63E-11	< 1.05E-11
106AN 4-7	< 1.08E-02	6.41E-04	4.49E-03	1.90E+01	< 2.10E-13	< 3.02E-12
106AN 4-8	< 1.08E-02	6.41E-04	5.13E-03	4.60E+01	< 1.99E-13	< 1.63E-12
106AN 4-9	< 1.08E-02	6.41E-04	5.77E-03	9.20E+01	< 1.48E-13	< 1.03E-12

TABLE B.6-1. Cs-137 Fraction Leached for ANS 16.1 Leach Test: Whole Grout In Hanford Ground Water (106AN 4-1)

	SAMPLE ID	TOT. LEACH (An)	CUM. LEACH	TIME DAYS	An/Ao	cum An/Ao	D inc. cm2/sec	D cum cm2/sec
106AN	4-1	89.18	89.18	0.08	1.42E-02	1.42E-02	6.90E-09	6.90E-09
106AN	4-2	27.95	117.13	0.29	4.44E-03	1.86E-02	8.97E-10	3.41E-09
106AN	4-3	46.17	163.30	1.00	7.34E-03	2.60E-02	7.21E-10	1.92E-09
106AN	4-4	34.26	197.56	2.00	5.45E-03	3.14E-02	4.93E-10	1.41E-09
106AN	4-5	22.70	220.26	3.00	3.61E-03	3.50E-02	3.67E-10	1.17E-09
106AN	4-6	23.40	243.66	4.00	3.72E-03	3.87E-02	5.50E-10	1.07E-09
106AN	4-7	118.34	362.00	19.00	1.88E-02	5.76E-02	1.81E-10	4.97E-10
106AN	4-8	74.84	436.84	46.00	1.19E-02	6.95E-02	6.87E-11	2.99E-10

TABLE B.6-2. Co-60 Fraction Leached for ANS 16.1 Leach Test: Whole Grout In Hanford Ground Water (106AN 4-1)

	SAMPLE ID	TOT. LEACH (An)	CUM. LEACH	TIME DAYS	An/Ao	cum An/Ao	D inc. cm2/sec	D cum cm2/sec
106AN	4-1	4.98E-03	4.98E-03	0.08	5.99E-03	5.99E-03	1.23E-09	1.23E-09
106AN	4-2	7.10E-04	5.69E-03	0.29	8.53E-04	6.84E-03	3.31E-11	4.60E-10
106AN	4-3	1.59E-03	7.28E-03	1.00	1.91E-03	8.75E-03	4.87E-11	2.18E-10
106AN	4-4	7.41E-04	8.02E-03	2.00	8.91E-04	9.64E-03	1.32E-11	1.32E-10
106AN	4-5	5.86E-04	8.60E-03	3.00	7.04E-04	1.03E-02	1.40E-11	1.02E-10
106AN	4-6	7.05E-04	9.31E-03	4.00	8.47E-04	1.12E-02	2.85E-11	8.92E-11
106AN	4-7	2.87E-03	1.22E-02	19.00	3.45E-03	1.46E-02	6.09E-12	3.21E-11
106AN	4-8	1.62E-03	1.38E-02	46.00	1.95E-03	1.68E-02	1.84E-12	1.70E-11

TABLE B.6-3. Sr-90 Fraction Leached for ANS 16.1 Leach Test: Whole Grout In Hanford Ground Water (106AN 4-1)

	SAMPLE ID	TOT. LEACH (An)	CUM. LEACH	TIME DAYS	An/Ao	cum An/Ao	D inc. cm2/sec	D cum cm2/sec
106AN	4-1	1.33E-03	1.33E-03	0.08	1.26E-05	1.26E-05	5.42E-15	5.42E-15
106AN	4-2	8.97E-04	2.23E-03	0.29	8.46E-06	2.10E-05	3.25E-15	4.34E-15
106AN	4-3	3.65E-04	2.59E-03	1.00	3.44E-06	2.45E-05	1.58E-16	1.71E-15
106AN	4-4	1.56E-03	4.16E-03	2.00	1.48E-05	3.92E-05	3.62E-15	2.19E-15
106AN	4-5	2.07E-03	6.22E-03	3.00	1.95E-05	5.87E-05	1.07E-14	3.28E-15
106AN	4-6	3.33E-03	9.55E-03	4.00	3.14E-05	9.01E-05	3.92E-14	5.79E-15
106AN	4-7	5.61E-03	1.52E-02	19.00	5.30E-05	1.43E-04	1.44E-15	3.07E-15
106AN	4-8	4.40E-03	1.96E-02	46.00	4.15E-05	1.85E-04	8.36E-16	2.11E-15

TABLE B.6-4. I-129 Fraction Leached for ANS 16.1 Leach Test: Whole Grout In Hanford Ground Water (106AN 4-1)

	SAMPLE ID	TOT. LEACH (An)	CUM. LEACH	TIME DAYS	An/Ao	cum An/Ao	D inc. cm2/sec	D cum cm2/sec
106AN	4-1	4.03E-05	4.03E-05	0.08	6.03E-02	6.03E-02	1.25E-07	1.25E-07
106AN	4-2	1.88E-05	5.92E-05	0.29	2.82E-02	8.84E-02	3.60E-08	7.69E-08
106AN	4-3	2.84E-05	8.76E-05	1.00	4.25E-02	1.31E-01	2.42E-08	4.89E-08
106AN	4-4	2.28E-05	1.10E-04	2.00	3.41E-02	1.65E-01	1.94E-08	3.88E-08
106AN	4-5	1.48E-05	1.25E-04	3.00	2.22E-02	1.87E-01	1.39E-08	3.33E-08
106AN	4-6	1.31E-05	1.38E-04	4.00	1.96E-02	2.07E-01	1.53E-08	3.35E-08
106AN	4-7	1.66E-04	3.04E-04	19.00	2.48E-01	4.55E-01	3.15E-08	4.15E-08
106AN	4-8	8.02E-05	3.85E-04	46.00	1.20E-01	5.75E-01	6.97E-09	3.09E-08

TABLE B.6-5. Tc-99 Fraction Leached for ANS 16.1 Leach Test: Whole Grout In Hanford Ground Water (106AN 4-1)

	SAMPLE ID	TOT. LEACH (An)	CUM. LEACH	TIME DAYS	An/Ao	cum An/Ao	D inc. cm2/sec	D cum cm2/sec
106AN	4-1	2.04E-03	2.04E-03	0.08	1.15E-02	1.15E-02	4.58E-09	4.58E-09
106AN	4-2	1.15E-03	3.19E-03	0.29	6.49E-03	1.80E-02	1.92E-09	3.20E-09
106AN	4-3	2.37E-03	5.56E-03	1.00	1.34E-02	3.14E-02	2.40E-09	2.82E-09
106AN	4-4	6.55E-02	7.10E-02	2.00	3.70E-01	4.01E-01	2.27E-06	2.30E-07
106AN	4-5	3.58E-02	1.07E-01	3.00	2.02E-01	6.04E-01	1.16E-06	3.48E-07
106AN	4-6	1.14E-02	1.18E-01	4.00	6.45E-02	6.68E-01	1.65E-07	3.18E-07
106AN	4-7	2.39E-02	1.42E-01	19.00	1.35E-01	8.03E-01	9.35E-09	9.68E-08
106AN	4-8	5.08E-02	1.93E-01	46.00	2.87E-01	1.09E+00	4.00E-08	7.37E-08

TABLE B.6-6. Am-241 Fraction Leached for ANS 16.1 Leach Test: Whole Grout In Hanford Ground Water (106AN 4-1)

	SAMPLE ID	TOT. LEACH (An)	CUM. LEACH	TIME DAYS	An/Ao	cum An/Ao	D inc. cm2/sec	D cum cm2/sec
106AN	4-1	6.71E-06	6.71E-06	0.08	5.28E-04	5.28E-04	9.58E-12	9.58E-12
106AN	4-2	3.55E-06	1.03E-05	0.29	2.79E-04	8.07E-04	3.55E-12	6.41E-12
106AN	4-3	3.47E-05	4.50E-05	1.00	2.74E-03	3.54E-03	1.00E-10	3.58E-11
106AN	4-4	4.13E-06	4.91E-05	2.00	3.25E-04	3.87E-03	1.76E-12	2.13E-11
106AN	4-5	1.22E-06	5.03E-05	3.00	9.57E-05	3.96E-03	2.58E-13	1.49E-11
106AN	4-6	2.67E-06	5.30E-05	4.00	2.10E-04	4.18E-03	1.76E-12	1.24E-11
106AN	4-7	1.09E-05	6.40E-05	19.00	8.61E-04	5.04E-03	3.80E-13	3.81E-12
106AN	4-8	1.07E-05	7.46E-05	46.00	8.42E-04	5.88E-03	3.44E-13	2.14E-12

APPENDIX C

MASS BALANCE CALCULATIONS

TABLE C.1. Mass Balance Calculations for Aluminum (Al)

STATIC LEACH TEST

SAMPLE NO.	EFFLUENT ppm Al	HGW CONC. ppm Al	ELUTED mg Al	TOTAL CHANGE mg Al
S1-1	0.04	0.64	-0.36	-0.36
S1-2	5.30	0.64	3.12	2.77
S1-3	8.25	0.64	2.00	4.77
S1-4	11.20	0.64	2.15	6.92

SAMPLE NO.	EFFLUENT ppm Al	HGW CONC. ppm Al	ELUTED mg Al	TOTAL CHANGE mg Al
S2-1	2.40	0.64	1.06	1.06
S2-2	6.40	0.64	2.49	3.54
S2-3	11.30	0.64	3.23	6.77
S2-4	14.20	0.64	2.27	9.04

ANS 16.1 LEACH TEST

SAMPLE NO.	EFFLUENT ppm Al	HGW CONC. ppm Al	ELUTED mg Al	SUM ELUTED mg Al
A3-1	0.35	0.64	-0.17	-0.17
A3-2	0.21	0.64	-0.26	-0.43
A3-3	0.24	0.64	-0.24	-0.68
A3-4	0.16	0.64	-0.29	-0.96
A3-5	0.10	0.64	-0.32	-1.29
A3-6	0.10	0.64	-0.33	-1.61
A3-7	1.33	0.64	0.41	-1.20
A3-8	0.97	0.64	0.20	-1.00
A3-9	0.20	0.64	-0.26	-1.27

SAMPLE NO.	EFFLUENT ppm Al	HGW CONC. ppm Al	ELUTED mg Al	SUM ELUTED mg Al
A4-1	0.37	0.64	-0.16	-0.16
A4-2	0.15	0.64	-0.29	-0.46
A4-3	0.17	0.64	-0.29	-0.74
A4-4	0.20	0.64	-0.26	-1.00
A4-5	0.16	0.64	-0.29	-1.29
A4-6	0.09	0.64	-0.33	-1.62
A4-7	2.29	0.64	0.99	-0.63
A4-8	1.48	0.64	0.50	-0.13
A4-9	0.21	0.64	-0.26	-0.39

TABLE C.2. Mass Balance Calculations for Boron (B)

STATIC LEACH TEST

SAMPLE NO.	EFFLUENT ppm B	HGW CONC. ppm B	ELUTED mg B	TOTAL CHANGE mg B
S1-1	5.17	0.51	2.80	2.80
S1-2	10.69	0.51	3.55	8.34
S1-3	13.70	0.51	2.31	8.85
S1-4	18.70	0.51	2.46	11.11

SAMPLE NO.	EFFLUENT ppm B	HGW CONC. ppm B	ELUTED mg B	TOTAL CHANGE mg B
S2-1	7.21	0.51	4.02	4.02
S2-2	9.84	0.51	1.91	5.93
S2-3	14.01	0.51	2.97	8.90
S2-4	18.01	0.51	3.08	11.98

ANS 16.1 LEACH TEST

SAMPLE NO.	EFFLUENT ppm B	HGW CONC. ppm B	ELUTED mg B	SUM ELUTED mg B
A3-1	2.02	0.51	0.91	0.91
A3-2	1.42	0.51	0.55	1.46
A3-3	1.77	0.51	0.76	2.22
A3-4	1.82	0.51	0.79	3.00
A3-5	1.42	0.51	0.55	3.55
A3-6	1.10	0.51	0.36	3.90
A3-7	5.26	0.51	2.85	6.78
A3-8	3.26	0.51	1.65	8.41
A3-9	2.72	0.51	1.33	9.73

SAMPLE NO.	EFFLUENT ppm B	HGW CONC. ppm B	ELUTED mg B	SUM ELUTED mg B
A4-1	2.05	0.51	0.93	0.93
A4-2	1.16	0.51	0.39	1.32
A4-3	1.49	0.51	0.59	1.90
A4-4	2.01	0.51	0.90	2.81
A4-5	1.45	0.51	0.56	3.37
A4-6	1.32	0.51	0.48	3.85
A4-7	8.69	0.51	3.71	7.56
A4-8	4.17	0.51	2.20	9.76
A4-9	2.87	0.51	1.41	11.17

TABLE C.3. Mass Balance Calculations for Calcium (Ca)

STATIC LEACH TEST

SAMPLE NO.	EFFLUENT ppm Ca	HGW CONC. ppm Ca	ELUTED mg Ca	TOTAL CHANGE mg Ca
S1-1	3.61	58.80	-33.11	-33.11
S1-2	2.25	58.80	-3.58	-36.69
S1-3	3.57	58.80	-2.04	-38.73
S1-4	4.88	58.80	-1.97	-40.70

SAMPLE NO.	EFFLUENT ppm Ca	HGW CONC. ppm Ca	ELUTED mg Ca	TOTAL CHANGE mg Ca
S2-1	2.09	58.80	-34.03	-34.03
S2-2	2.26	58.80	-2.73	-36.76
S2-3	5.99	58.80	-0.59	-37.35
S2-4	8.35	58.80	-1.22	-38.57

ANS 16.1 LEACH TEST

SAMPLE NO.	EFFLUENT ppm Ca	HGW CONC. ppm Ca	ELUTED mg Ca	SUM ELUTED mg Ca
A3-1	29.10	58.80	-17.82	-17.82
A3-2	30.50	58.80	-16.96	-34.80
A3-3	25.20	58.80	-20.16	-54.96
A3-4	19.60	58.80	-23.52	-78.48
A3-5	23.40	58.80	-21.24	-99.72
A3-6	25.60	58.80	-19.92	-119.64
A3-7	1.96	58.80	-34.10	-153.74
A3-8	2.67	58.80	-33.68	-187.42
A3-9	2.91	58.80	-33.53	-220.96

SAMPLE NO.	EFFLUENT ppm Ca	HGW CONC. ppm Ca	ELUTED mg Ca	SUM ELUTED mg Ca
A4-1	25.90	58.80	-19.74	-19.74
A4-2	31.70	58.80	-16.26	-36.00
A4-3	28.20	58.80	-18.36	-54.36
A4-4	16.60	58.80	-25.32	-79.68
A4-5	27.30	58.80	-18.90	-98.58
A4-6	21.70	58.80	-22.26	-120.84
A4-7	2.63	58.80	-33.70	-154.54
A4-8	2.61	58.80	-33.71	-188.26
A4-9	2.55	58.80	-33.75	-222.01

TABLE C.4. Mass Balance Calculations for Potassium (K)

STATIC LEACH TEST

SAMPLE NO.	EFFLUENT ppm K	HGW CONC. ppm K	ELUTED mg K	TOTAL CHANGE mg K
S1-1	17.90	7.37	6.32	6.32
S1-2	28.00	7.37	6.59	12.90
S1-3	32.45	7.37	3.70	16.61
S1-4	36.90	7.37	3.92	20.53

SAMPLE NO.	EFFLUENT ppm K	HGW CONC. ppm K	ELUTED mg K	TOTAL CHANGE mg K
S2-1	19.20	7.37	7.10	7.10
S2-2	26.00	7.37	4.67	11.77
S2-3	31.60	7.37	4.29	16.06
S2-4	37.20	7.37	4.57	20.63

ANS 16.1 LEACH TEST

SAMPLE NO.	EFFLUENT ppm K	HGW CONC. ppm K	ELUTED mg K	SUM ELUTED mg K
A3-1	10.40	7.37	1.82	1.82
A3-2	8.80	7.37	0.86	2.68
A3-3	10.00	7.37	1.58	4.25
A3-4	9.80	7.37	1.46	5.71
A3-5	9.10	7.37	1.04	6.75
A3-6	8.90	7.37	0.92	7.67
A3-7	16.00	7.37	5.18	12.85
A3-8	12.00	7.37	2.78	15.62
A3-9	11.80	7.37	2.66	18.28

SAMPLE NO.	EFFLUENT ppm K	HGW CONC. ppm K	ELUTED mg K	SUM ELUTED mg K
A4-1	10.80	7.37	2.06	2.06
A4-2	8.70	7.37	0.80	2.86
A4-3	9.30	7.37	1.16	4.01
A4-4	9.70	7.37	1.40	5.41
A4-5	8.90	7.37	0.92	6.33
A4-6	9.10	7.37	1.04	7.37
A4-7	17.60	7.37	6.14	13.51
A4-8	13.80	7.37	3.86	17.36
A4-9	12.20	7.37	2.90	20.26

TABLE C.5. Mass Balance Calculations for Magnesium (Mg)

STATIC LEACH TEST

SAMPLE NO.	EFFLUENT ppm Mg	HGW CONC. ppm Mg	ELUTED mg Mg	TOTAL CHANGE mg Mg
S1-1	0.06	14.00	-8.36	-8.36
S1-2	0.06	14.00	-0.70	-9.06
S1-3	0.06	14.00	-0.70	-9.76
S1-4	0.06	14.00	-0.70	-10.46

SAMPLE NO.	EFFLUENT ppm Mg	HGW CONC. ppm Mg	ELUTED mg Mg	TOTAL CHANGE mg Mg
S2-1	0.06	14.00	-8.36	-8.36
S2-2	0.06	14.00	-0.70	-9.06
S2-3	0.06	14.00	-0.70	-9.76
S2-4	0.06	14.00	-0.70	-10.46

ANS 16.1 LEACH TEST

SAMPLE NO.	EFFLUENT ppm Mg	HGW CONC. ppm Mg	ELUTED mg Mg	SUM ELUTED mg Mg
A3-1	11.70	14.00	-1.38	-1.38
A3-2	11.20	14.00	-1.68	-3.06
A3-3	9.17	14.00	-2.90	-5.96
A3-4	8.12	14.00	-3.53	-9.49
A3-5	8.81	14.00	-3.11	-12.60
A3-6	9.87	14.00	-2.48	-15.08
A3-7	0.06	14.00	-8.36	-23.44
A3-8	0.26	14.00	-8.24	-31.69
A3-9	0.91	14.00	-7.85	-39.54

SAMPLE NO.	EFFLUENT ppm Mg	HGW CONC. ppm Mg	ELUTED mg Mg	SUM ELUTED mg Mg
A4-1	11.40	14.00	-1.56	-1.56
A4-2	11.40	14.00	-1.56	-3.12
A4-3	9.41	14.00	-2.75	-5.87
A4-4	7.73	14.00	-3.76	-9.64
A4-5	9.27	14.00	-2.84	-12.47
A4-6	9.17	14.00	-2.90	-15.37
A4-7	0.06	14.00	-8.36	-23.74
A4-8	0.17	14.00	-8.30	-32.03
A4-9	0.68	14.00	-7.99	-40.02

TABLE C.6. Mass Balance Calculations for Molybdenum (Mo)

STATIC LEACH TEST

SAMPLE NO.	EFFLUENT ppm Mo	HGW CONC. ppm Mo	ELUTED mg Mo	TOTAL CHANGE mg Mo
S1-1	0.14	0.01	0.08	0.08
S1-2	0.31	0.01	0.11	0.19
S1-3	0.42	0.01	0.08	0.26
S1-4	0.52	0.01	0.08	0.35

SAMPLE NO.	EFFLUENT ppm Mo	HGW CONC. ppm Mo	ELUTED mg Mo	TOTAL CHANGE mg Mo
S2-1	0.21	0.01	0.12	0.12
S2-2	0.27	0.01	0.05	0.17
S2-3	0.39	0.01	0.08	0.25
S2-4	0.52	0.01	0.09	0.35

ANS 16.1 LEACH TEST

SAMPLE NO.	EFFLUENT ppm Mo	HGW CONC. ppm Mo	ELUTED mg Mo	SUM ELUTED mg Mo
A3-1	0.01	0.01	0.00	0.00
A3-2	0.01	0.01	0.00	0.00
A3-3	0.01	0.01	0.00	0.00
A3-4	0.01	0.01	0.00	0.00
A3-5	0.01	0.01	0.00	0.00
A3-6	0.01	0.01	0.00	0.00
A3-7	0.16	0.01	0.09	0.09
A3-8	0.01	0.01	0.00	0.09
A3-9	0.09	0.01	0.05	0.14

SAMPLE NO.	EFFLUENT ppm Mo	HGW CONC. ppm Mo	ELUTED mg Mo	SUM ELUTED mg Mo
A4-1	0.01	0.01	0.00	0.00
A4-2	0.01	0.01	0.00	0.00
A4-3	0.01	0.01	0.00	0.00
A4-4	0.01	0.01	0.00	0.00
A4-5	0.01	0.01	0.00	0.00
A4-6	0.01	0.01	0.00	0.00
A4-7	0.18	0.01	0.10	0.10
A4-8	0.12	0.01	0.07	0.17
A4-9	0.09	0.01	0.05	0.21

TABLE C.7. Mass Balance Calculations for Sodium (Na)

STATIC LEACH TEST

SAMPLE NO.	EFFLUENT ppm Na	HGW CONC. ppm Na	ELUTED mg Na	TOTAL CHANGE mg Na
S1-1	423.00	24.80	238.92	238.92
S1-2	880.00	24.80	294.11	533.03
S1-3	1071.00	24.80	157.36	690.39
S1-4	1262.00	24.80	166.91	857.30

SAMPLE NO.	EFFLUENT ppm Na	HGW CONC. ppm Na	ELUTED mg Na	TOTAL CHANGE mg Na
S2-1	548.00	24.80	313.92	313.92
S2-2	810.00	24.80	183.36	497.28
S2-3	1140.00	24.80	237.26	734.54
S2-4	1285.00	24.80	142.76	877.30

ANS 16.1 LEACH TEST

SAMPLE NO.	EFFLUENT ppm Na	HGW CONC. ppm Na	ELUTED mg Na	SUM ELUTED mg Na
A3-1	143.00	24.80	70.92	70.92
A3-2	87.60	24.80	37.68	108.60
A3-3	142.00	24.80	70.32	178.92
A3-4	140.00	24.80	69.12	248.04
A3-5	109.00	24.80	50.52	298.56
A3-6	89.10	24.80	38.58	337.14
A3-7	426.00	24.80	240.72	577.86
A3-8	291.00	24.80	159.72	737.58
A3-9	231.00	24.80	123.72	861.30

SAMPLE NO.	EFFLUENT ppm Na	HGW CONC. ppm Na	ELUTED mg Na	SUM ELUTED mg Na
A4-1	156.00	24.80	79.92	79.92
A4-2	81.90	24.80	34.26	114.18
A4-3	117.00	24.80	55.32	169.50
A4-4	138.00	24.80	67.92	237.42
A4-5	96.00	24.80	43.92	281.34
A4-6	98.60	24.80	44.28	325.62
A4-7	480.00	24.80	273.12	598.74
A4-8	339.00	24.80	188.52	787.26
A4-9	243.00	24.80	130.92	918.18

TABLE C.8. Mass Balance Calculations for Fluorine (F)

STATIC LEACH TEST

SAMPLE NO.	EFFLUENT ppm F	HGW CONC. ppm F	ELUTED mg F	TOTAL CHANGE mg F
S1-1	0.78	0.57	0.12	0.12
S1-2	1.18	0.57	0.25	0.38
S1-3	1.22	0.57	0.05	0.43
S1-4	1.26	0.57	0.06	0.49

SAMPLE NO.	EFFLUENT ppm F	HGW CONC. ppm F	ELUTED mg F	TOTAL CHANGE mg F
S2-1	0.89	0.57	0.19	0.19
S2-2	1.17	0.57	0.18	0.37
S2-3	1.23	0.57	0.07	0.44
S2-4	1.34	0.57	0.10	0.54

ANS 16.1 LEACH TEST

SAMPLE NO.	EFFLUENT ppm F	HGW CONC. ppm F	ELUTED mg F	SUM ELUTED mg F
A3-1	0.67	0.57	0.06	0.06
A3-2	0.83	0.57	0.03	0.09
A3-3	0.68	0.57	0.06	0.16
A3-4	0.72	0.57	0.09	0.25
A3-5	0.70	0.57	0.08	0.32
A3-6	0.65	0.57	0.05	0.37
A3-7	0.93	0.57	0.21	0.59
A3-8	0.74	0.57	0.10	0.69
A3-9	0.60	0.57	0.02	0.70

SAMPLE NO.	EFFLUENT ppm F	HGW CONC. ppm F	ELUTED mg F	SUM ELUTED mg F
A4-1	0.68	0.57	0.06	0.06
A4-2	0.66	0.57	0.05	0.12
A4-3	0.64	0.57	0.04	0.16
A4-4	0.65	0.57	0.05	0.21
A4-5	0.68	0.57	0.06	0.27
A4-6	0.64	0.57	0.04	0.31
A4-7	1.05	0.57	0.29	0.60
A4-8	0.81	0.57	0.14	0.74
A4-9	0.66	0.57	0.05	0.79

TABLE C.9. Mass Balance Calculations for Chloride (Cl)

STATIC LEACH TEST

SAMPLE NO.	EFFLUENT ppm Cl	HGW CONC. ppm Cl	ELUTED mg Cl	TOTAL CHANGE mg Cl
S1-1	28.20	22.50	3.42	3.42
S1-2	44.00	22.50	9.76	13.18
S1-3	51.00	22.50	5.27	18.46
S1-4	58.00	22.50	5.62	24.08

SAMPLE NO.	EFFLUENT ppm Cl	HGW CONC. ppm Cl	ELUTED mg Cl	TOTAL CHANGE mg Cl
S2-1	29.60	22.50	4.26	4.26
S2-2	42.50	22.50	8.09	12.35
S2-3	49.90	22.50	5.44	17.79
S2-4	57.00	22.50	5.63	23.42

ANS 16.1 LEACH TEST

SAMPLE NO.	EFFLUENT ppm Cl	HGW CONC. ppm Cl	ELUTED mg Cl	SUM ELUTED mg Cl
A3-1	26.20	22.50	2.22	2.22
A3-2	24.80	22.50	1.38	3.60
A3-3	26.40	22.50	2.34	5.94
A3-4	26.40	22.50	2.34	8.28
A3-5	26.60	22.50	2.46	10.74
A3-6	26.00	22.50	2.10	12.84
A3-7	34.50	22.50	7.20	20.04
A3-8	28.90	22.50	3.84	23.88
A3-9	27.00	22.50	2.70	26.58

SAMPLE NO.	EFFLUENT ppm Cl	HGW CONC. ppm Cl	ELUTED mg Cl	SUM ELUTED mg Cl
A4-1	26.20	22.50	2.22	2.22
A4-2	25.40	22.50	1.74	3.96
A4-3	27.60	22.50	3.06	7.02
A4-4	26.00	22.50	2.10	9.12
A4-5	26.40	22.50	2.34	11.46
A4-6	25.80	22.50	1.98	13.44
A4-7	37.50	22.50	9.00	22.44
A4-8	30.80	22.50	4.98	27.42
A4-9	27.80	22.50	3.18	30.60

TABLE C.10. Mass Balance Calculations for Nitrite (NO_2)

STATIC LEACH TEST

SAMPLE NO.	EFFLUENT ppm NO2	HGW CONC. ppm NO2	ELUTED mg NO2	TOTAL CHANGE mg NO2
S1-1	162.00	0.30	97.02	97.02
S1-2	390.00	0.30	144.89	241.91
S1-3	465.00	0.30	64.48	306.39
S1-4	540.00	0.30	68.23	374.62

SAMPLE NO.	EFFLUENT ppm NO2	HGW CONC. ppm NO2	ELUTED mg NO2	TOTAL CHANGE mg NO2
S2-1	215.00	0.30	128.82	128.82
S2-2	355.00	0.30	94.73	223.55
S2-3	449.00	0.30	74.13	297.69
S2-4	540.00	0.30	77.03	374.72

ANS 16.1 LEACH TEST

SAMPLE NO.	EFFLUENT ppm NO2	HGW CONC. ppm NO2	ELUTED mg NO2	SUM ELUTED mg NO2
A3-1	54.00	0.30	32.22	32.22
A3-2	27.30	0.30	16.20	48.42
A3-3	51.00	0.30	30.42	78.84
A3-4	51.00	0.30	30.42	109.26
A3-5	32.90	0.30	19.56	128.82
A3-6	25.90	0.30	15.36	144.18
A3-7	168.00	0.30	100.62	244.80
A3-8	96.00	0.30	57.42	302.22
A3-9	80.80	0.30	48.30	350.52

SAMPLE NO.	EFFLUENT ppm NO2	HGW CONC. ppm NO2	ELUTED mg NO2	SUM ELUTED mg NO2
A4-1	65.00	0.30	38.82	38.82
A4-2	24.50	0.30	14.52	53.34
A4-3	40.30	0.30	24.00	77.34
A4-4	48.00	0.30	28.62	105.96
A4-5	31.80	0.30	18.90	124.86
A4-6	32.50	0.30	19.32	144.18
A4-7	213.00	0.30	127.62	271.80
A4-8	122.00	0.30	73.02	344.82
A4-9	86.70	0.30	51.84	396.66

TABLE C.11. Mass Balance Calculations for Nitrate (NO_3)

STATIC LEACH TEST

SAMPLE NO.	EFFLUENT ppm NO3	HGW CONC. ppm NO3	ELUTED mg NO3	TOTAL CHANGE mg NO3
S1-1	382.00	0.50	228.90	228.90
S1-2	400.00	0.50	29.87	258.78
S1-3	805.00	0.50	262.97	521.75
S1-4	1210.00	0.50	283.22	804.97

SAMPLE NO.	EFFLUENT ppm NO3	HGW CONC. ppm NO3	ELUTED mg NO3	TOTAL CHANGE mg NO3
S2-1	505.00	0.50	302.70	302.70
S2-2	370.00	0.50	-55.78	246.92
S2-3	1010.00	0.50	402.47	649.40
S2-4	1210.00	0.50	170.47	819.87

ANS 16.1 LEACH TEST

SAMPLE NO.	EFFLUENT ppm NO3	HGW CONC. ppm NO3	ELUTED mg NO3	SUM ELUTED mg NO3
A3-1	121.00	0.50	72.30	72.30
A3-2	58.70	0.50	33.72	106.02
A3-3	104.00	0.50	62.10	168.12
A3-4	104.00	0.50	62.10	230.22
A3-5	65.00	0.50	38.70	268.92
A3-6	55.10	0.50	32.76	301.68
A3-7	367.00	0.50	219.90	521.58
A3-8	210.00	0.50	125.70	647.28
A3-9	176.00	0.50	105.30	752.58

SAMPLE NO.	EFFLUENT ppm NO3	HGW CONC. ppm NO3	ELUTED mg NO3	SUM ELUTED mg NO3
A4-1	150.00	0.50	89.70	89.70
A4-2	54.20	0.50	32.22	121.92
A4-3	90.00	0.50	53.70	175.62
A4-4	105.00	0.50	62.70	238.32
A4-5	69.00	0.50	41.10	279.42
A4-6	72.00	0.50	42.90	322.32
A4-7	431.00	0.50	258.30	580.62
A4-8	272.00	0.50	162.90	743.52
A4-9	194.00	0.50	116.10	859.62

TABLE C.12. Mass Balance Calculations for Sulfate (SO_4)

STATIC LEACH TEST

SAMPLE NO.	EFFLUENT ppm SO4	HGW CONC. ppm SO4	ELUTED mg SO4	TOTAL CHANGE mg SO4
S1-1	119.00	70.50	29.10	29.10
S1-2	235.00	70.50	72.02	101.12
S1-3	273.50	70.50	31.32	132.45
S1-4	312.00	70.50	33.25	165.70

SAMPLE NO.	EFFLUENT ppm SO4	HGW CONC. ppm SO4	ELUTED mg SO4	TOTAL CHANGE mg SO4
S2-1	208.00	70.50	82.50	82.50
S2-2	199.00	70.50	1.47	83.97
S2-3	268.00	70.50	47.82	131.80
S2-4	307.00	70.50	33.27	165.07

ANS 16.1 LEACH TEST

SAMPLE NO.	EFFLUENT ppm SO4	HGW CONC. ppm SO4	ELUTED mg SO4	SUM ELUTED mg SO4
A3-1	97.00	70.50	15.90	15.90
A3-2	86.20	70.50	9.42	25.32
A3-3	95.00	70.50	14.70	40.02
A3-4	95.00	70.50	14.70	54.72
A3-5	81.90	70.50	6.84	61.56
A3-6	83.00	70.50	7.50	69.06
A3-7	145.00	70.50	44.70	113.76
A3-8	119.00	70.50	29.10	142.86
A3-9	116.00	70.50	27.30	170.16

SAMPLE NO.	EFFLUENT ppm SO4	HGW CONC. ppm SO4	ELUTED mg SO4	SUM ELUTED mg SO4
A4-1	103.00	70.50	19.50	19.50
A4-2	77.70	70.50	4.32	23.82
A4-3	76.40	70.50	3.54	27.36
A4-4	92.00	70.50	12.90	40.26
A4-5	82.00	70.50	6.90	47.16
A4-6	96.00	70.50	15.30	62.46
A4-7	191.00	70.50	72.30	134.76
A4-8	136.00	70.50	39.30	174.06
A4-9	120.00	70.50	29.70	203.76

APPENDIX D

RAW DATA FOR RADIONUCLIDE COUNTING

TABLE D.1. Raw Data for Radionuclides

	Original Waste	A-4-1	A-4-2	A-4-3	A-4-4	A-4-5	A-4-6	A-4-7	A-4-8	Static
					dpm/ml					
^{3}H	1.27±0.16 E3	17.6±8.6	14.4±8.6	9.23±8.5	1.14±0.07	1.37±0.07	1.63±0.08	0.255±0.008	1.61±0.08	2.09±0.07
^{14}C	<1.2 E4	<1.66	<1.68	<1.79	<1.89	<5.3	<2.22	<1.81	<6.16	<21.8
^{55}Fe	2.64±0.11 E4	4.56±0.17	0.971±0.153	21.9±0.3	402±3	369±3	423±3	73.6±1.6	43.9±0.8	4387±13
^{59}Ni	1.34±0.04 E3	0.75±0.196	1.99±0.21	0.877±0.164	- - -	- - -	- - -	- - -	- - -	- - -
^{60}Co	7.26±1.58 E4	20.5±5.8	2.92±1.4	6.53±1.5	<3.05	<2.41	<2.9	<11.8	<6.67	<17.9
^{63}Ni	2.01±0.08 E3	21.7±4.5	31.7±4.8	14.7±4.2	- - -	- - -	- - -	- - -	- - -	1260±174
^{79}Se	- - -	<1.55	<1.52	<1.54	- - -	- - -	- - -	- - -	- - -	<33.5
^{90}Sr	9.24±0.28 E6	5.48±2.12	3.69±1.92	15±2.4	6.44±0.57	8.5±0.61	13.7±10.7	23.1±0.8	18.1±0.8	25.1±1.9
^{94}Nb	<5.56 E1	<9.78	<3.16	<4.13	- - -	- - -	- - -	- - -	- - -	42.7±21.4
^{99}Tc	1.54±0.16 E4	8.41±0.29	4.73±0.25	9.75±0.3	48.5±4.4	42.8±4.2	47±4.1	98.4±6.8	209±9.2	3780±129
^{129}I	5.65±0.48 E1	0.166±0.013	0.0775±0.0116	0.117±0.011	0.094±0.028	0.061±0.022	0.054±0.016	0.683±0.024	0.33±0.023	1.45±0.11
^{134}Cs	- - -	46.1±12.3	9.68±2.75	15.1±5.3	24±7	7.4±5.1	8.7±4.9	9.94±24	36.6±15.3	135±56
^{137}Cs	5.48±0.16 E8	3.67±0.11 E5	1.15±0.04 E5	1.90±0.06 E5	1.41±0.02 E5	9.34±0.02 E4	9.63±0.02 E4	4.87±0.07 E5	3.08±0.05 E5	1.24±0.02 E6
^{238}Pu	3.69±0.28 E1	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
$^{239,240}Pu$	1.2±0.55 E2	<0.027	0.0118±0.0118	<0.0106	- - -	- - -	- - -	- - -	- - -	- - -
^{241}Am	1.11±0.04 E3	0.0276±0.0145	<0.0146	0.143±0.023	0.017±0.002	0.005±0.002	0.011±0.003	0.045±0.005	0.044±0.004	0.169±0.027
^{244}Cm	3.17±0.29 E1	<0.0064	<0.0146	0.522±0.044	- - -	- - -	- - -	- - -	- - -	0.0064±0.0054

APPENDIX E

A_0 (INVENTORY) CALCULATIONS

TABLE E.1. A_o Total Inventories for Chemicals and Radioisotopes (includes liquid waste only--no dry blend)

ELEMENT	S-1 (mg)	S-2 (mg)	A-3 (mg)	A-4 (mg)
Ni	0.64	0.67	0.56	0.69
B	0.67	0.71	0.60	0.73
H_3BO_3	3.83	4.06	3.43	4.18
K	27.11	28.44	23.95	29.27
Mo	0.73	0.77	0.65	0.79
Na	2211.20	2319.54	1953.79	2387.16
Cr	15.61	16.37	13.79	16.85
F	3.98	4.18	3.52	4.30
Cl	57.47	60.29	50.78	62.05
NO_2	901.69	945.87	796.72	973.44
NO_3	2086.48	2188.48	1843.40	2252.27
SO_4	62.47	65.53	55.20	67.44

ISOTOPE	ANS-4 (μCi)	STATIC (μCi)
^{60}Co	8.32E-01	7.71E-01
^{137}Cs	6.29E+03	5.82E+03
^{3}H	1.46E-02	1.35E-02
^{59}Ni	1.54E-02	1.42E-02
^{63}Ni	2.30E-01	2.13E-01
^{90}Sr	1.06E+02	9.81E+01
^{99}Tc	1.77E-01	1.64E-01
^{129}I	6.49E-04	6.01E-04
^{241}Am	1.27E-02	1.18E-02
^{244}Cm	3.64E-04	3.37E-04
$^{239,240}Pu$	1.38E-03	1.28E-03
^{238}Pu	4.22E-04	3.91E-04

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